# PMF IAS Environment Third Edition PDF Version – Contents

# 1. Environment, Habitat and Ecosystem

## 1.1. Basics

### Environment

- An environment is a natural component in which **biotic** (resulting from living organisms) and **abiotic** (physical; not directly derived from living organisms) factors **interact** among themselves and with each other. These interactions shape the **habitat** and **ecosystem** of an organism or **ecological community** (a group of species found together).

⇨ ***Biotic*** *components include living organisms,* ***dead and decaying matter***, ***bones***, ***fossils***, *etc.*

⇨ ***Abiotic*** *components include climate, weather,* ***humus*** *(the* ***organic component*** *of soil formed by the decomposition of plant and animal material), natural phenomena like lightning, etc.*

⇨ ***Soil*** *usually has* ***both*** *biotic (dead and decaying matter) and abiotic components (humus, minerals, etc.).*

⇨ ***'Biotic' is not the same as 'organic'****:* ***Organic compounds*** *(****biomolecules*** *like carbohydrates, lipids, proteins, and nucleic acids having at least one* ***carbon-hydrogen bond****) are those obtained directly or indirectly from plants and animals. The compounds obtained from minerals are known as* ***inorganic compounds*** *(****typically lacking carbon-hydrogen*** *(****C-H****)* ***bonds****).*

- In the biological sense, an environment constitutes the **physical** (nutrients, water, air, climate) and **biological** factors (biomolecules, organisms) along with their **chemical interactions** (chemical cycles — carbon cycle, nitrogen cycle, etc.) that affect an organism or a group of organisms
- All organisms depend on the environment to carry out their natural life processes and meet their physical requirements (food, energy, water, oxygen, shelter, etc.).

### Habitat

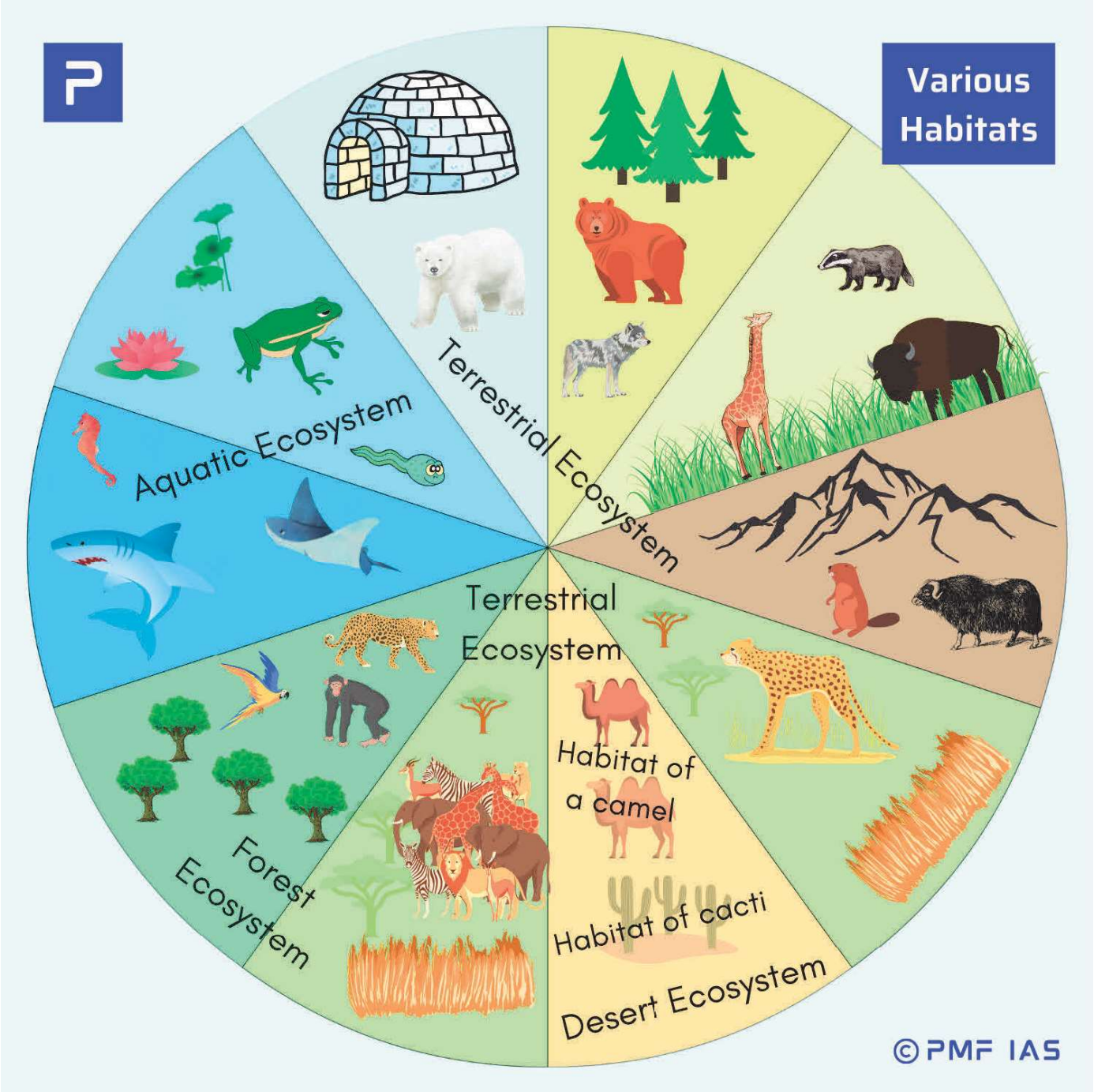
- **Habitat** is the **physical environment** in which an **organism lives (address of an organism)**. **Many habitats together make up the environment**.
- A single habitat may be common for multiple organisms that have **similar requirements**. For example, a single aquatic habitat may support a fish, frog, crab, phytoplankton, and many others. The various species sharing a habitat thus have the **same 'address'**. E.g., forest, lake, etc.

#### Habitat vs Environment

- **A habitat always has life in it**, whereas the environment does not necessarily have life in it ➔ **All habitats are environments**, **but all environments are not habitats**.
- A **habitat** is always a **preference of one species**. An **environment** could be a **preference of many species** that could eventually become many habitats.
- Usually, the **environment governs the properties of a habitat**, but not vice versa.

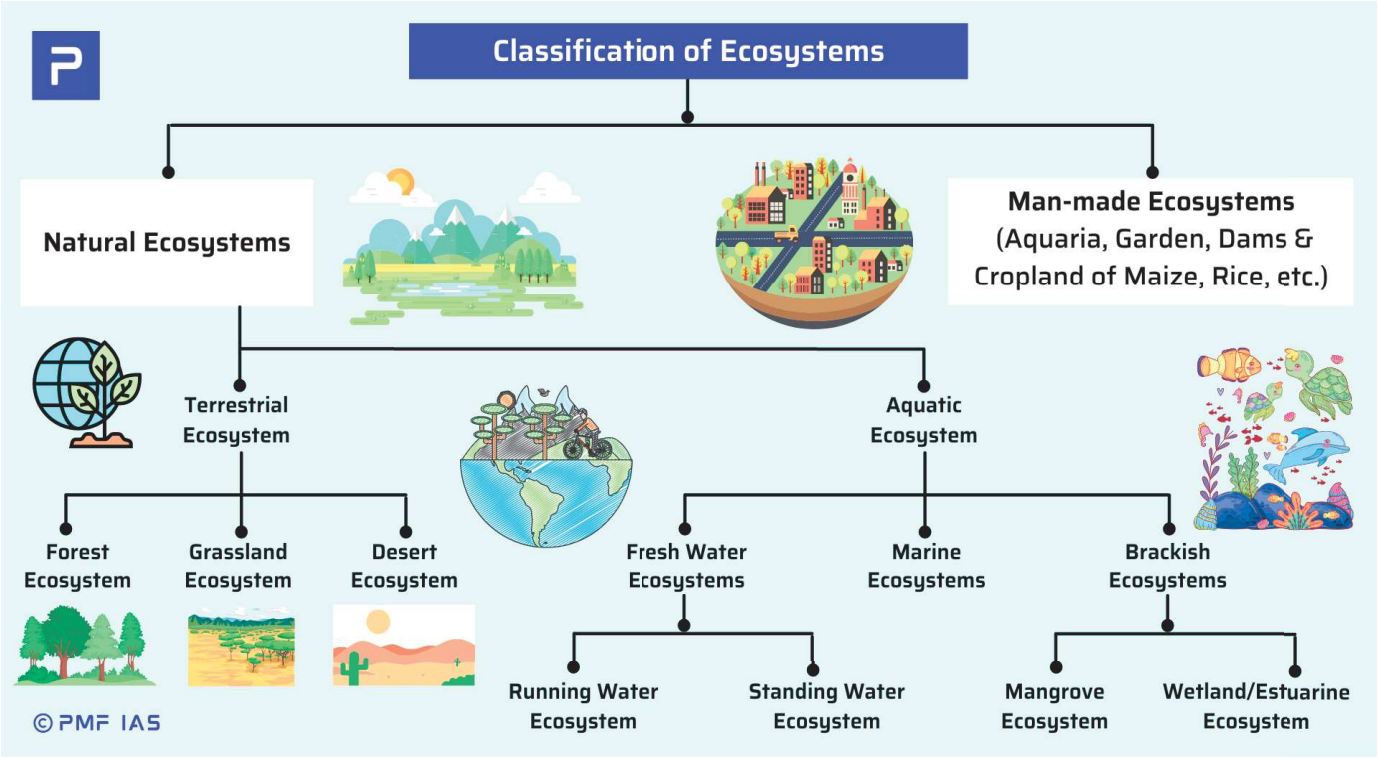
### Ecosystem

- An **ecosystem** can be visualised as a **functional unit of nature**, where living organisms (producers, consumers, and decomposers) **interact** among themselves and with the surrounding physical environment.
- An ecosystem can be of any size but usually encompasses **specific** and **limited species**, such as an Aquatic Ecosystem.
- In an ecosystem, **biotic** and **abiotic** components are **linked** together through **nutrient cycles** and **energy flows**.
- Every species in an ecosystem depends on the other species and elements that are also part of that ecological community. If one part of an ecosystem is damaged or disappears, it impacts everything else.



## Classification of Ecosystems

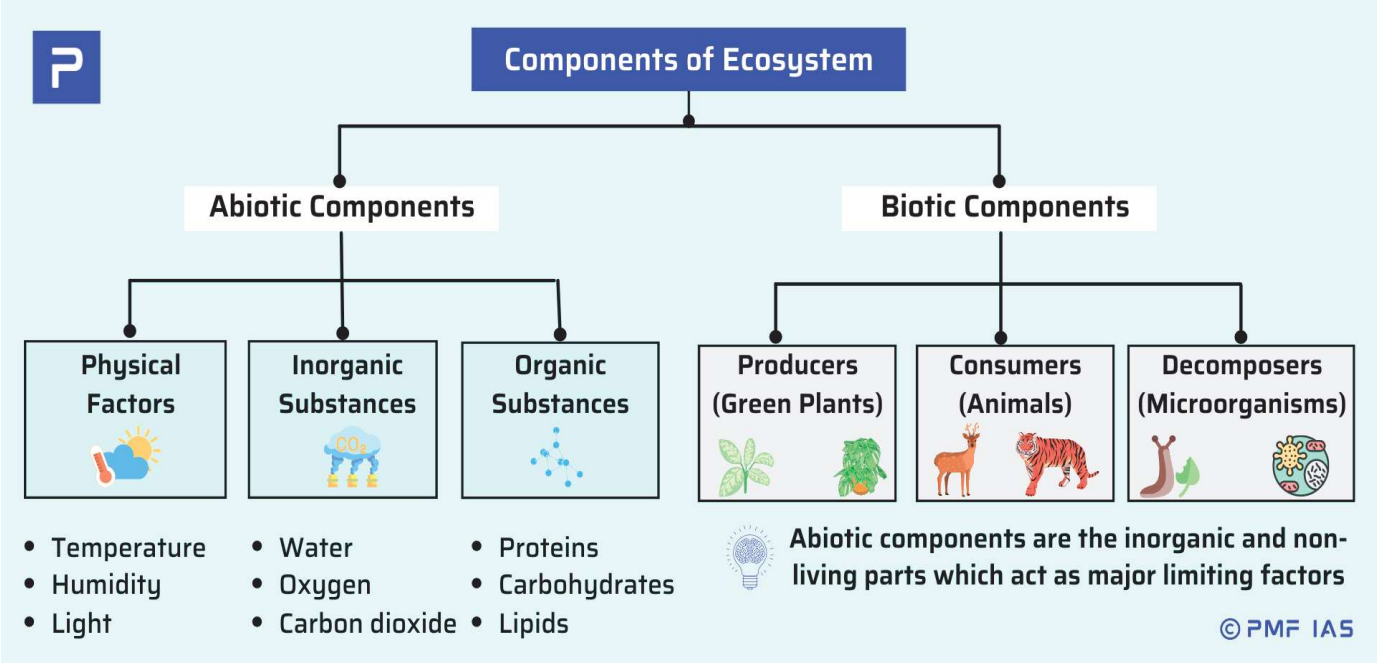
- Ecosystems are classified into **terrestrial** and **aquatic** ecosystems. Forests, grassland, and desert are some examples of terrestrial ecosystems; ponds, lakes, wetlands, rivers and estuaries are some examples of aquatic ecosystems. Crop fields and an aquarium are **human-made ecosystems**.


## Ecosystem vs Environment vs Ecology

- An **ecosystem (has life in it)** is a **functional unit of nature or environment**. A habitat is a **part of the ecosystem**.
- An **environment (may or may not have life)** is a **group of ecosystems**. (All ecosystems are environments, but not vice versa)
- **Ecology** is the **study of interactions** between organisms and organisms and the surroundings in an ecosystem.

## 1.2. Components of an Ecosystem




### Abiotic Components

- Many abiotic factors determine an organism's survival. However, **one single factor** can **limit an organism's range**. This single factor is called a **limiting factor**.
- For example, **seeds do not germinate quickly in evergreen rainforests** despite **good rains** and **luxuriant vegetation**. This is because the surface soil is **heavily leached (nutrients washed away)** by running water. Here, the **inferior surface soil** is the limiting factor that limits the germination of seeds.
- Likewise, germinated saplings may not survive due to a **lack of light** because of the **dense canopy**. Here, the absence of light (shade) is the limiting factor.

**[UPSC 2015] Which one of the following is the best description of the term "ecosystem"?**

a) A community of organisms interacting with one another
b) Part of the earth which is inhabited by living organisms
c) A community of organisms together with the environment in which they live.
d) The flora and fauna of a geographical area.

**Explanation**

- A community of organisms interacting with one another → **Ecological community**.
- Earth inhabited by living organisms → **Biosphere**.
- A community of organisms together with the environment in which they live → **Ecosystem**.
- The flora and fauna of a geographical area → **Biodiversity**.
- **Environment** → Almost everything or a small region.
- **Biosphere** → The part of the earth that supports life.

- ❖ **Habitat** → Area where an organism lives.
- ❖ **Ecosystem** → Producers, Consumers, Decomposers, and their relationships (tiny environment). It is the **functional unit of the environment**.
- ❖ **Ecology** → Study of interactions in an ecosystem

***Answer: c) A community of organisms together with the environment in which they live.***

**[UPSC 2012] If a tropical rainforest is removed, it does not regenerate quickly as compared to a tropical deciduous forest. This is because**

a) the soil of rain forest is deficient in nutrients
b) propagules of trees in a rainforest have poor viability
c) the rainforest species are slow growing
d) exotic species invade the fertile soil of rainforest.

**Explanation**

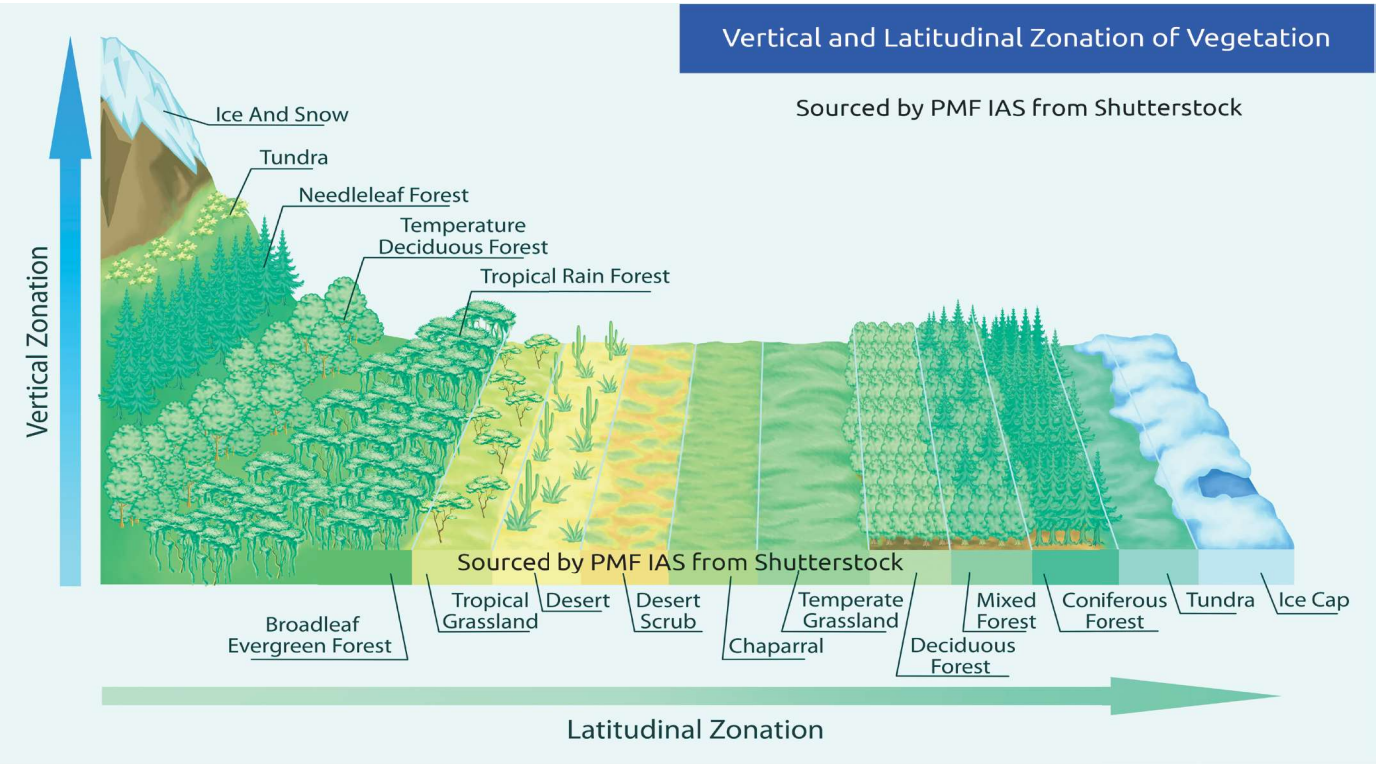
- **The rainforest soil is deficient in nutrients (true):** Rainforest ⇒ It rains almost every day ⇒ The topsoil is continuously washed away ⇒ nutrients are also washed away (**leaching of nutrients**) ⇒ **very little fertility remains in topsoil** ⇒ most of the seeds don't germinate for years ⇒ regeneration of rainforest is very slow (it takes decades). **But the layer below the topsoil is very fertile**. Thus, plants proliferate once their roots reach the **sub-soil** and if they receive enough sunlight.
- **Propagules of the trees in a rain forest have poor viability (true): Propagule** ⇒ detachable structure that can give rise to a new plant, e.g., a bud, sucker, spore (sexual reproduction in plants), etc. However, **seed-bearing plants (spermatophytes) are more significant** than propagules in a **rainforest**.
- **The rainforest species are slow-growing (false):** The plant species in rainforests **compete for sunlight**, so they **grow as rapidly as they can**.
- **Exotic species (non-native) invade the fertile rainforest soil (false):** Since the **rainforest topsoil is heavily leached**, **it is not fertile (only the topsoil)**. However, **exotic invasive species threaten the rainforests significantly when the forests are cleared**.

***Answer: a) the soil of rain forest is deficient in nutrients***

## Major Abiotic Limiting Factors

- **Light:** The spectral quality of solar radiation is essential for life. The **UV** component of the spectrum is harmful to many organisms.
- **Rainfall:** Most biochemical reactions take place in an aqueous medium.
- **Temperature:** A few organisms can tolerate and **thrive in a wide range of temperatures (eurythermal)**, while most are **restricted to a narrow range of temperatures (stenothermal)**.
- **Atmosphere:** 21% oxygen helps many organisms survive, **78% nitrogen prevents spontaneous combustion**, and **0.038% carbon dioxide** helps primary producers synthesize **carbohydrates**.

- **Organic compounds: Biomolecules** like proteins, carbohydrates, lipids, etc., are essential for energy transfer in the living world.
- **Inorganic compounds: Carbon**, **carbon dioxide**, **water**, **sulphur**, **nitrates**, **phosphates**, and ions of various metals are essential for organisms to survive.
- **Altitude:** Change in temperature with altitude is a limiting factor, and it results in **vertical zonation of vegetation**.




- **Buffering capacity of the earth:** A neutral pH (**pH of 7**) is maintained in the soil and water bodies due to the **buffering capacity of the planet**. The neutral pH is conducive to the survival and sustenance of living organisms.
- **Salinity:** Some organisms **tolerate a wide range of salinities (euryhaline)**. Others are **restricted to a narrow range of salinities (stenohaline)**.

## Effect of Abiotic Components on Terrestrial Autotrophs

### Light

- **High-intensity light favours root growth** more than shoot growth, resulting in **increased transpiration**, **short stems**, and **smaller**, **thicker leaves**. On the other hand, **low-intensity** light **retards** growth, **flowering**, and **fruiting**.
- When the light intensity is less than the minimum, the plants cease to grow due to the **accumulation of $CO_2$**.
- Of the visible part of the spectrum, **only red and blue are effective in photosynthesis**. Plants grown in **blue light** are **small; red light** results in the **elongation of cells (etiolated plants)**. Plants grown in **ultraviolet light** are **dwarf**.

### Frost

- Frost results in **freezing the soil moisture**. The plants are **killed due to increased transpiration** when their **roots cannot supply moisture**.
- Water in the intercellular spaces of the plant gets frozen into ice. This results in an **increased concentration of salts** and **dehydration of cells**.
- Also, frost leads to **canker formation** (various plant diseases with similar symptoms are caused by different fungi, bacteria, and viruses).

### Snow

- Snow **shortens the period of vegetative growth**.
- It acts as a blanket, prevents a further drop in temperature and **protects seedlings from excessive cold and frost**.
- Accumulation of snow on tree parts can break the branches or even uproot the tree.

### Temperature

- **High-temperature** results in the death of plants due to **coagulation of protoplasmic proteins** (**some bacteria can survive high temperatures** because their **protoplasmic proteins do not coagulate at normally high temperatures**).
- High temperature disturbs the balance between respiration and photosynthesis. It also results in the **desiccation** of plant tissues and depletion of moisture.

### Nitrogen

- Plants compete with microbes for the **limited nitrogen available in the soil**. Thus, nitrogen is a **limiting nutrient** for both natural and agricultural ecosystems.

#### Dieback

- Dieback refers to the progressive dying, usually backwards **from the tip** of any portion of the plant. This is one of the **adaptive mechanisms** to avoid adverse conditions like drought.
- In this mechanism, the **root remains alive** for years, but the **shoots die**. Examples are **sal**, **red sanders**, silk-cotton trees, etc.

## Biotic Components

### Primary Producers / Autotrophs

- Primary producers (**self-nourishing**) are green plants, **certain bacteria** and **cyanobacteria/blue-green algae** that carry out **photosynthesis**. In the aquatic ecosystem, **microscopic algae (plankton)** are the primary producers.

### Consumers / Heterotrophs

- Consumers (other nourishing) are **incapable** of producing their own food. They depend on organic food derived from plants, animals, or both.

- Consumers can be divided into two broad groups, namely micro and macro consumers.

### Macro Consumers

- **Herbivores** are **primary consumers** that feed mainly on plants. E.g., sheep, rabbit, etc.
- **Secondary consumers** feed on primary consumers. E.g., wolves, dogs, snakes, etc.
- **Carnivores** that feed on both primary and secondary consumers are called **tertiary consumers**. E.g., lions (can eat wolves), snakes etc.
- **Omnivores** are organisms that consume both plants and animals. E.g., humans, **bears**, **pigs**, etc.

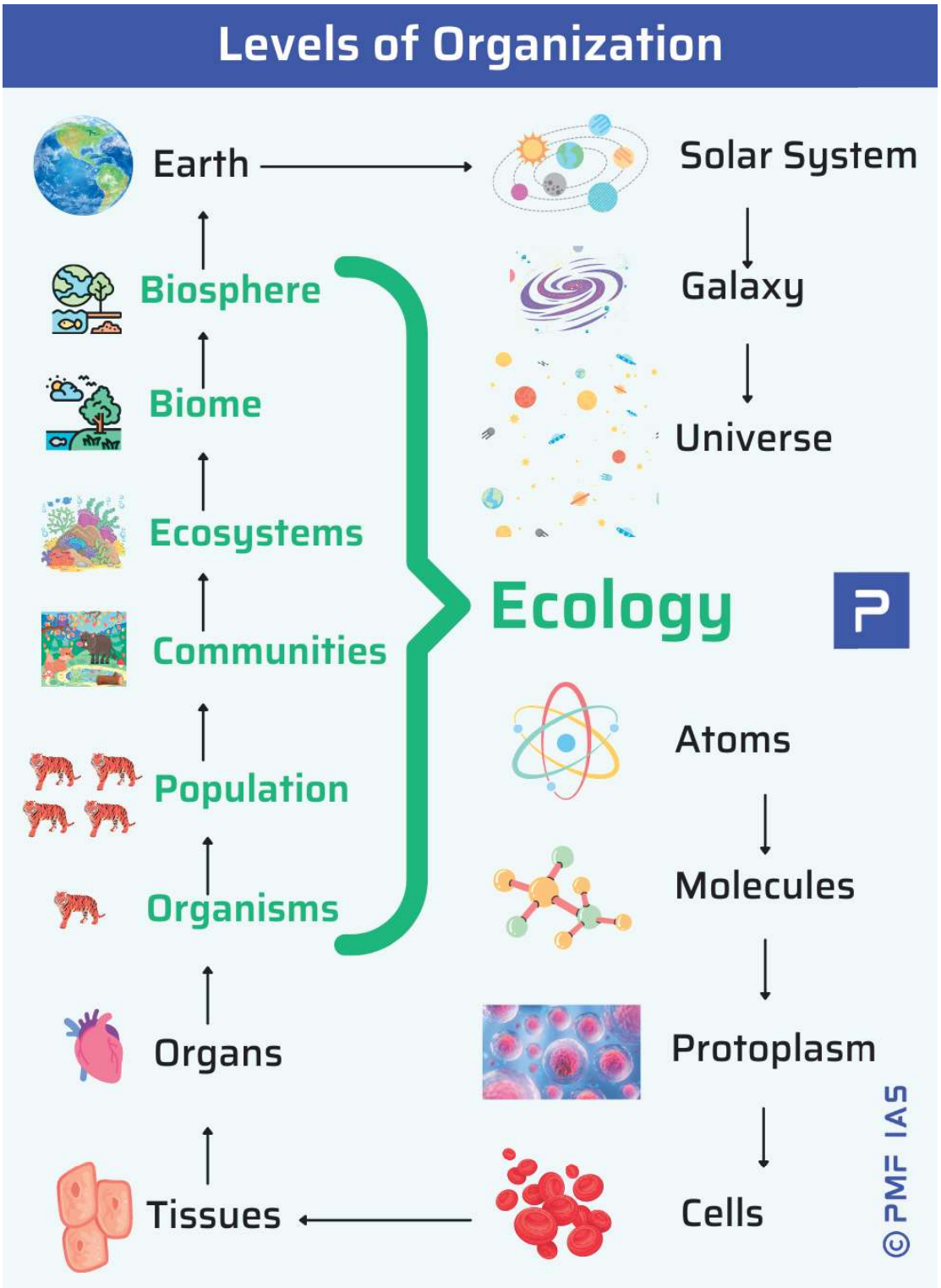
### Micro Consumers

- **Phagotrophs** are tiny organisms that feed by **ingesting organic matter or organisms**.
- **Osmotrophs** are organisms that obtain their nutrients by uptaking dissolved organic matter from the ambient medium through **osmosis** (movement of a solvent through a semi-permeable membrane).
- **Saprotrophs/decomposers** are **bacteria** and **fungi (e.g., mushrooms)** that obtain energy and nutrients from **dead organic substances (detritus)**.
- **Earthworms** and certain soil organisms (such as **nematodes** and **arthropods**) are **detritus feeders** and **help decompose organic matter**, which is why they are called **detrivores**.

**---------- End of Chapter ----------**

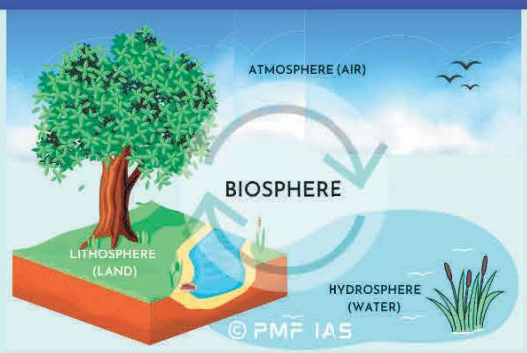
# 2. Ecology – Principles and Organizations

- The term ecology was derived from two Greek words, '*Oikos*' meaning home and '*logos*' meaning study.
- **Ecology** is the branch of biology concerned with the **relations** of **organisms to one another** (energy flow and mineral cycling) and **their physical surroundings** (environment).



# Levels of Ecological Organisation

**Biosphere**




**Ecosystem**

**Community**

**Population**

**Individual**

**Tissues**

**Cells**

**Molecules**


Ecology encompasses the study of individuals, organisms, populations, communities, ecosystems, biomes and biosphere which form the various levels of ecological organisation.

## 2.1. Levels of Organizations in Ecology

- Ecology encompasses the study of **individuals**, **organisms**, **populations**, **communities**, **ecosystems**, **biomes** and **biosphere**, which form the various levels of ecological organisation.

### Individual and Species

- An organism is an individual living being that can act or function independently.
- **Species** are a group of living organisms consisting of **similar individuals capable of exchanging genes (interbreeding)**. They are considered the **basic unit of taxonomy** and are denoted by a Latin binomial, e.g., *Homo sapiens*.

### Population

- The population is a **community of interbreeding organisms (same species)** occupying a defined area during a specific time.
- Population growth rate can be **positive** due to birth/immigration or **negative** due to death/emigration.

#### Identifying Populations using Pugmarks

- In large, mobile animals like tigers, leopards, lions, deer, etc., the population density may be determined by counting the **pugmarks** (foot imprints) left by the animals in a defined area. The study of pug marks can provide the following information reliably:
  - ✓ Presence of different species in an area.
  - ✓ Identification of individual animals.
  - ✓ Population of large cats (tigers, lions etc.).
  - ✓ **Sex ratio and age** of large cats (The sex of tigers can be determined from pugmarks!).

### Community

- Communities are named after the **dominant plant form**. For example, a grassland community is dominated by grasses, though it may contain herbs, trees, etc.
- **Major Communities:** These are large-sized and relatively independent. They depend only on the sun's energy from outside. E.g., **Tropical evergreen forests**.
- **Minor Communities:** These depend on neighbouring communities and are often called **societies**. They are secondary aggregations within a major community. E.g., **A mat of lichen on a cow dung pad**.

#### Stable Community

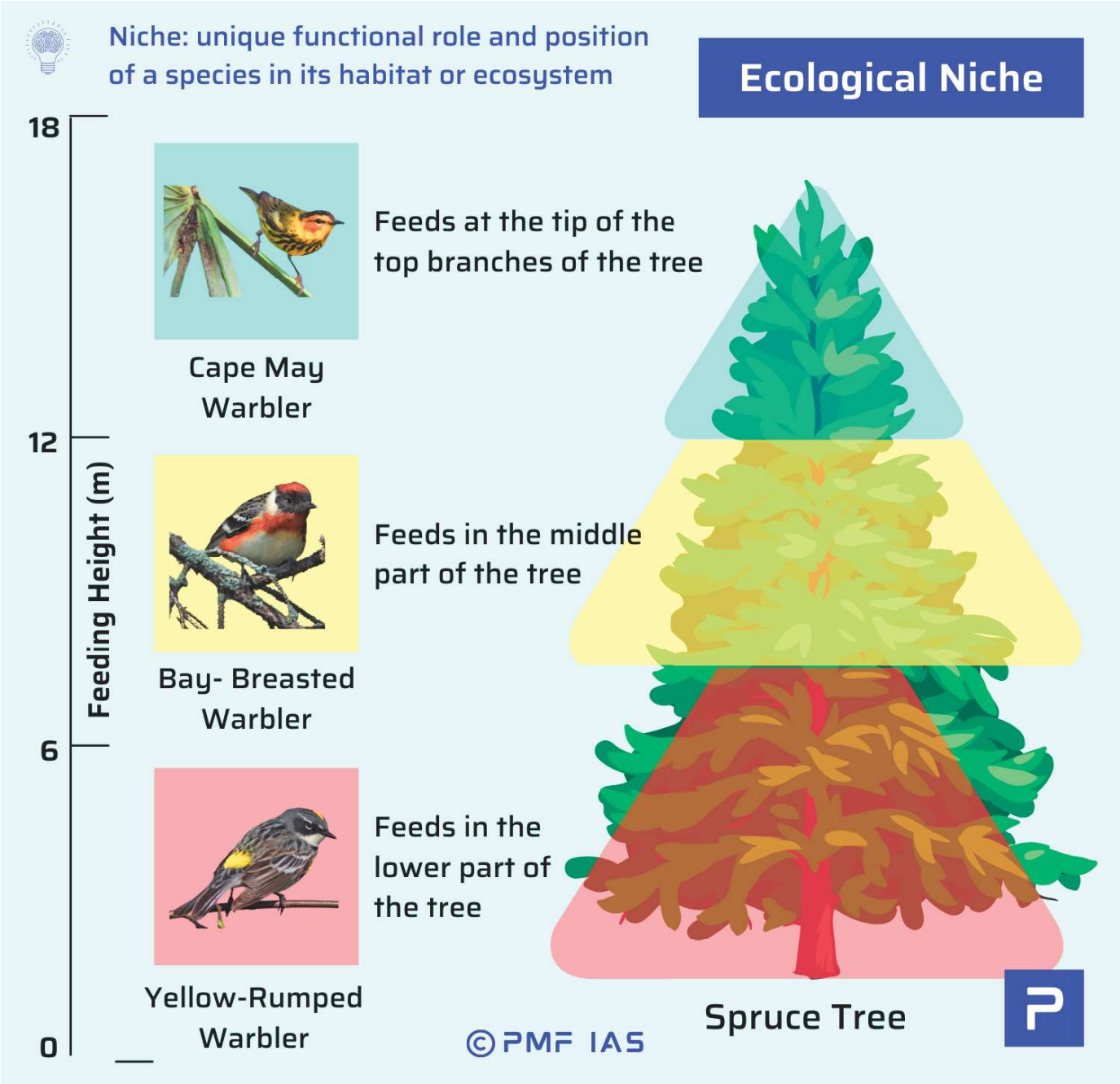
- A stable community means that **productivity does not vary much** from year to year. It is either resistant or **resilient to occasional disturbances** (natural or human-made) and invasions by alien species.

### Ecosystem

- An ecosystem constitutes **habitats of various species**, usually overlapping with each other.
- In an ecosystem, the organisms interact with each other and their environment such that energy is exchanged and system-level processes, such as the **cycling of elements**, emerge.

## Ecological Niche

- **Niche** refers to the **unique functional role** and **position of a species in its habitat or ecosystem**.
- In nature, many species occupy the same habitat, but they perform different functions:
  a) **habitat niche** — where it lives,
  b) **food niche** — what it eats or decomposes and what species it competes with,
  c) **reproductive niche** — how and when it reproduces,
  d) **physical and chemical niche** — temperature, land shape, land slope, humidity and other requirements.
- Niche plays an essential role in the **conservation of organisms**. If we must conserve species in their native habitat, we should know their **niche requirements**.



### Difference Between Niche and Habitat

- The **habitat** of a species is like its '**address**'. In contrast, **niche** can be considered its "**lifestyle and profession**" (i.e., activities and responses specific to the species).
- **A niche is unique for a species**, **while many species share the habitat**. **No two species in a habitat can have the same niche**. This is because of the **competition** with one another until one is displaced. For example, many different species of insects may be pests of the same plant, but they can co-exist as they feed on different parts of the same plant.

**[UPSC 2013] Which one of the following terms describes not only the physical space occupied by an organism but also its functional role in the community of organisms?**

a) Ecotone
b) Ecological niche
c) Habitat
d) Home range

**Explanation**

- **Ecotone** → zone of transition between two ecosystems. E.g., grasslands, mangroves etc.
- **Habitat** → surroundings in which an organism lives (home).
- **Home Range** → A home range is an area where an animal lives and moves on a daily or periodic basis (a little bigger than habitat — home → office → home).

***Answer: b) Niche***

## Biome

- A biome is a large, naturally occurring **community of flora and fauna** occupying a major habitat, such as a Rainforest or tundra biome.
- Biomes are distinct from habitats because any **biome can comprise a variety of habitats**.
- Plants and animals in a biome have **common characteristics due to similar climates** and **can be found over various continents**. For example, **taiga forests** are found beyond the temperate regions of all the continents in the northern hemisphere.

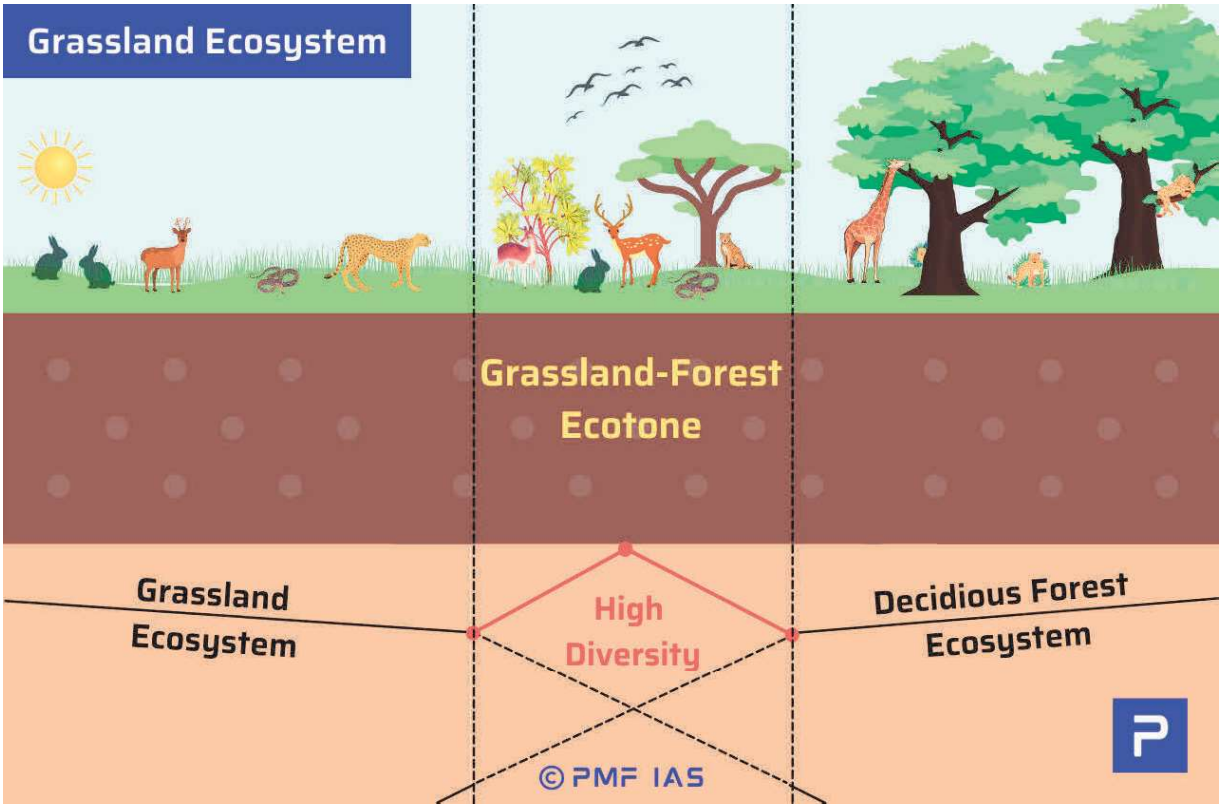
## Ecotone

- An **ecotone** is a **zone of junction or a transition** area between **two biomes (diverse ecosystems)**. It is the zone where two communities meet and integrate. For example, the **mangrove forests** represent an **ecotone** between **marine** and **terrestrial ecosystems**.
- Other examples are **grassland** (between forest and desert), **estuarine** (between fresh water and saltwater) and **riverbank or marshland** (between dry and wet).

### Characteristics of An Ecotone

- An ecotone may be **narrow (between grassland and forest)** or **wide (between forest and desert)**. It has **conditions intermediate** to the adjacent ecosystems. Hence, it is a **zone of tension**.

- ❖ Usually, the number and the population density of the species of an outgoing community **decrease** as we move away from the community or ecosystem.
- ❖ A well-developed ecotone contains **some organisms** which are **entirely different** from that of the adjoining communities.
- ❖ **Ecotone regions (transitional zones)** like **mangroves**, **wetlands**, **estuaries**, **grasslands** etc., **have far greater productivity than natural ecosystems** like a forest ecosystem, ocean ecosystem, pond ecosystem, riverine ecosystem, desert ecosystem, etc. This is because of the **wide-ranging species from the adjacent ecosystems** being present in the ecotone.




## Ecocline

- **Ecocline** is a **zone of gradual but continuous change from one ecosystem to another** when there is **no sharp boundary** between the two in terms of species composition. It occurs across the **environmental gradient** (gradual change in abiotic factors such as altitude, temperature (**thermocline**), salinity (**halocline**), depth, etc.).

⇨ ***Ecotone*** ➔ ***Zone of transition*** *between two ecosystems. It has characteristics of both ecosystems.*

⇨ ***Ecocline*** ➔ *An* ***indistinct boundary*** *(not-so-sharp environmental gradient of physiochemical factors such as* ***humidity***, ***temperature***, ***salinity***, *pH, etc.) between ecosystems.*

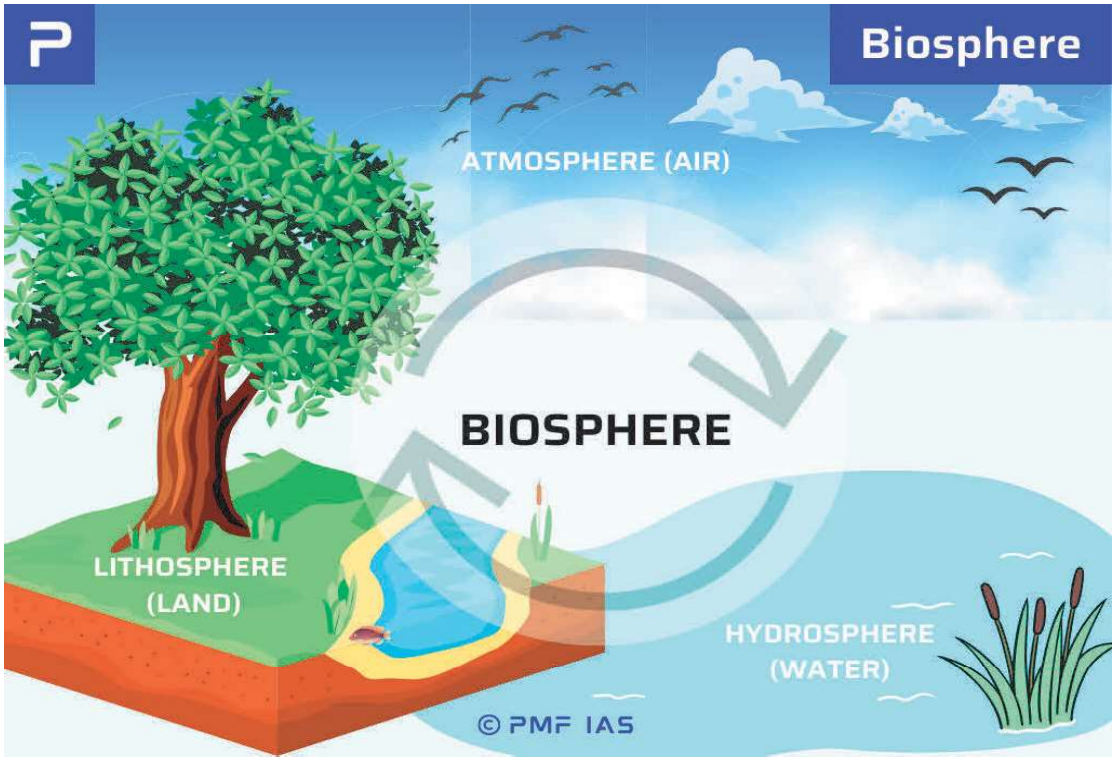
## Edge Effect and Edge Species

- Sometimes, due to the **more diverse ecological characteristics** found in an ecotone, the number of species (**biodiversity**) and the **population density** of **some species** in the **ecotone** is much **greater**

**than in either community**. This is called the **edge effect**, and the species that occur primarily or **most abundantly** in this zone are known as **edge species**.

- In terrestrial ecosystems, the edge effect is especially applicable to **birds**. For example, the **density of birds is greater in the ecotone** between the **forest** and the **desert**.

### Biosphere




- The biosphere is the earth's biological component (supporting life), including the **lithosphere**, **hydrosphere**, and **atmosphere**.
- It consists of all living organisms and the **dead organic matter** produced by them.
- The biosphere is **absent at extremes** of the North and South poles, the highest mountains, and the deepest oceans since existing hostile conditions do not support life.
- Occasionally, **spores of fungi and bacteria** occur at great heights beyond 8,000 metres, but they are metabolically inactive and hence represent only **dormant life**.

## 2.2. Principles of Ecology

- Certain principles govern the evolution of ecosystems. Such principles are discussed in this section.

### Adaptation

- An **adaptation** is the **appearance/behaviour/structure/mode of life** of an organism that **allows it to survive in a particular environment**. Adaptation may be:

1. **Morphological** — when trees grew higher, the giraffe's neck got longer.
2. **Physiological** — in the absence of an external water source, the kangaroo rat in North American deserts can meet all its water requirements through **internal fat oxidation** (in which water is a by-product). It

also has the ability to concentrate its urine so that a minimal volume of water is used to remove excretory products.

3. **Behavioural** — animals migrating temporarily to a less stressful habitat.

## Examples of Adaptation

### Morphological

- Many **desert plants** have **thick cuticles** on their leaf surfaces and **stomata arranged in deep pits** to **minimise water loss through transpiration**.
- Some desert plants, like Opuntia, have no leaves — **they are reduced to spines (to reduce transpiration)**, and the **photosynthetic function is taken over by the flattened stems (few leaves mean less area is available for transpiration)**.
- **Mammals from colder climates** generally have **shorter ears and limbs to minimise heat loss**. (This is called **Allen's Rule**.)
- Guess why an **elephant has enormous ears? Elephants don't sweat**. They use their **flapping ears** to **lose heat** and keep the rest of their bodies cool.
- A **hyperthermophile** is an organism that **thrives in extremely hot environments** (60 °C). E.g., **Archaebacteria** flourish in **hot springs** and **deep-sea hydrothermal vents**.

### Archaebacteria (Archaea) and Eubacteria

- **Archaebacteria (ancient bacteria)**, **eubacteria (true bacteria)** and **cyanobacteria (blue-green algae)** belong to the kingdom **Monera**, which contains the **least organised unicellular prokaryotic (genetic material is not stored within a membrane-bound nucleus) microorganisms on earth**.
- The main difference between archaebacteria and other groups in Monera is that **archaebacteria** can **survive in extreme environmental conditions**. A **special protein** helps these organisms form a **protective**, **lipid-linked cellular membrane** — a key to withstanding extremely **highly salty areas (halophiles)**, **hot springs** and **acidic habitats (thermoacidophiles)**.

### [UPSC 2023] Consider the following statements:

1. Some microorganisms can grow in environments with temperature above the boiling point of water.
2. Some microorganisms can grow in environments with temperature below the freezing point of water
3. Some microorganisms can grow in a highly acidic environment with a pH below 3.

***How many of the above statements are correct?***

a) Only one
b) Only two
c) All three
d) None

**Explanation**

***Statement 1 is correct***

- A hyperthermophile is an organism that thrives in an extremely hot environment — usually between 60 and 80 °C. However, a hyperthermophile named *Pyrolobus fumarii* has been found at temperatures of 113 °C.

***Statement 2 is correct***

- The nematode *Panagrolaimus davidi*, which occurs mainly along the coast of Antarctica, can withstand temperatures below freezing.

***Statement 3 is correct***

- Extreme **acidophiles** dwell in environments with a pH value < 3, and moderate acidophiles grow optimally in conditions having pH values ranging between 3 and 5.

**Answer: c) All**

### Physiological

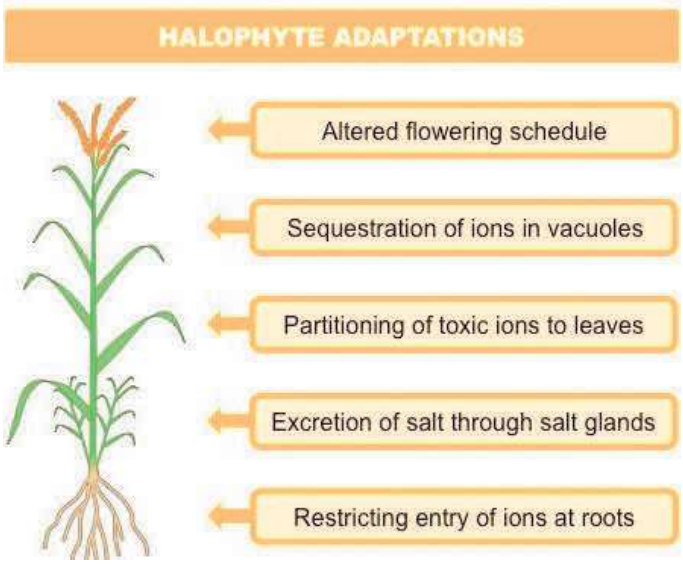
- We need to breathe faster when we are in high mountains. After some days, our body adjusts to the changed conditions. Such **small changes** taking place in the body of an organism **over short periods** to overcome minor challenges due to changes in the surroundings is called **acclimatisation**.
- The body compensates for low oxygen availability by **increasing red blood cell production**, **decreasing the binding capacity of haemoglobin**, and **increasing breathing rate**.

### Behavioural

- **Desert lizards** lack the physiological ability that mammals have. They bask in the sun and absorb heat when their body temperature drops but move into the shade when the ambient temperature increases.
- Some species can burrow into the soil to hide and escape from the above-ground heat.

## Halophytes

- **Halophytes** are plants that have developed unique physiological and morphological **adaptations** to thrive in **high-salt environments (e.g. mangroves)**, such as salt marshes, coastal areas, and saline soils. Some common adaptations include:
  - **Specialised Root System:** To overcome the respiration problem in saline conditions, some halophytes send arching **prop roots** and **stilt roots** down into the water (e.g. **Rhizophora**). While other species send vertical **Pneumatophores (air roots/blind roots)** up from the mud (e.g. **Avicennia**).
  - **Prop roots:** They develop from horizontally spread branches of the tree.
  - **Stilt roots:** They arise from basal nodes of the stem near the soil.
  - **Mode of reproduction:** Halophytes rely on **viviparity**, where **seeds germinate in the tree itself** to overcome the problem of germination in saline water (e.g. **Rhizophora** and **Avicennia**).
  - **Cellular sequestration:** They can sequester toxic ions and salts within the cell wall or vacuoles.
  - **Tissue partitioning:** Some of them can concentrate salts in particular leaves, which then drop off.
  - **Root level exclusion:** They are structured to exclude salt at the root level.
  - **Salt excretion:** Certain parts of the plant (e.g. leaves) may contain salt glands that actively eliminate salt.
  - **Altered flowering schedule:** Halophytes may flower during rainy seasons to minimise salt exposure.

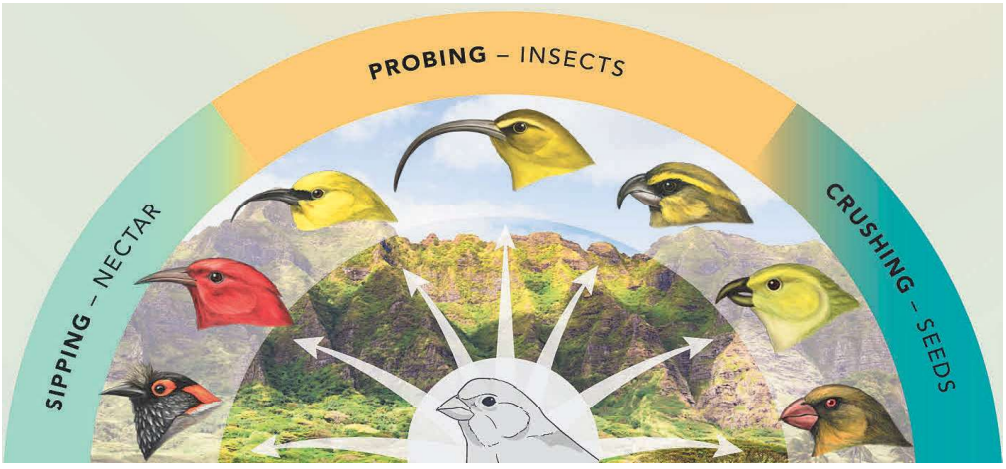



## Variation

- **Changes in genetic makeup** (addition or deletion of specific genes) induce **variations**.
- **Mutations**, **changes in climate**, **geographical barriers**, etc., induce variations over a period of time.
- The difference in the **colour of skin**, **type of hair**, **curly or straight**, **eye colour**, **and blood type** among different ethnic groups represents the variation within the human species.

## Adaptive radiation

- **Adaptive radiation** is a process in which **organisms diversify** from an **ancestral species** into **many new forms** when the environment creates new challenges or opens new **environmental niches**.

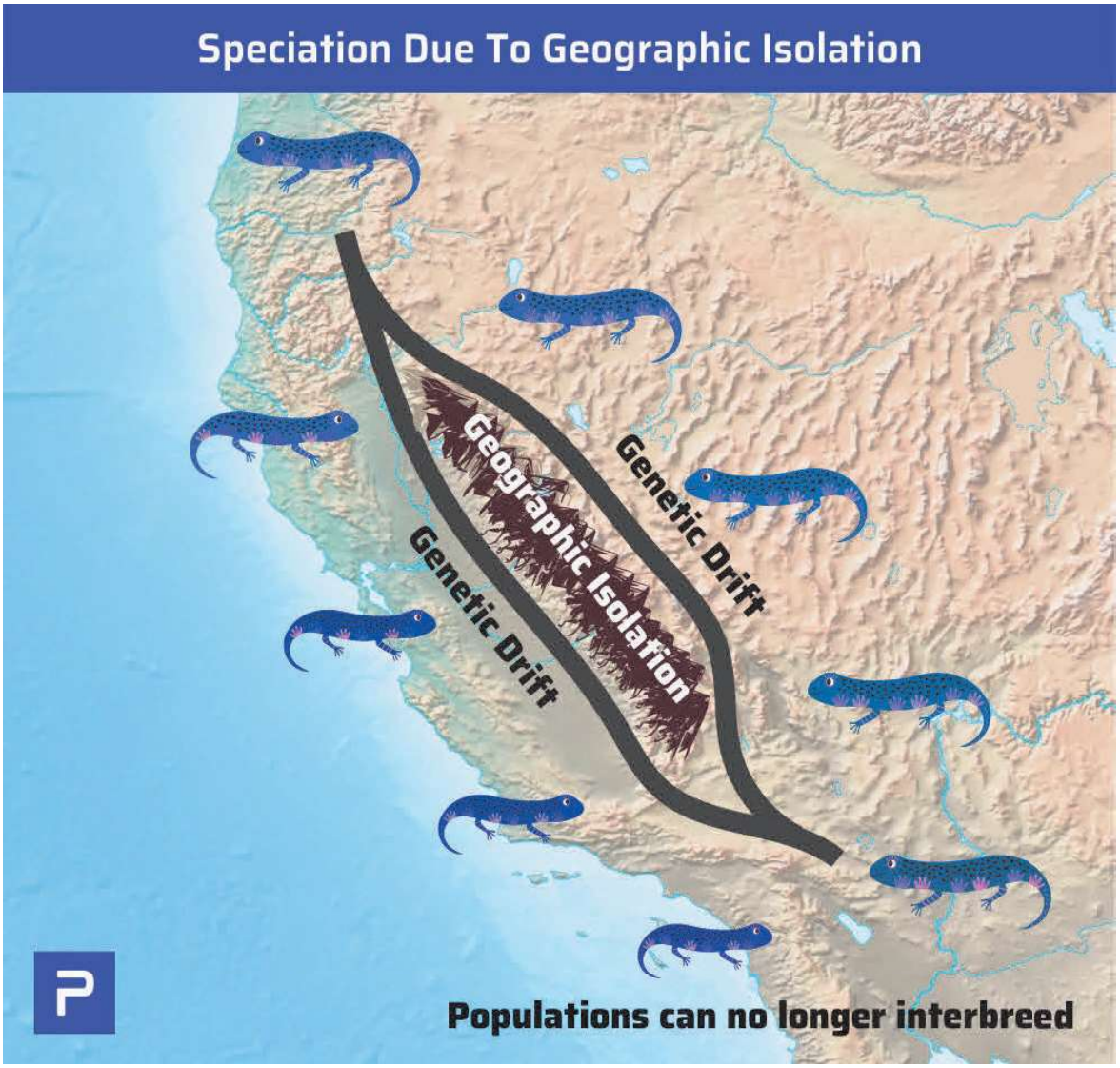


## Speciation

- **Speciation** is the process by which **new species are formed**, and **evolution** is the mechanism by which **speciation occurs**.

### Allopatric Speciation

- A species comprises many populations. Often, different populations remain isolated due to **geographic barriers (geographic isolation)** such as mountains, oceans, rivers, etc.
- After an extended period, the **isolated sub-populations** become very different (**genetic drift**) and become isolated reproductively (they **no longer interbreed**). Later, even when the barrier is removed, the subpopulations are unable to interbreed, and thus, they become different species (**allopatric/geographic speciation**).



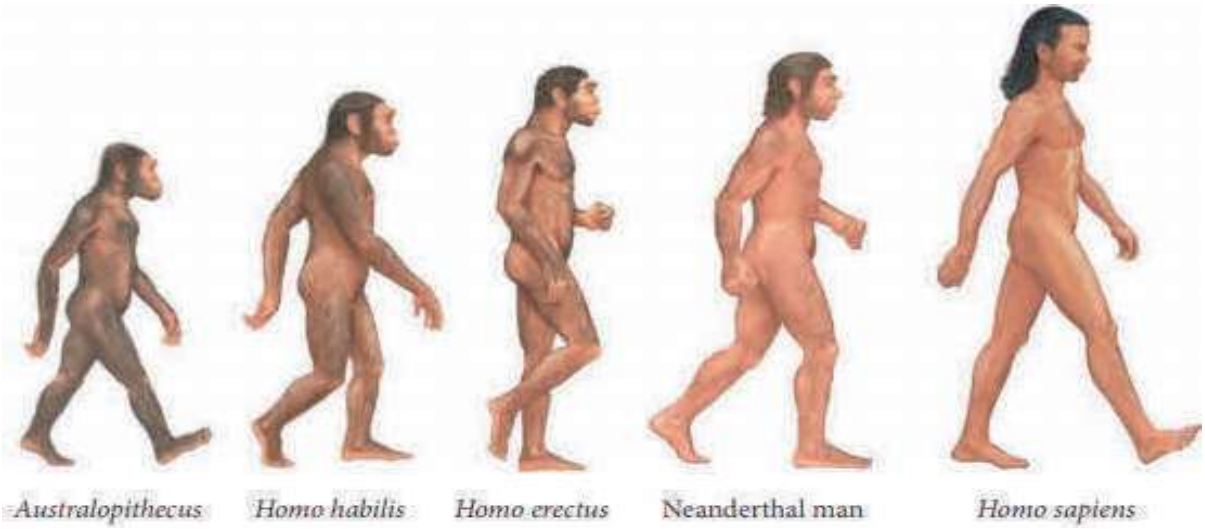

- **Masai giraffes** are geographically separated by the **Gregory Rift** in Tanzania and Kenya, dividing them into two populations. As a result, these factions have not interbred or exchanged genetic material in more than a thousand years.

### Parapatric Speciation

- **Parapatric Speciation** occurs when populations are only **partially separated** by a geographical barrier. Over time the limited gene flow results in the accumulation of genetic differences, leading to the development of distinct species.

### Sympatric Speciation

- In **sympatric speciation**, no physical barriers prevent the same species' populations from mating. Here, speciation happens spontaneously within the same geographic area due to **disruptive selection**, where different subgroups specialise in **different ecological niches**, **food sources** or mating preferences, leading to reproductive isolation.




### Hybridization

- **Hybridization** occurs when two different species mate and produce hybrid offspring. In some cases, these hybrids can give rise to new species. For example, the **mule** is a hybrid between a donkey and a horse.

## Mutation

- **Mutation** (a change in genetic material that results from an **error in DNA replication**) **causes new genes to arise** in a population.
- Further, in a sexually reproducing population, **meiosis** and **fertilisation** produce a **new combination of genes** every generation, which is termed **recombination**. Thus, members of the same species show 'variation' and are **not identical**.

## Natural Selection

- **Natural Selection** is the mechanism proposed by **Darwin and Wallace**. It is the process by which **species adapt to their environment**.
- It is an **evolutionary force** that **selects among variations**, **i.e. genes that help the organism to better adapt to its environment**. Such genes are reproduced more in a population due to natural selection.
- Natural selection helps create offsprings that are **better suited to their immediate environment**. Hence, such offsprings have a better chance of surviving, reaching reproductive age and passing on suitable adaptations to their progeny.

## Evolution

- **Evolution** involves the processes of **natural selection**, **adaptation**, **variation**, etc., that make the organism **better suited** to the present environment, ultimately **giving rise to new species**.
- Charles Darwin and Alfred Wallace propounded a valid theory of evolution in 1859. This theory has been extended in light of progress in genetics and is known as **Neo-Darwinism**.

## Extinction

- The primary reason behind extinctions is an environmental change or biological competition.
- Most extinctions occur when species cannot evolve fast enough to cope with the changing environment.
- Currently, the **6$^{th}$ Mass Extinction (Anthropogenic Extinction — human-induced)** is in progress.

### Q. Which of the following are true?

1. The presence of specific features or certain habits, which enable a plant or an animal to live in its surroundings, is called evolution.
2. The surroundings where an organism lives is called its habitat.
3. Small changes that take place in the body of a single organism over short periods, to overcome small problems due to changes in the surroundings, is called acclimatization
4. Gradual changes in an organism to survive in an environment is call adaptation

***Codes:***

a) All
b) 2, 3 only
c) 1, 2, 4 only
d) 1, 2, 3 only

**Explanation**

- The presence of **specific features/habits** that enable a plant or an animal to live in its surroundings is called **adaptation** and not evolution. For example, **Hibernation**.
- The surroundings where an organism lives is called its habitat (True).
- Small changes that take place in the body of a single organism over short periods to overcome minor problems due to changes in the surroundings is called **acclimatisation** (True). For example, **Soldiers undergo rigorous acclimatisation** training before serving in harsh climatic regions like the **Siachen**.
- **Gradual changes** in an organism to survive in an environment is called **evolution** and not adaptation (**adaptation may be gradual or quick**). E.g., the evolution of the Giraffes neck over a period of time.

***Answer: b) 2, 3 only***

### Q. Choose the incorrect pairs

| Characteristic feature | Vegetation |
|---|---|
| 1) Sloping branches and needle-like leaves | Desert vegetation |
| 2) Deep roots | Taiga vegetation |

| | |
|---|---|
| 3) Waxy stem, thick leaves or no leaves | Tundra vegetation |
| 4) Canopy | Tropical vegetation |

***Codes:***

a) All
b) 4 only
c) 1, 2, 3 only
d) 2, 3 only

**Explanation**

- **Sloping branches (prevent snow accumulation)** and **needle-like leaves (reduce transpiration) ➔ Taiga**.
- **Deep roots**, **waxy stem**, **thick leaves/no leaves ➔ Desert vegetation**
- **Canopy ➔** the characteristic feature of tropical forests — rainforests, deciduous forests etc.

***Answer: c) 1, 2, 3 only (incorrect pairs)***

**[UPSC 2018] The term "sixth mass extinction/sixth extinction" is often mentioned in the news in the context of the discussion of (2018)**

a) Widespread monoculture practices in agriculture and large-scale commercial farming with indiscriminate use of chemicals in many parts of the world that may result in the loss of good native ecosystems.
b) Fears of a possible collision of a meteorite with the earth in the near future in the manner it happened 65 million years ago that caused the mass extinction of many species, including those of dinosaurs.
c) Large-scale cultivation of genetically modified crops in many parts of the world and promotion of their cultivation in other parts of the world, which may cause the disappearance of good native crop plants and the loss of food biodiversity.
d) Mankind's over-exploitation/misuse of natural resources, fragmentation/loss of natural habitats, destruction of ecosystems, pollution, and global climate change.

**Extinction Events**

1. Ordovician-Silurian Extinction (440 million years ago) → Small marine organisms died.
2. Devonian Extinction (365 million years ago) → Many tropical marine species went extinct.
3. Permian-Triassic Extinction (250 million years ago) → The **largest mass extinction event** in Earth's history affected many species, including many vertebrates.
4. Triassic-Jurassic Extinction (210 million years ago) → The extinction of other vertebrate species on land allowed dinosaurs to flourish.
5. **Cretaceous-Tertiary Extinction** (65 million years ago) → **It wiped out dinosaurs** and some 50 per cent of plants and animals.
6. The **sixth mass extinction** is the **Anthropocene/Holocene Extinction → a result of human activity**.

⇨ *The ongoing **Anthropocene** (since the agricultural revolution 12,000–15,000 years ago to the present) is a **proposed geological epoch** dating from the commencement of significant human impact on Earth's geology and ecosystems, including, but not limited to, anthropogenic climate change.*

***Answer: d)***

**---------- End of Chapter ----------**

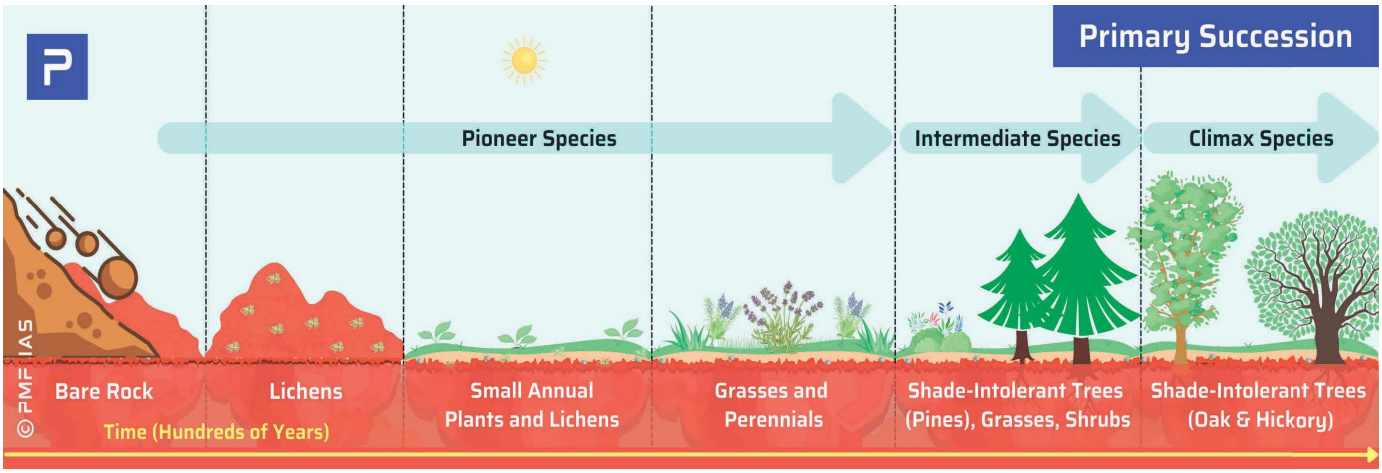
# 3. Functions of an Ecosystem – Succession and Homeostasis

The function of an ecosystem includes:

1. **Ecological succession or ecosystem development**
2. **Homeostasis (cybernetic)/feedback control mechanisms**
3. **Energy flow through the food chain**
4. **Nutrient cycling (biogeochemical cycles)**

## 3.1. Ecological Succession

- The process by which communities of plant and animal species in an area are **replaced** or **changed** into another over a period of time is known as **ecological succession**. It occurs due to large-scale changes or destruction (natural or manmade).




### Stages in Ecological Succession

- Succession is a directional change in vegetation on an ecological time scale. It involves a progressive series of changes, with one community replacing another until a stable **climax community** develops.
- The first plant to colonise an area is called the **pioneer community**. The final stage of succession is called the **climax community**, which is more complex, stable, mature and long-lasting.
- The stages leading to the climax community are called **successional stages** or **seres**. Each **transitional community (seres)** that is formed and replaced in between is called a **seral community**.
- Succession is characterised by the following:
  - ❖ **increased productivity**,
  - ❖ **the shift of nutrients from the reservoirs**,
  - ❖ **increased diversity of organisms**, and
  - ❖ **a gradual increase in the complexity of food webs**.
- Succession would occur **faster** in an area in the **middle of a large continent**. This is because **seeds** of plants belonging to **different seres** would **reach much faster** here.

## Primary Succession

- **Primary succession** takes place over an area **where no community has existed previously**. Such areas include **rock outcrops**, **newly formed deltas** and **sand dunes**, **emerging volcano islands** and **lava flows**, **glacial moraines** (areas exposed by a retreating glacier), **slopes exposed by landslides**, etc.
- In primary succession on a terrestrial site, the new site is first colonised by a few hardy **pioneer species** that are often **microbes**, **lichens**, and **mosses**. The pioneers, over a few generations, alter the habitat through their growth and development.

**[UPSC 2014] Lichens, which are capable of initiating ecological succession even on a bare rock, are actually a symbiotic association of**

a) algae and bacteria
b) algae and fungi
c) bacteria and fungi
d) fungi and mosses

**Explanation**

- **Lichen** are **plant-like organisms** that consist of a **symbiotic association** of **algae** and **fungi**. Fungi provide shelter, water and minerals to the algae and, in return, the alga provides food.

***Answer: b) Algae and Fungai***

**[UPSC 2021] In nature, which of the following is/are likely to be found surviving on a surface without soil?**

1) Fern
2) Lichen
3) Moss
4) Mushroom

***Select the correct answer using the code given below***

a) 1 and 4 Only
b) 2 Only
c) 2 and 3
d) 1, 3 and 4

**Explanation**

- Ferns are **vascular plants** (plants with xylem and phloem) that reproduce via spores and have neither seeds nor flowers. They differ from **mosses** by being vascular, i.e., having specialized tissues that conduct water and nutrients.
- **Some ferns** are **epiphytic plants**. They grow naturally in a **soilless** condition. They obtain water and nutrients through **leaching from trees**.
- Ferns are not of major economic importance, but some are used for food, medicine, as biofertilizer, as ornamental plants, and for remediating contaminated soil. Some ferns can fix nitrogen. Some fern species are significant **weeds**.

- Some ferns play a role in **ecological succession**, growing from the crevices of bare rock exposures and in open bogs and marshes prior to the advent of forest vegetation.

***Answer: c) 2 and 3***

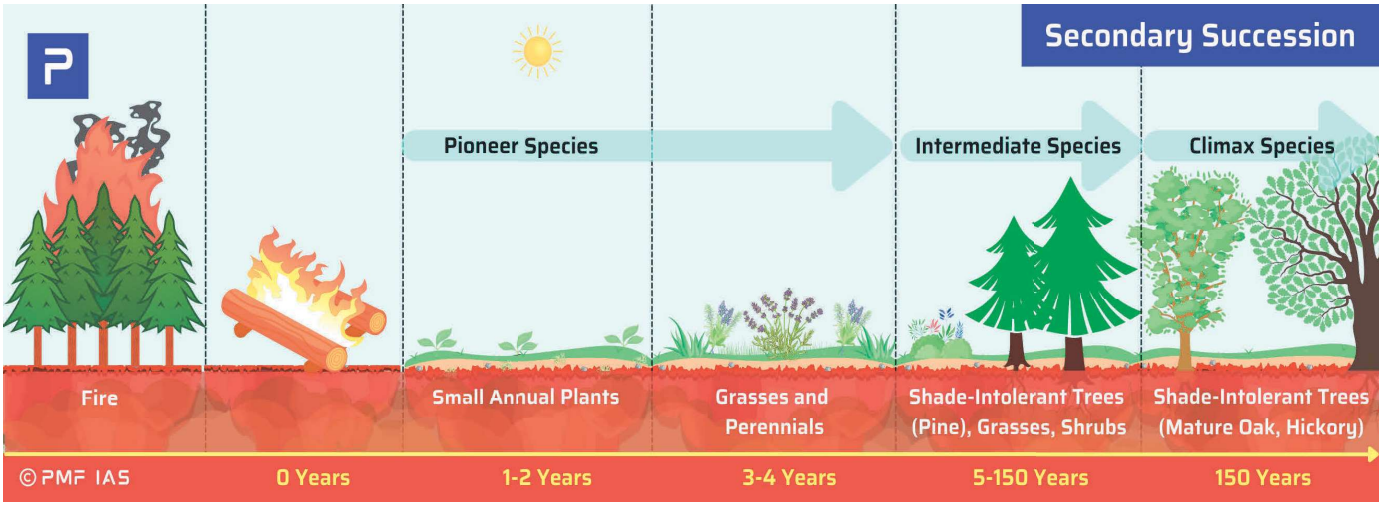
- The pioneers, through their death and decay, leave patches of **organic matter** in which small animals could live. During decomposition, the organic matter produces **organic acids** that dissolve and etch the substratum, releasing **nutrients**.
- Organic debris accumulates in pockets and crevices,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

### Autotrophic and Heterotrophic succession

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

## Secondary Succession

- **Secondary succession** is the sequential development of biotic communities after the complete or partial **destruction** of the existing community.




### Explanation

- A mature or intermediate community may be destroyed by natural events such as floods, droughts, fires, or storms or by human interventions such as deforestation, agriculture, overgrazing, etc.
- The abandoned land is first invaded by **hardy grasses** that can survive in bare, sun-baked soil. Tall grasses and herbaceous plants may soon join these grasses. For some years, these dominate the ecosystem, along with mice, rabbits, insects, and seed-eating birds.

- Eventually, some trees grow in this area, seeds of which may be brought by wind or animals. Over the years, a **forest community** develops. Thus, an abandoned land becomes dominated by trees and is transformed into a forest.

### Difference Between Primary and Secondary Succession

- Unlike the primary succession, the **secondary succession starts on a well-developed soil** already formed at the site. Thus, secondary succession is **relatively faster**.

## Autogenic and Allogenic Succession

- When **living inhabitants of that community itself bring about succession**, the process is called **autogenic succession**, while **change brought about by outside forces** is known as **allogenic succession**.

**[UPSC 2013] In the grasslands, trees do not replace the grasses as a part of an ecological succession because of**

a) insects and fungi
b) limited sunlight and paucity of nutrients
c) water limits and fire
d) None of the above

**Explanation**

- **Grasses** have one good trick to monopolise a place. In the dry season, the grasses dry up and **cause fires** which destroy other plant species and their seeds (**autogenic succession**). Also, grasslands develop in regions with **scanty rainfall** where plant growth cannot be achieved.
- Though forests form the **climax community** in most ecosystems, in the **grassland ecosystem**, **grasses form the climax community**. Thanks to fire and lack of water. **Grasslands are almost irreversible** once **deforestation** in water-scarce areas gives way to grasslands.

***Answer: c)***

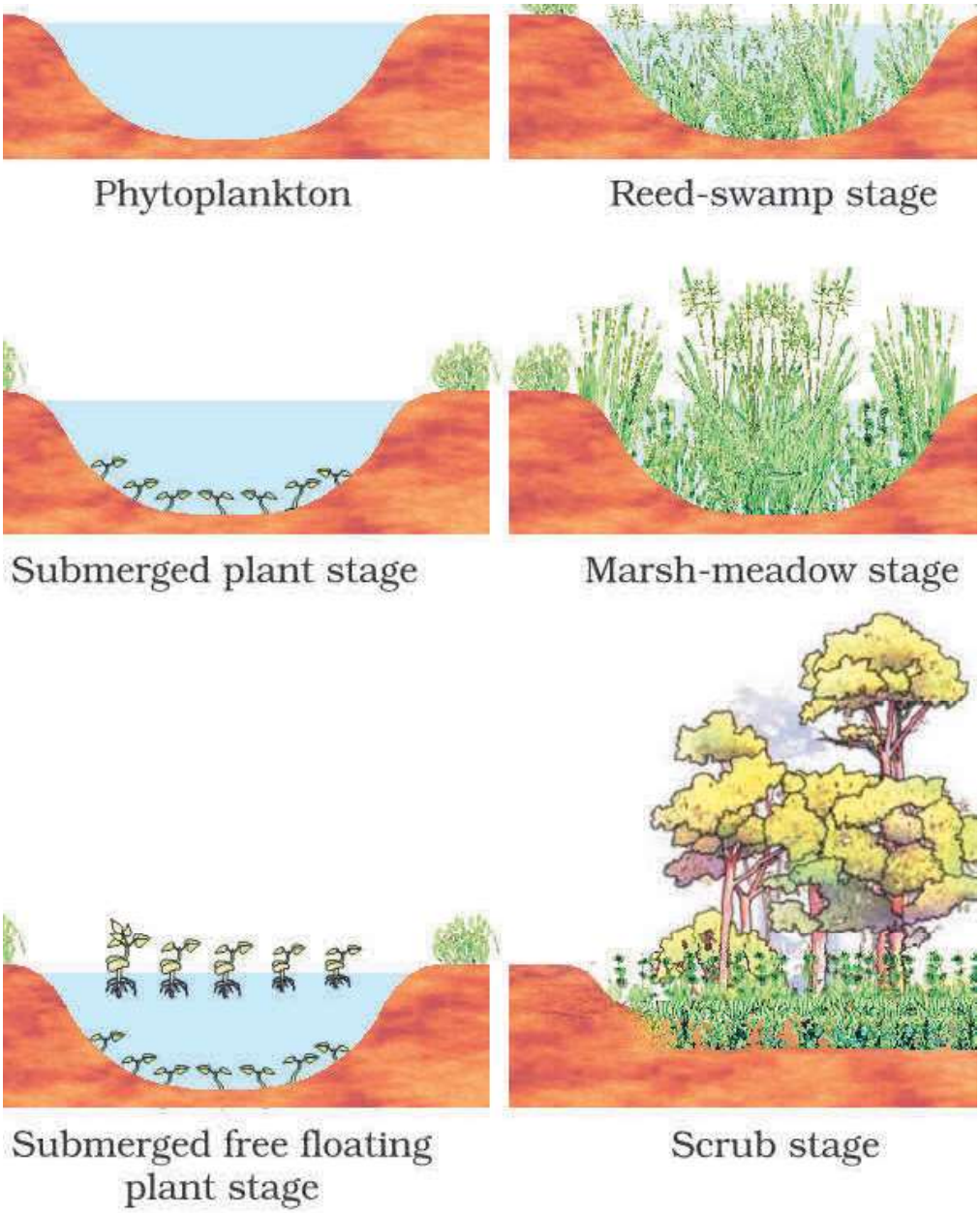
⇨ *The* **biotic components** *of an ecosystem drive* ***autogenic succession***.
⇨ ***Allogenic succession*** *is driven by the* ***abiotic components*** *(fire, flood) of the ecosystem*.

## Succession in Plants

- Succession that occurs on land where **moisture content is low**, e.g., on a bare rock, is known as **xerarch**.
- Succession that takes place in a water body, like a pond or lake, is called **hydrarch**.
- Both hydrarch and xerarch successions lead to medium water conditions (**mesic**) – neither too dry (xeric) nor too wet (hydric).
- With time, the **xerophytic habitat** gets converted into a **mesophytic habitat (requiring only a moderate amount of water)**.

## Succession in Water

- In primary succession in water, the pioneers are the **phytoplankton**. They are replaced by floating angiosperms, then by rooted **hydrophytes (aquatic plants)**, sedges (some monocotyledonous plants), grasses and finally, the trees. The climax again would be a **forest**. As time passes, the water body is converted to land.




⇨ ***Succession***, *whether taking place in water or on land, proceeds to a similar climax community – the* ***mesic***.

## 3.2. Homeostasis in Ecosystem

- Ecosystems can maintain their state of equilibrium. They can regulate their own species' structure and functional processes. This capacity of the ecosystem of **self-regulation (the tendency for a biological system to resist changes)** is known as **homeostasis**.
- For example, in a pond ecosystem, if the population of **zooplankton** increases, they consume more **phytoplankton (primary producers)**, and as a result, food becomes scarce for zooplankton. When the

number of zooplankton is reduced because of starvation, the phytoplankton population increases. After some time, the population size of zooplankton also increases, and this process continues at all the **trophic levels of the food chain**.

- In a homeostatic system, a **negative feedback mechanism** (an increase in one factor causes a decrease in another, and vice versa) induced by the **limiting resource** (here, it's the scarcity of food) is responsible for maintaining stability in an ecosystem.
- The homeostatic capacity of ecosystems is **not unlimited**, and **not** everything in an ecosystem is always well-regulated.

## Homeostasis

- In biology, homeostasis is the **maintenance of stable equilibrium**, especially through **physiological (bodily) functions**. E.g., Cooling one's body through sweating processes.
- Organisms try to maintain the constancy of their internal environment despite varying external environmental conditions that tend to upset their homeostasis.

### Regulate

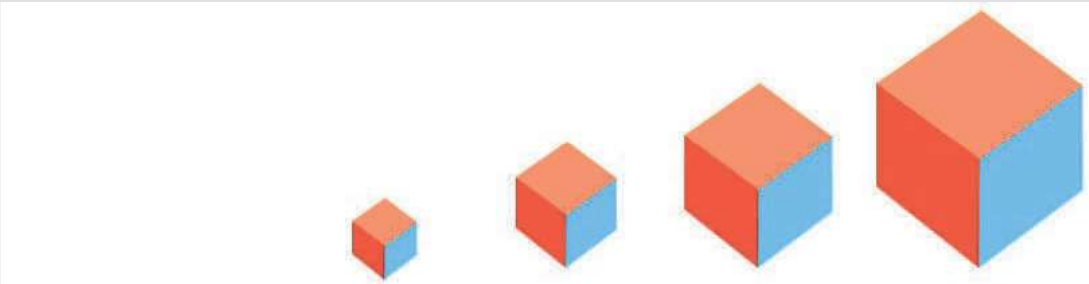
- Some organisms can maintain homeostasis by **physiological means** (sweating to cool the body, increasing metabolism to keep the body warm, etc.) and sometimes by **behavioural** means (animals migrating to under tree shade to avoid the summer heat), which ensure constant body temperature, **constant osmotic concentration**, etc.
- **All birds** and **mammals** and a very **few lower vertebrate and invertebrate species** are indeed **capable of such regulation** **(thermoregulation** and **osmoregulation)**.
- The **success of mammals** is largely due to their **ability to maintain constant body temperature** and thrive whether they live in Antarctica or the Sahara Desert. **Plants**, on the other hand, **do not have such mechanisms**. Hence their **range** is comparatively limited.

### Conform

- An overwhelming majority of animals and **nearly all plants cannot** maintain a constant internal environment. Their body temperature changes with the ambient temperature.
- In **aquatic animals**, the osmotic concentration of the body fluids changes with that of the ambient water osmotic concentration. These animals and plants are simply **conformers**.

#### Conformers have not evolved to become regulators

- **Thermoregulation** is **energetically expensive** for many organisms. This is particularly true for **small animals** like shrews and hummingbirds.
- Since **small animals** have a **larger surface area relative to their volume**, **they tend to lose body heat very fast** when it is cold outside. Hence, they **must expend much energy to generate body heat** (a lot of food energy goes into heat generation) through metabolism. This is the main reason why **very small animals are rarely found in polar regions**.



| | | | | |
|---|---|---|---|---|
| Surface Area ($cm^2$) | 24 | 96 | 216 | 384 |
| Volume ($cm^3$) | 8 | 64 | 216 | 512 |
| Surface area / volume | 3 | 1.5 | 1 | 0.75 |

## Migrate

- The organism can move away temporarily from the stressful habitat to a more hospitable area and return when a stressful period is over. For example, every winter, the famous **Keoladeo National Park (Bharatpur) in Rajasthan** hosts thousands of **migratory birds coming from Siberia** and other extremely cold regions.

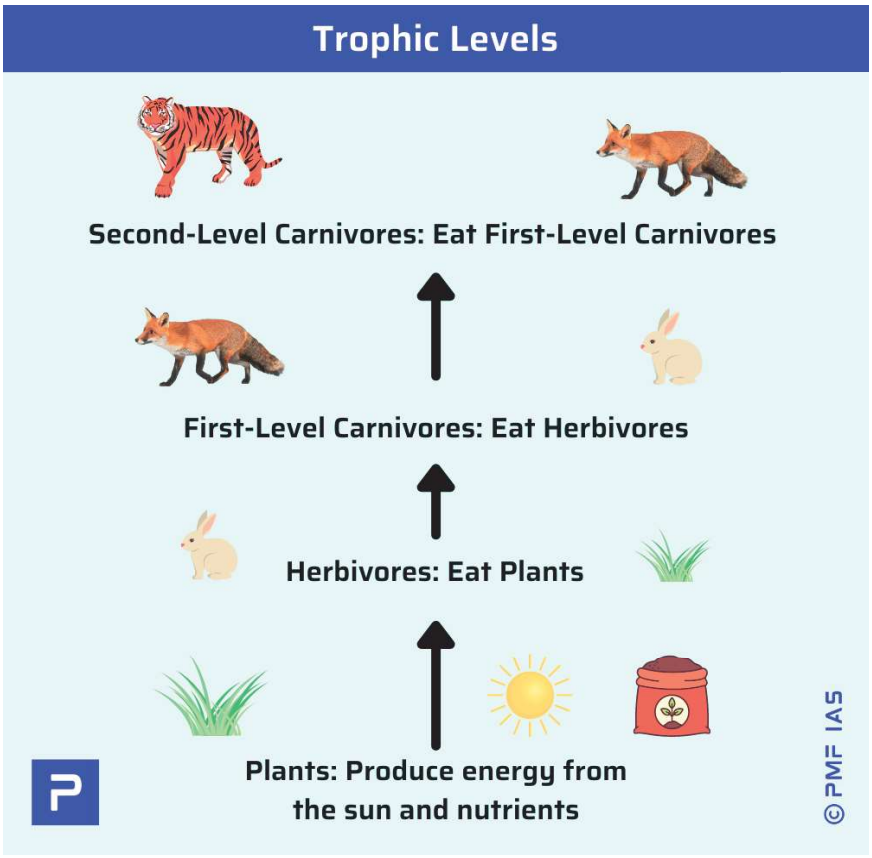
## Suspend

- In bacteria, fungi and lower plants, various kinds of **thick-walled spores** are formed, which help them to survive unfavourable conditions. They germinate on the availability of a suitable environment.
- In higher plants, seeds and some other vegetative reproductive structures help in dispersal and help to tide over periods of stress.
- In animals, if unable to migrate, the organism might avoid the stress by escaping in time. The familiar case of **polar bears hibernating** during winter is an example of an escape in time.
- Some **snails** and **fish** go into **aestivation** (prolonged dormancy of an **insect**, **fish**, or **amphibian** during a **hot** or **dry** period) to avoid summer-related problems — heat and desiccation.
- Under unfavourable conditions, many zooplankton species in lakes and ponds are known to enter **diapause**, **a stage of suspended development**.

**---------- End of Chapter ----------**

# 4. Functions of an Ecosystem – Trophic Levels

- A **trophic level** (trophe means nourishment) represents **energy flow in an ecosystem**. Energy flow (from producers to subsequent trophic levels) through trophic levels is **unidirectional**.
- An organism's trophic level is the position it occupies in a **food chain**. Energy level **decreases** from the first trophic level upwards **due to loss of energy in the form of heat** at each trophic level.
- The energy loss at each trophic level is quite significant. Hence, there are **usually not more than four trophic levels** (beyond this, the energy available is negligible to support an organism).




| Trophic Levels | |
|---|---|
| **Autotrophs** | **Green plants** (**Producers**) |
| **Heterotrophs** | **Herbivores** (**Primary consumers**) |
| **Heterotrophs** | **Carnivores** (**Secondary consumers**) |
| **Heterotrophs** | **Top Carnivore** (**Tertiary and Quaternary consumers**) |

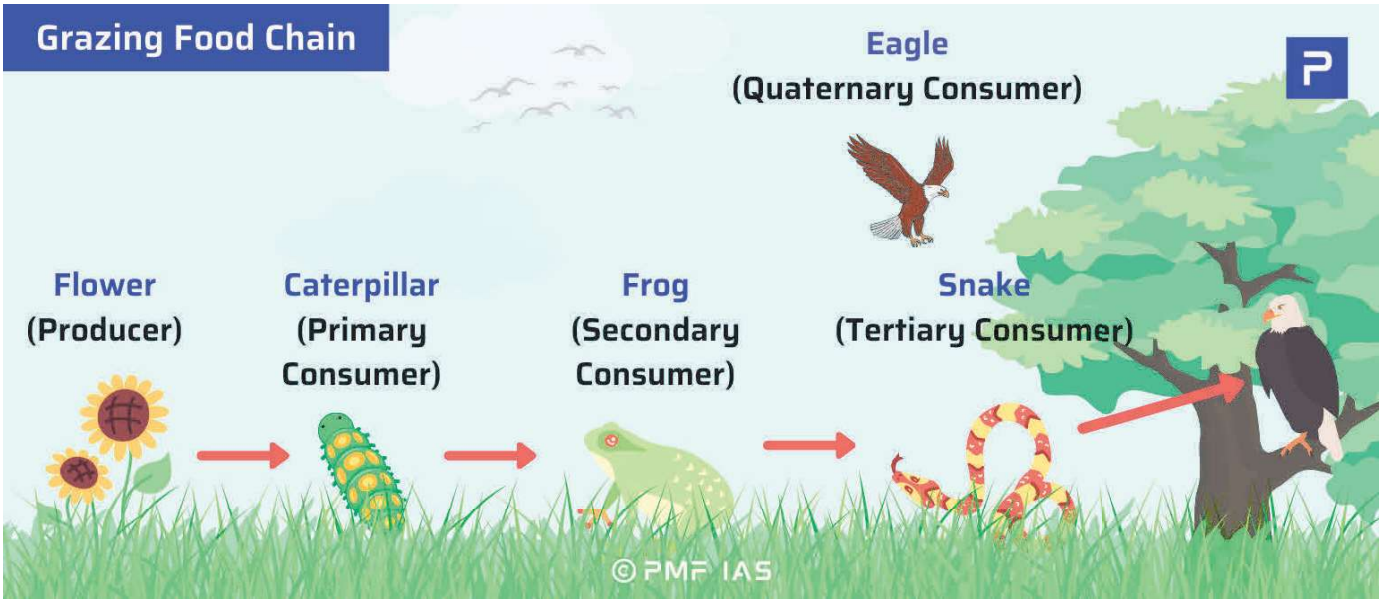
- The trophic level interaction involves three concepts, namely:
  1) **Food Chain**
  2) **Food Web**
  3) **Ecological Pyramids**

## 4.1. Food Chain

- Transfer of energy from producers through a series of organisms at each tropic level with repeated eating and being eaten link is called a **food chain**. For example, Grasses → Grasshopper → Frog → Snake → Eagle constitute a food chain.
- The two types of food chains are: **1) Grazing food chain** and **2) Detritus food chain**

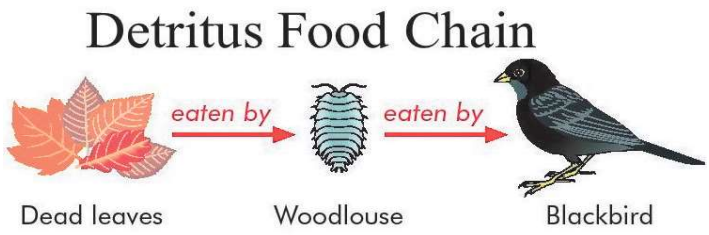
## Grazing food chain

- The consumer organisms that start the food chain utilising the **plant/plant part as their food** constitute the **grazing food chain**. For example,
  - ❖ In a terrestrial ecosystem, the grass is eaten by a caterpillar, which is eaten by a lizard and the lizard is eaten by a snake.
  - ❖ In an aquatic ecosystem, **phytoplankton (primary producers)** are eaten by **zooplankton**, which fishes eat, and **pelicans (birds)** eat fishes.




## Detritus food chain

- The **detritus food chain** starts with the **organic matter** of dead and decaying animal and plant bodies from the **grazing food chain**.
- Dead organic matter or detritus-feeding organisms are called **detrivores** or **decomposers**. Predators eat the detrivores.
- In an **aquatic ecosystem**, the **grazing food chain** is the major conduit for energy flow. In contrast, in a **terrestrial ecosystem**, a much larger fraction of energy flows through the **detritus food chain** than through the grazing food chain.



**[UPSC 2013] With reference to the food chains in ecosystems, which of the following kinds of organism(s) is/are known as decomposer organism(s)?**

1) Virus
2) Fungi
3) Bacteria

***Select the correct answer using the codes given below.***

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

**Explanation**

- **Fungi** and **Bacteria** are **decomposers**. They break down organic matter into simple inorganic substances.
- **Virus represents dormant life**. They are metabolically inactive if they are outside a host body. They are **not decomposers**. They invade host cells and use their nucleus (DNA machinery) to carry out their life processes.

⇨ ***Protists*** *are unicellular organisms.* ***Some protists****, such as* ***paramecium*** *and* ***euglena****,* ***are not decomposers****. Meanwhile, the other protists, like* ***slime moulds****, typically* ***grow on dead animals****,* ***rotting logs*** *and* ***compost****.*

**Humus**

- **Bacterial** and **fungal enzymes** decompose detritus into simpler **inorganic substances**. This process is called **catabolism**.
- **Humification** and **mineralisation** occur during decomposition in the soil. Humification leads to the accumulation of a **dark-coloured amorphous (formless)** substance called **humus**, which is highly resistant to microbial action and **undergoes decomposition at a very slow rate**.
- **Some microbes further degrade the humus**, and the release of **inorganic nutrients** occurs through **mineralisation**. Being **colloidal** in nature, the humus serves as a **reservoir of nutrients**.
- A warm and moist environment favours decomposition, whereas **low temperatures** and **anaerobiosis (lack of oxygen) inhibit decomposition**, resulting in a **buildup of organic matter**, and soils become **acidic (taiga climate)**.

***Answer: b) 2 and 3 only***

**[UPSC 2021] Which of the following are detritivores?**

1) Earthworms
2) Jellyfish
3) Millipedes
4) Seahorses

5) Woodlice

***Select the correct answer using the code given below.***

a) 1, 2 and 4 Only
b) 2, 3, 4 and 5 Only
c) 1, 3 and 5 Only
d) 1, 2, 3, 4 and 5

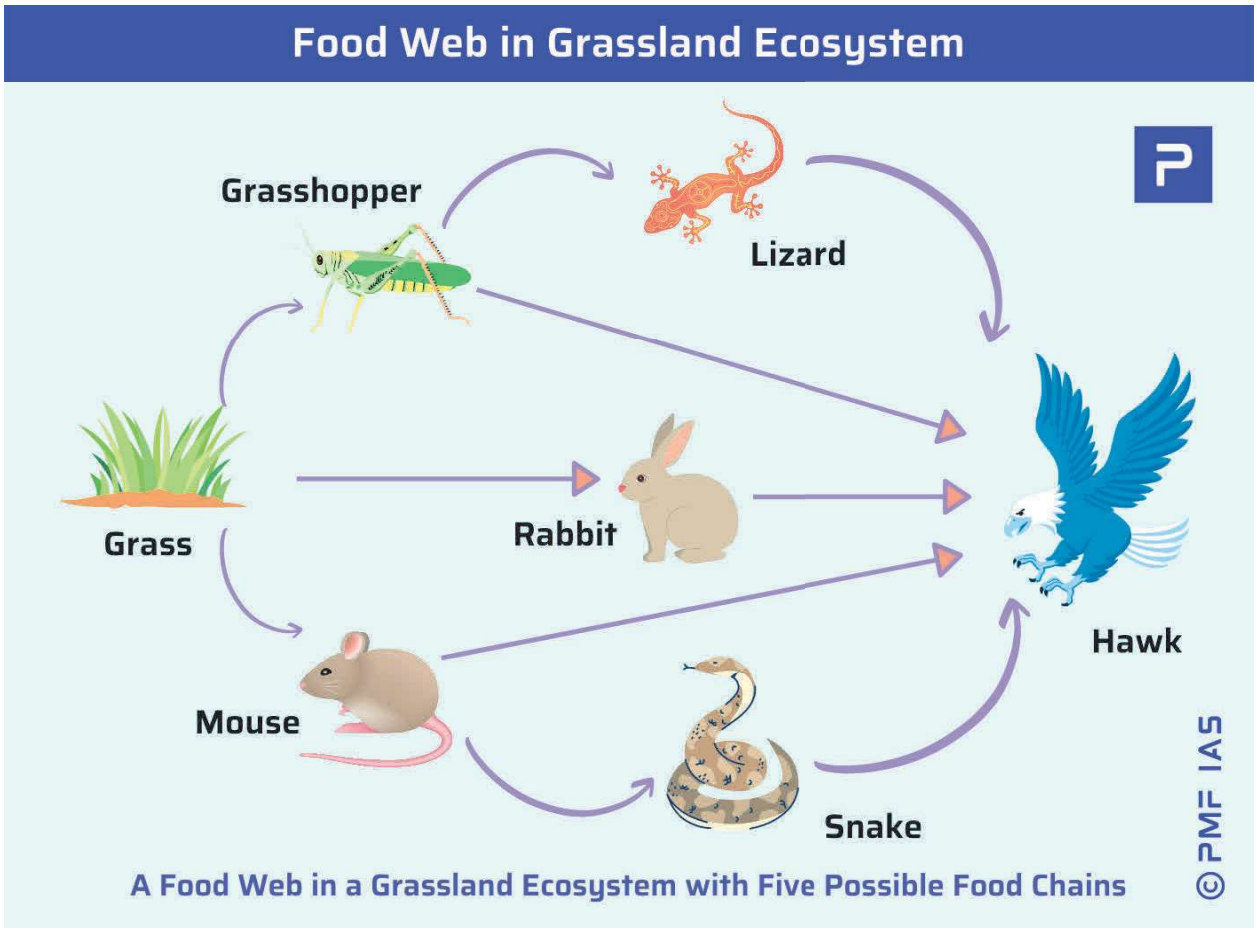
**Explanation**

- The easiest of the options: 1) **Earthworms (detrivores)**, 2) **Jellyfish (marine animals** of phylum **cnidaria**) and **Seahorses (small marine fishes)** — **Biology NCERT**.

***Answer: c) 1, 3 and 5 only***

## 4.2. Food Web

- **Multiple interlinked food chains make a food web**.
- A food web represents all the **possible energy flow pathways** in an ecosystem. If any of the intermediate food chains are removed, the succeeding links of the chain will be affected.
- A food web provides most organisms in an ecosystem with more than one alternative for food and, therefore, increases their chance of survival.



# Types of Biotic Interactions in a Food Web



## Amensalism

It is a type of negative ecological interaction where one of the species is harmed or destroyed while the other either benefits or remains unaffected.

| Species | |
|---|---|
| 1 | 2 |
| Detrimental | Zero |

### Antibiosis

The bread mould fungi Penicillium produce penicillin - an antibiotic substance which inhibits the growth of a variety of bacteria.


### Competition

A large tree shades a small plant & retarding the growth of the small plant. The small plant has no effect on the large tree.

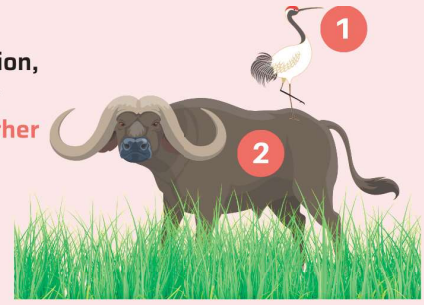

## Commensalism

One organism benefits from the other without harming it.

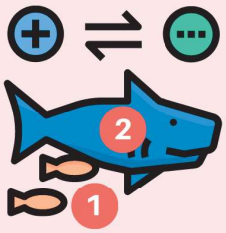
| Species | |
|---|---|
| 1 | 2 |
| Beneficial | Zero |

A Commensal species benefits from another species by obtaining locomotion, shelter food, or support from the host species, which (for the most part) neither benefits nor is harmed.

1. Suckerfish attaches to the shark
2. Relationship between Tree and Epiphytic Plant










## Mutualism

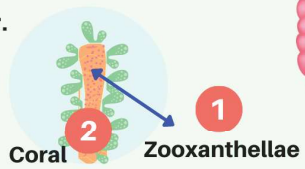
It is a type of ecological interaction between two species where both species are benefitted from the interaction

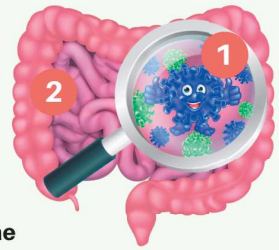
| Species | |
|---|---|
| 1 | 2 |
| Beneficial | Beneficial |

One of the species provides the other with some resource or service, and the other also reciprocates with a benefit.

Some mutualism are so intimate that the interacting species can no longer live without each other as they depend totally on each other.

Gut Microflora is one of the largest microflora in human beings. These microorganisms colonize all the parts of the digestive tract.

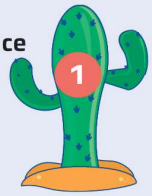

## Neutralism

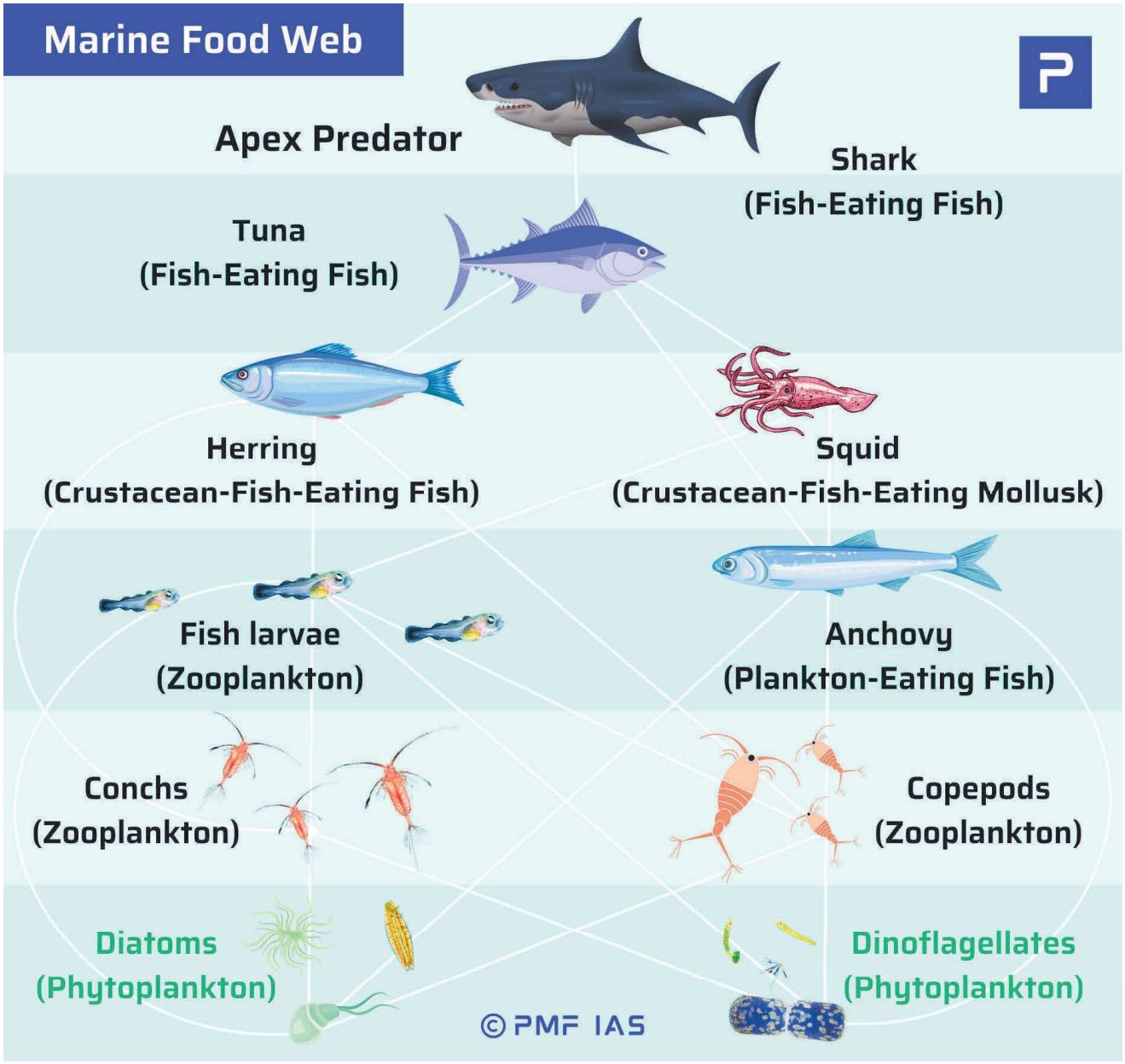
Neutralism describes the relationship between two species that interact but do not affect each other.

| Species | |
|---|---|
| 1 | 2 |
| Zero | Zero |

Examples of true neutralism are virtually impossible to prove; the term is in practice used to describe situations where interactions are negligible or insignificant.

Neutralism occurs when two populations interact without having an effect on the evolutionary fitness of each other. E.g. cacti and tarantulas living in the desert.




## Types of Biotic Interactions in a Food Web

'0' → no effect '–' → is detrimental '+' → beneficial

| *Interactions* | *Species* | | *Effect* | *Comments* |
|---|---|---|---|---|
| | *1* | *2* | | |
| ***Negative Interactions*** | | | | |
| **Amensalism** | – | 0 | **One species is inhibited, while** | • **Antibiosis:** The **bread mould fungus Penicillium** produces **penicillin**, an **antibiotic** that **inhibits the growth of various bacteria**. |

| | | | | |
|---|---|---|---|---|
| | | | **the other species is unaffected**. | • **<u>Competition</u>:** A **large tree shades a small plant** and retarding the growth of the small plant. The small plant does not affect the large tree. |
| **Predation** | + | – | One species (predator) benefits, while the second species (prey) is harmed. | • Predators like leopards, tigers and cheetahs use speed, teeth, and claws to hunt and kill their prey.<br>• **Predators help maintain species diversity** in a community by **reducing the intensity of competition** among competing prey species. |
| **Parasitism** | + | – | **Beneficial to one species (parasite)** and **harmful to the other species (host)**. | • Parasitism involves a parasite living in or on another living species called the host. The parasite gets its nourishment and often shelter from its host.<br>• **Tap worms**, **roundworms**, **malarial parasites**, **many bacteria**, **fungi**, and **viruses** are common parasites of humans.<br>⇨ *The **female mosquito is not considered a parasite**, although it needs our blood for reproduction. Why? **Because it does not live on the host**.* |
| **Competition** | – | – | Adversely affects both species. | • Competition occurs when two populations or species need a common vital resource that is in short supply. |
| **Competition** can sometimes be a subtype of **Amensalism** (one species is inhibited, while the other species is unaffected). For example, the interaction between **beetle** and **goat** to feed on the same **grass** is also a competition (due to the **same food niche** here), but beetle can't harm goat, but the other way around is true. The same is the case when a **large tree shades a small plant**. | | | | |
| ***Positive Interactions*** | | | | |
| **Commensalism** | + | 0 | **One species (the commensal) benefits**, **while the other species** (**the host**) **is neither harmed nor inhibited**. | • **Suckerfish often attaches to a shark**. This helps the suckerfish get protection, a free ride, and a meal from the leftovers of the shark's meal. The shark does not, however, get any benefit, **nor is it adversely affected** by this association.<br>• Another example of commensalisms is the **relationship between trees and epiphytic plants**. |

| | | | | |
|---|---|---|---|---|
| **Mutualism** | + | + | **Interaction is favourable to both species**. | • **Sea anemones** attach themselves to the shells of **hermit crabs** to **transport** them and obtain new food. The anemone, using its stinging cells, **provides camouflage** and protection to the hermit crab.<br>• Some mutualisms are so intimate that the **interacting species can no longer live without each other**, **as they depend totally on each other to survive**. Such close associations are called **symbiosis (symbiosis is intense mutualism** — e.g., **coral and zooxanthellae)**. |
| ***Neutral Interactions*** | | | | |
| **Neutralism** | 0 | 0 | Neither species affects the other | • True neutralism is **extremely unlikely**. |

**[UPSC 2014] Which one of the following is the correct sequence of a food chain?**

a) Diatoms-Crustaceans-Herrings
b) Crustaceans-Diatoms-Herrings
c) Diatoms-Herrings-Crustaceans
d) Crustaceans-Herrings-Diatoms

**Explanation**

- The food chain starts with producers and ends with top consumers.
- **Phytoplankton** are the primary producers in the oceans. They include:
  - ❖ **diatoms (unicellular algae)**,
  - ❖ **coccolithophores (unicellular**, **eukaryotic protist)**,
  - ❖ **Cyanobacteria (Bluegreen algae) — Synechococcus**, **Prochlorococcus**, **Nostoc**, **spirogyra**, etc., and
  - ❖ **Dinoflagellates (flagellated protists)**.
- **Crustaceans** form a large group of **arthropods**, including **crabs**, **lobsters**, **shrimp**, **krill**, **etc**.
- **Herrings** are fish, and they eat crustaceans.

***Answer: (a) Diatoms-Crustaceans-Herrings (NCERT)***

**[2021] Consider the following kinds of organisms:**

1) Copepods
2) Cyanobacteria
3) Diatoms
4) Foraminifera

***Which of the above are primary producers in the food chains of oceans?***

a) 1 and 2
b) 2 and 3
c) 3 and 4
d) 1 and 4

**Explanation**

- **Copepods** are a group of small **aquatic crustaceans**, and **foraminifera** are **amoeboid protists**.

***Answer: b) 2 and 3 only***

**[UPSC 2013] With reference to food chains in ecosystems, consider the following statements:**

1) A food chain illustrates the order in which a chain of organisms feed upon each other.
2) Food chains are found within the populations of a species.
3) A food chain illustrates the numbers of each organism which are eaten by others.

***Which of the statements given above is/are correct?***

a) 1 only
b) 1 and 2 only
c) 1, 2 and 3
d) None

**Explanation**

- Statement 1 is True.
- Statement 2 is False — **In a food chain**, **a species occupies a specific trophic level**.
- A food chain illustrates the numbers of each organism that are eaten by others (false — the **food web illustrates the number**, not the food chain).

***Answer: a) 1 only***

**[2021] Which of the following have species that can establish symbiotic relationship with other organisms?**

1) Cnidarians
2) Fungi
3) Protozoa

***Select the correct answer using the codes given below***.

a) 1 and 2 Only
b) 2 and 3 Only
c) 1 and 3 Only
d) 1, 2 and 3

**Explanation**

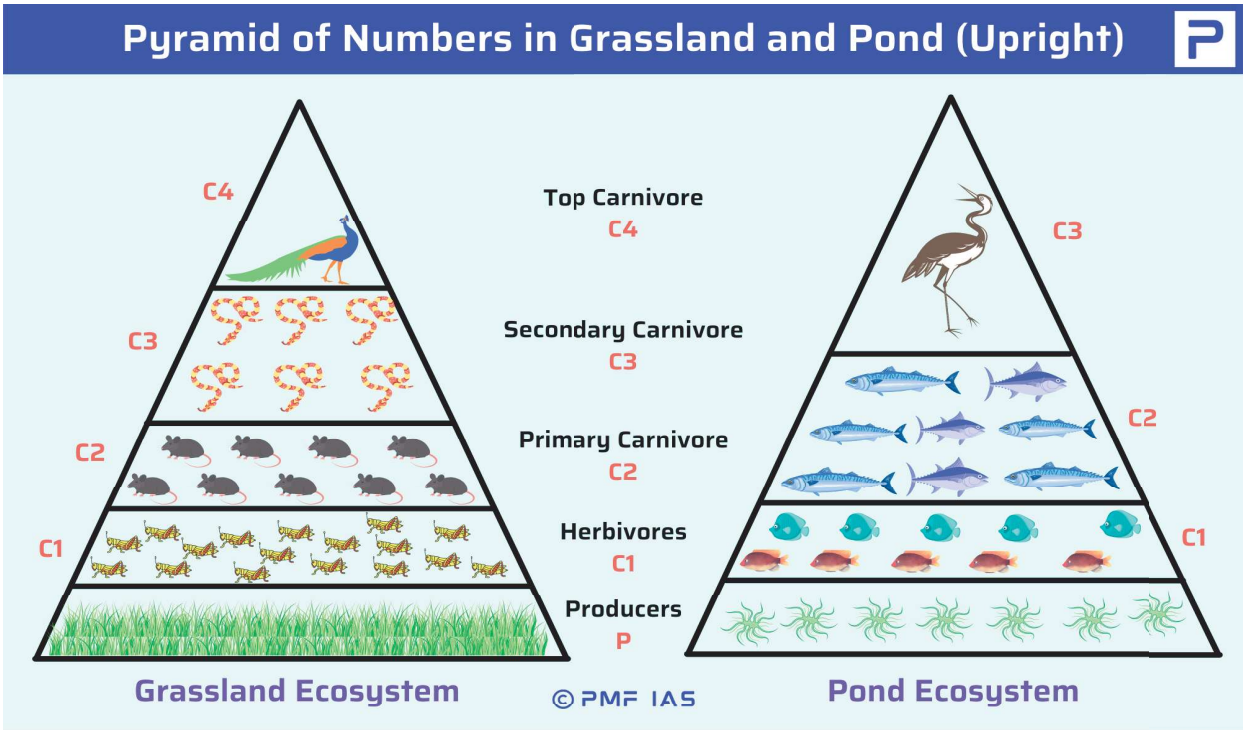
- **Corals** and **sea anemones** belong to **phylum Cnidaria**.
- **Lichen** are **plant-like organisms** that consist of a **symbiotic association** of **algae (usually green) or cyanobacteria** and **fungi**.
- **Protozoans** are mostly **predators** and **parasites**. A **few protozoans do exhibit symbiotic associations**. For example, **termites** have a mutualistic relationship with protozoa that live in the insect's gut.
- The termites provide food and lodging for the protozoa, and in return, the protozoa help termites digest wood (cellulose).

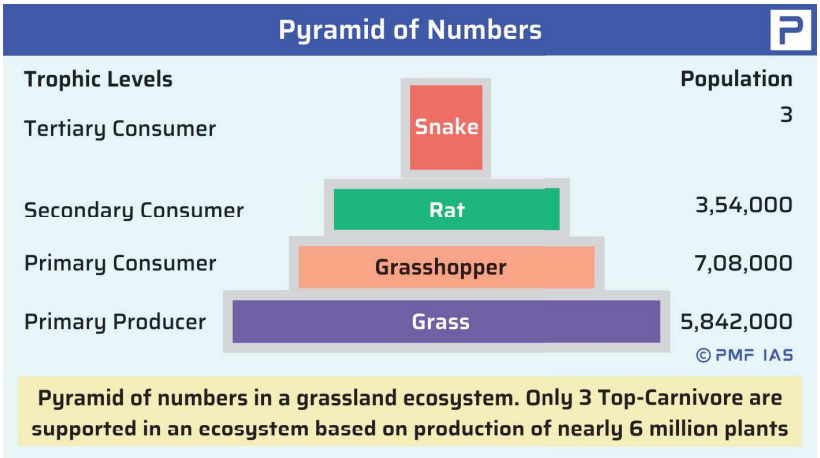
***Answer: d) 1, 2 and 3***

## 4.3. Ecological Pyramids

- The **pyramidal representation of trophic levels** of different organisms based on their **ecological position** (producer to final consumer) is called as an **ecological pyramid**.
- The pyramid consists of several horizontal bars depicting **specific trophic levels**. The length of each bar represents the **total number of individuals**, **biomass**, or **energy** at each trophic level in an ecosystem.
- The **producers form the base of the pyramid**, and the top carnivore forms the tip. Other consumer trophic levels are in between.
- The ecological pyramids are of three categories:
  1) **Pyramid of numbers**,
  2) **Pyramid of biomass**, **and**
  3) **Pyramid of energy or productivity**.

### Pyramid of Numbers






Pyramid of numbers in a grassland ecosystem. Only 3 Top-Carnivore are supported in an ecosystem based on production of nearly 6 million plants

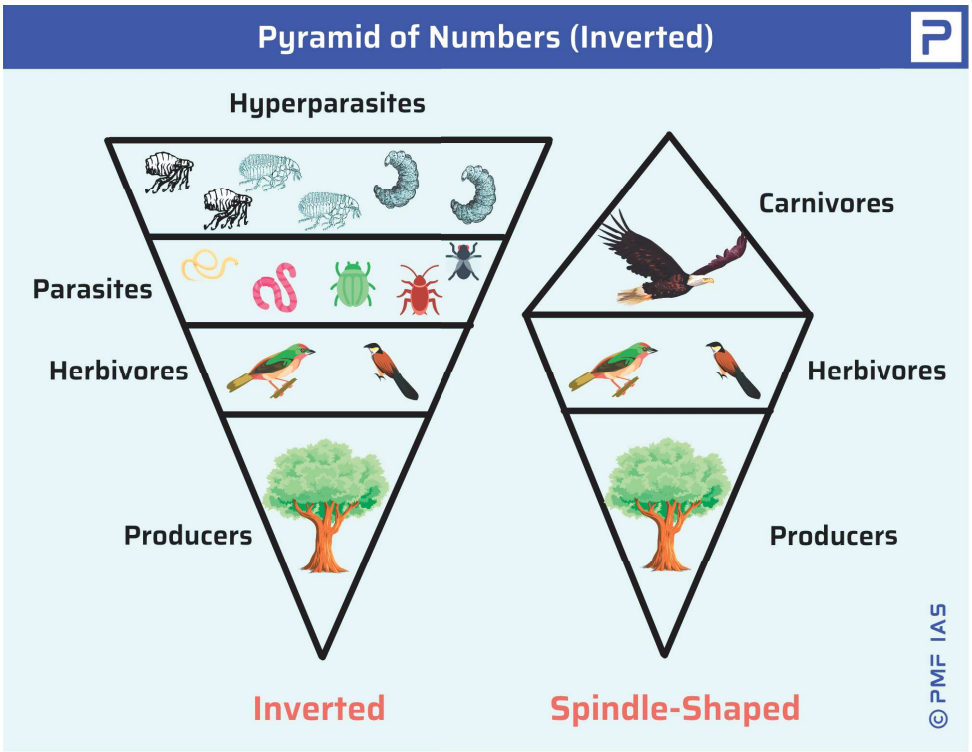
- A pyramid of numbers represents the **total number of individuals (population)** of different species at each trophic level.
- Depending upon its size, the pyramid of numbers **may not always be upright** and **may even be completely inverted**.
- It is very difficult to count all the organisms in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

## Pyramid of Numbers – Upright

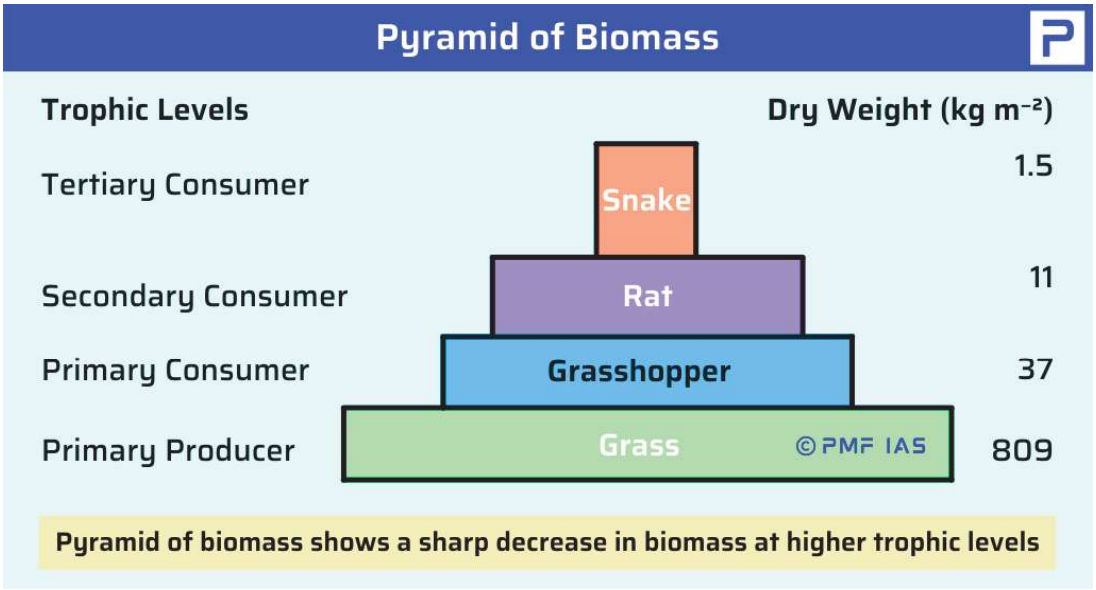
- In this pyramid, the **number of individuals decreases with each higher trophic level**. This type of pyramid can be seen in the **grassland ecosystem** and **pond ecosystem**.

## Pyramid of Numbers – Inverted

- In this pyramid, the **number of individuals increases with each higher trophic level**. E.g., **Tree ecosystem**.



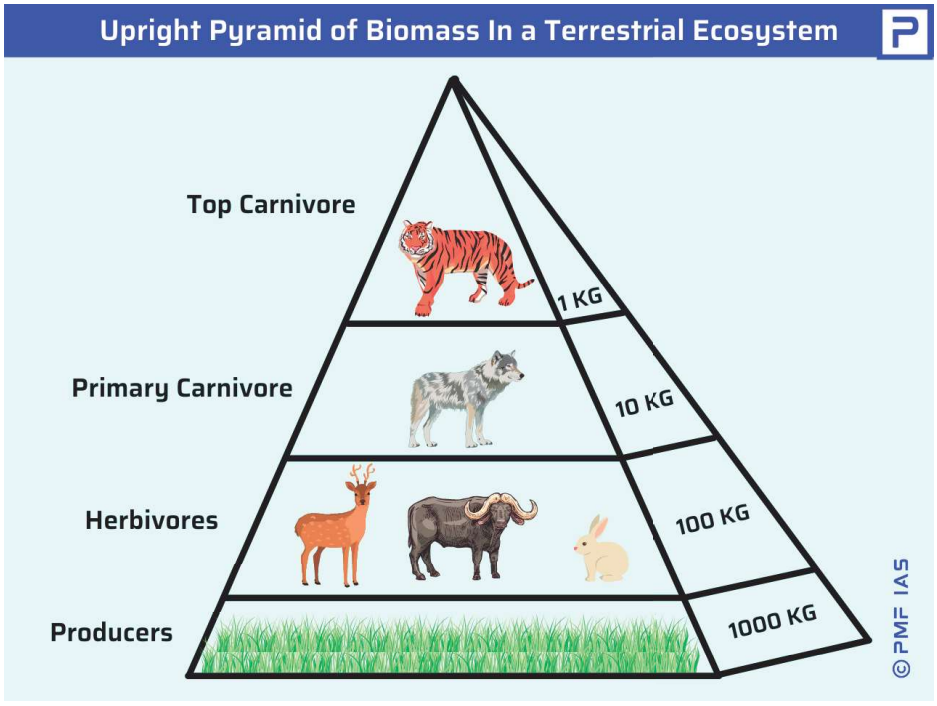
## Pyramid of Biomass



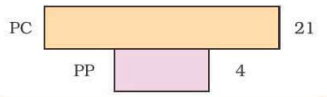

- Pyramid of biomass is usually determined by collecting all organisms occupying each trophic level separately and measuring their **dry weight**. This **overcomes the size difference problem** because all kinds of organisms at a trophic level are weighed.
- Each trophic level has a certain mass of living material at a particular time called the **standing crop**. The standing crop is measured as the mass of living organisms (biomass) or the number in a unit area.

## Pyramid of Biomass – Upright

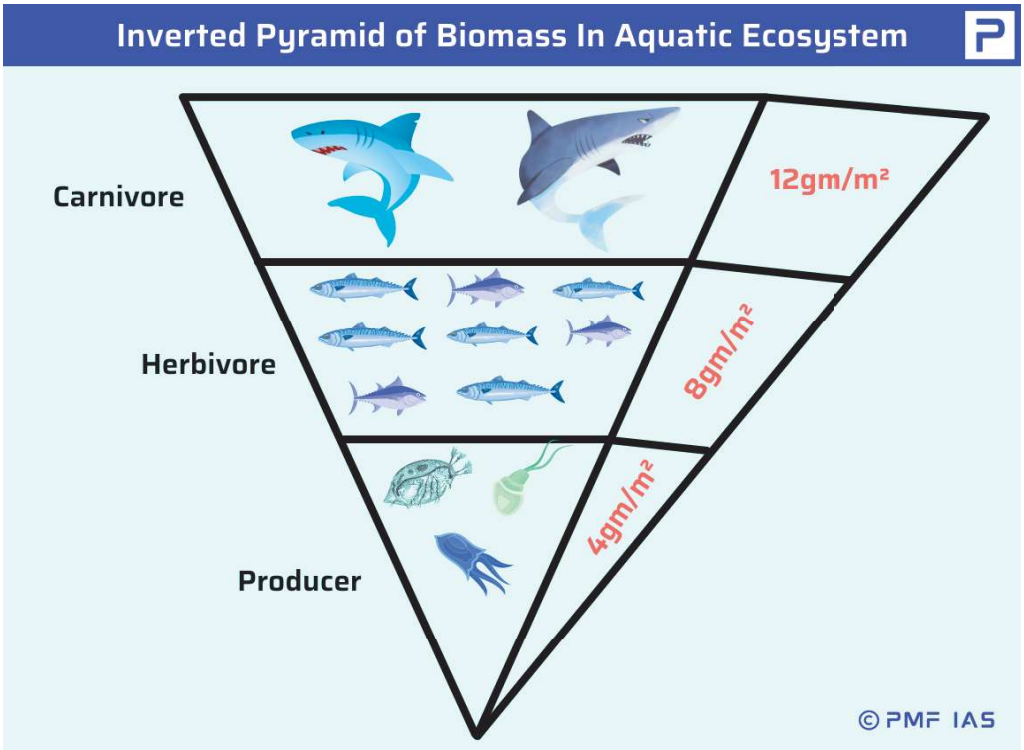
- For most **terrestrial ecosystems**, the pyramid of biomass has a **large base** of primary producers with a smaller trophic level perched on top. The biomass of the base trophic level, i.e., producers (autotrophs), is at the maximum. The highest trophic level has the least amount of biomass.



## Pyramid of Biomass – Inverted




Inverted pyramid of biomass-small standing crop of phytoplankton supports large standing crop of zooplankton




- In contrast to terrestrial ecosystems, in many **aquatic ecosystems**, the **pyramid of biomass may assume an inverted form**. (In contrast, a **pyramid of numbers** for the **aquatic ecosystem** is **upright**).
- In an aquatic ecosystem, the producers are **tiny phytoplankton** that grow and reproduce rapidly. Here, the pyramid of biomass has a small base with the **consumer biomass** at any instant, **exceeding the producer biomass**, and the pyramid assumes an **inverted shape**.

## Pyramid of Energy

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

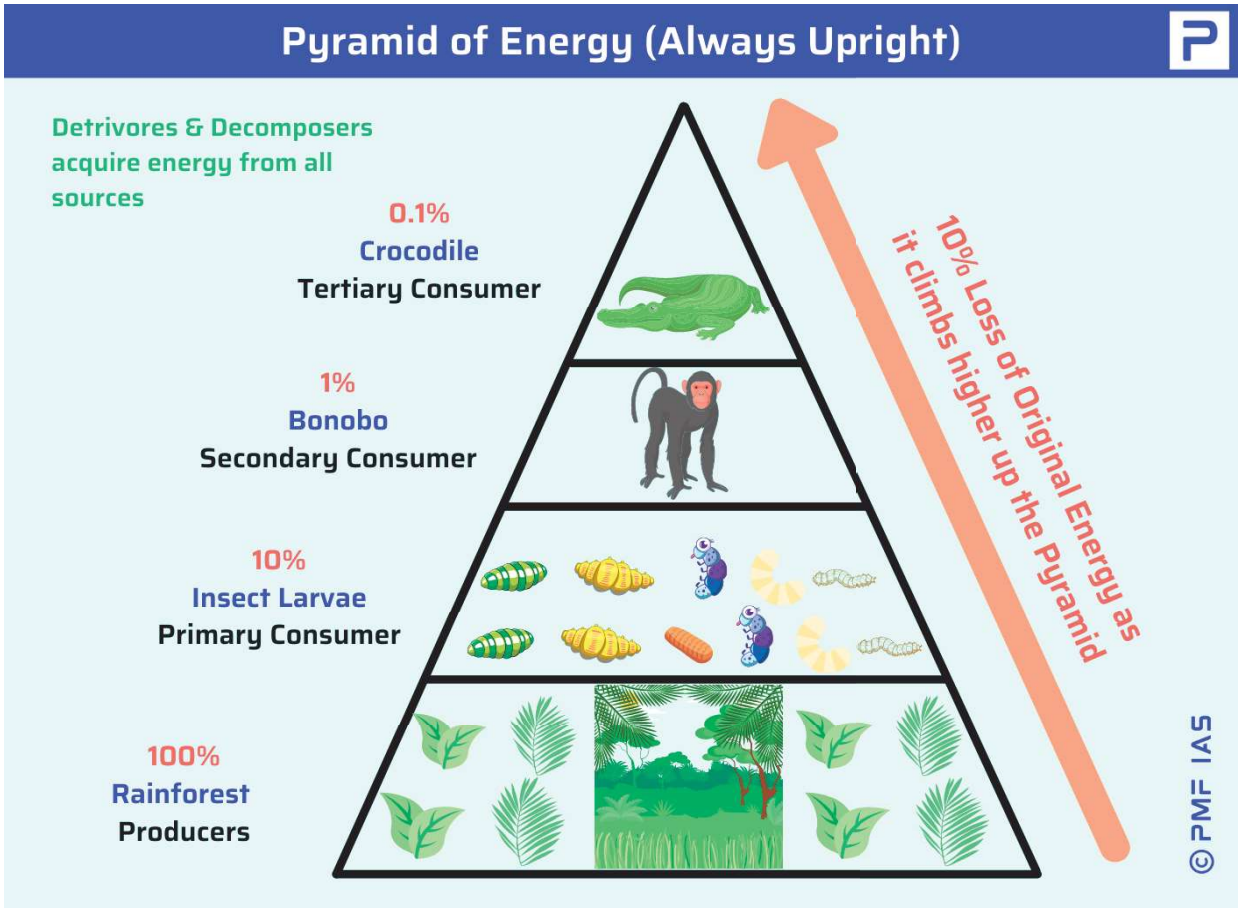
## Ecological Efficiency

- **Ecological efficiency** describes the efficiency with which energy is transferred from one trophic level to the next.
- The number of trophic levels in the **grazing food chain** is restricted as the energy transfer follows the **10 per cent law** — only 10 per cent of the energy is transferred to each trophic level from the lower trophic level.

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

**Explanation**

- Suppose an ecosystem receives 1000 calories of light energy on a particular day; some of it is reflected back to space. Of the energy absorbed, only a small portion is utilised by green plants, out of which the plant uses up some for respiration; therefore, only 100 calories are stored as energy-rich materials.
- When a deer eats a plant containing 100 calories of food energy, it uses some of it for its **metabolism** and stores only 10 calories as food energy. A lion that eats the deer gets an even smaller amount of energy. Thus, usable energy decreases from sunlight to producers, from herbivores to carnivores. Therefore, the **energy pyramid will always be upright**.



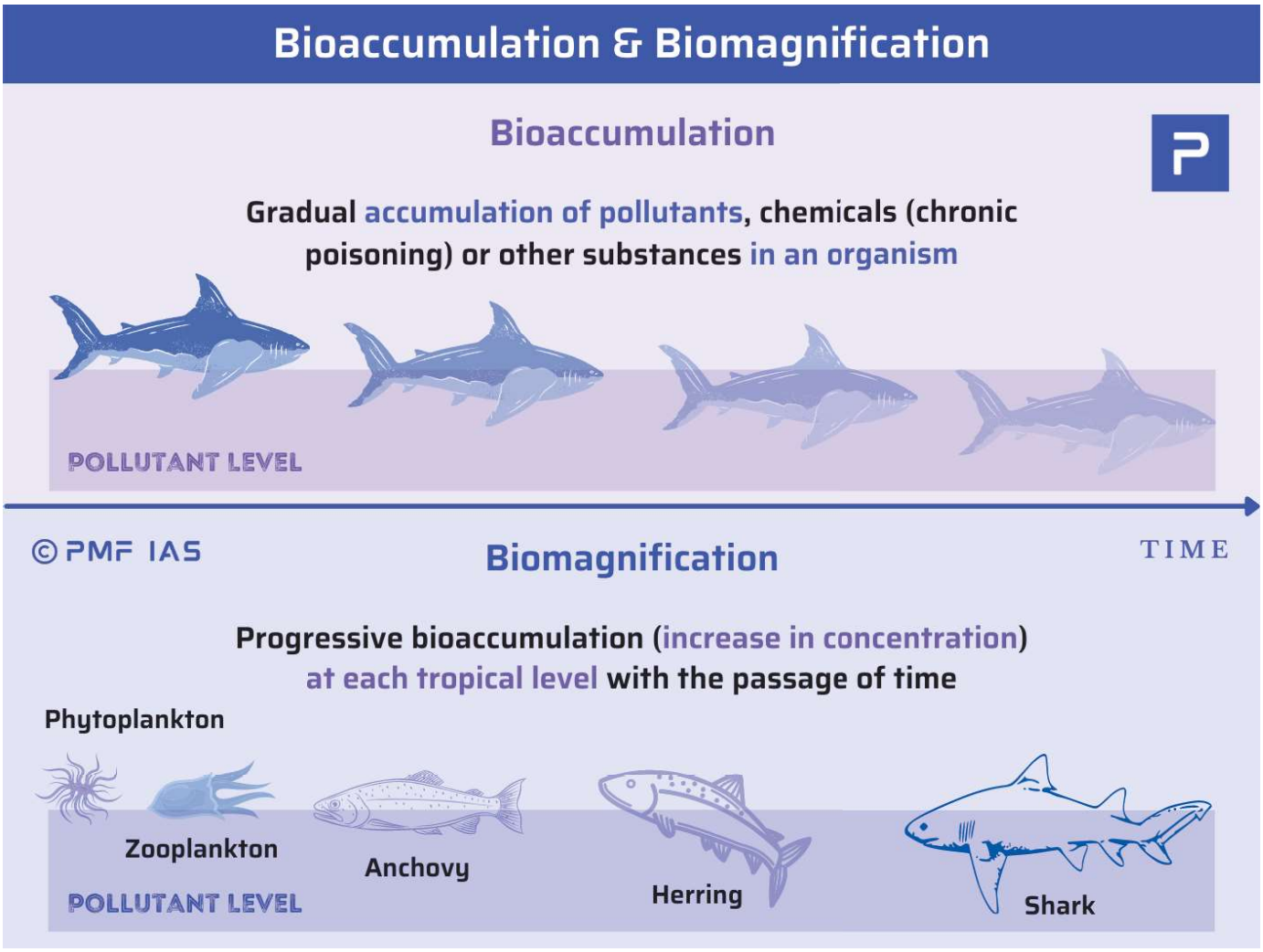

*The **energy pyramid** explains the phenomenon of **biological magnification** — the tendency for toxic substances to **increase in concentration** progressively **with higher trophic levels**.*

## Limitations of Ecological Pyramids

- Ecological pyramids **do not** consider the **same species belonging to two or more trophic levels**. It assumes a simple food chain, which seldom exists in nature; **it does not accommodate a food web**.
- Moreover, **saprophytes** (plants, fungi, or microorganisms that live on decaying matter) are **not included in ecological pyramids** even though they play a vital role in the ecosystem.

## Biomagnification – Pollutants and Trophic Level

- Pollutants move through the various trophic levels in an ecosystem. **Non-degradable pollutants (persistent pollutants)**, which **detrivores cannot break down**, not only **move through the various trophic levels** but also **remain in that tropic level for a very long duration**.
- **Chlorinated Hydrocarbons (Perfluoro Chlorides)** are the most damaging **non-degradable** pollutants that are long-lasting. The movement of these pollutants involves:
  1. **Bioaccumulation**
  2. **Biomagnification**

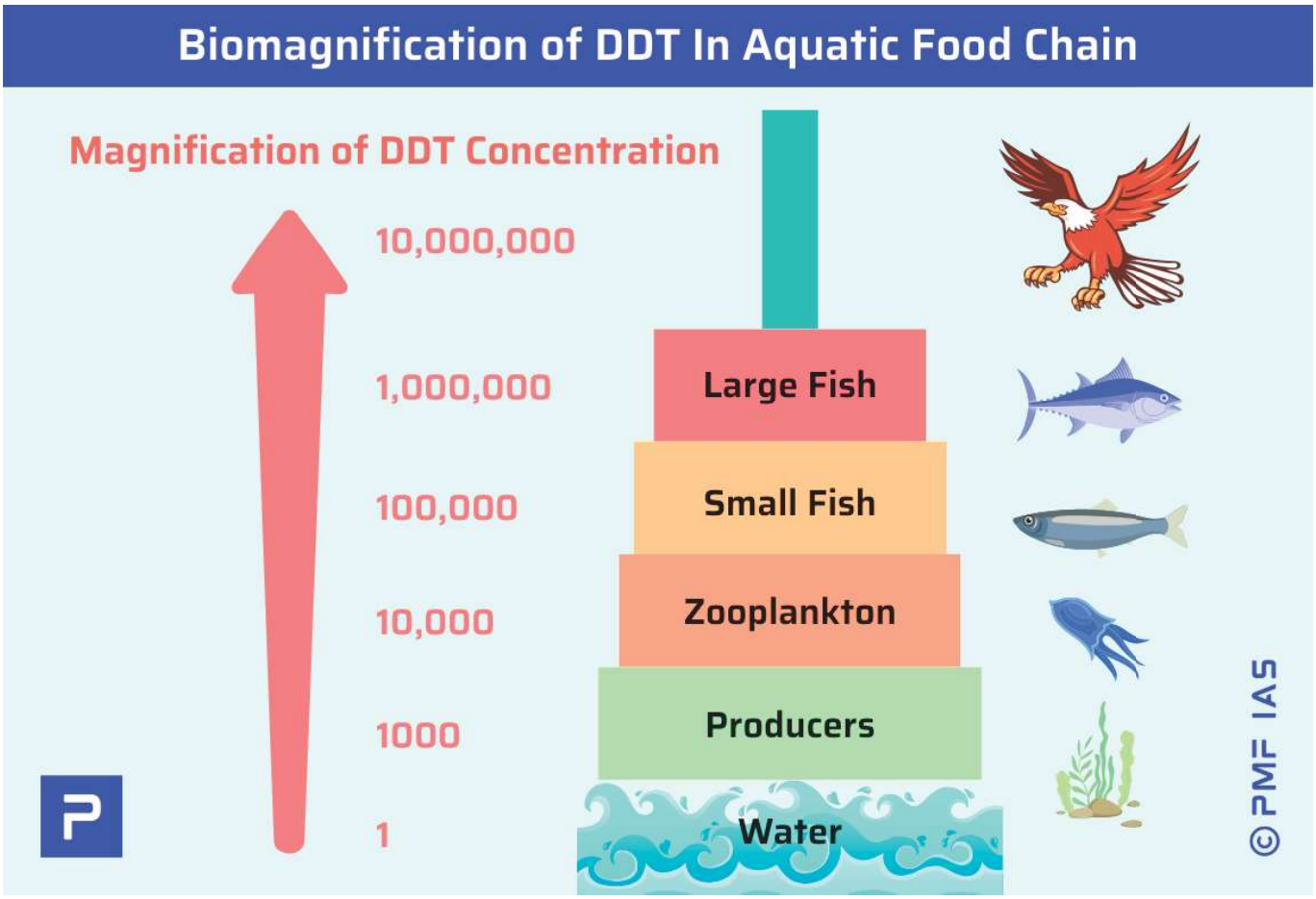



## Bioaccumulation

- **Bioaccumulation** is the **gradual accumulation of pollutants**, chemicals (chronic poisoning) or other substances **in an organism**. It occurs when the rate of loss of the substance from the organism's body through **catabolism** (breakdown of complex molecules in living organisms) or **excretion** is lower than the rate of accumulation of the substance.
- As **persistent organic pollutants** like **DDT** are long-lasting, the **risk of bioaccumulation is high** even if the pollutant's environmental levels are low.

## Biomagnification

- Biomagnification refers to **progressive bioaccumulation (increase in concentration) at each tropical level with the passage of time**.
- For biomagnification to occur, the pollutant must have a **long biological half-life (long-lived)** and **must not be soluble in water but be soluble in fats**. E.g., **DDT**. If the pollutant is soluble in water, it will be **excreted** by the organism.
- Pollutants that dissolve in **fats** are **retained for a long time**. Hence it is traditional to measure the **amount of pollutants in fatty tissues** of organisms such as fish. In mammals, **milk produced by females is tested** for pollutants since the **milk has a lot of fat in**.




---------- **End of Chapter** ----------

# 5. Functions of an Ecosystem – Biogeo Chemical Cycling

- **Energy flow** and **nutrient circulation** are the major functions of the ecosystem. Energy is forever gained and lost as heat and light. On the other hand, **nutrients never get used up**. They can be **recycled** again and again indefinitely.
- **Carbon**, **hydrogen**, **oxygen**, **nitrogen**, and **phosphorus**, as elements, compounds and nutrients, make up 97% of the mass of our bodies and more than 95% of the mass of all living organisms. In addition to these, about 15 to 25 other elements are needed in some form for the survival of plants and animals.

## Elements in the Human Body

1. **Oxygen (O):** Makes up about **65%** of the body's mass and is a key element in the molecules of **water**, **proteins**, **nucleic acids**, and **carbohydrates**.
2. **Carbon (C):** Accounts for about **18%** of the body's mass. Carbon is the fundamental building block of **organic molecules**, including proteins, lipids, nucleic acids, and carbohydrates.
3. **Hydrogen (H):** Comprises about 10% of the body's mass. It is found in water and all organic molecules.
4. **Nitrogen (N):** Makes up about 3% of the body's mass. Nitrogen is a critical component of **amino acids**, which are the building blocks of **proteins**, and of **nucleic acids**, which form **DNA** and **RNA**.
5. **Calcium (Ca):** Represents about 1.5% of the body's mass. It is essential for bone and tooth structure, muscle function, and nerve signalling.
6. **Phosphorus (P):** Accounts for about 1% of the body's mass. Phosphorus is a component of **DNA** and **RNA**.
7. **Potassium (K):** Makes up about 0.4% of the body's mass. Potassium is crucial for nerve function, muscle contraction, and maintaining fluid balance.
8. **Sulfur (S):** Comprises about 0.3% of the body's mass. Sulfur is a component of some **amino acids** and **vitamins** and is important in **protein synthesis**.
9. **Sodium (Na):** Accounts for about 0.2% of the body's mass. Sodium is important for nerve function, muscle contraction, and maintaining fluid balance.
10. **Chlorine (Cl):** Makes up about 0.2% of the body's mass. Chlorine is important for maintaining fluid balance and is part of hydrochloric acid in the stomach, aiding in digestion.

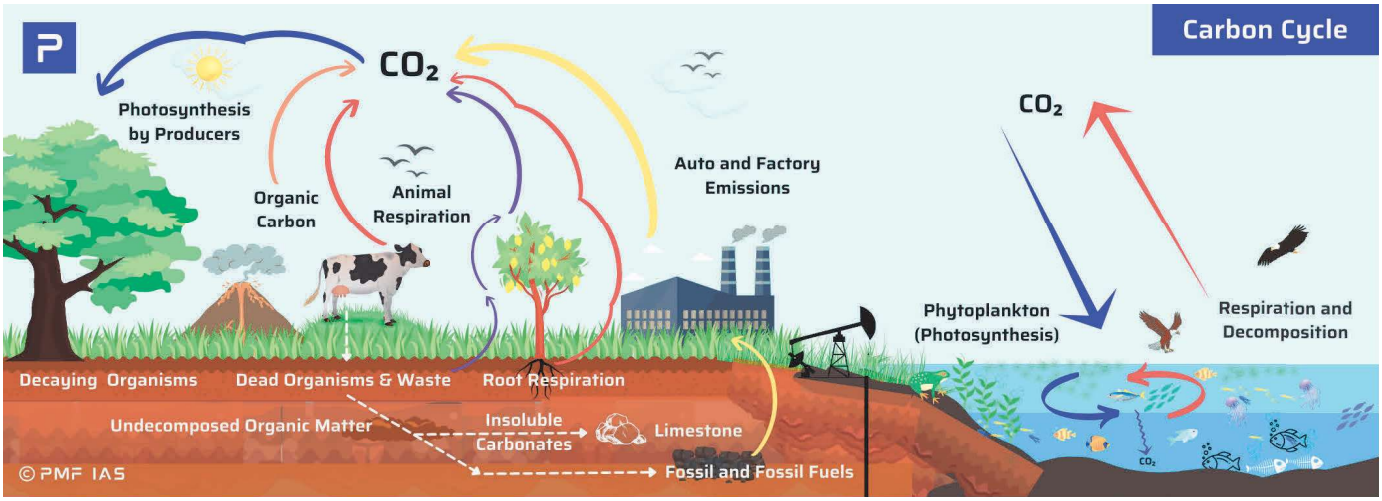
- Other elements, like magnesium, zinc, iron, and copper, are present in smaller amounts but are vital for various biochemical processes and maintaining health.

- The required elements or mineral nutrients are always in **circulation**, moving from non-living to living and back to the non-living components of the ecosystem in a **circular fashion**. This circular fashion is known as **biogeochemical/nutrient cycling** (bio for living; geo for atmosphere).
- The **carbon** and **nitrogen** nutrient cycles are among the most important nutrient cycles in ecology. Many other nutrient cycles, including trace mineral cycles, are also important.

## 5.1. Types of Nutrient Cycles

- A nutrient cycle is referred to as the perfect or imperfect cycle based on the replacement period. A perfect nutrient cycle is one in which **nutrients are replaced as fast as they are utilised**.
- **Most gaseous cycles** are generally considered **perfect cycles**. In contrast, **sedimentary cycles** are considered **relatively imperfect**, as **some nutrients are lost** from the cycle and are **locked in the sediments**, and so become unavailable for immediate cycling.
- Based on the nature of the reservoir, a nutrient cycle is referred to as the **Gaseous** or **Sedimentary**:
  1. **Gaseous Cycle:** the reservoir is the **atmosphere** or the **hydrosphere** — **water cycle**, **carbon cycle**, **nitrogen cycle**, **methane (compound) cycle**, etc. and
  2. **Sedimentary Cycle:** The reservoir is the **soluble elements** in the earth's crust — the **phosphorous cycle**, **sulphur cycle**, **calcium cycle**, **magnesium cycle**, etc.

## 5.2. Carbon Cycle (Gaseous Cycle)




- Carbon is a minor constituent of the atmosphere as compared to oxygen and nitrogen. However, without carbon dioxide, life could not exist because it is vital for the production of **carbohydrates (photosynthesis)** by plants and **phytoplankton**.
- Carbon is the element that anchors all **organic substances** from **coal** and **oil** to **DNA** (deoxyribonucleic acid: the compound that carries genetic information).

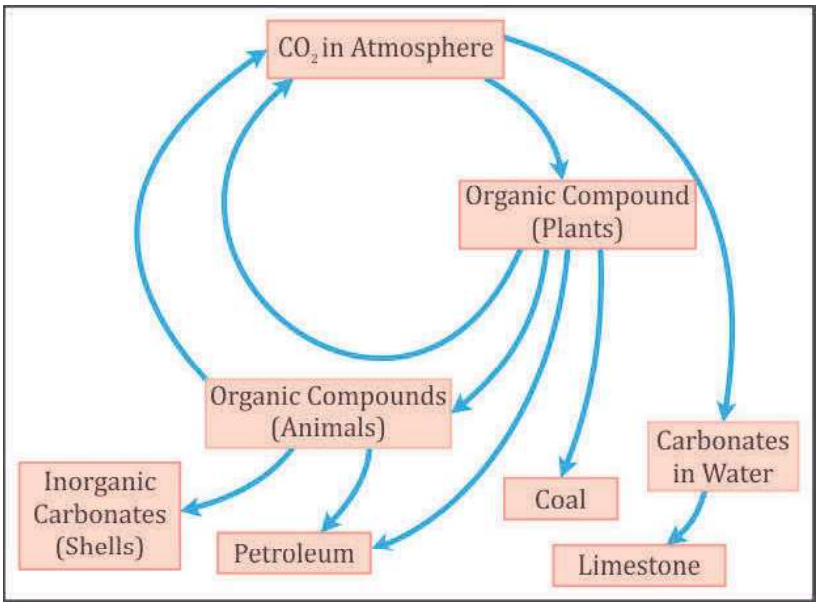
### Steps in the Carbon Cycle

- The carbon cycle involves a continuous exchange of carbon between the atmosphere and organisms. This is usually a **short-term cycle**.
- Carbon is present in the atmosphere, mainly in the form of **carbon dioxide ($CO_2$)**. Carbon from the atmosphere moves to **green plants** and **phytoplankton** through **photosynthesis** and then to animals.
- Through the process of **respiration** and **decomposition of dead organic matter**, it returns to the atmosphere.

⇨ *The decomposition of decaying **organic matter** produces **nitrogen** and **carbon dioxide**.*

⇨ ***Organic matter*** *includes* ***biomolecules*** *(carbohydrates, proteins, etc.), which are made up of* ***carbon***, ***oxygen***, ***hydrogen***, *and* ***nitrogen***.

- Some carbon enters a **long-term cycle**. It accumulates as **undecomposed organic matter in the peaty layers of marshy soil** or as **insoluble carbonates in the bottom sediments of aquatic systems**, which take a long time to be released.
- In **deep oceans**, **insoluble carbon** can remain buried for millions of years until geological movements lift these rocks above sea level. These rocks may then be exposed to erosion, releasing their **carbon dioxide**, **carbonates**, and **bicarbonates** into streams and rivers.
- Fossil fuels such as **coal**, **oil** and **natural gas** are **organic compounds** that were buried before they could be decomposed and were subsequently transformed by time and geological processes into fossil fuels. When they are burned, the carbon stored in them is released back into the atmosphere as **carbon dioxide**.




**[UPSC 2011] Consider the following:**

1) Photosynthesis
2) Respiration
3) Decay of organic matter
4) Volcanic action

***Which of the above adds carbon dioxide to the carbon cycle on Earth?***

a) 1 and 4 only
b) 2 and 3 only
c) 2,3 and 4 only
d) 1, 2, 3 and 4

**Explanation**

- Photosynthesis takes out $CO_2$ from the carbon cycle. Rest all add $CO_2$.

- **Decomposition** of organic matter **releases carbon dioxide**, whereas **undecomposed organic matter adds carbon to the soil** in the form of **insoluble carbonates** and hence contributes to the carbon cycle.

***Answer: c) 2, 3 and 4 only***

**[UPSC 2014] Which one of the following is the process involved in photosynthesis?**

a) Potential energy is released to form free energy
b) Free energy is converted into potential energy
c) Food is oxidised to release carbon dioxide and water
d) Oxygen is taken, and carbon dioxide and water vapour are given out

**Explanation**

- "Potential energy is released to form free energy" ➔ false — sun's free energy is converted into **potential energy** in photosynthesis.
- "Food is oxidised to release carbon dioxide and water" ➔ false — **oxygen** is released and not carbon dioxide.
- "Oxygen is taken, and $CO_2$ and water vapour are given out" ➔ false — **$CO_2$ is taken**, and oxygen is given out.

⇨ ***Photosynthesis:*** *Sunlight (free energy) is converted into* ***carbohydrates (potential energy)*** *using water and* ***carbon dioxide***. ***Oxygen*** *is released in the process.*

***Answer: b)***

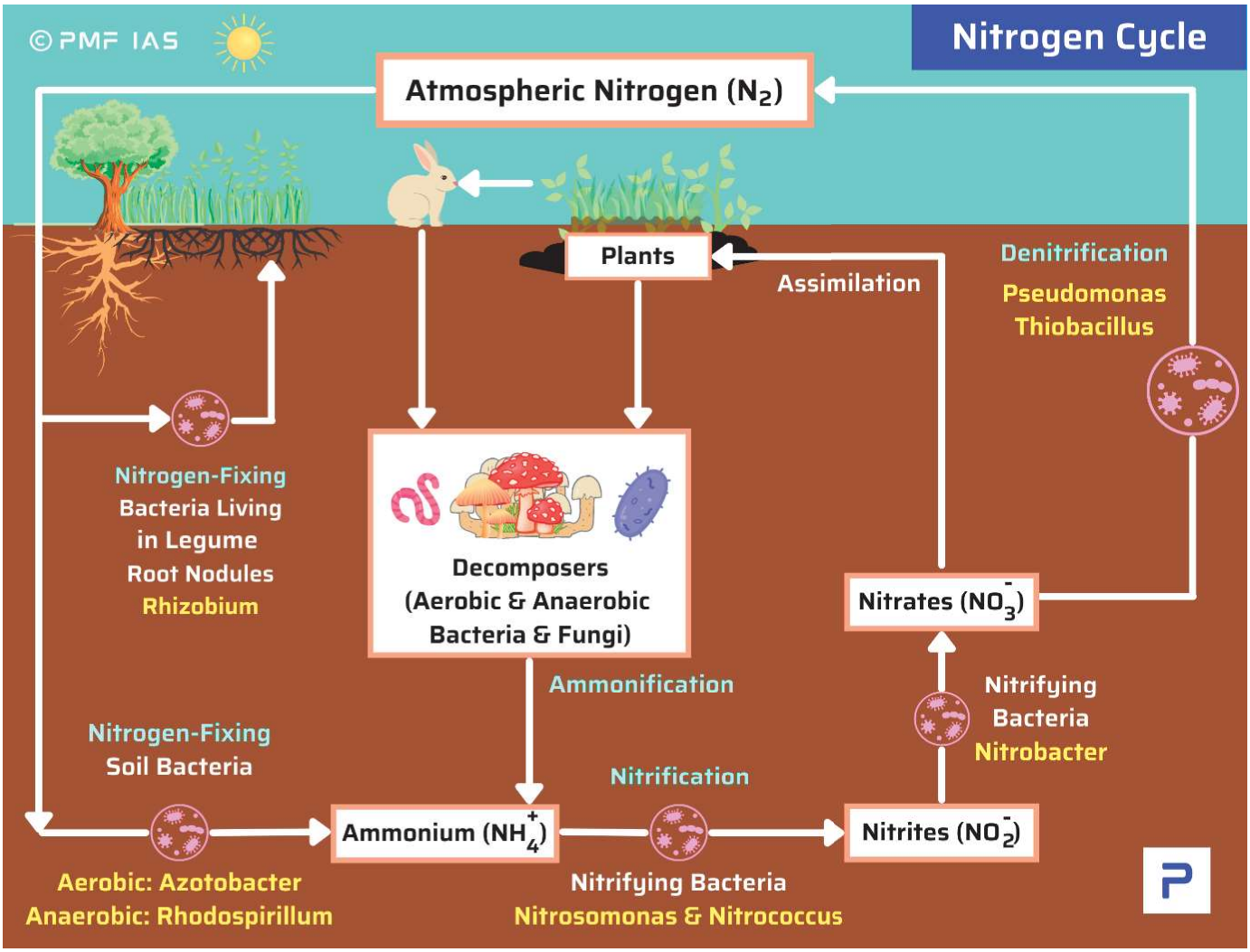
## 5.3. Nitrogen Cycle (Gaseous Cycle)

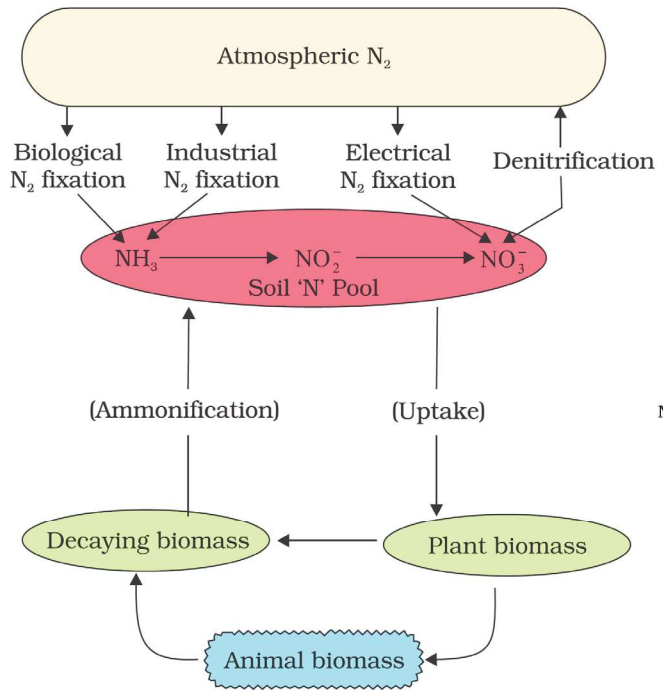
- Apart from **carbon**, **hydrogen** and **oxygen**, **nitrogen** is the most prevalent element in living organisms. It is a constituent of **amino acids**, **proteins**, **hormones**, **chlorophylls**, and many vitamins.
- In the atmosphere, nitrogen exists as **two nitrogen atoms ($N_2$)** joined by a **strong triple covalent bond (N ≡ N)**.
- In nature, **lightning** and **ultraviolet radiation** provide enough energy to convert **nitrogen ($N_2$)** to **nitrogen oxides (NO, $NO_2$, $N_2O$)**.
- **Industrial combustions**, **forest fires**, **automobile exhausts** and **thermal power-generating stations** are also sources of **atmospheric nitrogen oxides**.

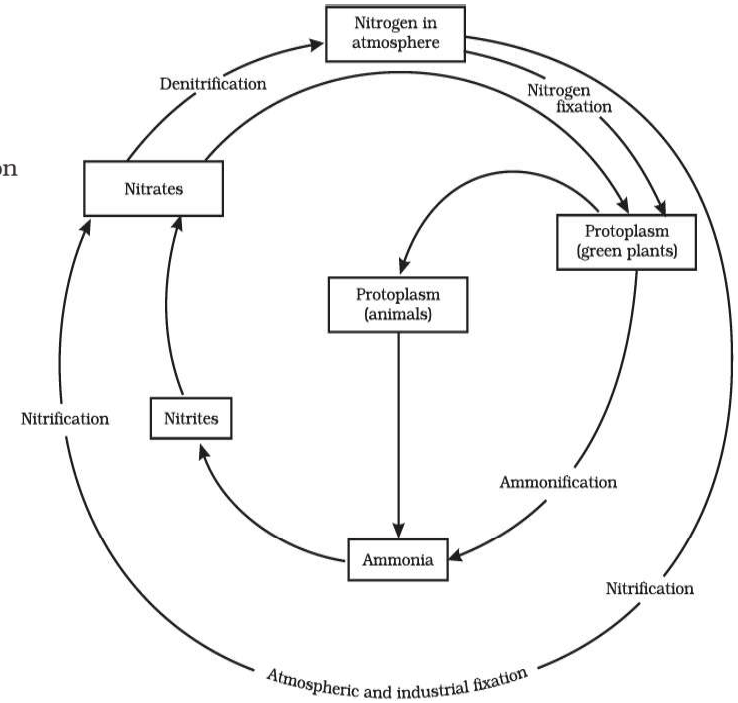
### Nitrogen Fixing – $N_2$ to Ammonia ($NH_3$)

- There is an inexhaustible supply of nitrogen ($N_2$) in the atmosphere, but most living organisms **cannot use the elemental form** directly. **Nitrogen must be** '**fixed**' — converted to **ammonia**, **nitrites**, or **nitrates** — before plants can take it up.
- **Nitrogen fixation** on Earth is accomplished in three different ways:
  1) By **N-fixing microbes** (**bacteria** and **blue-green algae**),
  2) By **industrial processes (fertiliser factories)** and

3) To a limited extent by **lighting**.



### $N_2$-Fixers

- **Nitrogenase (nitrogen reduction enzyme)** is present exclusively in **prokaryotes**. Such microbes are called **$N_2$-fixers**. They can fix **atmospheric nitrogen** into **ammonia ($NH_3$)** and **ammonium ions ($NH_4^+$)**. **$N_2$-fixers** include:
  1. **Free-living (non-symbiotic) nitrogen-fixing soil bacteria**, such as **aerobic Azotobacter** and **Beijemickia** and **anaerobic Clostridium** and **Rhodospirillum**.
  2. **Symbiotic nitrogen-fixing bacteria**, which live in symbiotic association with **leguminous plants** and **non-leguminous root nodule plants**. E.g., **Rhizobium**.
  3. Some **cyanobacteria (blue-green algae — source of N-fixation in oceans)**. E.g., **Nostoc**, **Anabaena**, **Spirulina**, etc.

⇨ ***Ammonia ($NH_3$)*** *is a molecule consisting of nitrogen and hydrogen, while* ***ammonium ($NH_4^+$)*** *is an* ***ammonia ion*** *formed by* ***accepting a hydrogen ion***.

⇨ ***Leguminous*** *denotes plants of the pea family (Leguminosae), typically with seeds in pods, distinctive flowers, and* ***root nodules containing N-fixing bacteria***.

⇨ *The amount of* ***nitrogen fixed by humans*** *through the* ***industrial process has far exceeded the amount fixed by the Natural Cycle***. *As a result, nitrogen fixed by humans has become a* ***pollutant*** *that can disrupt the balance of nitrogen. It may lead to* ***acid rain***, ***eutrophication*** *and* ***harmful algal blooms***.

## Nitrification – Ammonia to Nitrites and Nitrates

- Some plants can **directly absorb ammonium ions** as a source of nitrogen. Others absorb **nitrites ($NO_2^-$)** or **nitrates ($NO_3^-$)** obtained by **nitrification (oxidisation)** of **ammonia** and **ammonium ions** by two groups of specialised **nitrifying bacteria (chemoautotrophs)**.
  1. Ammonium ions are first oxidised to **nitrite** by the bacteria **Nitrosomonas** and/or **Nitrococcus**.
  2. The **nitrite** is further oxidised to **nitrate** with the help of the bacterium **Nitrobacter**.

⇨ ***Chemoautotrophs*** *use* ***inorganic chemical energy*** *to synthesise* ***organic compounds*** *from* ***carbon dioxide***.

- The **nitrate** thus formed is absorbed by plants and transported to the leaves. **In leaves**, it is **reduced to ammonia**, forming **amino acids** (building blocks of proteins). These then go through higher trophic levels of the ecosystem.

### Importance of Nitrification

- **Nitrification is essential in agriculture**, where fertiliser is often applied as **ammonia**. Conversion of this **ammonia** to **nitrate ($NO_3^-$) increases nitrogen leaching** because **nitrate is more water-soluble than ammonia**.
- **Nitrification** also plays an essential role in **removing nitrogen from municipal wastewater**. The conventional removal is nitrification, followed by **denitrification**.

## Ammonification – Urea, Uric Acid to $NH_3$ to Nitrite

- Living organisms produce **nitrogenous waste** products such as **urea** and **uric acid (organic nitrogen)**.
- These waste products, as well as **dead remains of organisms**, are converted back into **inorganic ammonia** and **ammonium ions** by the bacteria. This process is called **ammonification**. Most of it is converted into **nitrate** by soil bacteria. The remaining ammonia volatilises and **re-enters the atmosphere**.

## Denitrification – Nitrate to Nitrogen

- **Nitrates** present in the soil are **reduced to nitrogen** by **denitrification**. In the soil and oceans, special **denitrifying bacteria (pseudomonas** and **thiobacillus)** convert the nitrates/nitrites to elemental nitrogen. This nitrogen escapes into the atmosphere, thus completing the cycle.

## Nitrogen Cycle Summary

**Step 1**: **$N_2$ Fixing** ➔ **Nitrogen** → → **Ammonia ($NH_3$)/Ammonium Ions ($NH_4^+$)**

**Step 2**: **Nitrification** ➔ **Ammonia/Ammonium Ions** → → **Nitrite ($NO_2^-$)** → → **Nitrate ($NO_3^-$)**

**Step 3**: **Ammonification** ➔ **Dead Matter**, **Animal Waste** (**Urea**, **Uric Acid**) → → **Ammonia/Ammonium Ions** → → **Nitrate**

- ✓ **Most of the ammonia escapes into the atmosphere**.
- ✓ **Rest is nitrified (Step 2) to nitrates**.
- ✓ **Some of the nitrates are available for plants**. **Rest is Denitrified (Step 4)**.

**Step 4**: **Denitrification** ==> **Nitrate ($NO_3^-$)** → → **Nitrogen**

⇨ ***Nitrogen Cycle*** ==> ***Nitrogen*** → ***($N_2$ Fixing/Ammonification)*** → ***Ammonia/Ammonium Ions*** → ***(Nitrification)*** → ***Nitrite*** → → ***Nitrate*** → ***(Denitrification)*** → ***Nitrogen***

### [UPSC 2013] Which of the following adds/add nitrogen to the soil?

1) Excretion of urea by animals
2) Burning of coal by man
3) Death of vegetation

***Select the correct answer using the codes given below.***

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

**Explanation**

- All the above add nitrogen to the nitrogen cycle. But the question asks, "Which of the following adds/add nitrogen to the **soil**?" A few processes in the nitrogen cycle directly add nitrogen to the soil.

***Excretion of urea and Dead Biomass***

- **Animal waste** like urea, uric acid, dead vegetation & organisms add **nitrogen as nitrates directly into the soil**.

***Burning of coal***

- Burning coal releases **CO**, **$CO_2$**, **sulphur dioxide** and **nitrogen oxides**.
- **Oxides of nitrogen** fall on earth as **smog** and **acid rain**.
- **Acidic rain** is a complex mixture of **nitrous**, **nitric**, **sulphurous**, and **sulfuric acids**.
- Thus, burning **coal by humans adds nitrogen to the soil**, **but indirectly through acid rain**.

***Answer: c) 1 and 3 only (debatable between (c) and (d))***

**[UPSC 2015] What can be the impact of excessive use of nitrogenous fertilisers in agriculture?**

1) Proliferation of nitrogen-fixing microorganisms in soil can occur.
2) Increase in the acidity of soil can take place.
3) Leaching of nitrate to the groundwater can occur.

***Select the correct answer using the code given below.***

a) 1 and 3 only
b) 2 only
c) 2 and 3 only
d) 1, 2 and 3

**Explanation**

***Excessive Fertilization Suppresses $N_2$ Fixers***

- The **legume-rhizobium symbiosis** is an example of **mutualism** — **rhizobia** supplies **ammonia/amino acids** to the plant and, in return, **receives organic acids** as a carbon/energy source.
- Excessive/inappropriate use of nitrogenous fertilisers can **make the plants independent** of **both symbiotic** and **free-living nitrogen fixers**. Fixers do not get food from plants due to the broken relationship. So, their population decreases.

***Excessive Fertilization and Nitrogen Leaching***

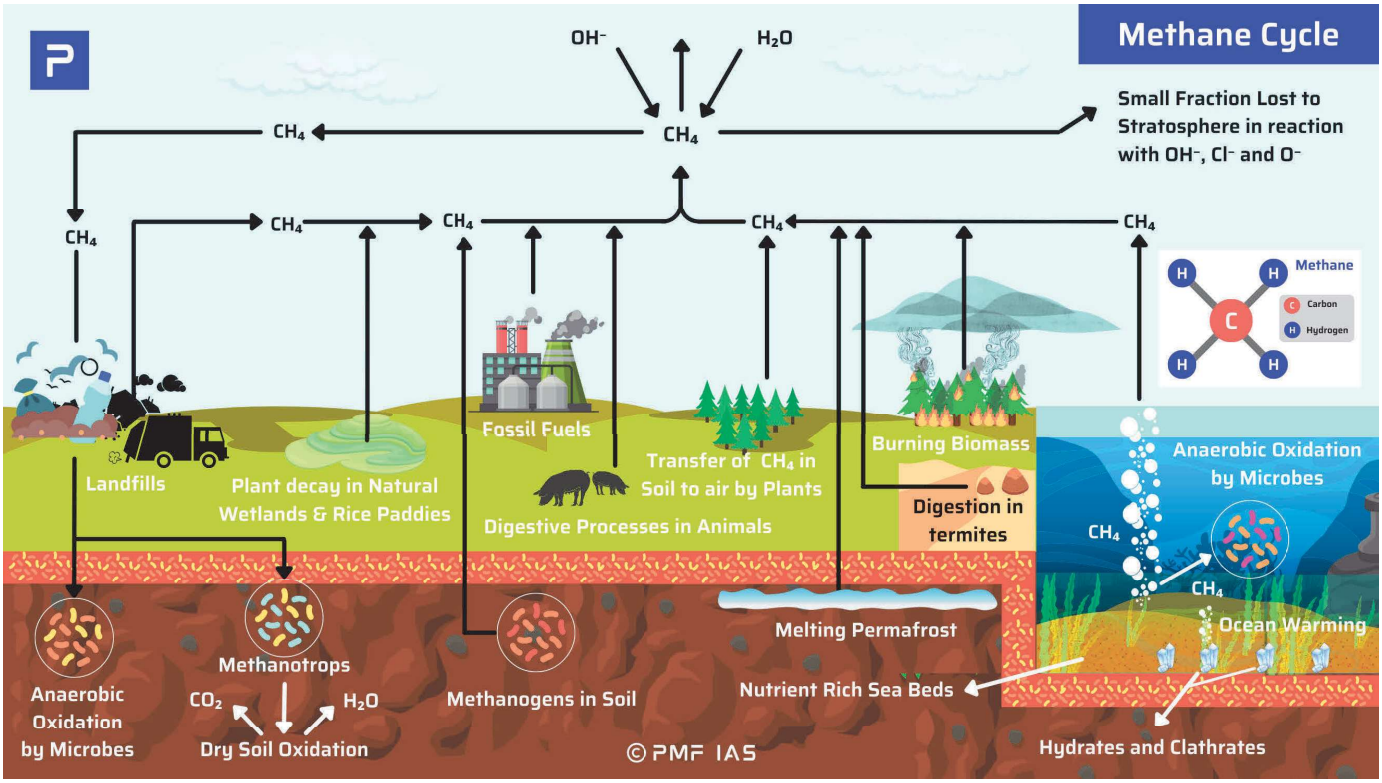
- Fertiliser is often applied as **ammonia** in agriculture. Nitrifying this ammonia to **nitrate increases nitrogen leaching** because **nitrate is more water-soluble**.

***Excessive Fertilization Contributes to Acid Rain***

- **Agricultural fertilisation** and **nitrogen-fixing plants** also **contribute to atmospheric $NO_x$** by promoting nitrogen fixation by microorganisms. **Excess $NO_x$ leads to acid rain**. Acid rain lowers the pH of the soil (**increase in acidity** of the soil).

***Answer: c) 2 and 3 only***

## 5.4. Methane Cycle (Gaseous Cycle)




- **Methane** is a **more potent GHG than $CO_2$**. However, **its lifetime** in the atmosphere is **much shorter (short-lived)** than **carbon dioxide**. It contributes to the formation of **ground-level ozone**, a dangerous air pollutant.

## Natural Sources of Methane Emissions

- Methane is naturally emitted from **decomposing a biological matter**. include **wetlands and oceans** and the **digestive processes of termites** (small detrivores insects).

### Wetlands

- **Methanogens** are **microorganisms** that produce methane as a **metabolic by-product** during the **de-composition of organic matter** in **hypoxic (low oxygen)** conditions. They are **prokaryotic archaea** (**archaebacteria** — less developed than bacteria).
- Wetlands provide a habitat favourable (hypoxic) to **methanogens** and contribute to about **80% of the global $CH_4$ emissions from natural sources**.

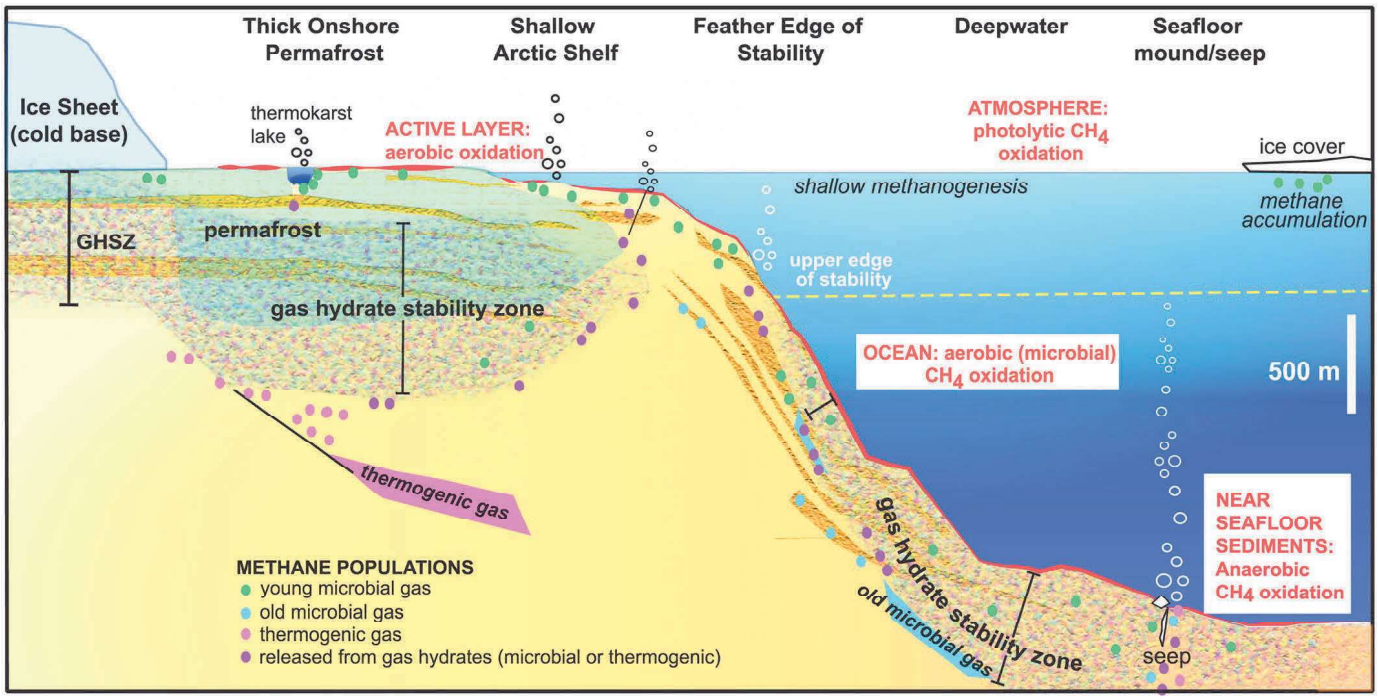
### Termites

- **Microbes** in the **guts of termites** produce methane through **anaerobic (lack of oxygen) fermentation** as part of their **normal digestive process**.

### Oceans

- The source of methane from oceans is not entirely clear. Two identified sources include the **anaerobic digestion** in marine **zooplankton** and fish and from methane produced in **sediments/drainage** areas in coastal regions.

## Methane Hydrates




- **Methane hydrates** or **clathrates** are formed when **hydrogen-bonded water** and **methane gas** come into contact at **high pressures** (due to depth) and **low temperatures** in oceans. They are in the form of **crystalline ice** that consists of a **methane molecule** surrounded by a **cage of interlocking water molecules**. Methane hydrates are also trapped in **permafrost** **(permanently frozen soil)**.
- Methane hydrates cannot be brought to the surface as the reduced pressure and increase in temperature will cause the ice to melt and the **methane to escape**.
- **Ocean acidification**, **climate change**, or any other **anthropogenic disturbance** can destabilise the **clathrates** (a lot in the ocean) and lead to the release of an **immense amount of methane — can lead to mass extinction**.

### Permian–Triassic Extinction (Third Mass Extinction)

- The Permian–Triassic (P-T) extinction event is also known as the **Great Dying**. It occurred about 252 million years ago. It is the **most severe** extinction event, with up to **96% of all marine species** and **70% of terrestrial vertebrate species** becoming extinct. It is the **only known mass extinction of insects**.
- Suggested causes include **large meteor impact events**, **massive volcanism** such as that of the **Siberian Traps**, and **runaway greenhouse effect triggered by the sudden release of methane from the seafloor due to methane-producing microbes** known as **methanogens**.

## Human Sources of Methane Emissions

- Globally, **50-65% of total $CH_4$ emissions come from human activities**.
- **More than 50%** of **global methane emissions** stem from human activities in 3 sectors:
  1. **Agriculture (40%)**

2. **Fossil Fuels (35%)**
3. **Waste (20%)**

- According to UNEP, **human-caused methane** emissions must be reduced **by 45% by 2030**. It has recommended different targets and areas for different countries. **For India**, it has **recommended** emission reduction in the **waste sector (by improving sewage disposal)**.

### Landfills

- Methane is generated in landfills as waste decomposes under **anaerobic (lack of oxygen) conditions**. The amount of methane created depends on the quantity and moisture content of the waste.

### Wastewater Treatment

- Wastewater from sewage is treated to remove soluble organic matter, pathogens, etc. These treatment processes can produce methane emissions if **organic ingredients** are treated without oxygen (**anaerobic** conditions).

### Fossil Fuels

- Fossil fuels are formed by natural processes such as the **anaerobic decomposition** o**f buried dead organisms**. Methane is the primary component of **natural gas**. It is released during the production, storage and transmission of natural gas. **Methane trapped in coal deposits (Coalbed Methane)** is released during normal mining operations.

### Livestock

- Domesticated livestock, such as cattle, buffalo, etc., produce large methane as part of their **digestive processes**.
- In the stomach, **microbial fermentation** converts feed into products that can be digested. This process produces **methane as a by-product**, which is **exhaled** by the animal.

### Rice Cultivation

- **Methane** is produced during **flooded rice cultivation** by decomposing organic matter in the soil. Flooded soils are ideal for methane production because of their high organic levels, **oxygen-poor conditions**, and moisture.

### Biomass Burning

- **Incomplete burning** of both living and dead organic matter results in methane emission.

⇨ ***Human source > Natural Source***
⇨ ***Natural Source ➔ Wetlands > Termites > Oceans > Methane Hydrates***
⇨ ***Human Source ➔ Agriculture > Fossil Fuels > Waste***

## Methane Sink

- Any process that **consumes methane from the atmosphere** can be considered a **methane sink**.

- **Soils act as a major sink** for atmospheric methane through the **methanotrophic bacteria** that reside within them. These bacteria use **methane as an energy source** in a process called **Methane Oxidation**.

### Reaction with the hydroxyl radical

- Methane is removed from the **troposphere** by the **oxidation of methane** by the **hydroxyl radical (OH)**. After reacting with OH, atmospheric **methane** is converted to **$CO_2$** and **water vapour** by a long series of chemical reactions. Some of the methane in the troposphere passes into the **stratosphere**, where the same process scrubs the methane there.

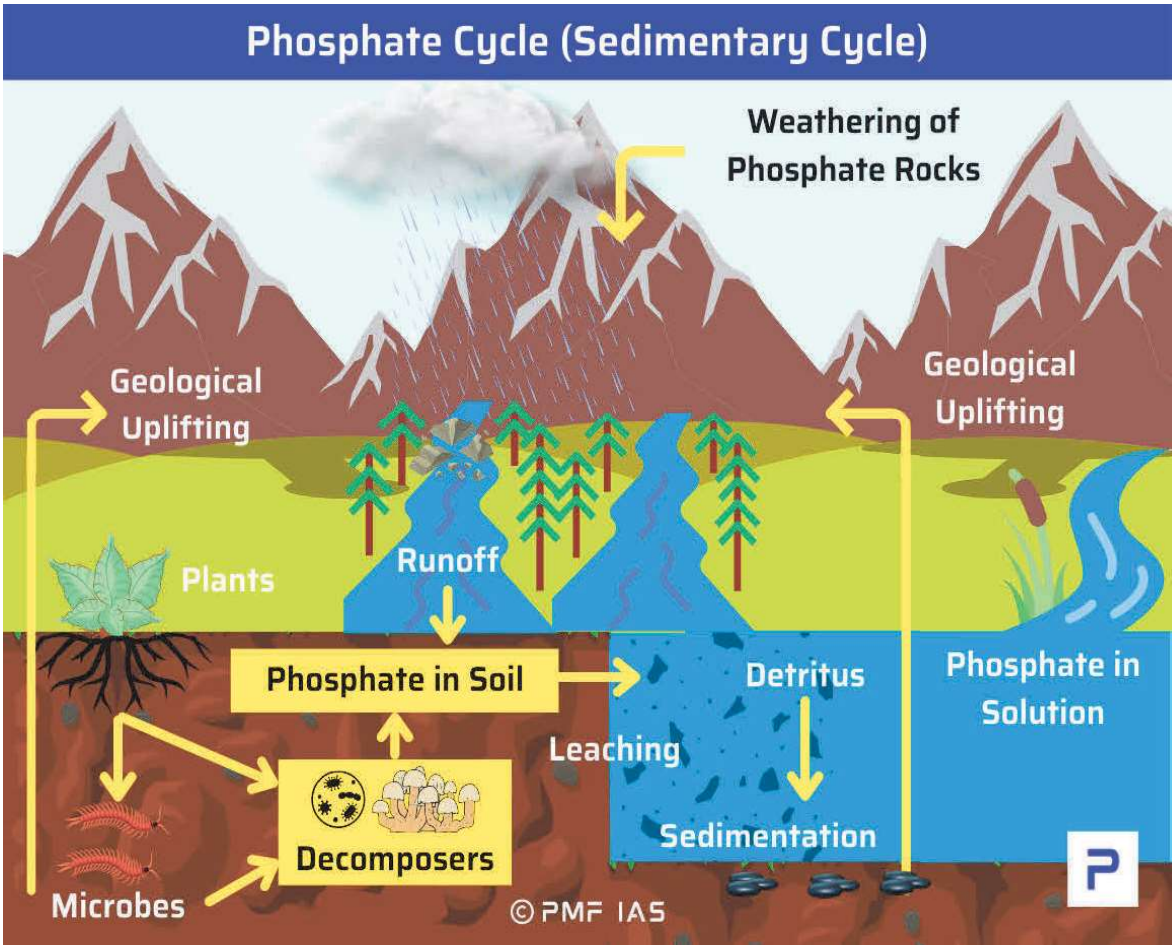
⇨ *A **hydroxyl radical** (**OH –** a neutral form of the hydroxide ion ($OH^-$)) is a negatively charged oxygen atom bonded with the hydrogen atom.*

⇨ ***Hydroxyl radicals are a form of sink** because **they scrub the atmosphere clean of pollutant molecules** and break them down. For this reason, **hydroxyl radical (OH)** is known as the **cleanser of the atmosphere**.*

### Methane Hydrates

- **Clathrate deposits** were **once sinks** where methane was isolated. However, **as the planet warms**, some of these deep, **cold sediments are melting**, sending methane bubbling to the surface.

## 5.5. Phosphorus Cycle (Sedimentary cycle)

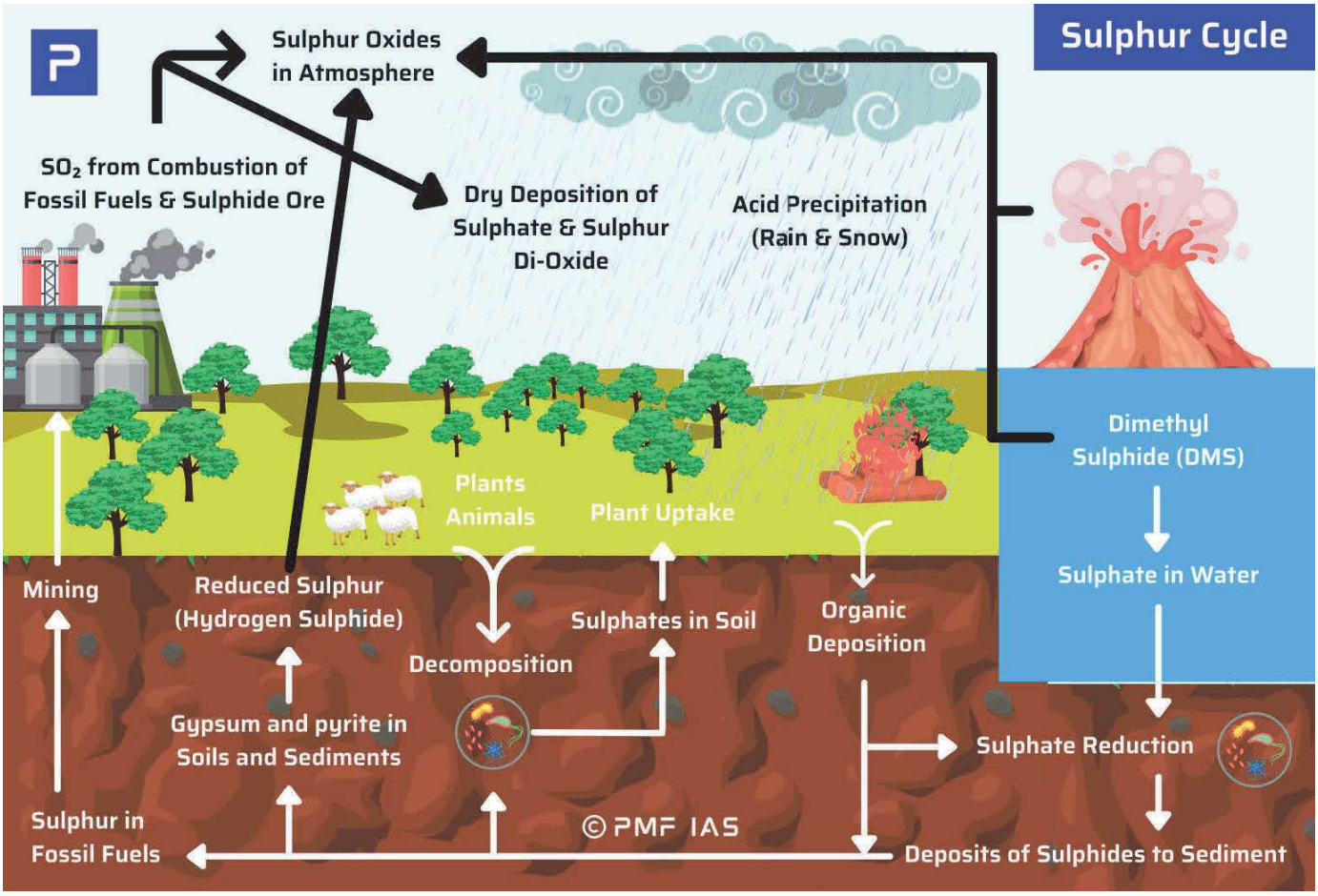


- Unlike carbon and nitrogen, which come primarily from the atmosphere, phosphorus occurs in large amounts as a **mineral in phosphate rocks**. Due to **weathering**, **erosion**, and **mining**, phosphates enter rivers, and, finally, oceans.
- In the ocean, they accumulate on continental shelves as **insoluble deposits**. After millions of years, the crustal plates rise from the seafloor and bring the phosphates to the crust, and the cycle's geochemical phase repeats.

⇨ ***Phosphorus*** *plays a central role in* ***aquatic ecosystems*** *and water quality. It is the* ***main cause of excessive growth of rooted and free-floating microscopic plants*** *(****phytoplankton bloom****) in lakes (which leads to* ***eutrophication****).*

## 5.6. Sulphur Cycle (Mostly Sedimentary Cycle)

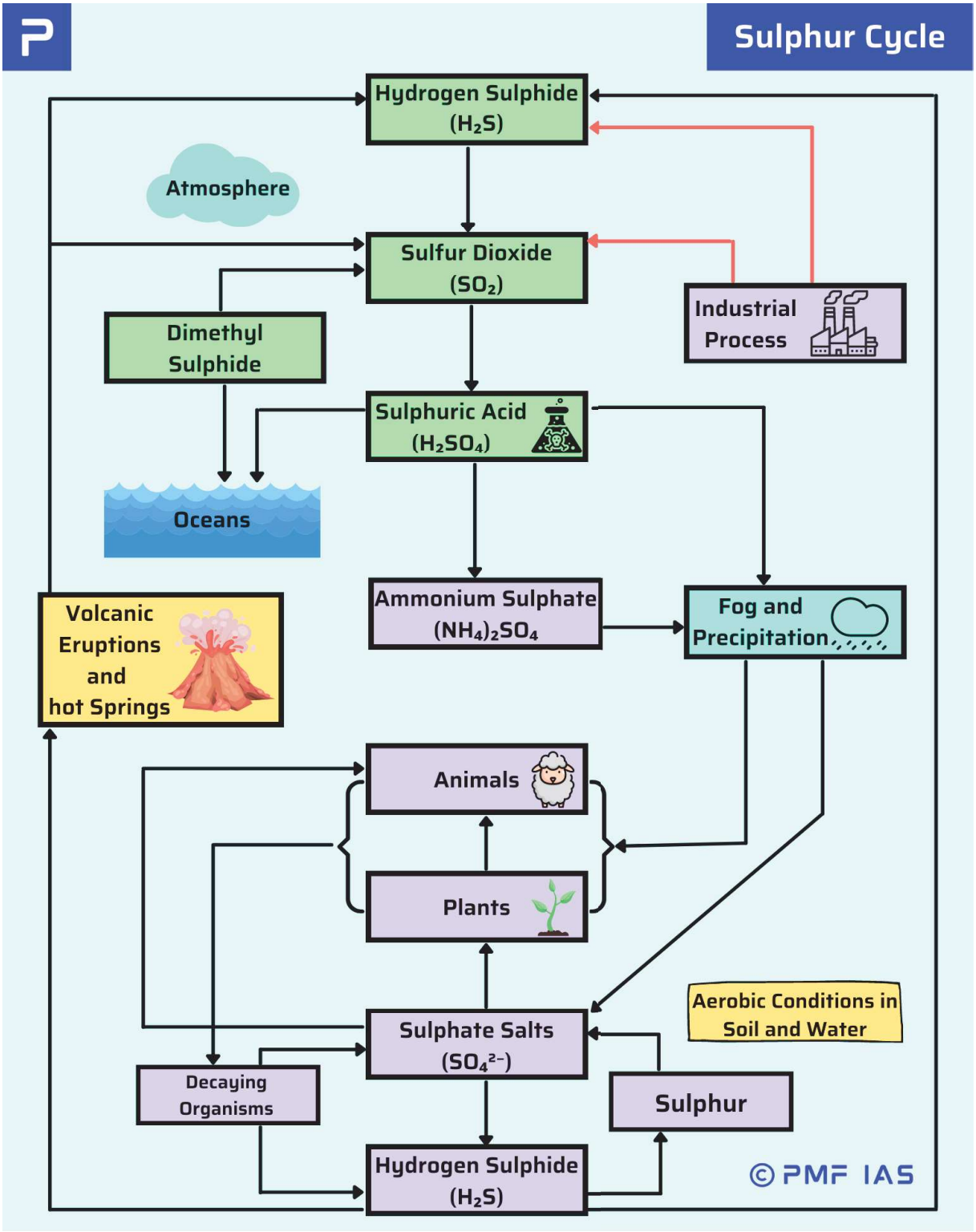
- Sulphur is locked in **organic (coal**, **oil**, **peat)** and **inorganic (pyrite rock**, **sulphur rock)** soil deposits in the form of **sulphates**, **sulphides**, and **organic sulphur**. It is released by weathering of rocks, erosional runoff and **decomposition of organic matter** and is carried to terrestrial and aquatic ecosystems in the salt solution.




### Steps in Sulphur Cycle

- Sulphur enters the atmosphere as **sulphur dioxide** from sources like **volcanic eruptions**, **combustion of fossil fuels (coal**, **diesel**, **etc.)**, **from the surface of the ocean (Dimethyl Sulfide (DMS))** and

**gases released by decomposition**. Atmospheric **hydrogen sulphide** also gets oxidised into **sulphur dioxide**.




⇨ ***Dimethyl Sulfide (DMS)*** *is an organosulfur (sulphur compound derived from some* ***marine algae***, ***plants***, ***and animals****). DMS is the primary source of* ***marine sulphate aerosols*** *and an essential* ***nutrient*** *for many organisms.*

- Atmospheric **sulphur dioxide** is carried back to the earth as weak **sulphuric acid (acid rain)**.

- Whatever the source, sulphur in the form of **sulphates** is taken up by plants and incorporated through a series of metabolic processes into **sulphur-bearing amino acids**, which are incorporated in the proteins of **autotroph tissues**. It then passes through the **grazing food chain**.
- Sulphur bound in **living organisms** is carried back to the soil, to the bottom of ponds and lakes and seas through **excretion** and **decomposition of dead organic material**.

**[UPSC 2022] Among the following crops, which one is the most important anthropogenic source of both methane and nitrous oxide?**

a) Cotton
b) Rice
c) Sugarcane
d) Wheat

**Explanation**

- **Methanogens** are most active in **hypoxic conditions** created by **excessive irrigation**.
- **Agriculture sector** (**nitrogenous fertilisers**) is one of the biggest emitters of **nitrous oxide** (**$N_2O$ – GHG**)

***Answer: b) Rice (excessive irrigation and overuse of fertilisers)***

**[UPSC 2019] Which of the following statements are correct about the deposits of methane hydrate?**

1. Global warming might trigger the release of methane gas from these deposits
2. Large deposits of 'methane hydrate' are found in Arctic Tundra and under the seafloor.
3. Methane in the atmosphere oxidizes to carbon dioxide after a decade or two.

***Select the correct answer using the code given below:***

a) 1 and 2 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

***Answer: d) all***

**[UPSC 2018] With reference to agricultural soils, consider the following statements:**

1) A high content of organic matter in soil drastically reduces its water-holding capacity.
2) Soil does not play any role in the Sulphur cycle.
3) Irrigation over a period of time can contribute to the salinization of some agricultural lands.

***Which of the statements given above is/are correct?***

a) 1 and 2 only
b) 3 only
c) 1 and 3 only

d) 1, 2 and 3

**Explanation**

- A high content of organic matter (humus) in the soil increases its water-holding capacity.
- The sulphur cycle is **mostly sedimentary** except for its two compounds, **hydrogen sulphide ($H_2S$)** and **sulphur dioxide ($SO_2$)**.
- In canal-irrigated areas, the **groundwater level rises**, and **saline and alkaline efflorescences** consisting of salts of sodium, calcium and magnesium appear on the surface as a layer of white salt through **capillary action**. Vast tracts of canal-irrigated areas in Uttar Pradesh. Punjab and Haryana, arid regions of Rajasthan, semi-arid areas of Maharashtra, Gujarat, Andhra Pradesh, Telangana and Karnataka etc., are facing this problem.

***Answer: b) 3 only***

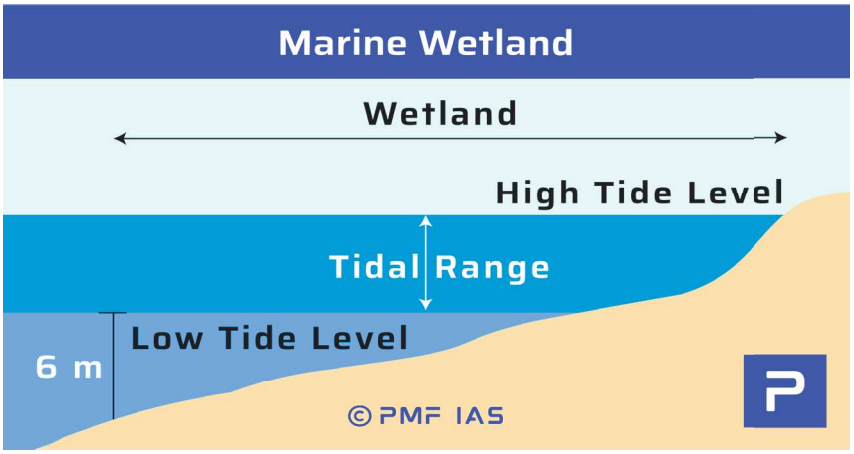
**[UPSC 2021] In case of which one of the following biogeochemical cycles, the weathering of rocks is the main source of release of nutrient to enter the cycle?**

a) Carbon Cycle
b) Nitrogen Cycle
c) Phosphorus Cycle
d) Sulphur Cycle

**---------- End of Chapter ----------**

# 6. Wetland Ecosystem

- Wetlands are **transition zones (ecotone)** between **terrestrial** and **aquatic ecosystems**. **Hydric soils (not enough $O_2$)**, **periodic flooding** from adjacent deepwater habitats and **plant life (hydrophytes)** adapted to **shallow waterlogged soils** are the chief characteristics.
- According to the definition under **Ramsar Convention** and **Wetlands (Conservation and Management) Rules 2017**, an area of **marsh**, **fen**, **peat land** or water, whether natural or **artificial**, permanent or **temporary**, with water that is static or flowing, fresh, brackish or salt, including **areas of marine water the depth of which at low tide does not exceed six meters**, is considered as a wetland.
- Wetlands include **all lakes** and **rivers**, **lake littorals** (marginal areas between the highest and lowest water level of the lakes), **floodplains** (areas lying adjacent to the river channels beyond the natural levees and periodically flooded during high discharge in the river), **underground aquifers**, swamps and marshes, **wet grasslands**, **peatland**, **oases**, **estuaries**, **deltas**, **tidal flats**, **mangroves** and other coastal areas, **coral reefs**, and all human-made sites such as fishponds, **rice paddies**, **reservoirs**, and **salt pans**.

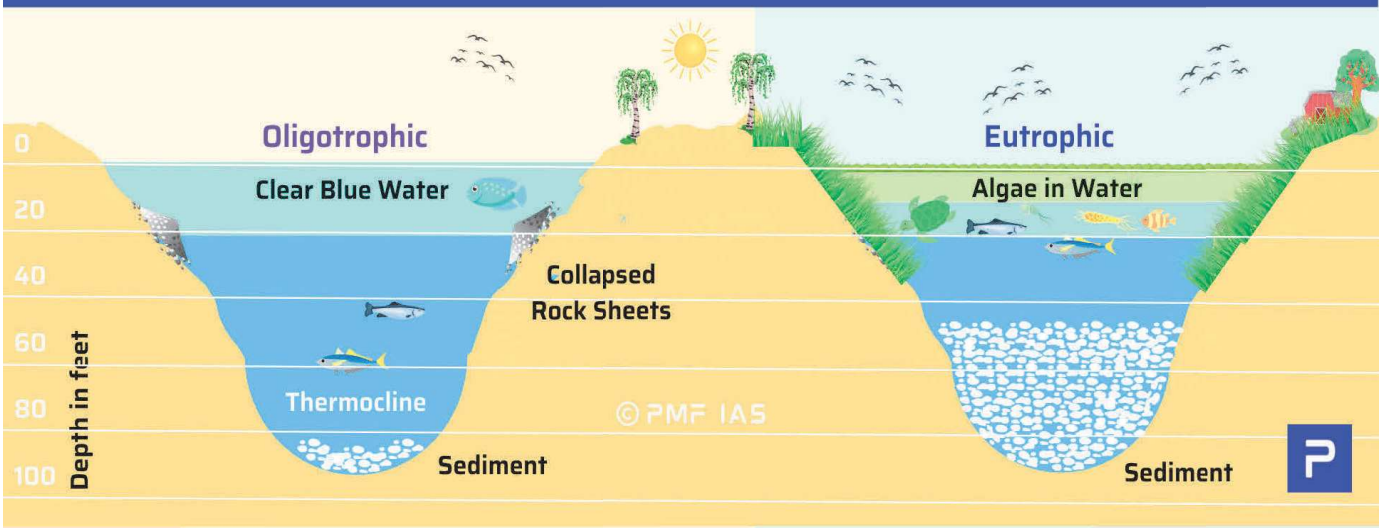



## 6.1. Differences Between Wetlands and Lakes

| Characteristic | Lake | Wetland (shallow lake) |
|---|---|---|
| **Origin** | Tectonic, fluvial, geomorphic, increase in the water table, etc. The largest lakes are due to tectonic forces. | Mostly fluvial, residual lakes. E.g., **Kolleru Lake** in Andhra Pradesh |
| **Water turnover** | Permanent | Permanent or Temporary |
| **Water level changes** | Relatively small | Relatively Large |
| **Thermal stratification** | Yes | No |
| **Vertical mixing** | Thermally regulated (because of depth) | Wind regulated |
| **Dominant Producers** | **Phytoplankton** | **Macrophytes** |

| Food chain | Grazing Pathway | Detritus Pathway |
|---|---|---|
| Productivity | Low | High |
| Trophic status | Oligotrophic (low nutrient levels; low turbidity; low sedimentation; low population density; low diversity) | Mostly Eutrophic (high nutrient levels, high turbidity, high sedimentation, high population density, high diversity) |
| Flood control | Negligible | Significant |
| Waste treatment | Negligible | Significant |

## Difference Between Oligotrophic and Eutrophic Lakes




| | Oligotrophic | Eutrophic |
|---|---|---|
| Definition | It is a lake that has few nutrients present and also a low primary productivity | It is a lake that has abundant nutrients present and also a high primary productivity |
| Water Parameters | Low Turbidity, High Oxygenation at depth, and clear water | High Turbidity, Low Oxygenation at depth, and water often is brown or with a greenish tint. |
| Primary Producers | Low Concentrations | High Concentrations |
| Primary Productivity | Is less than 100 mg of carbon/m² a day. | Is more than 100 mg of carbon/m² a day. |
| Consumers | Many fish at Deep Levels. | Few Fish at Deep Levels. |
| Microbes | Reduced Biomass. | Increased Biomass. © PMF IAS |

- There is no clear distinction between lakes & wetlands. Wetlands are **shallow water bodies**, whereas lakes can be **deep or shallow**. Lakes are generally **less critical** than wetlands from the viewpoint of ecosystem and conservation.
- The National Lake Conservation Programme (NLCP) considers lakes as standing water bodies that have a minimum water depth of **3 m**, generally cover a water spread of **more than ten hectares** and have **no or very little aquatic vegetation**.

- Wetlands (**generally less than 3 m deep**) are usually **rich in nutrients** (derived from surroundings and their sediments). They have **abundant growth of aquatic macrophytes (aquatic plants large enough to be seen by the naked eye)**. They support high densities and diverse fauna, particularly birds, fish and macroinvertebrates, and therefore, have **high value for biodiversity conservation**.

⇨ ***Excessive growth of macrophytes*** *(both submerged and free-floating) in wetlands affects the water quality adversely and interferes with the utilisation of the water body. However, marginal aquatic vegetation is desirable as it checks erosion, serves as a habitat for wildlife and helps improve water quality.*

## 6.2. Estuarine Wetland Ecosystem

- An estuary is a **partially enclosed** coastal area of **brackish water** (salinity of **0-35 ppt**) where a river or a stream opens into the sea **(mouth of the river)**. At the estuaries, freshwater carrying fertile silt and runoff from the land mixes with salty seawater. Examples of estuaries are **river mouths**, **coastal bays**, **tidal marshes**, **lagoons**, **and deltas**.
- Estuaries are formed due to the **rise in sea level**, **movement of sand and sandbars**, **glacial processes**, and **tectonic processes**. They are **greatly influenced by tidal action**. They are periodically washed by seawater once or twice a day based on the number of tides. In some narrow estuaries, **tidal bores** are significant. They cause **significant damage** to the estuarine ecology.

### Differences between Lagoon and Estuary

- A lagoon is a stretch of **saltwater** separated from the sea by a **low sandbank or coral reef**. **Backwaters in Kerala** are lagoons where seawater flows inwards through a small inlet that is open towards the sea.
- Lagoons (like **Chilika Lake in Odisha**) are formed due to **falling sea levels** (**coastline of emergence**. **E.g.**, **Kerala (Malabar) Coast**, **Odisha (Utkal) Coast and Tamil Nadu (Coromandel) Coast**).
- In contrast, estuaries (like **Mandovi** and **Zuari estuarine systems in Goa**) are mainly formed due to **rising sea levels** (**coastline of submergence**. **E.g.**, **Konkan Coast**).
- **Lagoons mostly do not have any fresh water source**, while the **estuaries have at least one**. **Hence**, **lagoons are more saline than estuaries**.
- **Estuaries** are usually **deeper**, and the water flows fast, while in **lagoons**, the water is **shallower and flows sluggishly**.

## Importance of Estuaries

### Ecological Importance

- ✓ **Estuaries (coastal wetlands)** form a **transition zone (ecotone)** between the river and maritime environments. They are the **most productive (more productive than other wetlands)** water bodies in the world because of the **mixing of freshwater and saline water zone** where **marine organisms of both ecosystems meet**.
- ✓ An estuary has **minimal wave action**, so it provides a calm refuge from the open sea and hence becomes ideal for the survival of numerous aquatic species. The vast **mangrove forests** on the seaward side of an estuary act as a **barrier for the coastal habitat** to check the wind speed during cyclones and high-velocity landward winds.
- ✓ **Precipitation** of clay and alluvium particles in the estuarine region is **high** because of **exposure to saline water (quick at precipitating fine alluvium)**. **Mangroves** act as a **filter trapping suspended mud** and sand carried by rivers, which leads to **delta formations** around estuaries.
- ✓ Estuaries **store and recycle nutrients**, trap sediment and form a **buffer** between coastal catchments and the marine environment. They also absorb, trap and **detoxify pollutants**, acting as a natural water filter.

### Economic Importance

- ✓ Estuaries are the most **heavily populated** areas worldwide, with about 60% of the world's population living along estuaries and the coast. Estuaries with their **wetlands**, **creeks**, **lagoons**, **mangroves** and **seagrass beds** are rich in natural resources, including **fisheries**. They are **deep and well protected from marine transgressions**, and hence, they are **ideal locations for the construction of ports** and **harbours**.

## Estuarine Vegetation

- Estuaries are subjected to large variations in salinity. Only certain types of plants and animals (capable of **osmoregulation**) adapted to the **brackish** estuarine waters flourish in the estuaries. **Salinity** and **flooding** determine the distribution (diversity and density) of organisms.
- Estuaries are **dynamic**, **productive ecosystems** since the river flow, tidal range, and sediment distribution are continuously changing. Hence, they support diverse habitats, such as **mangroves**, **salt marshes**, **seagrass**, **mudflats**, etc.
- They are homes to many terrestrial or land-based plants and animals, such as wood storks, pelicans, coniferous and deciduous trees, and butterflies. Estuaries are also home to unique aquatic plants and animals, such as **sea turtles**, **sea lions**, sea catfish, salt grasses, **seagrass**, bulrush, etc.
- The estuarian **phytoplankton** are **diatoms**, **dinoflagellates**, **green algae**, and **blue-green algae**. Towards the seacoast, there are **algae** and **seagrasses**. Near the mouth of the rivers and deltas, there are **mangrove forests**.

## Indian Estuarine Ecosystem

- India has 14 major, 44 medium, and 162 minor rivers draining into the sea through various estuaries. Most of **India's major estuaries occur on the east coast**. In contrast, the **estuaries on the west coast are smaller** (in environmental studies, deltas are subsections of estuaries). Many estuaries are locations of some of the **major seaports**. E.g., **Mormugao Port on the Zuari Estuary**.

### Threats Faced by the Estuarine Ecosystem

- Changes in water flow due to modifications of the catchments (E.g., Hooghly, Godavari, Pulicat, etc.).
- Pollution through industries and city sewage discharge.
- Navigation, **dredging and shipping** (e.g. **Hooghly**).
- Expansion of urban and rural settlements, mining and industries, agriculture and dumping of solid wastes.
- **Intensive aquaculture** in pens and **obstructing the migratory routes** of fish and prawns (e.g., Chilka, Pulicat).
- Polluting the environment through feeding stocked fish and prawns in pens (Chilka).
- Destruction of biodiversity through prawn seed collection through small-meshed nets (e.g., Hooghly, Chilka, Pulicat).
- Submergence of catchment areas due to water level rise.

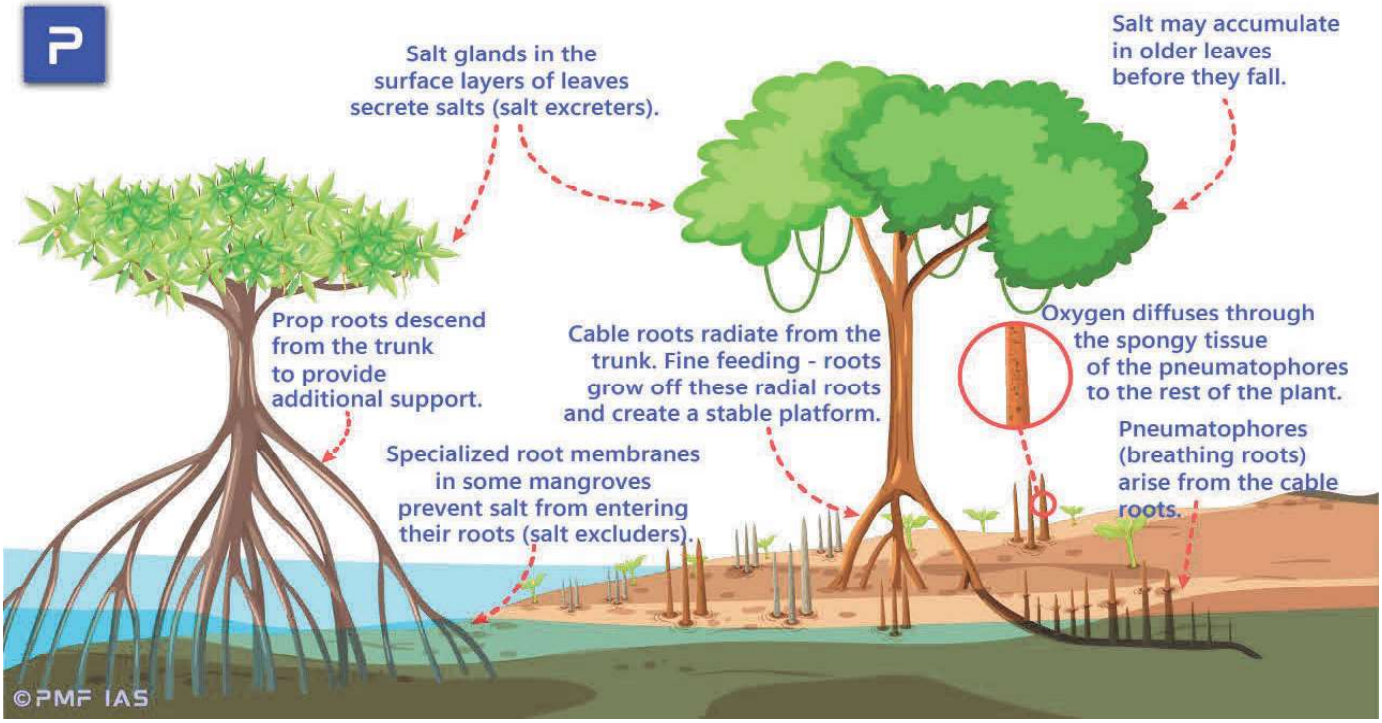
## 6.3. Mangroves

- Mangroves are **salt-tolerant (halophytes) evergreen** shrubs or small trees (vary in height from 8 to 20 m) that represent a characteristic **littoral (near the seashore)** forest ecosystem. They grow **below the high-water level of spring tides**.
- The best locations are where abundant silt is brought down by rivers or on the backshore of accreting sandy beaches. Such locations include **brackish waters** of **sheltered low-lying coasts**, **estuaries**, **mud-flats**, **tidal creeks**, **backwaters (coastal waters held back on land)**, **marshes** and **lagoons** of **tropical** and **subtropical regions**.

### Adaptive Mechanism of Mangroves

- Mangroves exhibit varied **morphological** (shape and structure) and **physiological** (functional) evolutionary adaptations to survive the limiting factors — **lack of oxygen**, **high salinity**, and **diurnal tidal inundation**. Some of the adaptations exhibited by mangroves are:
  - ✓ **Succulent leaves** (**thick leaves adapted to store water and reduce evapotranspiration**),
  - ✓ **Sunken stomata** (to protect from drying winds),
  - ✓ **Leaves with salt-secreting glands** (to flush out the excess salt)
  - ✓ **Aerial breathing roots** called **pneumatophores**,
  - ✓ **Vivipary** (seeds or embryos begin to develop before they detach from the parent),
  - ✓ **Stilt** and **prop roots** (they are **fibrous (adventitious)** support roots)
  - ✓ **Buttresses (large**, **wide support roots on all sides of a shallowly rooted (mangrove) tree)**.

- The **adventitious roots (prop** and **stilt roots)**, which emerge from the main trunk above ground level, act as **support roots**. The complex root system helps mangroves overcome the strong wave action and **diurnal tidal inundation**. The **pneumatophores (blind roots)**, **prop roots** and **stilt roots** help mangroves **overcome the respiration problem** in **anaerobic (low oxygen — anoxic)** soil conditions (a classic example of **adaptation**).




⇨ *Some species (e.g., **Rhizophora**) of mangroves send arching **prop roots** into the water. While others (e.g., **Avicennia**) send vertical **pneumatophores** (**air roots**) up from the mud.*

- Mangroves exhibit a **viviparity mode of reproduction**, i.e., **seeds germinate in the tree itself** (before falling to the ground). This is an **adaptive mechanism** to **overcome the problem of germination in saline water**.

## Mangroves in India

- In size, mangroves range from bushy stands of dwarf mangroves found in the **Gulf of Kutch** to taller stands found in the **Sundarbans**. On the Andaman and Nicobar Islands, the small tidal estuaries and the lagoons support a dense and diverse undisturbed mangrove flora.

### Mangroves of Sundarbans

- The **Sundarbans** received its name from the **Sundari mangrove tree**. It is the **largest single block** of tidal halophytic mangroves in the world. The eco-geography is dependent on the **tidal effect** — deposits silt back on the channels, raising the bed and forming new islands and creeks.
- The **Sundarbans delta** (India and Bangladesh) is the **only mangrove forest inhabited by tigers**. Sundarbans support **400+ tiger population** (**88 tigers are in the Indian part**).
- Major fauna of Sundarbans includes **Royal Bengal tiger (EN)**, **saltwater crocodile (LC)**, river terrapin, **olive ridley turtle (VU)**, **Ganges river dolphin (EN)**, hawksbill turtle, mangrove horseshoe crab, etc.


### Bengal tigers may not survive climate change

- 70 per cent of the land in the Sundarbans is **just a few feet above sea level**. In 2010, a study led by the **World Wide Fund for Nature** projected that a sea-level rise of 11 inches could reduce the number of tigers in the Sundarbans by 96 per cent within a few decades.

## Other major Mangrove Forests on the East Coast

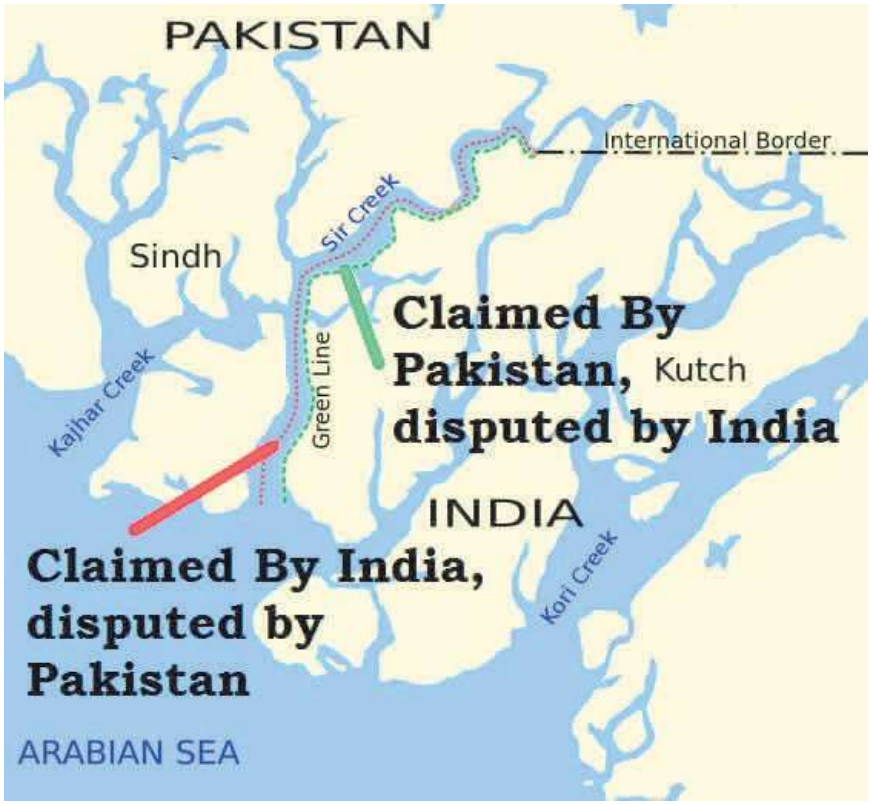
- The mangroves of **Bhitarkanika (Orissa)**, the **second largest in India**, harbour a high concentration of typical mangrove species and high genetic diversity. They cover the area of **Brahmani** and **Baitarani**

river deltas. Mangrove swamps occur in profusion in the intertidal mudflats on both sides of the creeks in the **Godavari-Krishna deltaic regions** of Andhra Pradesh.

- Mangroves of **Pichavaram** and **Vedaranyam** are degraded due to **aquaculture** ponds and **salt pans**.

## Mangrove Forests on the West Coast

- On the **west coast** of India, mangroves, mostly **scrubby (stunted)** and **degraded**, occur along the intertidal region of **estuaries** and **creeks** in Maharashtra, Goa, and Karnataka. The mangrove vegetation in the coastal zone of Kerala is **very sparse** and thin.
- In Gujarat (north-west coast), mangroves are found mainly in the **Gulf of Kutch** and the **Kori Creek region** (**paleo delta of the Indus River** (once upon a time, it was part of the Indus delta)). They are scrubby with stunted growth, forming narrow, **discontinuous patches** on soft clayey mud.




*Creeks in the Kutch Region*

**[UPSC 2016] What is/are unique about 'Kharai camel', a breed found in India? (2016)**

1. It is capable of swimming up to three kilometres in seawater.
2. It survives by grazing on mangroves.
3. It lives in the wild and cannot be domesticated.

***Select the correct answer using the code given below.***

a) 1 and 2 only
b) 3 only
c) 1 and 3 only
d) 1, 2 and 3

**Kharai Camel – India's swimming camels**

- Since 2015, **Kharai camels (India's swimming camels)** have been getting protection similar to endangered species. They depend on the **mangroves** of the **Kutch region** for their food for eight months of the year. During monsoons, they swim to the mangrove islands in hordes.
- **Kharai camels** are the primary source of livelihood for the **Jat**, **Rabari** and **Maldhari** communities of the Kutch region. Along with the **kankrej** and **Banni buffalos**, the **Maldharis** have developed other **tolerant breeds of livestock**, such as the **kharai camel**.

***Answer: a) 1 and 2 only***

## Mangrove Initiative for Shoreline Habitats and Tangible Incomes (MISHTI) Programme

- MISHTI Programme, announced in the 2023-24 Budget, is an initiative for mangrove plantations along the coastline and on salt pan lands. The Union Government launched it on World Environment Day on June 5th, 2023.
- Aim: Planting mangroves in 540 sq km of coastline, spanning 11 states and two union territories.
- Under MISHTI, the mangroves will be planted through initiatives under the **Compensatory Afforestation Fund Management and Planning Authority (CAMPA)**, Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) and public-private partnership.

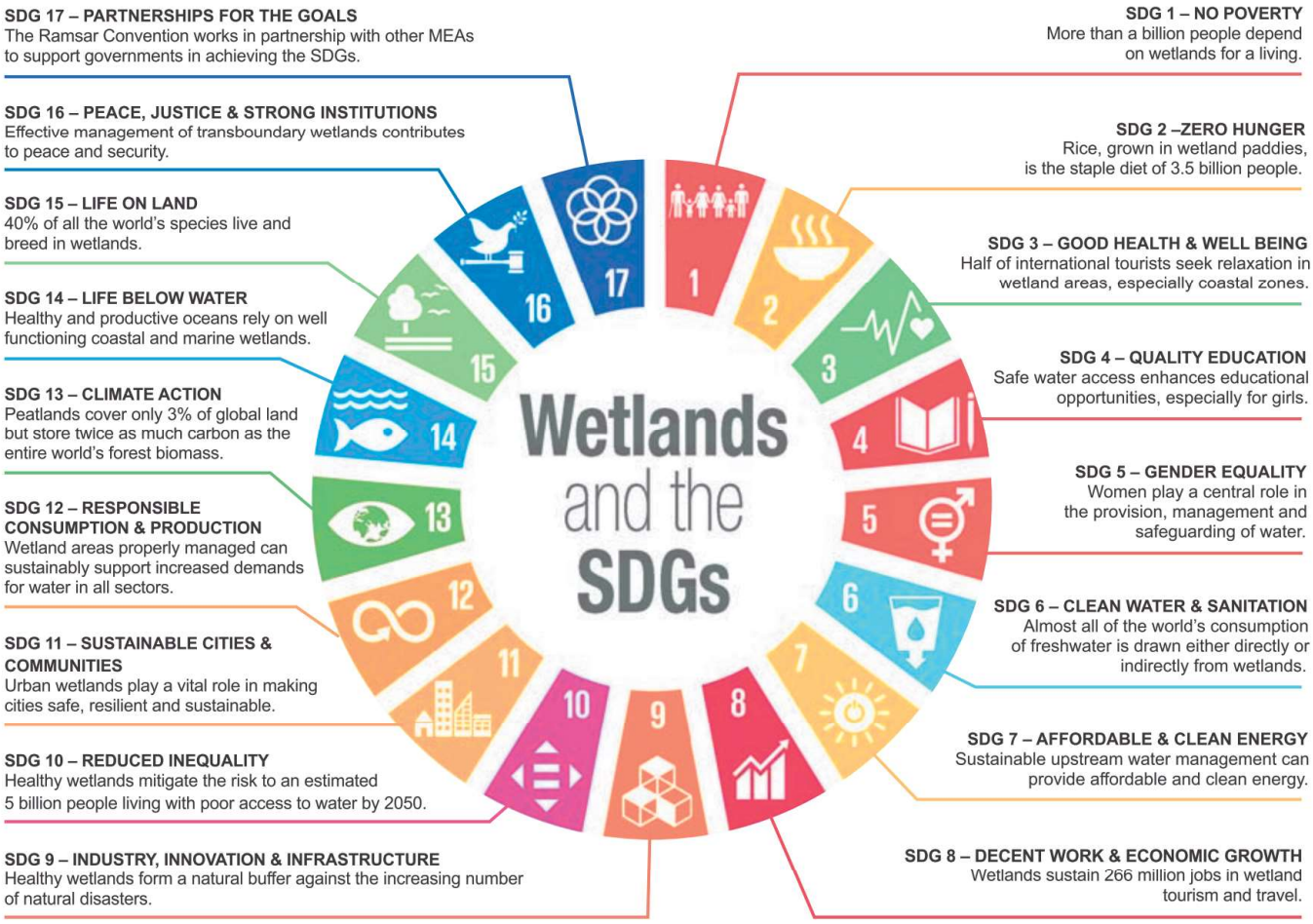
## Global Status of Mangrove Cover

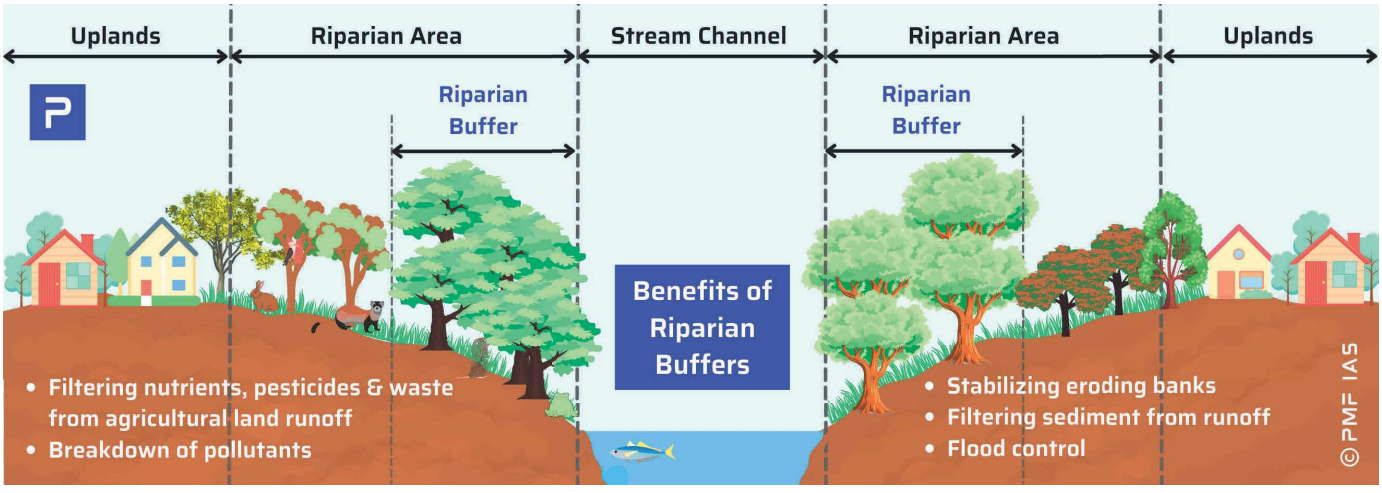
- According to FAO's Global Forest Resource Assessment, 2020, **113 countries** have mangrove forests covering ~14.79 million ha (1% of the tropical forests), primarily in **tropical and subtropical regions**. The largest mangrove area is in **Southeast Asia (5.55 mha)**, followed by **Africa**, the **Americas**, and **Oceania** (1.30 mha).
- More than 40 per cent of the total area of Mangroves was reported to be in just four countries: **Indonesia (19%)**, **Brazil** (9%), Nigeria (7%) and Mexico (6%). The mangrove cover in India is **4,992 sq km (ISFR 2021)**, which is **0.15%** of the country's total geographical area.

## Why are mangroves not found beyond subtropics?

- Mangroves are confined to the **tropics and subtropics**, occurring mainly in the **intertidal regions** between latitudes **24° N** and **38° S**. This is because the mangrove vegetation contains a **complex salt filtration system** that facilitates **high water loss at the root level** itself to cope with the brackish conditions. These **adaptive mechanisms** are energy-intensive and **require high solar radiation**.

## Importance of mangroves




✓ Mangroves (**ecotone** between land and sea) are **highly productive ecosystems** with rich biodiversity.

- ✓ They have a complex root system that is very efficient in **dissipating the sea wave energy**, thus **protecting the coastal areas** from **tsunamis**, **storm surges (produced by cyclones)** and **soil erosion**.
- ✓ Mangroves slow down water flow and act as a **zone of land accretion** by enhancing **sediment deposition**.
- ✓ They moderate monsoonal tidal floods and **reduce the inundation** of coastal lowlands.
- ✓ They act as a **riparian buffer** and trap pollutants, including **heavy metal contaminants**. They enhance the natural recycling of nutrients.
- ✓ Mangroves are an essential **carbon sink**.
- ✓ They provide a safe and favourable environment for breeding, spawning, and rearing several fishes.
- ✓ They act as an essential source of livelihood for the coastal communities dependent on the collection of honey, tannins, wax, firewood, medicinal plants, edible plants, and fishing.

**[UPSC 2013] Which one of the following is the correct sequence of ecosystems in the order of decreasing productivity?**

a) Oceans, lakes, grasslands, mangroves
b) Mangroves, oceans, grasslands, lakes
c) Mangroves, grasslands, lakes, oceans
d) Oceans, mangroves, lakes, grasslands

**Explanation**

- Productivity = production/unit area/unit time. It depends on the number and diversity of producers.
- **Ecotones (Mangroves**, **estuaries**, **and grasslands)** have **greater productivity** than the surrounding ecosystems. **Tropical Rainforests** and **coral reefs** are an exception, as **they have productivity comparable to wetlands** because of their rich diversity of primary producers.
- Note: **Grasslands are not transitional all the time**. E.g., Steppe and Savanna grasslands, which are very vast, are non-transitional and have very **low productivity** because of the minimal diversity of primary producers. (Grasslands become transitional only when they are narrow). So, the order of decreasing productivity will be like Mangroves, ……, ……, ……..
- Oceans are very deep, and hence productivity is limited to the surface only (deep below in the aphotic zone, productivity is negligible. The Aphotic zone in oceans is a few kilometres thick!). Also, **ocean surface water is abysmal (very poor) in nutrients** (except near the shoreline).
- **Nutrient-rich cold water flows** as a sub-surface flow in the **aphotic zone**. Sunlight and nutrients are far apart, so **primary productivity is very low** except in regions with an **upwelling of nutrient-rich cold water (cold and warm ocean current mixing zones)**.
- So, among the options, the **open ocean ecosystem has the least productivity**. (**Desert ecosystem also has very low productivity**, **lesser than the oceans**).
- So, the answer will look like Mangroves, ……., ……., Oceans. The only such option is c)
- Lakes, just like oceans, have low productivity. However, due to some plants in the photic zone, **lakes have productivity slightly greater than that of oceans**.

***Answer: c) Mangroves, grasslands, lakes, oceans***

## Threats to Mangroves

***[UPSC 2019] Discuss the causes of the depletion of mangroves and explain their importance in maintaining coastal ecology.***

### Aquaculture, Agriculture and Salt Ponds

- Agriculture and aquaculture pose the greatest threat. Mangroves are rich in nutrients, which makes them attractive for agriculture. They are also ideal for **shrimp farming** and **mariculture** (food production in a confined marine environment). Hence, thousands of hectares of mangrove forests have been cleared for the commercial production of shrimp and other species, cultivation of crops, and creation of salt ponds.

### Consequences

- The shrimp and other species in the artificial ponds are fed specific diets that often include chemicals. These chemicals enter the **food chain**.
- Extra nutrients from the concentration of food and animals cause **eutrophication**, which harms the surrounding marine habitats by **lowering oxygen levels**.

### Coastal Development and Lumbering

- The direct use of mangrove wood and leaf products and the conversion of wetland habitats for coastal development projects like hotels, resorts, infrastructure, desalination plants, port facilities, etc. lead to deforestation.
- Mangrove wood is used for building materials, fencing, and fuel. It also yields valuable, **high-quality charcoal**. In places where fishing has declined, people have turned to charcoal production, which furthers the cycle of habitat loss and fishery decline.

### Consequence: Habitat loss and climate vulnerability

- The delicate tidal regimes are interrupted, and the balance between fresh and saltwater is lost. It inevitably leads to altered hydrology, **erosion**, and **pollution**. Rivers that once travelled through the mangroves before emptying into the sea are blocked or re-routed, causing **changes in flooding**, **drainage**, filtration, sedimentation, temperature, and salinity. These changes, in turn, affect the aquatic species, including subsistence fish species for coastal communities.
- **Loss of species and genetic diversity:** The trees and associated species (e.g., birds, snakes, crabs) are visibly lost, but so too are the specific genotypes and phenotypes that have evolved in microhabitats to withstand insects, tidal fluctuations, precipitation patterns and salinity regimes.

### The Curious Case of Mumbai's Coastal Road Project

- **Mumbai**, **Guangzhou**, **Jakarta**, **Miami**, and **Manila** are on the list of cities endangered by climate change. The **anthropogenic climate change**, coupled with trends in coastal development, will inundate sections of Mumbai by 2050 and will increase annual flood damages by 2-3 times by 2100. Despite the need for action, the city is ignoring climate adaptation programs. Mumbai's Coastal Road Project is an example.
- The **29.2 km long Mumbai's Coastal Road Project** is being constructed on 90 hectares of reclaimed land prone to flooding and frequent tidal inundation. The road will cost the public Rs 11,300 crore. But it will serve only 2% of the populace. The project will extend tens of meters into the sea, and 1,000 mangrove trees, which act as a natural storm/flood barrier, will be cut for the project.

## Ecological and Economic Damage

- The project will **exacerbate the flooding situation (heavy rains + high tide)** during the SW monsoon season.
- **Changes in the tidal pattern** will lead to the **erosion** of Mumbai's beaches.
- **Tidal inundation** will block **the natural drainage systems**.
- Cutting mangroves will deplete fishing grounds.
- While the amendment to coastal rules mandates planting new mangroves three times the size of the destroyed mangroves, the new ones will take several years to grow. Also, since they will be at a different location, the **replanting will not replace the storm protection services** of the old mangroves.

## Climate Change

- Coastal wetlands, including mangrove forests, absorb a significant amount of GHG emissions. When these forests are cleared, it compounds the climate change problem by releasing even more carbon into the atmosphere.
- For mangroves, **sea-level rise** is the biggest climate-related threat, with some tree species unable to tolerate the influx of saltwater or escape the surging tides.

## Replantation Does not Produce Optimum Results

- In comparison with other tropical forests, mangroves are **not species-rich**. And in the areas where replanting is attempted, it is often done with seeds of one species rather than the mix of species that initially existed. Thus, reforestation/afforestation cannot reverse the habitat loss.

## 6.4. Importance of Wetlands

- ✓ Wetlands are indispensable because of the **ecosystem services** they provide, ranging from freshwater supply, food and building materials, and biodiversity to **flood control**, **groundwater recharge**, and **climate change mitigation**.
- ✓ Wetlands are habitats for aquatic flora and fauna and numerous species of native and **migratory birds**.
- ✓ They are an important resource for **sustainable tourism**.
- ✓ They carry out **water purification** and filtration of sediments and nutrients from surface water.
- ✓ They help in **nutrient recycling**, groundwater recharging and stabilisation of the local climate.
- ✓ They play an essential role in flood mitigation by controlling the rate of runoff.
- ✓ They buffer shorelines (act as a **riparian buffer**) against erosion and pollutants.
- ✓ They act as a genetic reservoir for various species of plants (especially rice).
- ✓ They act as a **carbon sink**.

**[UPSC 2022] "If rainforests and tropical' forests are the lungs of the Earth, then surely, 'wetlands function as its kidneys." Which one of the following functions of wetlands best reflects the above statement?**

a) The water cycle in wetlands involves surface runoff, subsoil percolation and evaporation.
b) Algae form the nutrient base upon which fish, crustaceans, molluscs, birds, reptiles and mammals thrive.
c) Wetlands play a vital role in maintaining sedimentation balance and soil stabilisation.
d) Aquatic plants absorb heavy metals and excess nutrients.

**Explanation**

- Kidneys **detoxify** by filtering toxins out of the blood into the urine. Similarly, aquatic plants in a wetland absorb heavy metals and excess nutrients.

## 6.5. Reasons for the Depletion of Wetlands

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

### Mitigation of Wetland Destruction

- ✓ Demarcation of wetlands using technology, proper enforcement of laws and stringent punishments for violators.

- ✓ Preventing unsustainable aquaculture and cultivation of shellfish.
- ✓ Treating industrial effluents and water from farmlands before discharging into wetlands.
- ✓ Utilizing wetlands sustainably by giving enough time for natural regeneration.
- ✓ Artificial regeneration for a quick recovery.
- ✓ Afforestation, weed control, and preventing invasive species are the key to wetland conservation.
- ✓ Preventive measures to stop introducing exotic **invasive species like water hyacinth**.
- ✓ Soil conservation measures and afforestation.
- ✓ Preventing grazing in peripherals of wetlands.
- ✓ Wildlife conservation, sustainable tourism, ecotourism and sensitising the local populace.
- ✓ **Eutrophication abatement by processing nutrient-rich discharge into the water body**.
- ✓ Involving the local population in the conservation.

## 6.6. Measures to Protect Wetlands of India

- As per the **National Wetlands Atlas**, published by **ISRO's Space Applications Centre**, **Ahmedabad**, India has **15.26 million ha area (4.6% of India's land area)** under wetlands. Of this, **70% are under paddy cultivation (human-made)**. **Inland wetlands constitute 69.22%** (10.56 million ha). Nearly 12% of the inland wetland area is in the form of lakes and ponds (including those less than 2.25 ha).
- Natural wetlands in India range from high altitude wetlands in the Himalayas (glacial lakes, swamps, and floodplain marshes); flood plains of the major river system, saline and temporary wetlands of the arid and semi-arid regions; coastal wetlands such as **lagoons**, **backwaters**, **estuaries**, **mangroves**, **swamps**, and **coral reefs**, and so on.

⇨ *The alluvial plains of River Ganga and Brahmaputra have extensive riverine wetland formations as floodplains and oxbows known as **maun**, **beel**, **chaur**, **jheel** and **pat**.*

⇨ *The arid zone spanning Rajasthan and Gujarat has vast saline flats, monsoon-fed freshwater lakes as well as **salt lakes** (for example, **Sambhar**, **Pachpadra**, **Deedwana** and **Lukransar**).*

⇨ *The Peninsular Deccan region is studded with man-made lakes. Several lakes act as suitable habitats for water birds (e.g., Varthur, Rachenahalli and Amruthalli Lakes in Bangalore).*

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

- For the integrated and cross-sectoral conservation (coordinating administrations at all levels) of **aquatic ecosystems (lakes and wetlands)**, the MoEF has been implementing the **Centrally Sponsored Schemes (CSS) National Plan for Conservation of Aquatic Eco-systems (NPCA)**.
- NPCA was formed by merging the **National Lake Conservation Plan (NLCA)** and the **National Wetlands Conservation Programme (NWCP)**. It envisages halting and reversing the continued degradation and loss of wetlands.
- The merged NPCA scheme has been operational since the **12th Plan Period (2012-17)** with a funding pattern of **70:30 cost-sharing** between the Central Government and respective State Governments (**90:10 for the NE States**).

- The **Central Government** (MoEF) coordinates **aquatic ecosystem (lakes and wetlands)** conservation programmes. It provides guidelines and financial and technical assistance to the state govt. Since the **land resources belong to states**, the **State/UT governments manage the aquatic ecosystems**.
- Criteria for identifying **wetlands of national importance** under **NPCA** are the **same** as those prescribed under the **Ramsar Convention on Wetlands**.

## Wetlands (Conservation-Management) Rules 2010

- MoEF has notified these **legally enforceable** rules under the provisions of the **Environment (Protection) Act**, **1986**, to ensure that there is **no further degradation** of wetlands.
- **Central Wetland Regulatory Authority (CWRA)** has been set up under the chairmanship of the Secretary, MoEF, to ensure proper implementation of the Rules.
- Wetlands have been classified for better management and easier identification. The rules encompass the **drainage area** of the wetlands as determined by the CWRA.
- The rules specify and **prohibit harmful activities** to wetlands, such as **industrialisation**, **construction of permanent nature**, **solid waste dumping**, **dumping untreated waste**, **reclamation** in the wetlands, etc.
- Other activities, such as **aquaculture**, **agriculture**, **harvesting of living and non-living resources**, **dredging to remove siltation**, etc., may be carried out in the wetlands but only with **prior permission** from the concerned authorities.
- The **Central Government may**, **however**, **permit** any **prohibited activities** or **non-wetland use in the protected wetland** on the **recommendation of CWRA**.

## Wetlands (Conservation-Management) Rules 2017

- The new rules replaced the 2010 version of the rules. They have **decentralised wetlands management by giving states/UTs powers to not only identify and notify wetlands within their jurisdictions but also keep a watch on prohibited activities**.
- The rules provide an advisory role for the **National Wetland Committee** to guide the state bodies on the integrated management of wetlands based on the **wise-use principle** and review the progress of integrated management of Ramsar Convention sites, among other roles.
- To oversee the work carried out by States, the rules stipulate setting up **National Wetlands Committee (NWC – headed by the MoEF Secretary)**. NWC is the nodal advisory body for the **National Plan for Conservation of Aquatic Eco-systems (NPCA)**. It guides the state bodies on the integrated management of wetlands based on the **wise-use principle**.

### State Wetland Authority

- **States/UTs** have been accorded the responsibility for wetland management by setting up **State/UT Wetland Authorities (SWAs)**. SWA will be **headed by Environment Minister** and includes experts from the fields of wetland ecology, hydrology, fisheries, landscape planning and socioeconomics.
- SWA of the state/UT must **identify** and **notify the wetlands for protection** within the stipulated time. They need to develop a comprehensive **list of activities to be regulated and permitted** within notified

wetlands and their zone of influence and recommend additional prohibited activities for specific wetlands.

- The State authorities will also need to prepare:
  - ✓ A list of all wetlands of the state or union territory within three months
  - ✓ A list of wetlands to be notified within 6 months
  - ✓ A comprehensive **digital inventory of all wetlands** within 1 year, which will be updated every 10 years.

### What CAN NOT be notified as wetlands under the Rules?

- River channels, **paddy fields**, human-made water bodies, **aquaculture**, **salt production**, **recreation**, irrigation projects, wetlands and protected areas falling within areas covered under the **Indian Forest Act**, **1927**, **Forest (Conservation) Act**, **1980**, **Wildlife (Protection) Act**, **1972** and the **Coastal Regulation Zone Notification**, **2019 cannot** be notified under the Wetlands Rules 2017.

### Prohibited activities (very much similar to the 2011 rules)

- ❖ Conversion of wetlands for non-wetland uses.
- ❖ Setting up of any industry and expansion of existing industries.
- ❖ Manufacture/handling/storage/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 settlements.
- ❖ The Rules also restrict encroachment, poaching, or permanent construction, **except for boat jetties**.

### Concerns

- ➢ A provision in the rules that states, "Central government may consider proposals from the state/UT governments for **omitting any of the (prohibited) activities** on the authority's recommendation" can be misused.
- ➢ According to the 2010 rules, anyone aggrieved with the CWRA's decisions could have filed an appeal with the **National Green Tribunal**, but the **2017 rules are silent on the appeal process**.
- ➢ The subjective definition of the term "**wise use**" is to be determined by the State Wetland Authority, which is prone to manipulation by vested interests.

## 6.7. Measures to Protect Global Wetlands

### Ramsar Convention on Wetlands

- The **Ramsar Convention on Wetlands** is an **international treaty** for "**the conservation** and **sustainable use of wetlands**". The convention was signed on the **2nd of February (World Wetlands Day)**, **1971**, in the city of **Ramsar in Iran**. The number of parties is 172. India is a party since 1982.
- At the centre of the Ramsar philosophy is the "**wise use — maintenance of ecological character for sustainable development**" of wetlands.

- The theme for 2023: **It's Time for Wetlands Restoration**.

## Criteria for Identification of Wetlands

1. **Unique wetland:** contains a **rare** or **unique** example of a **natural or near-natural** wetland type.
2. **Endangered species:** supports threatened, vulnerable, endangered, or critically endangered species/ communities.
3. **Essential species:** supports populations of plant and/or animal species important for maintaining biological diversity.
4. **Species protection:** supports plant and/or animal species at a critical stage in their life cycles or provides refuge during adverse conditions.
5. **Waterbirds:** regularly supports 20,000+ water birds.
6. **Single species of water birds:** regularly supports 1% of the individuals in a population of one species or subspecies of water birds.
7. **Indigenous fish:** supports a significant proportion of indigenous fish subspecies.
8. **Multirole:** is an essential food source for fishes, spawning ground, nursery and/or migration path.
9. **Ecotourism:** is an essential source of food and water resource, increased scope for recreation and ecotourism.

## Contracting Parties (COP) to Ramsar Convention

- COP is the policy-making organ of the Ramsar Convention. Every **three years**, representatives of the COP meet at the Conference of the Contracting Parties (COP).
- **COP13 took place in Dubai**, **United Arab Emirates**, **in 2018**. 14th Meeting of the Conference of the Contracting Parties to the Ramsar Convention on Wetlands **(COP14) took place in November 2022** in a hybrid format in **Wuhan**, **China**, and **Geneva**, **Switzerland**.

> ⇨ *COP14 was initially scheduled to be held in the **Chinese city of Wuhan** — situated on the **left bank of the Yangtze River (the longest river in Asia – 6,300 km)** — in 2021. It was postponed due to the COVID pandemic.*

- **Wuhan Declaration** and **2025-2030 Global Strategic Framework for Wetlands Conservation** were adopted at COP14. (They offer nothing new!)

## The Responsibilities of the Contracting Parties

- A vital commitment of the Contracting Parties is to **identify and place suitable wetlands** onto the **List of Wetlands of International Importance**, also known as the **Ramsar List**.
- Contracting Parties are **expected (not mandated)** to manage their Ramsar Sites to maintain their ecological character and retain their essential functions and values for future generations. The convention specifies that "Contracting Parties **shall (not may)** formulate and implement their planning to promote the conservation of the wetlands included in the List".

**[UPSC 2019] Consider the following statements:**

1. Under the Ramsar convention, it is mandatory on the part of the Government of India to protect and conserve all the wetlands in the territory of India
2. The Wetlands (Conservation and Management) Rules, 2010 were framed by the Government of India based on the recommendations of the Ramsar convention.
3. The Wetlands (Conservation and Management) Rules, 2010 also encompass the drainage area or catchment regions of the wetlands as determined by the authority

***Which of the statements given above is/are correct?***

a) 1 and 2 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

**Explanation**

- Contracting Parties are **expected (not mandated)** to manage their **Ramsar Sites** to maintain their ecological character and retain their essential functions and values for future generations.
  - ✓ It is expected (not mandated) for the government to protect the wetland included in the list.
- The convention specifies that "Contracting Parties **shall (not may)** formulate and implement their planning to promote the conservation of the wetlands included in the List".
  - ✓ It is expected (not mandated) for the government to protect the wetlands included in the list, **not all**.
  - ✓ The Ramsar Convention **recommends** making laws to protect such wetlands.

***Answer: c) 3 only***

## International Organisation Partners

The Ramsar Convention works closely with six organisations known as International Organisation Partners (IOPs):

1. **Birdlife International**
2. **International Union for Conservation of Nature (IUCN)**
3. **International Water Management Institute (IWMI)**
4. **Wetlands International**
5. **World Wide Fund for Nature (WWF)**
6. **International Wildfowl & Wetlands Trust (WWT)**

**Other Partners**

- **Convention on Biological Diversity (CBD)**
- **Convention to Combat Desertification (UNCCD)**,
- Convention on the Conservation of Migratory Species of Wild Animals
- **Convention on Migratory Species (CMS)**,
- World Heritage Convention (WHC) and

- ❖ **Convention on International Trade in Endangered Species**.
- ❖ Various groups that fund projects include **UN agencies such as UNEP**, **UNDP**, etc.

## Wetlands International

- **Wetlands International** is a global **non-governmental organisation** (**NGO**) that works to sustain and restore wetlands and their resources for people and biodiversity. Its work ranges from research, advocacy, and engagement with governments, corporate, etc.

**[UPSC 2014] With reference to a conservation organisation called 'Wetlands International', which of the following statements is/are correct?**

1) It is an intergovernmental organisation formed by the countries which are signatories to Ramsar Convention.
2) It works at the field level to develop and mobilise knowledge and use practical experience to advocate for better policies.

***Select the correct answer using the code given below.***

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

***Answer: Wetlands International is an NGO. b) 2 only***

## Ramsar Site

- When a country accedes to the convention, **it must designate at least one wetland** as a **Wetland of International Importance**. Including a "Ramsar Site" in the list embodies the **government's commitment** to take the steps necessary to ensure that its ecological character is maintained.
- Today, the Ramsar List is the world's largest protected area network. Over 2,400 Ramsar Sites cover 2.5 million sq km on the territories of **171 Ramsar Contracting Parties** worldwide.
- The world's first site was the **Cobourg Peninsula in Australia**, designated in 1974.
- The countries with the most Ramsar Sites are the United Kingdom with 175 and Mexico with **142**.
- Bolivia has the largest area under Ramsar protection.

## Deletion from the List

- A Contracting Party may, because of its urgent national interest, **delete or restrict** the boundaries of wetlands already included in the list. However, such deletions or restrictions **should be compensated** for by creating additional nature reserves in the same area or elsewhere. **No Ramsar Site has ever been "deleted" in this way**, and Parties have only extremely rarely restricted the boundaries of a Site on this basis (success of Ramsar Convention).

## Transboundary Ramsar Sites

- Many important wetlands extend as one ecologically coherent whole across national borders. In these cases, COP can agree to establish Ramsar Sites on their territory as parts of a bigger **Transboundary Ramsar Site**. The authorities on both sides of the border agree to collaborate in managing the site.

## The Montreux Record

- Ramsar Sites **potentially at risk** because of technological developments, pollution or other human interference may be placed on the **Montreux Record** of Ramsar Sites where **changes in ecological character have occurred**, **are occurring**, **or are likely to occur**.

**[UPSC 2014] If a wetland of international importance is brought under the 'Montreux Record', what does it imply?**

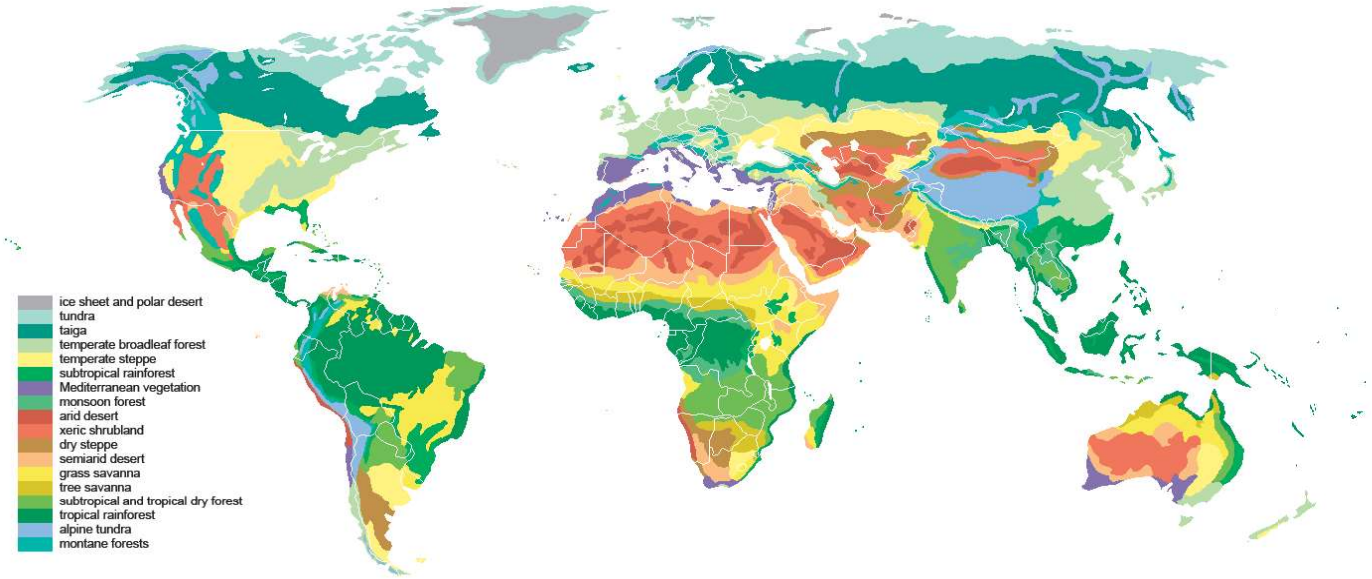
a) Changes in ecological character have occurred, are occurring or are likely to occur in the wetland because of human interference.
b) The country in which the wetland is located should enact a law to prohibit any human activity within five kilometres from the edge of the wetland
c) The survival of the wetland depends on the cultural practices and traditions of certain communities living in its vicinity, and therefore the cultural diversity therein should not be destroyed
d) It is given the status of 'World Heritage Site'

***Answer: a)***

***The list of Ramsar Sites is provided in the last chapter of the PMF IAS Indian Physical Geography Book.***

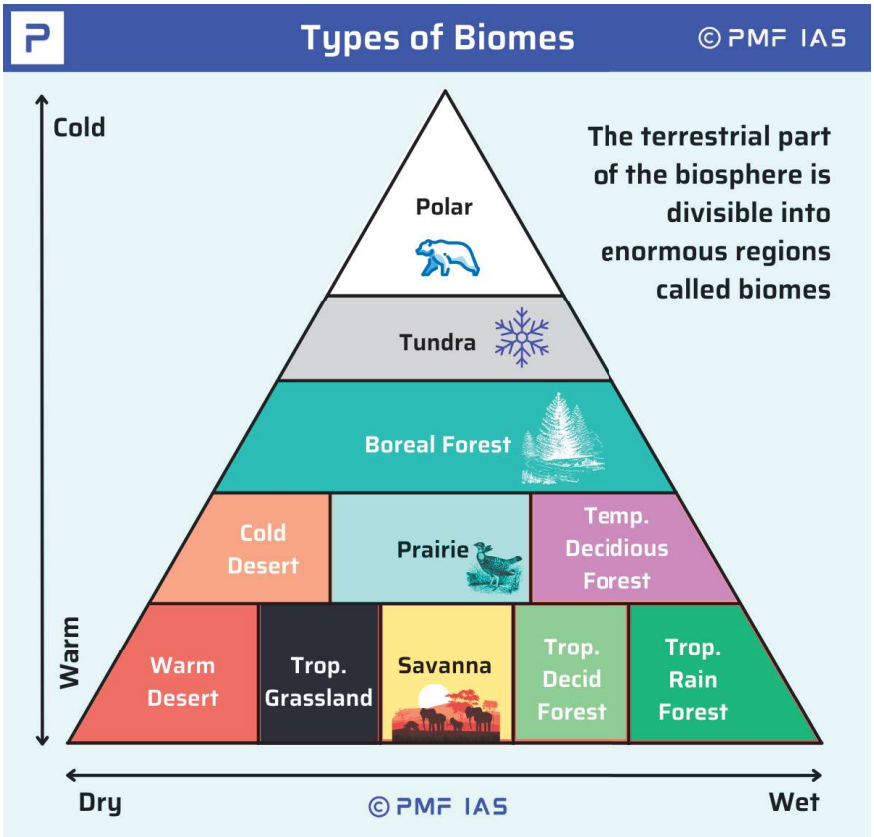
**---------- End of Chapter ----------**

# 7. Natural Ecosystems




- A natural ecosystem is an assemblage of plants and animals which functions as a unit and can maintain its identity. There are two main categories of ecosystems: 1) Terrestrial ecosystems and 2) Aquatic ecosystems.

## 7.1. Terrestrial Ecosystems or Biomes



- The terrestrial part of the biosphere is divisible into enormous regions called **biomes**. No two biomes are alike. They are characterised by a distinct climate (precipitation and temperature mainly), vegetation, animal life and general soil type.

## Major Biomes

***Tundra***

- Arctic and Alpine Tundra Biome

***Forest***

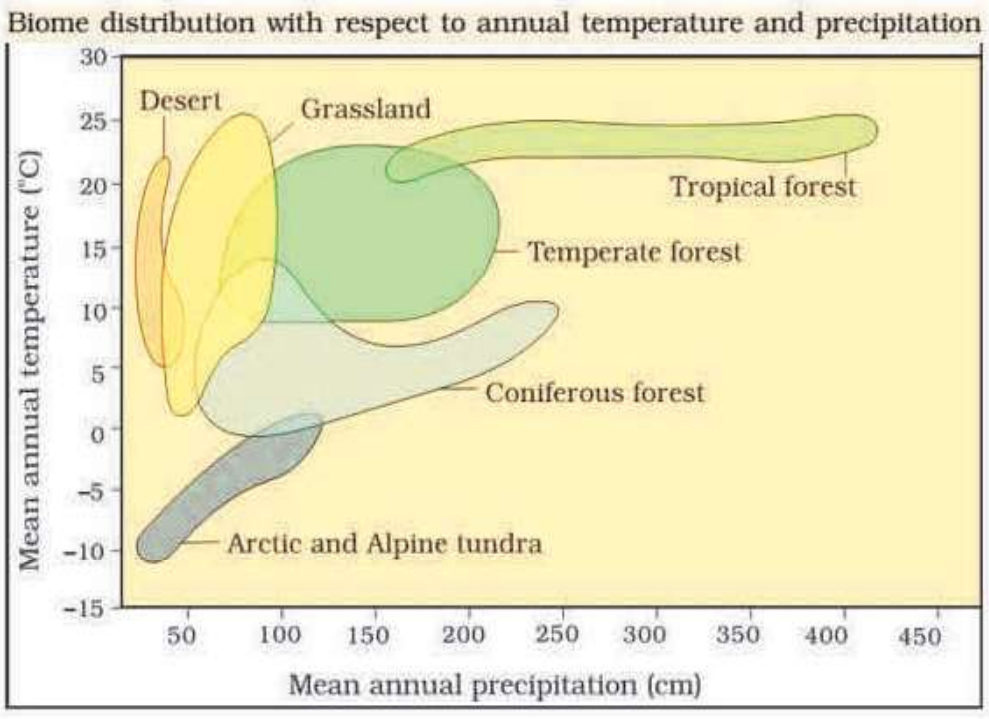
- Taiga or Boreal Biome (Evergreen Coniferous forests)
- Temperate Deciduous Biome (North-Western Europe – British Type Climate)
- Temperate Rainforest Biome
- Sub-Tropical Deciduous Biome in Eastern China, South Eastern USA
- Temperate Deciduous Biome (Mediterranean Climate)
- Tropical Deciduous Biome (Monsoon Climate)
- Savanna or Tropical Wet and Dry Biome
- Tropical Rain Forest Biome

***Grassland***

- Steppe or Temperate Grassland Biome
- Savanna or Tropical Wet and Dry Biome (Tropical Shrublands and Grasslands)

***Desert***

- Tropical and Mid Latitude Desert Biome



*For a detailed explanation* and *maps of biomes, you must go through* ***PMF IAS Physical Geography > Climatology > Climatic Regions***. *Here we have discussed the content only from the environment* and *ecology perspective*.

## Tundra Biome

- There are two types of tundra – arctic and alpine. Alpine tundra occurs at high mountains above the tree line. E.g., High ranges of the Himalayas, Andes, Alps etc.
- There are **no trees** in the tundra due to **permafrost** **(ground remains completely frozen — (0°C) or colder — for at least two years straight**). The lowest form of vegetation, like **mosses**, **lichens** are sparsely found on bare rocks. Coastal lowlands have **reindeer moss**, which provides the only pasture for reindeer. Arctic willow, a dwarf willow shrub, is adapted to survive in Arctic conditions, specifically tundras.

- In the summer, birds migrate north to prey on the numerous insects that emerge when the snow thaws. Insects have short life cycles, which are completed during the favourable period of the year. Animals like the reindeer, arctic fox, wolves, muskox, polar bear, lemming, arctic hare, etc. live in the tundra region. **Reptiles and amphibians are almost absent**.
- Most animals have a **long life**, e.g. arctic willow has a life span of 150 to 300 years. They are protected from chillness by **thick cuticle** and **epidermal hair or fur**. Mammals **have a large body size** and **small tails** and **ears** **to avoid heat loss from the surface**.

## Taiga or Boreal Biome

- The **productivity of boreal (Taiga) forests is the lowest** among the forest ecosystems. This is mainly because of the harsh weather and the thin and poor soils called **podzols**. Podzols are very poor because:
  - The **weathering of rocks proceeds slowly** in cold climates.
  - The litter derived from conifer leaves **decomposes very slowly**. It is not rich in nutrients (**humus content is low**, and the soils are **mostly acidic** due to the slow decomposition of organic matter).
  - **Conifers do not shed their leaves frequently**.
- The predominant vegetation is an **evergreen coniferous forest** with species such as **spruce**, **fir**, and **pine**. The conifers require little moisture and are best suited to the sub-Arctic climate. Animals found in this region include Siberian tiger, wolverine, lynx, wolf, bear, red fox, squirrel, and amphibians like Hyla, Rana, etc.

### Podzols

- **Podzols** are the typical soils of a **coniferous or boreal biome**. The top layer of the soil is **very thin** and is overlain over a sandy or loamy subsurface, which has **no organic matter** (**lost due to the leaching of nutrients** to the bottom layers). The soils are characterised by **low moisture levels (excessively drained)**. Others have shallow rooting zones and poor drainage due to subsoil cementation.
- A low pH further compounds the issue. The **low pH (acidic)** is due to **excessive leaching (loss) of alkaline (basic)** matter, which, if present, would neutralise the **organic acids of the accumulating litter**. Hence, most Podzols are **poor soils for agriculture**. They are primarily used for grazing.

## Temperate Deciduous Biome (North-Western Europe – British Type Climate)

- Soils of the temperate deciduous biome are **podzolic** and fairly deep. The natural vegetation is **deciduous** (**trees shed their leaves in the cold season**). This is an **adaptation** for protecting themselves against winter snow and frost. Shedding begins in autumn, the 'fall' season. Growth begins in spring. Some common species include **oak**, **elm**, **ash**, **birch**, **beech**, and **poplar**.

## Temperate Rainforest Biome

- Temperate rainforest biome is small in terms of the area covered. The main stretch of this habitat is along the **north-western coast of North America** from northern California through southern Alaska. There are also small areas in **southern Chile**, **New Zealand**, **Australia** and a few other places worldwide.
- **Large coniferous trees** dominate the habitat, including **Douglas fir**, **Western red cedar**, **Mountain hemlock**, **Western hemlock**, Sitka spruce and Lodgepole pine. In addition to the trees, **mosses and lichens** are very common, often growing as **epiphytes** (a plant that grows **harmlessly (commensalism)** upon another plant).

## Sub-Tropical Deciduous Biome in Eastern China, South-eastern USA

- Sub-tropical deciduous biome supports luxuriant vegetation. The lowlands carry both evergreen broad-leaved forests and deciduous trees (hardwood). On the highlands, various species of conifers, such as pines and cypresses, are important. **Perennial plant growth** is not checked by either a dry season or a cold season.

## Steppe or Temperate Grassland Biome

- Steppe biomes are practically **treeless**, and the **grasses are much shorter**, **fresh**, **and nutritious**. Poleward, an increase in precipitation gives rise to a transitional zone of wooded steppes where some conifers gradually appear. The steppes **do not have much animal diversity**.

## Temperate Deciduous Biome (Mediterranean)

- In temperate deciduous biomes, plants continuously struggle against heat, dry air, excessive evaporation, and **prolonged droughts**. They are, in short **xerophytic (drought tolerant)**. Trees with small broad leaves are widely spaced and **never very tall**. Regions with adequate rainfall are inhabited by low, broad-leafed evergreen trees (mostly **evergreen oaks**). **Fire is an important hazardous factor** in this ecosystem, and the adaptation of the plants enables them to regenerate quickly after being burnt.

## Tropical Deciduous Biome (Monsoon Climate)

- Tropical monsoon forests are also known as drought-deciduous/dry deciduous/tropical deciduous forests. **Teak**, **neem**, **bamboos**, **sal**, **shisham**, **sandalwood**, **khair**, **mulberry** are some important species.

## Savanna or Tropical Wet and Dry Biome

- The savanna landscape is typified by **tall grass and short trees**. The trees are deciduous, **shedding their leaves** in the **cool dry season** to prevent water loss through **transpiration**, e.g., **acacias**. Trees usually have **broad trunks** with **water-storing devices** to survive through prolonged droughts. Many trees are **umbrella-shaped**, exposing only a narrow edge to the strong winds. The savanna biome is **rich in mammal**, **bird**, **and reptile diversity**.

### Managed Fires Rejuvenates Savannas

- Lighting dry savanna grasslands is a key **ecosystem management** activity. Cattle farmers and authorities usually light fires to **stimulate the growth of fresh**, **nutritious grass** for their animals. Others are used **to control the numbers of parasitic ticks** or **manage the growth of thorny scrub**.

⇨ ***Fires in savannahs are carbon-neutral****: Fires in the savannah burn mainly dry grasses that regrow each year: the $CO_2$ released by fires is reabsorbed by the growth of new grass the next year.*

## Tropical Rainforest Biome

- High temperatures and abundant rainfall support luxuriant evergreen rainforests. The vegetation comprises many evergreen trees, e.g. **mahogany**, **ebony**, **dyewoods**, etc. In brackish waters, mangrove forests thrive. All plants, including **epiphytes**, struggle upwards for sunlight resulting in a peculiar layer arrangement (canopy).

⇨ ***Epiphyte (commensalism – epiphyte benefits without troubling the host)****: An epiphyte is a plant that grows harmlessly upon another plant (such as a tree) and derives its moisture and nutrients from the air, rain, and sometimes from debris accumulating around it.*

- In the recent few years, the rainforest has been under threat from deforestation and burning. **17 per cent of the entire rainforest** and about **20 per cent of the Brazilian rainforest** has been deforested.

## Importance of Rainforests

- ✓ Rainforests produce about **20% of the earth's oxygen**.
- ✓ **Carbon sink:** Rainforests can sequester much carbon released by human activities.
- ✓ **Precipitation:** Through evapotranspiration, the rainforests are responsible for creating 50-75 per cent of their precipitation.
- ✓ **Source of many rivers:** Rainforests are the source of many of the world's largest rivers. **Amazon**, **Mekong**, and **Congo (Zaire)** are some important rivers fed by the rainforests.
- ✓ **Biodiversity:** Rainforests contain over **30 million species of plants and animals**. That's half of the earth's wildlife and at least two-thirds of its plant species!
- ✓ **Commercial Agriculture:** Rainforests offer a conducive climate for cultivating commercial crops such as **coffee**, **cocoa (chocolate)**, **palm**, **rubber**, etc. (they all require 100-200 cm of rainfall).
- ✓ Indigenous communities: Many indigenous people have been living in harmony with the rainforest for thousands of years, depending on it for their food, shelter, medicines and subsistence agriculture (slash-and-burn agriculture).

### Climate

- ✓ Tropical forests exchange vast amounts of water and energy with the atmosphere and are thought to be important in controlling local and regional climates. Water released into oceans by the rainforest rivers **influences the circulation of ocean currents**. This works as a **feedback mechanism**, as the process also sustains the regional climate on which it depends.

### Importance of the Amazon Rainforest

- ✓ The Amazon basin produces about 20 per cent of the world's flow of fresh water into the oceans. It returns at least 75 per cent of the moisture to the westward-moving air mass. In fact, every country in South America other than **Chile (blocked from this moisture by the Andes)** benefits from Amazon moisture.

## Threats: Frequent Fires in the Amazon Rainforest

### Prolonged droughts due to climate change

- ➢ Amazonian forests and other tropical rainforest regions are **usually immune to fires** due to the **high moisture** content of the undergrowth beneath the protection of the **canopy tree cover**. But the **severe mega-droughts** in recent times have forever changed this perception.
- ➢ The severe **mega-droughts** in the Amazon were most likely driven by large-scale climatic events, with the **warming of the Atlantic** and the **drying effects** of **El Niño Southern Oscillation (ENSO)** events. These droughts are becoming far more frequent and more severe and are generating conditions conducive to wildfires.

### Slash and burn agricultural practice

- People clear the land by cutting down the vegetation during the rainy season, letting the trees dry out and burning them during the dry season. Clearing the forest for agricultural use can take several years of slashing and burning.

### Political Discourse and Land grabbers

- Ex-President of Brazil, Jair Bolsonaro, has decreased the power and autonomy of forest protection agencies. Forest clearing has been encouraged by agricultural subsidies, timber concessions, etc. This has been the case in rainforests worldwide. Hence, most fires are set illegally by landgrabbers who are clearing the forest for **lumbering**, **cattle ranching**, **rubber**, **palm** and **soybean cultivation**.

## How do the fires in the Amazon affect the world?

### Carbon sink to carbon source and global warming

- The Amazon is a **critical carbon sink**. Currently, the world is emitting around **40 billion tons of $CO_2$** into the atmosphere every year. **The Amazon absorbs 2 billion tons of $CO_2$ annually (or 5% of annual emissions)**. The fires have not only turned the Amazon into a **temporary carbon source** but also **reduced its potential to lock carbon in the future**.

### Forest fires intensify droughts

- The rainforest recycles its water to produce a portion of the region's rain, so deforestation and forest fires make rains less frequent, extending the dry season.

### Pollution and Global Warming

- Forest fires cause **15% of GHG emissions**, **more than 30% of global carbon monoxide emissions**, **10% of methane emissions** and more than **85% of global soot emissions**. They contribute greatly to global warming, making forests increasingly dry and weak. This destructive cycle often makes it easy for new fires to develop.

### Forest Fires and Droughts Make Way for Grasslands (Decrease in Productivity)

- Scientists describe tropical rainforests as **fire-sensitive ecosystems**. About a third of all ecosystems worldwide are considered **fire-sensitive**. Plants and animals **lack a natural ability to resist** and **recover from fires**.
- In a rainforest like the Amazon, massive forest fires are a disaster. Despite the lush vegetation, the **soils are particularly barren and poor in nutrients (due to leaching)**. If the rainforest burns down, **all nutrients are permanently lost (no recycling of nutrients) because they are stored in the plants themselves and not in the soil**.
- When the rainforests reach their tipping point, they will be unable to sustain themselves. This will lead to a situation when the trees, and in turn, the forest will start to **dieback**. In other words, some trees and, eventually, the forests will reach the physiological limits of dryness. Because of the dehydration, the trees will begin to **die from the tip of their leaves or roots backwards**.

➢ The fires combined with prolonged droughts can turn the jungle into a tropical savannah (grassland). **Grasses** are a **dominant species** that **can grow even in poorer soil**. **They do not make way for trees so easily**.

### Forefires are essential for other Ecosystems

- While forest fires are a disaster to rainforests, they are **necessary** for the **preservation** of other ecosystems. This is true for about three-quarters of all habitats worldwide, including the
  - ✓ **taiga (extremely fire-prone in the dry season)**,
  - ✓ **African savannahs**, the **South Asian monsoon forests**,
  - ✓ **Californian coniferous forests (extremely fire-prone in the dry season)**,
  - ✓ **Australian eucalyptus forests** and the **Mediterranean region (extremely fire-prone in the dry season)**.
- In these ecosystems, parts of the natural fauna and flora develop only due to fires. Animals and plants often have a natural capacity for resistance in such fire-dependent ecosystems. In **grasslands**, **savannahs**, some forests, and wetlands, only a **moderately intense ground fire sweeps through**, ensuring that the open landscape structure is maintained.

#### Fires give new life

- ❖ The **Douglas fir**, a conifer, survives most fires thanks to its thick bark — after a fire, it will sprout new shoots.
- ❖ The **North American lodgepole pine** also needs the heat of the fire to open its cones and release seeds.
- ❖ The Australian grass tree needs smoke to open its seed pods.
- ❖ After a fire, without the usually dense canopy, more sunlight reaches the forest floor, and the seedlings find enough nutrients to sprout. (**Small fires are good even for rainforests**).

### Catastrophic Forest Fires

- **Rare but very intense fires** are characteristic of **bush landscapes or forests**. They consume old and diseased trees, create new habitats, and ensure an **ecological rejuvenation** of the tree population. **Preventing small fires in these ecosystems can have fatal consequences**. This is because of the accumulation of more combustible material, which converts even harmless fires into destructive walls of flames. Such fires repeatedly occur in the **boreal forests (Siberian taiga** and **Canadian taiga)**, **forests of Eastern Australia** and **California (US)**.
- Recent examples: **2019-20 Australian Black Summer Bushfires** (caused by successive droughts) and **2021 July wildfires triggered by severe heatwave** (caused by a **heat dome created by the meandering jet stream**) in the **North-Western US and South-Western Canada**.

## Threats: Plantation Boom, Resource Extraction

➢ Petroleum extraction has caused a great deal of destruction in the rainforests of **Ecuador** and **Venezuela**.

- The rainforest climate is very favourable for the cultivation of certain high-value plantation crops. The plantations destroyed nearly half of the equatorial forests and continue to destroy them even today.

| Plantations | Region(s) |
|---|---|
| **Palm** | **Malaysia**, **Indonesia** |
| **Sugarcane** | **Brazil** |
| **Coffee** | **Brazil** |
| **Rubber** | **Malaysia**, **Indonesia** |
| **Cocoa** (**used to make chocolates**) | **Ghana**, **Nigeria** |

## Effects of Destroying Rainforests

### Soil Degradation

- The **soil in the rainforest is very poor in nutrients** (because of the **leaching of the nutrients** from the top layer). This is because the **nutrients are stored in the vast numbers of trees and plants rather than in the soil**.
- Tree roots bind the soil together, while the **canopy protects the soil from heavy rains**. When a tree dies, and its trunk falls to the forest floor, it decays, and the nutrients it contains are recycled. However, if trees are removed from the forest, the nutrients are removed with it. The **unprotected soil is then washed away in heavy rains**.

### Droughts and famine

- Without rainforests continually recycling huge quantities of water, feeding the rivers, lakes and irrigation systems, droughts would become more common, potentially leading to widespread famine and disease.

### Commercial plantation crops would fail in the long run

- The plantation crops thrive in the tropics because of the **conducive climatic conditions** created by the rainforests.

### Extinction of indigenous communities

- When oil and logging companies come to remove vast areas of forest, they bring **diseases** that the indigenous people have no resistance to, threatening their survival. Often, they are also forced to move away from their homes to unfamiliar places, sometimes even killed in the process.

**[UPSC 2013] Which of the following is/are unique characteristic/characteristics of equatorial forests?**

1) Presence of tall, closely set trees with crowns forming a continuous canopy.
2) Coexistence of a large number of species
3) Presence of numerous varieties of epiphytes

***Select the correct answer using the code given below:***

a) 1 only
b) 2 and 3 only

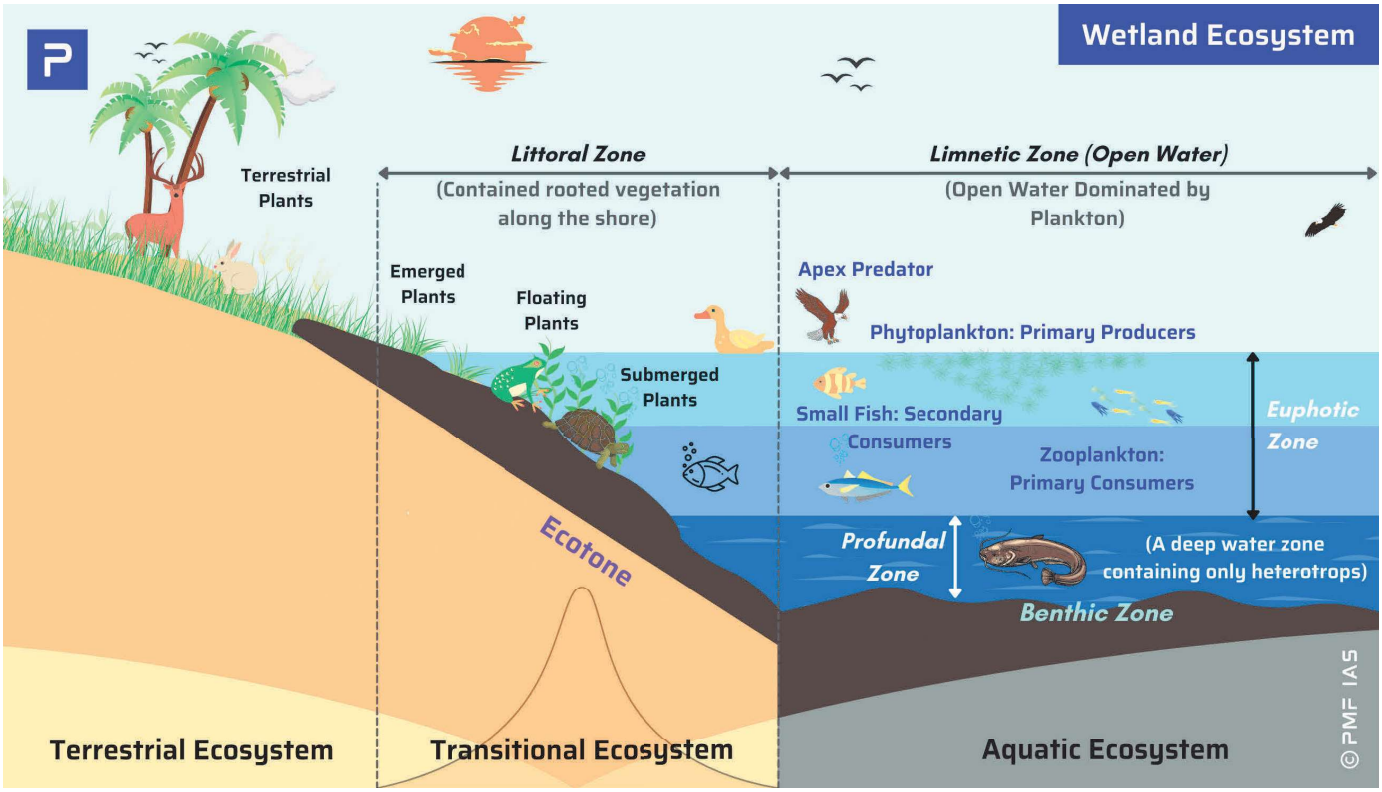
c) 1 and 3 only
d) 1, 2 and 3

***Answer: every single statement is correct***

## Desert Biome

- The predominant vegetation of both hot and mid-latitude deserts is **xerophytic or drought-resistant**. This includes the cacti, thorny bushes, long-rooted wiry grasses, and scattered dwarf acacias. The seeds of many grasses and herbs have **thick**, **tough skins** to protect them while they lie dormant.
- Most desert shrubs have **long roots and are well spaced out** to gather moisture and search for ground-water. Plants have **few or no leaves**, **and the foliage is either waxy**, **leathery**, **hairy**, **or needle-shaped to reduce water loss through transpiration**.

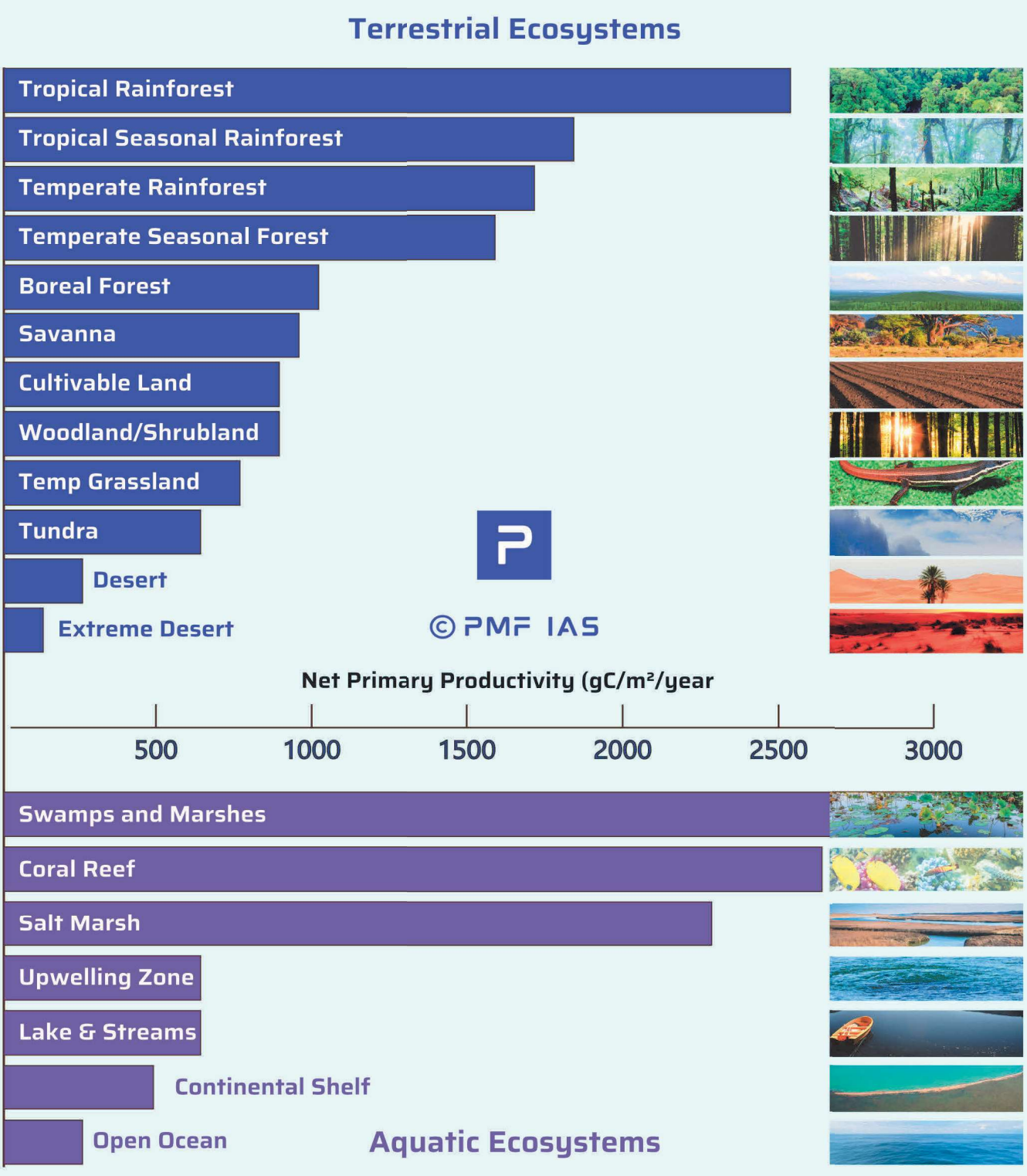
# 7.2. Aquatic Ecosystems




- Aquatic ecosystems refer to plant and animal communities occurring in water bodies. They are classified into two subgroups: 1) **Freshwater ecosystems**, such as rivers, lakes, and ponds; 2) **Marine ecosystems**, such as oceans, estuaries, and mangroves. They are classified based on salinity into the following types:
  1. **Freshwater ecosystems:** water on land that is continuously cycling and has low salt content (**always less than 5 ppt**) is known as freshwater. There are two types of freshwater ecosystems: 1) **Static/still water (Lentic) ecosystems**, e.g. ponds, lakes, bogs and swamps. 2) **Running water (Lotic) ecosystems**, e.g. springs, streams, rivers, etc.

2. **Marine ecosystems:** the water bodies containing salt concentration equal to or above that of seawater (i.e., **35 ppt or above**). E.g., shallow seas and open oceans.
3. **Brackish water ecosystems:** these water bodies have salt content between **5 to 35 ppt**. e.g., **estuaries**, **salt marshes**, **mangrove swamps** and **mangrove forests**.

## Net Primary Productivity of Terrestrial and Aquatic Ecosystems



## Aquatic Organisms

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

## Factors Limiting the Productivity

### Sunlight

- The depth to which light penetrates a water body determines the extent of plant distribution. Suspended particulate matters such as clay, silt, phytoplankton, etc., make the water turbid. **Turbidity** limits the extent of light penetration and photosynthetic activity in a significant way. Based on light penetration and plant distribution, layers of water are classified as **photic** and **aphotic zones**.

#### Photic zone

- **Photic (euphotic) zone** is the portion that extends from the water surface down to where the light level is **1%** of that at the surface. **Photosynthetic** activity is confined to the **photic zone**.

#### Aphotic zone

- The lower layers of the aquatic ecosystems, where light penetration and plant growth are restricted, form the **aphotic (profundal) zone**. It extends from the end of the photic zones to the bottom of the lake. There is **no photosynthesis** in this zone.
- Dissolved oxygenIn freshwater, the average concentration of dissolved oxygen is **10 parts per million by weight**. This is **150 times lower** than the concentration of oxygen in an equivalent volume of air. Oxygen enters the aquatic ecosystem through the **air-water interface** and the **photosynthetic activities** of aquatic plants. Dissolved oxygen escapes the water body through the **air-water interface**, **respiration**, and **decomposition** of organisms (fish, decomposers, zooplankton, etc.)

#### Winterkill

- An ice layer on the top of a water body can effectively cut off the light. Photosynthesis stops, but **respiration continues** in such a water body. If the water body is shallow, the dissolved oxygen gets depleted, and the fish die. This condition is known as **winterkill**.

#### Impact of Global Warming on Dissolved Oxygen

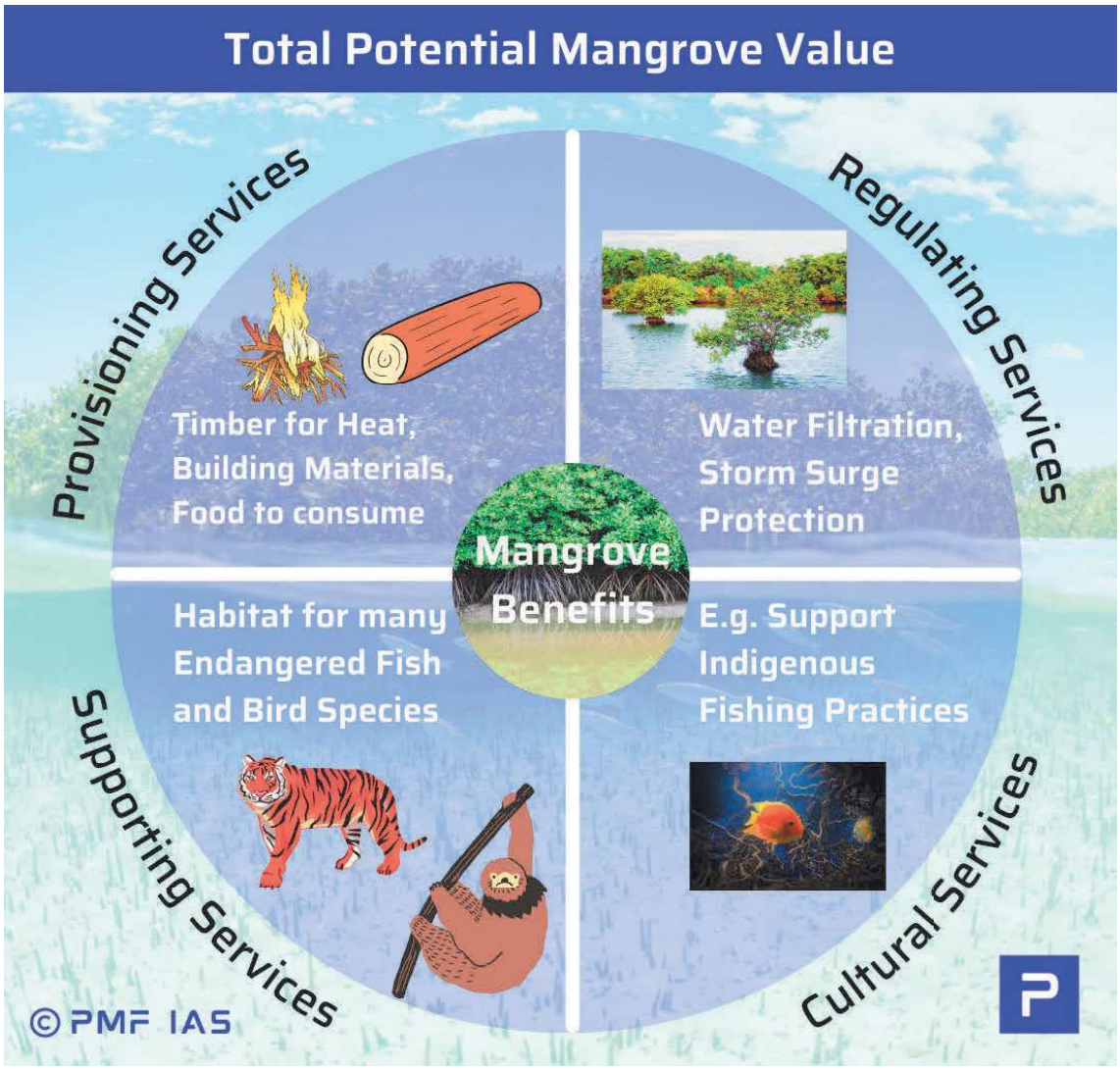
- The amount of dissolved oxygen retained in water is also influenced by **temperature**. **Oxygen is less soluble in warm water**. Warm water also **enhances decomposer activity**. Therefore, a **temperature increase in a water body (due to global warming) increases the rate at which oxygen is depleted**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

### Temperature

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

## 7.3. Natural Ecosystem Services and Goods

- **Ecosystem services** are the diverse benefits provided to humans by the natural environment and from healthy ecosystems. **Ecosystem goods** refer to the natural products harvested by humans from the environment, such as wild fruit and nuts, forage, timber, game, natural fibres, medicines and so on.



- The ecosystem services can be grouped under the following broad categories:
  - ✓ **Cultural:** tourism, recreation, etc.
  - ✓ **Provisioning:** food, drinking water, genetic resources, medicinal herbs, energy from biomass, etc.
  - ✓ **Economic:** crops, raw materials, etc.
  - ✓ **Regulating:** carbon sequestration, decomposition, detoxification, healthy biodiversity, climate stabilisation, reducing the risk of extreme weather events, etc.
  - ✓ **Ecological:** nutrient cycling, breakdown of pollutants, flood protection, generation and renewal of soils, etc.)

## Quantifying the Economic Value of Natural Ecosystems (Ecosystem valuation)

- **Ecosystem valuation** is an economic process assigning **monetary value** to an ecosystem and its **ecosystem services**. Quantifying the economic value of natural ecosystems provides a tool for policymakers to evaluate management impacts and compare a **cost-benefit analysis** of potential policies.
- For example, before replacing a forest with industry, considering the human welfare benefits of a forest — reducing flooding and erosion while sequestering carbon, providing habitat for endangered species, and absorbing harmful chemicals — will help policymakers make a better cost-benefit analysis and a better final decision.

## The Economics of Ecosystems and Biodiversity (TEEB)

- **TEEB** was a study hosted by the **United Nations Environment Programme** (**UNEP**) and led by Indian environmental economist **Pavan Sukhdev**. The study's objectives were to establish a global standard for **natural capital** accounting, mainstream the **values of biodiversity** and **ecosystem services** into **decision-making** at all levels and highlight the **growing cost of biodiversity loss**.

⇨ ***Natural Capital*** ➔ *ecosystems providing invaluable ecosystem services. E.g., Flood protection by mangroves.*

**[UPSC 2016] With reference to an initiative called 'The Economics of Ecosystems and Biodiversity (TEEB)', which of the following statements is/are correct? (2016)**

1) It is an initiative hosted by UNEP, IMF and World Economic Forum.
2) It is a global initiative that focuses on drawing attention to the economic benefits of biodiversity.
3) It presents an approach that can help decision-makers recognise, demonstrate and capture the value of ecosystems and biodiversity.

***Select the correct answer using the code given below.***

a) 1 and 2 only
b) 3 only
c) 2 and 3 only
d) 1, 2 and 3

***Answer: Statement 1) is false; d) 2 and 3 only***

### Tyler Prize for Environmental Achievement

- The **Tyler Prize** is an **annual award** administered by the **University of Southern California** for environmental science, environmental health, and energy. The **2020 Tyler Prize for Environmental Achievement** was awarded to **Pavan Sukhdev** in recognition of his work on the first report of **TEEB** published in 2008.

## Payment for Ecosystem Services (PES)

- The Himalayan states have been demanding a **green bonus** for keeping critical ecosystems intact. These states have been getting incentives based on their **forest cover** under a formula by the **Finance Commission**. This sort of incentive, called **payment for ecosystems services** (**PES**), is an **emerging global demand to conserve ecosystems**.
- The 13th FC allocated Rs. 5,000 crore to states based on the **area under forest cover** and **canopy density**. The 14th FC (2015-20) included **forest cover** as a determining factor in a state's share. In distributing funds to states, FC attached only a **7.5% weight to forest cover**. Population, demographic change, and area are the other factors that decide the share in the tax pool. Hence the Himalayan states have not been a clear winner under this arrangement.

### Ecological services offered by the Himalayan States

- ✓ Himalayan states have a forest in around **41.5 per cent** of their geographical area — **a third of the country's forest cover**, according to the **National Mission for Sustaining Himalayan Ecosystems** (**NAPCC**).
- ✓ The total value of forest ecosystem services flowing from the Indian Himalayas is Rs 94,300 crore per year.
- ✓ Himalayas are one of India's major **carbon sink**. Estimates of the **forest carbon pool** in the Indian Himalayas is about **5.4 billion tonnes** (forest biomass + forest soil).
- ✓ Himalayas forests avert soil erosion from the world's youngest mountain range.
- ✓ Annually, 1,200 billion cubic metres of water flow through the Himalayan rivers.

### Global scenario

- Globally, the services an ecosystem provides are getting increasing policy attention. In 2010, the Conference of Parties to the **Convention on Biological Diversity held in Nagoya** accepted **environmental goods as part of the national accounts** (monetary value of ecological services).

#### Amazon Fund

- There is a **billion-dollar Amazon Fund** backed by **Norway** (a petroleum exporter) and **Germany** to save the Amazon forests. It is a **REDD+ mechanism** created to raise donations for efforts to prevent, monitor & combat deforestation & promote sustainable use in the Brazilian Amazon.
- The **Brazilian Development Bank** manages the Amazon Fund. The Brazilian government wants to alter the governance model for the Amazon fund and wants to exploit forest resources and use forest land for economic development. Norway and Germany are against such a decision.

### Gross Environment Product (GEP) and Green GDP

- Gross Environment Product (GEP) is an assessment system that **measures ecosystem services** of any area in terms of biophysical value and monetary value. It is one of the components of **Green GDP**.
- **Green Gross Domestic Product (GGDP)** is an index of economic growth with the **environmental consequences of that growth factored** into a country's conventional GDP. It **monetises the loss** of biodiversity and accounts for costs caused by climate change.
- In **Bhutan**, culture, society, economy, and environment are linked in the development framework of **Gross National Happiness (GNH)**. The **Uttarakhand** government recently announced it will initiate the valuation of its natural resources as **Gross Environment Product (GEP)**.

⇨ ***Green GDP = GDP – Net natural capital consumption*** *(resource depletion + environmental degradation* and *protective and restorative environmental initiatives)*.

## Ecosystem Services by Seagrass

- Seagrass (**not** grass, as the name suggests) are **aquatic flowering plants** (**angiosperms**). They are found in **shallow salty** and **brackish waters** in many parts of the world, from the **tropics to the Arctic Circle**. The depth at which seagrass is found is limited by **turbidity**.
- Seagrasses occur all along with the **coast of India**. They are abundant in the **Palk Strait** and **Gulf of Mannar**.

### Importance of Seagrass

✓ Seagrass are considered **ecosystem engineers** (alter the ecosystem around them and adapt rapidly to changing environmental conditions). **Dugong or Sea Cow** (**VU**) is a **herbivorous marine mammal** that relies on seagrass for food.

✓ Seagrass can **store $CO_2$** using their own biomass as well as by filtering out fine organic material in water. An acre of seagrass can store about **three times** as much carbon as an acre of **rainforest**. Globally, seagrass meadows are responsible for more than **10% of carbon buried in the ocean**, even though they occupy just **0.2%** of the area.

✓ Seagrass **produces oxygen** and are **highly productive** and support a high diversity of organisms. The habitats act as **nursery grounds** for commercially and recreationally (tourism) valued fishery species.

✓ They dissipate wave energy, thereby **protecting vulnerable shorelines from erosion**. Large meadows of seagrass can help protect seawalls by adequate damping of waves.

✓ They **enhance water quality** by stabilising heavy metals, pollutants, and excess nutrients. They can trap fine sediment on the seabed and **prevent harmful algal blooms** (**eutrophication**).

✓ Seagrasses are collected as **fertilisers for sandy soil**.

**[UPSC 2015] With reference to 'dugong', a mammal found in India, which of the following statements is/are correct?**

1. It is a herbivorous marine animal.
2. It is found along the entire coast of India.
3. It is given legal protection under Schedule I of the Wildlife (Protection) Act, 1972.

***Select the correct answer using the code given below.***

a) 1 and 2
b) 2 only
c) 1 and 3
d) 3 only

**Explanation**

- The **dugong** is a herbivorous mammal. It eats **seagrass** and **aquatic plants** found in shallow oceans (at depths, seagrass and aquatic plants don't grow due to the absence of sunlight). In India, its range is limited to the **south** (**Palk Strait** and **Gulf of Mannar**) and **west coast** (**Gulf of Kutch**). The depletion of seagrass resources on the east coast has made the dugong locally extinct.

***Wildlife (Protection) Act, 1972***

- Harming **endangered** (vulnerable, endangered, critically endangered) species listed in **Schedule 1** of the Act is **prohibited** throughout India.
- **Hunting** species, like those requiring special protection (Schedule II), big game (Schedule III), and small game (Schedule IV), is **regulated through licensing**.
- A few species classified as **vermin** (**Schedule V**) may be **hunted without restrictions**.

***Answer: c) 1 and 3***

### Threats faced by seagrass

- **Natural disturbances:** grazing, storms, and desiccation.
- **Human disturbance: eutrophication**, mechanical destruction of habitat, and overfishing.

**Eutrophication**

- Excessive input of nutrients (**nitrogen**, **phosphorus**) is directly toxic to seagrasses. They stimulate the growth of **epiphyti**c and **free-floating macro-** and **micro-algae**. **Macroalgae** (**nuisance species**) form thick, unattached mats or epiphytes over seagrass leaves. This **increases turbidity**, reducing photosynthesis in seagrass (autotrophs).
- **Benthic** (**bottom**) **macroalgae** have low carbon/nitrogen content, causing their **decomposition** to stimulate bacterial activity, leading to sediment resuspension and a further increase in water turbidity. Decaying seagrass leaves and algae fuels increase in **algal blooms** (**algae start dominating seagrass**). **Eutrophication** eventually leads to **anoxic** (**deficient in oxygen**) **conditions** for the seagrass and other organisms.

## Ecosystem Services by Seaweed

- **Seagrasses** are **vascular plants** and have roots, stems and leaves. In comparison, **seaweed** is the common name for species of **primitive non-flowering marine plants** (without roots, vascular system, stem, and leaves), **microalgae** and **macroalgae**. They **grow in shallow waters in the tidal zone** (intertidal region), estuaries and backwaters.


- Some seaweeds are microscopic, such as the **phytoplankton** that lives suspended in the water column. Some are enormous, like the **giant kelp** that grows in abundant forests from their roots at the bottom.

## Commercial Significance

- ✓ Seaweed is **full of vitamins**, **minerals**, **and fibre**. They contain **anti-inflammatory** and **anti-microbial** agents. Certain seaweeds possess powerful **cancer-fighting agents**.
- ✓ Seaweeds are effective **binding agents (emulsifiers)** and are used in commercial goods like **tooth-paste**, **fruit jelly**, **and ice cream** and as **softeners (emollients) in organic cosmetics and skin-care products**.

## Ecological Importance of Seaweed Cultivation

### Treating coastal pollution

- ✓ Seaweeds absorb the excess nutrients and **reduce algal blooms**. They trap excess levels of iron in the water by **using iron for photosynthesis**. Similarly, most **heavy metals** found in marine ecosystems are removed by seaweeds.

### Oxygen and Nutrient Supply

- ✓ Seaweeds supply oxygen and organic nutrients to other marine life forms. Large seaweeds form **dense underwater forests** known as **kelp forests** which act as **underwater nurseries** for fish and other marine life forms.

### Ocean Macroalgal Afforestation (OMA)

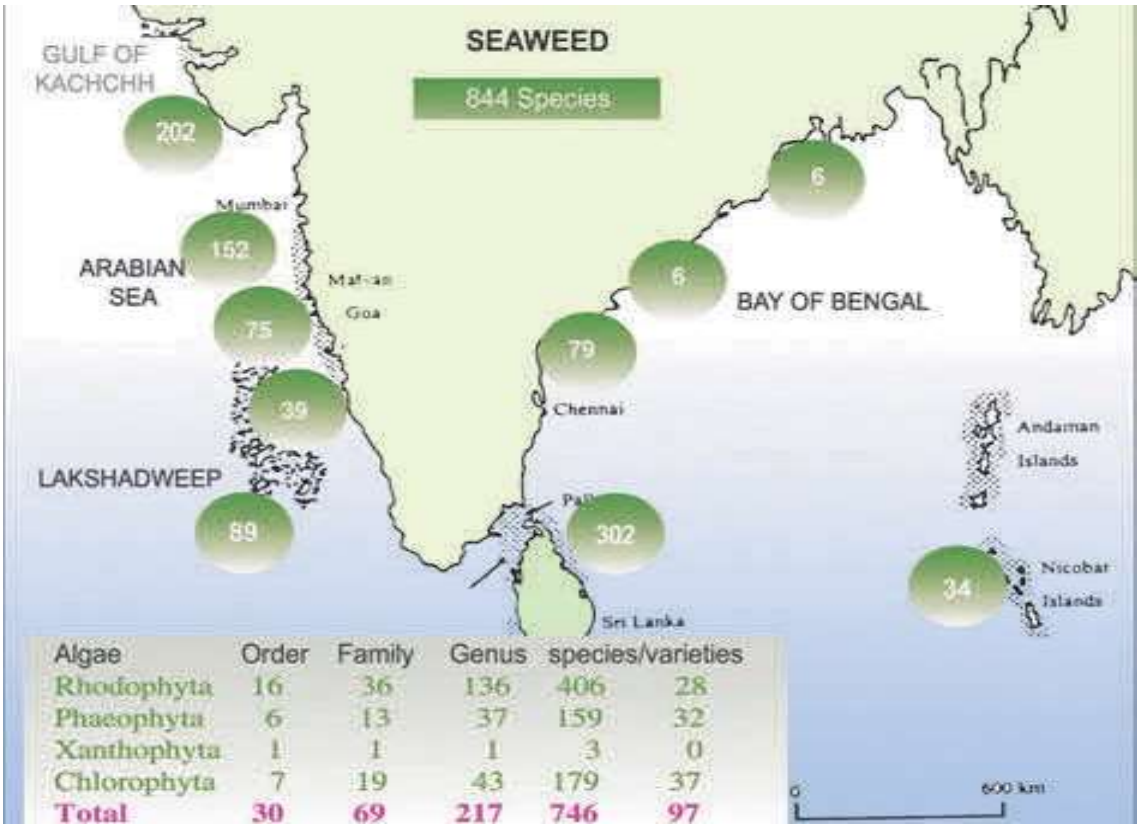
- ✓ Seaweeds exhibit **the highest photosynthesis efficiency** due to moist conditions. They contribute to about **50% of all photosynthesis**. Hence, seaweed farming is the ideal prospect for **Ocean Macroalgal Afforestation (OMA)**.
- ✓ **Ocean Afforestation** has the potential to reduce atmospheric carbon dioxide concentrations through expanding natural populations of **macroalgae (seaweed)**, **which absorb carbon dioxide**. Seaweed can then be harvested to produce **biomethane** via **anaerobic digestion**.

### Other Utilities

- ✓ They can be used as **fertilisers** in aquaculture.
- ✓ Methane emissions from cattle may be reduced substantially if seaweed is used as feed.
- ✓ Seaweed can be very helpful in combating beach erosion.

## Seaweed Cultivation: Potential in India

- **India** is among the **12 mega-biodiversity nations** in the world. It has an **Exclusive Economic Zone (EEZ) of 2.17 million km$^2$**. The Indian coastline, with its different coastal ecosystems, supports the luxuriant growth of **diverse seaweed** populations, having considerable economic importance.
- About 844 seaweed species are reported from India, which has a **coastline of 7,500 km**. On the **West Coast**, **especially in Gujarat**, abundant resources are present in the intertidal and subtidal regions. These resources have great potential for the development of **seaweed-based industries in India**.
- **Tamil Nadu (Gulf of Mannar and Pulicat)**, **Gujarat coasts**, **Lakshadweep**, **Andaman and Nicobar Islands** and **Lake Chilka** (Orissa) are abundant in seaweed. Rich seaweed beds are also found around Mumbai, **Ratnagiri**, Goa, Karwar, Varkala, Vizhinjam, and **Lake Chilka** (Orissa).




| Algae | Order | Family | Genus | species/varieties | |
|---|---|---|---|---|---|
| Rhodophyta | 16 | 36 | 136 | 406 | 28 |
| Phaeophyta | 6 | 13 | 37 | 159 | 32 |
| Xanthophyta | 1 | 1 | 1 | 3 | 0 |
| Chlorophyta | 7 | 19 | 43 | 179 | 37 |
| **Total** | **30** | **69** | **217** | **746** | **97** |

## Challenges to seaweed harvesting in India

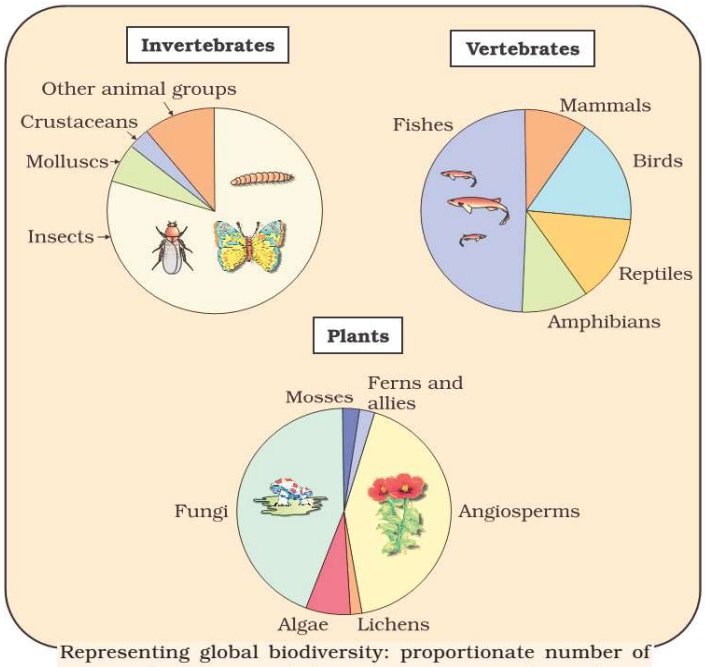
- Seaweed cultivation in India remains unpopular.
- Labour shortages occur during the paddy harvesting and transplanting season.
- Lack of livelihood security due to low wages and bad weather.
- Lack of technology to improve processed products.
- Lack of information on new and alternative sources of raw material.
- Risky as they must be collected from depths of more than 25 to 30 feet.
- Over-exploitation: While India has a rich source of seaweed varieties, we have **focused only on harvesting and not cultivation**, thus leading to over-exploitation.

- Less market demand: lack of awareness about health benefits acts as a hindrance to nutrition transition among the population.

**---------- End of Chapter ----------**

# 8. Biodiversity and Loss of Biodiversity

- Biodiversity refers to the **variety** of plant, animal, and microbial species plus all the genetic variations in the world or a particular habitat. The **Amazonian rainforest** has the most extraordinary biodiversity on earth.
- About **8.7 million** is the estimated total number of species on earth, with **6.5 million on land** and **2.2 million in oceans**. 86% of all species on land and 91% in the seas are yet to be discovered! A large proportion of the species waiting to be discovered are in the **tropics**.
- Only about **1.2 million** species have been formally described. More than **70 per cent** of all the species recorded are **animals**, while plants (including algae, fungi, bryophytes, gymnosperms, and angiosperms) comprise no more than 22 per cent of the total. Among animals, **insects** are the most species-rich taxonomic group, making up more than **70 per cent of the total**.



Representing global biodiversity: proportionate number of species of major taxa of plants, invertebrates and vertebrates

## 8.1. Terms Related to Biodiversity

### Biodiversity

- Definition by WHO: Biodiversity underpins all life on earth and refers to biological variety in all its forms, from the genetic makeup of plants and animals to cultural diversity. Biodiversity is measured by two major components: **species richness** and **species evenness**.

### Species Richness

- Species Richness measures the **number of species** found in a community. **Tropical rainforests** in the terrestrial ecosystem and **coral reefs** in the marine ecosystem have the highest degree of species richness.

### Species Evenness

- Species evenness is a measure of the **relative abundance of the different species** making up the richness of an area. **Low evenness** means a **few species dominate the site**. Example: A sample forest A has 2 tigers, 6 deer and 7 rabbits and sample forest B has 1 tiger, 6 deer and 8 rabbits. Both samples have the same richness (3 species) and the number of individuals (15). However, sample forest A has more evenness than sample forest B.

### Alpha, Beta and Gamma Diversity

- **Alpha Diversity:** It refers to the diversity within a particular area or ecosystem and is usually expressed by the number of species (i.e., **species richness**) in that ecosystem.
- **Beta Diversity:** It compares **diversity** (change in the number of species) **between ecosystems**.
- **Gamma Diversity:** It measures the overall **diversity of the different ecosystems** within a region.

## Genetic Diversity

- Genetic diversity is the **total number of genetic characteristics** in the **genetic makeup of a species**. A single species might show high diversity at the genetic level (E.g., *Homo sapiens*: Chinese, Indian, African etc.).
- Genetic diversity allows species to **adapt to changing environments**. It ensures that some species **survive drastic changes** and **carry on desirable genes**. Species that differ from one another in their **genetic makeup (not just the genetic characteristics) do not interbreed** in nature.
- Closely related species have in common many of their hereditary characteristics. For instance, about 98.4 per cent of the genes of humans and chimpanzees are the same.

## Species Diversity

- Species diversity is a measure of the diversity within an ecological community that incorporates **both species richness** and the **evenness of species**. It is the ratio of one species' population over the total number of organisms across all species in the given biome. '**0' would be infinite diversity**, and '**1' represents only one species present**. In general, **species diversity decreases as we move away from the equator towards the poles**, with a few exceptions.

## Ecological Diversity

- Ecological diversity refers to **different types of habitats**. India, for instance, with its deserts, rain forests, mangroves, coral reefs, wetlands, estuaries, and alpine meadows, has a greater ecosystem diversity than a Scandinavian country like Norway.

## Endemism

- **Endemism** is the ecological state of a **species unique to a defined geographic location**, such as an island, nation, country or other defined zone or habitat type. Organisms indigenous to a place are **not endemic if they are also found elsewhere**. A particular type of animal or plant may be endemic to a zone, a state, or a country. The opposite of endemism is **cosmopolitan distribution**.

# Types of Species

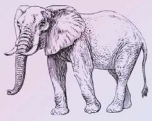
## Keystone Species

It is a species whose **addition to or loss** from an ecosystem leads to **major changes** in the **occurrence of at least one other species**.

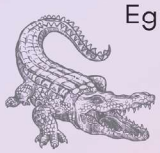
If keystone species is **lost**, it will result in the **degradation of the whole ecosystem.**

Considered more important in **determining the presence of many other species** in that ecosystem.





Eg: **Top Level Predators**



## Indicator Species

It is the one who's **presence or absence or abundance** reflects the environmental condition.

They serve as **early warning mechanism or signals** because they are **sensitive** to environmental conditions.

Also Known as **Sentinel Species.**

Eg: **Frogs, Lichens, Salmon**


## Endemic Species

They are **native to a single specific geographical location** such as an island, state, nation, country or other defined zone

A rare alternative term for a species that is endemic is '**precinctive**' (species that are restricted to a defined geographical area).

**Eg: Western Ghats -> Lion-tailed macaque**
**Eg: Western Ghats -> Nilgiri Tahr**
**Eg: Eastern Himalayas -> Red Panda**
**Eg: Eastern Ghats -> Flying Squirrel**
**Eg: Eastern Ghats -> Civet**




## Invasive Alien Species

An Exotic Species which is **introduced in an area (Intentionally or Unintentionally).**

Once introduced they **multiply so rapidly** that they destroy the local habitat of an area.

**Eg: Lantana, Fall Army Worm, Eucalyptus, Wattle, Prosopis Juliflora, Common Water Hyacinth**




## Flagship Species

It is a species chosen to **represent an environmental cause**, such as an ecosystem in need of conservation.

These species are chosen for their **vulnerability, attractiveness or distinctiveness** in order to engender support and acknowledgement from the public at large.

**Eg: Indian Tiger, African Elephant, Giant Panda of China, Kangaroo of Australia**

## Umbrella Species

The Species that are **selected for the conservation of an entire ecosystem** and forms an important part of National Parks and Wildlife Sanctuaries.

**Eg: Tigers** and **Giant Pandas** are an example of an umbrella species.

Efforts to save wild tigers in forests also accomplish the goal of saving other species there, such as leopards, boars, hares, antelopes, and monkeys.

## Foundational Species

Foundation species is a **dominant primary producer in an ecosystem** both in terms of abundance and influence.

**It is the species that creates or maintains an ecosystem.**

**Eg: Kelp in kelp forests**
**Eg: Corals in coral reefs.**



# Species Types

## Keystone species

- **Keystone species determine the survival of many other species** in an ecosystem. The addition or loss of a keystone species from an ecosystem leads to **significant changes in the occurrence of at least**

**one other species**. If a keystone species is lost, it will result in the **degradation of the whole ecosystem**. Hence **top predators** and other keystone species are given much consideration in conservation. **All top predators (Tiger**, **Lion**, **Crocodile)** and key species like **elephants**, **corals** and **pollinators** are considered **keystone species** because they **regulate all other animal populations** indirectly. For example, certain plant species (ebony tree, Indian laurel) exclusively depends upon **bats for their pollination**. If the bat population is reduced, then the regeneration of plants becomes more difficult.

### Bioprospecting

- **Bioprospecting** refers to **exploring biodiversity** for **commercially valuable genetic resources** and **biochemicals**. As an activity, it involves **deriving products of economic importance** by nations endowed with **rich biodiversity** by exploring their **molecular**, **genetic**, and **species diversity**.

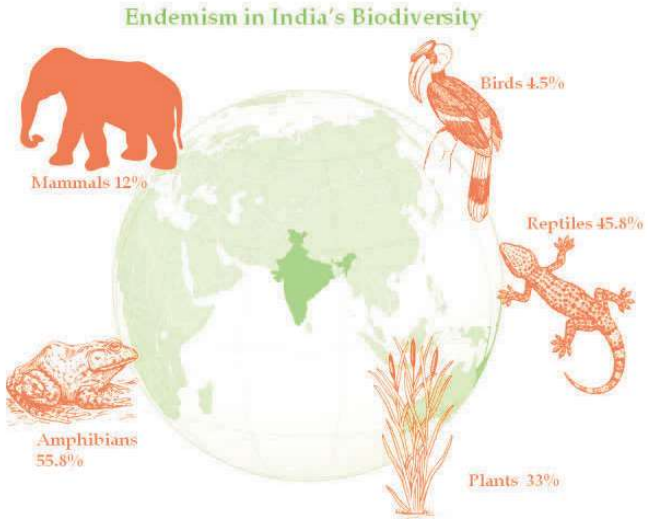
### Biopiracy

- **Biopiracy** occurs when **genetic resources** and **traditional knowledge** is **taken from biodiverse developing countries without permission**. In biopiracy, the **stolen traditional knowledge** is **used to benefit the non-indigenous people** through a product or patent with no compensation received by the indigenous people.
- Some in the west pass off **biopiracy** as **bioprospecting**. **Biopiracy of India's genetic resources and traditional knowledge** by advanced economies and large corporations is a significant concern. The **Nagoya Protocol** to the **Convention on Biological Diversity (CBD)** addresses the issues concerning the **fair and equitable sharing of benefits** from using **traditional knowledge** and **genetic resources**.

## 8.2. Biodiversity of India

- The **mega-diverse countries** are those whose ecosystems have **extraordinarily rich biodiversity** supporting the majority of the earth's species, including a **large number of endemic species**. Although they only account for around 10% of the earth's surface, they house at least 70% of the planet's terrestrial biological diversity.

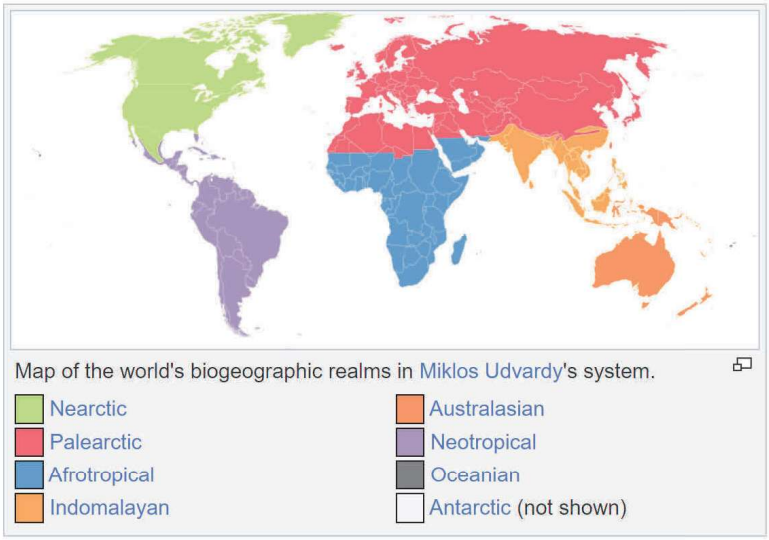
- The **World Conservation Monitoring Centre (WCMC)** of the **United Nations Environment Program (UNEP)** has identified a total of **17 mega-diverse countries: Australia**, **Brazil**, **China**, **Colombia**, **Ecuador**, **United States**, **Philippines**, **India**, **Indonesia**, **Madagascar**, **Malaysia**, **Mexico**, **Papua New Guinea**, **Peru**, **Democratic Republic of Congo**, **South Africa and Venezuela**.




- India is one of the **mega-diverse countries**, rich in biodiversity and associated traditional knowledge. It has **24.62% of its area under forest and tree cover**. With just **2.4% of the land area**, India accounts for nearly **7-8%** of the recorded species, even while supporting almost 18% of the human population.
- India represents two realms, five biomes, ten bio-geographic zones and twenty-five bio-geographic provinces with **91,000 species of animals** and **45,500 species of plants**. Of these 12.6% of mammals, 4.5% of birds, 45.8% of reptiles, 55.8% of amphibians and 33% of Indian plants are **endemic**.

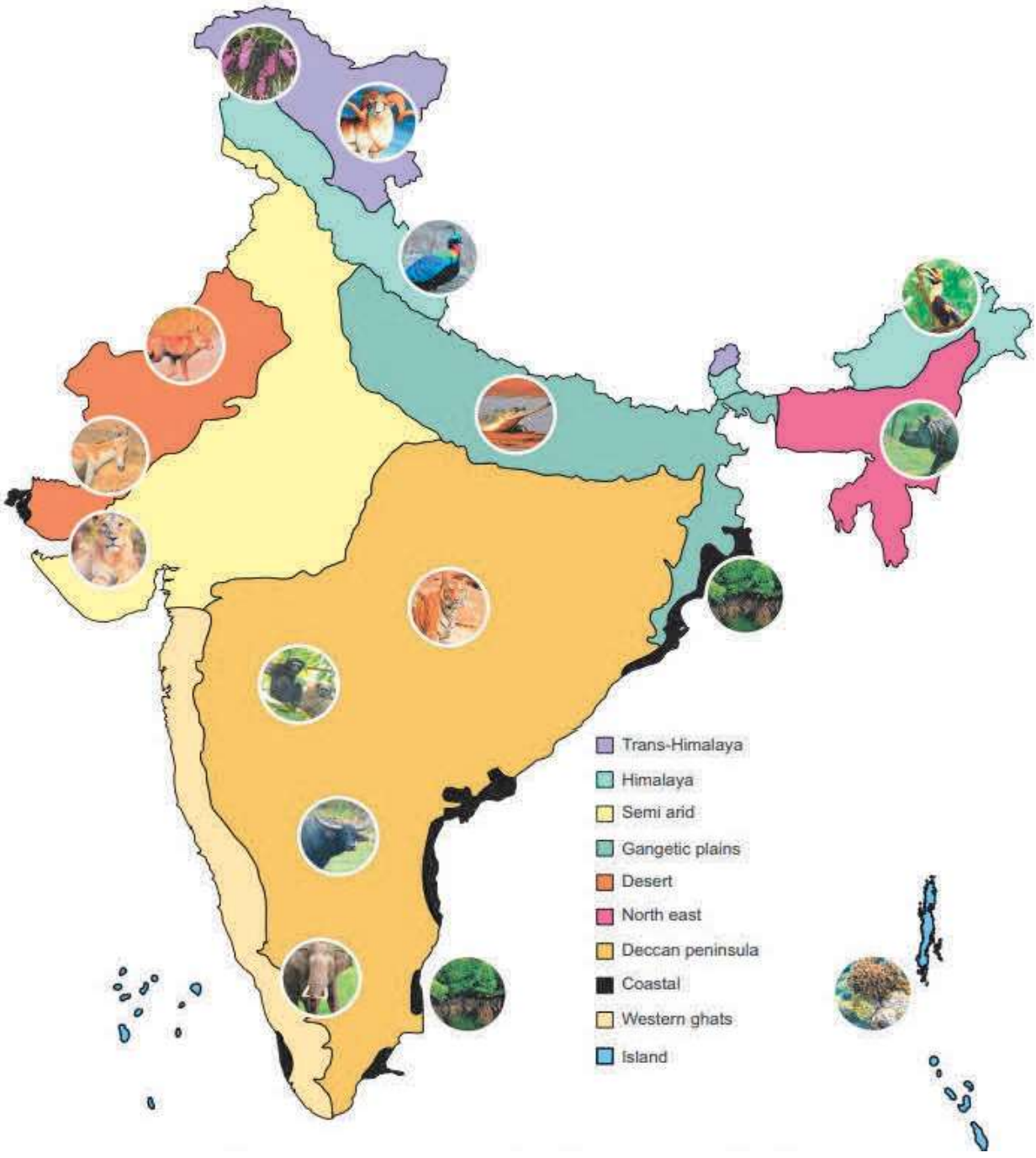
## Realms

- Biogeographic realms are **large spatial regions within which ecosystems share a broadly similar biota**. In the world, eight terrestrial biogeographic realms are typically recognised. The Indian region falls in two realms: 1) the Himalayan region represented by the Palearctic Realm, and 2) the rest of the sub-continent represented by the Malayan Realm.



## Biomes, Biogeographic Zones and Provinces

- The term biome means the main groups of plants and animals living in areas of specific climate patterns. It represents how animals, vegetation and soil interact together. The five biomes of India are:
  1. **Tropical Humid Forests**
  2. **Tropical Deciduous Forests (Monsoon Forests)**
  3. **Warm deserts and semi-deserts**
  4. **Coniferous forests**
  5. **Alpine meadows**



- Biogeography deals with the **geographical distribution of plants and animals**. The ten biogeographic zones were used as a **basis for planning wildlife-protected areas in India**. Bio-geographic Province is an ecosystemic or **biotic subdivision of realms**. India is divided into 25 biogeographic provinces.

| Biogeographic Zones (10) | Biogeographic Provinces (25) |
|---|---|
| Trans Himalaya | 1A: Himalaya – Ladakh Mountains<br>1B: Himalaya – Tibetan Plateau<br>1C: Trans – Himalaya Sikkim |
| The Himalaya | 2A: Himalaya – North West Himalaya<br>2B: Himalaya – West Himalaya<br>2C: Himalaya – Central Himalaya<br>2D: Himalaya – East Himalaya |
| The Indian Desert | 3A: Desert – Thar<br>3B: Desert – Kutch |
| The Semi-Arid | 4A: Semi-Arid – Punjab Plains<br>4B: Semi-Arid – Gujarat Rajputana |
| The Western Ghats | 5A: Western Ghats – Malabar Plains<br>5B: Western Ghats – Mountains |
| The Deccan Peninsula | 6A: Deccan Peninsular – Central Highlands<br>6B: Deccan Peninsular – Chotta Nagpur<br>6C: Deccan Peninsular – Eastern Highlands<br>6D: Deccan Peninsular – Central Plateau<br>6E: Deccan Peninsular – Deccan South |
| The Gangetic Plains | 7A: Gangetic Plain – Upper Gangetic Plains<br>7B: Gangetic Plain – Lower Gangetic Plains |
| The Coasts | 8A: Coasts – West Coast<br>8B: Coasts – East Coast<br>8C: Coasts – Lakshadweep |
| Northeast India | 9A: North-East – Brahmaputra Valley<br>9B: North-East – North East Hills |
| Islands | 10A: Islands – Andaman<br>10B: Islands – Nicobars |

## 8.3. Biodiversity Hot Spots

- **Biodiversity hotspots**, as defined by British biologist **Norman Myers**, are biogeographic regions characterised by **high species richness**, a **high degree of endemism**, and sometimes **severe levels of habitat loss**. **Conservation International (CI)** adopted Myers' hotspots, and in 1996, it undertook a reassessment of the hotspots concept.

⇨ ***Conservation International (CI)*** *is an* ***American non-profit*** *environmental organisation working towards protecting nature for the benefit of people.*

- According to CI, to qualify as a hotspot, a region must meet two strict criteria:
  1. **It must contain at least 1,500 species of vascular plants (> 0.5% of the world's total) as endemics** – which is to say that it must have a high percentage of plant life found nowhere else on the planet. A hotspot, in other words, is irreplaceable.

2. It must have **lost at least 70% of its original habitat**. (It must have **30% or less of its original natural vegetation**). In other words, it must be **threatened**.

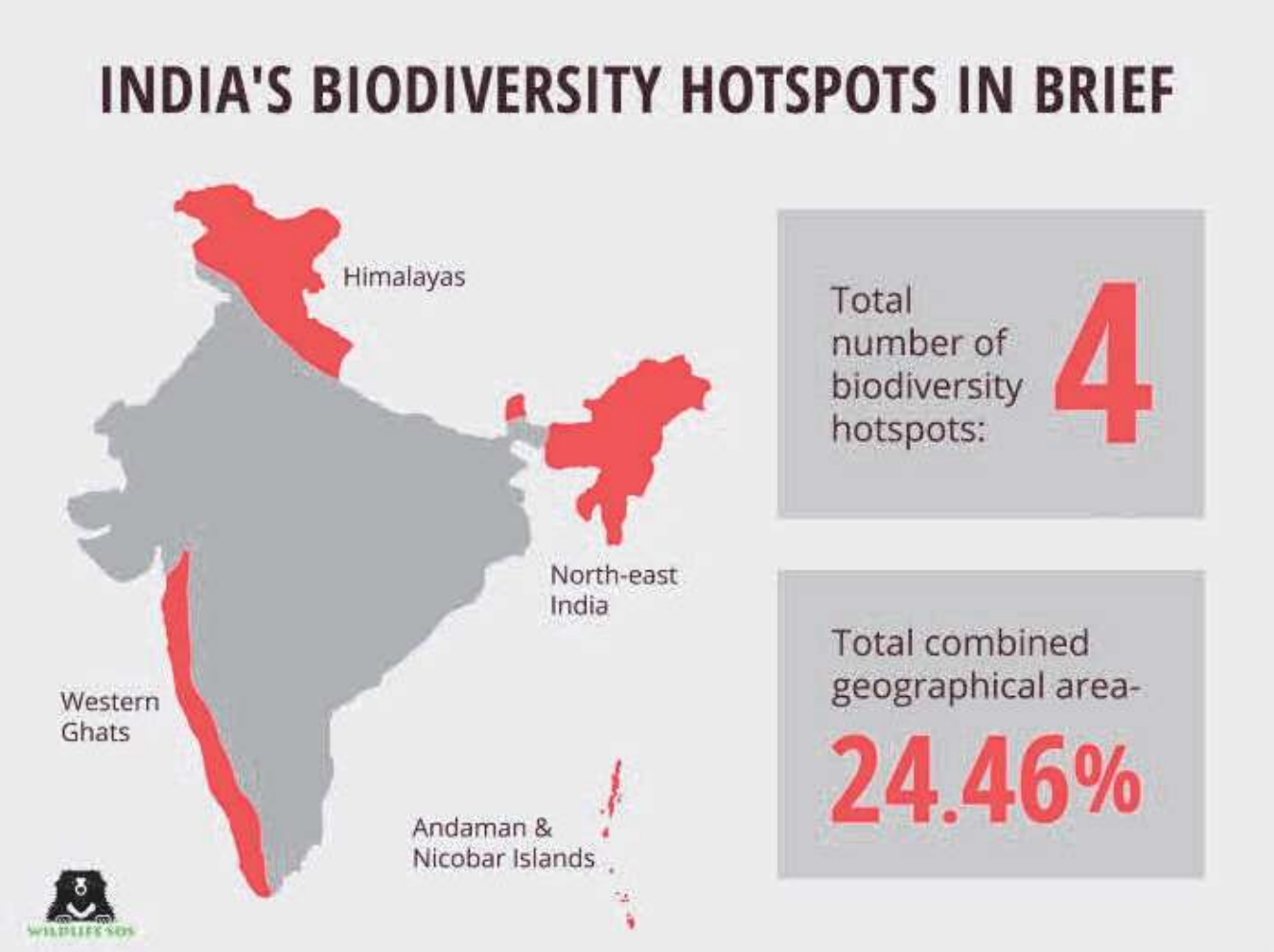
- In 1999, CI identified 25 biodiversity hotspots. Currently, 36 areas qualify as hotspots representing just **2.5% of the earth's land surface**. They support **more than half of the world's plant species as endemics** and nearly 43% of bird, mammal, reptile, and amphibian species as endemics.

⇨ *In 2011, the **Forests of the East Australia** region was identified as the 35th biodiversity hotspot. In 2016, the **North American Coastal Plain** region was identified as the **36th biodiversity hotspot**.*

### Hope Spots

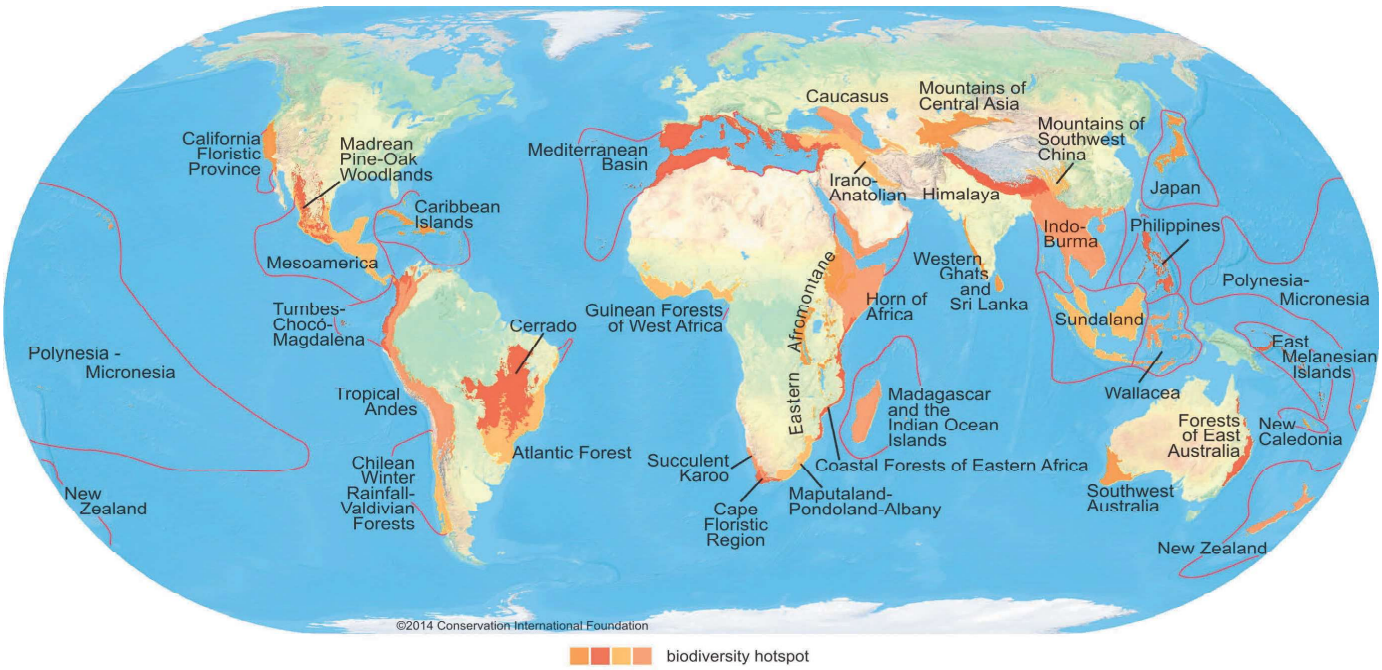
- Hope Spot Network is a joint initiative of **Mission Blue** (a global coalition) & **IUCN**. A hope spot is **Marine Protected Area** that needs special protection because of its **wildlife & significant underwater habitats**. **Lakshadweep Islands** and **Andaman Nicobar Islands** are the Hope Spots Sites from India.

## Biodiversity Hotspots in India




1) **Himalaya:** Includes the **entire Indian Himalayan region** of India and of **Pakistan**, **Nepal**, **Bhutan**, **China**, **& Myanmar**.

2) **Indo-Burma:** Includes entire **North-Eastern India**, **Andaman Group of Islands** and Myanmar, Thailand, Vietnam, Laos, Cambodia and southern China.
3) **Sundalands: Includes Nicobar group of Islands**, Indonesia, Malaysia, Singapore, Brunei, and the Philippines.
4) **Western Ghats and Sri Lanka**




**[UPSC 2010] Consider the following statements:**

1) Biodiversity hotspots are located only in tropical regions.
2) India has four biodiversity hotspots, i.e., Eastern Himalayas, Western Himalayas, Western Ghats and Andaman and the Nicobar Islands.

**Which of the statements given above is/are correct?**

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither I nor 2

**Explanation**

- Eastern Himalayas was originally part of the **Indo-Burma Biodiversity Hotspot** and included Bhutan, North-Eastern India, and southern, central, and eastern Nepal. In 2004, a hotspot reappraisal classified the region as part of two hotspots: Indo-Burma and the newly distinguished Himalaya.
- The **Himalaya Hotspot** is home to important populations of vultures, tigers, elephants, rhinos, and wild water buffalo. **Indo-Burma** holds remarkable endemism in **freshwater turtle species**, most of which are threatened with extinction due to over-harvesting and extensive habitat loss. **Sundaland Hotspot** is threatened by the explosive growth of **industrial forestry (palm and rubber plantations)**.

- Faced with tremendous population pressure, the forests of the **Western Ghats and Sri Lanka** have been dramatically impacted by the demands for timber and agricultural land. The region houses significant populations of **Asian Elephants**, **Indian Tigers**, **the Lion-tailed Macaque**, **Niligiri tahr**, **the Indian Giant squirrel**, etc.

***Answer: d) neither***

## 8.4. Loss of Biodiversity

- Biodiversity loss is a decrease in biodiversity within a species, an ecosystem, or a geographic area. It includes the decline in the number (species richness), genetic variability, variety of species, etc. in each area.
- The IUCN Red List (2014) documents the extinction of **784 species** in the last 500 years. Some examples include the extinction of the **Passenger Pigeon**, **Steller's Sea Cow** and **three subspecies of tigers** (**Bali**, **Javan** and **Caspian**).
- During the long period (> 3 billion years) since the origin and diversification of life on earth, there were **five episodes of mass extinction of species**. The **Sixth Extinction (anthropogenic)** is presently in progress, with species extinction rates estimated to be 100 to 1,000 times faster than in pre-human times. Ecologists warn that if the present trends continue, nearly **half of all the species** on earth might be wiped out within the next 100 years.

### The Extent of Biodiversity Loss as per IPBES Report

- The **IPBES 2019 report** is called the "**Global Assessment Report on Biodiversity and Ecosystem Services 2019**." According to this report, the estimated number of species on earth is **8 million** (including **5.5 million insect species**). Up to **1 million species are threatened with extinction**, many within decades. The threatened list includes **40% of amphibian species**, **33% of reef-forming corals**, and more than a **third of all marine mammals**.

#### Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)

- IPBES, based in Bonn, Germany, comprises 130 member countries, **including India**. It **examines scientific literature on biodiversity**. Hence, it is often described as the "**Intergovernmental Panel on Climate Change (IPCC) for biodiversity**". It prepared the **UN-sponsored Global Assessment Report on Biodiversity and Ecosystem Services 2019 report**.

**Key Points From Global Assessment Report on Biodiversity and Ecosystem Services 2019**

- Nearly **half of the natural ecosystems have vanished** due to human activities.
- Humans have severely altered 75% of the land, 40% of marine environments and 50% of inland waterways:
  - 300% increase in food crop production since 1970.
  - More than 100% growth in urban areas since 1992.
  - **23%** of land areas have decreased productivity due to **land degradation**.

- 50% of agricultural expansion at the expense of forests.
- **16-21 cm rise in global average sea level since 1900**.
- **100% increase since 1980 in GHG emissions**, raising the average global temperature by **0.7 degrees**.
- Plastic pollution alone has increased tenfold since 1980.

- **100-300 million people** in coastal areas are at increased risk due to the loss of coastal habitat protection.
- **Less than 1% of the land is used for mining**, but it has significant negative impacts on the environment.
- 1,000 green activists and journalists reporting environmental issues were killed between 2002 and 2013.

## Living Planet Report 2022

- **Living Planet Report** is a **biennial report** released by **World Wide Fund for Nature (WWF)** since 1998. According to the **2022 report**, there has been a **69% decline in the wildlife populations** of mammals, birds, amphibians, reptiles, and fish across the globe in the **last 50 years**.
- The highest decline in the wildlife populations (**94%**) was in **Latin America** and the **Caribbean**. **Africa** recorded a **66%** fall, whereas the Asia-Pacific recorded a decline of 55%.
- **Freshwater species** populations globally were reduced by **83%**. **Mangroves** continue to be lost to aquaculture, agriculture, & coastal development at a rate of **0.13% per year**.

## The State of the World's Birds

- **BirdLife International** recently published its **annual update**, **The State of the World's Birds**. Around **48%** of bird species **worldwide** are suspected to be **undergoing population declines**. Whereas 39% showed stable trends, **6% showed increasing trends**, & 7% with unknown trends. **1 in 8 bird species is threatened with extinction**.
- **867** species of Indian birds were assessed. **80%** of these are suspected to be undergoing **population declines**. Whereas 6% show stable trends and **14% show increasing trends**. The maximum decline occurs in bird species dependent on **forests**, followed by grasslands and wetlands.
- **Trophic cascade effect** is among the major threats.

⇨ *A **trophic cascade** is a side-effect when a trophic level (species) of the ecosystem is reduced or removed. This triggers a cascade (series of events/effects on other species) that changes the balance of the entire ecosystem.*

**Prelims Practice: Consider the following statements regarding 'The State of the World's Birds'.**

1. It's being published by the IUCN as a part of its Red List.
2. It found that about half of the existing bird species worldwide are suspected to be undergoing decline.

***Which of the statement(s) given above is/are correct?***

a) 1 only
b) 2 only
c) 1 & 2 both
d) Neither 1 nor 2

**Explanation**

- The **State of the World's Birds** is published by **BirdLife International** along with several other research organisations. Hence statement 1 is not correct.

***Answer: b) 2 only***

## 8.5. Causes Behind Biodiversity Loss

- Natural ecological disturbances, such as weather, wildfire, floods, and volcanic eruptions, change ecosystems drastically by eliminating local populations of some species. Such disturbances are temporary because natural disturbances are common, and ecosystems have adapted to their challenges (**ecological succession**).
- Permanent biodiversity loss is typically associated with **mass extinction events** and **anthropogenic causes** — **The Evil Quartet — Habitat loss**, **Overexploitation**, **Alien species** and **Secondary extinction**.
- **World Wide Fund for Nature (WWF)** identified **six key threats to biodiversity**. They are **agriculture**, **hunting**, **logging**, **pollution**, **invasive species**, and **climate change**.

### Habitat Loss and Fragmentation

- **Habitat loss** refers to the reduction in space where a particular species or a community of species can survive and reproduce. The most dramatic examples of habitat loss come from tropical rainforests. Once covering **more than 14 per cent of the earth's land surface**, the rainforests now cover **no more than 6 per cent**.
- The **Amazon rain forest** (called the '**lungs of the planet**') is being cleared for **cultivating soybean** or for **conversion to grasslands for raising beef cattle (ranching)**. Wetlands are being made dry through landfills as the demand for land increases. Natural forests are cleared for industry, agriculture, dams, habitation, recreational sports, etc.
- **Habitat fragmentation** is the process in which a large expanse of ecologically prominent habitat is transformed into many smaller patches (less productive) isolated by a matrix of habitats (human-made) unlike the original. Habitat loss and habitat fragmentation are the direst causes behind driving animals and plants to extinction.

## Consequence: Barrier Effect and Associated Damage

- Habitat fragmentation **increases the risk of inbreeding**. Inbreeding is the **mating of organisms closely related by ancestry**. It goes against the biological aim of mating, which is the shuffling of DNA. **Inbreeding limits the gene pool** and creates **inbreeding depression**, which means the population decreases due to a lack of healthy mates, and there is an increased risk of **local extinction**.

### Explanation

- Genes in DNA fall into two categories, **dominant** and **recessive**. If one of the genes in the pair is dominant, then the result is that the animal/organism gains the trait of the dominant gene. However, for traits that originate from the recessive gene, the **organism needs both genes to be recessive**. This is important as some **recessive alleles carry genetic diseases** and **congenital defects** (physical abnormalities present from birth) in humans and animals. Inbreeding increases the risk of offspring being born with such genetic conditions since the chances of parents carrying the same recessive gene are significantly increased.
- For example, **inbreeding in koalas in Australia** has put the species at risk of **local extinction** by just one disease.
- Central India's tigers have the **highest genetic variation**. This has been made possible by the significant habitats available in the past. But today, due to linear projects like highways that isolate populations, the **risk of inbreeding of disease and local extinction** has increased significantly.

### Fragmentation of India's Tiger Habitats Due to Highways

- According to an estimate, around 55,000 km of roads pass through India's forests and protected areas.
- GOI will construct a 36 km-long flyover above **NH 37**, which passes through the **Kaziranga National Park**.
- **NH 44** — India's longest highway (from Srinagar to Kanyakumari) — cuts through corridors connecting **Kanha**, **Satpura**, **Pench**, **Bandhavgarh & Panna tiger reserves**.

- **NH 6** — India's second-longest highway (from Surat to Kolkata) — passes through corridors around **Melghat**, **Bor**, **Nagzira**, and **Simlipal tiger reserves**.

## Alien Species Invasions

- **Invasive alien species** are **non-native species** that **spread rapidly** and **interfere in a new ecosystem** by posing a severe threat to the native biodiversity, leading to economic loss. **For example**, the **Nile perch** fish introduced into Lake Victoria in East Africa eventually led to the extinction of an ecologically unique assemblage of more than 200 species of cichlid fish in the lake.
- Invasive species are the **second-biggest cause of biodiversity loss**, **next to habitat destruction**. When invasive species are introduced into an ecosystem, they **may not have any natural predators or controls**, and native wildlife may not have evolved defences against the invading species. A resin-like substance that oozes from such alien plant species **makes the soil acidic**, preventing the growth of any other plant species.

### Consequence: Destruction of Sholas by Invasive Species

- The **Shola vegetation** is **tropical montane forests** found in the Western Ghats separated by rolling **grasslands** in high altitudes (upper Nilgiris with peaks and plateaus ranging from 1,700 to 2,600 metres). Owing to the altitude, the Shola patches occur only in the folds of the mountains that receive the **least fog**.
- Invasive species like **eucalyptus**, **tea plantations**, **wattle (acacia)**, **Lantana**, and naturalised alien species like **Parthenium hysterophorus** in the Nilgiris are **wiping out Shola forests**.

#### Even the grasslands are in danger

- **Frost** traditionally restricted the forests in the Nilgiris from expanding as it freezes the groundwater and stops the sapling from sprouting in new areas. Over the years, the nights have become warmer, and the amount of frost has reduced in the Nilgiris.
- The reduced frost has allowed the **acacia plantations** to move beyond the **Shola forests** and enter the **grasslands**. This change in vegetation is resulting in the loss of water sources, causing **massive landslides**, and has deprived the original habitat of endangered species like **Nilgiri Tahr (EN)**.

⇨ ***Toda tribes*** *are a Particularly Vulnerable Tribal Group settled in the* ***upper Nilgiris****. The pastoral Toda community's livelihood depends entirely on the* ***Shola grasslands****.*

### How are invasive species introduced into an ecosystem?

- Human activities like **transportation** primarily spread invasive species. Ships can carry aquatic organisms in their ballast water and on their propellers. Insects can get into wood that is shipped around the world. Some ornamental plants can escape into the wild and become invasive.
- Sometimes, humans voluntarily introduce an invasive species to control the population of another species. In addition, changes in rain and snow patterns caused by climate change will enable some invasive plant species to move into new areas.

### Threats to native wildlife from invasive species

- The direct threats of invasive species include:
  - preying on native species (E.g., African Catfish),
  - outcompeting native species for food or other resources,
  - causing or carrying disease, and
  - preventing native species from reproducing or killing a native species' progenies.
- There are indirect threats of invasive species as well.
  - They can **change the food web** by destroying or replacing native food sources.
  - They may provide little to no food value for wildlife.
  - Aggressive plant species can quickly replace a diverse ecosystem with a **monoculture**.
  - Additionally, some invasive species can change soil chemistry or the intensity of wildfires.

***The list of Invasive Species is included in the chapter 'Major Species and Species In News'***.

## Over-Exploitation

- When human **'needs' turns to 'greed'**, it leads to the over-exploitation of natural resources. In the last 500 years, many species extinctions (**Steller's Sea Cow** and **Passenger Pigeon**) were due to overexploitation by humans.
- Presently, many marine fish populations worldwide are over-harvested, endangering the continued existence of some commercially important species. Whales for oil, fish for food, trees for wood, plants for medicines etc., are being removed by humans at higher rates than they can be replaced.
- Excessive cutting of trees, overgrazing, collecting firewood, and hunting wild animals for skin and ivory result in the **gradual loss of species**. Large mammals such as the tiger, rhinoceros and elephant once faced the distinct possibility of complete extinction due to rampant hunting and poaching.

## Species Extinction

- Various processes cause extinction:

1) **Deterministic processes** that have a cause and effect. E.g., glaciations and human interference such as deforestation.

2) **Stochastic processes** (chance and random events) affect the survival and reproduction of individuals. E.g., unexpected changes in weather patterns decreased food supply, disease, an increase of competitors, predators, parasites, etc., that may act independently or add to deterministic effects.

- The impact of these processes will, of course, depend on the size and degree of genetic diversity and resilience of populations. Traits that adversely affect or increase a species' vulnerability to extinction due to habitat fragmentation are:
  - ✓ rarity or low abundance
  - ✓ poor dispersal ability
  - ✓ **high trophic status** — animals occupying a higher trophic level usually have smaller populations than those at lower levels (carnivores are fewer in number than herbivores and are more vulnerable)
  - ✓ low adult survival rates

### Co-extinctions

- When a species becomes extinct, the plant and animal species associated with it in an obligatory way also become extinct. For example, when a host fish species becomes extinct, its unique assemblage of parasites also meets the same fate. Another example is the case of a **coevolved plant-pollinator mutualism** where the extinction of one invariably leads to the extinction of the other.

## Genetically Modified Organisms (GMO/Transgenic Organisms)

- In GMOs, genetic material (**DNA**) is **altered or artificially introduced** using genetic engineering techniques like **mutation**, **insertion**, **or deletion of genes**. Inserted genes usually come from a **different organism** (e.g., In Bt cotton, Bt genes from the bacterium **Bacillus thuringiensis** are induced).
- Genetic modification is done to induce a **desirable new trait** that does not occur naturally in the species. The most common trait engineered into GMO crops is that they **generate toxins** within the plant cells. These toxins can be **far more potent than expected** and can **remain in the environment** for far too long.
- GMO species can become dominant and can overrun the existing species, thereby reducing biodiversity. Unintended transfer of transgenes through **cross-pollination** can cause unknown effects on other organisms (e.g., soil microbes) and lead to biodiversity loss.
- Also, most GMO crops are engineered for herbicide resistance, so weedkillers are liberally sprayed. Weeds are a problem, but diverse plant life protects the soil from erosion and nutrient loss. It supports the pollinators and other beneficial insects that do so much agricultural labour. While welcoming the weeds is not a practical solution, neither is wiping out plant life with toxic chemicals.

### The Curious Case of Genetically Modified Mosquitoes

- In the absence of an effective vaccine for dengue fever, Zika fever, chikungunya and other mosquito-borne diseases, researchers are exploring genetic strategies to reduce mosquito populations.
- A company called Oxitec developed **GM male mosquitoes (GM strain of Aedes aegypti)**. These male GM mosquitoes are said to have a **"self-limiting" gene**. When these so-called friendly mosquitoes mate, their **offspring inherit the self-limiting gene**, which is supposed to prevent them from

surviving into adulthood. In theory, when these mosquitoes are released in high numbers, a dramatic reduction in the mosquito population should follow.

- With approval from Brazilian authorities, Oxitec released nearly half a million GM mosquitoes every week into the environment from 2013 to 2015. Studies have since confirmed that some of the offspring of the GM mosquitoes did not succumb to the self-limiting lethal gene and survived to adulthood. They were able to breed with native mosquitoes and **introduced some of their genes into the wild population**. Thus, like in GM soybean or corn, there is legitimate concern about the **propagation of new genetic material in wild populations** with unknown consequences.

### Trade in Wildlife

- Many species of wildlife are threatened by unsustainable harvest and trade. The unsustainable use of wildlife creates a risk both for biodiversity and local livelihoods.
- Illegal wildlife trade contributes to habitat destruction, which **removes necessary buffer zones** between humans and wild fauna, making it more likely that animal pathogens come into contact with people.
- Specimens traded illegally are also much less likely to be sold or bought where sanitary standards are being adequately enforced, making the spreading of diseases more likely, thereby reducing local biodiversity.

### Pollution and Climate Change

- Marine biodiversity is affected by **ocean acidification** related to levels of carbon in the atmosphere. Terrestrial biodiversity is influenced by **climate variability**, such as extreme weather events. Longer-term climate changes affect the health of ecosystems, influencing shifts in the distribution of plants, pathogens, animals, and even humans.

## 8.6. Consequences of Loss of Biodiversity

### Affects Livelihood

- Human health depends on **ecosystem products & services** (such as the availability of freshwater, food, and fuel). Changes in ecosystem services affect livelihoods, income, and local migration and, on occasion, may even cause or **exacerbate political conflict**.
- Loss in biodiversity may limit the discovery of potential treatments for many diseases and health problems.

#### Food and Nutritional Security Crisis

- Biodiversity plays a crucial role in human nutrition through its influence on world food production. It ensures the sustainable productivity of soils and provides the **genetic resources** for all crops, livestock, etc.
- Nutrition and biodiversity are linked at many levels: the ecosystem, with food production as an ecosystem service; the species in the ecosystem and the **genetic diversity** within species.

- Intensified food production through irrigation, fertiliser use, plant protection (pesticides), or the introduction of crop varieties and cropping patterns affects biodiversity and thus impacts global nutritional status. Healthy local diets, with adequate average nutrient intake, necessitate maintaining high biodiversity levels.

## Human-animal Conflict

- Human-animal conflict refers to the interaction between wild animals and people and the **resultant negative impact** on people or their resources or wild animals or their habitat. It occurs when wildlife needs overlap with those of human populations, creating costs to residents and wild animals.

### Causes

- Human encroachment into forest lands.
- Land use transformation – industrialisation, infrastructure development, commercial farming etc.
- Species habitat loss, degradation and fragmentation due to the above-mentioned reasons.
- Increasing livestock populations and competitive exclusion of wild herbivores.
- The growing interest in **ecotourism** and increasing access to nature reserves.
- Abundant distribution of prey in the form of livestock on the **periphery** of forest lands.
- Increasing wildlife population as a result of conservation programmes.
- Climate change-induced habitat destruction.
- **Stochastic events** (e.g., fire, floods etc.)

### Impacts

- Crop and property damage.
- Livestock depredation: Himalayan snow leopard preys on goats in the Himalayan region. Farmers trap and kill snow leopards to save their livestock.
- Injuries & deaths: Man-eater tigers are reported to have injured and killed villagers on the periphery.
- Injuries to wildlife: leopards and other wild animals are hacked to death by mobs.

### Preventive and Mitigation strategies

- ✓ Artificial and natural barriers (physical/ biological) – costly.
- ✓ Guarding – very expensive.
- ✓ Alternative high-cost livestock husbandry practices.
- ✓ Relocation: voluntary human population resettlement.
- ✓ Waste management systems that restrict wildlife access to refuse.
- ✓ Community-based natural resource management schemes (CBNRMS)

### Culling – Conservation or Biodiversity loss?

#### Natural culling

- Culling means 'Selection'. In the wild, it is the process of weeding out the weak. Culling naturally occurs by starvation, disease and predation. It is **nature's way of controlling the population**.

### Culling by humans – controlled culling

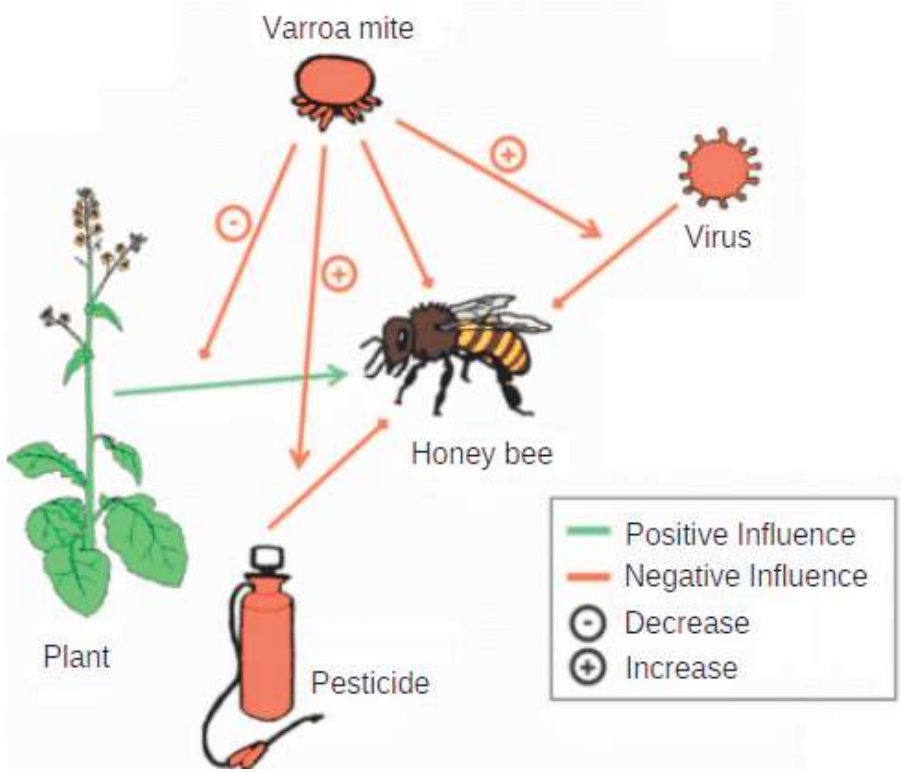
- In the post-conservation era, human intervention became necessary for the management of wildlife populations through controlled hunting, which is now referred to as culling.

### Why did controlled culling become necessary?

- Human-animal conflict – too many wild animals compete with humans for resources.
- Threats to life and livelihood (crop, property damage) make culling necessary.
- Loss of forestland to mines, industry, agriculture, etc., is the primary reason behind the human-animal conflict.
- Crop-raiding by smaller herbivores due to a population boom & animals raiding nutrient-rich crops like wheat and maize are other major reasons for human-animal conflict.

### The practice of Culling worldwide

- In the US, some areas require seasonal culling to ease pressure on livestock feed. In parts of Africa, culling has been used for commercial harvesting. Australia culls feral cats to protect native species. Australia also culls kangaroos. Recently Australia **culled camels** to regulate their overpopulation.
- In 2022, millions of **bees (important pollinators)** were exterminated in Australia amid the **Varroa Mite outbreak**. **Varroa mites (parasitic insects that transmit the virus)** are **known to kill entire colonies of honeybees**.




### Animal Welfare Activists vs Pro Culling Lobby

- **Culling lobby:** Affected farmers and government administration.

| Arguments against culling by activists | Arguments by Culling lobby |
|---|---|
| • Ethical grounds: humans do not have the right. | • They support a practical and realistic approach. |
| • They believe every animal is ethically indispensable, even at the cost of putting entire species at risk. | • Conservationists are concerned about the integrity of the ecosystem and the future of the entire species. |
| • Culling is against animal conservation.<br>  | • Culling is for conservation. By law, wildlife is protected because they are too few and require protection. But when certain pockets see a population boom in herbivores, farmers cannot wait for predators to reoccupy such areas.<br>• The absence of lawful intervention **often triggers retaliation by illegal means**. In anger, farmers may **indiscriminately target wildlife**, including those that may not be causing any problems. |
| • Culling can increase people's apathy (lack of interest or enthusiasm) for conserving other life forms. (Some people recruited to cull animals post their act on social media, glorifying killing an animal). | • No concrete evidence to prove that culling increases insensitivity among people.<br>• (But practically, it does. Many people enjoy hunting animals, and others might take inspiration from culling) |
| • They argue that human-animal conflict can be controlled through non-invasive means, including fencing crop fields, planting chilli around cropland, creating buffer areas between croplands and the forest's edge, selecting non-edible crops, providing adequate and regular compensation for crop loss, etc. | • Fencing merely shifts conflict to the next accessible cropland. It is expensive, and its maintenance is not practical.<br>• Even the selection of crops that traditionally repelled animals does not seem to work any longer. For example, farmers in Sirmour, Himachal Pradesh, now complain that monkeys raid garlic fields that they avoided until recently.<br>• Other measures are primarily long-term and can keep a check on conflict only in situations where crop damage is still reasonable. |

## Increased Zoonoses Due to Habitat Loss

- **Zoonoses (zoonotic diseases)** are diseases transmitted from animals to humans. E.g., Rabies (dogs), **Ebola (fruit bats)**, novel coronavirus Covid-19 (pangolin), etc.
- Zoonoses are opportunistic and thrive where there are changes in the environment, changes in animal populations that serve as hosts for specific pathogens, or changes in the pathogen itself.

- Zoonotic diseases are closely interlinked with the **health of ecosystems**. According to the **UN Environment Programme (UNEP)**, 60% of human infectious diseases are zoonotic. **IPBES** estimates that zoonoses kill some 700,000 people yearly (the current COVID-19 is not considered).

### How does the change in ecosystems and biodiversity loss help Zoonoses thrive?

- Ecosystems are inherently resilient, and by supporting diverse species, they help regulate diseases. The less biodiverse an ecosystem gets, the easier it is for a pathogen to spread rapidly.
- By destroying forests for agriculture, industries, etc., humans fragment and encroach into animal habitats. This brings wildlife close to human settlements as the **natural buffer** that generally separate humans from animals is destroyed. This creates opportunities for **pathogens to spill over** from wild animals to humans.

## Adverse Changes to Biotic Interactions

- Even though a species may not have been eliminated from the ecosystem, its **niche (the role the species plays in the ecosystems it inhabits)** diminishes as its numbers fall. If the niches filled by a single species or a group of species are critical to the proper ecosystem functioning, a sudden decline in numbers may produce significant changes in the ecosystem's structure. For example, clearing trees from a forest eliminates the shading, temperature and moisture regulation, animal habitat, and nutrient transport services they provide to the ecosystem.

**---------- End of Chapter ----------**

# 9. Biodiversity Conservation

- Biodiversity conservation leads to the conservation of **ecological** and **genetic diversity**, preserving the **continuity of food chains**. It assures sustainable utilisation of resources and a constant flow of ecosystem services and goods.
- When we conserve and protect the whole ecosystem, its biodiversity at all levels is protected. E.g., we save the entire forest to save the tiger. This approach is called **in-situ (on-site) conservation**. However, when an animal or plant is endangered or threatened and needs urgent measures to save it from extinction, **ex-situ (off-site)** conservation is the desirable approach.

## 9.1. In situ conservation

- In-situ conservation is the **on-site conservation** of genetic resources in natural populations of plant or animal species. In India, ecologically unique and biodiversity-rich regions are **legally conserved on-site** as **biosphere reserves**, **national parks**, **sanctuaries**, **reserved forests**, **protected forests** and **nature reserves**, each accorded a certain degree of protection.

### Reserved and Protected Forests

- **Reserved (reserve) forests** and **protected forests**, declared through a notification by the respective **state governments**, are granted protection under the **Indian Forest Act of 1927**. Typically, **reserved forests** are often upgraded to the status of **wildlife sanctuaries**, which in turn may be upgraded to **national parks**, with each category receiving a **higher degree of protection** and **government funding**.
- The protected forests and reserved forests differ in one single aspect: **rights to all activities like hunting**, **grazing**, **etc.**, **in Reserved Forests**, are **banned** unless specific orders are issued otherwise **(all activities are prohibited unless permitted**). In **Protected Forests**, such rights are **sometimes given** to **communities living on the fringes of the forest**, who sustain their livelihood from forest resources or products.

⇨ ***In terms of protection**, National Parks > Wildlife Sanctuary > Reserved forests > Protected forests*

### Wildlife Sanctuaries or Wildlife Refuges

- Wildlife Sanctuaries or wildlife refuges are areas where **endangered species** are safeguarded from extinction in their **natural habitat (home range)**. They are **safe from hunting**, **predation**, **or competition**. A sanctuary can be promoted to a **National Park**.
- Wildlife Sanctuaries, declared through a notification (no need to pass legislation) by the respective **state governments**, are granted protection under the **Wild Life (Protection) Act, 1972**. The State Government appoints an officer as a **collector** to determine the extent of the rights of any person. The **Chief Wildlife Warden** controls, manages and maintains the wildlife sanctuaries.

- **Certain rights** of people living inside the sanctuary **could be permitted**. **Grazing** and **firewood collection** by tribals is **allowed but strictly regulated**. **Settlements are not allowed** (but in some wildlife sanctuaries, tribal settlements exist. Constant efforts are made to relocate them).

### Tiger Reserves

- **The protection status of tiger reserves is the same as wildlife sanctuaries**. But they are monitored by the National Tiger Conservation Authority (**NTCA** — constituted under the **Wild Life Protection Act of 1972**. It is responsible for implementing **Project Tiger**). The various tiger reserves were created in the country based on the **core buffer strategy**.

***[UPSC 2023] Identify and discuss the factors responsible for diversity of natural vegetation in India. As-sess the significance of wildlife sanctuaries in rain forest regions of India. (Answer in 250 words)***

## National Park

- National parks, just like wildlife sanctuaries, are declared through a notification by the respective **state governments**. They are also granted protection under the **Wild Life (Protection) Act of 1972**. The significant difference between a sanctuary and a national park lies in the **vesting of rights of people living inside**.
  - **Unlike a Sanctuary**, **where certain rights can be allowed**, **in a National Park**, **no rights are permitted**.
  - **No livestock grazing shall also be permitted inside a National Park**, while in a **sanctuary**, **the Chief Wildlife Warden may regulate**, **control**, **or prohibit it**.
  - **Boundaries of wildlife sanctuaries are not specified**, while they are **clearly defined** **(demarcated)** in the case of **national parks** by the **state governments**.
- The state government has all the rights of lands to be included in the national parks. But only on the recommendation of the **National Board of Wildlife** the **state legislature** can **make the changes to the boundaries of national parks** and other **protected areas (sanctuaries**, **conservation/community reserves)**.

⇨ *The Supreme Court in June 2022 directed that "mining within the national parks and wildlife sanctuaries shall not be permitted".*

## Biosphere Reserve

- Biosphere reserves are large areas of protected terrestrial, marine and coastal ecosystems. UNESCO terms biosphere reserves as 'learning places for sustainable development' involving the conservation of wildlife, plant and animal resources and the **traditional life of the tribals**. A biosphere reserve in India **may have one or more national parks or wildlife sanctuaries**.
- Biosphere Reserves are designated (recognised) under **UNESCO's** intergovernmental **Man and the Biosphere (MAB) Programme** after the **national governments nominate them**. They are internationally recognised by UNESCO's MAB but are **administered under the sovereign jurisdiction of countries**.

Designation of a site as a biosphere reserve **does not affect the legal status** of the land, forests and regulations for natural resources, and their ownership remains unchanged.

- The **Indian National Man and Biosphere (IN-MAB) Committee** under MoEF identifies and recommends potential sites for designation as biosphere reserves, following UNESCO's guidelines and criteria. The State Government prepares the Management Action Plan which is approved and monitored by In-MAB. The **Government of India provides financial assistance** in a **90:10** ratio to the North Eastern states and three Himalayan states and a ratio of **60:40** to other states for maintenance, improvement, and development.

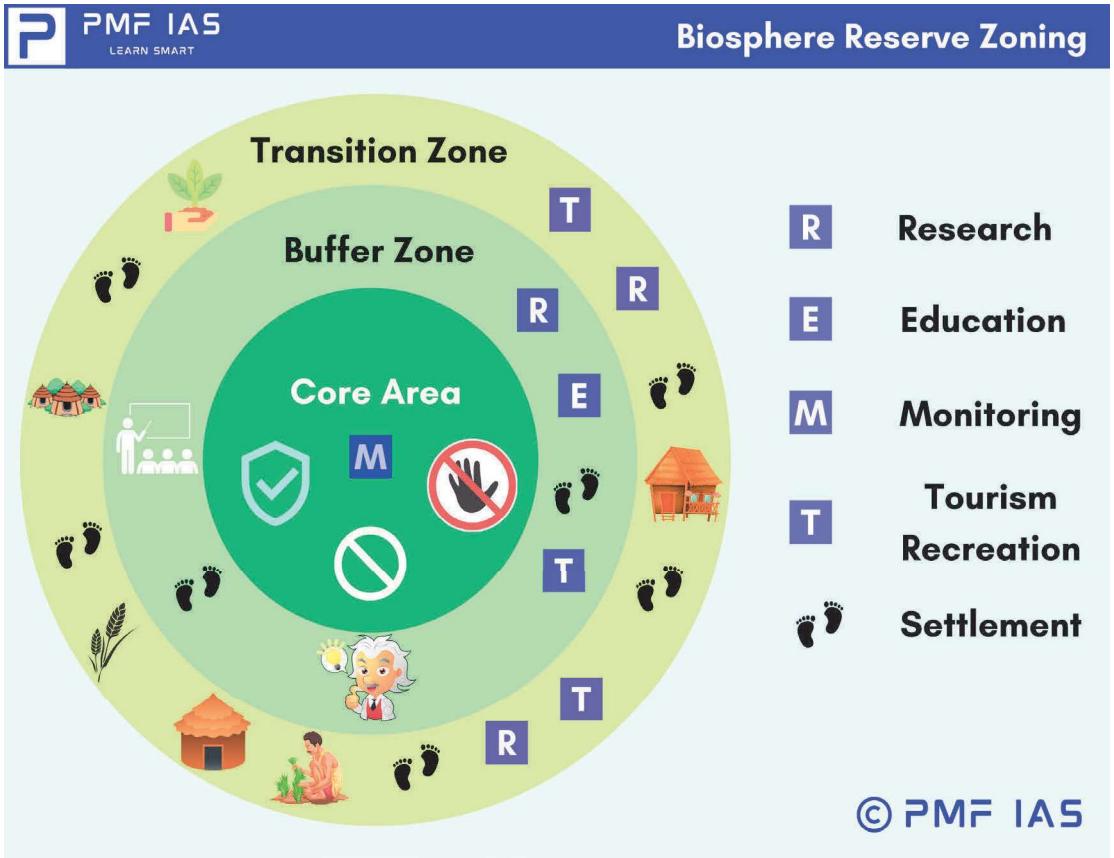
## UNESCO's Criteria for designation

- A site must contain an effectively protected and minimally disturbed **core area**.
- The core area should sustain viable populations representing all trophic levels in the ecosystem.
- A management authority to ensure the cooperation of local (tribal) communities.

## Seville Strategy

- In 1995, after an international conference in Seville, Spain, **Seville Strategy** for biosphere reserves was adopted. Under the strategy, criteria for biosphere reserves were revised to include the social, cultural, spiritual, and economic needs of society (**community-based approach** — enhancing the relationship between people and their environments) alongside **scientific research**.

## Core Buffer Strategy



**Core area**

- It comprises a strictly protected ecosystem for conserving ecosystems, species and genetic variation. In the core or natural zone, **human activity is not allowed**. A core zone, primarily a national park or sanctuary, is regulated mainly under the **Wildlife (Protection) Act 1972**.

**Buffer zone**

- **Limited human activity** is permitted. The zones are used for scientific **research**, **monitoring**, **training**, **limited recreation and education**.

**Transition area**

- **Ecologically sustainable** human **settlements** and **economic activities (tourism**, **agriculture**, **forestry)** are **permitted** in the transition area.

**[UPSC 2014] The most important strategy for the conservation of biodiversity together with traditional human life is the establishment of**

a) biosphere reserves
b) botanical gardens
c) national parks
d) wildlife sanctuaries

**Explanation**

- **National Parks and Wildlife Sanctuaries discourage all sorts of human activity**.

***Answer: a)***

## Eco-Sensitive Zones (ESZs)

- **ESZs** are areas notified by the MoEF **around national parks & wildlife sanctuaries**. The purpose of the ESZ was to provide more protection to the parks and sanctuaries by acting as a **shock absorber or transition zone to minimise forest depletion** and **human-animal conflict**.
- The **National Wildlife Action Plan** (2002–2016) of MoEF stipulated that **state governments** should declare **land falling within 10 km of the boundaries of national parks and wildlife sanctuaries as eco-fragile zones or ESZs** under the **Environmental (Protection) Act**, **1986**.
- The width of the ESZ and the type of regulation may vary from protected area to area. The **GOI can also notify areas beyond 10 km as ESZs** if they hold larger ecologically important "sensitive corridors".
- The Supreme Court in June 2022 directed that every **protected forest**, **national park**, and **wildlife sanctuary** across the country should have a **mandatory eco-sensitive zone (ESZ) of a minimum of one km** starting from their demarcated boundaries.
- ESZ areas are based on the **core and buffer model** of management. The **core area has the legal status of being a national park**. The **buffer area**, **however**, **does not have the legal status of being a national park** and **could be a reserved forest**, **wildlife sanctuary or tiger reserve**.

⇨ *Recently, the **Bhagirathi Eco-Sensitive Zone** (**4179.59 sq km**) from **Gaumukh** to **Uttarkashi** was notified by MoEF.*

### Legal Status

- The **Environment (Protection) Act**, **1986 does not mention** the word **"Eco–Sensitive Zones"**. The act only states that **GOI can restrict areas in which any industries**, **operations**, **or processes shall or shall not be carried out** subject to certain safeguards. Besides, the **Environment Rules**, **1986** also states that **GOI can prohibit or restrict the location of industries**. The government has effectively used these two rules to declare ESZs or EFAs.

### Activities Prohibited/Restricted/Allowed in ESZs

- **Prohibited: commercial mining**, setting of **sawmills** and **industries causing pollution**, **commercial use of firewood** & **major hydropower projects** are prohibited in ESZ areas. It also bans tourism activities like **flying over protected areas in an aircraft or hot air balloon** and the **discharge of effluents** and **solid waste** in water bodies or terrestrial areas.
- **Regulated:** felling of trees, drastic change in agriculture systems, commercial use of natural water resources, including groundwater and **setting up of hotels and resorts** are the activities regulated in the areas.
- **Permitted:** ongoing agriculture and horticulture practices by local communities, rainwater harvesting, **organic farming**, **adoption of green technology** and use of renewables.

**[UPSC 2014] With reference to 'Eco-Sensitive Zones', which of the following statements is/are correct?**

1) Eco-Sensitive Zones are the areas that are declared under the Wildlife (Protection) Act, 1972.
2) The purpose of the declaration of Eco-Sensitive Zones is to prohibit all kinds of human activities, in those zones except agriculture.

***Select the correct answer using the code given below.***

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

**Explanation**

- Eco-Sensitive Zones areas are based on the **core (all kinds of human activity are prohibited)** and **buffer (grazing**, **collection of minor forest produce**, **subsistence agriculture**, **etc**. **are allowed on a sustainable basis)** model of management.

***Answer: d) Neither***

## Conservation Reserves

- A **State Government** can declare **Conservation Reserves** in **any area owned by it**, particularly those adjacent to National Parks and Sanctuaries and those that link one protected area with another. Such a declaration should be made after consultations with the **local communities**.

## Community Reserves

- The **State Government** can declare **Community Reserves** in **any private or community land where an individual or a community has volunteered** to conserve wildlife and its habitat. Such land **should not** be comprised within a National Park, Sanctuary or Conservation Reserve.
- The **rights of people living inside a Conservation Reserve and Community Reserve are not affected**.

⇨ ***Protected Area (PA)*** *has been defined in the* ***Wildlife (Protection) Act of 1972****. Protected Areas include* ***National Parks****,* ***Sanctuaries****,* ***Conservation Reserves*** *and* ***Community Reserves****.*

**[UPSC 2023] Consider the following statements: Once the Central Government notifies an area as a 'Community Reserve'**

1. the Chief Wildlife Warden of the State becomes the governing authority of such forest
2. hunting is not allowed in such area.
3. people of such area are allowed to collect non-timber forest produce.
4. people of such area are allowed traditional agricultural practices.

***How many of the above statements are correct?***

a) Only one
b) Only two
c) Only three
d) All four

**Explanation**

***Statement 1 is incorrect, and Statements 2, 3 and 4 are correct***

- As per Wildlife (Protection) Amendment Act 2002 (WLPAA):
  - ❖ The **State Government** shall constitute a **Community Reserve management committee**, which shall be the authority responsible for conserving, maintaining and managing the community reserve.
  - ❖ The Committee shall consist of five representatives nominated by the **Village Panchayat** or where such Panchayat does not exist by the **members of the gram sabha** and **one representative of the State Forests or Wildlife Department** under whose jurisdiction the community reserve is located.
  - ❖ Restrictions and regulations applicable to the **wildlife sanctuaries** are applicable to the Community reserves, too.

***Answer: c) Only three***

## Sacred Groves

- **Sacred groves** are tracts of forests preserved by ancient societies on religious and cultural grounds. All the trees and wildlife within were venerated and protected by the communities.

- Such sacred groves are found in the **Khasi and Jaintia Hills in Meghalaya**, **the Aravalli Hills of Rajasthan**, **the Western Ghats of Karnataka**, **and Maharashtra**, **the Chanda and Bastar areas of Chhattisgarh**.

## 9.2. Ex Situ Conservation

- In this approach, **threatened animals and plants** are **taken out of their natural habitat** and placed in a unique setting where they can be protected and given special care. **Zoological Parks**, **Botanical Gardens**, **Wildlife Safari Parks**, and **Seed Banks** serve this purpose.
- Many animals have become extinct in the wild but continue to be maintained in zoological parks. The initial purpose of zoos was entertainment. Over the decades, zoos have transformed into centres for wildlife conservation (through captive breeding) and environmental education.
- In recent years, ex-situ conservation has advanced beyond keeping threatened species. Now **gametes** of threatened species can be preserved in viable and fertile conditions for extended periods using cryopreservation techniques. Eggs can be fertilised in vitro, and plants can be propagated using tissue culture.
- Seeds of different genetic strains of commercially important plants can be kept for long periods in **seed banks**. The **National Gene Bank** at the **National Bureau of Plant Genetic Resources (ICAR-NBPGR)**, **Delhi**, is primarily responsible for conserving unique accessions on a long-term basis as base collections for posterity, predominantly in the form of seeds.

**[UPSC 2011-12] Which one of the following is not a site for in-situ method of conservation of flora?**

a) Biosphere Reserves
b) Botanical Garden
c) National Park
d) Wildlife Sanctuary

**Explanation**

- A **botanical garden** is a scientifically planned collection of living trees, shrubs, herbs, climbers and other plants from various parts of the globe. It augments **conserving rare and threatened species**.

***Answer: b) Botanical Garden***

## 9.3. National Initiatives

### Wildlife Mitigation Measures – Eco-Bridges

- Several underpasses and overpasses (**eco-bridges**) are being built along **NH 44** that cuts through corridors connecting **Kanha**, **Satpura**, **Pench**, **Bandhavgarh and Panna tiger reserves**.
- **Eco-bridges** **enhance wildlife connectivity** in areas disrupted by highways. Usually, these bridges are overlaid with planting to give them a contiguous look with the landscape. Eco-bridges include:

1. **canopy bridges** (usually for monkeys, squirrels and other arboreal species);
2. **concrete underpasses or overpass tunnels** or **viaducts** (usually for larger animals); and
3. **amphibian tunnels** or **culverts**.

## Quarantine Centres to Check Invasive Species

- India has several plant quarantine centres at major airports, seaports, and railway stations. They are under the control of the **Central Board of Indirect Taxes and Customs**, which works in coordination with the **Directorate of Plant Protection and Quarantine Storage (DPPQS)**.
- The import of agricultural products is governed by the **Destructive Insects and Pests act**, **1914**. **DPPQS** of **Ministry of Agriculture and Farmers Welfare (MAFW)** is responsible for the **control of invasive pests/weeds**. MAFW has lists of plants whose import is allowed/restricted/banned.
- When an agricultural product arrives, customs officials check if it has a **phytosanitary certificate**. This certificate, showing that the product is without any pest/weed infestation, is issued by the exporting country.
- If the product is certified, **it is cleared by DPPQS after a sample test**. If the product has not been given a phytosanitary certificate, DPPQS fumigates the product with **methyl bromide (gas fumigant for soil-borne diseases and pests)** and issues a phytosanitary certificate.

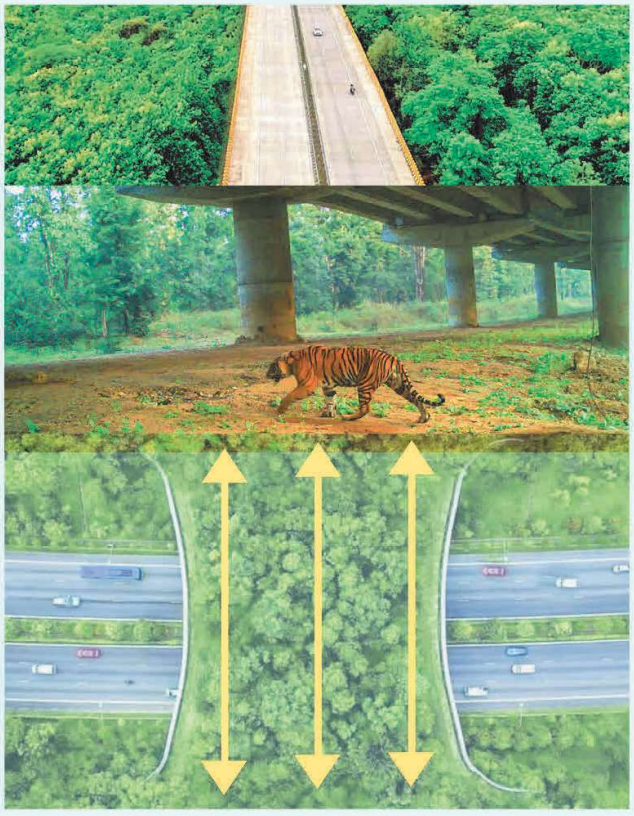
### Issues with the functioning of the quarantine centres

- Only half of India's quarantine centres are functional. The rest are shut down as the import-export is negligible or because of staff shortage.
- Customs officials often release the cargo without referring it to DPPQS. Nepal, for instance,

**Eco-Bridge or Eco-Duct**

**Canopy Bridges**
**(For monkeys, squirrels & arboreal species)**

**Concrete Underpasses or Overpass Tunnels or Viaducts (For larger animals)**



**Amphibian Tunnels or Culverts**

stopped the entry of agricultural products from India without a phytosanitary certificate after the outbreak of acute encephalitis syndrome in Bihar a year ago.

- Security at India's quarantine stations is also virtually non-existent, and items disappear in transit.

## Preservation of the Western and Eastern Ghats

- Western and Eastern Ghats play an irreplaceable role in mediating the monsoon over the country, and the forests harbour **rich biodiversity**. Human encroachment, tourism, deforestation, sand mining, iron mining (Goa), etc., pose severe threats to the ecosystem of the ghats.

### Western Ghats

- Western Ghats (1,64,280 sq km) runs from Kanyakumari to Gujarat, spanning **six states — Maharashtra**, **Karnataka**, **Tamil Nadu**, **Kerala**, **Gujarat**, and **Goa**. It exhibits a remarkably high degree of species endemism. It is a **UNESCO World Heritage Site** and one of the eight "hottest hotspots" of biological diversity in the world.

### Eastern Ghats

- The Eastern Ghats are spread across ~75,000 sq km and run from northern **Odisha** through **Andhra Pradesh** to **Tamil Nadu** in the south, passing some parts of **Karnataka** and **Telangana**.
- Unlike the Western Ghats, these are **discontinuous hills** as they are eroded and cut through by the Godavari, Mahanadi, Krishna, and Kaveri rivers.
- Deforestation has made the hills of the Eastern Ghats barren, and its streams are running dry. Large-scale plantations of coffee, tea and orchards have been raised in these hills. Valuable trees like **red sanders** (from **Seshachalam Hills**) are removed illegally.

### Madhav Gadgil Committee

- The MoEF constituted the **Western Ghats Experts Ecology Panel (WGEEP)** in 2010. The Panel submitted its report in 2011 with a **stringent assessment** of the condition of the Western Ghats. It was criticised that the committee **failed to balance development and conservation**.
- The report suggested many **radical changes** that need to be brought to conserve the Western Ghats. The recommendations, if implemented, would severely affect the mining mafia, sand mafia and local encroachers.

#### Recommendations of Gadgil Committee (WGEEP) Report

- The report asked for a **bottom-to-top approach**, i.e., from Gram sabhas to the top. It had recommended that a massive **64% of the area come under Ecologically Sensitive Area (ESA)**. Within this area, smaller regions were to be identified as **ecologically sensitive zones (ESZ) I**, **II or III**.
  - ✓ **75% would fall under ESZ I or II** or already existing protected areas such as natural parks.
  - ✓ **No new dams** based on large-scale storage should be permitted in **ESZ I**.
  - ✓ **No new polluting industries**, including thermal power plants, should be allowed in **ESZ I and II**.
  - ✓ The existing **red and orange category industries** should be asked to switch to zero pollution by 2016.

- The committee proposed a **Western Ghats Ecology Authority** with **statutory powers** to regulate these activities.

### Kasturirangan Committee

- Under pressure from various stakeholders, MoEF set up the **High-Level Working Group (HLWG)** under the Chairmanship of **Dr K. Kasturirangan** to study the recommendations of the Gadgil Committee.
- The HLWG had **diluted** many recommendations of WGEEP to satisfy the interests of the various mafia. HLWG had suggested that **37%** (60,000 hectares) of the Western Ghats should be declared as ESA.

#### Recommendations of the Kasturirangan Committee

- ✓ A ban on mining, quarrying and sand mining.
- ✓ No new thermal power projects, but hydropower projects are allowed with restrictions.
- ✓ A ban on new polluting industries.
- ✓ Building and construction projects up to 20,000 sq m were to be allowed, but townships were to be banned.
- ✓ Forest diversion could be allowed with extra safeguards.

### October 2018 notification

- To protect the **Western Ghats**, the MoEF has notified ~57,000 sq km of the Western Ghats spread along with six states as **ecologically sensitive areas (ESA)**. The draft notification, if it gets final clearance, **will ban** activities such as
  - ✓ **red category industries**,
  - ✓ **construction of thermal power plants**,
  - ✓ **large scale construction**, **mining**, **quarrying**, **sand mining**.
- However, **hydropower projects**, **orange category industries** and other existing activities will be allowed. Angry at repeated delays in finalising the Eco-sensitive Zones (ESZ) of the Western Ghats, the NGT has set a March 2020 deadline for the MoEF. However, the draft notification has **not received approval to date**.

## Historic Citizen Movements

- **Environmentalist Sundarlal Bahuguna**, who led the **Chipko and Tehri dam movements**, breathed his last due to COVID-19 in 2021. He is known as the **Defender of the Himalayas** and **Environmental Gandhi**.
- He protested for the preservation of forests in the **Himalayas** and led the **Chipko Movement** in the 1970s and the **Anti- Tehri Dam movement** starting in the 1980s. He believed that **'Ecology is the permanent economy'**.

### Chipko Movement

- Chipko means 'To Hug'. It is a social-ecological movement that practised the **Gandhian methods of satyagraha** and nonviolent resistance through **hugging trees to protect them from falling**. The first

recorded event occurred in Khejarli Village, Jodhpur, in 1730 AD. 363 Bishnois, led by Amrita Devi, sacrificed their lives while protecting **Khejri trees (the state tree of Rajasthan)**, considered sacred by the **Bishnoi community**.

- The first Chipko movement in independent India took place in April 1973 in **Upper Alakanada valley** (**Garhwal Region** in Uttarakhand (back then, it was in UP)) when the government had allotted land inside forest territory to a manufacturer. By the 1980s, the movement had spread throughout India and led to the formulation of people-sensitive forest policies, which stopped the open felling of trees in regions as far-reaching as the Western Ghats.

#### Role of Sunderlal Bhaguna

- Sunderlal Bhaguna travelled 5000 km on foot from village to village, gathering support for the movement. He had a meeting with Indira Gandhi and that resulted in **15 years ban on cutting green trees in 1980**.

#### Role of Women in the Movement

- A woman named Gaura Devi noticed that local loggers are cutting trees in Reni Village. She mobilised many other women in Reni village and confronted and challenged them to shoot her instead of cutting trees. Therefore, the Chipko Movement is aptly called as **Women's Movement**.

### Appiko Movement

- Appiko is a **local term** for **Hugging** in **Kannada**. It was inspired by the massive success of the Chipko Movement in North India. It first started in Karnataka in 1983. It gave birth to a new awareness all over southern India.

### Anti-Tehri Dam Protest

- Sunderlal Bahuguna was instrumental in protests against the construction of **Teri Dam** (Garhwal region, Uttarakhand). The dam and the floods cause massive **damage to downstream** public life.

⇨ *Tehri Dam is a 2,400-megawatt multipurpose dam on the **Bhagirathi River** (a tributary of the **Ganga** in Uttarakhand). It is **India's tallest dam**. It lies in the Himalayas Seismic Gap, a **Major fault zone** (prone to landslides and earthquakes).*

## 9.4. Convention on Biological Diversity (CBD)

- The **UN Convention on Biological Diversity (CBD)** is a **legally binding multilateral treaty**. It was opened for signature at the **Earth Summit in Rio de Janeiro in 1992** and entered into force in 1993. All UN member states — **except the United States** — have ratified the treaty.
- With a focus on **sustainable development**, the convention has three main goals:
  1) **conservation of biological diversity**,
  2) **sustainable utilisation of its benefits/components**, **and**
  3) **fair and equitable sharing of benefits arising from genetic resources**.

- Parties to the Convention: 196 (195 countries and the European Union). (*States that have agreed to be bound by the convention are known as Parties)*

## Cartagena Protocol on Biosafety

- The **Cartagena Protocol** on **Biosafety** to the **Convention on Biological Diversity** (CBD) is an **international agreement** adopted in 2000. It entered into force in 2003 and covers the field of **biotechnology**. It currently has 173 parties. **India** has ratified CBD and its Catanga Protocol (signed in Cartagena, Colombia).
- Cartagena Protocol aims to ensure the safe handling, transport, and use of **living modified organisms (LMOs)** resulting from **modern biotechnology**. It addresses technology development and transfer, benefit-sharing and biosafety issues.

## Nagoya Protocol on Access and Benefit-sharing

- At the 10th Conference of Parties (COP10 2010) to the Convention on Biological Diversity in Nagoya, Japan, the **Nagoya Protocol** was adopted. It is the **second Protocol (supplementary agreement)** to the **CBD**. It entered into force in 2014. It presently has 137 parties, including India.
- **Nagoya Protocol** is about "**Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization**", one of the three objectives of the **CBD**.

## International Treaty on Plant Genetic Resources for Food and Agriculture (PGRFA)

- **PGRFA** is popularly known as the **International Seed Treaty**. It is an international agreement in harmony with CBD. It aims at **guaranteeing food security** through the conservation, exchange, and **sustainable use of the world's plant genetic resources for food and agriculture**, as well as the **fair and equitable benefit sharing** arising from its use.

### [UPSC 2016] Consider the following pairs:

| Terms sometimes in the news | Their origin |
|---|---|
| 1) Annex-I Countries | Cartagena Protocol |
| 2) Certified Emissions Reductions | Nagoya Protocol |
| 3) Clean Development Mechanism | Kyoto Protocol |

***Which of the pairs given above is/are correctly matched?***

a) 1 and 2 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

**Explanation**

- **Annex-I Countries**, **Clean Development Mechanism**, **Certified Emission Reductions (CERs) or carbon credits** ➔ **Kyoto Protocol**.

***Answer: c) 3 only***

**[UPSC 2014] Consider the following international agreements:**

1) The International Treaty on Plant Genetic Resources for Food and Agriculture
2) The United Nations Convention to Combat Desertification
3) The World Heritage Convention

***Which of the above has/have a bearing on the biodiversity?***

a) 1 and 2 only
b) 3 only,
c) 1 and 3 only
d) 1, 2. and 3

***Answer: d) all***

## Aichi Biodiversity Targets

- At CBD COP 12 (2014), parties discussed the implementation of the **Strategic Plan for Biodiversity 2011-2020** & its **Aichi Biodiversity Targets** — to be achieved before 2020:
  1. Goal A: Address the underlying **causes of biodiversity loss**.
  2. Goal B: Reduce the direct pressures on biodiversity and **promote sustainable use**.
  3. Goal C: Safeguard ecosystems, species & genetic diversity.
  4. Goal D: Enhance the **benefits to all from biodiversity** and ecosystem services.
  5. Goal E: Enhance participatory management.
- **None of the 20 'Aichi Biodiversity Targets'** agreed on by national governments through theCBD has been met, according to CBD's Global Biodiversity Outlook 5 report.

### Sharm El Sheikh Declaration – New Deal for Nature

- COP 14 of CBD adopted this declaration in Sharm El city (also called the city of peace) in Egypt. It focuses on **integrating biodiversity into legislative & policy frameworks**.
- It aims to develop a **Post-2020 Global Biodiversity Framework** (after **failed Aichi Biodiversity Targets**) to achieve the **2050 vision for biodiversity** known as **New Deal for Nature** — catalyse action from all stakeholders in support of biodiversity conservation.

## COP-15 of the UN CBD

- **CBD COP15** serves as the **10th** Meeting of the Parties to the **Cartagena Protocol** on Biosafety and the **4th** Meeting of the Parties to the **Nagoya Protocol** on Benefit-sharing.
- **CBD COP15** was initially scheduled to take place in October 2020 in **Kunming**, China. It was rescheduled to December 2022 & moved to **Montreal**. **China & Canada co-hosted it**.
- **CBD COP15** adopted the **Kunming-Montreal Global Biodiversity Framework** (**Post-2020 Global Biodiversity Framework**). It sets out **four global goals to achieve by 2050**, as well as **23 global targets by 2030**.

- A new **Global Biodiversity Framework Fund** will be established under the **Global Environment Facility**. It targets at least **USD 200 billion annually by 2030**.

### India's Demands at COP 15

- India called for an urgent need to create a new and dedicated fund to help developing countries. So far, the **Global Environment Facility**, which caters to multiple conventions, including the **UNFCCC** and **UNCCD**, remains the only funding source for biodiversity conservation.
- India also said that biodiversity conservation must be based on '**Common but Differentiated Responsibilities and Respective Capabilities' (CBDR)** as climate change also impacts nature.

## Post-2020 Global Biodiversity Framework

### 4 Global Goals by 2050

1. **Reducing the extinction rate** and **risk of all species tenfold (by 2050)**.
2. Biodiversity is sustainably used for achieving **sustainable development**.
3. Substantially increase **fair and equitable benefit-sharing** from utilising genetic resources.
4. Adequate **finance and technology** to implement the Kunming-Montreal Global Biodiversity Framework, progressively closing the biodiversity finance gap of 700 billion $ annually.

### 23 Global Targets By 2030

- The targets are divided into three broad categories:

#### 1) Reducing threats to biodiversity (by 2030) – 8 Targets

1. Bring biodiversity loss in areas of high biodiversity close to zero.
2. **30×30 Pledge: Restore at least 30% of areas of degraded ecosystems** (terrestrial, inland water, coastal, marine).
3. **Conserve at least 30% of ecosystems** (terrestrial, coastal, marine), especially areas of high biodiversity.
4. Halt human-induced **extinction** of known threatened species and significantly reduce extinction risk.
5. Ensure that the harvesting/**trade of wild species** is sustainable and safe (reducing pathogen spillover).
6. **Reduce invasive alien species by at least 50%**.
7. Reduce **pollution** risks, by 2030, to levels that are not harmful to biodiversity and **reduce the nutrients lost and overall risk from pesticides and hazardous chemicals by 50%**.
8. Minimize the impact of **climate change** and **ocean acidification** on biodiversity.

#### 2) Meeting people's needs through sustainable use and benefit-sharing (by 2030) – 5 Targets

1. Sustainable use of **wild species**.
2. Ensure that areas under agriculture, aquaculture, fisheries, and forestry are managed sustainably.
3. Enhance **ecosystem functions and services** —pollination, disaster protection, etc.

4. **Sustainable urbanisation** by increasing green and blue spaces (trees and water bodies).
5. Ensure **fair and equitable benefit-sharing** for utilising genetic resources and information.

**3) Tools and solutions for implementation and mainstreaming (by 2030) – 10 Targets**

1. Ensure the full integration of biodiversity into policies, planning, **national accounting**, etc.
2. Take measures to encourage **corporations** to **reduce negative impacts** on biodiversity.
3. Ensure sustainable consumption choices and reduce **overconsumption**, food waste, etc.
4. Strengthen the handling of biotechnology and **biosafety** measures in CBD.
5. **Phase out subsidies harmful to biodiversity** and **reduce them by at least USD 500 billion annually**.
6. Increase **finance** by 2030 by mobilising at least **200 billion $ per year**. Wealthier countries should contribute at least **20 billion $ of this annually by 2025** and at least **30 billion $ annually by 2030**.
7. Ensure the transfer of technology and scientific cooperation.
8. Ensure the best available data, information, and knowledge for decision-makers.
9. Ensure social and **gender-responsive representation** and participation in decision-making.
10. Ensure **gender equality** in the implementation of the framework.

## 9.5. Other International Efforts

### Global Partnership on Forest and Landscape Restoration (GPFLR)

- GPFLR is a global network initiated by **IUCN** to unite governments, organizations, communities, etc. working towards a common goal: to **restore the world's lost and degraded forests** and their surrounding landscapes.
- Specifically, the GPFLR responds directly to the **Bonn Challenge** to **restore 150 million hectares of deforested and degraded land by 2020** and **350 million hectares by 2030**.

### Bonn Challenge

- The **Bonn Challenge**, launched in 2011 by the **Government of Germany** and **IUCN**, aimed to **restore 150 million hectares** o**f deforested and degraded land by 2020**.
- In 2014, at the UN Climate Summit, countries extended this target to **350 mha by 2030** under the **New York Declaration on Forests** — a **voluntary and non-binding international declaration** to take action to **halt global deforestation**.
- At the **UNFCCC 2015 in Paris**, India joined the **voluntary Bonn Challenge**. It pledged to restore **13 million hectares of degraded and deforested land by 2020** and an **additional 8 mha by 2030** (**21 mha in total by 2030**). This was raised to a target of **26 mha by 2030** during the **UNCCD 2019** conference held in Delhi.

**[UPSC 2021] With reference to the 'New York Declaration on Forests,' which of the following statements are correct?**

1) It was first endorsed at the United Nations Climate Summit in 2014.

2) It endorses a global timeline to end the loss of forests.
3) It is a legally binding international declaration.
4) It is endorsed by governments, big companies and indigenous communities.
5) India was one of the signatories at its inception.

***Select the Correct answer using the code given below***.

a) 1, 2 and 4
b) 1, 3 and 5
c) 3 and 4
d) 2 and 5

**Explanation**

- The **New York Declaration on Forests (NYDF)** is a **political declaration** calling for **global action to protect and restore forests**. It was adopted in **2014** at **UN Secretary-General's Climate Summit**. It offers a common, multi-stakeholder framework for forest action. **India did not sign the declaration** citing that the **trade is being interlinked with climate change and forest issues** by NYDF.
- NYDF's ten goals include **halting natural forest loss by 2030**, **restoring 350 million hectares of degraded landscapes and forestlands**, improving governance, increasing forest finance, and reducing emissions from deforestation and forest degradation as part of a **post-2020 global climate agreement**.

***Answer: a) 1, 2 and 4 only***

## Forest Landscape Restoration (FLR)

- **IUCN and** the **World Wide Fund for Nature (WWF)** coined the term **FLR** in 2000. **FLR** is a planned process that aims to **regain ecological integrity** and **enhance human well-being** in **deforested and degraded landscapes**. FLR is **not site-based** but is applied across large areas. FLR has received global attention since 2011, after the launching of the **Bonn Challenge**.
- The **seven** guiding principles of FLR are:
  1. Maintain **natural ecosystems**.
  2. Focus on **entire landscapes** rather than individual sites.
  3. Enhances the **conservation**, **recovery**, **and sustainable management** of forests.
  4. Actively **engages all stakeholders**.
  5. Adopts **traditional and indigenous knowledge**.
  6. Restore **multiple ecological**, **social**, **& economic functions**.
  7. Manage adaptively for **long-term resilience**.

**Mains Practice: What do you understand by Forest Landscape Restoration (FLR)? While identifying the principles of FLR enumerate the initiatives taken by the Government to restore India's Forest and Tree Cover..**

- Briefly define Forest Landscape Restoration (FLR) approach and its underlying principles.

- Concisely explain how FLR is different from conventional forest conversation methods.
- Integrated Landscape Management: Inclusive approach (engaging all stakeholders) → Collaborative community-linked plans → Integrated resource management (Resource Optimization) → Sustainable development.
- Enumerate the efforts taken by the government: **National Afforestation Programme (NAP)**, **National Mission for a Green India (Green India Mission – NAPCC)**, **National Forest Policy 1988**, **Joint Forest Management (JFM)**, **Compensatory Afforestation Fund Management** and **Planning Authority (CAMPA)**, **Green Highway Policy 2015**, **Policy for enhancement of Urban Greens**, **Bonn Challenge**, **National Agroforestry Policy**, **and Sub-Mission on Agroforestry (SMAF)**, **etc**.

## World Forestry Congress and Seoul Declaration

- **XV (15th) World Forestry Congress (WFC)** was hosted in **Seoul** by the Korea Forest Service and **FAO**. It was the second World Forestry Congress held in Asia, with Indonesia hosting the first congress in Asia in 1978. **Theme: Building a Green, Healthy and Resilient Future with Forests**.
- WFC is the largest gathering of the world's forestry sector. It has been held **every six years** since 1926 under the auspices of **FAO** and is organised by the government of the host country. It is a **forum** for the sharing of knowledge and experience.
- The **Seoul Declaration** stressed the transition towards a **circular bioeconomy** (basic building blocks for materials, chemicals, and energy are derived from **renewable biological resources**) and achieving **climate neutrality**.

### Prelims Practice: "Seoul Declaration", which was in the news recently, is related to?

a) Universal Declaration of Human Rights
b) WTO agreement on reducing subsidies
c) World Forestry Congress
d) Freedom of the Press

**Explanation**

- **Seoul Declaration** was adopted at the XV World Forestry Congress, held in Seoul, South Korea. Its theme was **Building a Green, Healthy and Resilient Future with Forests**. **Hence option (c) is the correct answer**.

### Prelims Practice: Recently AFFIRM and SAFE initiatives were in news. They are related to?

a) Forest management
b) Wildlife protection
c) Human trafficking
d) Wetlands

**Explanation**

- **Assuring the Future of Forests with Integrated Risk Management (AFFIRM) Mechanism** and **Sustaining an Abundance of Forest Ecosystems (SAFE) Initiative** were among important initiatives undertaken during the **XV World Forestry Congress**, **held in Seoul**, **South Korea**. **Hence option (a) is the correct answer**.

## Initiatives By The UN

### United Nations Strategic Plan for Forests 2017–2030

- The Strategic Plan, forged at **UN Forum on Forests** held in 2017 and adopted by the **UN General Assembly**, features **six Global Forest Goals** and 26 associated targets to be reached by **2030**, which are **voluntary** and universal. It includes a target to **increase forest area by 3% worldwide by 2030**, signifying an increase of **120 million hectares**.

### Decade on Ecosystem Restoration

- The **United Nations General Assembly** has proclaimed **2021–2030 as the Decade on Ecosystem Restoration**. **UNEP**, **FAO** and many partners across the planet will work towards 2021-2030 ecosystem restoration. The Work planned for 2021–2030 will contribute to achieving targets set by international conventions and agreements, such as:
  - ✓ 2030 Agenda for Sustainable Development,
  - ✓ **Strategic Plan for Biodiversity 2020**, **Aichi Targets**,
  - ✓ UN Framework Convention on Climate Change,
  - ✓ Paris Agreement,
  - ✓ UN Convention to Combat Desertification and **Land Degradation Neutrality LND**,
  - ✓ Ramsar Convention,
  - ✓ **Global Partnership on Forest and Landscape Restoration**,
  - ✓ **Global Restoration Council and the UN Strategic Plan for Forests 2017– 2030**.

### Biodiversity Finance Initiative (BIOFIN)

- BIOFIN was launched by **UNDP** in 2012. It aims to fill the biodiversity finance gap at the national level. It helps in implementing the **National Biodiversity Action Plan (NBAP)** and making progress towards achieving the **National Biodiversity Targets (NBTs)**.
- BIOFIN in India is hosted by the **National Biodiversity Authority (NBA – MoEF)**, working with relevant **State Biodiversity Boards**, with technical assistance from **Wildlife Institute of India (WII)** and the **National Institute of Public Finance and Policy (NIPFP)**.

### UNESCO World Heritage Sites

- UNESCO adopted the World Heritage Convention, an international treaty, in 1972. It provides a framework for international cooperation in preserving and protecting **cultural treasures and natural areas (including those of exceptional biodiversity)**.

- The convention defines the kind of sites that can be considered for inscription to the **World Heritage list**. It sets out the duties of the State Parties in identifying potential sites and their role in protecting them.
- World Heritage Sites means "Sites any of various areas or objects inscribed on the United Nations Educational, Scientific, and Cultural Organization (**UNESCO**) World Heritage List". The sites are designated as having **outstanding universal value concerning the Protection of the World's Cultural** (ancient monuments, museums) **and Natural Heritage** (biodiversity, geological heritage).
- UNESCO has a set of ten criteria. Nominated sites (both cultural and natural) must be of "**outstanding universal value**" and must meet **at least one of the ten criteria**.
- Natural heritage sites are restricted to those natural areas that
  1) furnish outstanding examples of the **earth's record of life** or its **geologic processes**.
  2) provide excellent examples of ongoing ecological and biological evolutionary processes.
  3) contain natural phenomena that are rare, unique, superlative, or of outstanding beauty.
  4) furnish habitats or rare **endangered** animals or plants or are sites of **exceptional biodiversity**.

**---------- End of Chapter ----------**

# 10. Wildlife Conservation Part I

- Conservation generally means **judicious** use of biotic and abiotic resources. It involves the prevention of wasteful and/or harmful utilisation of resources. Wildlife conservation refers to protecting wild species and their **habitats** to keep the natural ecosystems healthy.

## 10.1. Regulating Trade in Wildlife

### Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

- **CITES**, also known as the **Washington Convention**, is an international agreement (**multilateral treaty**) between governments to ensure that **international trade in specimens of wild animals and plants does not threaten their survival**. It was drafted in **1963** following a resolution adopted by members of IUCN and entered into force in 1975.

#### Parties to CITES

- **CITES is legally binding on the Parties** (184 (including EU)). However, it **does not take the place of national laws**. It only **provides a framework** to be respected by each Party. The parties need to adopt their own domestic legislation to ensure that CITES is implemented at the national level.

**[UPSC 2015] With reference to the IUCN and the CITES, which of the following statements is/are correct?**

1) IUCN is an organ of the United Nations and CITES is an international agreement between governments.
2) IUCN runs thousands of field projects around the world to better manage natural environments.
3) CITES is legally binding on the States that have joined it, but this convention does not take the place of national laws.

***Select the correct using the code given below.***

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

**Explanation**

- **IUCN is an NGO**. **CITES** is an **international agreement** between governments (multilateral treaty).

***Answer: b) 2 and 3 only***

#### Conference of Parties to CITES (CoP)

- The CITES CoP (**World Wildlife Conference**) is where parties convene **every two to three years** to review and decide on regulating trade in endangered species. The CoP will decide on proposals to **list**, **remove**, **or change species listing on the CITES appendices**.

## Functioning of CITES

- CITES works by subjecting **international trade in specimens** of **selected species** to specific controls. All import and export of species covered by CITES must be authorised through a **licensing system**.
- Each Party designates one or more **Management Authorities** for administering the licensing system and one or more **Scientific Authorities** to advise them on the effects of trade on the status of the species.
  - **Management Authority in India: Director of Wildlife Preservation**, MoEFCC.
  - **Management Authorities competent to grant permits: Wildlife Crime Control Bureau (WCCB)**.
  - **Scientific Authorities:** Zoological Survey of India, Botanical Survey of India, **Wildlife Institute of India**, etc.

## The protection offered to species by CITES

- The species covered by CITES are listed in **three Appendices** according to the required degree of protection:
  1. **Appendix I** includes **species threatened with extinction**. **Trade in specimens** of these species is **permitted only in exceptional circumstances** — like for captive breeding. (**Legal international trade of the species does not take for commercial purposes**)
  2. **Appendix II** includes species **not necessarily threatened with extinction** but in which **trade must be controlled** to avoid utilisation incompatible with their survival.
  3. **Appendix III** contains species **protected in at least one country**, **which has asked other CITES Parties for assistance in controlling the trade**.
- At each regular meeting of the CoP, Parties submit proposals to amend **Appendices I and II**. Those amendment proposals are discussed and then submitted for a vote.

## The 18th Conference of the Parties to CITES (CoP18)

- In CoP18, held in **Geneva**, **Switzerland**, **in 2019**, India submitted proposals
  - ✓ to move Smooth-Coated Otter (VU), Small-Clawed Otter (VU), Indian Star Tortoise (VU), Tokay Gecko (LC) and Wedgefish (CR) from Appendix II to Appendix I.
  - ✓ to remove Indian Rosewood (VU) from **Appendix II**.
- In 2019, **Star Tortoise (VU)**, **Asian Small-Clawed (VU)** and **Smooth-Coated Otters (VU)** were moved to **Appendix I**. **A complete ban was enforced on their trade**.

## 19th Conference of the Parties to CITES (CoP19)

- CoP19 was held in **Panama** in November 2022. 52 proposals have been put forward that would affect the regulations on international trade for sharks, reptiles, elephants, turtles, etc.
- **Operation Turtshield**, India's efforts to curb turtle wildlife crime, was acknowledged at CoP19.

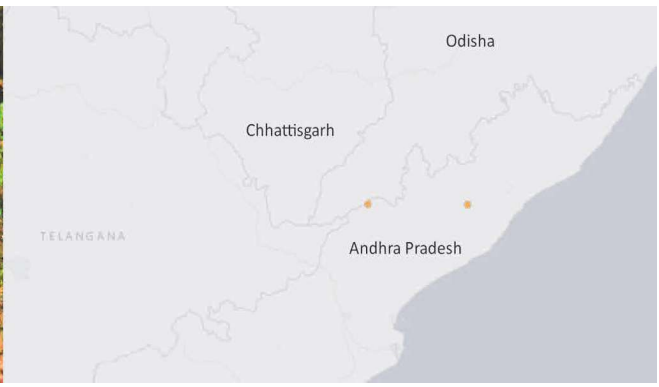
- **First World Wildlife Trade Report** was released at the COP19. It gave insights into the international trade in animals and plants regulated under the **CITES treaty**. According to the report, majority of CITES-regulated trade involved **artificially propagated** (for plants) or **captive-produced** (for animals bred or born in captivity) species. **Only 18% of all trade involved wild-sourced species** (which are **dominated by plants**).

## India's Proposals

- India proposed moving the **Red-Crowned Roofed Turtle (*Batagur kachuga* – CR)** and **Leith's softshell turtle (*Nilssonia leithii* – CR)** from **Appendix II to I**.
- India's proposal to include the **Jeypore Ground (Indian) Gecko (EN)** in **Appendix II** was adopted by the members of the CITES Working Group.

### Jeypore Ground (Indian) Gecko (EN)

- The wild reptile species is **endemic to the Eastern Ghats** and is known to be present in a handful of locations in **southern Odisha** and **northern Andhra Pradesh**. The species resides below rock boulders in high forested hills at an altitude of 1,100-1,400 metres.
- Threats: international pet trade, habitat loss and degradation, forest fires, tourism, quarrying, mining, etc.
- **IUCN Red List: EN | CITES: NA | WPA: NA**

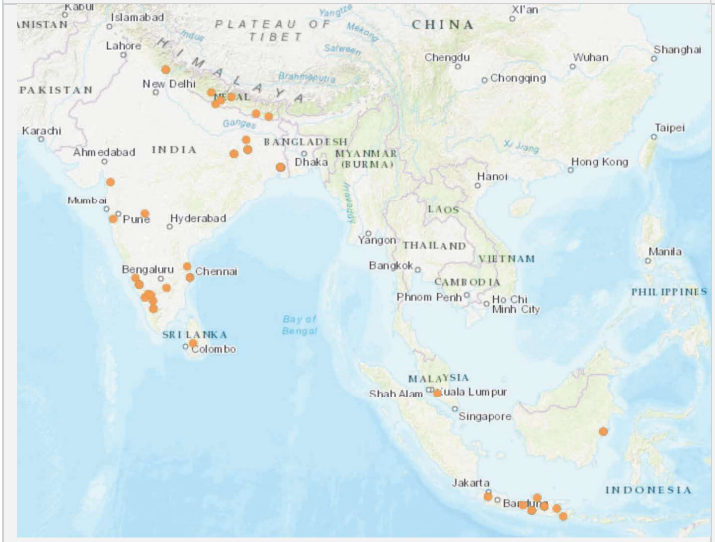
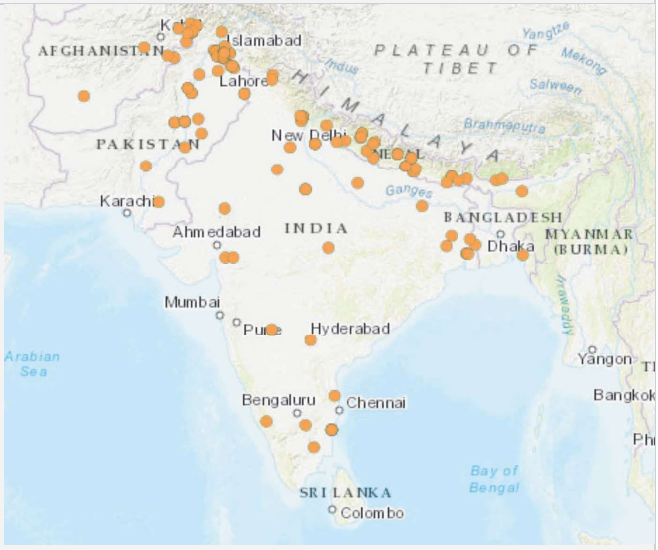



### North Indian Rosewood/Shisham (*Dalbergia sissoo*)

- **Shisham (LC)** is found in **abundance** in India. However, it is included in **CITES Appendix II** because of the challenges in distinguishing different species of genus Dalbergia in their finished forms.
- As of now, **every shisham consignment of weight above 10 kg** requires a **CITES permit**. Due to this restriction, exports of furniture and handicrafts made of shisham from India have continuously fallen.
- On India's initiative at CoP19, it was agreed that **any number of shisham timber-based items of weight less than 10kg could be exported as a single consignment without CITES permits**. Further, it was agreed that for the net weight of each item, only shisham timber used would be considered.

⇨ *India has two species of **Dalbergia** — D. latifolia or **Indian rosewood (VU)**, and D. sissoo or **North Indian rosewood/Shisham (LC)**. (Both are in CITES: App. II | WPA: NA)*

| ***D. latifolia*/Indian Rosewood (VU)** | ***D. sissoo*/North Indian Rosewood/Shisham (LC)** |
|---|---|

| | |
|---|---|
| Large **evergreen** tree native to low-elevation **monsoon forests of south India**. Its drier subpopulations are deciduous. | Fast-growing, hardy, medium to large **deciduous tree** native to the **foothills of the Himalayas**. |
| The tree produces a hard, durable, heavy wood that is durable and resistant to rot and insects. | Its timber is less valuable because of its abundance. |
|  |  |

## Other Proposals

### Thelenota (Sea Cucumbers)

- The EU proposed three species under the **genus Thelenota (sea cucumbers)** to be included in **Appendix II**. CoP19 accepted the proposal. Sea cucumbers were one of the most frequently trafficked marine species from coastal India.

### Ivory Trade

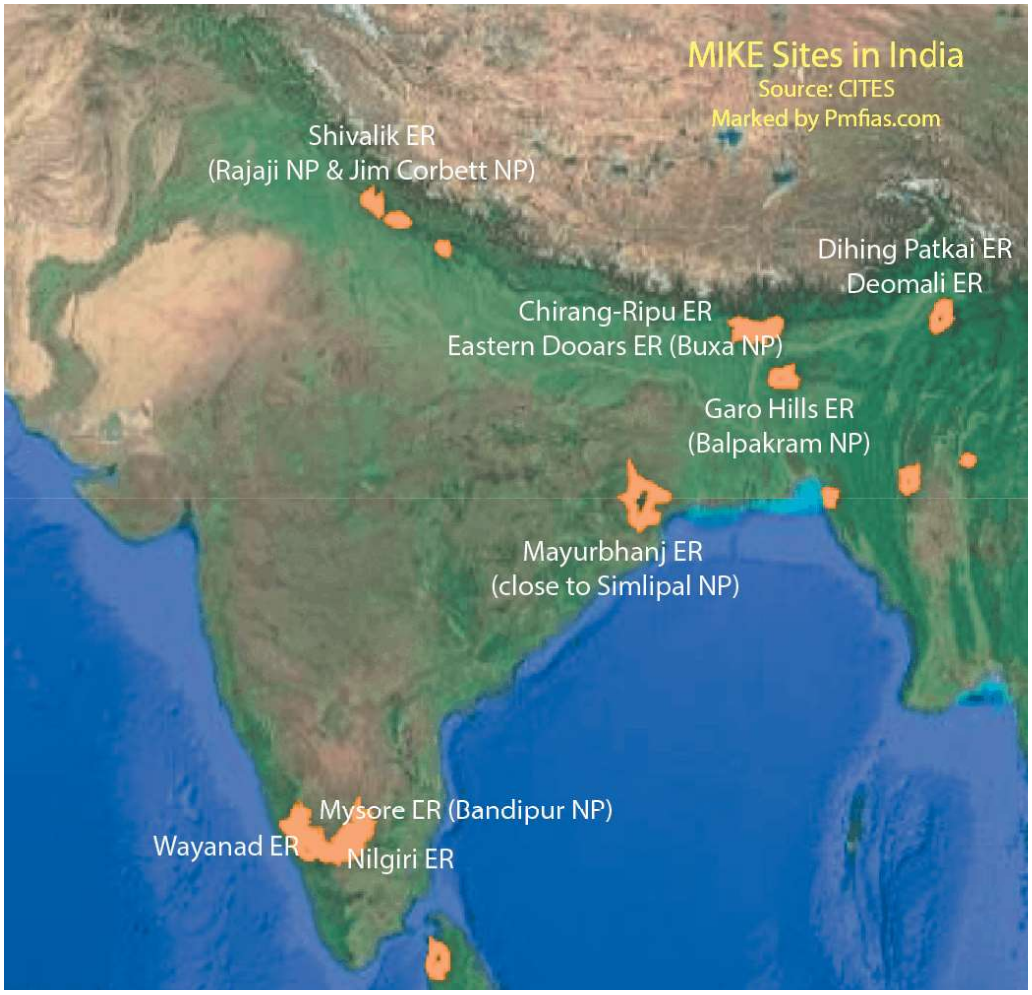
- The ivory trade was **banned globally in 1989** when all African elephant populations were put in **CITES Appendix I**. However, the African elephants of South Africa, Namibia, Botswana, and Zimbabwe were later transferred to **Appendix II** to allow one-time sales of ivory accumulated from deaths and poacher seizures. The endangered Asian elephant was included in CITES Appendix I in 1975, which banned the export of ivory from the Asian range countries.
- In CoP18, Zambia floated a proposal to downlist its elephants from **Appendix I** to **Appendix II**, which in effect, would have meant **resuming the sale of its ivory stockpile**. CoP rejected the proposal. **India had abstained from voting** against a similar proposal at CoP19.

## CITES Tiger Enforcement Task Force

- CoP19 has proposed a tentative budget of $150,000 for the **Big Cat Task Force**. The objective of the task force is to curb illegal trade in big cats like lions, tigers, leopards, cheetahs, etc, in their range.

# Monitoring the Illegal Killing of Elephants (MIKE)

- MIKE is an **international collaboration** that measures the trends and causes of elephant mortality. It was established by a **CITES Resolution** adopted in 1997. One of the core mandates is to build capacity in **elephant range States**.
- MIKE's information base is used to support international decision-making related to the **conservation of elephants in Asia and Africa**. The information and analyses are also presented at annual **CITES** meetings.




- There are currently **28 sites** participating in the MIKE programme in Asia, distributed across **13 countries**. **India has 10 MIKE sites**, followed by two sites each in **Cambodia**, **Indonesia**, **Lao PDR**, **Malaysia**, **Myanmar** and **Thailand**, and one site each in **Bangladesh**, **Bhutan**, **China**, **Nepal**, **Sri Lanka** and **Vietnam**.
- In 2017, **IUCN** was engaged by **CITES** to implement the **MIKE Asia programme** in two sub-regions:
  1. **South Asia – Bangladesh**, **Bhutan**, **India**, **Nepal & Sri Lanka**
  2. **Southeast Asia – Cambodia**, **China**, **Indonesia**, **Lao PDR**, **Malaysia**, **Myanmar**, **Thailand and Vietnam**.
- MIKE is entirely dependent on **donor support**. The **EEU** has been the most important donor for the MIKE programme in Africa since 2001 and in Asia since 2017.

## The Wildlife Trade Monitoring Network (TRAFFIC)

- TRAFFIC is an **NGO** (**CITES**, **on the other hand**, **is a multilateral treaty**) founded in 1976 as a **joint programme** of the **World Wide Fund for Nature (WWF)** and **IUCN**. Its headquarters is in Cambridge, UK.
- TRAFFIC is complementary to CITES. Its mission is to ensure that **trade in wild plants and animals is not a threat to the conservation of nature**. It investigates wildlife trade trends, patterns, impacts and drivers to provide the leading **knowledge base on trade in wild animals and plants**.

**[UPSC 2017] Consider the following statements in respect of TRAFFIC:**

1. TRAFFIC is a bureau under United Nations Environment Programme (UNEP).
2. The mission of TRAFFIC is to ensure that trade in wild plants and animals is not a threat to the conservation of nature.

***Which of the above statements is/are correct?***

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

***Answer: b)***

### Coalition Against Wildlife Trafficking (CAWT)

- CAWT is a coalition that promises to collaborate in the fight **against illegal trade in wildlife and wildlife parts**. It is a **US-led** Coalition Against Wildlife Trafficking (CAWT) launched in 2005. **India is a member**.
- CAWT's initial partners include:
  - ✓ **Conservation International**
  - ✓ **Save the Tiger Fund**
  - ✓ **Smithsonian Institution**
  - ✓ **TRAFFIC International**

## 10.2. Policies/Laws Concerning CITES in India

- International trade in all wild fauna and flora is regulated jointly through the provisions of the
  - ✓ **Wild Life (Protection) Act 1972**,
  - ✓ **Foreign Trade (Development Regulation) Act 1992**,
  - ✓ **Foreign Trade Policy of the Government of India and**
  - ✓ **Customs Act**, **1962**.

### Wildlife (Protection) Act, 1972

- Wildlife species are given **varying levels of protection** under different schedules within the act.

| Schedules | Protected Species | Protection |
|---|---|---|

| | | |
|---|---|---|
| Schedule I | Critically endangered animals | Hunting and trade are prohibited throughout India |
| Schedule II | Less endangered than Schedule I | Hunting and trade are prohibited throughout India |
| Schedule III | Big game species | Hunting is prohibited, but penalties are less severe |
| Schedule IV | Small game species | Hunting is prohibited, but penalties are less severe |
| **Schedule V** | **Vermin** | **Hunting without restriction** |
| Schedule VI | Plants | Prohibited from cultivation and planting |

⇨ ***Vermin*** *are small wild animals that carry disease and destroy plants and food.*

**Exceptions**

- Wild animals listed under the first four schedules can **only be hunted or killed with permission** from the **state's Chief Wildlife Warden (CWLW)** if:
  1. A **Schedule I**-listed wild animal poses a **threat to human life** or is **irreversibly disabled**
  2. A wild animal listed in **Schedules II**, **III**, **or IV** is a **threat to human life or property** or is **irreversibly disabled or diseased**
- Killing or injuring a wild animal in **self-defence** or **defence of others**.

- **GoI can declare any wild animal not listed in Schedules I and II** as **vermin** through notification.
- GoI can **modify Schedules** by **adding**, **deleting**, or **transferring** entries between them.
- **Trade in Scheduled animals** (**Schedule I** and **Part II of Schedule II**) **are prohibited** under the act.
- The act **disallows trade in all kinds of imported ivory**.
- In 1986, India **banned domestic sales of ivory**. After the ivory trade was banned globally, India again amended the act to ban the import of African ivory.
- The act was amended in 2006 to establish the **National Tiger Conservation Authority (NTCA)** & the **Wild Life Crime Control Bureau (WCCB)** with **statutory backing**.

### WPA 2022

- The 2022 Act **reduces** the **number of schedules to four**:
  - ❖ **Reduced** the **schedules for specially protected animals** to **two** (one for greater protection level)
  - ❖ **Removed the schedule for vermin species**
  - ❖ Inserts a **new schedule** for **specimens listed in the Appendices under CITES**

1. **Schedule I:** Animal species that receive the **highest level of protection**, including critically endangered species
2. **Schedule II:** Animal species that receive a **lower level of protection**
3. **Schedule III:** Protected plant species
4. **Schedule IV:** Specimens listed in the Appendices under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (**CITES**)

## Policies Regulating Foreign Trade

### Foreign Trade (Development and Regulation) Act 1992

- No export or import should be made except in accordance with the provisions of this act. The act empowers GOI to make provisions for prohibiting/regulating the import or export of any class of goods, which includes **wildlife specimen** and their products.

### Foreign Trade Policy (2009-2014)

- Foreign Trade Policy announced periodically by the **Ministry of Commerce** contains information regarding the wildlife and wildlife products which are prohibited/permitted for the purpose of import or export.
- The policy is decided in consultation with the **Management Authority for CITES** in India as far as matter relating to wild fauna and flora are concerned and is enforced through the **Customs Act**, **1962**.

### EXIM Policy

- Export/import of wild animals and plants, their parts and products is **allowed** for the purpose of **research** and **exchange between Zoos**, subject to licensing by the **Director-General of Foreign Trade (DGFT)**. The current policy does not permit the commercial import of African ivory in view of the ban imposed by CITES. Import of other derivatives of wildlife is **restricted** and can be made only with the prior permission of DGFT. The import of wild animals as **pets** is also subject to the provisions of CITES.

## Enforcement: Wildlife Crime Control Bureau

- Considering the seriousness of Wildlife Crime and the illegal trade of wildlife parts and products, the **Wildlife Crime Control Bureau (WCCB)** was created in 2007 under the provisions of the **Wildlife Protection Act 1972**. It is the designated **nodal agency for CITES related enforcement**.
- WCCB is a **statutory** body under the **MoEFCC**. It has its five regional offices at Delhi (headquarters), Kolkata, Mumbai, Chennai and Jabalpur; and five border units at Ramanathapuram, Gorakhpur, Motihari, Nathula and Moreh.
- **Wild Life (Protection) Act**, **1972** mandates WCCB is to
  - ✓ collect and collate **intelligence related to organized wildlife crime**; disseminate the same to State and other enforcement agencies;
  - ✓ to establish a **centralized wildlife crime data bank**;
  - ✓ **coordinate** actions by various agencies in connection with the enforcement of the provisions of the act;
  - ✓ **assist international organizations and foreign authorities** to facilitate wildlife crime control;
  - ✓ capacity building of the wildlife crime enforcement agencies;
  - ✓ assist State Governments to **ensure success in prosecutions related to wildlife crimes**; and
  - ✓ **advise** the Government of India on issues relating to wildlife crimes.
- It also assists/advises the **Customs authorities** in inspection of the consignments of flora and fauna as per the provisions of Wild Life Protection Act, CITES and EXIM Policy.

### WCCB's Operation 'Clean Art

- **Operation Clean Art** was the first pan India operation by **WCCB** to crackdown on the smuggling/trade of **mongoose hair** used for making **hairbrush**. For about 150 kg of mongoose hair, at least 6,000 animals would have been killed.
- All **mongoose species** found in India are protected under **Schedule II of WPA**. The species are also covered under the **CITES Appendix 1** with a **complete ban on its commercial trade**.

### 'Not all animals migrate by choice' campaign

- It was launched by the **WCCB** and **UN Environment** to **raise awareness on illegal wildlife trade** and reduction in demand for wildlife products. The campaign also complements worldwide action on illegal trade in wildlife through **UN Environment's global campaign**, **Wild for Life**.
- Phase I of the campaign featured **Tiger (EN)**, **Pangolin (EN)**, **Star Tortoise (VU) and Tokay Gecko (LC)**. Phase II will see more threatened species.

## 10.3. Convention on Migratory Species (CMS)

- **Convention on the Conservation of Migratory Species of Wild Animals (CMS)** is an **international treaty**, concluded under the aegis of the **UN Environment Programme** in 1979 in Bonn, Germany. It entered into force in 1983.
- CMS is also known as **Bonn Convention** or **Global Wildlife conference**. It is the only global and UN-based intergovernmental organization established exclusively for the conservation of terrestrial, aquatic, and avian **migratory species throughout their range**.
- Under CMS, **migratory species threatened with extinction** are listed on **Appendix I (CMS global conservation list)**, and Parties strive towards strictly protecting these animals. Migratory species that would **significantly benefit from international cooperation** are listed in **Appendix II**.

### The 13th Conference of the Parties to CMS (CoP13)

- **CoP13** was organized in 2020 in **Gandhinagar**, **Gujarat**. **India** has been designated the **President of the COP** for the next **three years**. **Uzbekistan** will host CoP14 in 2023.
- Ten new species were added to CMS Appendices at COP13. **Seven species** were added to **Appendix I**, which provides the **strictest protection**.
- The **Asian Elephant (EN)**, **Great Indian Bustard (CR)**, **Bengal Florican (CR)**, Little Bustard (NT) are among the 7 species.

- COP13 also adopted the **Gandhinagar Declaration**. It calls for **ecological connectivity** for migratory species to be integrated in the **Post-2020 Global Biodiversity Framework**.

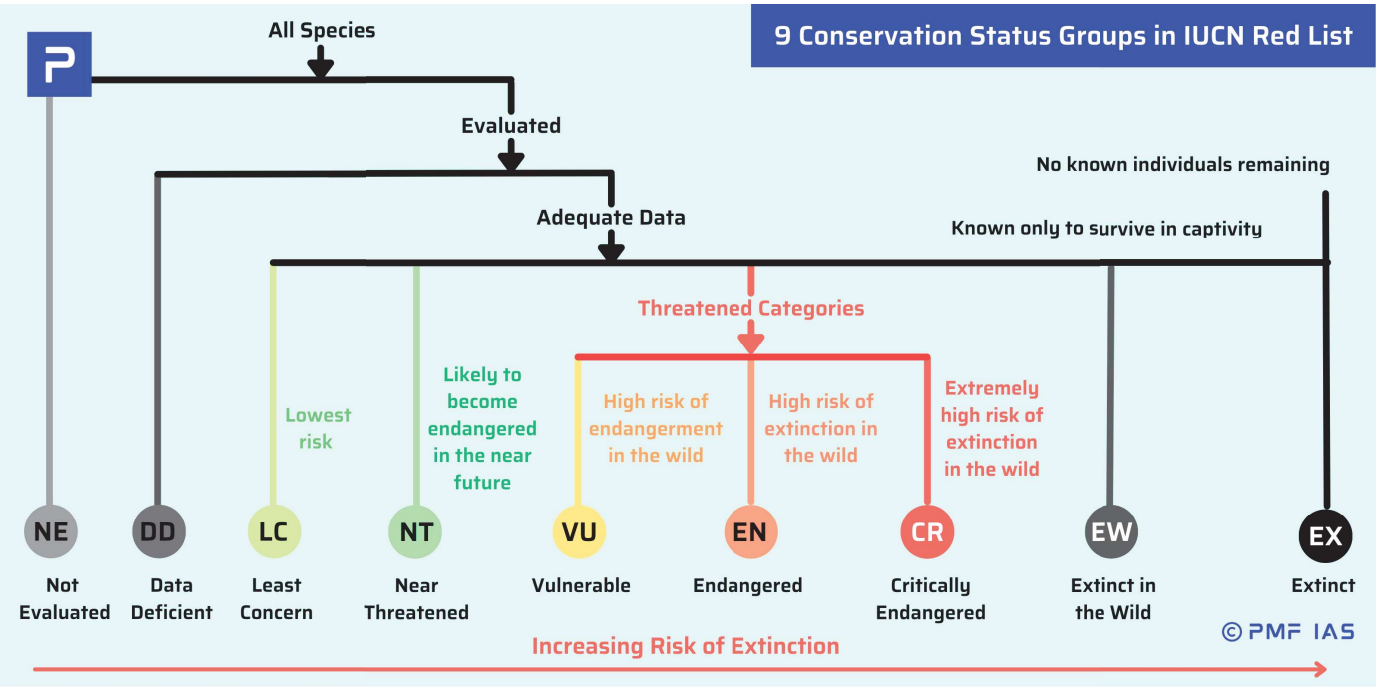
## Central Asian Mammals Initiative

- Through its **Central Asian Mammals Initiative**, the **CMS** aims to conserve **15 migratory mammal species** and their habitats in **Central Asia**. CAMI's working is approved for **2021-2026**, incorporating **IUCN Save Our Species' Central Asia initiative** as a possible **funding mechanism** for the conservation of key threatened migratory species.

### Major Animals Included in Central Mammals Initiative

- Wild Yak (VU) – **Aksai Chin**
- **Snow Leopard (VU) – Himalayas**
- **Asiatic Wild Ass / Khulan (NT) – Rann of Kutch**
- **Cheetah (VU) / Asiatic Cheetah (CR) – Kuno NP, MP**
- **Saiga Antelope (CR) – Not found in India**
- **Wild or Bactrian Camel (CR) – Not found in India**
- Argali / Mountain Sheep (NT) – **Trans-Himalayas**
- Kiang / Tibetan Wild Ass (LC)
- Chiru / Tibetan Antelope (NT)
- Tibetan Gazelle (NT)
- Chinkara / Indian Gazelle (LC) – Western and Central India
- Leopard (VU) – Forested landscapes with elevations below 2,500 m

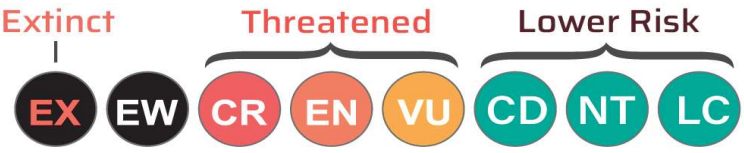
# 10.4. International Union for Conservation of Nature (IUCN)



- **IUCN** is an **international NGO** working in the field of **nature conservation** and **sustainable use of natural resources**. Its headquarters are in **Gland**, **Switzerland**.
- IUCN is involved in research, field projects, advocacy, lobbying and education. The organization is best known for compiling and publishing the **IUCN Red List**, which assesses the **conservation status of species worldwide**.

## IUCN Red List or Red Data List or Red Book

- The **IUCN Red List of Threatened Species**, founded in 1964, is the world's most comprehensive inventory of the global conservation status of biological species. When discussing the IUCN Red List, the official term **"threatened"** is a grouping of three categories: **Critically Endangered**, **Endangered**, and **Vulnerable**.




The **pink pages** in this publication include the **critically endangered species**. **Green pages** are used for those species that were **formerly endangered but have now recovered to a point where they are no longer threatened**. With time, the number of pink pages continue to increase.

### Critically endangered (CR)

- **Reduction in population (> 90% over the last 10 years)**,
- **Population size < 50 mature individuals — not applied strictly. Many CR species have populations > 50)**,
- **Probability of extinction in wild in at least 50% in 10 years**

**[UPSC 2011-12] The 'Red Data Books' published by the International Union for Conservation of Nature and Natural Resources (IUCN) contain lists of**

1) Endemic plant and animal species present in the biodiversity hotspots.
2) Threatened plant and animal species.
3) Protected sites for conservation of nature and natural resources in various countries.

***Which of the statement given above is/are correct?***

a) 1 and 3
b) 2 only
c) 2 and 3
d) 3 only

**Explanation**

- **IUCN is an NGO**. It publishes Red data book, which contains a list of **'Threatened species' (vulnerable**, **endangered** and **critically endangered)**.

***Answer: b) 2 only***

**[UPSC 2023] Invasive Species Specialist Group' (that develops Global Invasive Species Database) belongs to which one of the following organisations?**

a) The International Union for Conservation of Nature
b) The United Nations Environment Programme
c) The United Nations World Commission for Environment and Development
d) The World Wide Fund for Nature

**Explanation**

- The Global Invasive Species Database (GISD) is managed by the Invasive Species Specialist Group (ISSG) of the **IUCN** Species Survival Commission. It was developed between 1998 and 2000 as part of the global initiative on invasive species led by the erstwhile Global Invasive Species Programme (GISP).

## BirdLife International (BI)

- **BirdLife International** is the world's largest **nature conservation partnership** comprising 120 national nature conservation organizations worldwide.
- **BI** strives to **conserve birds**, **their habitats** and **global biodiversity**, working with people towards sustainability in the use of natural resources.
- **BirdLife International** is the **official Red List authority for birds**, for the **IUCN**. It identifies the sites known as **Important Bird and Biodiversity Areas (IBA)**, which hold significant numbers of one or more threatened bird species or have exceptionally large numbers of migratory birds.
- There are 13,000+ IBAs worldwide. The **Bombay Natural History Society** (BNHS is BirdLife International partner from India) and BI have identified 554 IBAs in India.

**[UPSC 2015] With reference to 'Birdlife International' which of the following statements is/are correct?**

1) It is a Global Partnership of Conservation Organizations.
2) The concept of 'biodiversity hotspots' originated from this organization.
3) It identifies the sites known/referred to as 'Important Bird and Biodiversity Areas'.

***Select the correct answer using the code given below.***

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

**Explanation**

- BirdLife International has nothing to do with the concept of "biodiversity hotspots".

***Answer: c) 1 and 3 only***

## *10.5. Tiger Conservation and Project Tiger*

- Since the early 1900s, the global population of **Tigers (EN)** fell from around 100,000 to fewer than 4,000. Indian tiger numbers had hit an **all-time low of 1,411 in 2006**. The tigers from the Sariska reserve in Rajasthan had all disappeared. Serious conservation efforts by India after 2006 led to a steady increase in the tiger population.

⇨ *There are eight subspecies of tiger. Among the eight, at present, five subspecies are present in the wild. They are **Bengal**, **South China**, **Indochinese**, **Sumatran**, and **Siberian**. Three subspecies of tiger — **Caspian**, **Bali**, and **Javan** — **are extinct**.*

## Challenges to Tiger Conservation

- **Pressure on habitat**, **Habitat fragmentation** and **Habitat destruction**: Caused due to large-scale development projects such as dams, industry, mines, railway lines etc.
- **Invasive species:** They destroy the local producers. This has a **cascading effect on the food chain**. Tigers are the worst hit as they are at the top of the food chain. (Tigers represent an "**Umbrella Species**" that indicate the health of the ecosystem.)
- **Poaching and Wildlife Crime Control:** Poaching and wildlife crime continue to be major concerns, with poaching remaining a significant issue. Tigers are killed so their body parts can be used for **Traditional Chinese Medicine**.
- **Demand Elimination:** Eliminating demand for tiger products remains a significant hurdle.
- **Rebuilding Tiger Populations:** It remains a tough task, and countries except **India**, **Nepal** and **Russia** have struggled to rebuild their dwindling tiger populations.

### Canine Distemper Virus (CDV)

- **Canine Distemper Virus (CDV)** can be transmitted to wildlife from CDV-infected dogs living in and around wildlife sanctuaries. Is a contagious disease that attacks the respiratory, gastrointestinal and nervous systems of puppies and dogs. In 2018, over 20 lions from the Gir forest succumbed to the viral infection.

#### Prevention is better than cure

- Managing any disease in a wildlife population is extremely difficult. The main aim should be to vaccinate the free-ranging and domestic dogs in the area around NPs.

## Measures Taken by GOI

### Legal

✓ Amendment of the Wild Life (Protection) Act, 1972 to Wild Life (Protection) Act, 2006 for constituting the **National Tiger Conservation Authority (NTCA)** and the ***Tiger and Other Endangered Species Crime Control Bureau (Wildlife Crime Control Bureau (WCCB))***.

✓ Enhancement of punishment in cases of offence relating to a tiger reserve or its core area.

### Administrative

✓ Strengthening of ant poaching activities, including special strategy for monsoon patrolling.

- ✓ State-level Steering Committees under the Chairmanship of Chief Ministers and establishment of **Tiger Conservation Foundation**.
- ✓ Creation of **Special Tiger Protection Force** (STPF)

### Financial

- ✓ Financial and technical help is provided to the States under various Centrally Sponsored Schemes, viz. Project Tiger and **Integrated Development of Wildlife Habitats**.

### 3-pronged strategy to manage negative interactions

- ✓ **Material and logistical support:** Funding support is provided through the ongoing **Project Tiger**.
- ✓ **Restricting habitat interventions:** Based on the carrying capacity of tigers in a tiger reserve, habitat interventions are restricted. The habitat interventions are kept limited to minimize man/animal conflict.
- ✓ **Standard Operating Procedure (SOPs):** The NTCA has issued SOPs to deal with man/animal conflict.

### International Cooperation

- ✓ India has a bilateral understanding with **Nepal** on controlling trans-boundary illegal trade in wildlife.
- ✓ India has signed protocols on tiger conservation with Bangladesh and China.
- ✓ A sub-group on tiger/leopard conservation has been constituted for cooperation with Russia.
- ✓ A **Global Tiger Forum of Tiger Range Countries** has been created for addressing international issues related to tiger conservation.
- ✓ India is a party to **CITES**. CITES's landmark decision states that 'tigers should not be bred for trade in their parts and derivatives'.

#### Global Tiger Forum (GTF)

- ✓ Established in 1994, the GTF has its headquarters in **New Delhi**. The General Assembly of GTF meets after **every three years**. It was set up to promote a worldwide campaign to save the tiger, its prey and its habitat.

## *Project Tiger (PT)*

- Indian tiger population at the end of the 20th century was estimated at 20,000 to 40,000 individuals. The first country-wide tiger census conducted in 1972 estimated the population to comprise a little more than 1,800 individuals, an alarming reduction in tiger population.
- In 1973, with an aim to **protect tigers from extinction by ensuring a viable population in their natural habitats**, Project Tiger was launched in **Jim Corbett National Park** of Uttarakhand, and various tiger reserves were created since then based on a ***core-buffer*** strategy.
- All the tiger reserves are governed by the **Project Tiger (1973)**, a ***Centrally Sponsored Scheme*** of MoEF, administered by the **National Tiger Conservation Authority**. It funds **relocation of villagers** to minimize human-tiger conflicts. **Tiger Protection Force** was set up under Project Tiger to combat poachers.

### Tiger Task Force

- The implementation of Project Tiger over the years has highlighted the need for a **statutory authority** with the legal backing to ensure tiger conservation. On the basis of the recommendations of **National Board for Wild Life**, a Task Force was set up to look into the problems of tiger conservation in the country. The recommendations of the **Task Force** include strengthening of **Project Tiger** by giving it **statutory and administrative powers**.

***NBWL ➔ Tiger Task Force ➔ NTCA***

## National Tiger Conservation Authority (NTCA)

- The **Wild Life (Protection) Amendment Act, 2006** provides for creating:
  1. ***National Tiger Conservation Authority*** (***NTCA*** – a **statutory body** under MoEF) *and*
  2. ***Tiger and Other Endangered Species Crime Control Bureau*** (***Wildlife Crime Control Bureau*** (***WCCB*** – a **statutory body** under MoEF)).
- NTCA administers **Project Tiger**. Tiger reserves in India are administered by field directors in accordance with the guidelines of NTCA.
- **No alteration in the boundaries** of a tiger reserve shall be made **except on a recommendation of the NTCA** and the **approval of the National Board for Wild Life**.
- **No State Government shall de-notify a tiger reserve**, except in public interest with the **approval of the NTCA and National Board for Wild Life**.

### NTCA members

- NTCA was set up under the **Chairmanship of the Minister for Environment and Forests**.
- The Authority will have
  a) ***eight experts*** having qualifications in wildlife conservation and welfare tribals,
  b) **3 MPs**,
  c) The **Inspector-General of Forests**, in charge of project Tiger, will be ex-officio Member Secretary
  d) Others

### Functions of NTCA

- The Authority lays down standards, guidelines for **tiger conservation** in the Tiger Reserves, National Parks and Sanctuaries.
- It would be required to prepare an **Annual Report**, which would be laid in the Parliament along with the Audit Report.

### Mandates to the states

- **State level Steering Committees** will be set up in the Tiger States under the **Chairmanship of respective Chief Ministers**. This has been done with a view for ensuring coordination, monitoring and protection of tigers in the States.
- A provision has been made for the State Governments to prepare a **Tiger Conservation Plan** and establish a **Tiger Conservation Foundation** based on the good practices emanating from some tiger reserves.

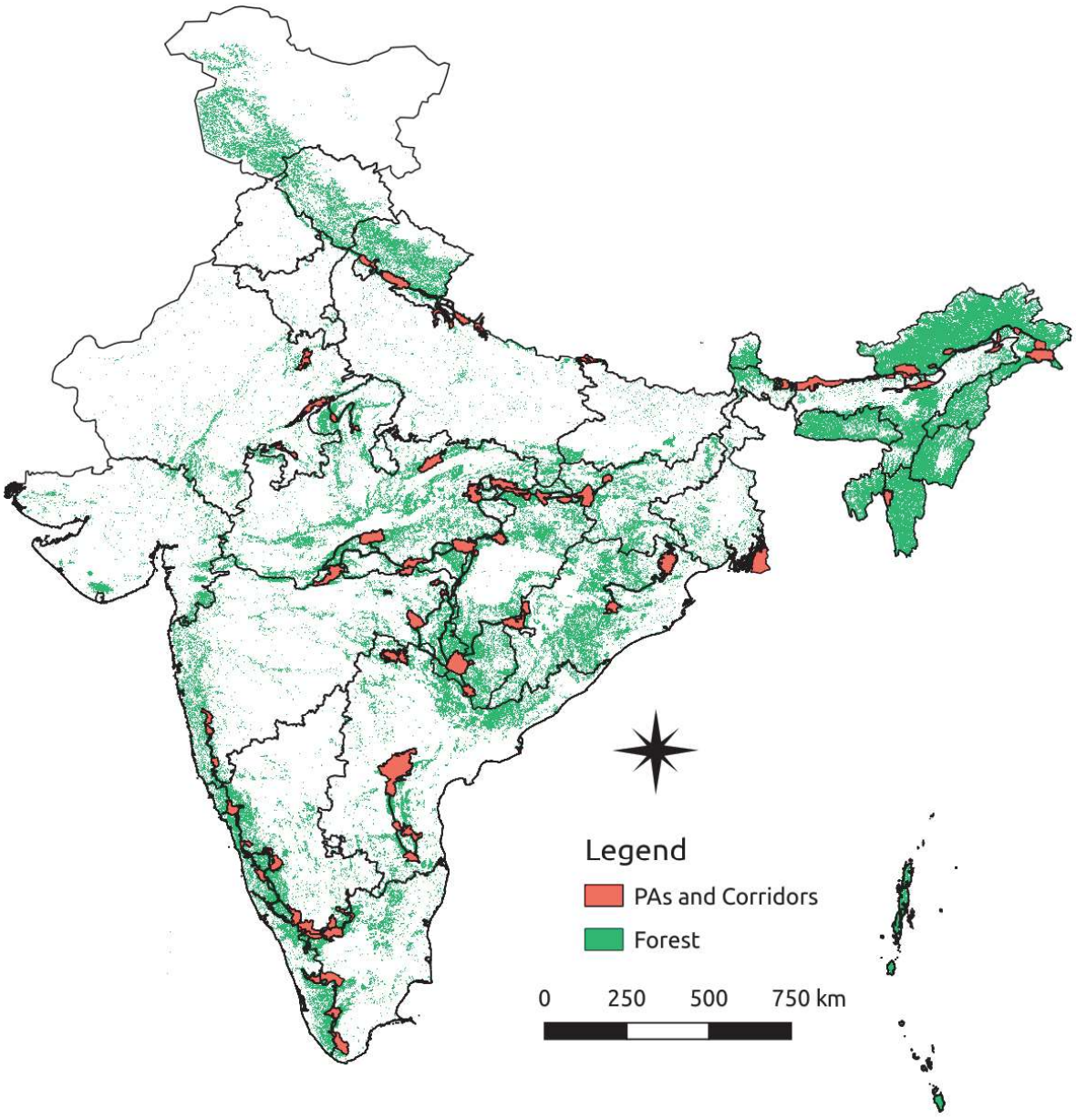
### Challenges

- The **Forest Rights Act** passed by the Indian government in 2006 **recognizes the rights of some forest-dwelling communities** in forest areas. This has led to controversy over the implications of such recognition for Project Tiger.
- Under the current green cover, habitats reach **tiger-saturation** points far too early (the existing habitats cannot accommodate more tigers).

## Tiger Corridors

- NTCA, in collaboration with the Wildlife Institute of India, has published a document titled "**Connecting Tiger Populations for Long/term Conservation**". The document has mapped out **32 major corridors** across the country.

### List of macro-landscape level tiger corridors



| Landscape | Corridor | States/Country |
|---|---|---|
| **Shivalik Hills and Gangetic Plains** | Rajaji-Corbett | Uttarakhand |
| | Corbett-Dudhwa | Uttarakhand, Uttar Pradesh, Nepal |
| | Dudhwa-Kishanpur-Katerniaghat | Uttar Pradesh, Nepal |
| **Central India and Eastern Ghats** | Ranthambhore-Kuno-Madhav | Madhya Pradesh, Rajasthan |
| | Bandhavgarh-Achanakmar | Madhya Pradesh, Chhattisgarh |
| | Bandhavgarh-Sanjay Dubri-Guru Ghasidas | Madhya Pradesh |
| | Guru Ghasidas-Palamau-Lawalong | Chhattisgarh and Jharkhand |
| | Kanha-Achanakmar | Madhya Pradesh, Chhattisgarh |
| | Kanha-Pench | Madhya Pradesh, Maharashtra |
| | Pench-Satpura-Melghat | Madhya Pradesh, Maharashtra |
| | Kanha-Navegaon Nagzira-Tadoba-Indravati | MP, Maharashtra, Chhattisgarh, AP |
| | Indravati-Udanti Sitanadi-Sunabeda | Chhattisgarh, Odisha |
| | Similipal-Satkosia | Odisha |
| | Nagarjunasagar-Sri Venkateshwara NP | Andhra Pradesh |
| **Western Ghats** | Sahyadri-Radhanagari-Goa | Maharashtra, Goa |
| | Dandeli Anshi-Shravathi Valley | Karnataka |
| | Kudremukh-Bhadra | Karnataka |
| | Nagarahole-Pusphagiri-Talakavery | Karnataka |
| | Nagarahole-Bandipur-Mudumalai-Wayanad | Karnataka, Kerala, Tamil Nadu |
| | Nagarahole-Mudumalai-Wayanad | Karnataka, Kerala, Tamil Nadu |
| | Parambikulam-Eranikulam-Indira Gandhi | Kerala, Tamil Nadu |
| | Kalakad Mundanthurai-Periyar | Kerala, Tamil Nadu |
| **North East** | Kaziranga-Itanagar WLS | Assam, Arunachal Pradesh |
| | Kaziranga-Karbi Anglong | Assam |
| | Kaziranga-Nameri | Assam |
| | Kaziranga-Orang | Assam |
| | Kaziranga-Papum Pane | Assam |
| | Manas-Buxa | Assam, West Bengal, Bhutan |
| | Pakke-Nameri-Sonai Rupai-Manas | Arunachal Pradesh, Assam |
| | Dibru Saikhowa-D'Ering-Mehaong | Assam, Arunachal Pradesh |
| | Kamlang-Kane-Tale Valley | Arunachal Pradesh |

| | | |
|---|---|---|
| | Buxa-Jaldapara | West Bengal |

## Core and Buffer Zones in Tiger Reserves

- The protection status of tiger reserves is the **same as wildlife sanctuaries**, but they are **monitored by NTCA**.

### Core area

- The **core areas** are notified by the **State Government** in consultation with an Expert Committee (constituted for that purpose). They are **freed of all human activities** **(but some tribes continue to live in the core area (illegally)**. **However**, **they do not possess any forest rights)**.
- **A core area has the legal status of a national park or wildlife sanctuary**. **Collection of minor forest produce**, **grazing**, **and other human disturbances are not allowed**.

⇨ The **Soligas of Karnataka's Chamarajnagar district** created history by becoming the **first tribal community living in the core area of a tiger reserve to get their forest rights recognised** (a very rare and exceptional case).

⇨ Soligas inhabit the peripheral forest areas of **Biligiri Rangana** and **Male Mahadeshwara Hills**. Their forest rights were recognised by the courts as they lived in the area in harmony with nature for hundreds of years, and their way of living was not causing any harm to the tiger population.

⇨ In 1974, the BR Hills (including Biligiri Ranganatha Swami Temple) area was declared as BRT Wildlife Sanctuary. The government evicted many Soligas and relocated them to nearby plains. In 2011, the sanctuary was declared a tiger reserve, and the forest officials restricted access and collection of non-timber forest produce.

### Buffer areas

- **The buffer zone** is the area **peripheral to the critical tiger habitat or core area** providing **supplementary habitat** for dispersing tigers, besides offering scope for **co-existence of human activity (tribals)**. The limits of such areas are determined with the concerned **Gram Sabha** and an Expert Committee constituted for the purpose.
- The **Forest Rights Act** passed by the Indian government in 2006 **recognizes the rights of some forest-dwelling communities** in buffer areas. Collection of minor forest produce and **grazing by tribals is allowed** on a **sustainable** basis.

## Tiger Census

- The process of estimating the number of tigers in each area is called 'Tiger census'. Tiger Census Report is a **four-yearly report**. It is carried out by the **Wildlife Institute of India** (WII — autonomous institution under the MoEF) and the **NTCA**. The 2014 tiger census had resulted in the **first-ever estimate of India's leopard population (11,000)**.

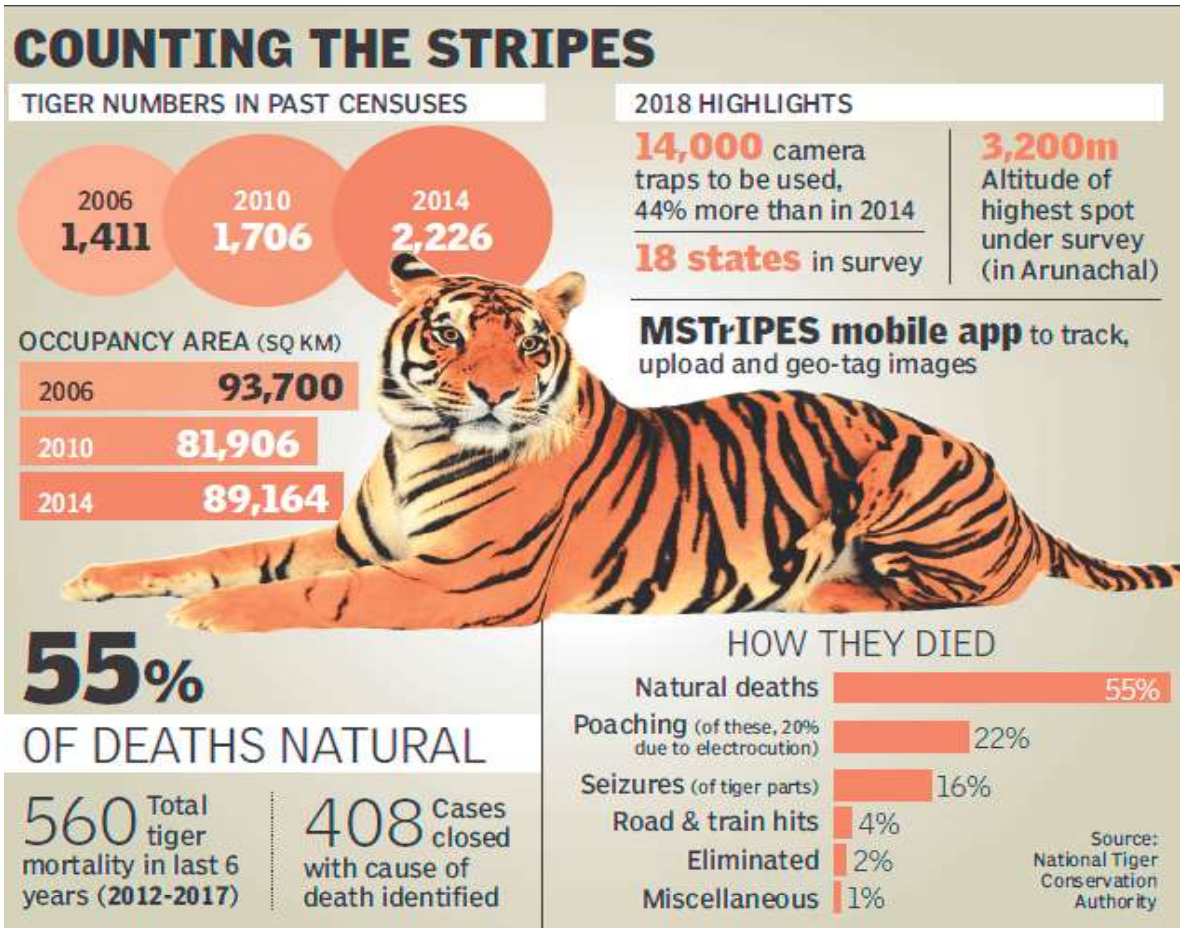
### Estimation of Tiger Populations

- The most used technique in Tiger Census in the past was '**Pugmark Census Technique'**. In this method, the imprints of the pugmark of the tiger were recorded and used as a basis for the identification of individuals (**and their sex**). Now it is largely used as one of the indices of tiger occurrence and relative abundance.
- Recent methods used to estimate the numbers of tigers are **camera trapping** and **DNA fingerprinting**. In camera trapping, the photograph of the tiger is taken, and individuals are differentiated based on the **stripes** on the body. In the latest technique of **DNA fingerprinting**, tigers can be identified from their **scats (faeces)**.

## 2018 Census Methodology

- The census methodology is based on double sampling (based on ground-based surveys and actual images captured on **camera-traps)**. It was introduced in 2006 as the **pugmark surveys** were found to be inaccurate.
- In the 2018 census, 83% of the big cats censused were **individually photographed** using camera traps. In Phases 1 and 2, ground-based surveys were carried out by Forest Department officials to collect signs of tiger presence like **scat and pugmarks**.
- In phase 3, the information was plotted on the forest map prepared with **remote-sensing** and **GIS (MSTrIPES)**. In the last phase, data were extrapolated to areas where cameras could not be deployed.

## MSTrIPES – Technology in Wildlife Conservation



- MSTrIPES (**Monitoring system for Tigers – Intensive Protection and Ecological Status**) was launched across Indian tiger reserves by **NTCA** and **WII** in 2010. It is a software-based monitoring system, designed to assist wildlife protection. The system consists of two components:
  1) field based protocols for patrolling, law enforcement, recording wildlife crimes and ecological monitoring,
  2) a customized GIS software for storage, retrieval, analysis, and reporting.
- Under MSTrIPES, **forest guards are expected to record their tracks** using a **GPS**, in addition to recording observations in site-specific data sheets and uploading **geo-tagged pictures** into the central **GIS database**.

### Advantage of MSTrIPES

- MSTrIPES will help identify shortcomings in patrolling efforts in real-time. It acts as proof of the presence and patrolling of forest guards in a particular area.

## 2018 Tiger Census Report (All-India Tiger Estimate)

- 2018 census is the **fourth cycle** of the tiger census based on **double sampling**. The first was conducted in 2006, second in 2010 and third in 2014. The **All-India Tiger Estimate 2022** will be published in mid-2023.
- India's five tiger landscapes are:
  1. **Shivalik Hills and Gangetic Plains**,
  2. **Central Indian Landscape and Eastern Ghats**,
  3. **Western Ghats**, **North-East Hills and**
  4. **Brahmaputra Plains**, **and**
  5. **the Sundarbans**.

| Tiger population growth in India | | | | |
|---|---|---|---|---|
| **State** | **2006** | **2010** | **2014** | **2018** |
| ***Shivalik Gangetic Plain*** | | | | |
| **Uttarakhand** | **178** | **227** | **340** | **442** |
| Uttar Pradesh | 109 | 118 | 117 | 173 |
| Bihar | 10 | 8 | 28 | 31 |
| ***Central Indian Landscape and Eastern Ghats*** | | | | |
| AP and Telangana | 95 | 72 | 68 | 48 \| 26 |
| Chhattisgarh | 26 | 26 | 46 | 19 |
| **Madhya Pradesh** | **300** | **257** | **308** | **526** |
| **Maharashtra** | **103** | **169** | **190** | **312** |
| Odisha | 45 | 32 | 28 | 28 |
| Rajasthan | 32 | 36 | 45 | 69 |
| Jharkhand | - | 10 | 3 | 5 |
| ***Western Ghats*** | | | | |
| **Karnataka** | **290** | **300** | **406** | **524** |

| | | | | |
|---|---|---|---|---|
| **Kerala** | **46** | **71** | **136** | **190** |
| **Tamil Nadu** | **76** | **163** | **229** | **264** |
| Goa | - | - | 5 | 3 |
| ***The Northeast*** | | | | |
| **Assam** | **70** | **143** | **167** | **190** |
| Arunachal Pradesh | 14 | - | 28 | 29 |
| Mizoram | 6 | 5 | 3 | 0 |
| Northern West Bengal | 10 | - | 3 | 0 |
| Sundarbans | - | 70 | 76 | 88 |
| **Total** | **1,411** | **1,706** | **2,226** | **2967** |

## Important Observations from 2018 tiger census

1. **Madhya Pradesh (526) has the highest tiger population**.
2. **Karnataka (524) has the second-highest tiger population**.
3. **Uttarakhand (442) has the third-highest tiger population**.
4. Among the NE states, **Assam (190)** has the highest tiger population.
5. Tiger population **fell** in **Chhattisgarh** and **Mizoram**.
6. There is no change in the tiger population in **Odisha**.

## Other Important observations

| Region | Tiger Population (2014) |
|---|---|
| **1. Western Ghats** | **776** |
| **2. Central Indian Landscape and Eastern Ghats** | **688** |
| 3. Shivalik Gangetic Plain | 485 |
| **India** | **2226** |
| **Region** | **Tiger Population (2018)** |
| **1. Central Indian Landscape and Eastern Ghats** | **1033** |
| **2. Western Ghats** | **981** |
| 3. Shivalik Gangetic Plain | 646 |
| **India** | **2967** |

- India is home to **70% of the world tiger population**. It has **2,967 tigers**, **a rise of 33%** over the figure found in the previous census of **2014 (2,226)**. This is by far the biggest increase in terms of both numbers and percentage since the capture-mark-recapture method began in **2006 (1,411)**.
- **India achieved the goal of doubling the tiger numbers in 2018**, **four years before the targeted year 2022**.

⇨ ***St. Petersburg Declaration****: 13 tiger home range countries agreed to* ***Global Tiger Recovery Program*** *that aimed to* ***double the global tiger population by 2022***.

- **MP** saw the highest increase — 218 individuals (71%).
- **Maharashtra** saw a 64% jump **(**190 to 312).
- Uttarakhand has gained over 100 tigers (340 to 442).

- **Corbett TR** recorded the **highest number of tigers (266)**.
- **In terms of population and density: 1) Corbett TR (266) > 2) Nagarahole TR (127) > 3) Bandipur (126) > 4) Bandhavgarh (104) > 5) Kaziranga (104)**
- **Sathyamangalam Tiger Reserve** in Tamil Nadu registered the "maximum improvement" since 2014.
- In **Buxa**, **Dampa** and **Palamau**, which are **tiger reserves**, **no trace of the animal was found**.
- The report does not contain the numbers of other predators like leopards.

## Tiger Census 2022

- **Tiger Census 2022** (5th cycle of the All India Tiger Estimation, 2022) was released, and the **International Big Cat Alliance** was launched on the **50th anniversary of Project Tiger**.

⇨ *India is the **most extensive tiger range** and Asiatic Elephant range country globally.*

### Highlights of the Tiger Census 2022

- **Population:** The number of tigers in India is **3,167** in 2022, **75% of the world's tiger population**. A total of 3,080 individual tigers (> 1 year of age) were photo-captured which is larger than the ones captured in 2018. The minimum population estimate is 3,167 individuals.

| Landscape | Tiger Population Estimate | | | |
|---|---|---|---|---|
| | 2006 | 2010 | 2014 | 2018 |
| Shivalik Hills & Gangetic Plains Landscape | 297 (259-335) | 353 (320-388) | 485 (427-543) | 646 (567-726) |
| Central Indian Highlands & Eastern Ghats Landscape | 601 (486-718) | 601 (518-685) | 688 (596-780) | 1,033 (885-1,193) |
| Western Ghats Landscape | 402 (486-718) | 534 (500-568) | 776 (685-861) | 981 (871-1,093) |
| North Eastern Hills & Brahmaputra Plains Landscape | 100 (84-118) | 148 (118-178) | 201 (174-212) | 219 (194-244) |
| Sunderbans Landscape | Not Sampled | 70 (62-96) | 76 (62-96) | 88 (86-90) |
| **India** | 1,411 (1,165-1,657) | 1,706 (1,507-1,896) | 2,226 (1,945-2,491) | 2,967 (2,603-3,346) |

| Landscape | Camera Trapped Tigers |
|---|---|
| | 2022 |
| Shivalik Hills & Gangetic Plains Landscape | **804** |
| Central Indian Highlands & Eastern Ghats Landscape | **1,161** |
| Western Ghats Landscape | **824** |
| North Eastern Hills & Brahmaputra Plains Landscape | **194** |
| Sunderbans Landscape | **100** |
| **India** | **3,080*** |

- **Growth Rate:** The tiger population in India has **increased by 200 or 6.7%** in the past four years. However, the **growth rate slowed** from around 33% during 2014-2018.
- **Increase:** The tiger population has grown in the **Shivalik hills** and **Gangetic flood plains**, followed by **Central India**, the **Northeastern hills**, the **Brahmaputra flood plains**, and the **Sundarbans**.
- **Decrease:** There is a **decline tiger population in the Western Ghats**. Tiger occupancy in **Jharkhand**, **Odisha**, **Chhattisgarh**, and **Telangana** declined.
- **Zero tigers in the core area:** Tigers are locally extirpated (eradicated) from **Kawal Tiger Reserve** and **Chennur of Telangana**, **Sri Venkateswara National Park** in Andhra Pradesh, **Satkosia Tiger Reserve** in Odisha, and **Sahyadri Tiger Reserve** from Maharashtra.
- **Tiger Reserves:** Since 1973 (when Project Tiger was established), the **number of tiger reserves has grown** from 9 reserves to **53 reserves**, which is roughly **2.3% of India's land area**.
- **Threats:** The Protected Areas and corridors face a range of threats, including habitat encroachment, illegal hunting of tigers and their prey, human-wildlife conflict, unregulated cattle grazing, excessive harvesting of non-timber forest produce, human-induced forest fires, mining, and infrastructure. The Central Indian highlands and Eastern Ghats region have several mines.
- **Problem from Population Growth:** Nearly all of the five major tiger zones face challenges to the growth of the tiger population due to the increasing demands from infrastructure development.
  - ⇨ *Following the translocation of cheetahs from Africa, India is now looking to translocate tigers into other locations. It is in talks with **Cambodia** (where the tiger has gone extinct due to poaching) to ship a few tigers from India to revive the big cat population in that country.*
- **Genetically Unique Population:** Genetically unique tiger population in **Bihar's Valmiki Tiger Reserve** and **Orissa's Simlipal National Park** needs to be conserved at high priority.
- **Drawback of the Census:** The current census **does not give numbers of tigers outside protected areas**, **which are a growing number** and **a key marker of environmental threats and human-animal conflicts**.

## The International Big Cat Alliance (IBCA)

- Union Cabinet approved the creation of **International Big Cat Alliance (IBCA)** to set up a global network for the conservation of tigers and other big cats. It allocated a one-time budgetary support of Rs 150 crore for IBCA for a **five**-year period — **2023-24 to 2027-28**.
- IBCA is a multi-country, multi-agency coalition of 96 big cat range countries, **non-range countries** interested in big cat conservation and scientific organizations working in the field of big cat conservation.
- IBCA was launched by the Ministry of Environment, Forest and Climate Change (MoEFCC) to conserve seven big cats: **Tiger**, **Lion**, **Leopard**, **Snow Leopard**, **Cheetah**, **Jaguar**, and **Puma**.

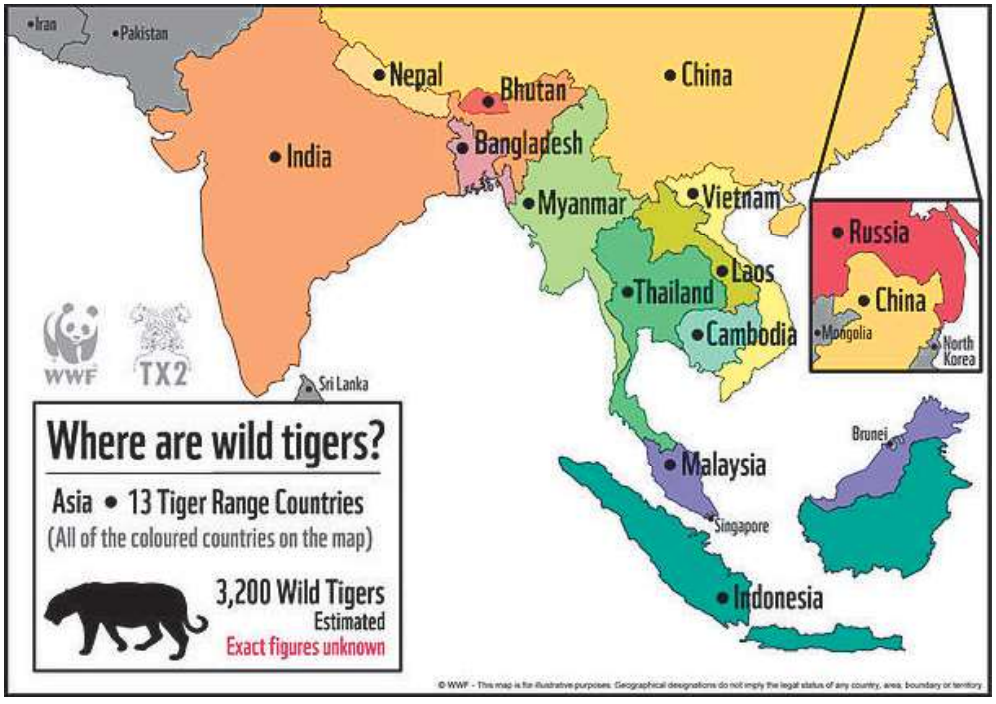
## Measures that led to the increase in tiger population

- ✓ Wireless communication systems and outstation patrol camps have been developed within the tiger reserves, due to which poaching has declined considerably.
- ✓ Many states deployed **special tiger forces** to combat organised poachers.
- ✓ Relocation of villages away from tiger reserves: ₹10 lakh was provided per family **that moved out of critical habitat**.
- ✓ From 28 in 2006, the number of tiger reserves went up to **53 in 2023**.

## 10.6. International Efforts Towards Tiger and Snow Leopard Conservation

### The Global Tiger Initiative

- **GTI** was launched in 2008 as a **global alliance** of governments, NGOs, civil society, and scientific communities with the aim of working together to **save wild tigers from extinction**. In 2013, the scope was broadened to include **Snow Leopards (VU)**.
- The **GTI's founding partners** included:
  - ✓ the **World Bank**,
  - ✓ the **Global Environment Facility (GEF)**,
  - ✓ the **Smithsonian Institution** (**world's largest museum**, education, and research complex),
  - ✓ **Save the Tiger Fund** (from 1995 to 2011, it supported tiger conservation projects in Asia), and
  - ✓ **International Tiger Coalition** (representing more than 40 **non-government organizations**).
- GTI is led by the **13 tiger range countries** — **Bangladesh**, **Bhutan**, **Cambodia**, **China**, **India**, **Indonesia**, **Laos**, **Malaysia**, **Myanmar**, **Nepal**, **Russia**, **Thailand**, & **Vietnam**.




### Global Snow Leopard and Ecosystem Program (GSLESP)

- In 2013, the scope of **Global Tiger Initiative** was broadened to include **Snow Leopards**. Member countries adopted **Bishkek Declaration** that aims members to work together to **identify and secure**

**at least 20 snow leopard landscapes** across the cat's range **by 2020** or, in short – "**Secure 20 by 2020**."

- **Members include:**
  1. Kyrgyzstan
  2. Afghanistan
  3. Kazakhstan
  4. Mongolia
  5. Pakistan
  6. **13 Tiger Range Countries**

### Snow Leopard Population Assessment in India

- Snow Leopard Population Assessment in India was launched during the 4th steering committee meeting of the **GSLEP**. It is a part of **Population Assessment of the World's Snow Leopard (PWAS)** launched by **GSLEP**. This is the **1st time** that India will have a national level protocol to count snow leopard's population.

## St. Petersburg Declaration

- In 2010, leaders of the tiger range countries (TRCs) assembled at an **International Tiger Forum in St. Petersburg**, **Russia**, to adopt the **St. Petersburg Declaration on Tiger Conservation** and endorsed its implementation mechanism, called the **Global Tiger Recovery Program**. Their overarching goal was to **double the number of wild tigers (TX2)** across their geographical area from about 3,200 to more than **7,000 by 2022**.

✓ **Successes:** India, Nepal, and Russia have shown that tiger recovery is possible, despite challenges in funding and sustaining community livelihoods. In India, Tiger Population in India increased from 1706 in 2010 to 2226 in 2015.

➢ **Failures:** According to **World Wildlife Fund (WWF)**, there are only around **3,900 tigers** remaining in the wild across the globe. In **SE Asia**, the tiger numbers kept dwindling.

### International Consortium on Combating Wildlife Crime

- International Consortium on Combating Wildlife Crime (ICCWC) was established in **2010 in St. Petersburg** at Tiger Forum Meeting. It aims to **strengthen criminal justice systems** and provide **coordinated support** at the national, regional and international levels to combat wildlife crime.
- Partner agencies to ICCWC are **CITES** Secretariat, **INTERPOL**, United Nations Office on Drugs and Crime (UNODC), **World Bank** and World Customs Organization (WCO).

## TX2 and Tiger Conservation Excellence Award

- **TX2 Award** and **Tiger Conservation Excellence Award** are awarded to sites that are contributing towards achieving the **TX2 (Tigers times two) goal** — **to double the population of wild tigers by 2022**. India is party to the TX2 agreement of **World Wildlife Fund (WWF)**.

### Conservation Assured | Tiger Standards (CA|TS or CATS)

- CA|TS is a set of criteria which allows tiger sites to check if their management will lead to successful tiger conservation. Officially launched in 2013, CA|TS is an important part of TX2 goal. **WWF** is helping tiger range countries to implement CA|TS. **17 Tiger Reserves in India have CA|TS international accreditation**.

### TX2 Award

- The **TX2 Award** will go to one site that has achieved a **remarkable increase in its tiger population** since 2010. **Pilibhit Tiger Reserve** **won the inaugural 2020 TX2 Award**.

### Tiger Conservation Excellence Award

- **Conservation Excellence Award** recognizes one site that has **achieved excellence in at least 2/5 themes**:
  1. Tiger and prey population monitoring (tiger translocation/prey augmentation)
  2. Effective site management (**CA|TS assessments**)
  3. Enhanced Law Enforcement
  4. Community based conservation and Human-Wildlife conflict mitigation
  5. Habitat and prey management
- The **Transboundary Manas Conservation Area** (India-Bhutan border) has **received the Conservation Excellence Award for 2020**.
- Transboundary Manas Conservation Area comprises of
  1. The 500 $km^2$ **Manas National Park** in Assam and
  2. The 1,057 $km^2$ **Royal Manas National Park** in Bhutan.

⇨ ***Gandhinagar Declaration****: adopted by all parties to CMS. It underscores the* ***importance of migratory species****. It calls for migratory species and the concept of '****ecological connectivity****'.*

⇨ ***Bishkek Declaration****: it wanted the members of the* ***Global Snow Leopard and Ecosystem Program (GSLESP)*** *to work together to* ***identify and secure at least 20 snow leopard landscapes*** *across the cat's range* ***by 2020*** *or, in short – "****Secure 20 by 2020****."*

⇨ ***St. Petersburg Declaration****:* ***doubling the Tiger Population (T*2 Program)****. An initiative by* ***Global Tiger Recovery Program (GTRP)****.*

## Project Snow Leopard

- Project Snow Leopard was launched in **2009** with the objective to safeguard and conserve India's unique natural heritage of **high-altitude wildlife** populations and their habitats. For conservation, India has identified three large landscapes:
  1. **Hemis-Spiti**, **across Ladakh and Himachal Pradesh**;
  2. **Nanda Devi – Gangotri**, **in Uttarakhand**; and
  3. **Khangchendzonga – Tawang**, **across Sikkim and Arunachal Pradesh**.
- In 2003, the **Convention on Migratory Species** included the snow leopard as a **Concerted Action Species** under its **Appendix I**. Similarly, in 2003, the CITES expanded the scope of the **CITES Tiger Enforcement Task Force** to **include all Asian big cat species**, including the snow leopard.

# SNOW LEOPARD

*(Panthera uncia)*

They inhabit the high mountains of northern and central Asia, including the Himalayas, at elevations up to 18,000 feet. They primarily dwell in alpine regions above the tree line.

## HABITAT


- China,
- Bhutan,
- Nepal,
- India,
- Pakistan,
- Russia,
- Mongolia
- Afghanistan,
- Uzbekistan,
- Kazakhstan,
- Kyrgyzstan,


In India they are found in Himachal Pradesh, Sikkim, Jammu-Kashmir, Uttarakhand, Arunachal Pradesh.

## THREATS

Poaching
Conflict with Communities
Shrinking Habitat
Climate Change

Adapt in various athletic events, the snow leopard excels in the long jump, with some leaping up to 9 meters, six times their body length.

The wild leopard population may be as low as 4,000, but their elusive nature makes the exact count uncertain.

Generally found alone, except during the breeding season

Excellent camouflage

Commonly referred to as the "Ghosts of the Mountains"

Sounds- Hisses, Growls and Meows. (They can't roar)

Closer in kinship to tigers than leopards.

Inhabits cold mountainous regions, rocky landscapes, forests, and montane grasslands

Coat has Rosettes unique to each Individual.

Possesses a thick, lengthy tail utilised for maintaining balance on steep mountain slopes.

Snow leopards live in high-altitude mountainous terrain, usually at elevations of 3,000-4,500m.

IUCN Status

RED LIST
VULNERABLE
VU

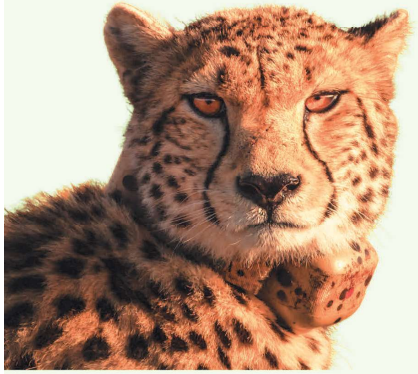
Most Active at Dawn and Dusk

Gestation - approx. 90-100 days, litter of 2-4 cubs

# Cheetah vs Leopard vs Jaguar



Tear Marks on face



## Cheetah

*(Acinonyx jubatus)*

Large **Slender Spotted Cat** found in **African Savannah** and **Iran**. **It is the fastest animal on land.**

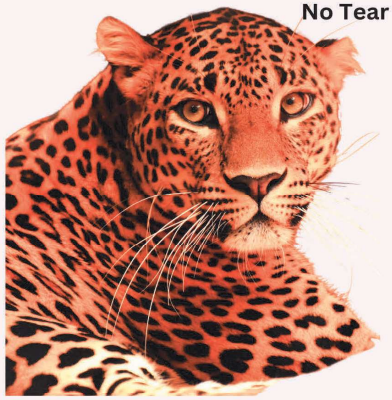
**Fur Color:** Upper coat of fur is tawny, pale buff or grayish white, with underparts that are paler and whiter.
**Spots:** **Solid black spots**

Habitat: **Savanna Grasslands**

**Build:** Tall but Slender build with a **small head** (**body design is optimized for speed**).
**Tail:** **Long tail striped with white tip**

**Speed:** 120 kmph

No Tear Marks on face



## Leopard

*(Panthera pardus)*

A large Solitary cat that has a fawn or brown coat with black spots, native to the **forests of Africa and southern Asia**.

**Fur Color:** Coat is cream-yellow on the belly and it darkens slightly to an orange-brown on the back.
**Spots:** Spots grouped into small rosettes

Habitat: **Dense Bush**

**Build:** Robust build with a large and strong body and larger head.
**Tail:** Covered in rosettes



**Speed:** 60 kmph

## Jaguar

*(Panthera Onca)*

A **large heavily built** cat that has a yellowish-brown coat with black spots. found mainly in the **dense forests of Central and South America**.

**Fur Color:** Tawny-colored fur with black rosettes, but some have black-on-black (melanistic) coloration.
**Spots:** Large rosettes with spots inside

Habitat: **Wet Lowlands**

**Build:** Sturdier than leopard.
**Tail:** Covered in rosettes

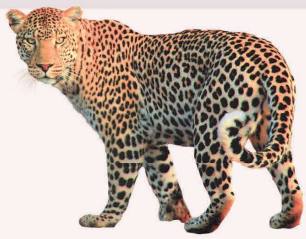
**Panther is a Melanistic Jaguar**

**Speed:** 80 kmph

**Unlike leopards and jaguars, the claws of the cheetah do not retract completely, so they are not made for climbing trees. This is another feature that enables it to run so fast.**

**IUCN: African Cheetah):** Vulnerable
**CITES:** Appendix I **& CMS:** Appendix I
**Asian Cheetah:** Critically Endangered

**IUCN Status:** Vulnerable
**CITES:** Appendix I
**CMS:** Appendix II



**IUCN Status:** Near Threatened
**CITES:** Appendix I
**CMS:** Appendix I

### Why to conserve the high-altitude ecosystem?

- The high altitudes of India (> 3000 m) (including the Himalaya and Trans-Himalaya biogeographic zones) support highly endangered populations of species such as the **Snow Leopard (VU)**, two species of bears, **Red Panda (EN)**, mountain ungulates such as the Wild Yak (VU), Chiru/Tibetan Antelope (NT), Tibetan Gazelle (NT), Tibetan Argali/Mountain Sheep (NT), Ladakh Urial (VU), two species of Musk Deer (EN), **Hangul/Kashmir stag – CR)**, Himalayan Goral (NT), Serow (VU), Takin (VU), etc.
- High altitude lakes and bogs provide breeding grounds for a variety of avifauna including the **Black-Necked Crane (NT)**, Bar-Headed Geese (LC), etc.

## 10.7. Reintroduction of Cheetahs in India

- Over 70 years after they went extinct, **eight cheetahs (five females and three males)** from **Namibia** were reintroduced in India on an experimental basis. Spread over 748 $km^2$, **Kuno Palpur National Park in MP** is their new home. This is the **world's first intercontinental translocation of a carnivore**. It is unique because, for the first-time cheetahs will be reintroduced in an **unfenced protected area (PA)**.

> ⇨ *In South Africa, **all PAs** that support large predator populations are **fully fenced** to reduce human-wildlife conflict. This is called **'fortress conservation'**. Social scientists criticise it as it barred neighbouring communities from using natural resources within these PAs.*
>
> ⇨ *In India, **PAs** are **not fenced** rather they are **surrounded by buffer zones (neutral zones)** that allow neighbouring communities to utilise natural resources within these PAs. This **co-existence approach** is considered more favourable by social scientists.*

- Cheetahs can **help restore open forest and grassland ecosystems** in India. The success of this batch of animals will be the **touchstone of India's initiative to be home to four wildcats** — the tiger, lion, leopard, and cheetah.
- The Government has constituted a **Task Force** for monitoring cheetah introduction. The task force will be in force for a period of **two years**. It will monitor the health status of cheetahs, upkeep of the quarantine enclosures, and open cheetah habitat for eco-tourism and suggest and advise on developing tourism infrastructure in the fringe areas of Kuno National Park and other protected areas.

### Cheetah vs Leopard vs Jaguar

| African Cheetah | Asiatic Cheetah |
|---|---|
| **IUCN: Vulnerable** | **IUCN: Critically Endangered** |
| **CITES: Appendix-I** | **CITES: Appendix-I** |
| Found all over African continent. Population around 6,500-7,000. | 40-50 are found in **Iran** (**Declared extinct in India in 1952**). |
| **Bigger** in size as compared to Asiatic Cheetah. | **Smaller and paler** than the African cheetah. It usually has red eyes and a **more cat-like appearance**. |

## Why Kuno NP?

- Cheetahs do not prey on humans or attack large livestock. **Space is the most important consideration**. Barring high altitudes, coasts and the northeast region, a large part of India is considered a cheetah habitat. However, Kuno was chosen as the most preferred habitat based on the assessment carried out by the **Wildlife Institute of India** and **Wildlife Trust of India (WTI)** based on climatic variables, prey densities, the population of competing predators, and the **historical range**.

  - ✓ **No human settlements:** There has been a complete relocation of roughly 24 villages and their domesticated livestock from inside the park years ago.
  - ✓ **Savannah habitat:** The village sites and agricultural fields have now been taken over by grasses.
  - ✓ **Range:** The region is very close to the Sal forests of Chhattisgarh, the historical range of the cheetah.
  - ✓ **Scope for coexistence:** Kuno offers the prospect of housing all four large felines in India — tiger, lion, leopard and cheetah. (**Kuno** was initially proposed to provide a **second home for the lions**).

### Concerns

- The forest has a significant population of **leopards**. This remains a concern as the **much-stronger leopard** has an advantage over the **slender cheetah**, whose strength mainly lies in its blazingly fast speed. Leapords are also believed to have **more adaptive potential** and a **wider habitat (forests and grasslands)** than the **cheetah (grasslands – open spaces are critical for survival)**.

# 10.8. Conservation of Lions

## Asiatic Lion

- Asiatic Lion (also known as ***Persian Lion***) is restricted to India. Earlier, it was found in West Asia and the Middle East. In India, they are found at **Gir National Park and Wildlife Sanctuary** (the only abode of the Asiatic lion). Earlier, it was also found in West Bengal and central India.
- **IUCN Red List: EN | CITES: Appendix I | WPA: Sch I**

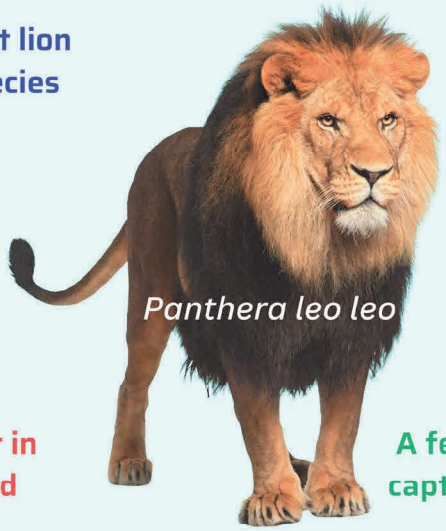
## Project Lion

-

## Barbary Lion (Atlas, North African Lion)

Largest lion subspecies

The mane of the adult male lion extends beyond its underbelly



*Panthera leo leo*

Extinct in the wild

A few survive in captive breeding

## African Lion (South and East Africa)

Most populous lion subspecies

*Panthera leo melanochaita*

IUCN Red List: VU

CITES: Appendix II

## Asiatic Lion (Gir National Park)

Has a fold of skin along it's underbelly

Usually smaller than African lions

*Panthera leo persica*

IUCN Red List: EN

CITES: Appendix I

Extinct in most of its historical range

- Project Lion envisages **landscape ecology-based conservation** of the Asiatic Lion by integrating conservation and eco-development. It is being **implemented in the Gir landscape in Gujarat**, which is the last home of the Asiatic lion.
- Objectives include securing and restoring lions' habitats for managing their growing population, scaling up livelihood generation & participation of local communities, etc.
- The population of Asiatic Lions has shown a steady increase, with a population of **674 individuals (2020)**, 28.87 per cent (one of the highest growth rates so far) higher than the 523 lions in 2015.
- India now (2020) has 12,852 leopards compared to the previous estimate of 7910 conducted in 2014. More than a 60 per cent increase in population has been recorded.

**Mains Prectise: Explain the importance of India's Cheetah Reintroduction Project. Should a similar project be taken up for Gir Lions? Analyse. (200 words)**

- Here, the question DOES NOT ask you to list the advantages and disadvantages of the Cheetah Reintroduction Project. It assumes the importance of the project and demands that you explain it.
- The second part demands an analysis of a similar project for Gir Lions, which are at a greater risk of extinction due to the **extreme concentration of population** in a tiny pocket of Gir forests, which are vulnerable to calamities like Cyclone Biparjoy, **zoonitic diseases**, **inbreeding depression**, etc.
- You must explain the potential reintroduction sites and associated challenges.

**Mains Prectise: Compare and contrast (differentiate) the challenges in conserving Bengal Tiger and Asiatic Lion. (200 words)**

- Habitat fragmentation and **habitat saturation** due to increasing population (most tiger habitats have reached the threshold of their **carrying capacity**) and associated human-animal conflict are the significant challenges in the case of the conservation of the Bengal Tiger.
- Since the population of the Bengal Tiger is distributed among various regions, you must explain the region-specific challenges. (Use the information from Tiger Census Report).
- Restricted range and the **extreme concentration** of population in a tiny pocket of Gir forests is the most significant challenge in the case of Gir Lions.

**---------- End of Chapter ----------**

# 11. Wildlife Conservation Part II

## 11.1. Conservation of Elephants

- More than 60 per cent of the Asian elephant population is in India. While the tigers face the threat of extinction, the Asian elephants (**WPA: Sch I**) face the threat of attrition (gradual reduction). Their numbers have not increased or decreased drastically, but there is increasing pressure on their habitats.
- Poaching and land-use changes remain major challenges to elephant populations. As **both male and female African elephants possess tusks**, the impact of ivory poaching is especially severe. **African Forest Elephants (CR)** have a **more prolonged pregnancy than any other mammal — almost 22 months**. This further compounds the challenge of conservation.

**[UPSC 2020] With reference to Indian elephants, consider the following statements:**

1. The leader of an elephant group is a female
2. The maximum gestation period can be 22 months.
3. An elephant can normally go on calving till the age of 40 years only.
4. Among the States in India, the highest elephant population is in Kerala.

***Which of the statements given above is/ are correct?***

a) 1 and 2 only
b) 2 and 4 only
c) 3 only
d) 1, 3 and 4 only

**Explanation**

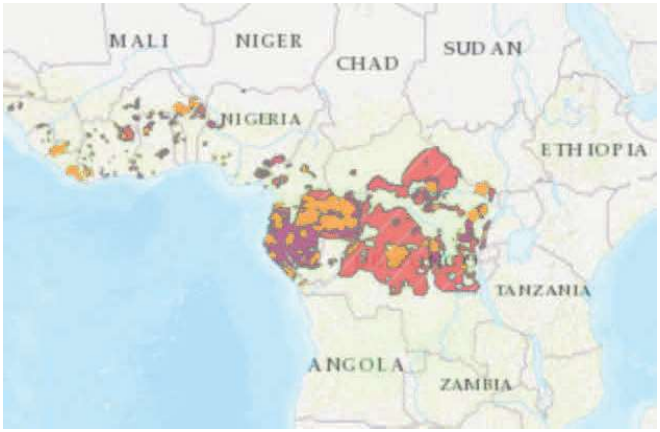
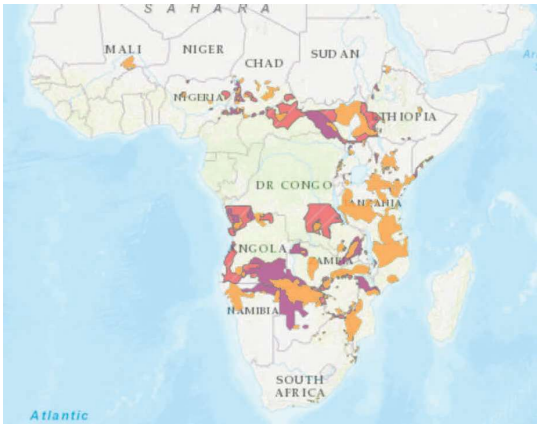
- **African elephants** are pregnant for an average of **22 months**, whilst, for **Asian elephants**, it's **18 to 22 months**.
- **Karnataka (6000+)** has the highest number of elephants in India, followed by **Assam (5700+)** and **Kerala (5700+)**.
- Most females give birth for the first time between 14 and 15 years old in African elephants, and slightly later in Asian elephants. Fertility is constant between the ages of 16 and 40 and then declines slightly, though females over 60 can still give birth.

***Answer: a) 1 and 2 only***

### Asian Elephant vs African Elephant and African Forest Elephant vs African Savanna (Bush) Elephant

- **African Savannah (Bush) Elephant** is the **largest living terrestrial animal**.

| African Forest Elephant | African Savannah (Bush) Elephant |
|---|---|

| | |
|---|---|
| Habitat: **Tropical forests** of Central and Western Africa.<br>  <br> | Habitat: **Savannah Grasslands** and **semi-arid regions of Sub-Saharan Africa**.<br>  <br> |
| Tusks point downward. | Tusks curve outward. |
| IUCN Red List: **Critically Endangered** | IUCN Red List: **Endangered** |
| **CMS: Appx II \| CITES: Appx I** (Bush Elephants of Botswana, Namibia, South Africa and Zimbabwe are included in **Appendix II**). | |

## Ecological Importance of Elephants

- The **elephant** was declared the **National Heritage Animal of India** in 2010. Elephants are a **keystone species**. Their nomadic behaviour — the daily and seasonal migrations they make through their home ranges — **create an umbrella effect —** preserving a large area for elephants to roam freely provides a suitable **habitat for many other animal and plant species** of an ecosystem.

✓ **Landscape architects:** Elephants create clearings in the forest, preventing the overgrowth of certain plant species, and allowing space for the regeneration of others, which in turn provide sustenance to other animals.

✓ **Seed dispersal:** Elephants release the seeds when they defecate in other places as they travel.

✓ **Nutrition:** Elephant dung nourishes plants and acts as a breeding ground for insects.

✓ **Water providers:** In times of drought, they access the water by digging holes, which benefits other wildlife. Further, their large footprints collect water when it rains, benefitting smaller creatures.

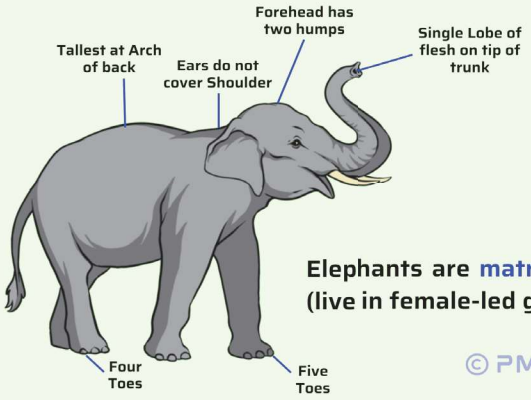
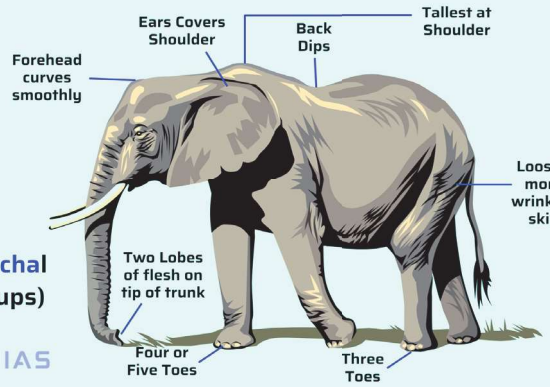
✓ **Food chain:** Apex predators like tigers will sometimes hunt young elephants. Further, elephant carcasses provide food for other animals.

## Elephant Corridor

- Elephant corridors are **linear**, **narrow**, **natural habitat linkages** that allow elephants to move between secure habitats without being disturbed by humans.
- The **Right of Passage**, a study published by the **Wildlife Trust of India (WTI)** in collaboration with **Project Elephant**, has identified 101 elephant corridors across India. Most of these corridors are in **north-eastern India**, followed by **South India**, **central India**, northern West Bengal and north-western India.

# Asian Elephant vs African Elephant



| CATEGORIES | ASIAN ELEPHANT (*Elephas maximus*)<br>*Subspecies: Indian, Sumatran & Sri Lankan* | AFRICAN ELEPHANT<br>*Species: Forest (Loxodonta cyclotis) & Savannah Elephant (Loxodonta africana)* |
|---|---|---|
| |  <br>Elephants are **matriarchal** (live in female-led groups)<br> |  |
| **Head Shape** |  They have a **twin-domed head** with an indent running up the center of their head |  They **have fuller, more rounded heads**, and the top of their head is a **single dome shape.** |
| **Ear Shape** |  Their ears are **smaller**, and **more semi-circular.** |  They have much **larger ears**, shaped a little like the continent of Africa. |
| **Size & Weight** |  The biggest Asian males reach no more than 3.5 meters. |  The African elephant is the larger of the two elephants, with bulls growing up to 4 meters tall. |
| **Tusks** |  **Only male Asian elephants have tusks. Female Asian elephants have rudimentary tusks called tushes.** |  **Both male and female African elephants can have tusks.** African elephant tusks are bigger than Asian elephant tusks. |
| **Trunk** |  They have **only one 'finger' at the end of their trunk**, which they compensate for by holding objects against the underside of their trunk. |  The African elephant trunk has **two distinct 'fingers'** which they use to pick up and manipulate objects. |
| **Lifespan** | Asian elephants can live up to **48 years.** | African elephants can live up to **70 years.** |
| **IUCN / CMS** | **Endangered / Appendix I** | **Forest Elephant** **CR / Appx II** **Savannah Elephant** **Endangered / Appx II** |
| **CITES** | **Appendix I (Elephants of Botswana, Namibia, SA & Zimbabwe are included in Appendix II)** | |
| **Population** | **40,000 to 50,000** (28,000 Elephants in India with around **25% of them in Karnataka**) | **4,15,000** (More than 3,50,000 are bush elephants) |
| **Gestation Period** | They are pregnant for **18 to 22 months.** | They are pregnant for an average of **22 months.** |
| **Region** |  They live in forested areas across **Southern Asia** – from **Nepal**, through **India**, and across **Sri Lanka** – and throughout **Southeast Asia**, including **Myanmar, Thailand, Malaysia, Laos, and Cambodia.** |  They range across the rainforests of **West and Central Africa**, and through the savannas. The most northern area of the African elephant's range is the **Sahel area of Mali** where a small, nomadic herd of Mali elephants perform a circular annual migration in search of water. |

### Threats to Elephant Corridors

- **Habitat loss** happens due to fragmentation and destruction caused by developmental activities like mining, tourism, the construction of roads, railways, energised electric fencing, etc. **Coal** and **iron ore mining** are the two biggest threats to elephant corridors in **central and eastern India**.
- Elephants need extensive grazing grounds, and most reserves cannot accommodate them. If protected areas are not large enough, elephants may search for food elsewhere. This often results in human-elephant conflict leading to loss of life (~400 humans are killed in encounters with elephants annually), crops, and property.

### Mitigation

- ✓ Fusion of the corridors with nearby protected areas wherever feasible.
- ✓ Prevention of further fragmentation of the continuous forest habitat by encroachment from urban areas.
- ✓ Declaration of the corridors as **Ecologically Sensitive Areas** or conservation reserves for protection.
- ✓ Securing the corridors by sensitising local communities and ensuring relocation voluntarily outside the conflict zones to safer areas.

## Project Elephant

- The **centrally sponsored scheme** Project Elephant was launched in 1992 to conserve the elephant population in their **natural habitats**. The objectives of the scheme include:
  - ✓ Assisting states having populations of wild elephants.
  - ✓ Ensuring the long-term survival of identified viable populations in their **natural habitats**.
  - ✓ Addressing **human-animal conflict**.
  - ✓ Developing scientific and planned management measures for the conservation of elephants.
  - ✓ Protecting the elephants from poachers, preventing illegal ivory trade and other unnatural causes of death.

## Other Intitiatives

### Haathi Mere Saathi

- **Haathi Mere Saathi** is a campaign launched by **MoEF** in partnership with the **Wildlife Trust of India (WTI)**. The campaign was launched at the "Elephant- 8" Ministerial meeting held in Delhi in 2011.
- The **E-8 countries** comprise of **India**, **Botswana**, **the Republic of Congo**, **Indonesia**, **Kenya**, **Sri Lanka**, **Tanzania**, and **Thailand**. This public initiative was aimed at increasing awareness among people and developing friendship, and companionship between people and elephants.

### Project RE-HAB

- **RE-HAB Project** is an innovative way of **preventing elephant–human conflicts** without causing any harm. It is demonstrated by **Khadi and Village Industries Commission's (KVIC)**. The project has sig-

nificantly reduced elephants' presence at places in Karnataka's Kodagu district. It will soon be replicated in all states affected by elephant attacks, like **West Bengal**, **Jharkhand**, **Odisha**, **Chhattisgarh**, **Assam**, **Tamil Nadu and Kerala**.

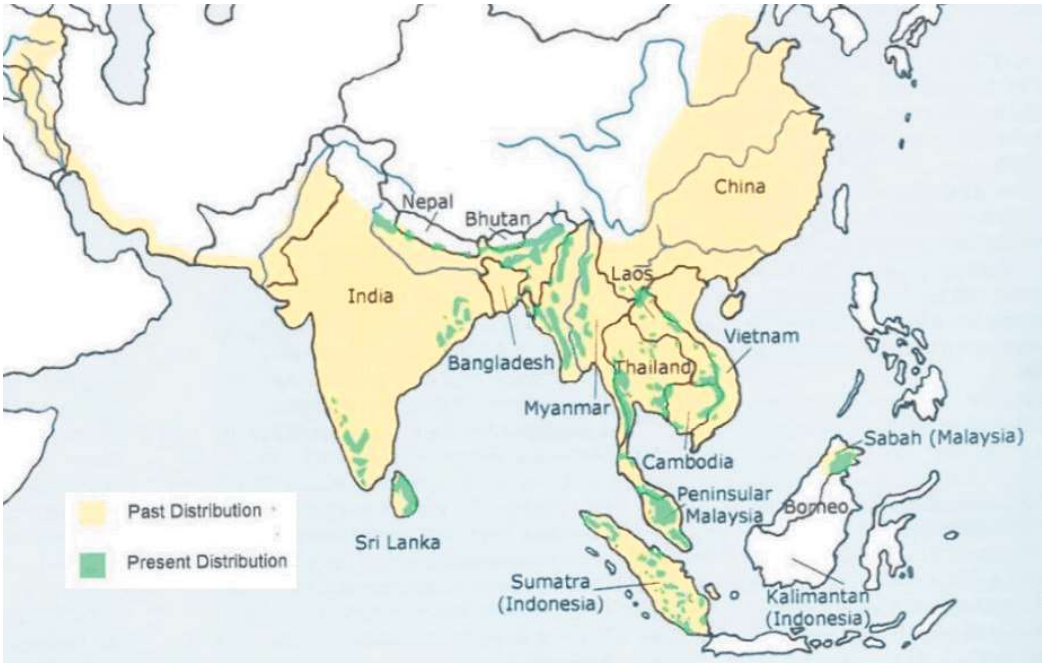
- Under this project, **bee boxes are used as a fence** to prevent elephants from entering human habitation. Elephants fear that the honeybees might sting them in their eyes and the inner side of the trunk. Also, the buzz of the bees irritates the elephants the most.

## Asian Elephant Alliance

- It is a collation of **5 NGOs**
  1. **Elephant Family**
  2. **International Fund for Animal Welfare**
  3. **IUCN**
  4. **Wildlife Trust of India**
  5. **World land Trust**
- It has come together to **secure 96 out of the 101 existing corridors** used by elephants across 12 States in India.

## IUCN Asian Elephant Specialist Group (AsESG)

- AsESG is a global network of **voluntary specialists** concerned with the study, monitoring, management, and conservation of Asian elephants. It is an integral part of the **Species Survival Commission (SSC) of the IUCN**. **Gajah** is the **bi-annual journal** published by **AsESG**.
- AsESG provides the best available scientifically grounded evidence to the abundance, distribution, and demographic status of Asian elephant populations in all **13 range states** — **Bangladesh**, **Bhutan**, **Cambodia**, **China**, **India**, **Indonesia**, **Laos PDR**, **Malaysia**, **Myanmar** (**Burma**), **Nepal**, **Sri Lanka**, **Thailand**, and **Vietnam**.



## 11.2. Conservation of Great One-Horned Rhino

- Rhinos are killed for their horns, which consist of **keratin** similar to human hair and nails and are used in **traditional medicines in Southeast Asia**.

### Rhino Species Across the World

- **White Rhino and Black Rhino: found in Africa**. Black Rhino is the smaller of the two.
- **Javan Rhino:** only a few survive in **Java** and **Vietnam**.
- **Sumatran Rhino:** Sumatran rhino is the **smallest species of rhinoceros**. 30 to 80 Sumatran rhinos remain in the world, mainly on the **Indonesian island of Sumatra**.
- **Great One-Horned Rhino: Only the Great One-Horned Rhino is found in India**. It is the **largest of the rhino species** (second in size only to the Asian elephant).
- Only about 24,500 rhinos survive in the wild. Of these, more than **two-thirds are white rhinos**.
- **African and Sumatran rhinoceros have two horns**, **while the others (Indian** and **Javan) have a single horn**. The Indian rhino's horn is present in **both males** and **females**.

### India's Greater One-Horned Rhinoceros

- **Habitat:** Tropical and Subtropical Savannas & Shrublands.
- **Distribution:** Indian rhinos once ranged across **northern parts of the Indian subcontinent**. Now they are confined to the **Terai alluvial grasslands of India**, **Bhutan** & **Nepal**.
- **Populations: Kaziranga** & **Manas NPs** & **Pobitora WLS**.
- **Threats:** Poached for its horn, habitat loss and habitat fragmentation, human-animal conflict.
- **IUCN Red List: VU | CITES: Appx I | WPA: Schedule I**

**[UPSC 2019] Consider the following statements:**

1. Asiatic lion naturally found in India only
2. Double-humped camel is naturally found in India only
3. One-horned rhinoceros is naturally found in India only

***Which one of the statements given above is/are correct?***

a) 1 only
b) 2 only
c) 1 and 3 only
d) 1, 2 and 3

**Explanation**

- **Asiatic Lions are is naturally found only in the Gir NP**.
- Bactrian Camel (double-humped camel) is endemic to Central Asian Cold Deserts.

***Answer: a) 1 only***


## Conservation Measures

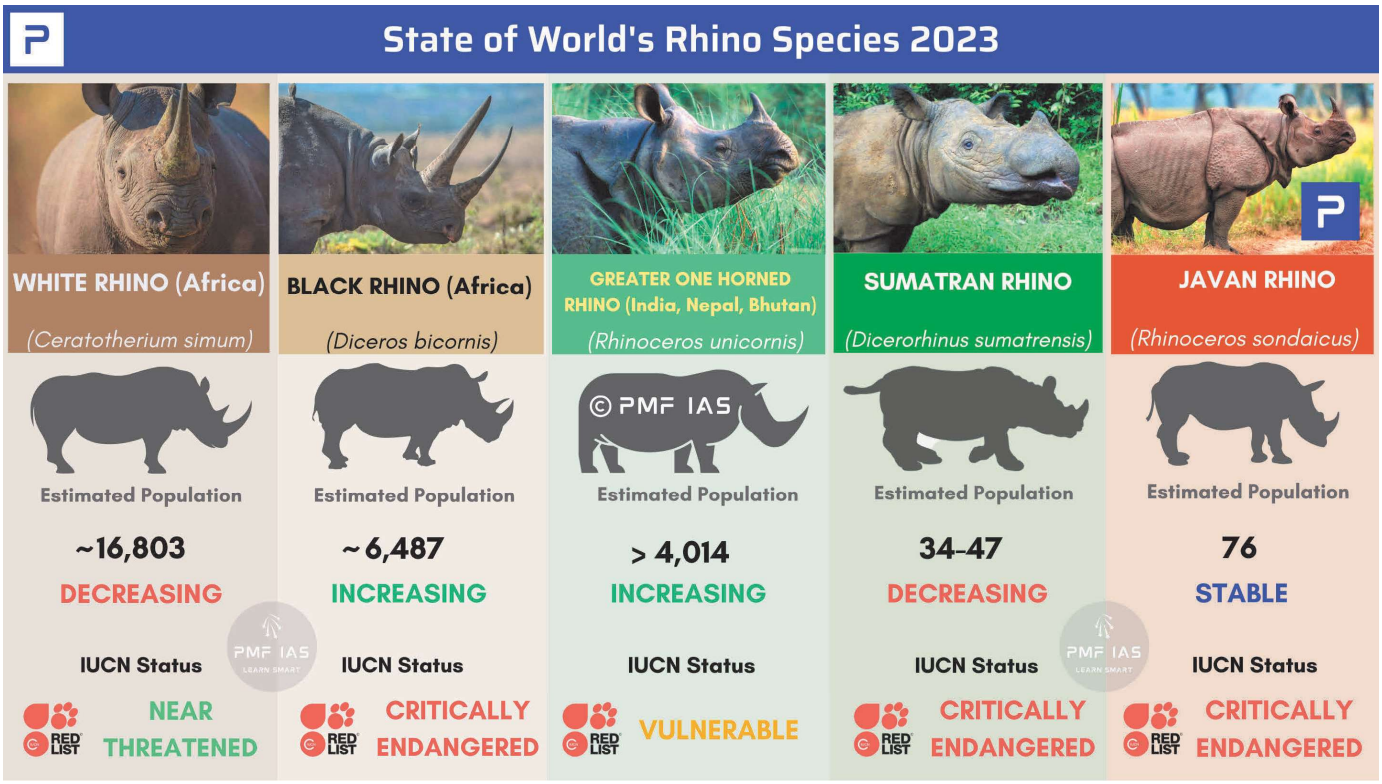
- ✓ In **2005**, Assam adopted the ambitious **Indian Rhino Vision (IRV) 2020** program in partnership with **WWF India** and the **International Rhino Foundation**.
- ✓ **New Delhi Declaration on Asian Rhinos 2019** was announced for the conservation and protection of the species by five rhino range nations (**India**, **Bhutan**, **Nepal**, **Indonesia and Malaysia**).
- ✓ GOI launched a project to create **DNA profiles** of all rhinos.
- ✓ **National Rhino Conservation Strategy** was launched in 2019 to conserve the Indian Rhino.

## India Rhino Vision (IRV) 2020

- Concentrating so many rhinos in a single protected area like **Kaziranga** exposed the species to risks of calamities (epidemics, floods, massive poaching attempts). Therefore in **2005**, conservationists, alongside the **Bodoland Territorial Council** and **government of Assam**, came together to develop a long-term strategy to manage and protect the species. Their vision was to build a **3000 wild population** of **Greater One Horned Rhinos by 2020**, spread across **7 protected areas in Assam**.
- Translocations are the backbone of the IRV 2020 program. Potential rhino habitat areas identified viz. **Manas NP** (first site for the translocation of rhinos), **Dibru Saikhowa WLS**, **Laokhowa-Bura Chapori WLS** with a viable rhino population through translocations from **Kaziranga NP and Pobitora WLS**.
- The **Indian Rhino Vision 2020 ended** with the release of two rhinos in **Assam's Manas NP** transported from **Pobitra WLS**.

## Evaluation of IRV 2020

- IRV 2020 is believed to have **achieved its target** of attaining a population of **3000 rhinos in Assam**. With a viable Rhino population, **Manas regained her (UNESCO) World Heritage Site** status. But the plan to spread the Rhinoceros across other protected areas beyond **Kaziranga NP**, **Orang NP** and **Pobitra WLS could not fully materialise**.
- Translocation to these wildlife areas remained a daunting task as the target sites remained vulnerable to poaching activities.There was negligence towards security and health monitoring of the animals. Unchecked tourism activities and road construction along the Indo-Bhutan border further compounded the problem.




### Way forward

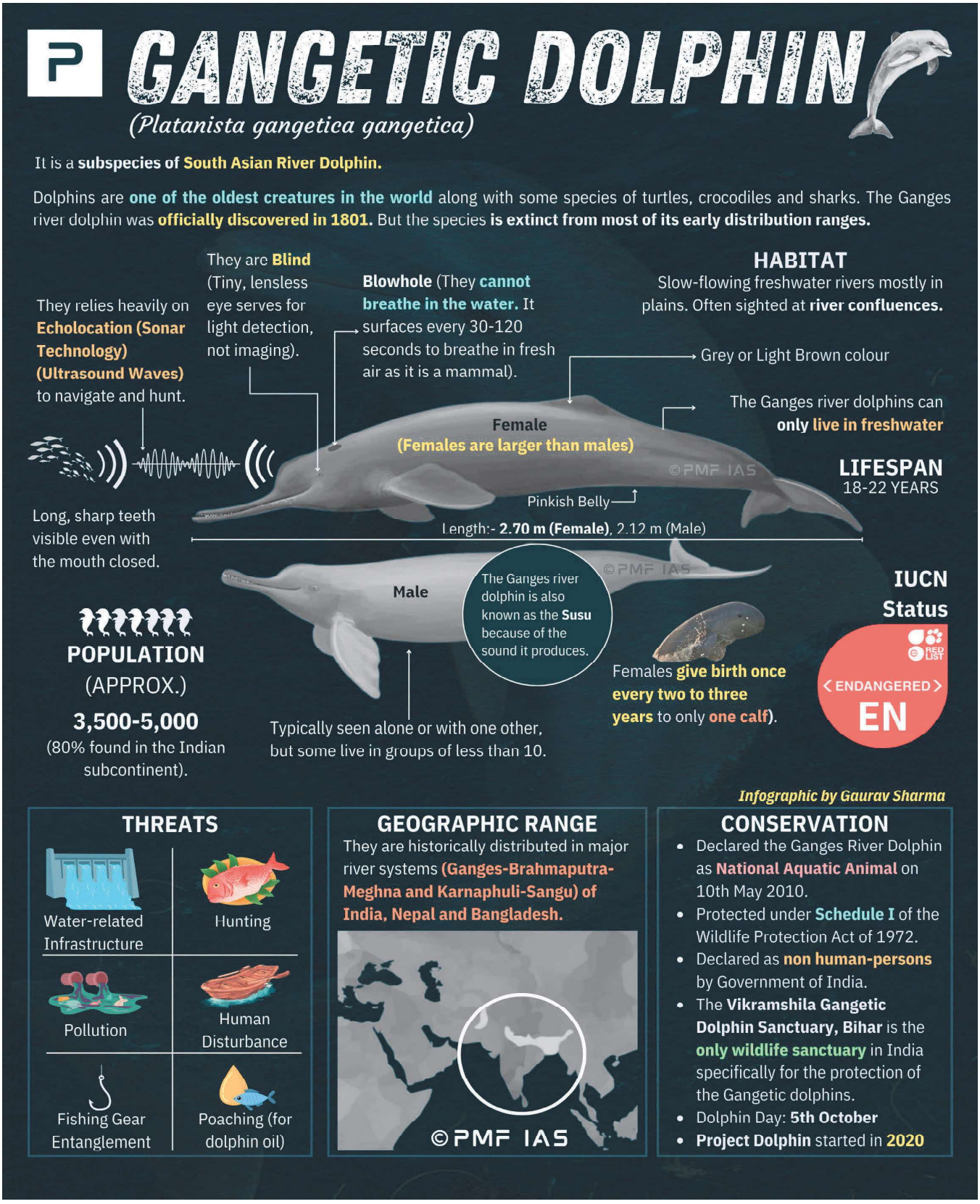
- Rather than Manas, Assam must diversify its search areas to include the rhino range around **Pobitora and Amchang WLS**. The **Brahmaputra river channel** from **Kaziranga** to **Orang** should also be declared a rhino zone.

## 11.3. Conservation of the Indian Dolphins

### Indian Dolphin Species

#### South Asian River Dolphin (*Platanista gangetica*)


- South Asian River Dolphin (**freshwater dolphin species**) is divided into **2 sub-species**.
  - ✓ **Ganges River Dolphin (*P. g. gangetica*)**
  - ✓ **Indus River Dolphin (*P. g. minor*)**
- **Distribution: India**, **Bangladesh**, **Nepal** and **Pakistan**.




- **Threats:** Unintentional killing through entanglement in fishing gear, habitat loss and degradation – water development projects (barrages, high dams, and embankments), pollution – industrial waste and pesticides, municipal sewage discharge and noise from vessel traffic.
- **IUCN: EN | CITES: Appx I | CMS: Appx I | WPA: Sch I**

### Ganges River Dolphin – Susu (*P. g. gangetica*)

- GOI recognised the **Ganges River dolphin** as its **National Aquatic Animal** in 2009. It is also the **State Aquatic Animal of Assam**. Because of the sound it produces when breathing, the animal is popularly referred to as the '**Susu**'. It is an **indicator species** for the river Ganga. It can **only live in freshwater** and is essentially blind **(blind dolphin)**. They hunt by emitting **ultrasonic sounds**.
- **Distribution: Ganges-Brahmaputra-Meghna**
- Only the **Ganges River Dolphin** is currently listed in **Convention on Migratory Species**.

### Indus River Dolphin (*P. g. minor*)

- It is the **State Aquatic Animal of Punjab**.
- **Habitat: Indus River** in Pakistan and its **Beas (only habitat of the Indus River Dolphin in India)** and **Sutlej** tributaries.

**[UPSC 2015] Which one of the following is the national aquatic animal of India?**

a) Saltwater crocodile
b) Olive ridley turtle
c) Gangetic dolphin
d) Gharial

**[UPSC 2014] Other than poaching, what are the possible reasons for the decline in the population of Ganges River Dolphins?**

1) Construction of dams and barrages on rivers
2) Increase in the population of crocodiles in rivers
3) Getting trapped in fishing nets accidentally
4) Use of synthetic fertilizers and other agricultural chemicals in crop-fields in the vicinity of rivers

***Select the correct answer using the code given below.***

a) 1 and 2 only
b) 2 and 3 only
c) 1, 3 and 4 only
d) 1, 2, 3 and 4

**Explanation**

- 'Susu' shares its habitat with crocodiles (gharials), turtles and wetland birds, many of which are fish eaters and are potential competitors with dolphins.

***Answer: c) 1, 3 and 4 only***

**[UPSC 2017] If you want to see gharials in their natural habitat, which is the best place to visit?**

a) Bhitarkanika Mangroves
b) Chambal River

c) Pulicat Lake
d) Deepor Beel

### Irrawady Dolphin (Orcaella brevirostris)

- **Habitat:** **brackish water** near coasts, river mouths, and estuaries and in **freshwater rivers**, including the **Ganges**, **Mekong** and **Irrawaddy rivers**.
- **Distribution:** Concentrated lagoon populations in India are found in **Chilika Lake in Odisha**.


- **Threats:** Human conflict, drowning in gillnets, etc.
- **IUCN: EN | CITES: Appx I | CMS: Appx I | WPA: Sch I**

### Ganges River Dolphin Conservation Measures

- ✓ After the launch of **Ganga Action Plan** in 1985, GOI included Gangetic dolphins in the **Sch I** of the **WPA, 1972**. **National Ganga Council** was set up to save their population. **Vikramshila Gangetic Dolphin Sanctuary** (**Biha**r), only sanctuary for dolphin conservation, was created.
- ✓ In 2020, PM Modi announced the government's plan to launch **Project Dolphin**. Such an initiative got in-principal approval at the first meeting of the **National Ganga Council (NGC)**, **headed by the Prime Minister**. The proposed project is aimed at saving **both** river and marine dolphins.
- ✓ **Conservation Action Plan for Gangetic Dolphin (2010-2020):** identified threats to Gangetic Dolphins and impact of river traffic, irrigation canals and depletion of prey-base on dolphin populations.
- ✓ **Ganges River Dolphin** is included among 21 species under the **Integrated Development of Wildlife Habitat**.
- ✓ In 2009, the then PM while chairing the maiden meeting of the **National Ganga River Basin Authority**, declared the **Gangetic River dolphin as the national aquatic animal**.
- ✓ The **National Mission for Clean Ganga**, which implements the government's flagship scheme Namami Gange, celebrates October 5 as National Ganga River Dolphin Day.

## 11.4. Conservation of Indian Crocodile Species

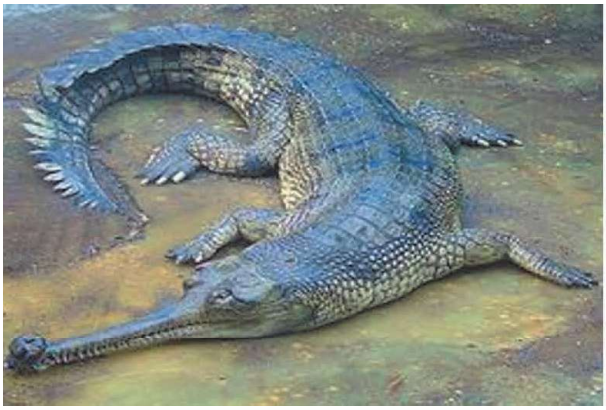
### Crocodile vs Alligator vs Gharial

| Aspects | Crocodiles | Alligators | Gharials |
|---|---|---|---|
| Family | Crocodylidae | Alligatoridae | Gavialidae |
| Habitat | **Saltwater** | **Freshwater** | **Freshwater** |
| Distribution | Throughout the tropics | US, Mexico and China | Gharial: Ganges and Indus; False gharial: Indonesian Is. |
| Snout Shape | Pointed and V-shaped | Wide and U-shaped | **Long and thin snout** |
| Behaviour | **Aggressive** | **Less Aggressive** | **Very shy** |
| Size | **Large** | **Small** | **Medium** |
| Bite Force | **High** | **Medium** | **Low** |
| Diet | Opportunistic feeders | Opportunistic feeders | **Fish** |
| Species | 13 | 8 | 2 |

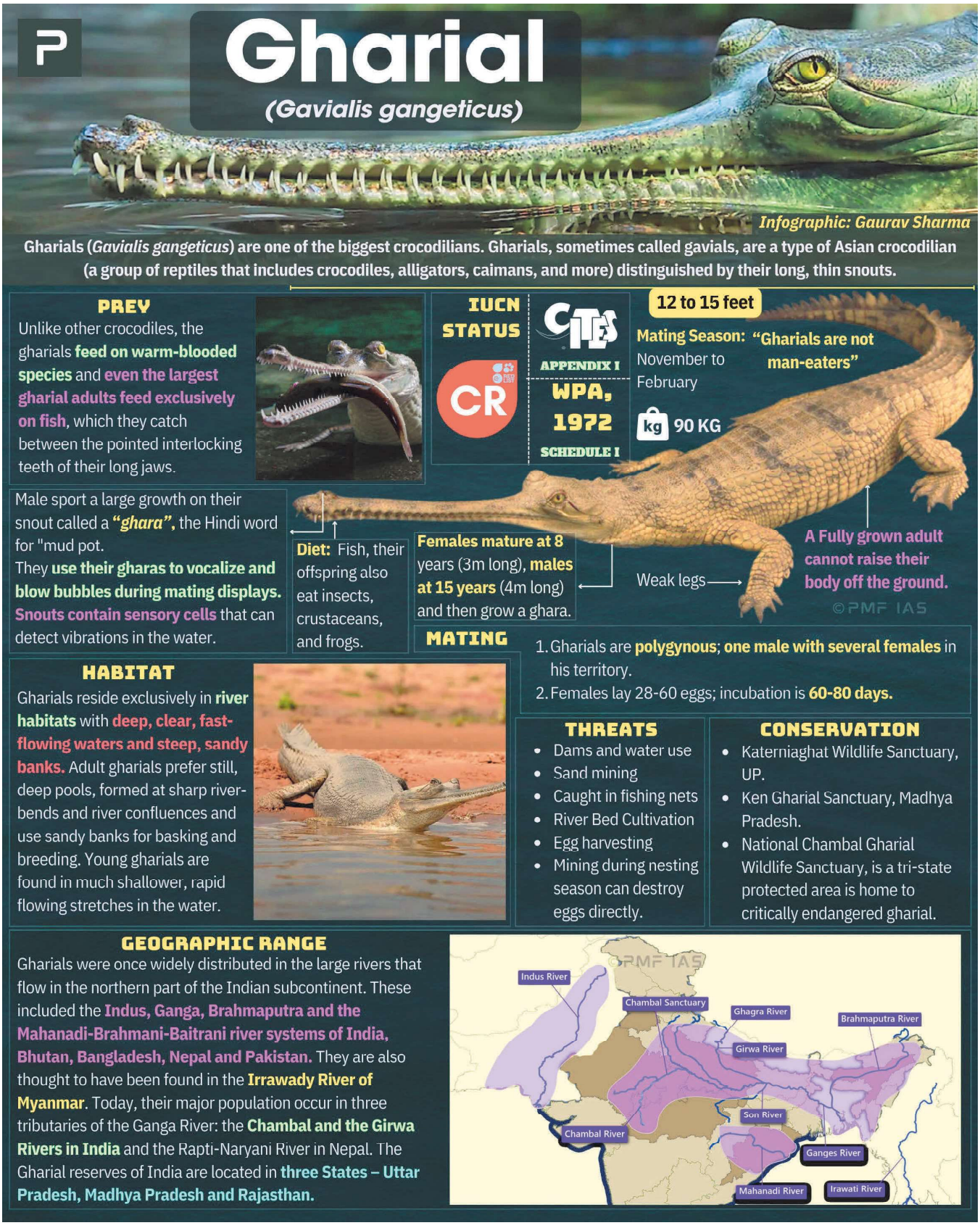
## Indian Crocodile Species

### Gharial (CR)

- Gharial (CR) are **fish-eating freshwater crocodiles**. They are amongst the **longest** of all living crocodilians. They once thrived in all the major rivers of the Indian subcontinent. Today, they are extinct in the Indus, the Brahmaputra of Bhutan and Bangladesh, and in the Irrawaddy River.




- **Habitat:** clean rivers with sand banks.
- **Distribution:** Only viable population is in the **National Chambal Sanctuary** spread across 3 states of **UP**, **Rajasthan** & **MP**.
- Small non-breeding populations exist in **Son**, **Gandak**, **Hoogly**, **Ghagra rivers** & **Satkosia WLS** (**Odisha**).




- **Threats:** combined effects of dams, barrages, artificial embankments, change in river course, pollution, sandmining, riparian agriculture & ingress of domestic & feral livestock.
- **IUCN: CR | CITES: Appx I | CMS: Appx I | WPA: Sch I**

# CROCODILES OF INDIA



## MUGGER CROCODILE
**(CROCODYLUS PALUSTRIS)**

Mugger, Muggar, Broad-snouted Crocodile, **Marsh Crocodile**

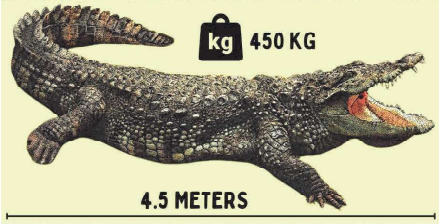
## SALT WATER CROCODILE
**(CROCODYLUS POROSUS)**

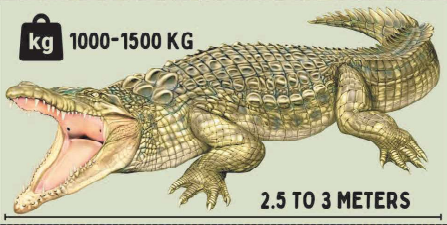
Salt-water Crocodile, Estuarine Crocodile, Saltie

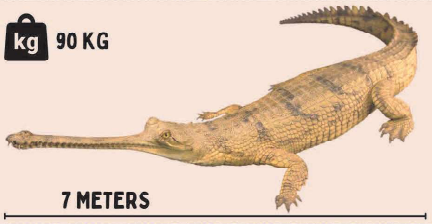
## GHARIAL
**(GAVIALIS GANGETICUS)**

Indian Gharial, Fish Eating Crocodile, Indian Gavial, Long Nosed Crocodile

### SIZE & WEIGHT




### HABITAT

**Freshwater lakes, rivers, marshes, wetlands** in the Indian subcontinent; also found in artificial aquatic environments and marine neritic wetlands.

**Coastal regions**, rivers, and swamps in Southeast Asia, Northern Australia, and the Indian subcontinent.

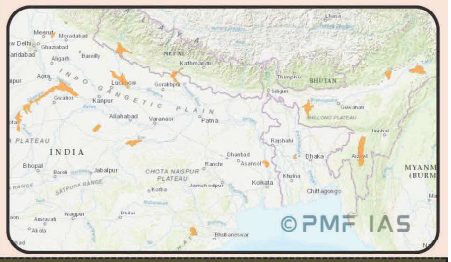
Gharials live in **deep, fast rivers with sandy banks.** Adults prefer deep pools at bends, while young stay in shallow, fast waters.

### GEOGRAPHIC RANGE

This species is found in India, Sri Lanka, Pakistan, Nepal, possibly Bangladesh, and eastern Iran. Major populations are in India and Sri Lanka, with significant numbers in the **Ganga River drainage, Bihar, Jharkhand, Chambal River, and Gujarat.**


Swamps in Southeast Asia, Northern Australia, and the Indian subcontinent. Saltwater crocodiles are **rare on the Indian subcontinent except for the eastern coast.** They are in Bangladesh, **Odisha's Bhitarkanika Sanctuary**, Sundarbans, and Andaman and Nicobar Islands. Historically, they were widespread in Sri Lanka.


Gharials were once widespread in northern rivers of India, Bhutan, Bangladesh, Nepal, Pakistan, and possibly Myanmar. Now, major populations are in the **Chambal, Girwa (India), and Rapti-Narayani (Nepal) rivers.** Indian reserves are in Uttar Pradesh, Madhya Pradesh, and Rajasthan.




### CONSERVATION

| | | |
|---|---|---|
| IUCN VU | CITES APPENDIX I | WPA,1972 SCHEDULE I |
| IUCN LC | CITES APPENDIX I | WPA,1972 SCHEDULE I |
| IUCN CR | CITES APPENDIX I | WPA,1972 SCHEDULE I |

### THREATS

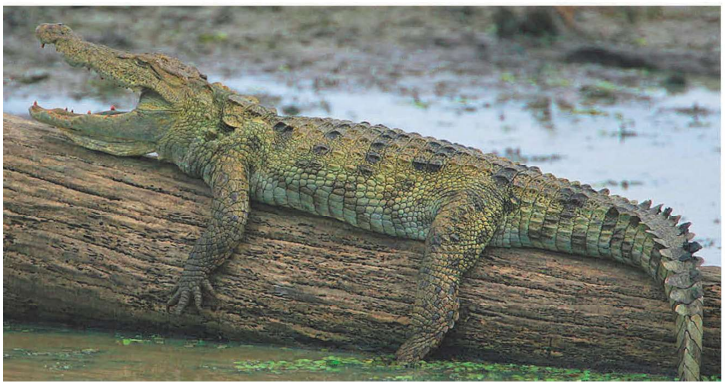
- Habitat destruction
- Fishing equipment entanglement
- Egg predation and poaching
- Human-wildlife conflict

- Illegal hunting for meat, eggs, and skin
- Habitat loss and alteration
- Negative attitudes hinder conservation

- Habitat destruction by dams, irrigation, crops and livestock
- Prey depletion from fishing
- Egg harvesting and poaching

## Mugger/Indian Crocodile (VU)

- The **mugger (marsh/Indian/Broad Snouted) crocodile (VU)** is a **freshwater species**.
- **Habitat:** freshwater lakes, rivers and marshes, reservoirs, and **slow-moving**, **shallow water bodies**.
- **Distribution: found throughout India**. Extinct in Bhutan.
- **Threats:** Habitat destruction because of conversion of natural habitats for agricultural and industrial use, sacrificed in superstitious practices or used as **aphrodisiacs** (any food or drug that arouses sexual instinct).
- **IUCN: VU | CITES: Appendix I | WPA: Schedule I**




## Saltwater Crocodile (LC)

- Saltwater Crocodile (LC) is the **largest living reptile** and crocodilian known to science.
- **Habitat:** saltwater habitats and brackish wetlands.


- **Distribution:** India's east coast **(Odisha's Bhitarkanika Wildlife Sanctuary**, **Andaman and Nicobar Islands coasts and Sundarbans)**, across Southeast Asia and the Sundaic region to northern Australia.
- **Threat:** Hunted for its skin, illegal killing and habitat loss.
- **IUCN: LC | CITES: Appendix I | WPA: Schedule I**

## Indian Crocodile Conservation Project

- The Indian Crocodile Conservation Project has pulled back the once threatened crocodilians from the brink of extinction and placed them on a good path of recovery. Its objectives are:
  - ✓ To protect the remaining population of crocodilians in their natural habitat by creating sanctuaries.
  - ✓ To rebuild natural population quickly through 'grow and release' or 'rear and release' technique.
  - ✓ To promote captive breeding — members of a wild species are captured, then bred and raised in a special facility under the care of wildlife biologists and other experts. Bringing an animal into captivity may represent the last chance to preserve a species in the wild.

### Madras Crocodile Bank Trust

- It is a reptile zoo and research station on the outskirts of Chennai. It has one of the world's largest collections of crocodiles and alligators.
- It was established to save Indian species of crocodile — the **marsh or mugger crocodile (VU)**, **the saltwater crocodile (LC)**, and the **gharial (CR)**. The place offers a secure nesting beach for **olive ridley sea turtles (VU)** also.

## 11.5. Conservation of Turtles

- **Threats faced by Indian turtles:** poaching for consumption, illegal trade, habitat loss, pollution, etc.

| Tortoise | Turtle |
|---|---|
| **Lives on land (land-dwelling)** | **Lives in water (water-dwelling)** |
| Everything happens on land | **Come to land to lay eggs** |
| Bad swimmers | **Good swimmers (limbs are paddle shaped)** |
| **Herbivores (plant eating)** | **Omnivores (they eat both meat and plants)** |
| They usually have **long life span (80-120 years)**. | They usually have **short life span (20-40 years)**. |
| They are generally large. | They are generally smaller. |
| Their heads can completely withdraw into shells. | Their heads can partially withdraw into shells. |


- **All tortoises are turtles** as they belong to the order Testudines/Chelonia (bodies encased in a bony shell). **Turtles are omnivores** (eat both meat and plants). The only exception is the **Green Turtle** (**mostly herbivore**).

- Tortoises are generally larger in size. However, **Leatherback Sea Turtles (VU)**, the l**argest of all living turtles**, can weight upto 500 kgs. **Giant tortoises** on the Galápagos Is. are the largest tortoises weighting upto 415 kgs.
- **Terrapins** are almost a **combination of turtles and tortoises** that **live mostly in water** but can also live on land.

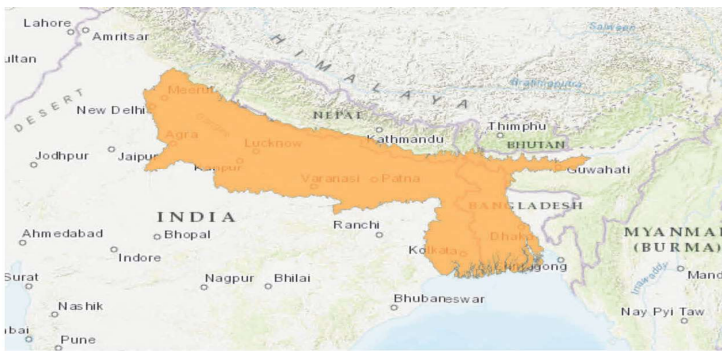
## Batagur Turtles Species

- **Batagur** is a genus of **large river turtles** from **South** and Southeast Asia. Major species include:
  - Southern River Terrapin (CR): found in SE Asian rivers.
  - **Northern River Terrapin (CR)**: native to river deltas of Southeast Asia and **Sundarbans**.
  - Painted Terrapin (CR): found in SE Asian rainforests.
  - **Three-Striped Roofed Turtle (CR)**: **endemic to the Ganges**.
  - **Red-Crowned Roofed Turtle (CR)**: **endemic to the Ganges**.
  - Burmese Roofed Turtle (CR): **Irrawaddy River** of Myanmar.
- Southern River Terrapin (CR) and Northern River Terrapin (CR) are currently listed in **CITES Appendix I**. The rest are listed in **CITES Appendix II**.

### Northern River Terrapin (CR)

- It is one of Asia's largest freshwater turtles.
- **Distribution:** river deltas of SE Asia and **Sundarbans**.
- **IUCN: CR | CITES: Appendix I | WPA: Schedule I**


### Three-Striped Roofed Turtle (CR)

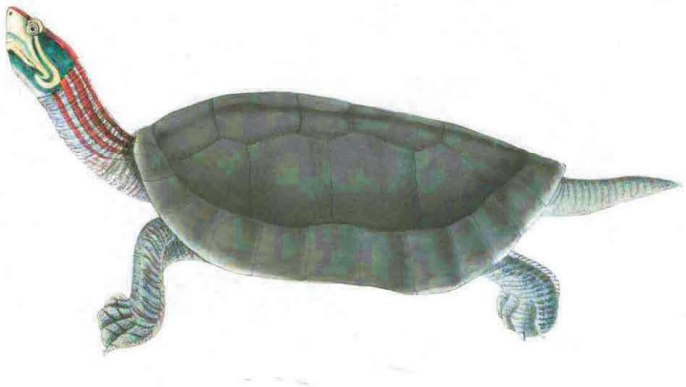



- **Habitat:** nests on the sand banks of large rivers.

- **Distribution: Ganges plains** of India, Nepal & Bangladesh.
- **IUCN: CR | CITES: Appendix II | WPA: Schedule I**

## Red-Crowned (Bengal) Roofed Turtle (CR)

- Males are smaller than females.
- **Habitat:** Ganga and Brahmaputra River basins.
- Distribution: substantial numbers found only in the **National Chambal River Gharial Sanctuary**.
- **IUCN: CR | CITES: Appendix II | WPA: Schedule I**




## Nissilonia Turtle Species

- **Nilssonia** is a genus of **freshwater softshell turtles** found in **South Asian rivers**. Major species include:
  - Burmese Peacock Softshell Turtle (CR): found in Myanmar and Karbi Anglong district of **Assam**.
  - **Leith's Softshell Turtle (CR): endemic to peninsular rivers**.
  - **Black Softshell Turtle (CR):** native to the **lower Brahmaputra River**. At present, only a few of them survive in a **human-made pond in Chittagong**.
  - Indian (Ganges) Softshell Turtle (EN): found in the waters of the **Ganges**, **Indus**, and **Mahanadi**.
  - Indian Peacock Softshell Turtle (EN): found in the **Indus**, **Ganges**, and the **Brahmaputra**.
- Burmese peacock softshell turtle (CR) is currently listed in **CITES Appendix II**. The rest are listed in **CITES Appendix I**.

## Leith's Softshell Turtle (CR)

- **Distribution: peninsular Indian rivers**.
- It is listed in **Schedule IV** WPA and **its possession is an offence**. WPA Act and protects it from hunting and trade.
- **IUCN: CR | CITES: Appendix I | WPA: Schedule IV**

## Black Softshell Turtle (CR)

- **Habitat: Lower Brahmaputra River**.
- **Distribution:** only a few of them survive in a human-made pond in **Chittagong** & **temple ponds in NE India**.
- **IUCN: CR | CITES: Appendix I | WPA: N/A**


## Indian (Ganges) Softshell Turtle (EN)

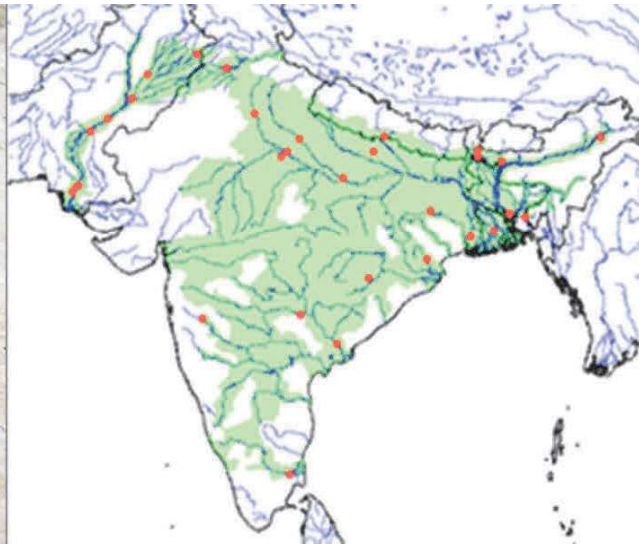
- It is distinguished by its flattened shell.
- **Distribution: Ganges**, **Indus**, and **Mahanadi**.
- **IUCN: EN | CITES: Appendix I | WPA: Schedule I**


## Indian Peacock Softshell Turtle (EN)

- **Habitat:** rivers, lakes & ponds with mud or sand bottoms.
- **Distribution: Indus**, **Ganges**, and the **Brahmaputra**.
- **IUCN: EN | CITES: Appendix I | WPA: Schedule I**


## Indian Narrow (Small) Headed Softshell Turtle (EN)

- Unlike the other softshell turtle species, Indian Narrow Headed Softshell Turtle belongs to **genus Chitra**.
- It is **one of the largest freshwater turtles**. Just like other softshell turtles, it uses its flexible shell to dig itself deep into sandy bottoms, waiting for its potential prey.
- Distribution: **Sutlej**, **Indus**, **Ganges**, **Brahmaputra**, **Godavari**, **Mahanadi**, **Padma etc**.
- **IUCN: EN | CITES: Appendix II | WPA: Schedule IV**

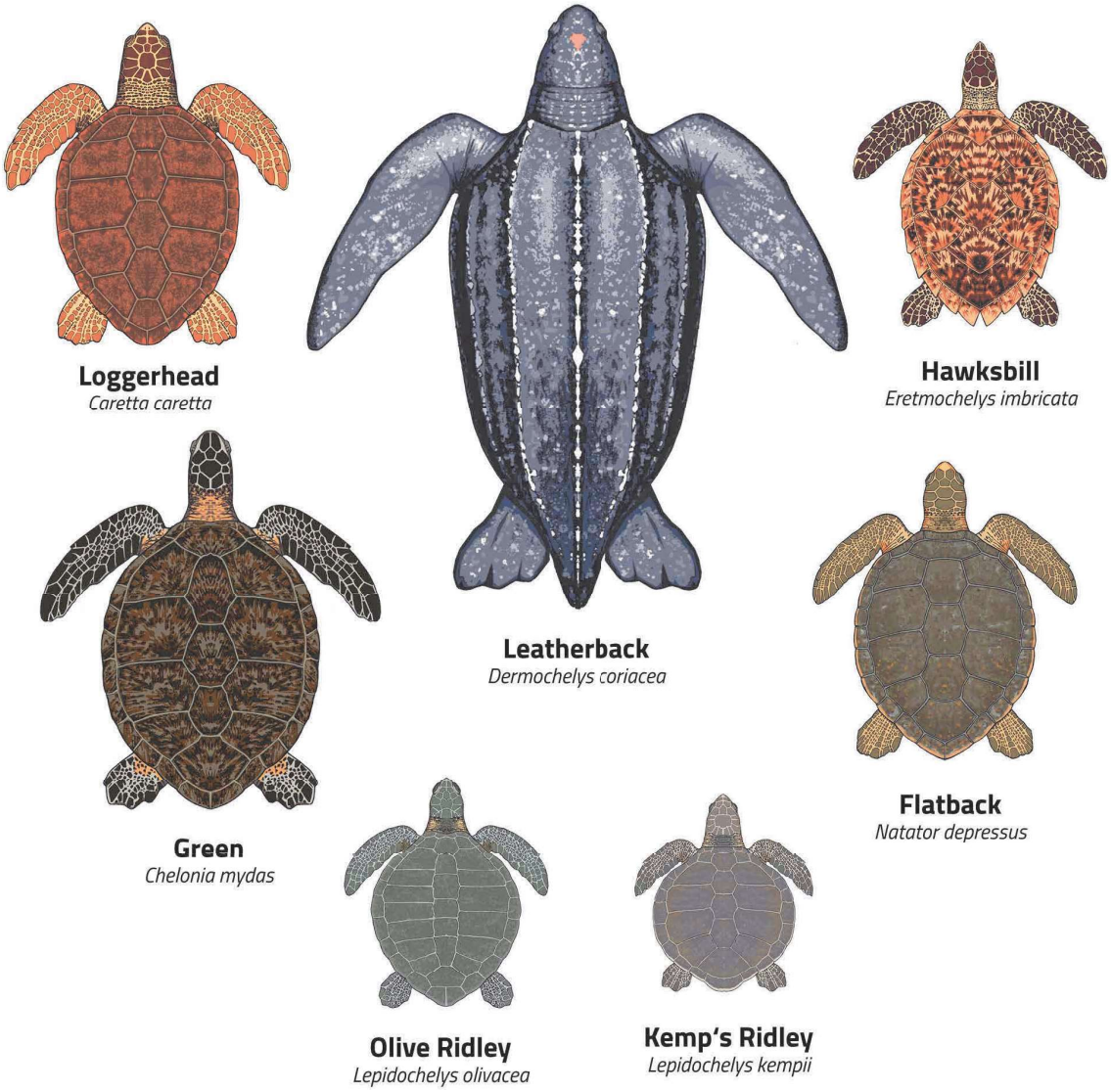


## Sea Turtle Species

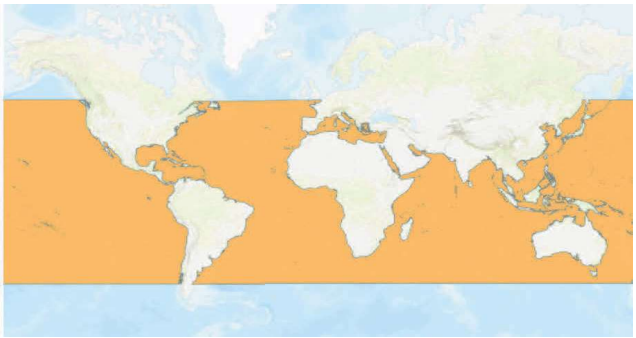
- The **seven** known sea turtle species in the decreasing order of their size: **Leatherback** > **Green** > **Log-gerhead** > **Hawksbill** > Flatback (endemic to the sandy beaches of the Australian continental shelf) > **Olive Ridley** > **Kemp's Ridley**.

### Hawksbill Sea Turtle (CR)

- It is **migratory** and nesting occurs insular sandy beaches.
- **Distribution:** In India, they are found in the Andaman and Nicobar Islands, the coast of Tamil Nadu and Orissa.
- **IUCN: CR | CITES: Appx I | CMS: Appendix I | WPA: Sch I**




Credits: Turtle-Foundation

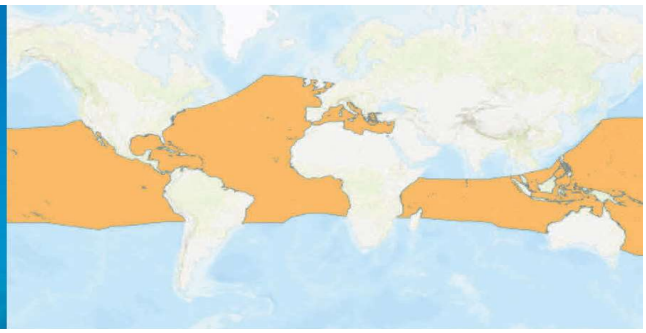


## Kemp's (Atlantic) Ridley Sea Turtle (CR)

- It is the world's **rarest and the smallest** **sea turtles**.**Kemp's Ridley** and **Olive Ridley Turtles** are known for **ARRIBADA** — **synchronized**, **large-scale nesting**.
- Distribution: subtropical to temperate Northern Atlantic.
- **IUCN: CR | CITES: Appendix I | CMS: Appx I | WPA: N/A**


## Green Sea Turtle (EN)

- It is the **only herbivore** turtle specie.
- **Distribution:** tropical and subtropical seas; rare in India.
- **IUCN: EN | CITES: Appx I | CMS: Appx I | WPA: Sch I**

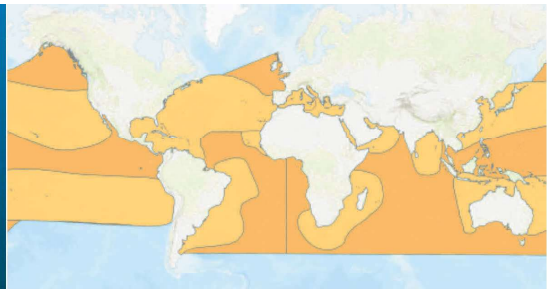


## Leatherback Sea Turtle (VU)

- It is the **largest of the living sea turtles** (250-700 kg).
- **Distribution:** tropical and temperate seas and oceans.
- **Threats:** artificial lighting disorients hatchlings and causes them to migrate inland.
- **IUCN: VU | CITES: Appx I | CMS: Appx I | WPA: Sch I**

## Loggerhead Sea Turtle (VU)

- **Distribution:** tropical and temperate seas and oceans.
- **IUCN: VU | CITES: Appx I | CMS: Appx I | WPA: Sch I**

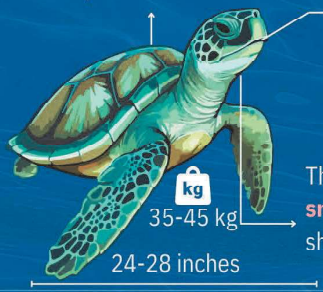


# OLIVE RIDLEY TURTLE

## (Lepidochelys olivacea)

(The olive ridley is the smallest of all the sea turtle species).

Olive ridley gets its name from its **olive colored carapace**, which is heart-shaped and rounded.




**Diet:** They are **carnivores**, and feed mainly on jellyfish, shrimp, snails, crabs, molluscs and a variety of fish and their eggs.

**POPULATION**

800,000 nesting females

They has a slightly **smaller head** and smaller shell than the **Kemp's.**

*Infographic: Gaurav Sharma*

Male


Female

Males and females grow to the **same size**; however, **females have a slightly more rounded carapace** as compared to the male.

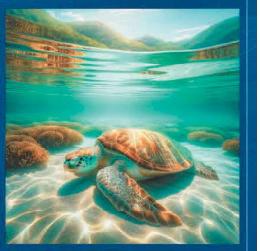
Females return to the **very same beach** from where they first hatched, to lay their eggs.

### NESTING

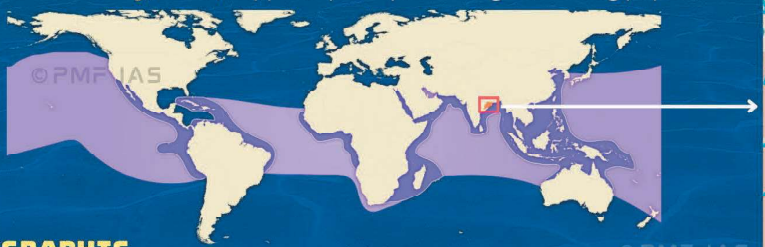
1. The Olive Ridley Turtle (ORT) is the **most abundant sea turtle species globally.**
2. Known for **mass nesting aggregations called "arribadas"** on tropical and subtropical beaches.
3. Lay around **100 eggs per nest** during the nesting season from **June to December.**
4. The **coast of Orissa in India is the largest mass nesting site** for the Olive Ridley, followed by the coasts of Mexico and Costa Rica.

### ECOSYSYEM AND HABITAT

- Typically found in **coastal bays and estuaries**, but can also be oceanic in some parts of their range.
- 2. They forage offshore in surface waters or dive to depths of up to 500 feet (150 m) to feed on bottom-dwelling crustaceans.



Olive ridley turtles, the most abundant sea turtle species, inhabit the coastal waters of over 80 countries but typically **do not migrate across ocean basins**, staying near their nesting beaches. Their population is significant due to mass nesting events in **Mexico, India, Nicaragua, and Costa Rica.** In the **Indian Ocean, Gahirmatha located in the Bhitarkanika Wildlife Sanctuary**, India, supports perhaps the largest nesting population .



### GEOGRAPHIC RANGE

Most common range of adults and large juvenile

Most common range of adults and large juvenile and range of ocean juvenile


### IUCN STATUS

RED LIST

VULNERABLE

VU

CITES: Appendix I

WPA, 1972: Schedule 1

### THREATS

Fishing in Ocean

Egg Poaching

Predation

Marine Pollution

Light Pollution

Habitat Loss

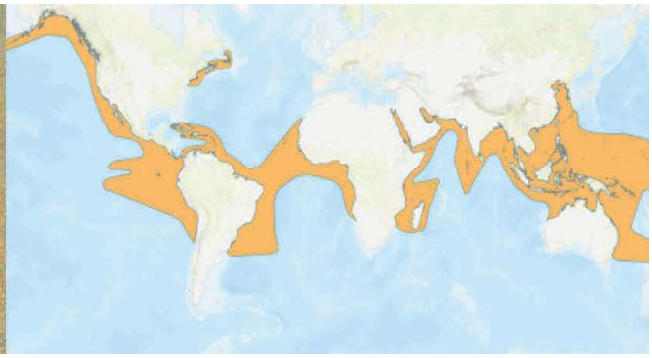
Fisheries Bycatch

Illegal Trade

Climate Change

- They are best known for their **synchronized nesting**. Most of them migrate **every winter** to Indian coastal waters for nesting, mainly at the eastern coast. **Gahirmatha Marine Sanctuary** **and** **Rushikulya Rookery Coast** are the main **Nesting sites** in India.

- **Distribution:** warm tropical seas and oceans.
- **Threats:** unsustainable egg collection, slaughtering nesting females on the beach, and direct harvesting adults at sea for commercial sale of both the meat and hides, etc.
- **IUCN: VU | CITES: Appx I | CMS: Appx I | WPA: Sch I**



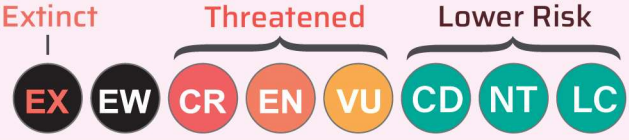
**[UPSC 2013] Consider the following fauna of India:**

1) Gharial
2) Leatherback turtle
3) Swamp deer

***Which of the above is/are endangered?***

a) 1 and 2 only
b) 3 only
c) 1, 2 and 3
d) None

**Explanation**




- **Gharials** are '**Critically Endangered**'. **Swamp deer (barasingha) (VU)** and **Leatherback turtle** are 'Vulnerable'.

***Answer: d) none***

### Sea Turtle Conservation Project

- With the objective of conservation of **olive ridley turtles (VU)** and other endangered marine turtles, MoEF initiated the **Sea Turtle Conservation Project** in collaboration of **UNDP** in 1999 with **Wildlife Institute of India (WII)**, **Dehradun** as the Implementing Agency. The project is being implemented in 10 coastal states of the country, with special emphasis in Odisha.
- The project has helped in the preparation of an inventory map of breeding sites of Sea Turtles, identification of nesting and breeding habitats along the shoreline, and migratory routes taken by Sea Turtles, etc.
- One of the important achievements have been demonstration of use of Satellite Telemetry to locate the migratory route of **Olive Ridley Turtles** in the sea and sensitizing the fishermen and State Government for the use of **Turtle Exclusion Device (TED)** in fishing trawlers to check turtle mortality in fishing net.

## 11.6. Conservation of Indian Vultures

- India is the most favourable region for vultures. Hindus do not eat cows, and when a cow dies, it is left to be fed on by vultures. India also has **high species diversity**, and hence vultures get a lot of food.
- Nine species of vulture can be found in India. Most are in **danger of extinction** due to a **veterinary drug** called **diclofenac** (vultures do not have a particular enzyme required to break down diclofenac).

### Diclofenac and Indian Vulture Crisis

- **Diclofenac** is a common **nonsteroidal anti-inflammatory drug** (**NSAID** – works like steroids, but without as many side effects) **administered to livestock** and is used to treat the symptoms of inflammation, fevers and/or pain associated with disease or wounds. It leads to **renal failure in vultures damaging their excretory system** (direct inhibition of uric acid secretion in vultures).
- ***Gyps* species** were the most affected by diclofenac:
  - The population of the **White-Rumped Vulture** fell 99.7% between 1993 and 2002.
  - The populations of the **Indian Vulture and the Slender-Billed Vulture** fell 97.4%.
- 2 other species of *Gyps*, **Himalayan Vulture** and **Eurasian Griffon**, were less affected because they come to India **only in winters**. They are exclusively mountain-dwelling and hence less vulnerable to diclofenac contamination.

#### Consequences of Depopulation of Vultures

- Vultures played an important role in public sanitation. The carcasses formerly eaten by vultures' rot in village fields leading to **contaminated drinking water**. Their disappearance has resulted in an **explosion of rats and wild dogs and the spread of diseases**. The newly abundant scavengers are **not as efficient as vultures**. A **vulture's metabolism is a true "dead-end" for pathogens**, but dogs and rats become carriers of the pathogens. They carry diseases from rotting carcasses such as rabies, anthrax, plague etc.

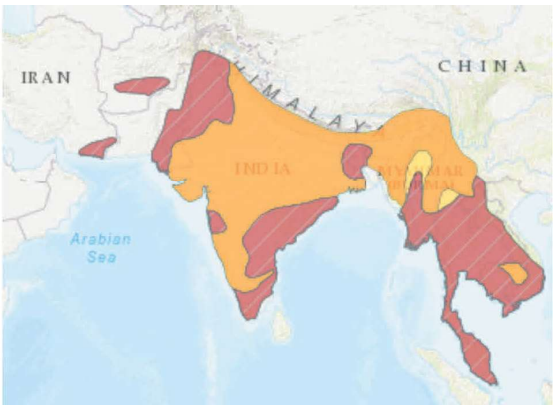
| Drug name | Threat / safety | Known effect |
|---|---|---|
| **Meloxicam** | **Confirmed Safe** | Tested and shown to be safe for vultures (Swarup D. *et al.* 2007) |
| **Tolfenamic acid** | **Confirmed Safe** | Recently tested and results show it is also safe. (Chandramohan et al. 2022) |
| **Carprofen** | **Toxic at high doses** | Shown to be at toxic levels for vultures in cattle tissues around the injection site (Fourie *et al.* 2015) |
| **Flunixin** | **Toxic** | Shown to be toxic to *Gyps* vultures in Spain and Italy with dead wild birds showing gout & flunixin in tissues. But not fully safety-tested on vultures. (Zorrilla et al. 2014, Eleni et al. 2019) |
| **Nimesulide** | **Confirmed Toxic** | Banned in many countries due to safety issues in humans and banned in India for under 12s. Fast becoming popular in India & Nepal. Confirmed cases of dead wild vultures with gout and nimesulide but no diclofenac (Nambirajan et al. 2021) and safety-trials demonstrate toxicity. (Galligan et al. 2022). |
| **Aceclofenac** | **Confirmed Toxic** | Metabolises into diclofenac in cattle so equivalent effect to diclofenac (Galligan *et al.* 2016, Sharma 2012) |
| **Ketoprofen** | **Confirmed Toxic** | Trials carried out on Gyps vultures showed toxicity at concentrations found in treated cattle in India (Naidoo *et al.* 2009). National ban in Bangladesh 2021. |
| **Diclofenac** | **Confirmed Toxic** | Confirmed highly toxic in 2003 (Oaks *et al.* 2004), and banned as veterinary drug in Bangladesh, Cambodia, India, Iran, Nepal, Oman, Pakistan and Socotra. |

## India Vultures Species

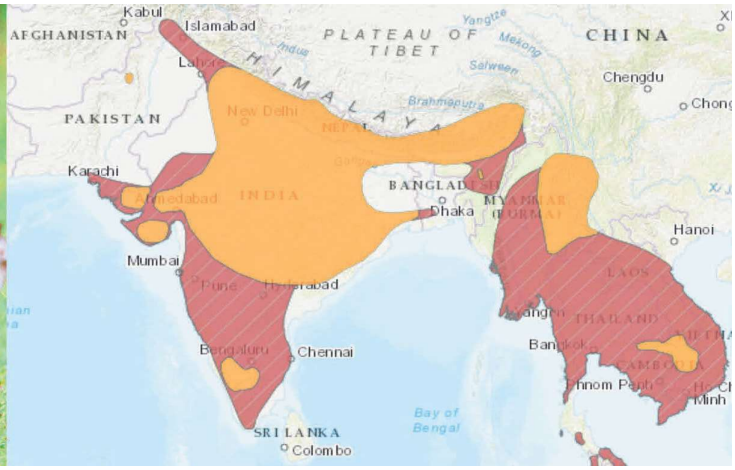
- Indian vulture species are old world vultures — found in the Old-World continents of Europe, Asia, and Africa. They belong to **Accipitridae** family.

### White-Rumped Vulture (CR)

- Was once very common in the **Gangetic plains of India**.
- **IUCN: CR | CMS: Appendix I | WPA: Schedule I**



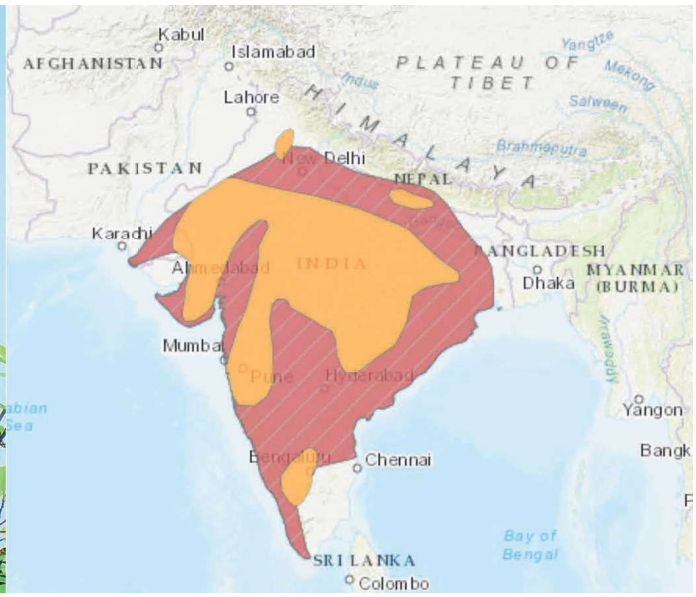

## Red-Headed Vulture (CR)




- It is also known as the **Asian King Vulture**, **Indian Black Vulture** or **Pondicherry Vulture**.
- **IUCN: CR | CMS: Appendix I | WPA:** Schedule IV

## Indian (Long-Billed) Vulture (CR)

- It is native to **India**, **Pakistan**, and **Nepal**.
- **IUCN: CR | CMS: Appendix I | WPA: Schedule I**



# INDIAN VULTURE
## OR (INDIAN LONG-BILLED VULTURE)
### (GYPS INDICUS)



**Breeding season**: November to March

**Population**
30,000

Females of this species are smaller than males

**IUCN Status**
CR

CITES
APPENDIX II

**WPA, 1972**
SCHEDULE I

## WHY VULTURES ARE SO IMPORTANT?

- **Ecosystem Role**: Vultures are vital for ecosystem health, **efficiently disposing** of dead animals and organic waste.
- **Disease Control**: They **help reduce disease spread** among wildlife, livestock, and humans by consuming carcasses.
- **Nutrient Cycling**: As obligate scavengers, each vulture species **contributes uniquely to nutrient cycling.**
- **Absence Consequences**: Without vultures, decomposition times lengthen, raising disease transmission risks such as anthrax, botulism, and rabies.
- **Impact on Health**: Their absence adversely affects wildlife and human health.

## VULTURE HABITAT AND LIFESTYLE

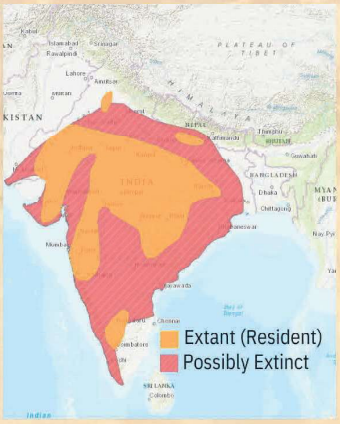
- Indian vultures are **social and often found in groups.**
- They are **active during the day**, soaring in search of food.
- Non-migratory but can travel up to 100 km daily for food.
- Usually silent, but emit grunts and hisses around carcasses.
- Inhabit open habitats like **savannas, villages, cities, and cultivated areas.**
- Found in wooded areas, ravines, valleys, scrub, and deciduous forests.


## BREEDING

- Nesting: **In colonies** on various elevations.
- Eggs: **One egg** per nesting period.

## GEOGRAPHIC RANGE

- Distribution: Indian vultures are native to **India, Pakistan, and Nepal.**
- Decline: Severe decline of over 97% since the mid-1990s.
- Population Plummet: **Population in Keoladeo National Park** dropped from 816 to 25 birds between 1985 and 1999.
- **Current Status: Small populations persist in Ramanagaram Hills, Karnataka, and Nilgiri Forest Division, Tamil Nadu.**
- Rarity: Indian vultures are now rare across their former range.
- New Breeding Colony: Recently identified near the **India-Pakistan border in Bikaner District.**




## THREATS

- Single Greatest Threat: **Diclofenac**, an **anti-inflammatory drug given to livestock.**
- Impact: Vultures feeding on treated carcasses **suffer kidney failure** and die.
- Environmental Poisons: Threaten vultures' survival.
- Carcass Disposal: Changes reduce vultures' food sources.
- Veterinary Drugs: Use of toxic drugs harms vulture populations.

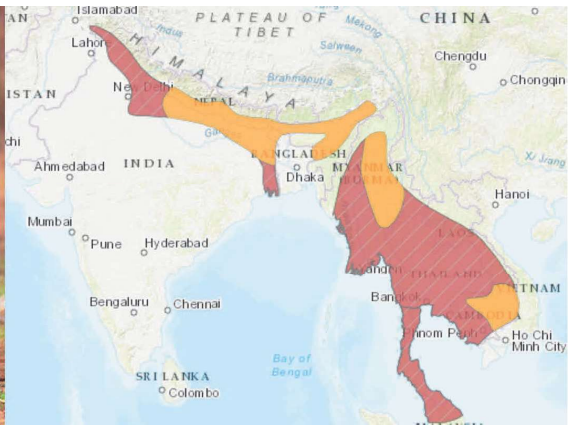
## CONSERVATION

- The **Ministry for Environment, Forests, and Climate Change** introduced a **Vulture Action Plan 2020-25** aimed at conserving vultures in the country.

***Infographic: Gaurav Sharma***

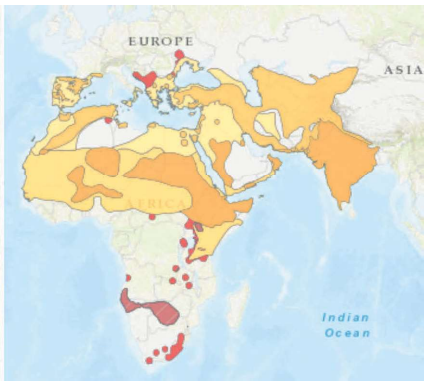
## Slender-Billed Vulture (CR)

- It is native to **sub-Himalayan region** and **Southeast Asia**.
- **IUCN: CR | CMS: Appendix I | WPA: Schedule I**



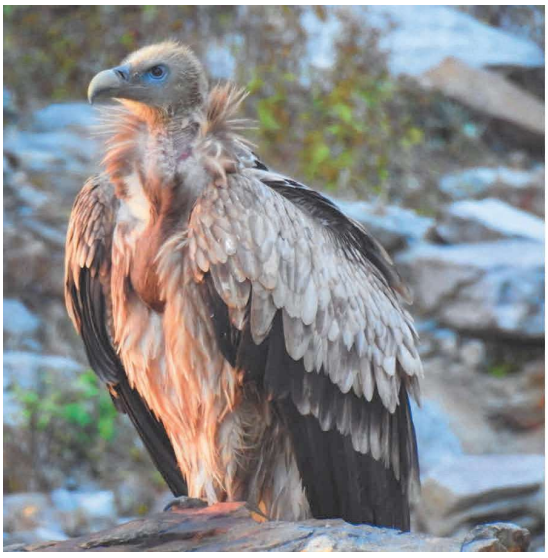

## Egyptian Vulture (EN)

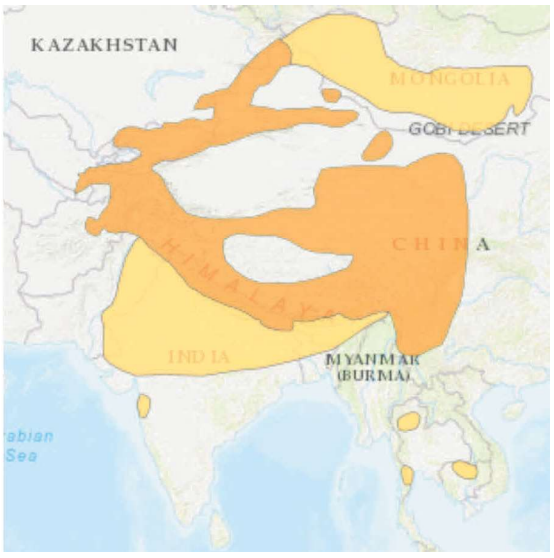
- **IUCN: EN | CMS: Appendix I | WPA:** Schedule IV




## Himalayan (Griffon) Vulture (NT)

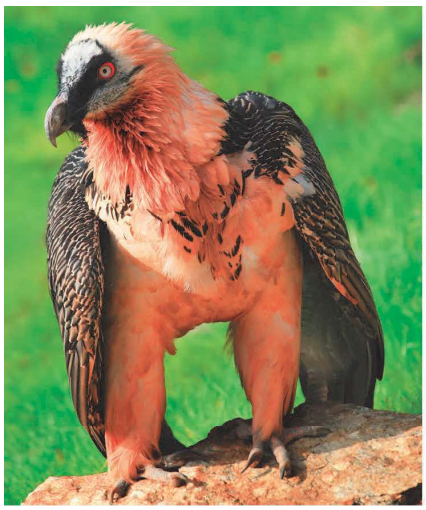
- It is native to the **Himalayas** and **Tibetan Plateau**.
- **IUCN: NT | CMS: Appendix II | WPA:** Schedule IV

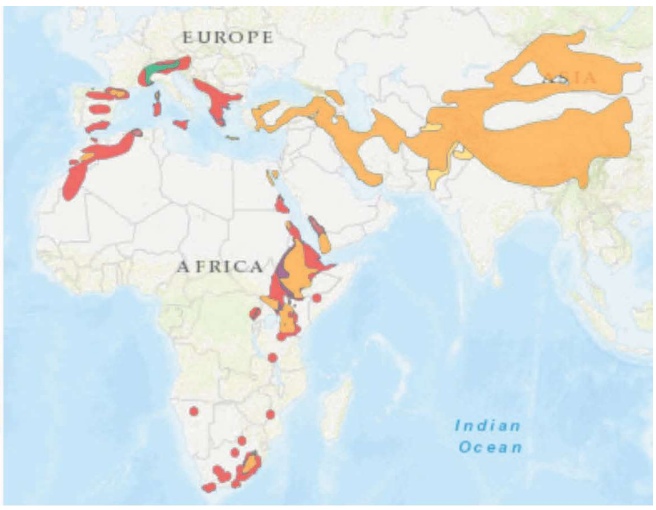




## Bearded Vulture (NT)

- It lives and breeds on the high mountains.
- **IUCN: NT | CMS: Appendix II | WPA:** Schedule IV



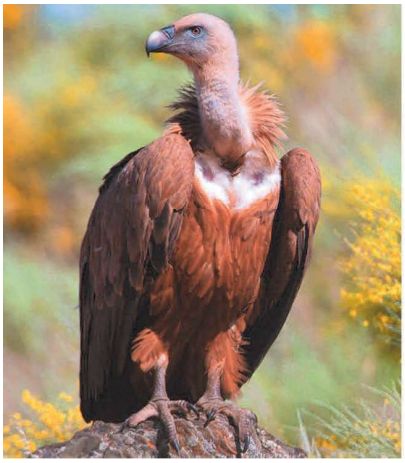


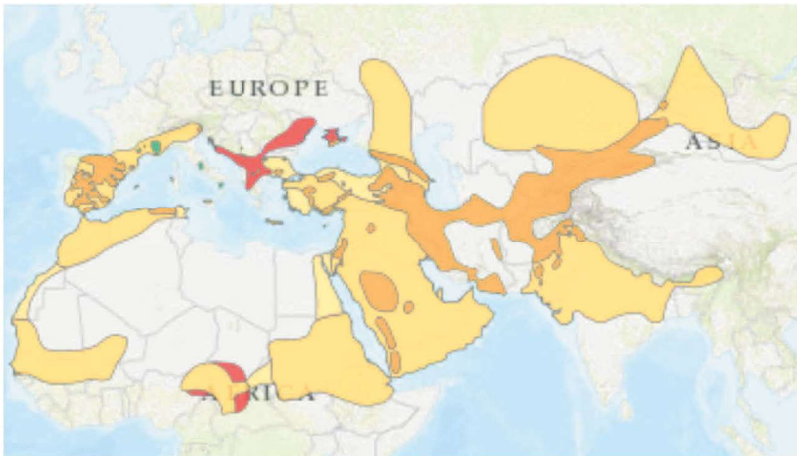

## Cinereous Vulture (NT)

- Distributed throughout **Eurasia**.
- **IUCN: NT | CMS: Appendix II | WPA:** Schedule IV


## (Eurasian) Griffon Vulture (LC)

- **IUCN: LC | CMS: Appendix II | WPA:** Schedule IV

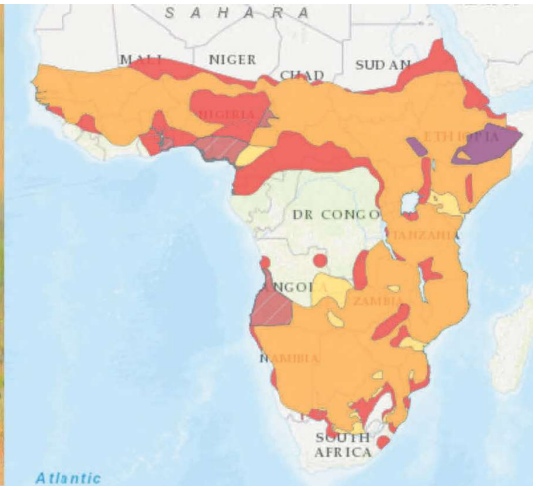




## Major Non-Indian Vulture Species

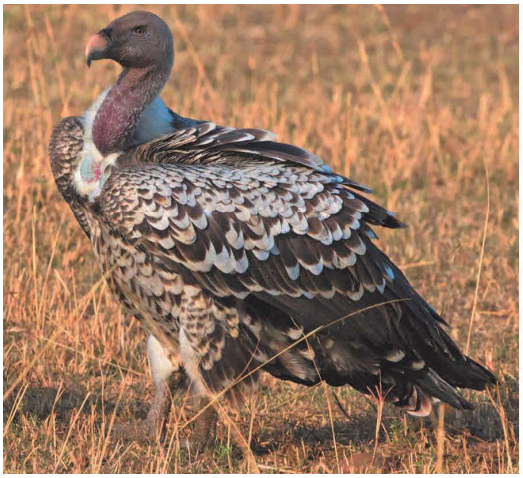
### White-Backed Vulture (CR)

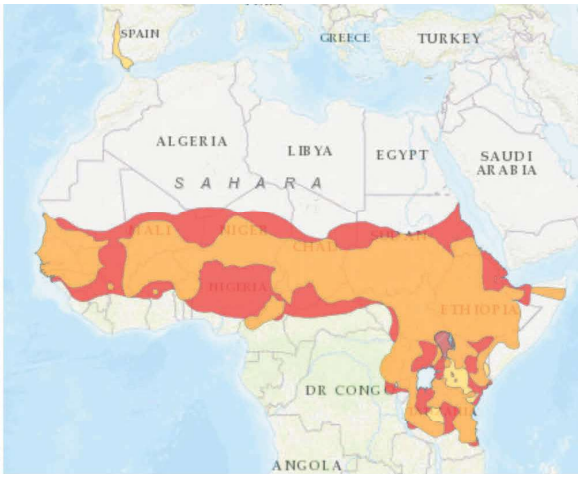
- **IUCN: CR | CMS: Appendix I | WPA:** Schedule IV




### Ruppell's (Griffon) Vulture (CR)

- It is native to the **Sahel region** and **East Africa**.
- **IUCN: CR | CMS: Appendix I | WPA:** Schedule IV






## Steps Taken by The Government

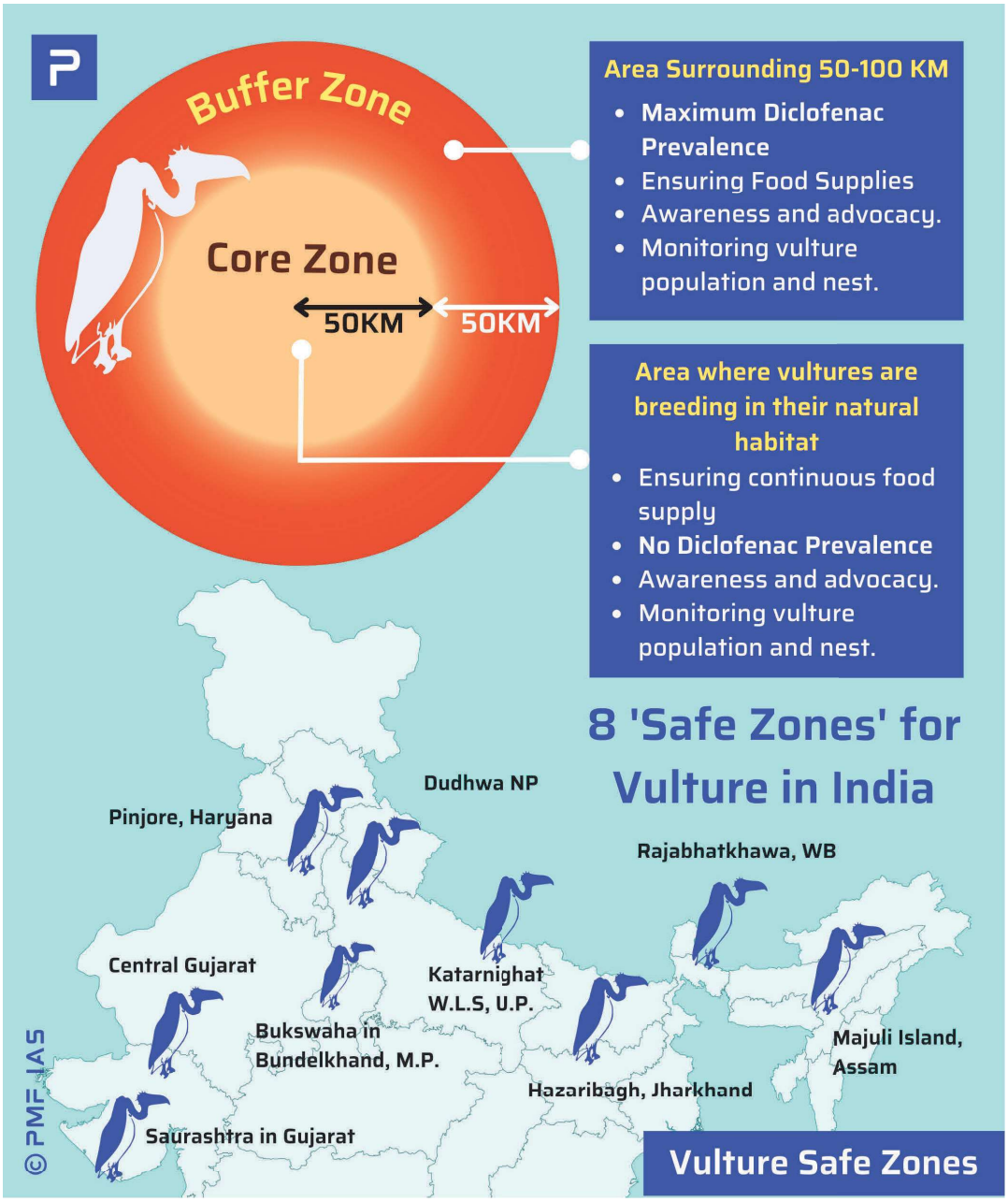
- ✓ The vulture species are conserved under **Integrated Development of Wildlife Habitats (IDWH)** '**Species Recovery Programme**'.
- ✓ The Protection status of **White-Rumped**, **Long-Billed (Indian Vulture)** and **Slender Billed Vultures** was upgraded from **Sch IV to Sch I** of the Wild Life (Protection) Act, 1972. The rest of the vulture species remain in **Schedule IV**.
- ✓ **Vulture Restaurants** are created where tables are reserved only for the unique and rare vultures by Maharashtra and Punjab Forest departments.
- ✓ **Central Zoo Authority and Bombay Natural History Society (BNHS)** led the establishment of the **Vulture Conservation Breeding Programme** (has been highly successful).

- ✓ **Vulture Safe Zones** are created to conserve the remaining population and facilitate **reintroduction of vultures into the wild** from Vulture Conservation Breeding Centres.
- ✓ Recently, the Union Ministry of Health and Family Welfare banned the manufacture, sale, and distribution of **ketoprofen** and **aceclofenac** and their formulations for animal use under the Drugs and Cosmetics Act, 1940.

## Diclofenac Alternative

- ✓ **Diclofenac was banned for veterinary use** in India in 2006. A replacement drug **Meloxicam** was quickly developed and tested. It affects cattle the same way as diclofenac but is **harmless for vultures**. **Diclofenac** for human use is **still being diverted for veterinary uses** through black markets.

## Vulture Safety Zones (VSZ)



- Aim of developing VSZs is to establish **targeted awareness** activities surrounding **150 km radius** of vultures' colonies so that **no diclofenac or the veterinary toxic drugs are found** in cattle carcasses.
- The VSZ is spread around in several hundred kilometres covering the **Jim Corbett in Uttarakhand**, **Dudhwa and Kartamiaghat forest reserves in UP** which is adjoining the Indo-Nepal border. Nepal has already set up many VSZ on the Indian borders.

### Action Plan for Vulture Conservation in India 2020-25

- **Action Plan for Vulture Conservation** (APVC) 2006 was released to save the vultures from possible extinction. The main objective was the **removal of diclofenac from the food chain**. The plan was extended to 2025 aiming not just halting the decline but to actively increase the vulture numbers in India. Main objectives are to:
  1) ensure that sale of veterinary **Non-steroidal anti-inflammatory drugs (NSAIDs)** is **strictly regulated**.
  2) carry out **safety testing of available molecules of veterinary NSAIDs** on vultures and to introduce new molecules in the market only after they are proved to be safe following safety testing on vultures.
  3) Include drugs other than **diclofenac** that are toxic to vultures like **Aceclofenac** and **Ketoprofen** to be **banned for veterinary use**.
  4) **cover all 9 species of vultures** recorded from India.
  5) have **at least 1 vulture safe zone in each state**.

### Vulture Safe Zones

✓ Vulture Safe Zones are created to conserve the remaining population and facilitate reintroduction of vultures into the wild from Vulture Conservation Breeding Centres.

### Other Steps Taken for Vulture Conservation

✓ The vulture species are conserved under **Integrated Development of Wildlife Habitats (IDWH) 'Species Recovery Programme'**.

✓ Central Zoo Authority and **Bombay Natural History Society (BNHS)** led the establishment of the Vulture Conservation Breeding Programme (has been highly successful).

## 11.7. Other National Efforts

### Project Hangul (Kashmiri Stag)

- The **Hangul/Kashmiri Stag (CR)** is a subspecies of **Central Asian Red Deer** native to northern India. It was the state animal of erstwhile Jammu and Kashmir. In Kashmir, it is found in **Dachigam NP** at **elevations of 3,035 meters**.
- These deer once numbered from about 5,000 animals in the beginning of the 20th century. They are now threatened due to habitat destruction, over-grazing by domestic livestock and poaching. The species dwindled to as low as 150 animals by 1970.

- The erstwhile state of **Jammu and Kashmir**, along with the **IUCN** and the **WWF** prepared **Project Hangul** for the protection of these animals and the population increased to over 340 by 1980. According to the census in 2019, there were only 237 Hanguls.

## Integrated Development of Wildlife Habitats

- Integrated Development of Wildlife Habitats (IDWH) is an on-going **Centrally Sponsored Scheme**. Under IDWH, **financial assistance is provided to State/UTs** for protection and conservation of wildlife.

### Components of the Scheme

1. **Support to Protected Areas** (National Parks, Wildlife Sanctuaries, Conservation and Community Reserves)
2. **Protection of Wildlife Outside Protected Areas**
3. **Species Recovery Programmes** for **saving Indian critically endangered species and habitats**.

### 22 Indian Critically Endangered (Locally) Species Under Species Recovery Programme

- **IDWH** provides financial assistance for the conservation of the **22 species** included in **Indian (locally) critically endangered list**.

#### Mammals

1. **Hangul (Kashmir Stag – CR)**
2. **Malabar Civet (CR)**
3. **Asian Wild Water Buffalo (EN)**
4. **Asiatic Lion (EN)**
5. **Brow-Antlered Deer / Sangai / Eld's Deer (EN)**
6. **Nilgiri Tahr (EN)**
7. **Red Panda (EN)**
8. **Clouded Leopard (VU)**
9. **Indian Rhino / Great One-Horned Rhinoceros (VU)**
10. **Snow Leopard (VU)**
11. **Swamp Deer / Barasingha (VU)**
12. **Caracal Cat (LC)** **(most recent addition to the list)**

#### Marine Mammals

1. **Dugong (VU)**
2. **Gangetic River Dolphin (EN)**

#### Birds

1. **Great Indian Bustard (CR)**
2. **Jerdon's Courser (CR)**
3. **Nicobar Megapode (VU)**
4. **Edible Nest Swiftlet (LC)**

5. **Vultures (all species found in India)**

**Reptiles**

1. **Arabian Sea Humpback Whale (EN)** (it is a subpopulation of Humpback Whales (LC))
2. **Marine Turtles**
3. **Northern River Terrapin (CR)**

## Animal Welfare Board of India

- **Animal Welfare Board of India (AWBI)** (not to be confused with **National Board for Wildlife**) is a **statutory advisory body** advising the government on animal welfare laws & promotes animal welfare in India. It was established under the **Prevention of Cruelty to Animals Act**, **1960**.
- AWBI functions under the aegis of **Ministry of Fisheries**, **Animal Husbandry and Dairying** **(MFAHD – Department of Animal Husbandry and Dairying)**. (The subject of Prevention of Cruelty to Animals was transferred from **MoEF to MFAHD** in 2019). Well-known humanitarian **Rukmini Devi Arundale** ((1904-1986) an eminent Bharatanatyam dancer) was instrumental in setting up the board.
- The board is highly concerned about "**abuse of animals in research**" and "**cruelty involved when animals were used in entertainment**". It oversees **Animal Welfare Organizations (AWOs)** by granting recognition to them. It also provides **financial assistance** to recognized AWOs.
- In 2014, in **AWBI** vs A. Nagaraja, the SC declared **jallikattu** illegitimate stating that the practice was cruel and caused the animal unnecessary pain and suffering.

**[UPSC 2014] Consider the following statements:**

1) Animal Welfare Board of India is established under the Environment (Protection) Act, 1986.
2) National Tiger Conservation Authority is a statutory body.
3) National Ganga River Basin Authority is chaired by the Prime Minister.

***Which of the statements given above is/ are correct?***

a) 1 only
b) 2 and 3 only
c) 2 only
d) 1, 2 and 3

**Explanation**

- **Genetic Engineering Appraisal Committee (GEAC)** is the **statutory body** constituted in the **MoEF** under 'Rules 1989', under the **Environment Protection Act**, **1986**.
- The **National Board for Wildlife (NBWL)** is a **statutory board** constituted under the **Wild Life (Protection) Act**, **1972**.
- **Animal Welfare Board of India** is established in the **MoEF** and was transferred to **MFAHD** in 2019. It derives its powers under the **Prevention of Cruelty to Animals Act**.

***Answer: b) 2 and 3 only***

## National Wildlife Action Plan (NWAP) 2017-2031

- **1st NWAP** was adopted in 1983. **2nd NWAP** was put in place for the period (2002-2016). **3rd NWAP is for the period 2017-31**. It has 5 components & 103 conservation actions.
- NWAP adopts the **landscape approach** of conservation by emphasizing on **preservation of genetic diversity** and **sustainable utilization of species and ecosystem**. It underscores the role of **private sector** in the wildlife protection by ensuring adequate fund flow from the **Corporate Social Responsibility (CSR)** fund.

### Components of 3rd NWAP (2017 – 2031)

1. **Integrated management** of wildlife and their habitats and **wildlife conflict mitigation**.
2. Adaptation to **climate change** and promoting integrated sustainable management of **aquatic biodiversity**.
3. Promoting eco-tourism, nature education and **participatory management**.
4. Strengthening **wildlife research** and development of **human resources** in wildlife conservation.
5. Enabling policies and resources for conservation of wildlife in India.

#### Landscape Approach to Conservation

- It is a **holistic approach to landscape management**, aiming to reconcile the **competing objectives** of nature conservation and economic activities across a given landscape.
- It is based on the importance of conservation of natural flora and fauna (uncultivated flora and undomesticated fauna) that had ecological value irrespective of their place of occurrence.
- It can be seen as an **alternative to site-based conservation** i.e., strategies more concentrated on national parks and wildlife sanctuaries.

## National Action Plan for Conservation of Migratory Birds (2018-2023)

- **MOEF** has developed the plan for Conservation of Migratory Birds and their Habitats along **Central Asian Flyway (CAF)** for the **period 2018-23**.
- Longer-term goal is to **arrest population decline** and **secure habitats** of migratory bird species. In the short run the plan seeks to halt the downward trends in declining meta-populations by **2027**.

### Central Asian Flyway (CAF)

- **Flyways** are used by groups of birds during their **annual cycle** which includes **breeding areas**, **stop over areas and wintering areas**. Many of these areas are used by birds are highly productive and also enable benefits to local people.
- The Central Asian Flyway (CAF) is one among the **nine flyways** identified under **Convention on Migratory Species**.
- **Route Extent: Russia (Siberia)** to the southernmost non-breeding (wintering) grounds in **West and South Asia**, the **Maldives and British Indian Ocean Territory**. **India** has a strategic role in the flyway, as it provides critical stopover sites to >90% of the bird species known to use this route.


### Green Good Deeds Initiative

- The MoEF coordinates a **Central Sector Scheme** called '**Environment Education**, **Awareness and Training**'. This '**Green Good Deeds**' initiative is about simple, practical steps that students/teachers/citizens can perform in their day-to-day life towards protection of environment.
- A component of this scheme is the **National Green Corps (NGC)** programme. Under NGC, 1.5 lakh Eco Clubs have been established in schools/colleges across the country. Students are actively involved in the NGC programmes related to environment protection and conservation.
- Activities of **EcoClubs** include conducting cleanliness drives as part of Swachh Bharat Abhiyan, plantation drives, awareness on waste minimization, waste segregation, etc.

### Bombay Natural History Society (BNHS)

- **BNHS**, founded in **1883**, is one of the largest **NGO**s in India engaged in **conservation and biodiversity research**. It supports many research efforts through grants and publishes the **Journal of the BNHS**.
- Many prominent naturalists, including the ornithologists **Sálim Ali** & **S. Dillon Ripley**, have been associated with BNHS.

## 11.8. International Efforts

### World Wildlife Fund for Nature (WWF)

- **WWF** is an **NGO** established in 1961 and is headquartered at **Gland**, **Switzerland**. It was formerly named the **World Wildlife Fund**. It works in the field of **wilderness preservation**, & the **reduction of human impact** on environment.
- WWF aims to "**stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature**."

#### Initiatives by WWF

✓ **The Wildlife Trade Monitoring Network (TRAFFIC, an NGO)** is a joint programme of **WWF** and **IUCN**.
✓ **Living Planet Report** has been published **every two years** by WWF since 1998.

✓ WWF has launched notable worldwide campaigns like **Earth Hour** and **Debt-for-Nature Swap**.

### Earth Hour

- **Earth Hour** is a worldwide movement organized by the **WWF** since 2007. It encourages people to **switch off the lights from 8.30 pm to 9.30 pm** as per their local time every year on the **last Saturday of March**. The idea is to refrain from the use of non-essential lighting to save energy in a symbolic call for environmental protection.
- Earth Hour has been successful in **pursuing legislative changes** by harnessing the power of the people and **collective action**. For example, it helped create a 3.5-million-hectare marine-protected area in Argentina and ban all plastics in the **Galapagos** in 2014, etc.

### Debt-for-Nature Swap

- It is a transaction where a country has its debt purchased, renegotiated, or forgiven by its creditors (fully or partially) with the condition that **savings on debt** are **invested in environmental conservation activities**.

**[UPSC 2014] With reference to Bombay Natural History Society (BNHS), consider the following statements:**

1) It is an autonomous organization under the MoEF.
2) It strives to conserve nature through action-based research, education and public awareness.
3) It organizes and conducts nature trails and camps for the general public.

***Which of the statements given above is/are correct?***

a) 1 and 3 only
b) 2 only
c) 2 and 3 only
d) 1, 2 and 3

**[UPSC 2014] Consider the following statements regarding 'Earth Hour'**

1. It is an initiative of UNEP and UNESCO.
2. It is a movement in which the participants switch off the lights for one hour on a certain day every year.
3. It is a movement to raise the awareness about the climate change and the need to save the planet.

***Which of the statements given above is / are correct?***

a) 1 and 3 only
b) 2 only
c) 2 and 3 only.
d) 1, 2 and 3

***Answer: c)***

**Similar Topic: Earth Day Network (EDN) & Earth Day**

- **Earth Day** is an annual event, organized on April 22 since 1970 by **Earth Day Network (EDN, an NGO)** to diversify, educate, and **activate the environmental movement** worldwide. In the year 2020, the **50th anniversary** of the first Earth Day was celebrated. The theme for Earth Day 2020 was **climate action**.

## International Whaling Commission (IWC)

- IWC is a **non-UN** body set up by terms of **Internal Convention for Regulation of Whaling (ICRW)**. Its headquarters is in the **United Kingdom**. It provides for the proper **conservation of whale stocks** and orderly development of the whaling industry. It can **designate areas as whaling sanctuaries**. E.g., **Indian Ocean Whale Sanctuary (Seychelles)**
- Participation in IWC is **not limited to states involved in Whaling**. **India is a member**.
- In **1982** it adopted **Moratorium on Commercial Whaling**. Whaling under **Scientific Research** and aboriginal subsistence provisions of ICRW are **still allowed**.
- **Florianopolis Declaration:** In 2018, IWC members gathered in Florianopolis (Brazil), where they rejected proposal by Japan to renew Commercial Whaling. As a result, **Japan announced its withdrawal**.

**---------- End of Chapter ----------**

# 12. Air Pollution – Causes and Air Pollutants

### Environmental Issues and Environmental Degradation

- **Environmental degradation** makes the environment **unfit or less suitable** for the survival of different life forms, thereby causing immense **ecological damage**. Population explosion, urbanisation and the associated **increase in human needs and comforts** have resulted in rapid industrialisation. **Rapid industrialisation**, in turn, has led to the **overexploitation** of natural resources. The consequences of such exploitation are evident in major environmental issues such as **climate change**, **ocean acidification**, **soil erosion**, **desertification**, **loss of biodiversity**, **pollution**, etc.

## 12.1. Pollution

- **Pollution** may be defined as the **addition/release of undesirable** physical, chemical or biological **agents (substances/pollutants)** into the environment due to **human (anthropogenic) activities**. The agents that cause pollution are called **pollutants**. They are directly or indirectly **harmful** to humans and other living organisms. Pollution may be of the following types: **Air pollution**, **Noise pollution**, **Water pollution**, **Soil pollution**, **Thermal pollution**, **Radiation pollution**, **et**c.

### Air Pollution

- Air pollution may be defined as the presence of any solid, liquid or gaseous substances, **including noise** and **radioactive radiation**, in the atmosphere in such concentration that may be directly and/or indirectly injurious to humans or other living organisms, property or **interferes with the normal environmental processes**. The ever-increasing use of **fossil fuels** in power plants, industries, transportation, mining, construction of buildings, and stone quarries has led to air pollution.
- **Fossil fuels** contain small amounts of **nitrogen** and **sulphur**. Burning fossil fuels like **coal (thermal power plants)** and **petroleum** releases different **oxides of nitrogen (nitrogen oxides)** and **sulphur** into the atmosphere. These gases react with the **water vapour** present in the atmosphere to form **sulphuric acid** and **nitric acid**. The acids drop down with rain, making the rain acidic. This is called **acid rain**.

⇨ *Acid rain corrodes the marble monuments like the Taj Mahal. This phenomenon is called **Marble cancer**.*

- Other kinds of pollutants are **chlorofluorocarbons (CFCs)**, which are used in **refrigerators and air conditioners** and as **pressurising agents in aerosol sprays**. **CFCs damage the ozone layer** of the atmosphere.
- The combustion of fossil fuels also increases the number of **suspended particles** in the air. These suspended particles could be **unburnt carbon** particles or substances called hydrocarbons. The presence of high levels of all these pollutants causes visibility to be lowered, especially in cold weather when water also condenses out of the air. This is known as **smog** and is an indication of air pollution.

## Major Causes of Air Pollution

### Vehicular and Industrial Emissions

- **Carbon monoxide (CO)**, **oxides of Nitrogen ($NO_X$)**, and **Non-Methane Volatile Organic Compounds (NMVOCs — benzene**, **ethanol**, **formaldehyde**, **cyclohexane**, **1**,**1**,**1-trichloroethane or acetone)** are the major pollutants (>80%) from vehicular emissions.
- Other trace emissions include **methane ($CH_4$)**, **carbon dioxide ($CO_2$)**, **oxides of sulphur ($SO_x$)**, and **total suspended particles (TSPs)**.
- Critical industries such as iron and steel, sugar, paper, cement, fertiliser, copper, and aluminium contribute to **suspended particulate matter (SPM)**, **$SO_X$**, **$NO_X$**, and **$CO_2$**.

### Improper Use of Pyrolysis

- Pyrolysis is a technique of **breaking down synthetic material** at high temperatures (300-400 °C) for an hour **without oxygen**. While pyrolysis is a **safer technique than burning**, pyrolysis leaves **fine carbon matter**, **pyro gas** and **oil** as residue. Many tyre pyrolysis and other industrial pyrolysis units employ sub-optimum pyrolysis technologies.

#### Applications of Pyrolysis

- ✓ Used in the chemical industry to produce **methanol**, **activated carbon**, **charcoal**, etc., from wood.
- ✓ **Synthetic gas** from pyrolysis can be used in gas turbines to produce electricity.
- ✓ A mixture of soil, stone, ceramics, and glass obtained from pyrolytic waste can be used in building materials.
- ✓ **Pyrolysis** was recently proposed for converting billions of disposable COVID-19 PPE kits into **biocrude synthetic fuel (biofuel)**.

#### Advantages of Pyrolysis

- ✓ Inexpensive for processing a wide variety of feedstocks.
- ✓ Reduces waste going to landfill and GHG emissions.
- ✓ Reduces the risk of water pollution.
- ⇨ *The **National Green Tribunal**, in 2014, **prohibited used tyres from being burnt in the open** or **used as fuel in brick kilns**.*

### Fuel adulteration

- The taxes on diesel and gasoline are high compared to those on **kerosene**, which is meant as a cooking fuel. Adulteration of gasoline and diesel with lower-priced kerosene is hence rampant in India. Adulterated fuel increases emissions of **carbon monoxide (CO)**, **nitrogen oxides ($NO_x$)** and particulate matter.

### Emissions from Agriculture, Waste Treatment and Biomass Burning

- **Ammonia (NH3)**, **methane (CH4)** and **nitrous oxide ($N_2O$ – GHG)** are the critical pollutants from agricultural activities.
- **Methane ($CH_4$)** is the major pollutant released from landfills and wastewater treatment plants.

- **Ammonia (NH3)** is a by-product released from the composting process.

## Stubble Burning

- Stubble burning is **intentionally** setting fire to the straw stubble that remains after grains, like paddy and wheat, have been harvested. It is practised in all parts of India.
- Stubble burning in **Punjab**, **Haryana**, and **UP** to clear the fields for the sowing of **Rabi Crop** from the last week of September to November is causing severe pollution in the NCR region in winter. There is only a two to three weeks window between the harvesting of paddy crops and the sowing of the next crop. Hence, the pollution levels quickly rise, leaving the NCR region gasping for breath.
- Burning crop residue is a crime under IPC and the **Air and Pollution Control Act of 1981**. The National Green Tribunal (NGT) banned crop residue burning in Rajasthan, UP, Haryana, and Punjab, but the practice is still rampant.

### Effects of Stubble Burning

- **Pollution:** Stubble burning **emits large amounts of toxic pollutants** into the atmosphere, which contain harmful gases like **methane (**$CH_4$**)**, **Carbon Monoxide (CO)**, **and Volatile Organic compounds (VOC)**. These pollutants adversely affect health by creating **a thick blanket of smog**.
- **Loss of Soil Fertility:** Burning crop residues on the fields **destroys the nutrients and useful bacteria and fungi in the soil**, making it less fertile.
- **Loss of Soil Moisture:** The heat generated by stubble burning penetrates the soil and leads to the loss of moisture.

**[UPSC 2015] Mumbai, Delhi and Kolkata are the three mega cities of the country, but air pollution is a much more severe problem in Delhi compared to the other two. Why is this so? (200 words)**

- In 2014, a global study on air quality by the WHO declared **Delhi the most polluted city in the world**. Despite similar urbanisation, air pollution is much more severe in Delhi than in Mumbai and Kolkata. This is because of the following reasons:

### Geography and Climate

- This is the most determining factor. Delhi is a **continental city**, while the other two are coastal. **Land and Sea Breezes** in Mumbai and Kolkata carry pollutants away from the city. There is no such advantage to Delhi as it is landlocked. Also, the duration of monsoon winds is short in Delhi compared to the other two.
- Delhi faces severe cold waves in winter compared to the other two. The cold climate creates **temperature inversion**, which traps the pollutants, mainly **smog**, for a longer duration. Also, the Himalayas are a barrier to cleaner air from the north.
- In winter, Delhi receives 72% of its wind from the NW and only 28% from the Indo-Gangetic plains. With the SW monsoon withdrawal, the **direction of wind over NW India** changes to northwesterly. The NW winds **bring farm fire-released pollutants** to Delhi from Haryana, Punjab, and Rajasthan.

**Polluting Industries in close vicinity**

- Delhi and its neighbourhoods (Noida, Gurugram, Ganga-Yamuna Doab) are the hotbeds of **coal-powered** polluting industries. Burning coal releases **oxides of sulphur**, which forms **sulphurous smog**. This type of smog is more pronounced in Delhi than in the other two cities due to geography and climate.

**Vehicular Emissions**

- All three cities contribute nearly equal vehicular emissions rich in $CO_2$ and $NO_2$. **$NO_2$** results in **photochemical smog**. Here again, Delhi is the worst hit due to its geography and climate.

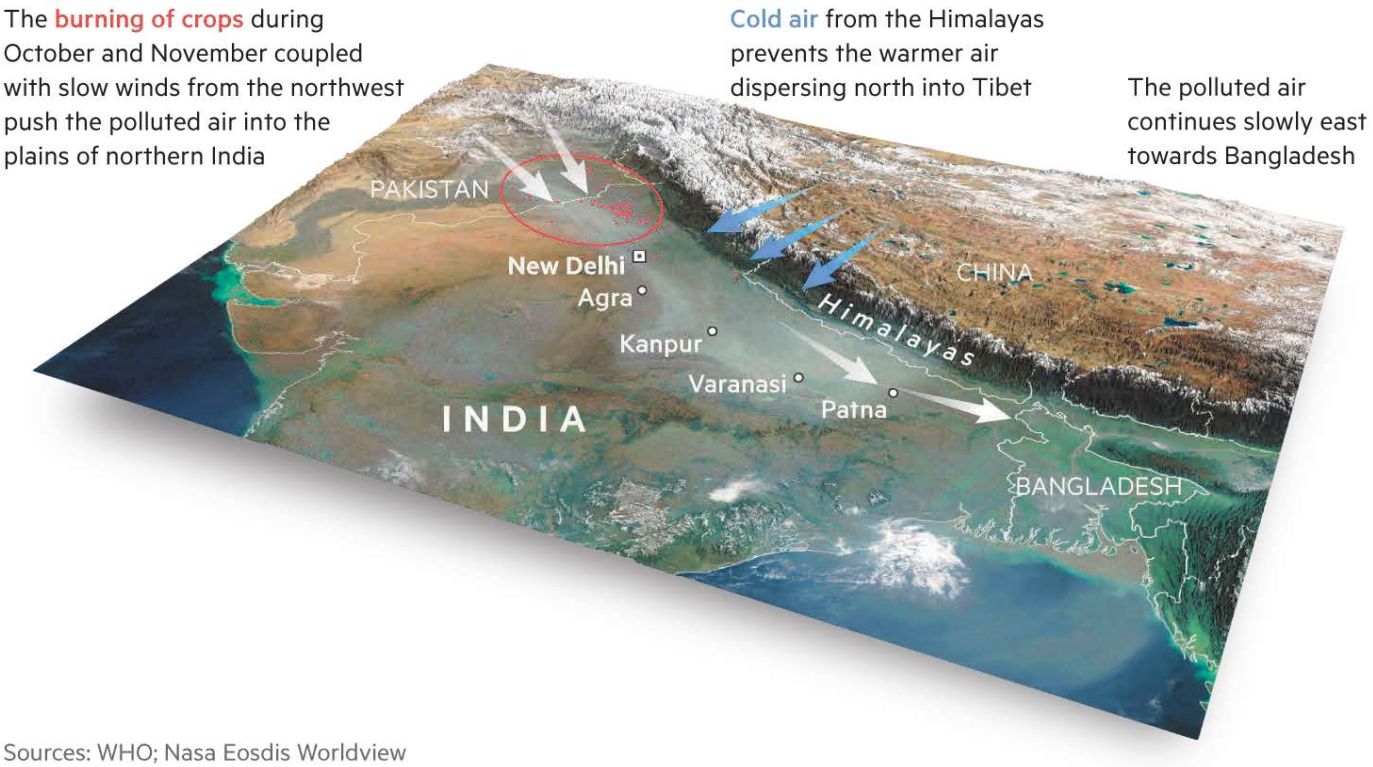
**Farm Straw Burning**

- Delhi is at the heart of the most densely populated agricultural region of India. Burning farm straw in the surrounding regions adds to Delhi's pollution levels.

**Winters are more polluted than summers in Delhi. Why?**

- The most polluted months are November, December and January. Most of the crop residue is burnt in Haryana, Punjab and UP during November. Locally, the burning of leaves also picks up in November. All this coincides with the cold, foggy, windless days (**temperature inversion**), leading to the accumulation of pollutants.

## The Himalayas form a natural barrier to cleaner air in northern India




Sources: WHO; Nasa Eosdis Worldview

## Household Air Pollution (Indoor Air Pollution)

- Household air pollution results from the burning of various fuels (coal, charcoal, wood, agricultural residue, animal dung, and kerosene, among others) for heating or cooking with limited ventilation. This produces an array of pollutants, including fine **particulate matter (PM2.5)**, **black carbon**, **carbon dioxide**, **carbon monoxide** and **methane**. On the other hand, paints, carpets, furniture, etc., in rooms may give out **volatile organic compounds (VOCs)**.

## Volcanism – Acid Rain, Ozone Destruction

- The volcanic gases that pose the most significant hazard to people, animals and property are **sulphur dioxide**, **carbon dioxide**, **hydrogen fluoride** and **hydrogen sulphide**.
- Locally, **sulphur dioxide** can lead to **acid rain** and air pollution downwind from a volcano. Globally, significant explosive eruptions inject a tremendous volume of **sulphur aerosols** into the **stratosphere**, leading to lower surface temperatures and **promoting the depletion of the ozone layer**.

### [UPSC 2021-22] Consider the following:

1) Carbon dioxide
2) Oxides of Nitrogen
3) Oxides of Sulphur

***Which of the above is/are the emission/emissions from coal combustion at thermal power plants?***

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

**Explanation**

- **Burning coal releases CO**, **$CO_2$**, **$SO_2$** and **$NO_x$**.

***Answer: d) 1, 2 and 3***

## Noise Pollution

- Any unwanted sound that causes annoyance, irritation and pain to the human ear is termed noise. Noise is measured in **dB (decibels)**, which indicates the **loudness** of the sound. World Health Organization (WHO) has prescribed optimum noise level as **45 dB by day** and **35 dB by night**.
- The human ear can tolerate noise levels up to **85 dB**, and anything beyond that can affect the quality of life. Sound above **80 dB** is considered as **loud** and **hazardous**. Sound between **100-125 dB** is termed **uncomfortable**.

### Permissible noise level in India

- The Central Pollution Control Board has laid down the permissible noise level in India for different areas. All the machines operating in an area should produce noise within the acceptable noise level.

| Zone | Daytime (dB) | Night (dB) |
|---|---|---|

| | | |
|---|---|---|
| Industrial Zone | 75 | 70 |
| Commercial Zone | 65 | 55 |
| Residential Zone | 55 | 45 |
| Silent Zone | 50 | 40 |

- **Silent zone** includes areas within **100 meters** of the premises of schools, colleges, hospitals and courts.

**Laws to control Noise Pollution**

- Earlier, noise pollution and its sources were addressed under the **Air (Prevention and Control of Pollution) Act**, **1981**. Currently, they are regulated separately under the **Noise Pollution (Regulation and Control) Rules**, **2000**, under the **Environment (Protection) Act**, **1986**.
- Additionally, noise standards for **motor vehicles**, air conditioners, refrigerators, diesel generators, and certain construction equipment are prescribed under the **Environment (Protection) Act**, **1986**.
- Noise emanating from **industry** is regulated by **State Pollution Control Boards (SPCBs)** under the **Air (Prevention and Control of Pollution) Act**, **1981**.

### Classification of Air Pollutants

- **Primary pollutants:** These are persistent (exist or occur over a prolonged period) in the form in which they are added to the environment, e.g. **DDT**, **plastic**, **CO**, **$CO_2$**, **oxides of nitrogen** and **sulphur**, **etc**.
- **Secondary Pollutants:** These are formed by interaction among the primary pollutants. For example, **peroxyacetyl nitrate (PAN)** is formed by the interaction of **nitrogen oxides** and **hydrocarbons**. **Ozone** is formed
  - ❖ when **hydrocarbons (HC)** or **VOCs** and **nitrogen oxides ($NO_x$)** combine in the presence of **sunlight**;
  - ❖ when **NO** combines with **oxygen** in the air; and
  - ❖ due to **acid rain** (**sulphur dioxide** or **nitrogen oxides** react with rainwater to form acid rain).
- Quantitative Pollutants: These occur in nature and become pollutants when their concentration reaches beyond a threshold level. E.g., **carbon dioxide**, **nitrogen oxide**, **etc**.
- **Qualitative Pollutants:** These do not occur in nature and are human-made. E.g., fungicides, herbicides, DDT etc.

## 12.2. Air Pollutants

### Particulate Pollutants

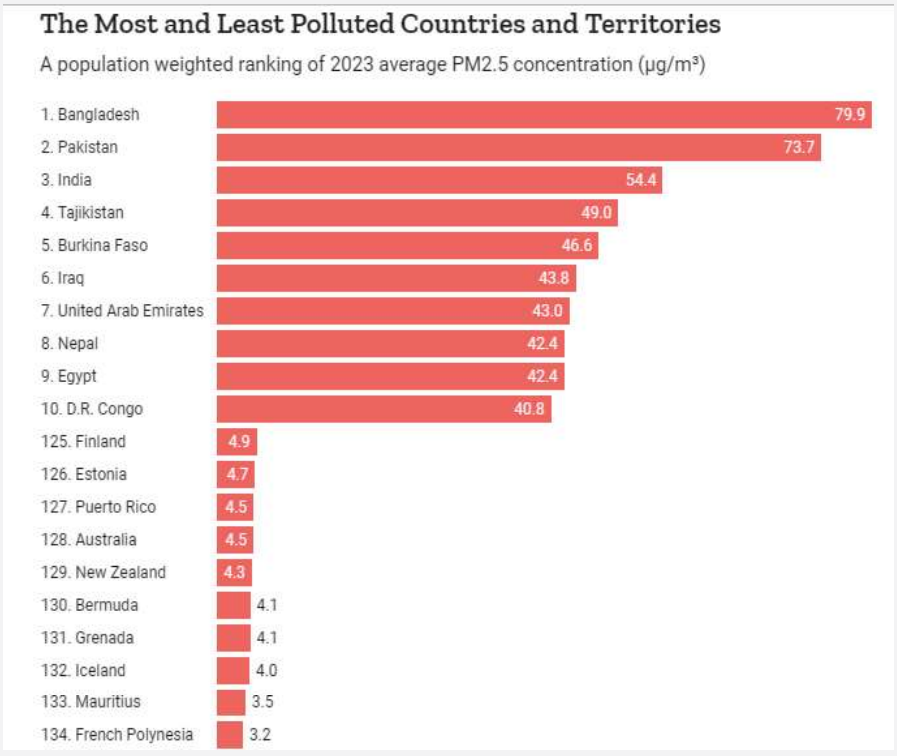
- Particulate pollutants are matter suspended in the air, such as **dust** and **soot**. Their size ranges from **0.001 to 500 micrometres** (μm) in diameter. Particles **less than 10 μm float and move freely with the air current**. Particles that are **more than 10 μm** in diameter **settle down**. Particles **less than 0.02 μm** form **persistent aerosols**.
- Major sources of **suspended particulate matter (SPM)** are industries, vehicles, power plants, construction activities, oil refineries, railway yards, marketplaces, industries, etc.

- **Inhalable particulate matter PM10** and **PM2.5** have been regarded as **criteria pollutants** because several studies have documented their adverse health effects. According to the Central Pollution Control Board (CPCB), particulate size **2.5 µm or less** in diameter **(PM2.5)** is responsible for causing the **most significant harm to human health**.
- These fine particulates can be inhaled deep into the lungs. They can cause breathing and respiratory symptoms, irritation, inflammations, and **pneumoconiosis** (a disease of the lungs caused due to inhalation of dust. It is characterised by inflammation, coughing, and fibrosis – excess deposition of fibrous tissue).

## Particulate Matter Less than 2.5 µm (PM 2.5)

- In the atmosphere, **arsenic** and **nickel** exist as particulate matter, mostly **less than 2 µm in diameter**. Combustion processes like petroleum processing and the combustion of fossil fuels in vehicles or power plants emit nickel. **Nickel compounds** are classified to be **carcinogenic**.
- There has been rising concern about **PM1 (size less than 1 µm)**. While PM2.5 is 30 times finer than human hair, PM1 is 70 times finer. Evidence for the health effects of PM1 is limited due to a **lack of monitoring**.
- There are no standards set even by the WHO for these ultra-fine particles. 40 per cent of the particulate matter is as tiny as PM0.7 and is not even monitored officially.
- PM1 is likely to reach deeper into the respiratory system and **small enough to penetrate through the skin**. PM1 also contains more toxins, including metals, which can cause lung injury and lead to **gene damage** and cancer. The primary source of PM1 is **vehicular and industrial emissions**.

## 5th World Air Quality Report



- According to the 5th World Air Quality Report prepared by **IQAir**, **India was the 3rd most polluted country** in 2023 and **39 out of the world's 50 most polluted cities are in India**.
- IQAir is a **Swiss air quality technology company** that prepares annual world air quality reports based on data from governments, institutions and organisations worldwide.
- **Bhiwadi in Rajasthan** was found to be the most polluted city in India and **3rd most polluted city in the world**. **Delhi** emerged as the **most polluted metropolitan city** and among the **4th most polluted city in the world**.
- 5 most polluted countries of the world are **Chad**, Iraq, Pakistan, Bahrain, and Bangladesh.
- Top 10 most polluted cities in the worls are: **1st Lahore (Pakistan)** > 2nd Hotan (China) > **3rd Bhiwandi (India) > 4th Delhi (India)** > 5th Peshawar (Pakistan) > 6th Darbhanga (India) > 7th Asopur (India) > 8th N'Djamena (Chad) > 9th New Delhi (India) > 10th Patna (India)
- **New Delhi** is the **2nd most polluted capital city** in the world, while N'Djamena (Chad) is the most polluted capital city.

## Fly ash

- Fly ash is ejected mainly by **thermal power plants** as by-products of **coal burning**. It pollutes air and water and may cause **heavy metal pollution** in **water bodies**. It affects crops and vegetation due to its **direct deposition on leaves**.

### Composition

- Fly ash is **oxide-rich** and consists of **silica**, **alumina**, **oxides of iron**, **calcium**, and **magnesium** and **toxic heavy metals** like **lead**, **mercury**, **cadmium**, **arsenic**, **cobalt**, and **copper**. Oxides present in large quantities are **aluminium silicate**, **silicon dioxide** ($SiO_2$) and **calcium oxide** (CaO).

**[UPSC 2020] Consider the following statements:**

1. Coal ash contains arsenic, lead and mercury.
2. Coal-fired power plants release sulphur dioxide and oxides of nitrogen into the environment.
3. High ash content is observed in Indian coal.

***Which of the statements given above is/are correct?***

a) 1 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

**Explanation**

- Unlike the **carboniferous coal of the US and Europe**, **Indian coal or Gondwana coal has high moisture and ash content**. **Hence it causes more pollution**.

***Answer: d) all***

### Uses

- ✓ **Cement can be replaced by fly ash by up to 35%**, thus reducing the cost of construction.
- ✓ Fly ash **bricks** are lightweight and durable.
- ✓ Fly ash is a better fill material for road embankments and concrete roads.
- ✓ It can be used in the reclamation of wastelands.
- ✓ Abandoned mines can be filled up with fly ash.
- ✓ Fly ash **can increase crop yield** when added to the soil. It also enhances the soil's **water-holding capacity**. (But if it gets deposited on the leaf, **it will reduce photosynthesis**).

### Policy measures of MoEF

- MoEF has made it **mandatory to use Fly Ash-based products** in all **construction** projects, road embankment works, and **low-lying landfilling** works within a **100 km radius** of **thermal power stations** and **mine-filling activities** within a **50 km radius**.

**[UPSC 2015] Regarding 'fly ash' produced by power plants using coal as fuel, which of the following statements is/are correct?**

1. Fly ash can be used in the production of bricks for building construction
2. Fly ash can be used as a replacement for some of the Portland cement contents of concrete
3. Fly ash is made up of silicon dioxide and calcium oxide only and contains no toxic elements.

***Select the correct answer using the code given below***

a) 1 and 2
b) 2 only
c) 1 and 3
d) 3 only

**Explanation**

- **Aluminium silicate** is the major oxide present in fly ash.
- Fly ash does contain heavy toxic elements like arsenic, cobalt, lead etc.

***Answer: a) 1 and 2***

## Nanoparticles (NPs)

- Nanoparticles have dimensions comparable to $1/10^9$ of a meter (1 divided by 100 crores). Major natural processes that release NPs into the atmosphere are **forest fires**, **volcanic eruptions**, **weathering**, **dust storms**, etc. Naturally occurring NPs are pretty heterogeneous in size. They can be transported over thousands of kilometres and remain suspended in the air for several days.
- NPs have the large surface area to volume ratios and react rapidly in the atmosphere, commonly growing into particles large enough to interact with radiation and have severe consequences for visibility and climate.

- Nanotechnology has a global socioeconomic value, with applications ranging from electronics to biomedical uses (delivering drugs to target sites). Human-made NPs are unknowingly or purposely released into various environmental matrices such as air, water, soil and sediments, including wastewater sludge, during various industrial and mechanical processes.

## Effects of Nanoparticles on the environment

### Dust cloud formation

➢ NPs coagulate and form **dust clouds**, which **decrease the intensity of sunlight**. Asian brown (dust) clouds carry large amounts of **soot** and **black carbon (NP)** and deposit them on the Himalayan glaciers (**reduces albedo**). This could lead to higher absorption of the sun's heat and potentially contribute to the **increased melting of glaciers**.

### NPs and hydroxy radical (OH)

➢ NPs, being very reactive, immediately bind with **hydroxyl radicals** and ultimately **result in their reduction** in the troposphere. This **reduces** the natural **'pollutant scrubbing capacity'** of the atmosphere.

⇨ *The **hydroxyl radical** (sometimes called the **'detergent' of the atmosphere**) is one of the most reactive **oxidants** in the **troposphere** and **lower stratosphere**. It plays an important role in the **photochemical degradation** of **natural organic matter**, **volatile organic compounds (VOCs)** and pollutants like **carbon monoxide**, **methane**, **$NO_x$** and **hydrochlorofluorocarbons (HCFCs)**. Therefore, it plays a crucial role in maintaining air quality.*

### NPs and ozone depletion

➢ NPs can increase the production of **free radicals** (atoms, molecules, ions with unpaired valence electrons) like **$Cl^-$**, which **destroy ozone**.

### Effect of NPs on stratospheric temperature

➢ NPs in the troposphere interact with **molecular hydrogen** accidentally released from **hydrogen fuel cells** and other sources. Molecular hydrogen, along with NPs, moves up to the **stratosphere**, resulting in abundant **water vapour** in the **stratosphere**. This will cause **stratospheric cooling** due to the formation of **stratospheric clouds (mostly ice crystals)**, which **destroy ozone**.

**[UPSC 2014] There is some concern regarding the nanoparticles of some chemical elements that are used by the industry in the manufacture of various products. Why?**

1. They can accumulate in the environment and contaminate water and soil.
2. They can enter the food chains.
3. They can trigger the production of free radicals.

***Select the correct answer using the code given below.***

a) 1 and 2 only
b) 3 only

c) 1 and 3 only
d) 1, 2 and 3

***Answer: d) all***

## Black Carbon (Soot) and Himalayan Glaciers

- **Black carbon** (commonly known as soot) is a solid or **aerosol** (suspension of fine solid particles or liquid droplets in air or another gas) **particulate (PM) short-lived air pollutant** released from **incomplete combustion**. Regionally, it **disrupts cloudiness** and **monsoon rainfall**.
- BC is the most robust **absorber of sunlight (much more than carbon dioxide)** and **heats the air directly**. When it is deposited on snow, it darkens the snowpack, **reducing the albedo** (the ability to reflect sunlight) and heats the surface directly, leading to the **melting** of ice and snow.
- Black carbon is **short-lived** and remains only for days to weeks in the atmosphere before it descends as rain or snow. Thus, the effects of black carbon on atmospheric warming disappear within months of reducing emissions.
- **India** and **China** are the largest emitters of black carbon in the world.
- The **Indo-Gangetic plain** will become the most significant contributor of black carbon, with about 20 per cent from biofuels, 40 per cent from fossil fuels and about 40 per cent from **biomass burning**.

⇨ *The presence of **pollutants in glaciers** (far from sources of pollution) is critical to establishing a baseline for pollution loads and estimating the contribution of various sources to pollution.*

⇨ *The monthly mean concentration of black carbon in India was found to be minimum in **August (rainy season)** and maximum in May (dry season).*

### Brown Carbon

- Black carbon is primarily released by high-temperature combustion, and brown carbon (brown smoke and aerosols) is emitted mainly by the impure combustion of organic matter (biomass combustion).

## Carbon Monoxide (CO)

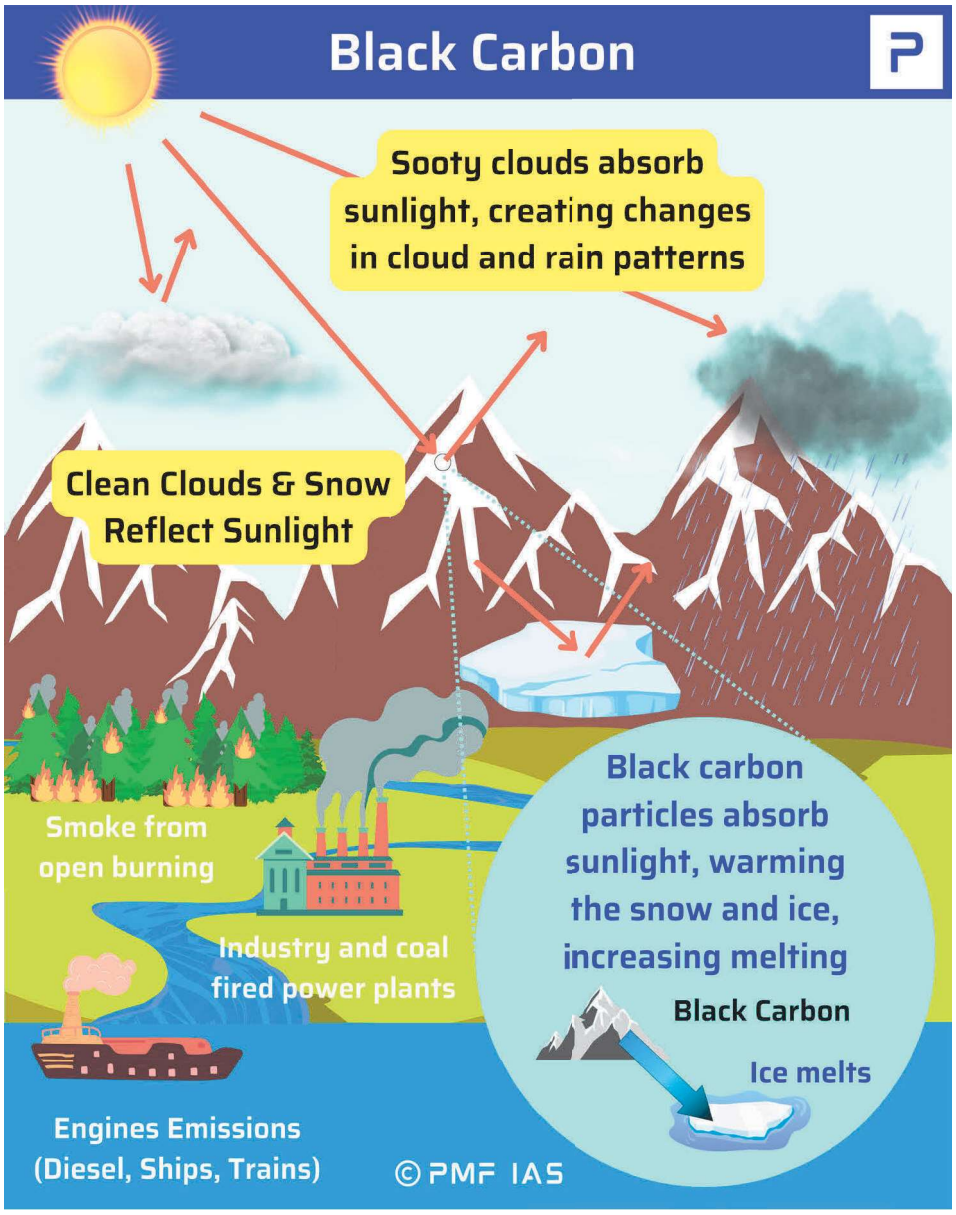
- **Carbon monoxide (CO)** is a colourless, odourless, tasteless, and highly toxic gas **slightly less dense than air**. It is **short-lived** (lasts only a few months) in the atmosphere.
- It forms when there is **insufficient oxygen to produce carbon dioxide ($CO_2$)**. In the presence of oxygen, carbon monoxide burns with a **blue flame**, producing carbon dioxide.
- Worldwide, the largest source of carbon monoxide is **natural in origin** due to **photochemical reactions in the troposphere**. Other natural sources of CO include **volcanoes**, **forest fires**, and other forms of combustion. Anthropogenic carbon monoxide is produced from the exhaust of **internal combustion engines** and **incomplete combustion** of various other fuels. **Iron smelting** produces carbon monoxide as a by-product.

### Health Effects

- **Carbon monoxide poisoning** is the most common type of fatal air poisoning (poor ventilation and heat management in laptops and other electrons can lead to the release of CO). It is toxic to **haemoglobin animals (including humans)** when encountered in concentrations above **35 ppm**. It combines with **haemoglobin** to produce **carboxyhaemoglobin**, which **usurps the space in haemoglobin**, **which usually carries oxygen**.

### Environmental Effects

- Carbon monoxide (CO) is **not considered a direct greenhouse gas (GHG)**. In the atmosphere, it is spatially variable and **short-lived**, having a role in forming **ground-level ozone (tropospheric ozone)** and **can elevate methane concentrations (a strong GHG)**.




## Carbon Dioxide ($CO_2$)

- Carbon dioxide is a colourless and odourless gas. It is **heavier than air**. Natural sources include **volcanoes**, **hot springs** and **geysers**, and it is freed from **carbonate rocks by dissolution in water and**

**acids**. As it is **soluble in water**, it occurs naturally in groundwater, rivers, lakes, ice caps, glaciers and seawater.

### Effects on Health

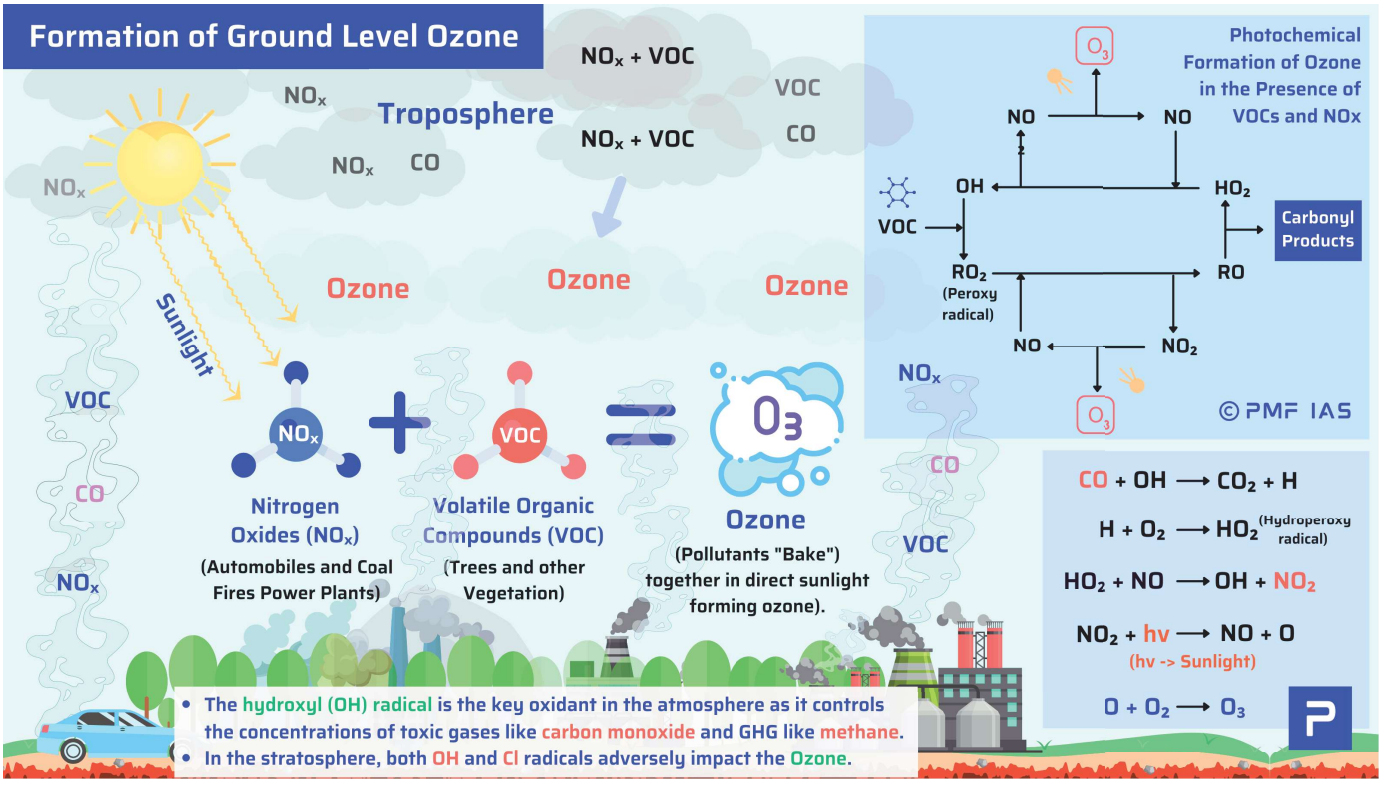
- $CO_2$ is an **asphyxiant gas** (asphyxia: a condition arising when the body is deprived of oxygen, causing unconsciousness or death.). Concentrations of 7% may cause suffocation, even with sufficient oxygen, manifesting as dizziness, headache, and unconsciousness.

### Effects on the Environment

- **Carbon dioxide** is an important **GHG**. Burning of carbon-based fuels since the Industrial Revolution has led to **global warming**. It is also a major cause of **ocean acidification** because it dissolves in water to form **carbonic acid**.

## Ozone ($O_3$)

- **Ozone ($O_3$)** forms less than 0.00005% by volume of the atmosphere and is unevenly distributed. It is formed naturally in the **stratosphere (good ozone — formed due to the interaction between $O_2$ and UV light)** and absorbs harmful **ultraviolet rays** of the sun. However, at the **ground level (bad ozone)**, it is a pollutant (**short-lived greenhouse gas**) with highly toxic effects.
- Ground-level ozone is **not emitted directly into the air**. Some of it is **transported** from the **stratosphere**. The rest is formed when pollutants like **carbon monoxide**, **nitrogen dioxide** and **volatile organic compounds (VOC — released from oil and gas extraction)** react **in the presence of sunlight at the ground level** and **convert $O_2$ to $O_3$**.



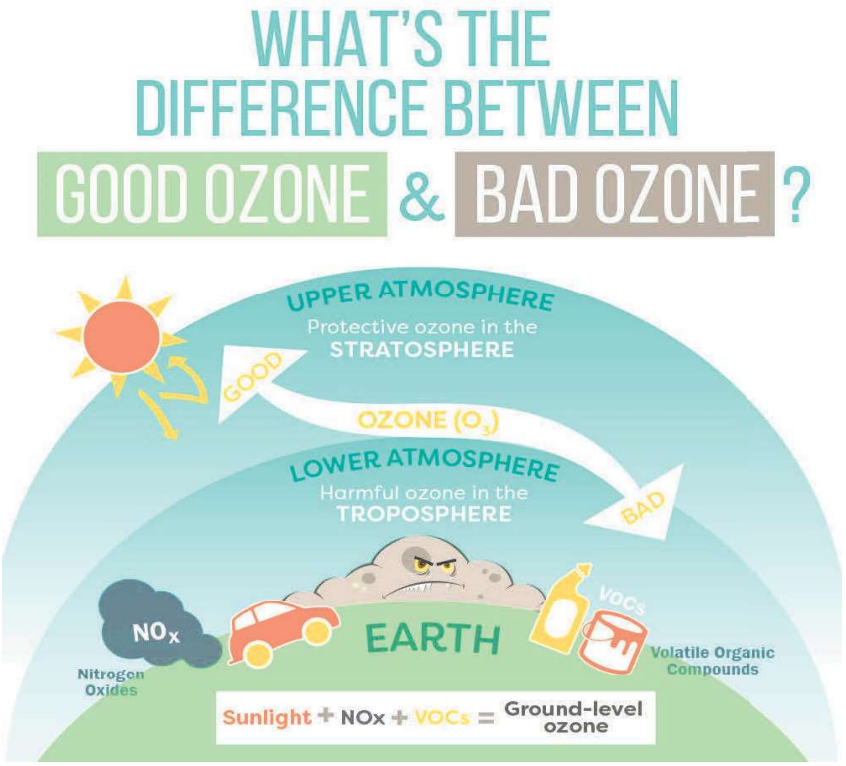

### Tropospheric ozone formation reactions

1. **Carbon Monoxide** reacts with the **hydroxyl radical (-OH)** to produce **hydroperoxy radical ($HO_2$)**.
2. **Volatile Organic Compounds** react with **hydroxyl radical (-OH)** to produce **peroxy radical ($RO_2$)**.
3. **Hydroperoxy radicals** react with **Nitrogen Oxide (NO)** to form **$NO_2$** and **hydroxyl radical (OH) / alkoxy radical (RO)**.
4. **$NO_2$ gives $O_3$ via photolysis** (molecule separation by light).

## Harmful Effects of Ozone

- Ozone at ground level is a **harmful air pollutant** and one of the main ingredients of **smog**.
- Ozone makes our eyes itchy and watery. It lowers our resistance to colds and pneumonia.
- Asthma patients are at the most significant risk from breathing air containing ozone.
- Elevated ozone exposure can affect sensitive vegetation and ecosystems, including forests, especially during the growing season.

*Ozone is most likely to reach unhealthy levels on **hot sunny days**. Wind can also transport it long distances, so even rural areas can experience high $O_3$ levels.*




## Stratospheric Ozone Depleting Substances (ODS)

- **ODS** are human-made gases that release chlorine and bromine atoms on exposure to UV rays and destroy **stratospheric ozone (good ozone)**. They include:
  1. **chlorofluorocarbons (CFCs)**
  2. **hydrochlorofluorocarbons (HCFCs)**
  3. **hydrobromoflurocarbons (HBFCs)**
  4. **halons** (halocarbon gases were used in **fire extinguishers**)
  5. **methyl bromide** (was used as a **fumigant** for pest control — suffocating pests with poison)

6. **carbon tetrachloride** (formerly widely used in **fire extinguishers**, **refrigerants and** as **cleaning agents**)
7. **methyl chloroform** (aerosols, **solvent for organic compounds**; used for **cleaning metals and circuit boards**).

- ODS have been used as **refrigerants** in air conditioners and refrigerators, **foam-blowing agents**, components in **electrical equipment**, **industrial solvents**, **solvents for dry cleaning**, **aerosol spray propellants** and **fumigants**.

## Chlorofluorocarbons (CFCs)

- **CFCs** are used in **aerosol sprays** and as **refrigerants** in **refrigerators and air conditioners**. They are also considered **greenhouse gases**. Since the late 1970s, the use of CFCs has been heavily regulated because of their **destructive effects on the ozone layer**. There are still CFCs left in older industrial air conditioning and refrigeration systems.

## HCFCs and HBFCs

- **Hydrochlorofluorocarbons (HCFCs) and Hydrobromofluorocarbons (HBFCs)** have been used as a **substitute for CFCs**. They are composed of molecules containing one, two or three carbon atoms and at least one atom each of hydrogen, bromine/chlorine and fluorine. They do **less damage to the ozone layer than CFCs**. They are, however, **GHGs**.

## Halons

- Halons are **halocarbon gases** that were initially developed for use in **fire extinguishers**. In halons, one or more carbon atoms are linked by **covalent bonds** with one or more **halogen atoms (fluorine**, **chlorine**, **bromine or iodine)**. Production and consumption of halons ended in 1994 in developed countries.

⇨ *The **Montreal Protocol** on **Substances that Deplete the Ozone Layer** (a protocol to the **Vienna Convention for the Protection of the Ozone Layer**) is an **international treaty** designed to **protect the ozone layer** by **phasing out the production of numerous ozone-depleting substances**, including **CFCs**.*

**[UPSC 2011-12] Consider the following statements: Chlorofluorocarbons, known as ozone-depleting substances, are used**

1. in the production of plastic foams
2. in the production of tubeless tyres
3. in cleaning certain electronic components
4. as pressurising agents in aerosol cans

***Which of the statements given above is/are correct?***

a) 1, 2 and 3 only
b) 4 only
c) 1, 3 and 4 only
d) 1, 2, 3 and 4

**Explanation**

- CFCs were used as refrigerants and pressurising agents (aerosol cans) and for cleaning electronic equipment.

***Answer: c) 1, 3 and 4 only***

### [UPSC 2023] Consider the following

1. Aerosols
2. Foam agents
3. Fire retardants
4. Lubricants

***In the making of how many of the above are hydrofluorocarbons used?***

a) Only one
b) Only two
c) Only three
d) All four

**Explanation**

- HFCs and other ozone-depleting substances (ODS) do not possess lubricating properties.

***Answer: c) Only three***

## Nitrogen Oxides (Oxides of Nitrogen) ($NO_x$)

- $NO_x$ is a generic term for the various **nitrogen oxides** produced during **combustion**. They are produced mainly in **internal combustion engines** and **coal-burning power plants**.
- They are also produced naturally by **lightning**. **Agricultural fertilisation** and **nitrogen-fixing plants** also contribute to atmospheric $NO_x$ by promoting N-fixation by microbes.

⇨ *Oxygen and nitrogen do not react at ambient temperatures. However, at **high temperatures**, they produce various oxides of nitrogen. Such temperatures arise inside an **internal combustion engine** or a **power station boiler**.*

⇨ ***The term nitrogen oxides ($NO_x$) is usually used to include Nitric Oxide (NO – colourless, odourless gas) and Nitrogen Dioxide ($NO_2$ – a reddish-brown gas with a pungent odour). Other oxides of nitrogen include Nitrogen Trioxide ($NO_3$), Nitrous Oxide ($N_2O$), Dinitrogen Tetroxide ($N_2O_4$) and Dinitrogen Pentoxide ($N_2O_5$).***

⇨ ***Nitrogen Oxide (NO)** and **Nitrogen Dioxide ($NO_2$)** **contribute to global cooling** and should not be confused with **Nitrous Oxide ($N_2O$)**, which is a **greenhouse gas** and has many uses as an **oxidiser**.*

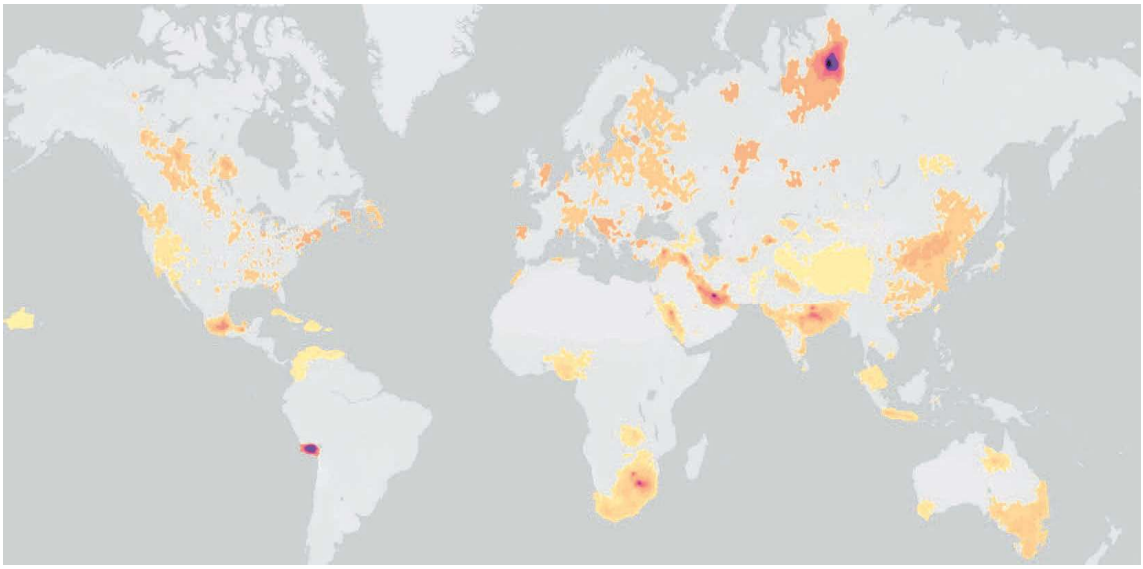
### Effects on Health and Environment

- The reduction of $NO_x$ emissions is one of the most critical technical challenges facing **biodiesel**.
- $NO_x$ gases are believed to aggravate **asthmatic conditions** and create many respiratory health issues.
- $NO_x$ gases react to form **acid rain** and **tropospheric ozone**. When **NOx** and **VOCs** react in the **presence of sunlight**, they form **photochemical smog**.

- Mono-nitrogen oxides, when dissolved in atmospheric moisture, form **nitric acid**, a component of **acid rain**.
- **NO** and **$NO_2$ emissions** cause **global cooling** by forming **-OH radicals** that **destroy methane molecules (methane cycle)**, **countering the effect of greenhouse gases**.

## Sulphur dioxide ($SO_2$)

- Sulphur dioxide is a toxic gas with a pungent, irritating smell. It is produced for sulfuric acid manufacture. It is released naturally by **volcanic activity**. It is also produced by:
  - **burning coal in thermal power plants** and **diesel fuels**.
  - some industrial processes, such as the **production of paper** and the **smelting of metals like copper**.
  - reactions involving **Hydrogen Sulphide (H2S)** and **oxygen**.
  - The **roasting of sulphide ores** such as **pyrite**, **sphalerite**, and **cinnabar (mercury sulphide)**.
- Sulphur dioxide is a poisonous air pollutant that increases the risk of stroke, heart disease, lung cancer, and other health issues that can lead to premature death. It also contributes to **acid rain**.



**World's Sulphur Dioxide ($SO_2$) Hotspots: 2019-2020**

- *Sulphur dioxide is abundantly available in the **atmosphere of Venus**, possibly due to extensive volcanism.*
- *The Venusian atmosphere supports **opaque sulfuric acid clouds**, making the planet's atmosphere highly reflective.*

### India's $SO_2$ Emissions

- **Greenpeace India** and the **Centre for Research on Energy and Clean Air (CREA)** has released its annual report titled **"Ranking the World's $SO_2$ Hotspots: 2019-2020"**.
- **India** has occupied the **top spot in the world** in **sulphur dioxide ($SO_2$) emissions** for the **fifth consecutive year** in 2019. **China's success** in reducing $SO_2$ emissions has made **Russia** the second-highest emitter after India.

- In 2019, India emitted **21%** of global anthropogenic (human-made) $SO_2$ emissions. **Electricity generation using coal** remains the most significant contributor to $SO_2$ emissions. However, India's $SO_2$ emissions have recorded a decline of approximately six per cent in 2019 compared to 2018, the steepest dip in four years.

### $SO_2$ Emission Hotspots in India

- India has more than 15% of all anthropogenic sulphur dioxide ($SO_2$) hotspots detected by the **OMI (Ozone Monitoring Instrument) satellite**. The emission hotspots in India are **thermal power stations** in:
  - **Singrauli in MP**,
  - **Neyveli and Chennai in Tamil Nadu**,
  - **Talcher and Jharsuguda in Odisha**,
  - **Korba in Chhattisgarh**,
  - **Kutch in Gujarat**,
  - **Ramagundam in Telangana and**
  - **Chandrapur and Koradi in Maharashtra**.
- Among large cities, **Chennai** is the biggest hotspot.

## Polyaromatic Hydrocarbons (PAHs)

- PAHs are ubiquitous environmental pollutants generated primarily during the **incomplete combustion of organic materials (e.g. coal, oil, petrol, and wood)**. **Cigarette smoke** contains many PAHs. High-temperature cooking will form PAHs in meat and other foods. **Naphthalene** is a PAH produced commercially in the US to make other chemicals and mothballs.
- Many PAHs have toxic, **mutagenic** and **carcinogenic** properties. They are highly **lipid soluble** and thus readily absorbed from the gastrointestinal tract of mammals **(Bioaccumulation)**. They can associate with other particulate matter, like PM2.5, and PM10, and make them more toxic.

## Volatile organic compounds (VOCs)

- VOCs are a large group of **carbon-based** chemicals that **quickly evaporate** at room temperature. For example, **formaldehyde**, which evaporates **from paint**, has a boiling point of only –19 °C. It irritates the eyes and nose and causes allergies.
- Common examples of VOCs are **benzene**, **ethylene glycol (manufacture of polyester fibres and antifreeze formulations)**, **formaldehyde**, **methylene chloride (dichloromethane — paint remover manufacturing, metal cleaning and degreasing)**, **tetrachloroethylene (primary solvent used in dry cleaning)**, **toluene**, **xylene**, and **1,3-butadiene (precursor to synthetic rubber)**.
- The primary **indoor** sources are **perfumes**, **hair sprays**, **furniture polish**, **glues**, **air fresheners**, **moth repellents**, **wood preservatives**, and other products. Health effects include irritation of the eye, nose and throat, headaches, nausea and loss of coordination. Long-term health effect includes liver damage.

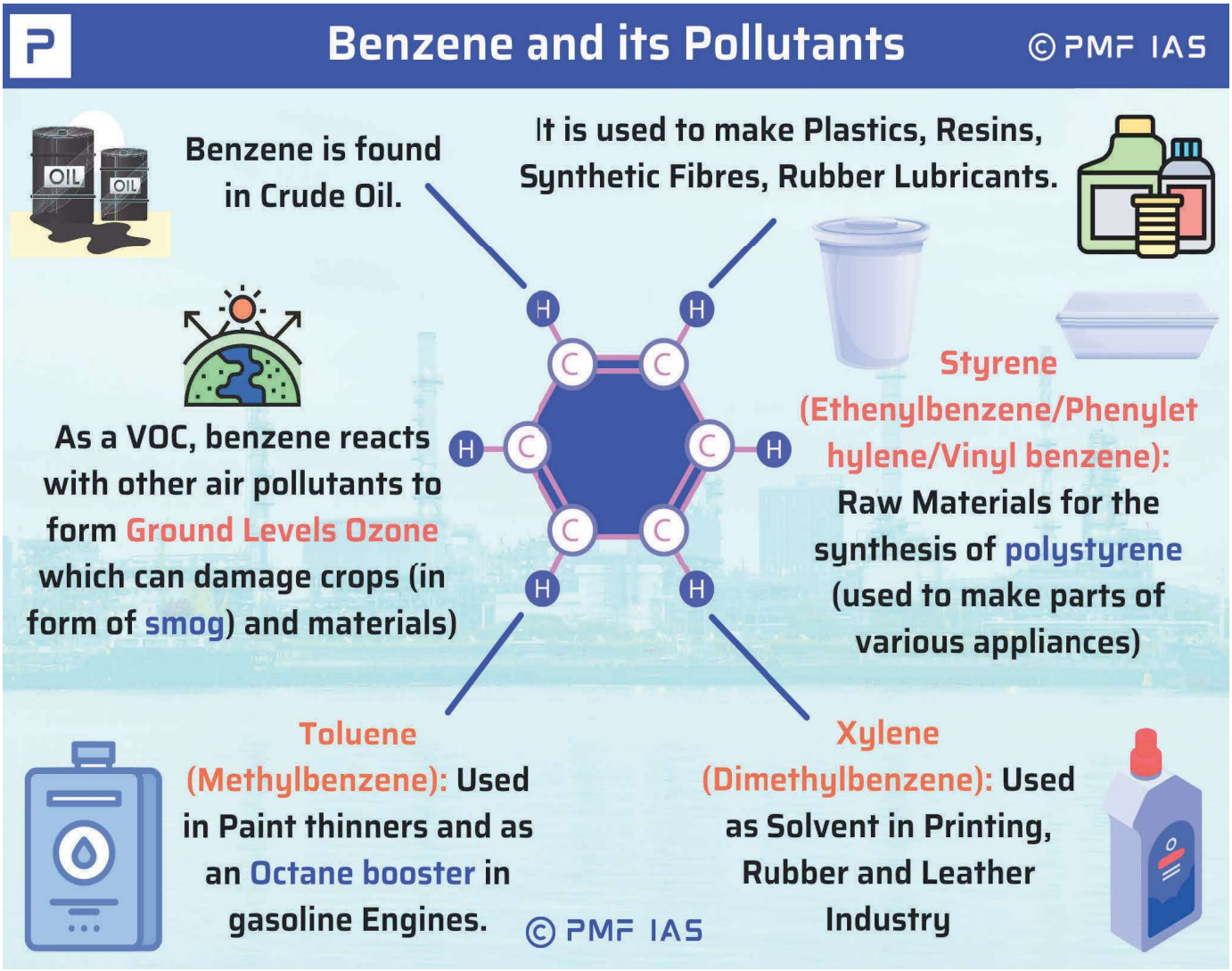
### Ethylene

- **Ethylene** is widely used in the chemical industry. Much of its production goes toward **polyethylene**, a widely used **plastic** containing polymer chains of ethylene units in various lengths. It is also an important **natural plant hormone** used in agriculture **to force the ripening of fruits**.
- Ethylene is of low toxicity to humans, and exposure to excess ethylene causes adverse health effects like headache, drowsiness, and unconsciousness. Ethylene is not, but **ethylene oxide** is a **carcinogen (cancer-causing agent)**.

### Formaldehyde

- Formaldehyde is used in building materials such as **particleboard**, **plywood**, **and other pressed-wood products**. It is commonly used as a **fungicide**, **germicide**, and **disinfectant** and as a **preservative in mortuaries** and laboratories.
- Formaldehyde also occurs **naturally** in the environment. It is produced during the **decay of plant material** in the soil and normal chemical processes in most living organisms. It is also a combustion product found in **tobacco smoke**.

### Benzene



- **Benzene (VOC and Polyaromatic Hydrocarbon)** is a **natural constituent** of **crude oil** and is one of the elementary petrochemicals. It is also a natural part of **cigarette smoke**. Natural sources of benzene include **volcanoes and forest fires**. It is used to make **plastics**, **resins**, **synthetic fibres**, **rubber lubricants**, etc. As it has a **high octane number** (the higher the octane number, the more stable the fuel is), it is an essential component of **gasoline (petrol)**.
- As a **Volatile Organic Compound**, benzene reacts with other air pollutants to form **ground-level ozone**, damaging crops (in the form of **smog**) and materials. Benzene increases the **risk of cancer** and **bone marrow failure**.

### Benzene Pollutants (VOCs and Polyaromatic Hydrocarbons)

- **Toluene (methylbenzene):** used in **paint thinners** and as an **octane booster in gasoline engines**.
- **Xylene (dimethylbenzene): used as a solvent** in the printing, rubber, and leather industry.
- **Styrene (ethenylbenzene/phenylethylene/vinylbenzene):** raw material for synthesising **polystyrene** (used to make **parts of various appliances** such as refrigerators, micro-ovens, automotive parts, computers, etc.). A styrene gas leak from the LG Polymers chemical factory in Visakhapatnam in 2020 left several dead.

**[UPSC 2020] Which of the following are the reasons/factors for exposure to benzene pollution?**

1. Automobile exhaust
2. Tobacco smoke
3. Wood burning
4. Using varnished wooden furniture
5. Using products made of polyurethane

***Select the correct answer using the code given below:***

a) 1, 2 and 3 only
b) 2 and 4 only
c) 1, 3 and 4 only
d) 1, 2, 3, 4 and 5

**Explanation**

- Automobile exhaust, wood burning, and varnished furniture are apparent answers.
- **Nicotine**, **aerosol particles**, **carbonyls**, **VOCs** and hundreds of other chemicals are used in cigarettes.
- **Polyurethane** is a polymer used in the insulation of refrigerators, cushioning for furniture, sportswear, etc.

***Answer: d) all***

## Minor Air Pollutants

### Lead

- Lead is present in **petrol**, **diesel**, **lead batteries**, **paints**, **hair dyes**, etc. **Tetraethyl lead (TEL)** is used as an **anti-knock agent in petrol** for the smooth and easy running of vehicles. The lead particles coming out from vehicle exhausts, when inhaled, produce injurious effects on the **kidney and liver** and interfere with the **development of RBCs**.
- Lead can cause **nervous system damage** and digestive problems and, in some cases, cause cancer. It has **long-term effects on children** as it **lowers intelligence**. Lead mixed with water and food can create cumulative poisoning.

## Ammonia ($NH_3$)

- **Ammonia** is a **corrosive**, colourless gas with a distinctive, pungent odour. It is commonly emitted in nature by **decaying organic matter** and **human and animal waste**. Most anthropogenic ammonia emissions come from **livestock management** and **agricultural fertilisers**.
- Ammonia is poisonous and irritates the eyes, nose, and throat. It combines in the atmosphere with **sulphates** and **nitrates** to form **ammonium salts**, which are **secondary fine particulate matter (PM2.5)**.
- Ammonia is **highly soluble** in water and can contribute to the **nitrification** and **eutrophication** of aquatic systems.

### [UPSC 2019] Consider the following statements:

1. Agricultural soils release $NO_x$ into the environment.
2. Cattle release ammonia into the environment.
3. Poultry industry releases reactive nitrogen compounds into the environment.

***Which of the statements given above is/are correct?***

a) 1 and 3 only
b) 2 and 3 only
c) 2 only
d) 1, 2 and 3

**Explanation**

- **Agricultural fertilisation** and **N-fixing plants** contribute to atmospheric $NO_x$ by promoting N-fixating microbes.

***Answer: d) all***

## Asbestos

- Asbestos refers to a set of six naturally occurring **silicate fibrous minerals** — chrysotile, crocidolite, amosite, anthophyllite, tremolite, and actinolite. Prolonged inhalation of asbestos fibres can cause severe and fatal illnesses, including **lung cancer**, **mesothelioma**, and **asbestosis** (a type of pneumoconiosis).

## Metallic Oxides

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

### Biological pollutants

- They include **pollen** from plants, mites, hair from pets, fungi spores, parasites, and some bacteria. Most are allergens and can cause asthma and other allergic diseases.

### Radon

- It is a gas that is emitted naturally by the **soil**. Due to modern houses having poor ventilation, it is confined inside the house and causes lung cancers.

## 12.3. Radioactive Pollution

- **Radioactivity** is a phenomenon of **spontaneous emission of protons (alpha-particles)**, **electrons (beta-particles) and gamma rays (short-wave EMR)** due to the **disintegration of atomic nuclei** of some elements. Radiations can be categorised into two groups, namely **non-ionizing radiations** and **ionising radiations**.
- Radioactive Pollution is defined as the increase in the radiation levels (**nuclear radiation/radioactive contamination**) in the environment that pose a severe threat to humans and other life forms.
- **Radioactive contamination** is the presence of radioactive substances on surfaces or within solids, liquids or gases, where their presence is unintended or undesirable.
- **Natural** radiation sources include **cosmic rays** from space and terrestrial radiations from **radionuclides** present in the earth's crust, such as **radium-224**, **uranium-238**, **thorium-232**, **potassium-40**, **carbon-14**, etc.
- Artificial radiation pollution occurs primarily due to **accidental leaks from nuclear power plants** and **unsafe disposal of radioactive wastes**. Other artificial sources include nuclear weapon testing and nuclear fallout (which contains radioactive substances such as **strontium-90**, **caesium-137**, **iodine-131**, etc.), mining of radioactive material like **uranium** and **thorium** (**monazite is the ore of thorium**), exposure to radiation for diagnostic purposes (e.g., **X-rays**, **CT Scan**), chemotherapy, etc., and slow nuclear radiations emanating from nuclear reactors, laboratories, etc.

### Accidents at Nuclear Power Plants

- **Nuclear fission** in the reactor core produces much heat, which, if not controlled, can lead to a **meltdown of fuel rods in the reactor core**. If a meltdown happens by accident, it will release large quantities of hazardous radioactive materials into the environment, with disastrous consequences to humans, animals, and plants.
- To prevent these types of accidents and reactor blow-ups, the reactors are designed to have several safety features. Despite these safety measures, three disasters in the nuclear power plants are noteworthy: **Three Mile Island** (**USA**) **in 1979**, **Chernobyl** (**USSR/Ukraine**) **in 1986** and the **Fukushima Daiichi nuclear disaster in 2011** (**Japan**).

- In the first two cases, a series of errors resulted in the **overheating of the reactor core** and meltdown, releasing a lot of radiation into the environment. The leakage from the Three Mile Island reactor was low, and no one was injured immediately.
- However, in the case of **Chernobyl**, the leakage was very heavy, causing the death of many workers and **radiation spread over large areas scattered all over Europe**. The latest one – the **Fukushima Daiichi nuclear accident** was **triggered by an earthquake**.

## Safe Disposal of Nuclear Wastes

- Radioactive wastes are of two types:
  1. **Low-level radioactive wastes (LLW)**, which include civilian applications of radionuclides in medicine, research and industry, materials from decommissioned reactors, protective clothing worn by persons working with radioactive materials or working in nuclear establishments.
  2. **High-level radioactive wastes (HLW)** resulting from **spent nuclear fuel rods** and **obsolete nuclear weapons**. (The fission creates radioactive isotopes of lighter elements such as **cesium-137** and **strontium-90**)
- Presently, **waste fuel rods** are stored in unique storage ponds at reactor sites or sent to reprocessing plants. Even though reprocessing is more expensive, some countries use it as an alternative to waste storage. In the US, nuclear waste is buried deep underground in insulated containers.

⇨ ***Radioactive Nuclear Wastes**: Argon 41, radioiodine, cobalt-60, strontium-90, tritium and caesium-137.*

## Non-Ionizing Radiation

- Non-ionizing radiation includes electromagnetic waves at the **longer wavelength of the spectrum**, ranging from **long wavelength UV radiation** to **radio waves (including microwaves)**. These waves have enough energy to **excite the atoms and molecules of the medium** through which they pass, **causing them to vibrate faster** but **not strong enough to ionise them**.
- Non-ionizing radiation may damage eyes due to **reflections from sand** and **snow (snow blindness)** and directly looking towards the sun during an eclipse. They injure the cells of skin and blood capillaries, producing blisters and reddenings called sunburns.

⇨ *In a **microwave oven**, the (non-ionizing) radiation causes **water molecules in the cooking medium to vibrate faster**, thus raising its temperature.*

⇨ ***Ionisation** is the process by which an atom or a molecule **acquires a negative or positive charge** by gaining or losing electrons to form ions, often in conjunction with other chemical changes.*

### Impact of Non-Ionizing Radiation from Cell Phone Towers

#### Health Impacts

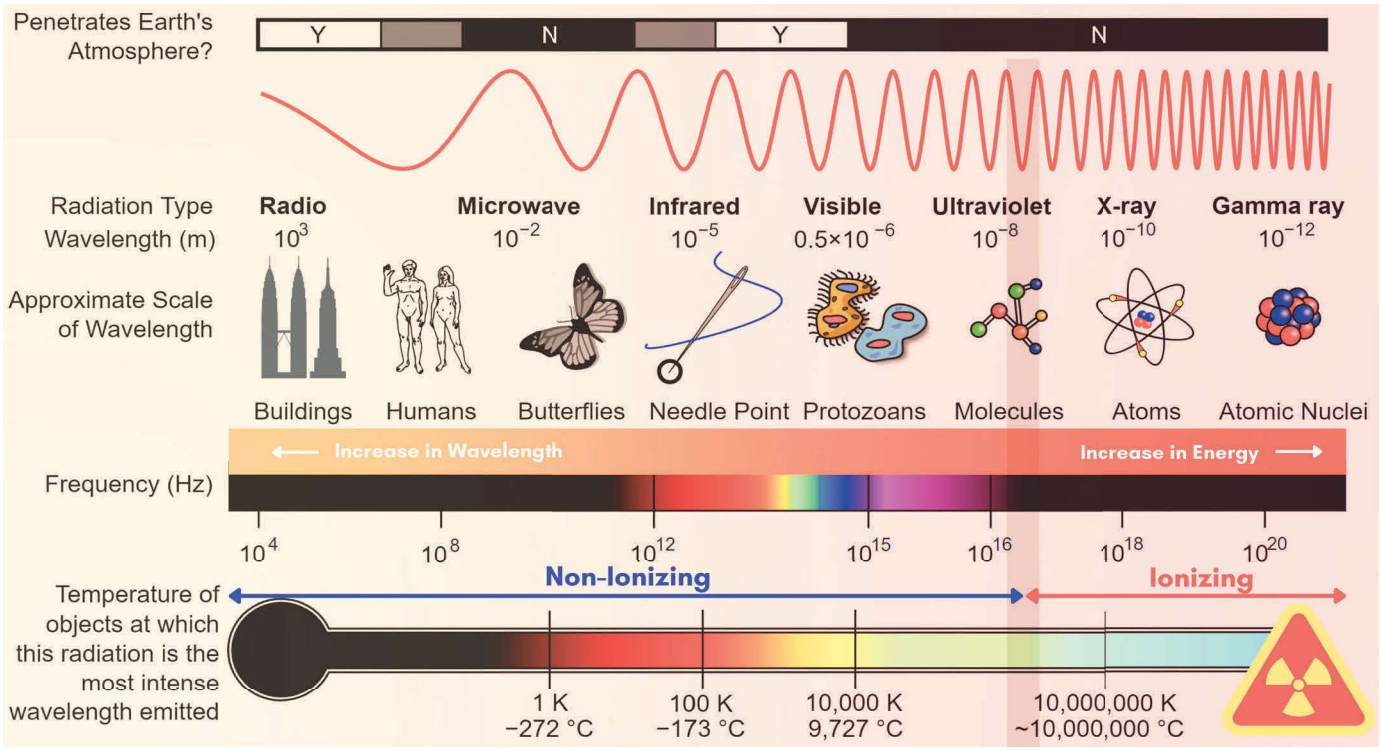
➢ Every antenna on a cell phone tower radiates **non-ionizing electromagnetic radiation (EMR)**. When many operators use one tower, more will be the number of antennas and more is the power intensity in the nearby area. The power level near towers is higher and reduces as we move away.

- EMR may cause cellular and psychological changes in human beings due to **thermal effects** that are generated due to the **absorption of microwave radiation**. The exposure can lead to **genetic defects**, **effects on reproduction** and **development**, **Central Nervous System** behaviour, etc.
- EMR can also cause **non-thermal effects** caused by **radio frequency fields** at levels too low to produce significant heating and are due to the **movement of calcium and other ions across cell membranes**. Such exposure may be responsible for fatigue, nausea, irritability, headaches, loss of appetite and other psychological disorders.
- The current exposure safety standards are purely based on the **thermal effects** and consider only a few pieces of evidence from exposure to non-thermal effects.

### Impact on Birds

- The **surface area of birds is relatively larger** than their body weight in comparison to the human body, **so they absorb more radiation**. Also, the **fluid contained in the body of the birds is less** due to the small body weight, so they **get heated up quickly**.
- The **magnetic field** from the towers **disturbs birds' navigation skills**; hence when birds are exposed to EMR, **they become disoriented** and begin to fly in all directions and die from collisions with tele-communication masts.

## Ionising Radiation




- **Ionising radiations — short wavelength ultraviolet radiations (UV), X-rays** and **gamma rays** and **energetic particles** produced in nuclear processes, electrically charged particles like **alpha and beta particles** produced in **radioactive decay** and **neutrons** produced in nuclear fission — cause **ionisation (one or more electrons are pealed out from the outer shells of an atom) of atoms and molecules** of the medium through which they pass.

⇨ ***Non-ionizing radiations*** *have* ***low penetrability*** *and affect only those components which* ***absorb*** *them.*

⇨ ***Ionising radiations*** *have* ***high penetration power*** *and cause* ***breakage of macromolecules***.

## The Damage Potential of Radiation Particles

- **Alpha particles** can be blocked by paper and human skin.
- **Beta particles** can penetrate through the skin, while some pieces of glass and metal can block them.
- **Gamma rays can penetrate easily** through human skin and damage cells on their way through, reaching far, and **can only be blocked by thick and massive walls of concrete**.

## Half-Life Period of Radioactivity

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

## Radiation Dose

- A traditional unit of human-equivalent dose is the **rem**, which stands for **radiation equivalent in man**. At low doses, such as what we receive every day from background radiation (<1 rem), the cells repair the damage rapidly.
- At higher doses (up to 100 rem), the cells might not be able to repair the damage, and the cells may either be changed permanently or die. E.g., **radiation sickness**. Cells changed permanently may go on to produce abnormal cells when they divide and may become **cancerous**.

## Impact of Ionizing Radiation

- **Ionising radiations** are highly damaging to living organisms. They can cause chemical changes by breaking chemical bonds and damaging living tissues. Short-term effects include burns, impaired metabolism, dead tissues, and death of the organisms. Long-term effects are **mutations** increasing the incidence of **tumours and cancer**, shortening of lifespan and developmental changes.
- At high doses, nuclear radiation is lethal, but at lower doses, it creates various disorders, the most frequent of all being cancer. Continued exposure to small doses can cause **childhood leukaemia**, **miscarriage**, **underweight babies**, **infant deaths**, **and increased susceptibility to AIDS and other immune disorders**.

### DNA Damage

- Electrically charged particles produced in the nuclear processes can have **sufficient energy to knock electrons out of the atoms or molecules of the medium**, **thereby producing ions**. The ions produced in water molecules, for example, can induce reactions that can **break bonds in proteins** and other important molecules. An example of this would be when a **gamma ray** passes through a cell, the **water molecules near the DNA might be ionised**, and the **ions might react with the DNA**, **causing it to break**.

## Biological Damage

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

**---------- End of Chapter ----------**

# 13. Air Pollution – Effects and Control Measures

## 13.1. Effects of Air Pollution

### Smog (Smoke + Fog)

- Smog is caused by the burning of **coal**, **vehicular emissions** and **industrial fumes** (primary pollutants). Smog contains soot particulates like smoke, **ozone ($O_3$)**, **carbon monoxide (CO)**, **sulphur dioxide ($SO_2$)**, **nitrogen dioxide ($NO_2$)** and others. At least two distinct types of smog are recognised: **sulphurous smog** and **photochemical smog**.

### Sulphurous Smog

- Sulphurous smog is also called **London smog** (first formed in London due to the **Industrial Revolution**). It results from a high concentration of **sulphur oxides** in the air. It is caused by the use of **sulphur-bearing fossil fuels**, **particularly coal** (the primary source of electricity generation in India). This smog is aggravated by **dampness** and a **high concentration of suspended particulate matter** in the air.

### Photochemical Smog

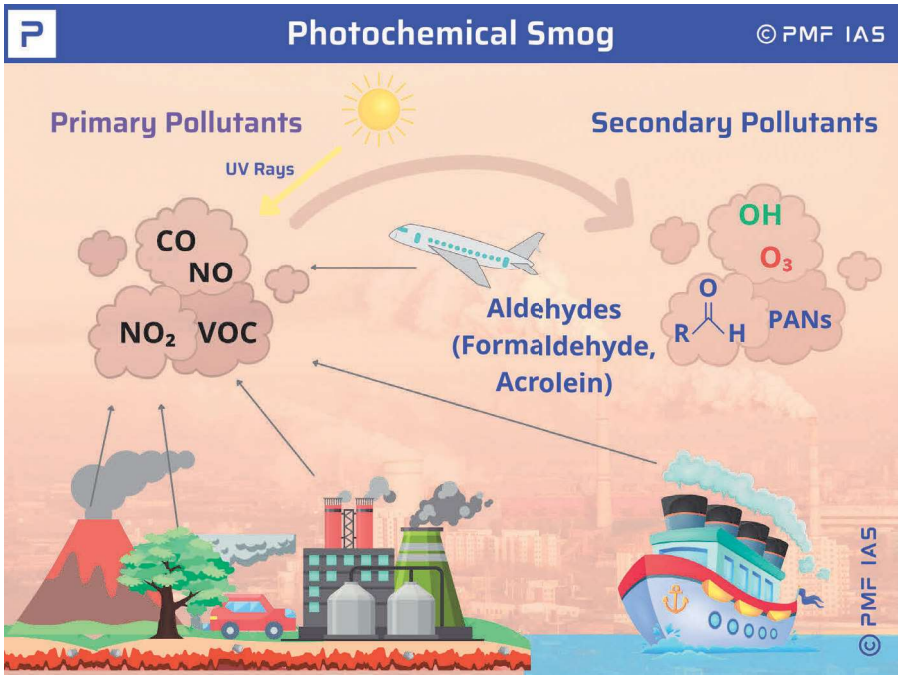
- Photochemical smog is also known as **summer smog** or **Los Angeles smog**. It occurs most prominently in urban areas with **high vehicular emissions**. It forms when **nitrogen oxides** and **volatile organic compounds** react together in the presence of **sunlight** to form **ozone** **(a secondary pollutant)**. The resulting smog causes a light brownish colouration of the atmosphere, reduced visibility, plant damage, irritation of the eyes, and respiratory distress.

#### Haze

- Haze is traditionally an atmospheric phenomenon where dust, smoke and other dry particles obscure the clarity of the sky (**no condensation involved**. Smog is like haze, but **there is condensation in smog**). Sources for haze particles include farming (ploughing in dry weather), traffic, industry, and wildfires.

- The **atmospheric pollution** level of Los Angeles, Beijing, Delhi, etc., is increased by **inversion** that traps **smog** near the ground. It is highly toxic to humans and can cause severe sickness and shorten life. **Temperature inversions are accentuated**, and **precipitation is reduced** due to smog.

## Effects of Photochemical Smog




***NO* + *VOC* (*volatile organic compounds*) ------> $NO_2$ (*Nitrogen Dioxide*)**

**$NO_2$ + *UV* (*sunlight*) ------> *NO* + *O* (*Nitrogen Oxide + atomic oxygen*)**

**$O + O_2$ ------> $O_3$ (*Ozone*)**

**$NO_2$ + *VOC* ------> *PAN* (*peroxyacetyl nitrate – $C_2H_3NO_5$*)**

***Result*: *NO* + *VOC* + $O_2$ + *UV* ------> $O_3$, *PAN*, *and other oxidants like OH***

| Toxic Chemical | Sources | Environmental Effects |
|---|---|---|
| **Nitrogen Oxides (NO and $NO_2$)** | • Combustion of oil, coal, gas<br>• Bacterial action in the soil<br>• Forest fires, volcanic action<br>• Lightning | • Decreased visibility due to the yellowish colour of $NO_2$<br>• $NO_2$ can suppress plant growth |
| **Volatile Organic Compounds (VOCs)** | • Evaporation of fuels<br>• Incomplete combustion of fossil fuels | • Eye irritation<br>• Respiratory irritation<br>• Some are carcinogenic<br>• Decreased visibility due to blue-brown haze |
| **Ozone ($O_3$)** | • Formed from **photolysis of $NO_2$**<br>• Sometimes, results from **stratospheric ozone intrusions** | • Decreased crop yields<br>• Retards plant growth<br>• **Damages plastics**<br>• Breaks down rubber |
| **Peroxyacetyl Nitrates (PAN)** | • Formed by the reaction of $NO_2$ with VOCs | • Eye irritation<br>• High toxicity to plants<br>• **Damaging to proteins** |

## Acid Rain – Acidification

- Acid rain refers to any precipitation (rain, fog, mist, snow) more acidic than usual (**pH < 5.6**; **pH < 7 is acidic**).

### The pH scale

- The pH scale measures how acidic or basic (alkaline) a solution is. It ranges from 0 to 14. A **pH of 7 is neutral**. A **pH less than 7 is acidic**, and a **pH greater than 7 is basic**. A solution with pH 4 is ten times more acidic than pH 5 and a hundred times more acidic than pH 6.
- pH is based on **hydrogen ion concentration** in an aqueous solution. **pH values decrease** as **hydrogen ion levels increase**. Whilst the pH range is usually 0 to 14, lower and higher values are theoretically possible.

### Gases that cause acid rain

| Acidic gases | Source |
|---|---|
| **$SO_x$ (Sulphur Oxides)** | Fossil fuel burning, thermal power plants, smelting of metal sulphide ores, industrial sources, industrial production of sulfuric acid in metallurgical, chemical and fertiliser industries, **volcanoes**, **seas and oceans**, **decomposition of organic matter**, etc. |
| **$NO_x$ (Nitrogen Oxides – NO, $NO_2$ and $N_2O$)** | Fossil fuel burning, lightning, **biomass burning**, **forest fires**, **oceans**, and power plants. |

(NO and $N_2O$ are mentioned in NIOS Environment)

- **Nitrogen** will only react with **oxygen** at **high temperatures and pressures** in **lightning bolts** and **combustion reactions in power plants** or **internal combustion engines**. **Nitric oxide (NO)** and **nitrogen dioxide ($NO_2$)** are formed under these conditions. Eventually, **nitrogen dioxide may react with water** in the rain to form **nitric acid**, **$HNO_3$**. The nitrates thus formed may be utilised by plants as a nutrient (so, the **soil gets nitrogen from acid rain**)."

### Chemistry of Acid Rain

Basic steps involved in the formation of acid rain:

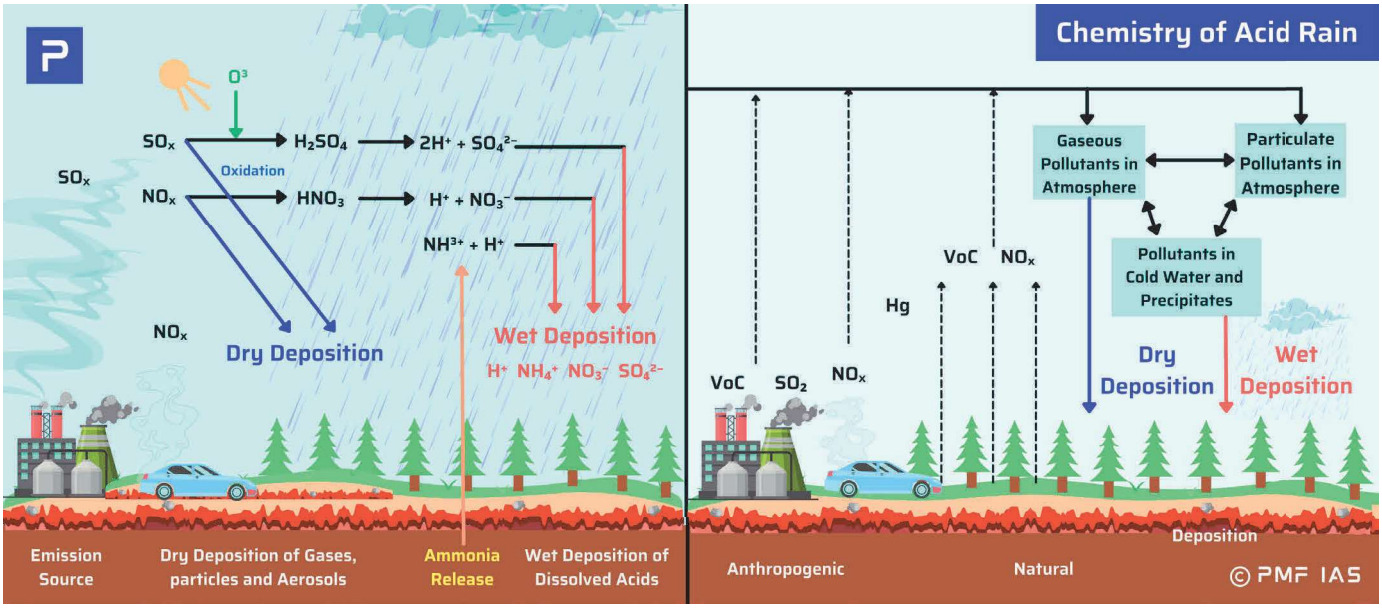
1. The atmosphere receives **oxides of sulphur and nitrogen** from natural and human-made sources.
2. Some of these oxides fall back directly to the ground as **dry deposition**.
3. **Sunlight** stimulates the formation of **photo oxidants** (**such as ozone**) in the atmosphere.
4. These photo oxidants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

#### Wet Deposition

- If the acids in the air are blown into areas where the weather is wet, they can fall to the ground as **rain**, **snow**, **fog**, **or mist**, settling on vegetation as **acid depositions**.

### Dry Deposition

- In areas where the weather is dry, the acid chemicals may become incorporated into **dust** or **smoke** and fall to the ground through dry deposition, **sticking to the ground**, **buildings**, **vegetation**, **cars**, etc.
- About half of the acidity in the atmosphere falls back to earth through **dry deposition**.




**[UPSC 2013] Acid rain is caused by the pollution of the environment by**

a) carbon dioxide and nitrogen
b) carbon monoxide and carbon dioxide
c) ozone and carbon dioxide
d) nitrous oxide and sulphur dioxide

**Explanation**

- **CO** and **$CO_2$** react with rainwater to form **weak carbonic acid**. Hence, rainwater is **naturally slightly acidic**. But this is not enough to call it acid rain (it must have a **pH < 5.6**). **Even a high concentration of CO and $CO_2$ is not enough to cause rainwater of pH less than 5.6**.
- Only NIOS (10.3.2 Gaseous pollutants > Table 10.3 – Page 167) mentions **$N_2O$ (nitrous oxide)**.

***More details:***

⇨ **$N_2O$ and NO are neutral in nature**. $N_2O_3$, $NO_2$ and $N_2O_5$ are acidic in nature. These **acidic oxides react with water** and produce acids like **$HNO_3$ (nitric acid)** and **$HNO_2$ (nitrous acid)**, which causes acid rain.

⇨ The neutral oxides are comparatively less, and they combine with oxygen and produce **nitrogen di-oxide**. Thus, **$N_2O$** and **NO** are **indirectly involved** ($2NO + O_2 \dashrightarrow 2NO_2$) in causing acid rain.

***Answer: d) nitrous oxide (laughing gas; a strong GHG) and sulphur dioxide***

**[UPSC 2022] Consider the following**

1. Carbon monoxide

2. Nitrogen oxide
3. Ozone
4. Sulphur dioxide

***Excess of which of the above in the environment is/are the cause(s) of acid rain?***

a) 1, 2 and 3
b) 2 and 4 only
c) 4 only
d) 1, 3 and 4

**Explanation**

- **Photooxidants like $O_3$ catalyse acid rain formation**; they are not the primary causative agents.

***Answer: b) 2 and 4 only***

## Harmful Effects of Acid Rain

### Effects on soil

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

### Effects on humans

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

### Effects on aquatic life

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

### Effect on terrestrial life

- Acid rain damages the **cuticle** of plant leaves and reduces photosynthesis.
- Acidic medium promotes the **leaching of heavy metals** like **aluminium**, **lead** and **mercury**. Such metals, percolating into groundwater, affect soil microflora/fauna.

### Effects on microorganisms

- pH determines the proliferation of any microbial species. The optimum pH of **most bacteria** and **protozoa** is near **neutrality**. **Most fungi** prefer an **acidic environment**. **Blue-green bacteria** prefer an

**alkaline environment**. So, **microbial species** in the soil and water shift from **bacteria-bound to fungi-bound**. This causes a **delay in the decomposition of soil organic material (like in taiga vegetation)**.

### Effect on buildings, monuments and materials

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

### Acid Rain Areas

- They are concentrated in the industrialised belt of the northern hemisphere — Scandinavia, Canada, Japan, the Northeast United States and North-western Europe.
- In India, the first acid rain occurred in Bombay in 1974. Instances of acid rain are being reported in many metropolitan cities. Low soil pH is reported from north-eastern India, coastal Karnataka and Kerala, parts of Orissa, West Bengal and Bihar.

### Acid Rain Control Measures

- Using **low sulphur fuel** or **washed coal** (chemical washing of pulverised coal) in **thermal plants**.
- **Buffering:** adding a neutralising agent to the acidified water to increase the pH. Usually, lime in the form of **calcium oxide and calcium carbonate** is used.

## Ocean Acidification

- Ocean acidification has been called the "**evil twin of global warming**" and "**the other $CO_2$ problem**". It is the ongoing decrease in the pH of the Earth's oceans (ocean water is **alkaline** (**pH of ~8.1**)) caused by the uptake of **$CO_2$** from the **atmosphere**. Checking **CO** and **$CO_2$ emissions** are the only means to reduce ocean acidification.

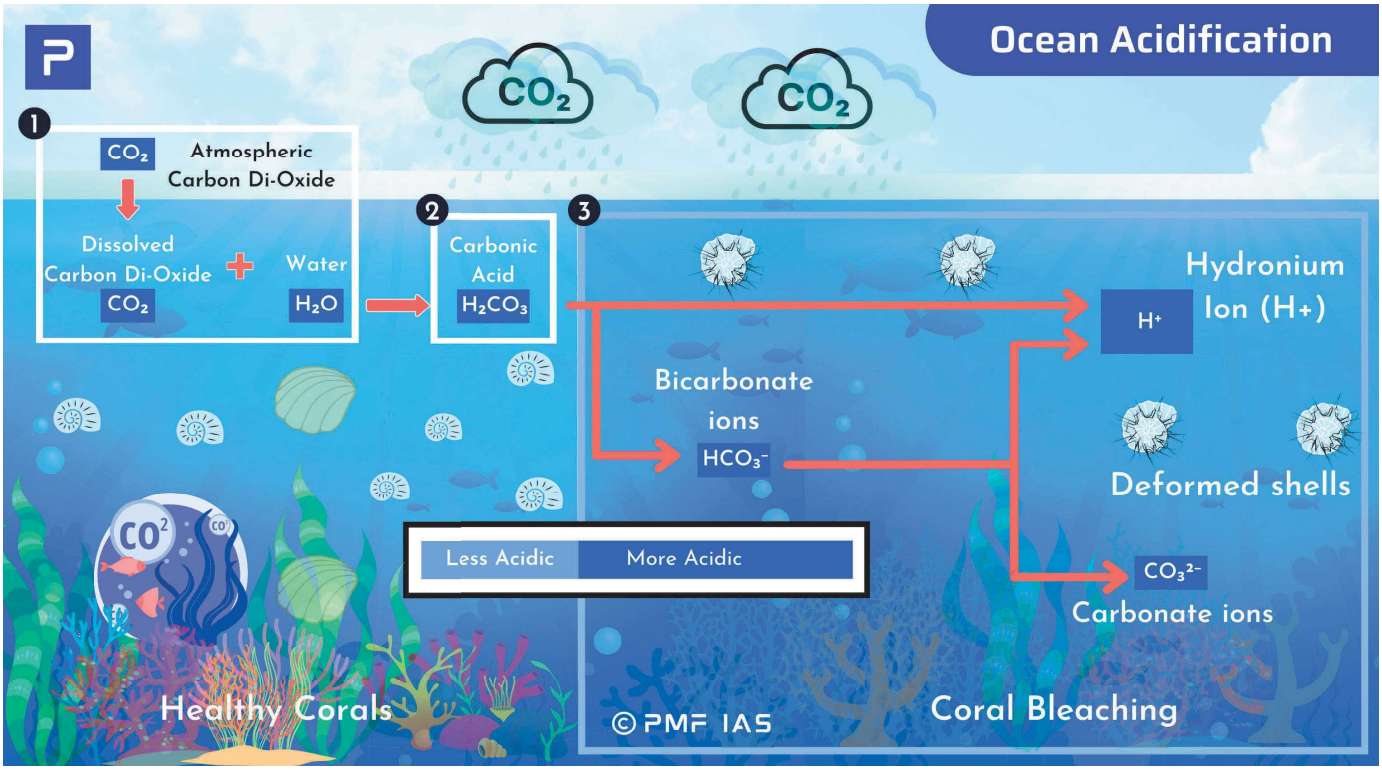
### Mechanism

- An estimated **30-40%** of the carbon dioxide from human activity released into the atmosphere dissolves into oceans, rivers, and lakes. To achieve chemical equilibrium, a part of it reacts with water to form **carbonic acid**. Some **carbonic acid molecules** react with a **water molecule** to give a **bicarbonate ion** and a **hydronium ion (H+)**, thus **increasing ocean acidity (H+ ion concentration)**.

### Other contributors

- **Eutrophication** leads to **plankton blooms**. When these blooms collapse and sink to the seabed, the **respiration of bacteria decomposing the algae** leads to a **decrease in seawater oxygen** and an **increase in $CO_2$ (a decline in pH)**.
- Accelerated **melting of Arctic ice** is increasing **Arctic ocean acidification**. Water under the sea ice, which had a **deficit of $CO_2$**, is now **exposed to atmospheric $CO_2$** and can take it up freely. Also, the **meltwater dilutes the carbonate ion concentration** and **neutralises the seawater's ability to convert $CO_2$** into bicarbonate, which results in a rapidly decreasing ocean pH. And since the **seawater**

**mixed with meltwater is light** and **can't mix easily into deeper waters**, the **$CO_2$ is concentrated at the surface**.




## Effects of Ocean Acidification

### Reduced Buffering Capacity

- **Oceans** are an essential **reservoir of $CO_2$**, absorbing a significant quantity of it (one-third) produced by anthropogenic activities and effectively **buffering climate change**. The uptake of atmospheric carbon dioxide is occurring at a rate **exceeding the natural buffering capacity** of the oceans. Increasing acidity **depresses metabolic rates** and **immune responses** in some organisms.

### Adversely Affects Marine Calcifying Organisms

- Seawater absorbs $CO_2$ to produce **carbonic acid**, **bicarbonate** and **carbonate ions**. However, the increase in atmospheric $CO_2$ levels leads to a decrease in pH level and an increase in the concentration of carbonic acid and bicarbonate ions, causing a **decrease in the concentration of carbonate ions**.
- The decreased amount of carbonate ions makes it more **difficult for marine calcifying organisms**, **such as coral (calcareous corals)** and **some plankton (calcareous plankton)**, to form biogenic calcium carbonate. This **accentuates coral bleaching**, and commercial fisheries are also threatened as the **calcifying organisms** form the **base of the aquatic food webs**.

### Impact on Cloud Formation

- Most of the **sulphur** in the atmosphere is **emitted from the ocean**, often in the form of **dimethylsulfide (DMS)** **produced by phytoplankton**. Some DMS produced by phytoplankton enters the atmosphere and reacts to form **sulphuric acid**, which clumps into **aerosols**. **Aerosols seed the formation of clouds**,

which help **cool the Earth** by reflecting sunlight. But, in acidified ocean water, **phytoplankton produces less DMS**. This reduction in sulphur may lead to **decreased cloud formation**, **raising temperatures**.

**[UPSC 2011-12] The acidification of oceans is increasing. Why is this phenomenon a cause of concern?**

1) The growth and survival of calcareous phytoplankton will be adversely affected.
2) The growth and survival of coral reefs will be adversely affected.
3) The survival of some animals that have phytoplanktonic larvae will be adversely affected.
4) The cloud seeding and formation of clouds will be adversely affected.

***Which of the statement(s) given above is/are correct?***

a) 1, 2 and 3 only
b) 2 only
c) 1 and 3 only
d) 1, 2, 3 and 4

**Explanation**

- **Ocean acidification decreases the calcifying ability** of corals, calcareous plankton, crustaceans etc., and **adversely affects the aquatic food webs**. It also **adversely affects cloud formation and cloud seeding**.

***Answer: d) 1, 2, 3 and 4***

### Artificial Cloud seeding

- Cloud seeding involves **spreading either dry ice** or, more commonly, **silver iodide aerosols** into the upper part of clouds to try to **stimulate the precipitation process (condensation)**.
- Since most rainfall starts through the growth of **ice crystals** from super-cooled cloud droplets in the upper parts of clouds, the **silver iodide** particles are meant to **encourage the growth of new ice particles**.

## Aerosols and their Impact on Monsoon Rainfall

- Scientists have found that **aerosols** have led to **increased incidents of high rainfall events in the foothills of the Himalayan Region (causing regional disparity in rainfall distribution)**. The region is associated with **high aerosol loading**, much of which is black carbon **and dust**. Here, the **air mass** is also forced from a low elevation to a higher elevation (rainfall due to orographic forcing).

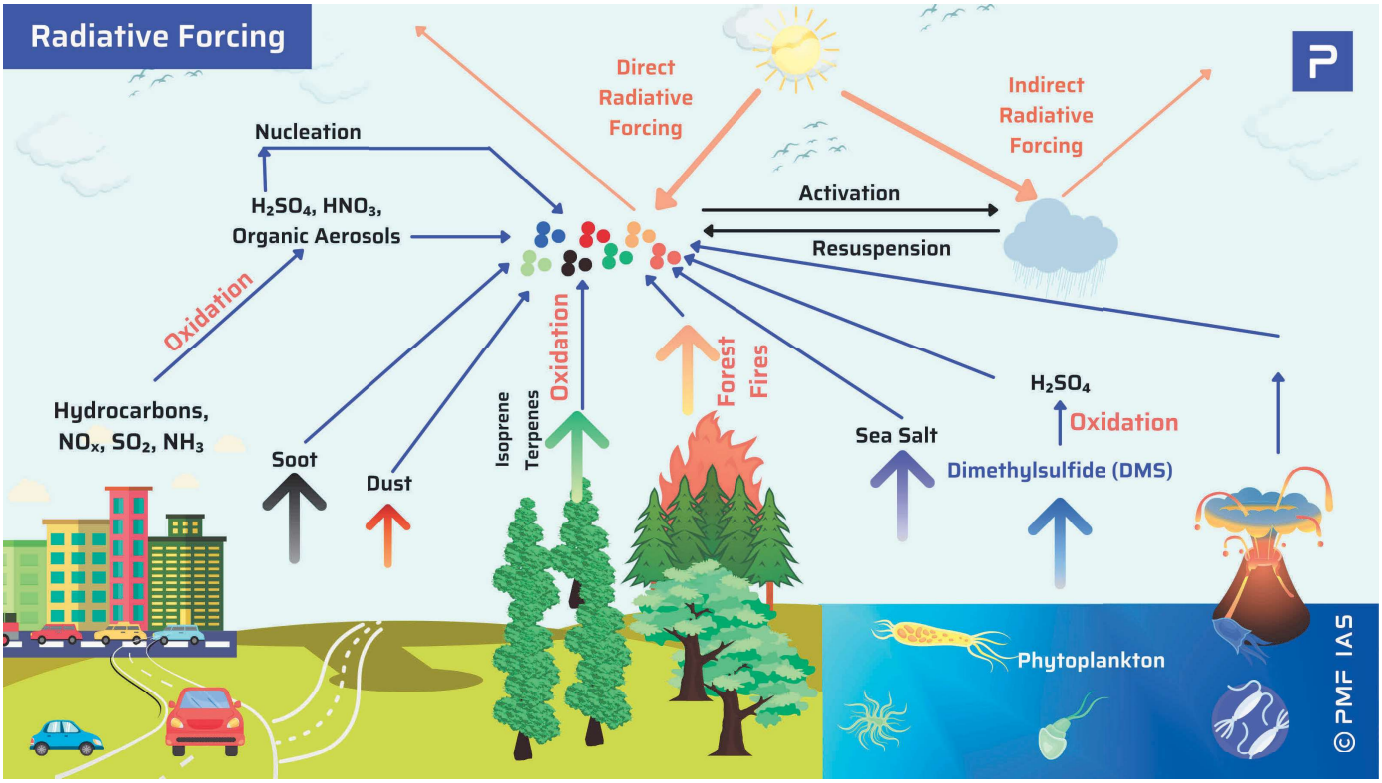
### Aerosols

- An **aerosol** is a **suspension of fine solid particles** or **liquid droplets in air** or **another gas**. Aerosols can be natural or anthropogenic. Examples of **natural aerosols** are **fog**, **mist**, **dust**, **forest exudates and geyser steam**. Examples of **anthropogenic aerosols** are **particulate air pollutants and smoke**. Aerosols serve as **nuclei for cloud droplets or ice crystals** in ice clouds.

- In the atmosphere, aerosols are mainly situated in the **low layers of the atmosphere (<1.5 km)** since aerosol **sources** are located on the **terrestrial surface**. However, certain aerosols can still be found in the stratosphere, especially **volcanic aerosols** ejected to high altitudes.

## Impact of Aerosols on Monsoon Rainfall

- Aerosols remain one of the most uncertain factors in climate projection. They can affect the **radiative balance** of the climate system by **directly scattering or absorbing sunlight** or acting as **cloud condensation nuclei** and thus **modifying the optical properties** and **lifetimes of clouds**.
- **Aerosols** lead to **enhancement** or **suppression** of the Indian summer monsoon rainfall depending on their duration and scale, along with their **tendency to scatter sunlight** directly back into space or by **increasing the size of cloud particles**, thus negatively affecting their capacity to absorb sunlight. This leads to reduced temperatures over land (due to smog), resulting in a **weaker land-sea temperature gradient**, a vital force required to pull the monsoon circulation from ocean to land.




## ATAL – Negatively Affects Indian Monsoon

- **Asian Tropopause Aerosol Layer (ATAL)** covers **South Asia** during the **monsoon season** and has been suspected of having a role in controlling the monsoon precipitation. ATAL is formed because of the **convective transport of aerosols** from the lower atmosphere to the **Upper Troposphere and Lower Stratosphere (UTLS —** 12-18 km**)**.
- ATAL is made up of **sulphates** along with **black carbon**, **organic aerosols**, **nitrates** and dust particles. **Black carbon** aerosols in ATAL are transported from **North India and East China** during **El Niño**. **Sulphate aerosols** are transported from **East Asia**. The increase of these pollutants in the UTLS leads to the thickening and widening of the ATAL.

- The **higher amounts of sulphate aerosols** in the UTLS lead to a **cooling effect on the earth's surface** by scattering incoming solar radiation and **negatively affecting the monsoon**.
- While **El Niño leads to a decrease in rainfall over India**, the **inclusion of aerosols amplifies the decrease in rainfall by 17% over central India**.

## Impact of Aerosols on Regional Rainfall Patterns

- The **incidence of high rainfall events** is **increasing in urban areas** due to **high aerosol loading**. This is causing a **rainfall deficit in rural areas**.

**[UPSC 2015] How far do you agree that the behaviour of the Indian monsoon has been changing due to humanising landscapes? Discuss.**

- **Humanising landscapes** refers to the large-scale interaction of humans with the environment and the consequent changes brought upon due to such interactions.
- Examples of such interactions include urbanisation, industrialisation, deforestation and desertification, depletion of water resources, etc.
- Consequences of such interactions include a rapid increase in the concentration of greenhouse gases and aerosols in the atmosphere, global climate change, changes in sea surface temperature, an alarming rate of depletion of natural resources, imbalances in the ecosystems, etc.

### Impact on Monsoons

- Significant delay in the onset of monsoons, high temporal and spatial variability, frequent long breaks, abnormally heavy downpours (2018 Kerala Floods; 2015 Chennai floods), etc. are all attributed to anthropogenic climate change.
- The **increasing incidence** of El Nino, La Nina, El Nino Modoki, and IOD due to climate change post-industrial revolution has an overarching effect on the overall mechanism of the Indian Monsoons.
- **Localised pollution (condensation nuclei) and deforestation**, on the other hand, cause a **change in regional monsoon patterns**.

### High concentration of condensation nuclei disrupts regional patterns of Indian monsoons

- Increase in the number of **condensation nuclei** due to the increased availability of pollutants and dust particles will increase the condensation of water vapour.
- As the urban atmosphere tends to have a greater concentration of condensation nuclei due to vehicular pollution and construction activity, the monsoonal rainfall is disproportionately high in urban areas.
- Consequently, agriculture-dependent rural areas tend to receive disproportionately low rainfall.

***Urbanisation ➔ High Pollution ➔ High Aerosol Loading ➔ More Cloud Condensation Nuclei ➔ More Precipitation ➔ Floods in Urban Reas* and *Drought in rural areas ➔ Less water percolation ➔ Lower Groundwater Table ➔ Bad For Agriculture***

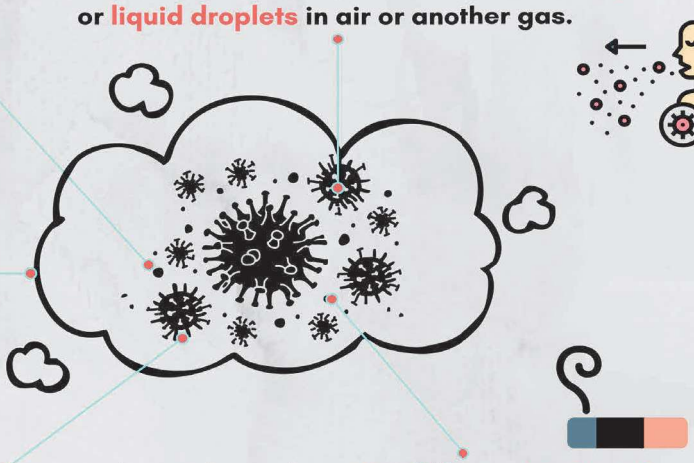
# Aerosols from Air Pollution and their Impact on Monsoon Rainfall

**Why in News?**

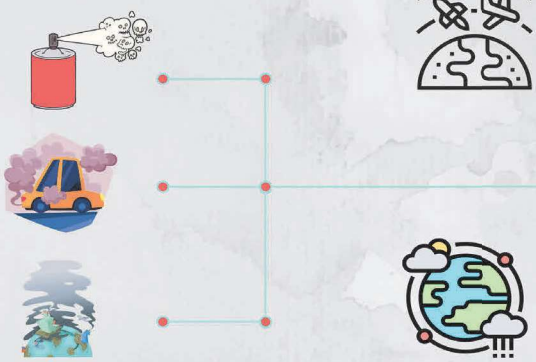
Scientists have found that aerosols have led to increased incidents of high rainfall events in the foothills of the Himalayan Region (causing regional disparity in rainfall distribution).

## What are Aerosols?

An aerosol is a suspension of fine solid particles or liquid droplets in air or another gas.



Certain aerosols can still be found in the stratosphere, especially volcanic aerosols ejected into the high-altitude layers.



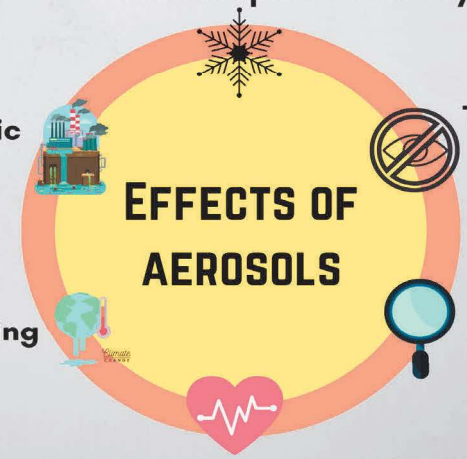
In the atmosphere, these particles are mainly situated in the low layers of the atmosphere (< 1.5 km).

Aerosols can be natural (fog, mist, dust, forest exudates & geyser steam) or anthropogenic (particulate air pollutants & smoke).



## Effects of Aerosols

They serve as nuclei for cloud droplets or ice crystals in ice clouds.




They affect the atmospheric chemical composition.

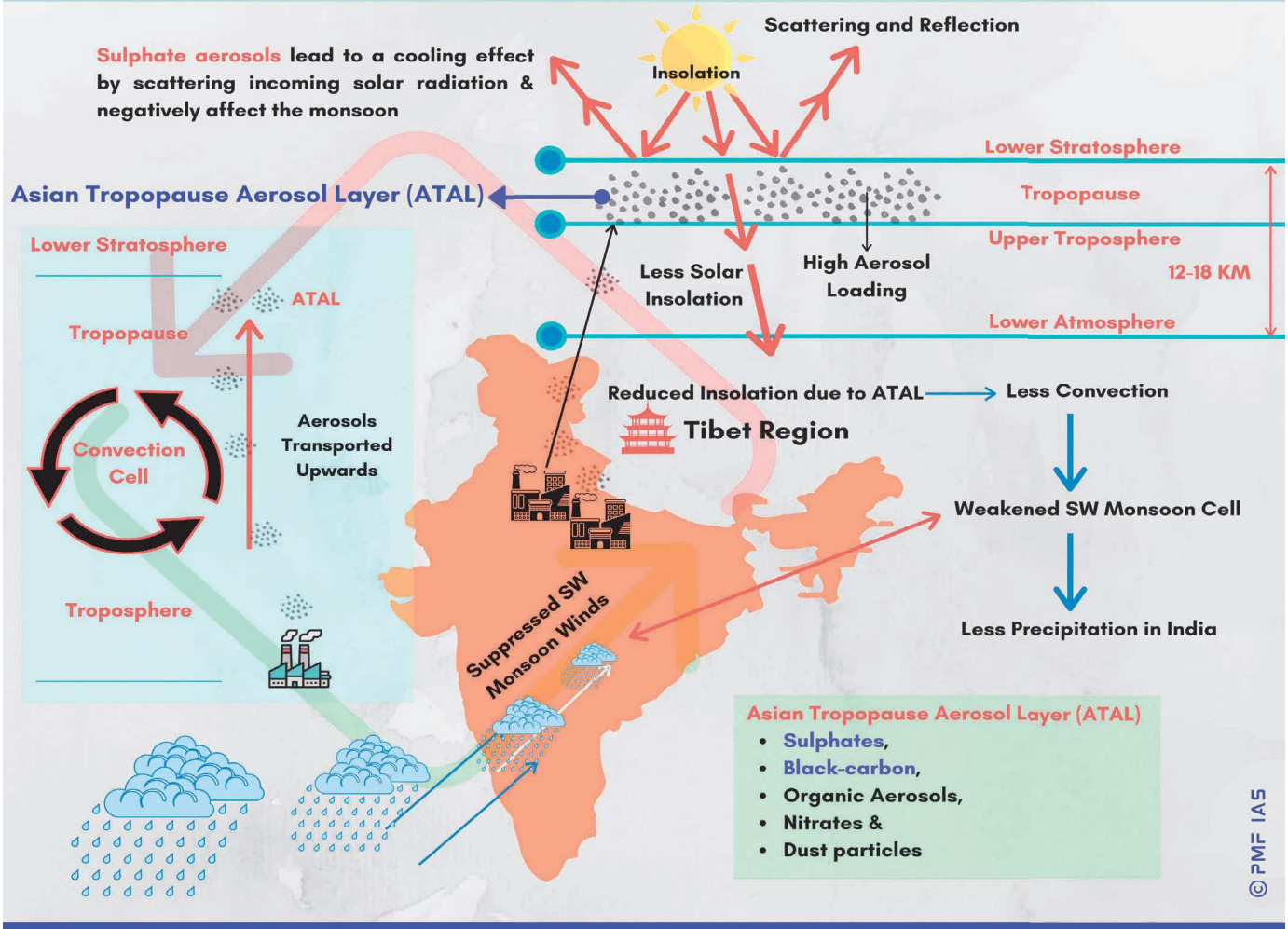
They can reduce the visibility.

Affects radiative balance of Climate Change (by Scattering or Absorbing)

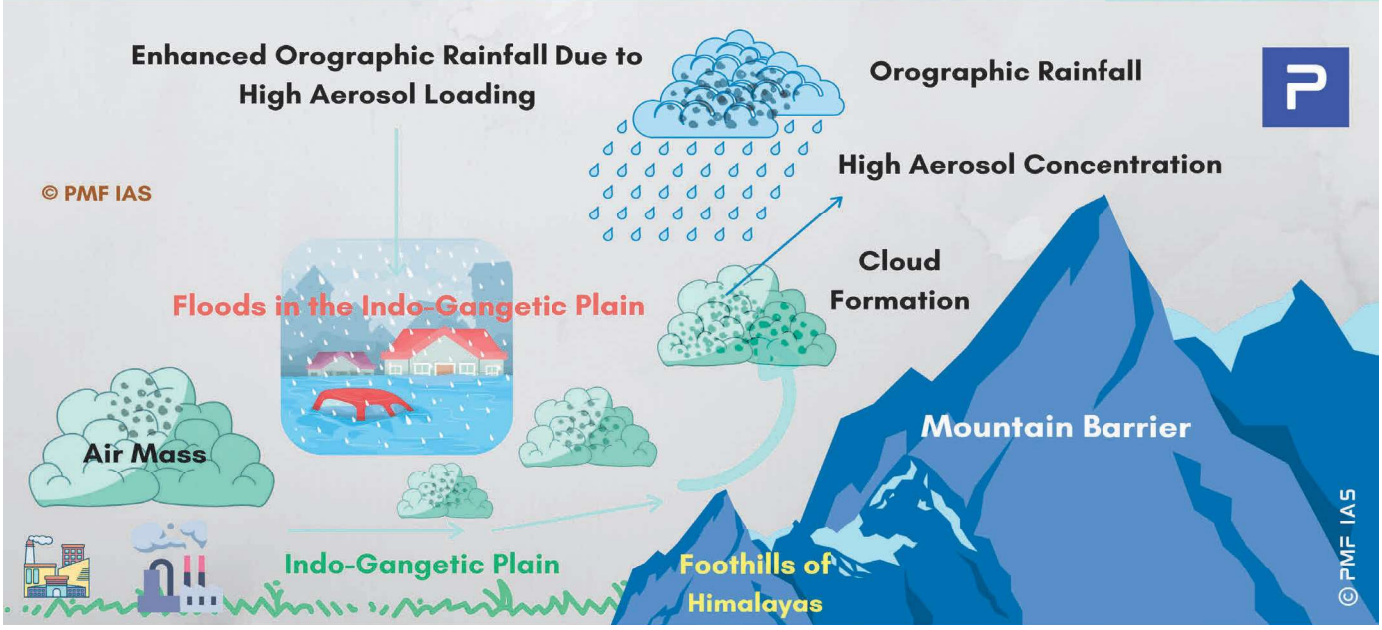
Modify Optical properties & Lifetime of Clouds

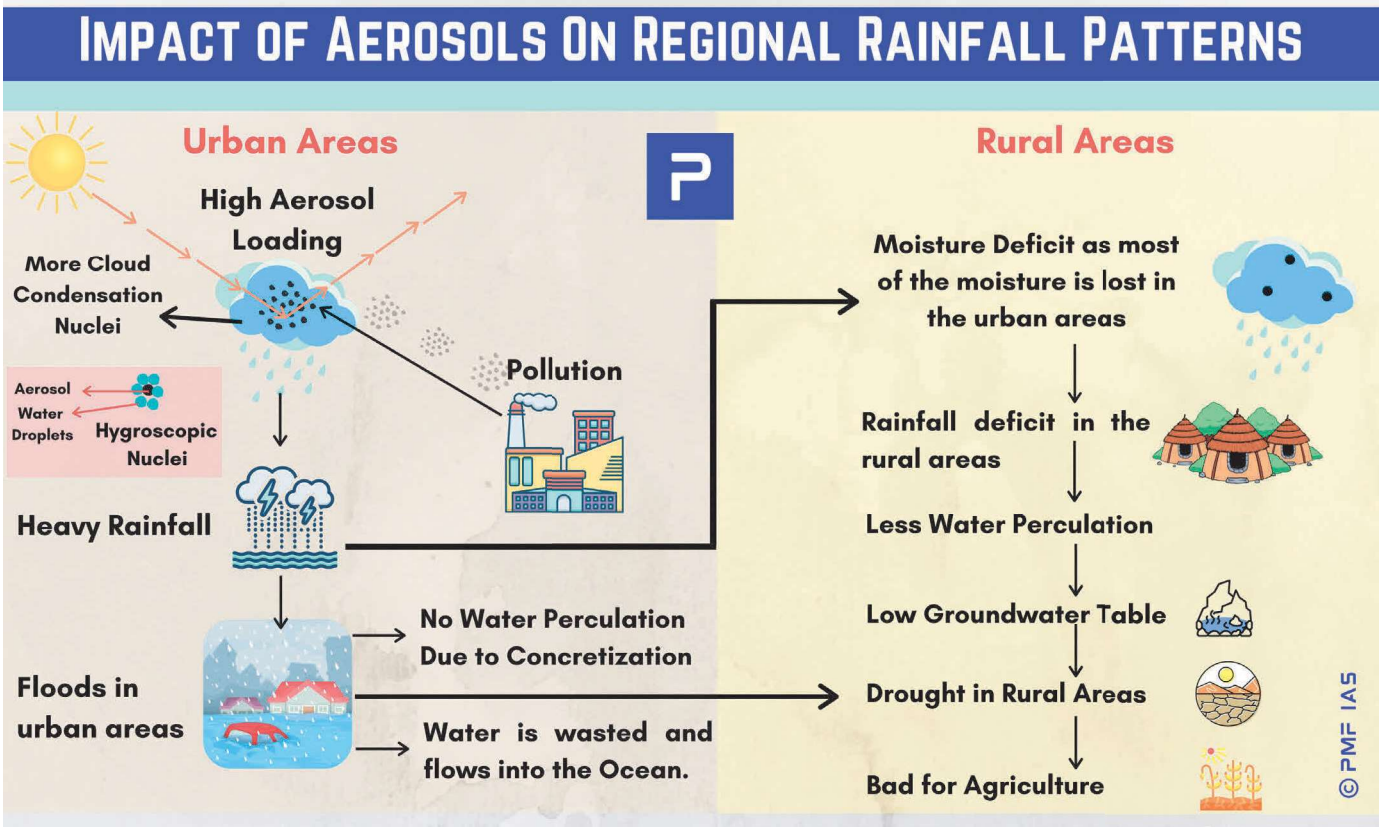
They have important impacts on air quality & human health.

# Impact of Aerosols on a Macroscale (Indian Monsoon)

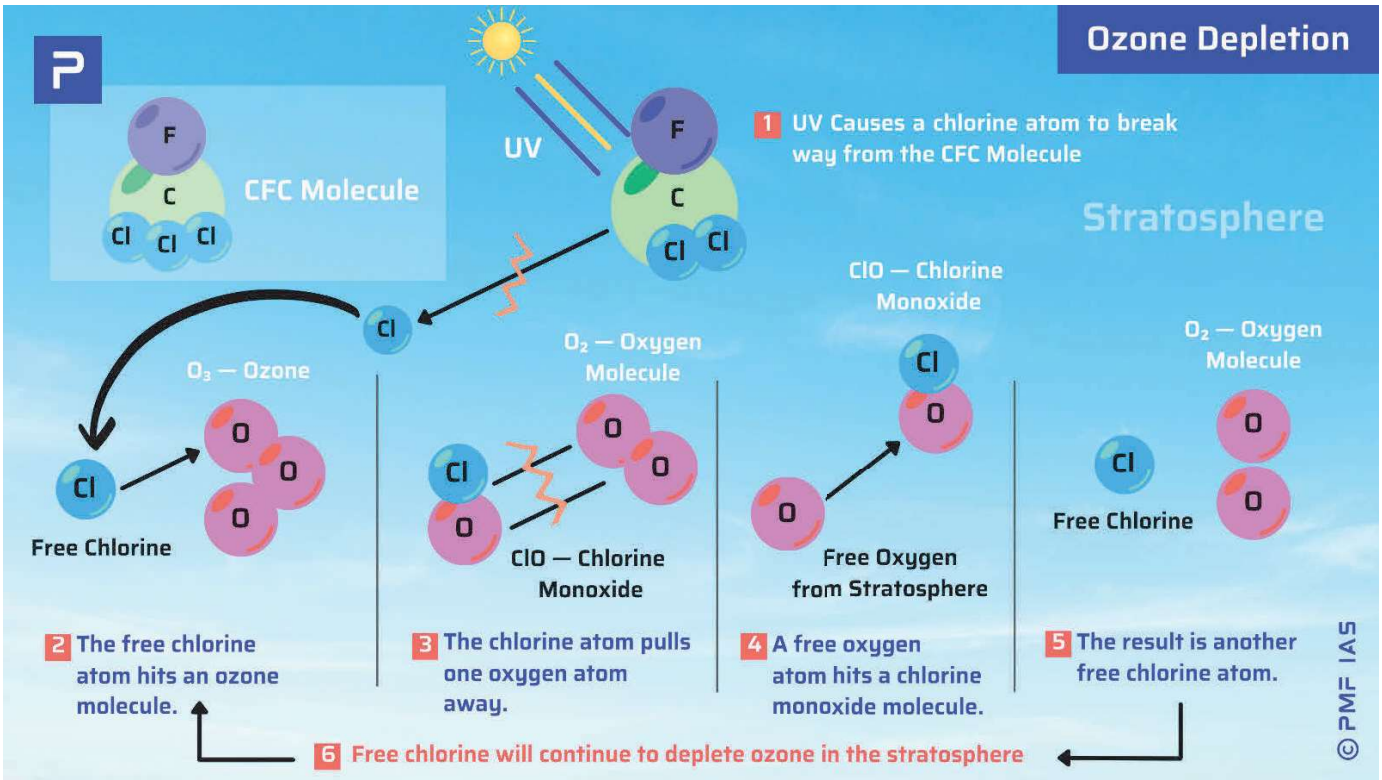



# Impact of Aerosols on Monsoons in the Himalayan Foothills





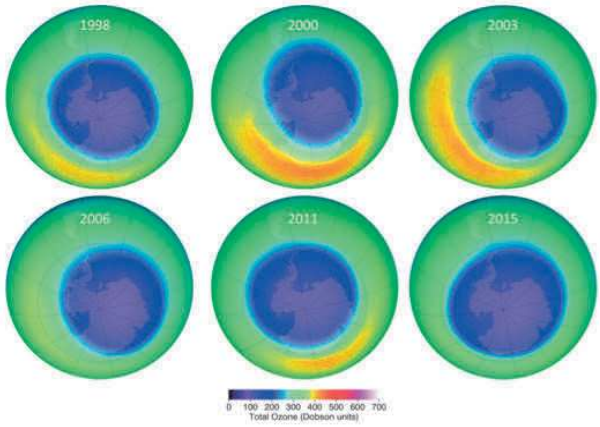

## Ozone Depletion




- There is a steady decline in the total ozone volume in **Earth's stratosphere**. A much more significant decrease in **stratospheric ozone** is observed around **Earth's polar regions**. The unique cocktail of the

powerful **polar vortex** and **low temperatures** generates **stratospheric clouds** that react with **CFCs** and other **ozone-depleting substances** and **destroy the Ozone layer** in the process.

- Ozone holes are most commonly found over the **Antarctic region (which experiences a strong polar vortex)**. They are comparatively **rare and small over the Arctic** (because the polar vortex here is comparatively weak and temperatures are relatively high).



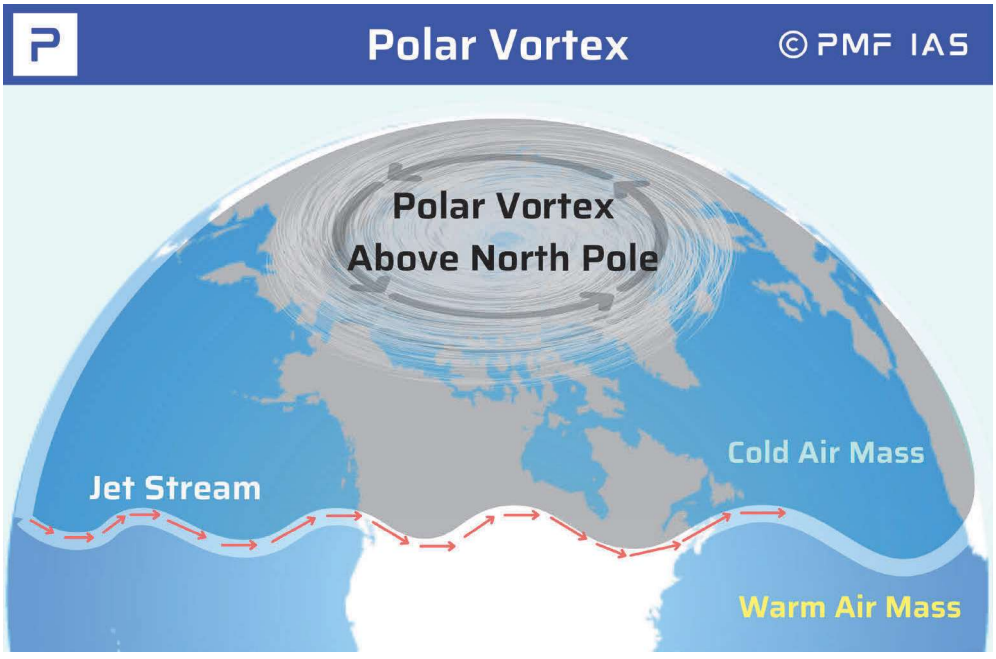

*Ozone Hole at the South Pole*

- Depletion of ozone is due to increased **halocarbons** in the atmosphere. **Halocarbons** are compounds in which the **hydrogen** of a hydrocarbon is replaced by **halogens** — a group of **reactive non-metallic elements** like **fluorine**, **chlorine**, **bromine**, **iodine**, etc.

## Halogen Atoms Like Chlorine Destroy Ozone

- **Photodissociation** (under the influence of sunlight) of **ozone-depleting substances (CFCs**, **HCFCs**, **carbon tetrachloride** and **trichloroethane**, **freons**, **halons)** like **halocarbon refrigerants**, **solvents**, **propellants**, and **foam-blowing agents** creates **free chlorine atoms** that destroy ozone.

## Polar Vortex Acts as a Transporter for Halogens

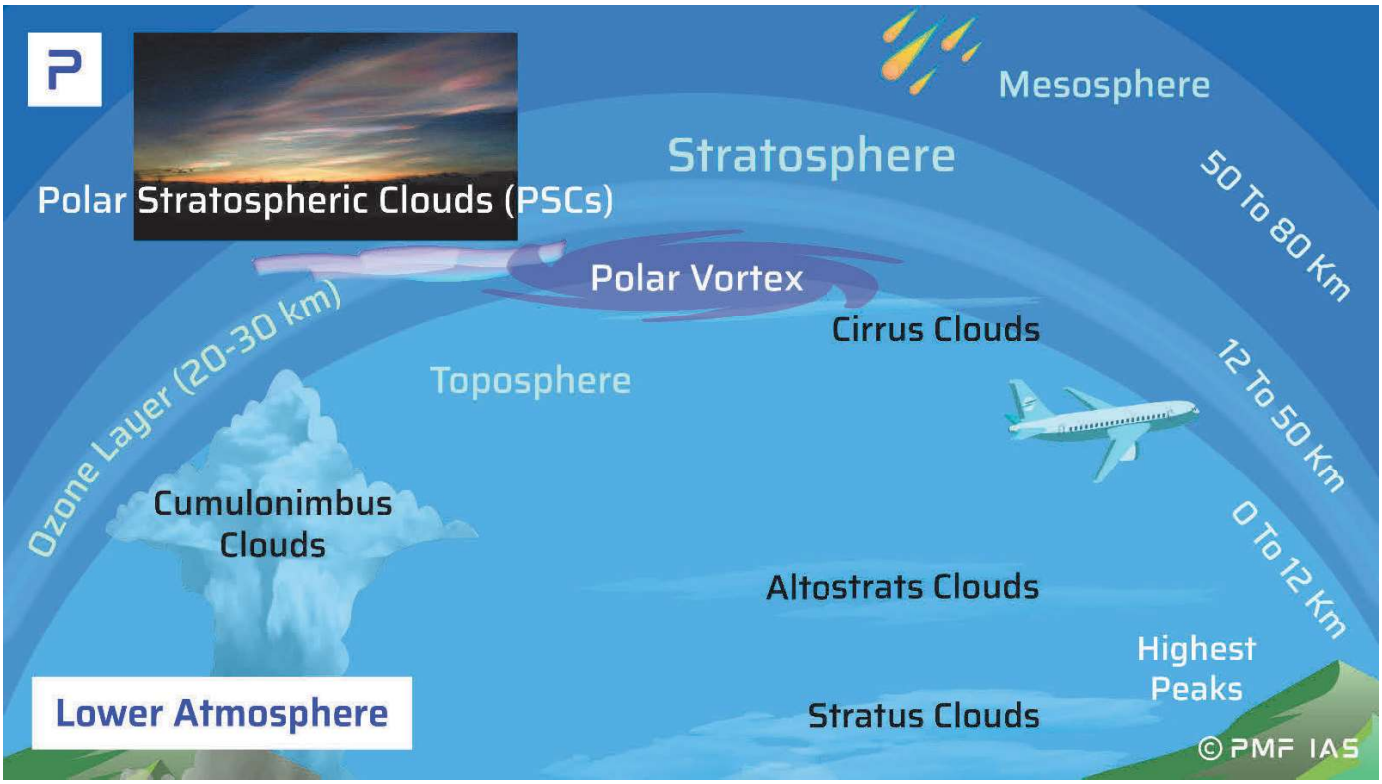


- Polar vortex (circumpolar vortex) is a **polar cyclone**. It gives rise to **Polar Stratospheric Clouds (PSCs)**.

> ⇨ *Polar cyclones occur in polar regions and can reach up to 2,000 km wide. They sometimes extend to the lower levels of the **stratosphere** (at the poles, the troposphere extends only up to 8-9 km).*

### Polar Stratospheric Clouds (PSCs)

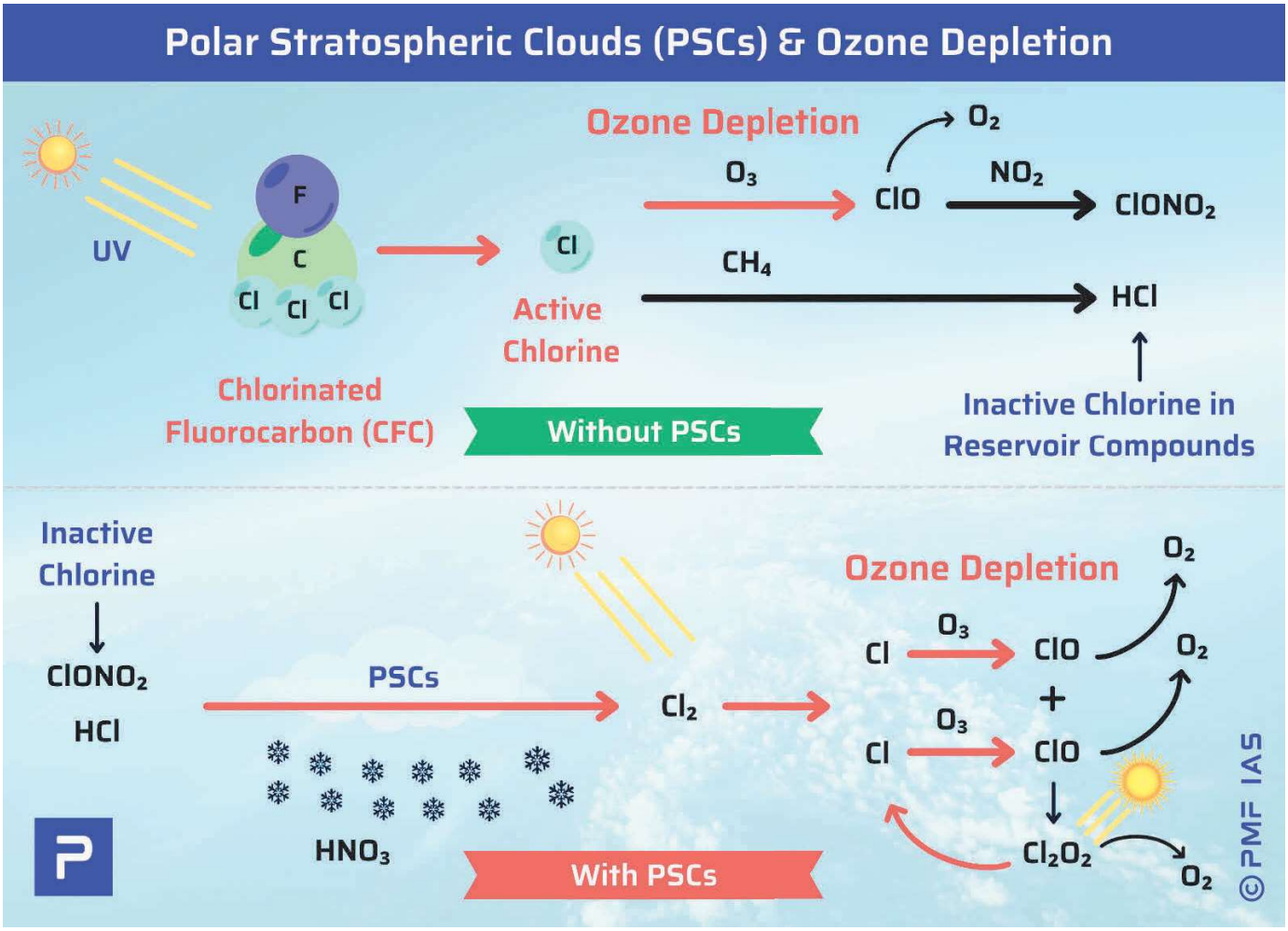
- **Polar Stratospheric Clouds (PSCs)** are **nacreous clouds** that extend from **12-22 km above the surface**. They are formed mainly during the **polar vortex event in winter**, **more intense at the south pole**.




- Nacreous clouds are **rare clouds** in the **frigid regions** of the **lower stratosphere**. They are mostly visible within two hours after sunset or before dawn. They are bright even after sunset and before dawn (because at those heights, **there is still sunlight**). They are seen mainly during winter at **high latitudes**.
- PSCs or nacreous clouds contain water, **nitric acid** and **sulfuric acid**. **Cl-catalysed ozone depletion is enhanced in the presence of polar stratospheric clouds**.
- **PSCs** convert **reservoir compounds** into **reactive free radicals (Cl** and **ClO)**, thereby significantly **increasing the reactive halogen radicals**. These **free radicals accelerate the depletion of ozone**. Thus, **polar vortexes**, **in the form of PSCs**, **accelerate ozone depletion**.

### Impact of Nanoparticles (NPs)

- The **hydroxyl radical (OH)** is the most important oxidant in the **troposphere** and **lower stratosphere**. **OH initiates the removal of stratospheric ozone-depleting compounds** such as **hydrochlorofluorocarbons (HCFCs)**. **NPs** being very reactive, **bind with OH** and ultimately result in its **reduction of OH radicals**, **maintaining the concentration of ozone-depleting substances**.




**[UPSC 2011-12] The formation of ozone hole in the Antarctic region has been a cause of concern. What could be the reason for ozone depletion at poles?**

a) Presence of prominent tropospheric turbulence; and inflow of chlorofluorocarbons
b) Presence of prominent polar front and stratospheric Clouds and inflow of chlorofluorocarbons
c) Absence of polar front and stratospheric clouds; and inflow of methane and chlorofluorocarbons
d) Increased temperature at polar region due to global warming

**Explanation**

- Ozonosphere lies **between 20 km and 55 km from the earth's surface** and spans the **stratosphere and lower mesosphere**. But the **highest concentration** occurs between **20 km and 30 km**. To destroy ozone, **ozone-depleting substances** (ODS) need to be **carried up to the lower levels of the stratosphere**.
- The only **weather phenomena** that can reach this level are **Polar Vortex and towering tropical cumulus clouds**. But **towering cumulus clouds do not occur at the poles**.

***Question: The formation of ozone hole in the Antarctic region has been a cause of concern. What could be the reason for ozone depletion at poles?***

- Presence of prominent tropospheric turbulence: they do not reach the stratosphere.

- Presence of a prominent polar front: essential to keep the polar vortex in its place. Polar vortex gives rise to stratospheric Clouds.
- Presence of **stratospheric Clouds**: they have the necessary ingredients (**nitric acid** and **sulfuric acid**) to amplify ozone depletion.
- Absence of polar front and stratospheric clouds: polar vortex slips into the temperate region.
- Inflow of methane: **methane ($CH_4$) is not in the list of ozone-depleting substances**. It does not contain a halogen like chlorine, bromine, fluorine, etc. But it reacts with halogens to create **reservoir compounds**.
- Increased temperature in the polar region due to global warming: this does not have any direct impact on ozone depletion at the poles.

### Tropical Ozone Hole

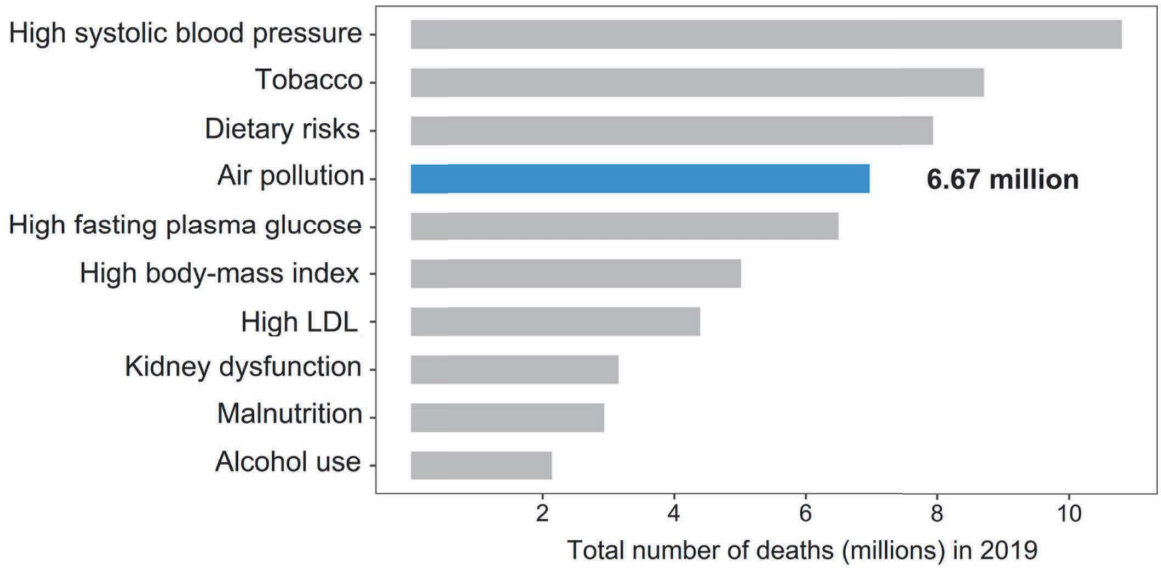
- Recently, a large, year-round ozone hole was discovered in the lower stratosphere **over the tropics**. It has been in the tropics since the 1980s but was discovered recently.
- The tropical Ozone Hole is an **all-season ozone hole** compared to the Antarctic Ozone Hole, which is predominantly **visible during springtime**. It is seven times **greater in area** than the Antarctic ozone hole and the depth of both is almost the same.

### Mesosphere's Role in Antarctic Ozone Depletion

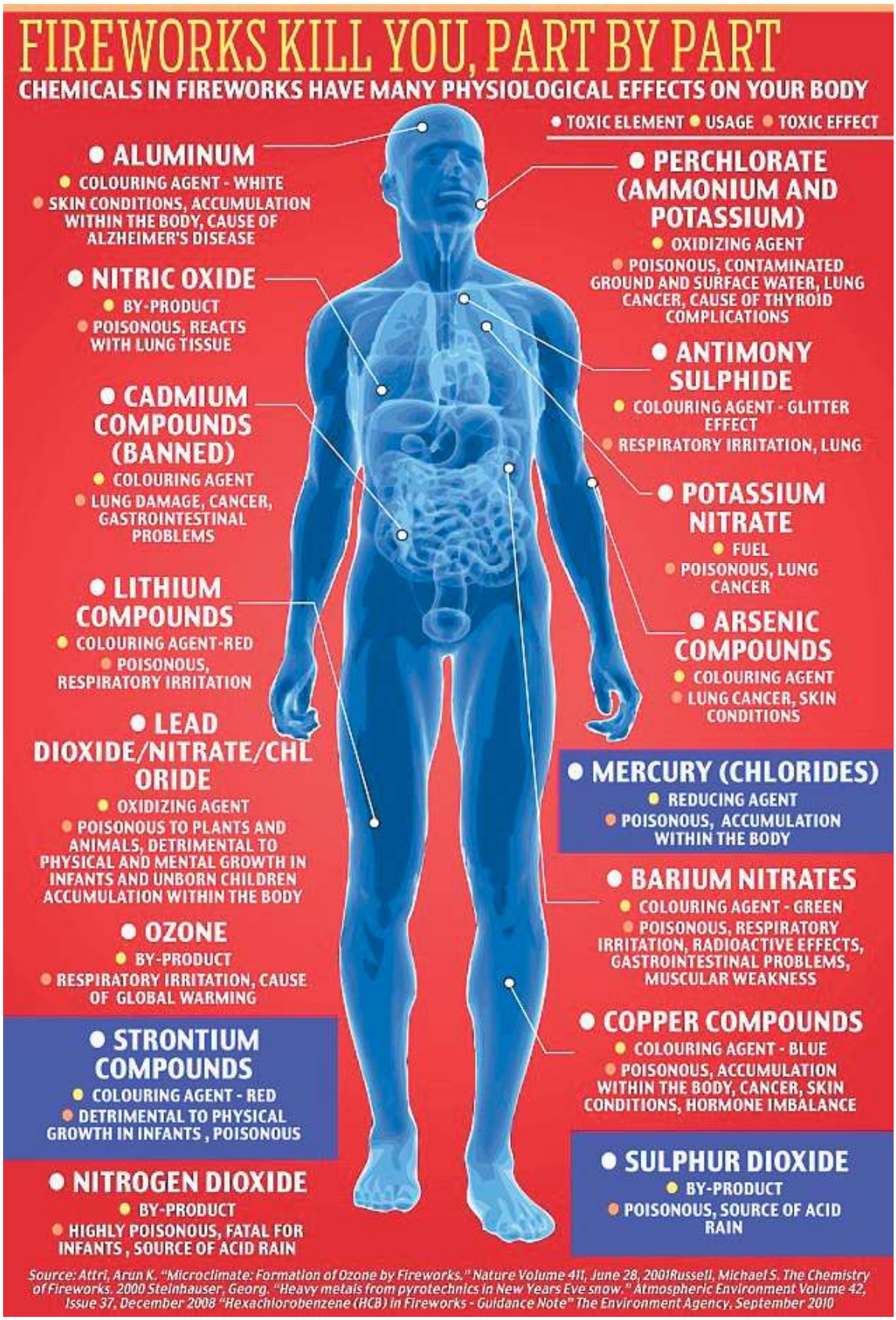
- Antarctic ozone hole sits within the **polar vortex**. Within this vortex, the Antarctic air from the **mesosphere** falls into the stratosphere bringing **nitrogen oxides (NOx)** in contact with stratospheric ozone. In the mesosphere, $NO_x$ is produced by the breakdown of **nitric acid ($HNO_3$)**. The NOx destroy ozone molecules.

## Effects on Health

### Air Pollution is the 4th Greatest Killer Worldwide




*Global ranking of risk factors*




- '**State of Global Air 2020**', released by the **Health Effects Institute** (an **independent** global health and air pollution research institute), showed that exposure to outdoor and indoor air pollution contributed to over **1.67 million annual deaths** (**55%** of these were due to **outdoor pollution**) in India in 2019.

- **India** had the **highest** population-weighed annual average exposure to **PM2.5**. It also had the **3rd highest** population-weighed annual average exposure to **Ozone**.
- Globally, **6.67 million deaths** in 2019 were attributable to air pollution (the **fourth major cause of all deaths**). **4.14 million** of these deaths were due to **outdoor PM2.5 exposure**, and the rest **2.31 million** deaths were due to **household air pollution**.

### Air Pollution and Occupational Health Hazards

- Substances such as **benzene**, **chromium**, **nitrosamines**, and **asbestos** may cause cancers of the lungs, bladder, skin, mesothelium, liver, etc.
- Occupational asthma is caused by exposure to organic dust, microorganisms, bacteria, fungi, moulds and several chemicals.
- **Silicosis**, first reported from Kolar gold mines in 1947, is a common disease among miners and pottery and ceramic industry workers.
- **Pneumoconiosis** and **byssinosis** are common among mica and textile industry workers, respectively.

#### Black lung disease

- Black lung disease is the common name for **pneumoconiosis or anthracosis**, a lung disease of older workers in the coal industry caused by inhalation over many years of small amounts of coal dust. The coal dust deposits make miners' lungs look black instead of a healthy pink.

## 13.2. Prevention and Control of Air Pollution

### Control of Industrial Pollution

- ✓ Industrial pollution can be significantly reduced by using cleaner fuels such as **liquefied natural gas (LNG)** in power plants, fertiliser plants, etc., employing environment-friendly industrial processes and installing devices like filters, **electrostatic precipitators**, **inertial collectors**, **scrubbers**, **gravel bed filters or dry scrubbers** which reduce the release of pollutants.

### Filters

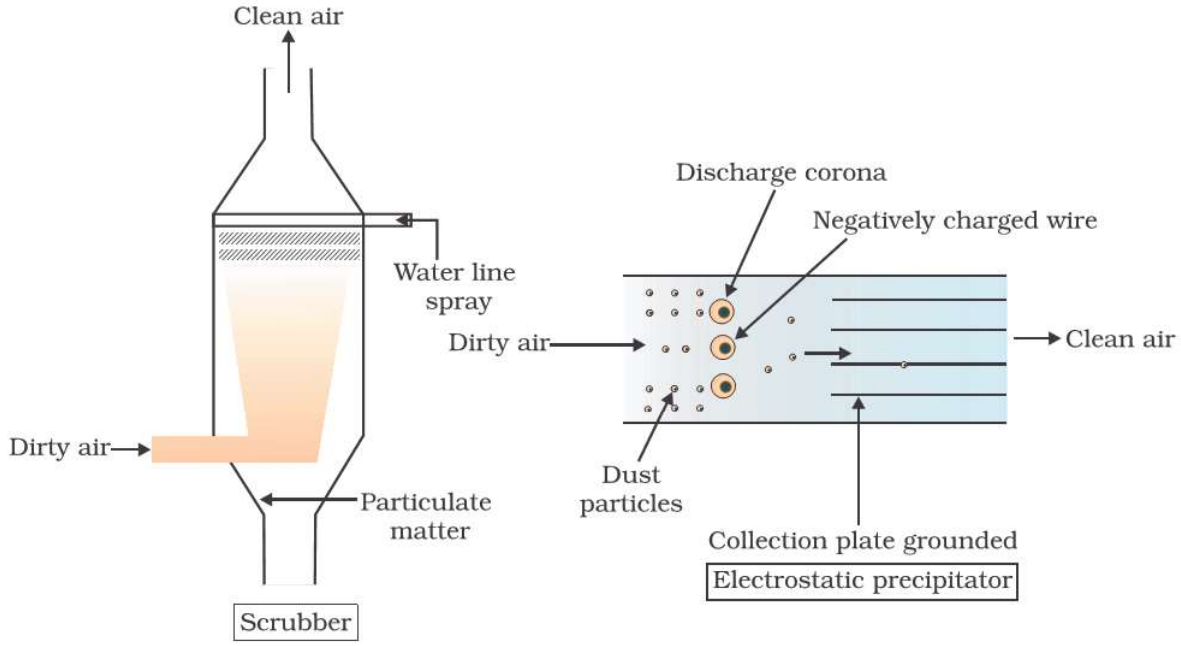
- Filters remove **particulate matter** from the gas stream. The most common filtration system is the Baghouse, which is made of cotton or synthetic fibres (for low temperatures) or glass cloth fabrics (for higher temperatures).

### Electrostatic Precipitators (ESP)

- Electrostatic precipitation can remove over **99% of particulate matter** present in the exhaust. They are used in **boilers and furnaces**, **thermal power plants**, **cement factories**, **steel plants**, etc.
- In electrostatic precipitation, emanating **dust is charged with ions**, and the **ionised particulate matter is collected at an oppositely charged surface**.

#### Working

- An electrostatic precipitator has electrode wires that are maintained at several thousand volts, which produce a **corona** that releases **electrons**. These **electrons attach to dust particles**, giving them a net negative charge. The collecting plates are grounded (relatively positive charge) and **attract the charged dust particles**. The air velocity between the plates must be low enough to allow the dust to fall. The particles are removed from the collection surface by occasional shaking or rapping.




## Inertial Collectors

- Inertia of SPM in gas is higher than its **solvent**. As inertia is a function of the mass of the particulate matter, the device collects heavier particles more efficiently (**centrifugation** is the technique). '**Cyclone**' is a common inertial collector used in gas cleaning plants.

## Scrubbers

- Scrubbers are **wet collectors**. They remove **aerosols** from a stream of gas either by collecting wet particles on a surface or the particles are wetted by a scrubbing liquid. The particles get trapped as they travel from the supporting gaseous medium across the interface to the liquid scrubbing medium (this is similar to mucus in trachea trapping dust). A scrubber can remove gases like **sulphur dioxide**.

## Catalytic Converter

- Catalytic converters, having **expensive metals**, **platinum-palladium** and **rhodium** as the catalysts, are fitted into **automobiles** to reduce the emission of poisonous gases. Motor vehicles equipped with catalytic converters should use **unleaded petrol** because the **lead in the petrol inactivates the catalyst**.

### Working

- As the exhaust passes through the catalytic converter, **unburnt hydrocarbons** are converted into **carbon dioxide** and **water**, and **carbon monoxide** and **nitric oxide** are changed to **carbon dioxide** and **nitrogen gas**, respectively.

## Pollution Index to Control Industrial Pollution

- Based on a study jointly carried out by the Central Pollution Control Board (**CPCB**) and State Pollution Control Board (**SPCB**) in 2009-10, **industrial clusters (sectors)** were notified as **Polluted Industrial Areas (PIAs)**.
- MoEF has developed the criteria for the categorisation of industrial sectors based on the **Pollution Index (PI)**, which is a function of the emissions (**air pollutants**), effluents (**water pollutants**), hazardous wastes generated and **consumption of resources**. The PI of any industrial sector is a number from **0 to 100** and the increasing value of PI denotes the increasing degree of pollution load from the industrial sector.
- The criteria of categorisation will prompt industrial sectors to adopt **cleaner technologies**. It also facilitates self-assessment by industries. It enables authorities to take appropriate action when the need arises. For example, **NGT** can order certain industries to be closed when air pollution reaches a particular level.

### Categories of Industrial Sectors Based on Pollution Index

- ✓ **Red category (critically polluted):** Industrial Sectors with a Pollution Index score of 60+. **(60 industries)**
- ✓ **Orange category (severely polluted):** Pollution Index score of 41 to 59. **(83 industries)**
- ✓ **Green category (other polluted):** Pollution Index score of 21 to 40. **(63 industries)**
- ✓ **White category (practically non-polluting):** Pollution Index score including and up to 20. **(36 industries)**
- ⇨ The newly introduced **White category industrial sectors will not require Environmental Clearance (EC) and Consent to Operate**. They have to just **intimate SPCB and CPCB**.
- ⇨ **No Red category of industries shall normally be permitted in the ecologically fragile/protected area**.

#### Industries falling in various categories

- **Red category: Cement**, **Petrochemicals**, **pharmaceuticals**, **sugar**, **paper and pulp**, **nuclear power plants**, **organic chemicals**, **fertilisers**, **firecrackers**, **etc**.
- **Orange category: Coal washeries**, **glass**, **paints**, **stone crushers**, **aluminium**, and **copper extraction from scrap**, **etc**.
- **Green category: aluminium utensils**, **steel furniture**, **soap manufacturing**, **tea processing**, **etc**.
- **White category: air cooler or air conditioning units**, **chalk factories**, **biscuit tray units**, **etc**.

## Coal Gasification

- Gasification is a technological process that can convert any **carbonaceous (carbon-based)** raw material such as coal into fuel gas, also known as **synthesis/synthetic gas (syngas)** or **producer gas — a mixture of Carbon Monoxide** and **Hydrogen**. After cleaning, syngas can be used to produce **synthetic natural gas (SNG – methane ($CH_4$))** or liquid biofuel such as **synthetic diesel**.

- Gasification occurs in a gasifier, generally a **high-temperature (>700 °C)/pressure** vessel where **oxygen** and **steam** are directly contacted with coal, causing a series of thermochemical reactions **(without combustion)** that convert the feed to **syngas** and **ash/slag**.
- Coal gasification provides one of the cleanest ways to convert coal into electricity, **hydrogen**, and other valuable energy products. It thus **reduces carbon monoxide**, **carbon dioxide** and **sulphur dioxide emissions**. India aims to achieve a **100 MT coal gasification target by 2030**.
- Similarly, the **gasification of waste reduces** the need for landfill space, **decreases methane emissions** and reduces the use of fossil fuels.

## Measures to Control Vehicular Pollution in India

✓ Standards have been set for the **durability of catalytic converters** that reduce vehicular emissions.

✓ In cities like Delhi, vehicles need to obtain **Pollution Under Control (PUC) certificate** at regular intervals. This ensures that levels of pollutants emitted from vehicles are not beyond the prescribed legal limits.

✓ The fuel quality has improved significantly from BS-IV to BS-VI norms by reducing the permissible **Sulphur content** from **50 Parts Per Million (ppm) in BS-IV** to **a maximum of 10 ppm in BS-VI-compliant fuel**.

✓ Earlier **lead** in the form of **tetraethyl lead** was added in the petrol to **raise octane level** for the **smooth running** of engines. The addition of **lead in petrol** has been **banned** to prevent the emission of lead particles.

✓ Usage of alternative fuels like **CNG in public transport vehicles is made mandatory** in cities like Delhi. All the buses of Delhi are converted to run on CNG by the end of 2002.

⇨ *CNG burns most efficiently, unlike petrol or diesel, in automobiles and very little of it is left unburnt. Moreover, **CNG is cheaper than petrol or diesel**, cannot be siphoned off by thieves and **cannot be adulterated like petrol or diesel**. The main problem with switching over to CNG is the **difficulty of laying down pipelines** to deliver CNG through distribution points/pumps and ensuring uninterrupted supply.*

✓ As per **Vehicle Scrappage Policy 2021**, all the central and state government vehicles that have completed **15 years** will be **scrapped from April 1, 2023**. The policy aims to **de-register private cars over 20 years old** and **commercial vehicles over 15 years old**.

### Bharat Stage (BS) norms

- The BS norms are instituted by GOI to regulate the emission of **air pollutants from motor vehicles**. The norms were introduced in **2000**. The norms are meant to be adopted by using appropriate fuel and technology. As the stage goes up, the control of emissions becomes stricter.

✓ The norms limit the release of air pollutants such as **nitrogen oxides**, **carbon monoxide**, **hydrocarbons**, **particulate matter (PM)** and **sulphur oxides** from vehicles using **internal combustion engines**.

#### BS VI from 2020

- From April **2017**, BS IV norms were to be applicable nationwide. However the SC had ordered a **ban on the sale of Bharat Stage IV vehicles from April 1, 2020**. The central government had announced the **April 1, 2020, deadline for adopting Bharat Stage VI** emission norms by manufactures. However, existing vehicles (BS III, BS IV) will continue to run beyond the cut-off date of 01/04/2020.
- BS IV and BS VI norms are based on similar norms in Europe called Euro 4 and Euro 6. As decided initially, BS V would have been rolled out by 2021 and BS VI in 2024, but leapfrog to **BS VI norms by 2020** (**skipping BS V**) had to be done because of the **carbon footprint obligations**.

***India's UNFCCC commitments (INDCs)***

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

## Advantages of BS-VI vehicles and fuel

- ✓ **Particulate Matter** in **diesel cars** is said to **come down by 80 per cent**. **Nitrogen oxides** from **diesel cars** by **70 per cent** and **petrol cars** by **25 per cent**.
- ✓ Reduction in sulphur makes it possible to equip vehicles with **better** catalytic converters.
- ✓ BS VI makes **onboard diagnostics mandatory** for all vehicles. OBD device informs the vehicle owner or the repair technician how efficient the systems in the vehicle are.
- ✓ **RDE (Real Driving Emission)** will be introduced for the first time, which will measure the emission in real-world conditions and not just under test conditions.
- ✓ Bharat Stage VI norms will also change the way particulate matter is measured. It will now be measured by **number standard** instead of **mass standard**.

### Impact

- ➢ Compliance required a higher investment in technology to make new vehicles.
- ➢ Upgrading vehicles in stock and built-up infrastructure was an additional burden for the manufacturers.
- ➢ BS VI-compliant vehicles and fuel became expensive.

## Electric Mobility

- In 2017, the GOI declared that it wanted India to go **fully electric by 2030**. This aim has not yet turned into a commitment due to the lack of infrastructure and the financial risks faced by the automobile industry in making the transition to EVs.
- After a series of flip-flops over policy on EVs, GOI is pushing aggressively for a switchover from fossil fuel. For the time being, the government's focus is on two- and three-wheelers. NITI Aayog has **proposed** to **ban all IC (internal combustion) engine-powered two-wheelers** and **three-wheelers** in India starting in **2025 for two-wheelers** and in **2023 for three-wheelers**.

### Phase II of the Faster Adoption and Manufacturing of Electric (& Hybrid) Vehicles in India (FAME India) Scheme

- For the promotion of **EVs and hybrid vehicles** in the country, the **Department of Heavy Industry** has notified **Phase II of the FAME India Scheme**. The scheme places much required thrust on the **localisation of EV parts**.
- The policy aims to create a market for **one million e-2Ws** and **five lakh e-3Ws** in the next three years. The scheme offers an outlay of **₹10,000 crore** to give a fillip to EVs and to set up charging stations.
- The **Ministry of Power** has already issued guidelines and standards, setting technical parameters for public charging stations that can enable normal and fast charging.

### EV Charging Guidelines to Encourage EV Adoption

- The Minister of Power has approved amendments to the EV Charging Guidelines and Specifications to boost EVs.
- It has been envisaged that in the first phase (i.e. 1-3 years), all **mega-cities** with a population of 4 million plus and **all existing highways connected to/connecting these mega-cities** will be covered. In the second phase (3-5 years), **big cities** like State Capitals and UT headquarters may be covered.
- **The Bureau of Energy Efficiency (BEE)**, a **statutory body under the Ministry of Power (not MoEFCC)** has been nominated as the **Central Nodal Agency**.

***Electric Vehicle Charging Guidelines and Specifications:***

- At least one Charging Station in a grid of 3 x 3 Km in cities.
- A charging station at every 25 km and a fast charging station at every 100 km on both sides of highways.
- Private charging at residences/offices managed by DISCOMs.
- Public Charging Stations (PCS) should be a **de-licensed** activity (anyone can set up a PCS).
- Freedom to Public Charging Stations to install the chargers as per the market requirement.

### Tax incentives

- The Finance Minister has announced an additional income **tax exemption of ₹1.5 lakh** for purchasers of electric vehicles in Budget 2019-2020.
- The GST Council decided to reduce the GST rate on electric vehicles from **12% to 5%** and chargers or charge stations from 18% to 5% to boost the EV market.

### Scepticism Surrounding Adaptation of Electronic Mobility

- The long-term environmental gains of a global transition to EVs remain unclear.
- India's automobile market is the fourth largest in the world. Installing charging facilities to serve such a vast market will prove much harder than in Western countries.
- **China** has a strategic advantage in a mass switchover, given its **easy access to lithium and cobalt** and **low-cost**, **high-output automobile batteries**. India, on the other hand, will have to **depend entirely on imports**.

### Challenges for the automobile industry

- Automotive sales have plummeted in recent times due to GST. The situation continues to be made worse by increasing insurance costs, **high taxes (28% GST on bikes up to 350cc and cars)**, high prices of raw materials and volatile fuel prices.
- The industry has already invested heavily in upgrading to BS-VI (Euro VI) from **BS-IV**. It has a heavily built-up infrastructure and human resources for the production and servicing of IC engine-based vehicles.

### Will electric vehicles reduce carbon emissions?

- As 55% of electricity generation in India is **primarily using coal**, the **net reduction in carbon emission will not be much**, even if there is large-scale adoption of EVs in India.
- However, electric vehicles will **help reduce pollution in cities** (14 of 20 most polluted cities in terms of harmful particulates (PM 2.5) are in India).

## Green Tax on Old Vehicles

- Recently, the Government proposed a **'green tax' for old petrol** and **diesel vehicles**. Based on the principle of **"polluters must pay"**, this charge would be levied when commercial vehicles go to obtain a **fresh fitness certificate** and private vehicles seek **renewal of registration**.
- **State governments** would be allowed to levy this tax over and above the regular road taxes. Currently, similar taxes are levied in Andhra Pradesh, Maharashtra Karnataka, Telangana, UP and Jharkhand.
- Revenue collected from the Green Tax is to be kept in a **separate account** and used to tackle pollution and for States to set up state-of-the-art emission monitoring facilities.

### Proposed tax structure

- ✓ **Transport vehicles older than 8 years** could be charged Green Tax at **10-25% of road tax**.
- ✓ **Personal vehicles** are to be charged Green Tax after **15 years**.
- ✓ **Public transport** vehicles, such as city buses, are to be charged a **lower Green tax**.
- ✓ **Higher Green tax (50% of Road Tax) for vehicles being registered in highly polluted cities**.
- ✓ **Differential tax**, depending on fuel (petrol/diesel) and type of vehicle.
- **Vehicles used for farming** and **vehicles running on clean fuel** — CNG, LPG, ethanol and strong hybrid — **would be exempted**.

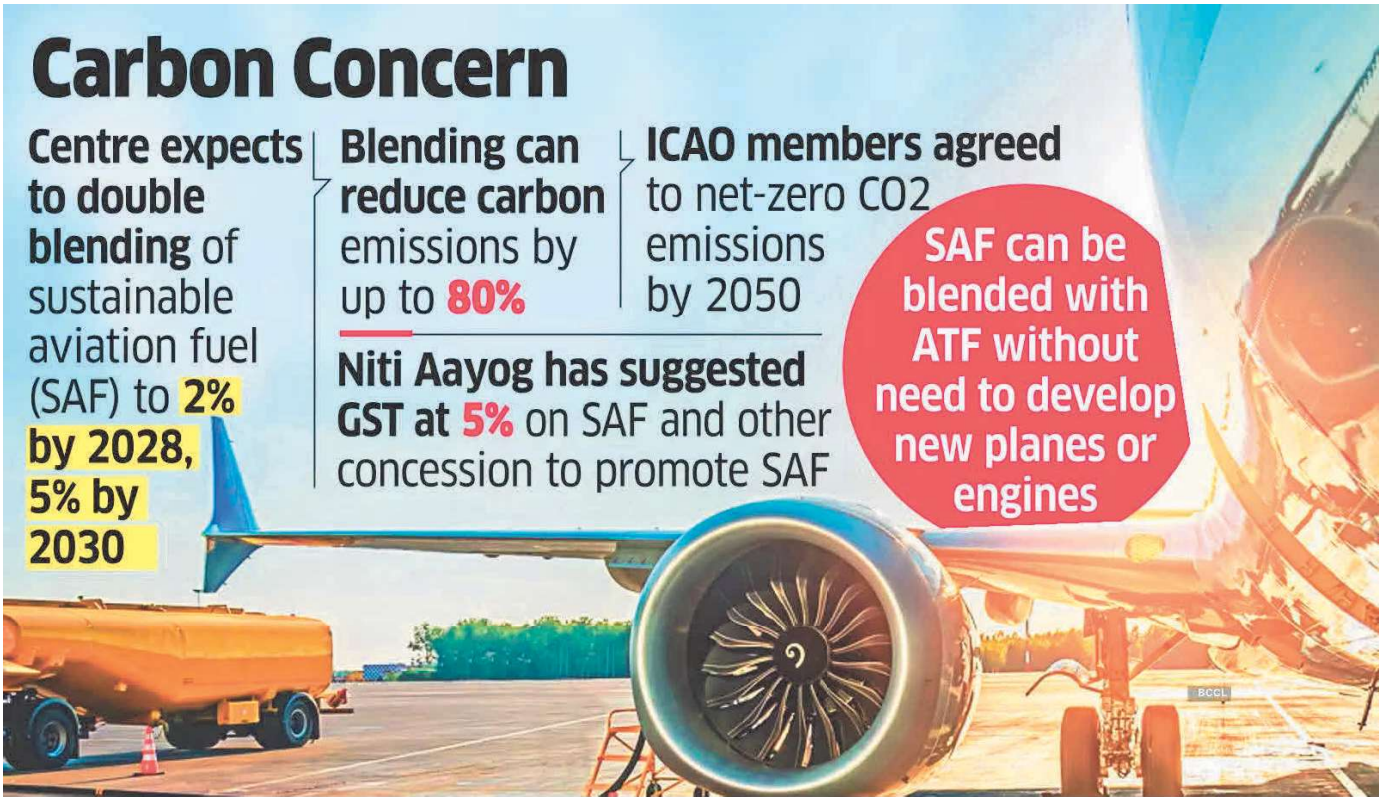
### Polluters Pay Principle

- The **'polluter pays' principle** is the commonly accepted practice that **those who produce pollution should bear the costs** of managing it to prevent damage to human health or the environment.
- For instance, a factory that produces a potentially poisonous substance as a by-product of its activities is usually held responsible for its safe disposal.
- When the pollution cost from the release of GHGs is not imposed on emitters, these costs are thus **'externalised' to society**, representing '**market failure**'. Society bears these costs as GHGs are emitted into the atmosphere, which is described as a '**global commons**' as everyone shares and has the right to use.

- The **polluter pays principle** is part of a set of broader principles to guide sustainable development worldwide (formally known as the **1992 Rio Declaration**).

## Sustainable Aviation Fuel (SAF)

- GoI has set an indicative target of **1%** for blending **Sustainable Aviation Fuel (SAF)** with conventional jet fuel for all international flights by **2027**. Also known as **Bio-Jet Fuel**, Sustainable Aviation Fuel is a carbon-reduction solution that is available for use in aircraft and helicopters.
- Unlike traditional fuels, it is **produced from renewable sources** such as agricultural waste, municipal solid waste, and agroforestry residues. It can also be produced artificially using a method that collects carbon out of the air.




## National Clean Air Program (NCAP)

- GOI launched NCAP in 2019 to **reduce pollution levels (PM2.5 and PM10) by 40% by 2024 in cities**, with **2017 as the base year** for comparison. In 2022, GOI set a new target of **40% by 2026**. (Acceptable annual standards for **PM 2.5 is 40** µg/$m^3$and **PM 10 is 60** µg/$m^3$)
- NCAP is the **first national-level strategy to tackle the air pollution problem** across the country comprehensively with a **time-bound reduction target**. It will be a **mid-term**, **five-year action plan**, with **2019 as the first year**. It takes inspiration from Beijing's success in reducing PM2.5 by 33.3 per cent in five years.
- The NCAP is working on expanding the **national air quality monitoring network**, building capacity for air pollution management, and **strengthening public awareness** about the dangers of air pollution. It covers **132 non-attainment cities** (cities that have fallen short of the **National Ambient Air Quality Standards** for over five years), which were identified by the **Central Pollution Control Board (CPCB)**.

- "**PRANA**," the Portal for Regulation of Air Pollution in Non-Attainment Cities, is a portal for monitoring the implementation of NCAP.

### NGT has Criticised NCAP Plan

- The NCAP plan includes 131 non-attainment cities across 23 states and UTs, which the **Central Pollution Control Board (CPCB)** identified based on their ambient air quality data between 2011 and 2015. **Non-attainment cities** cover only cities where **standards were not consecutively met for five years**.
- NGT said the MoEF's plan was against Article 21. The **Right to Clean Air** stood recognised as part of the **Right to Life and** failure to address air pollution was a **denial of the Right to Life**. It also said the enforcement of the 'Sustainable Development' principle and '**Public Trust Doctrine**' required stern measures to be adopted.
- Under the **NCAP**, the target was to **achieve norms in 10 years** and reduce load to 35% in the first three years, with a further reduction of pollution later. This meant that **pollution would remain unaddressed for 10 years**, which was too long a period of tolerating violations when clean air was Right to Life.

#### Other Criticism of NCAP

- The NCAP is **only a cooperative and participatory initiative**. The Central Pollution Control Board (**CPCB**) will execute the programme in consonance with the Air (Prevention and Control of Pollution) Act, 1986. It is not clear what type of pollutants or all pollutants would be reduced. It will **not be notified under any Act** to create a firm mandate with a strong legal backup.
- 11$^{th}$ and 12$^{th}$ Five-Year Plans had taken on board the NCAP strategy of the **National Clean Air Action Plan** for all major cities to meet the National Ambient Air Quality Standards. But that remained a non-starter as it was not backed by a clear legal mandate and was underfunded.

***[UPSC 2020] What are the key features of the National Clean Air Programme (NCAP) initiated by the Government of India? (250 words).***

## National Air Quality Monitoring Programme

- The Central Pollution Control Board (CPCB) has been executing a nationwide ambient air quality monitoring programme known as the **National Air Quality Monitoring Programme (NAMP)**. The network consists of 804 operating stations covering 344 cities/towns in 28 states and 6 UTs of the country.
- NAMP is undertaken to determine the **status and trends of ambient air quality**, ascertain the compliance of **NAAQS**, **identify non-attainment cities**, understand the natural process of cleaning the atmosphere, and undertake preventive and corrective measures.
- Under NAMP, four air pollutants viz., **Sulphur Dioxide (**$SO_2$**)**, **Oxides of Nitrogen (**$NO_2$**)**, **Respirable Suspended Particulate Matter (RSPM / PM10)** and **Fine Particulate Matter (PM2.5)** have been identified for regular monitoring at all the locations. The monitoring of wind speed and wind direction, relative humidity (RH) and temperature were also **integrated** with the monitoring of air quality.

## National Ambient Air Quality Standards (NAAQS)

- NAAQS is developed by the **Central Pollution Control Board (CPCB)**. They are applicable all over the country. The CPCB has been conferred this power by the Air (Prevention and Control of Pollution) Act, 1981.

| National Ambient Air Quality Standards, as of 2009 | | | |
|---|---|---|---|
| **Pollutants (12)** | **Time Weighted Average** | **Concentration in Ambient Air** | |
| | | **Industrial, Residential, Rural and Other Area** | **Ecologically Sensitive Area (notified by GOI)** |
| **$SO_2$**, µg/$m^3$ | Annual | 50 | 20 |
| | 24 hours | 80 | 80 |
| **$NO_2$**, µg/$m^3$ | Annual | 40 | 30 |
| | 24 hours | 80 | 80 |
| **$PM_{10}$**, µg/$m^3$ | Annual | 60 | 60 |
| | 24 hours | 100 | 100 |
| **$PM_{2.5}$**, µg/$m^3$ | Annual | 40 | 40 |
| | 24 hours | 60 | 60 |
| **$O_3$**, µg/$m^3$ | 8 hours | 100 | 100 |
| | 1 hour | 180 | 180 |
| **Lead (Pb)**, µg/$m^3$ | Annual | 0.50 | 0.50 |
| | 24 hours | 1 | 1 |
| **CO**, mg/$m^3$ | 8 hours | 2 | 2 |
| | 1 hour | 4 | 4 |
| **Ammonia ($NH_3$)**, µg/$m^3$ | Annual | 100 | 100 |
| | 24 hours | 400 | 400 |
| **Benzene**, µg/$m^3$ | Annual | 5 | 5 |
| **Benzopyrene**, µg/$m^3$ | Annual | 1 | 1 |
| **Arsenic (As)**, ng/$m^3$ | Annual | 6 | 6 |
| **Nickel (Ni)**, ng/$m^3$ | Annual | 20 | 20 |

## 2021 WHO Air Quality Guidelines (AQGs)

- **WHO** has released an **updated version** of the **Global Air Quality Guidelines (AQGs)**. The revised guidelines consider how air pollution damages human health at even lower concentrations than previously thought.

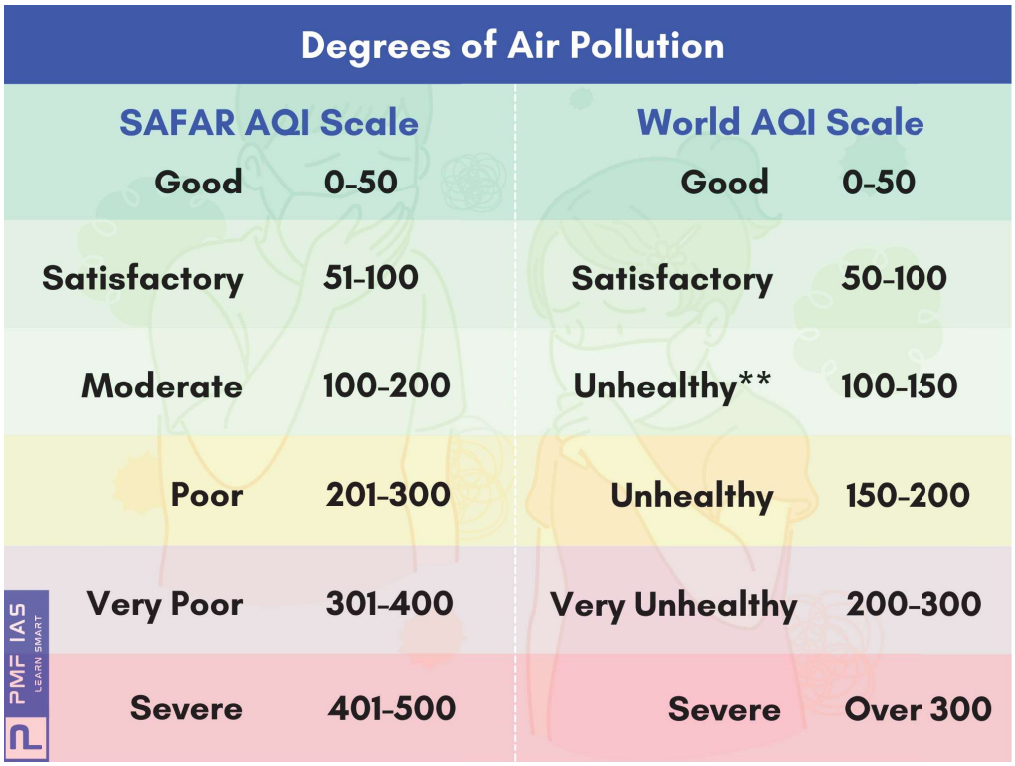
| Pollutants (6) | Averaging Time | 2005 | 2021 AQGs |
|---|---|---|---|
| **PM2.5**, µg/$m^3$ | Annual | 10 | 5 |
| | 24-hour mean | 25 | 15 |
| **PM10**, µg/$m^3$ | Annual | 20 | 15 |
| | 24-hour mean | 50 | 45 |
| **$O_3$**, µg/$m^3$ | Peak season | - | 60 |

| | | | |
|---|---|---|---|
| | 8-hour mean | 100 | 100 |
| $NO_2$, µg/$m^3$ | Annual | 40 | 10 |
| | 24-hour mean | | 25 |
| $SO_2$, µg/$m^3$ | 24-hour mean | 20 | 40 |
| CO, µg/$m^3$ | 24-hour mean | - | 4 |

- The new air quality guidelines mean that **most of India would be considered a polluted zone** for most of the year. WHO's guidelines are **not binding** and don't immediately impact India as the **NAAQS don't meet the WHO's existing standards**.

## SAFAR System for Monitoring Air Pollutants

- The **System of Air Quality and Weather Forecasting and Research (SAFAR)** is a national initiative introduced by the **Ministry of Earth Sciences (MoES) (not MoEF)**. It is an integral part of **India's first Air Quality Early Warning System** operational in Delhi.
- SAFAR will measure the air quality of a **metropolitan city**. It also monitors **all weather parameters** like temperature, rainfall, humidity, wind speed, and wind direction, **UV radiation**, and solar radiation. The network has multiple air quality monitoring stations in each city, equipped with real-time, continuous monitors for various pollutants.




- The system was indigenously developed by the **Indian Institute of Tropical Meteorology (IITM), Pune** and operationalised by the **India Meteorological Department (IMD)**. It has a giant colour LED display that gives out real-time air quality indexes on a 24x7 basis with colour coding (along with a 72-hour advance forecast). The ultimate objective of the project is to **increase awareness** among the public regarding the air quality in their city.
- Pollutants monitored under the SAFAR System include:

1. **PM2.5**,
2. **PM10**,
3. **Ozone**,
4. **Carbon Monoxide (CO)**,
5. **Nitrogen Oxides ($NO_x$)**,
6. **Sulphur Dioxide ($SO_2$)**,
7. **Benzene** (found in **crude oil**. It is used to make **plastics**, **resins**, **synthetic fibres**, **rubber lubricants**, etc. As a **VOC**, **benzene** reacts with other air pollutants to form **ground-level ozone**, which can damage crops (in the form of **smog**) and materials),
8. **Toluene** (**methylbenzene** — used in **paint thinners and** as an **octane booster in gasoline engines**),
9. **Xylene** (**dimethylbenzene** — used as a **solvent in printing**, **rubber**, and **leather industry**) and
10. **Mercury**

## National Air Quality Index (AQI)

- AQI was launched by MoEF in April 2015 under **'Swachh Bharat'**. It helps the citizens to judge the air quality within their vicinity. There are six AQI categories, namely Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe. The AQI will consider **eight pollutants** (**PM10**, **PM2.5**, **$NO_2$**, **$SO_2$**, **CO**, **$O_3$**, **$NH_3$**, and **Pb**).

**[UPSC 2016] In the cities of India, which among the following atmospheric gases are normally considered in calculating the value of Air Quality Index? (2016)**

1) Carbon dioxide
2) Carbon monoxide
3) Nitrogen dioxide
4) Sulphur dioxide
5) Methane

***Select the correct answer using the code given below.***

a) 1, 2 and 3 only
b) 2, 3 and 4 only
c) 1, 4 and 5 only
d) 1, 2, 3, 4 and 5

***Answer: b) 2, 3 and 4 only***

**[UPSC 2022] In the context of WHO Air Quality Guidelines, consider the following statements:**

1. The 24-hr mean of PM2.5 should not exceed 15 µg/$m^3$ and annual mean of PM2.5 should not exceed 5µg/$m^3$.
2. In a year, the highest levels of ozone pollution occur during the periods of inclement weather.

3. PM10 can penetrate the lung barrier and enter the bloodstream.
4. Excessive ozone in the air can trigger asthma.

***Which of the statements given above are correct?***

a) 1, 3 and 4
**b) 1 and 4 only**
c) 2, 3 and 4
d) 1 and 2 only

## Measures to Control Air Pollution in NCR

- The **Environment Pollution (Prevention and Control) Authority** is a **Supreme Court-appointed body**. It was notified in 1998 by MoEF under the **Environment Protection Act**, **1986**. Its initial mandate was to ensure that Delhi's bus and auto fleet moved entirely to **CNG**. Its present mandate is to prevent and control environmental pollution in the National Capital Region and enforce **Graded Response Action Plan (GRAP)**.

### Graded Response Action Plan (GRAP)

- GRAP works only as an **emergency measure**. As such, the plan does not include action by various state governments to be taken throughout the year to tackle industrial, vehicular and combustion emissions. The plan is **incremental in nature** — therefore, when the air quality moves from 'Poor' to 'Very Poor', the measures listed under **both sections** must be followed.
- GRAP has been successful in doing two things that had not been done before — 1) **creating a step-by-step plan** for the entire Delhi-NCR region, and 2) **getting on board several agencies:** all pollution control boards, industrial area authorities, municipal corporations, regional officials of the India Meteorological Department, and others.
- The plan requires action and coordination among 13 different agencies in Delhi, Uttar Pradesh, Haryana and Rajasthan (**NCR areas**). Before implementing any measures, EPCA holds a meeting with representatives from all NCR states.

### Actions Under GRAP

**Severe+ or Emergency (PM 2.5 > 300 µg/m$^3$ or PM10 > 500 µg/m$^3$ for 48+ hours)**

- **Stop entry of trucks** (except essential commodities)
- Stop construction work.
- Introduce an **odd/even scheme** for private vehicles.

**Severe (PM 2.5 > 250 µg/m$^3$ or PM10 > 430 µg/m$^3$)**

- **Close brick kilns**, hot mix plants, and stone crushers.
- Maximise power generation from natural gas to reduce generation from coal.
- Mechanised cleaning of roads and sprinkling of water.

**Very Poor (PM2.5 > 120 µg/m$^3$ or PM10 > 350 µg/m$^3$)**

- Stop the use of diesel generator sets.
- Apartment owners should discourage burning fires in winter.

**Poor (PM2.5 > 60 µg/$m^3$ or PM10 > 100 µg/$m^3$)**

- Heavy fines for garbage burning and enforcing pollution control regulations in brick kilns and industries.
- Mechanised sweeping and water sprinkling on roads.
- **Strictly enforce a ban on firecrackers**.

***Other measures***

- NGT ordered a ban on old vehicles within the city.
- Open burning has been largely curtailed.
- Completion of the eastern and western peripheral expressways for vehicles not destined for Delhi.

***Has GRAP helped?***

- The most significant **success** of GRAP has been in fixing accountability and deadlines. For each action to be taken under a particular air quality category, executing agencies are clearly marked. Coordination among as many as 13 agencies from four states is simplified because of the clear demarcation of responsibilities.
- Three major policy decisions that can be credited to EPCA and GRAP are the closure of the thermal power plant at Badarpur, bringing BS-VI fuel to Delhi before the deadline set initially, and the ban on **Peat coke** as a fuel in Delhi-NCR.

## Measures to Reduce Stubble Burning

### PUSA Decomposer

- Scientists at ICAR Indian Agriculture Research Institute (IARI) have invented the PUSA Decomposer. It will be **used for the speedy decomposition of stubble** in the national capital and nearby states. In one capsule of **fungal solution**, a farmer can make 25 litres of liquid substance. After making the liquid, he has to add jaggery and gram flour and sprinkle that liquid on the stubble, after which it would biodegrade in 20 days.

### Super SMS and Happy Seeders

- The Punjab government provided 50,000+ subsidised stubble management machines. Super Stubble Management Systems (**Super SMS**) helps in **chopping the stubble and spreading that evenly**. The **Happy Seeder** helps in the **direct showing of wheat without clearing the stubble**.

### Baler Machine

- The balers compress agricultural residue into transportable bales. These bales are transported to factories or dumping sites. Fields can be immediately plowed and sowed for the next crop.

## Crop Residue Management (CRM) Scheme

- CRM is a central sector scheme launched under the Ministry of Agriculture. Under the scheme, financial assistance of 50% is provided to the farmers to purchase crop residue management machinery.
- **Machines covered by CRM:** Super Straw Management Systems, Happy Seeder, Super Seeder, Smart Seeder, Mulcher, Paddy Straw Chopper, Crop reapers, Reaper, and Balers.

**Objectives**

- Preventing loss of nutrients and soil micro-organisms caused by burning of crop residue.
- Promoting management of crop residue by in-situ (baler machine, happy seeders, Super SMS, etc.) and ex-situ mechanisms (biomass co-firing in thermal power plants and production of bio-CNG).


## Smog Towers

- In 2020, SC directed the government to prepare a plan to install 'smog towers' across the capital to deal with air pollution. Smog towers are structures designed to work as large-scale air purifiers. They are fitted with multiple layers of **carbon nanofiber** air filters, which clean the air of pollutants as it passes through them.
- SC had further ordered that **anti-smog guns** should be mandatory in projects that require **environmental clearance (EC)** and have a built-up area of over **20,000 square metres**.

## Emissions Trading Scheme (ETS) by Gujarat

- The Gujarat government launched the Emissions Trading Scheme (ETS) for trading in **particulate matter emissions**. While trading mechanisms for pollution control do exist, **none** of them is for **particulate matter** emissions. For example,
  - ✓ the Clean Development Mechanism **(CDM – Kyoto Protocol)** allows trade in '**carbon credits**'
  - ✓ the **European Union's Emission Trading System** is for **GHG emissions**
  - ✓ India has a scheme run by the **Bureau of Energy Efficiency** that enables **trading in energy units**
- Launched in **Surat**, the ETS scheme aims to reduce pollution and **minimise the cost of compliance** for the industry.

### How does the Emission Trading Scheme (ETS) work?

- The Gujarat Pollution Control Board (GPCB) **caps on the total emission load** for all industries. Under this cap, various industries can buy and sell the ability to emit particulate matter by trading permits (in kilograms) under this cap. For this reason, ETS is also called a cap-and-trade **market**. These permits are a way to allow industries to buy some time and make investments in clean technologies.

### Why was Surat chosen for the scheme?

- Surat is facing severe pollution and industries in Surat have already installed **Continuous Emission Monitoring Systems**, which makes it possible to estimate the mass of particulate matter being released.

## Other Measures

### Pradhan Mantri Ujjwala Yojana

- In 2015, India's annual air pollution level was **55 µg/m$^3$** of fine particulate matter. Levels in **New Delhi** often soared beyond **300 µg/m$^3$**. Replacing biomass with **cleaner fuels like LPG** would cut India's average annual air pollution to **38 µg/m$^3$**. This is just below the **National Ambient Air Quality standard** of **40 µg/m$^3$** and above the **WHO standard of 10 µg/m$^3$**.
- In 2016, the **Pradhan Mantri Ujjwala Yojana** was instituted by the **Ministry of Petroleum and Natural Gas** to provide **LPG connections** to **women** from **Below Poverty Line (BPL)** households. LPG cylinders are now used by 89% of households in India (it was 56.2% on April 1, 2015).

### Green crackers

- In 2019, SC mandated the use of **green crackers** for Diwali. Traditionally, firecrackers (90% of India's crackers are made in **Sivakasi**, **TN**) have been made with **barium nitrate**, **antimony** and a range of metals. The SC had banned the use of **barium nitrate**, a key pollutant in crackers.
- The **National Environmental Engineering Research Institute (NEERI)**, a part of the **CSIR**, was asked to facilitate the development of green crackers. NEERI substituted **barium nitrate** with **potassium nitrate** and **zeolite** to reduce PM10 and PM2.5 by 30%.
- Green crackers only causes 30% less emissions and lower noise pollution than traditional crackers. They still release harmful pollutants and high noise pollution.

### Government Initiatives to Reduce $SO_2$ emissions

- In 2015, the MoEF introduced $SO_2$ emission limits for **coal power stations**. 2022 was the deadline for the installation of **flue-gas desulfurisation units**. It is now extended by two more years.

#### Flue-Gas Desulfurisation (FGD) systems

- FGD systems may involve **wet scrubbing** or **dry scrubbing** to remove acidic gases, particularly **sulphur dioxide ($SO_2$)** and **HCl**, from flue gases (gases flowing out of vertical exhaust pipes). **Lime** is used in both.
- In wet FGD systems, flue gases are brought in contact with a liquid or solid slurry absorbent. The sulphur dioxide dissolves in or reacts with the absorbent and becomes trapped in as wet **calcium sulphite**. The sulphite can be converted to **gypsum** (used in cement production). In dry FGD scrubbing, lime is injected directly into flue gas to remove $SO_2$ and HCl from **low-sulphur fuels**.

## 13.3. Measures to Regulate Ozone-Depleting Substances (ODS)

### Vienna Convention and Montreal Protocol

- The **Vienna Convention for the Protection of the Ozone Layer (Vienna Convention)** was agreed in **1985**. It established **global monitoring and reporting on ozone depletion**. It also created a **framework for the development of protocols** for taking **more binding action**.

#### Montreal Protocol on Ozone-Depleting Substances

- The **Montreal Protocol**, under the **Vienna Convention**, was agreed upon in **1987**. It facilitates **global cooperation in reversing the rapid decline in atmospheric concentrations of stratospheric ozone (good ozone)**. Under the protocol, countries agreed to **phase out the production and consumption of certain chemicals that deplete ozone**. Phase out of these substances is required by **specific deadlines**.
- The **Vienna Convention and its Montreal Protocol** are the **first and only global environmental treaties** to achieve **universal ratification**, with **197 parties**. As a result of the international agreement, the ozone hole in Antarctica is **slowly recovering** because of the **decrease** in the overall concentration of stratospheric ODS. Climate projections indicate that the ozone layer will return to 1980 levels between 2050 and 2070.
- The US National Oceanic and Atmospheric Administration (NOAA) study found that the overall concentration of stratospheric ODS has decreased.

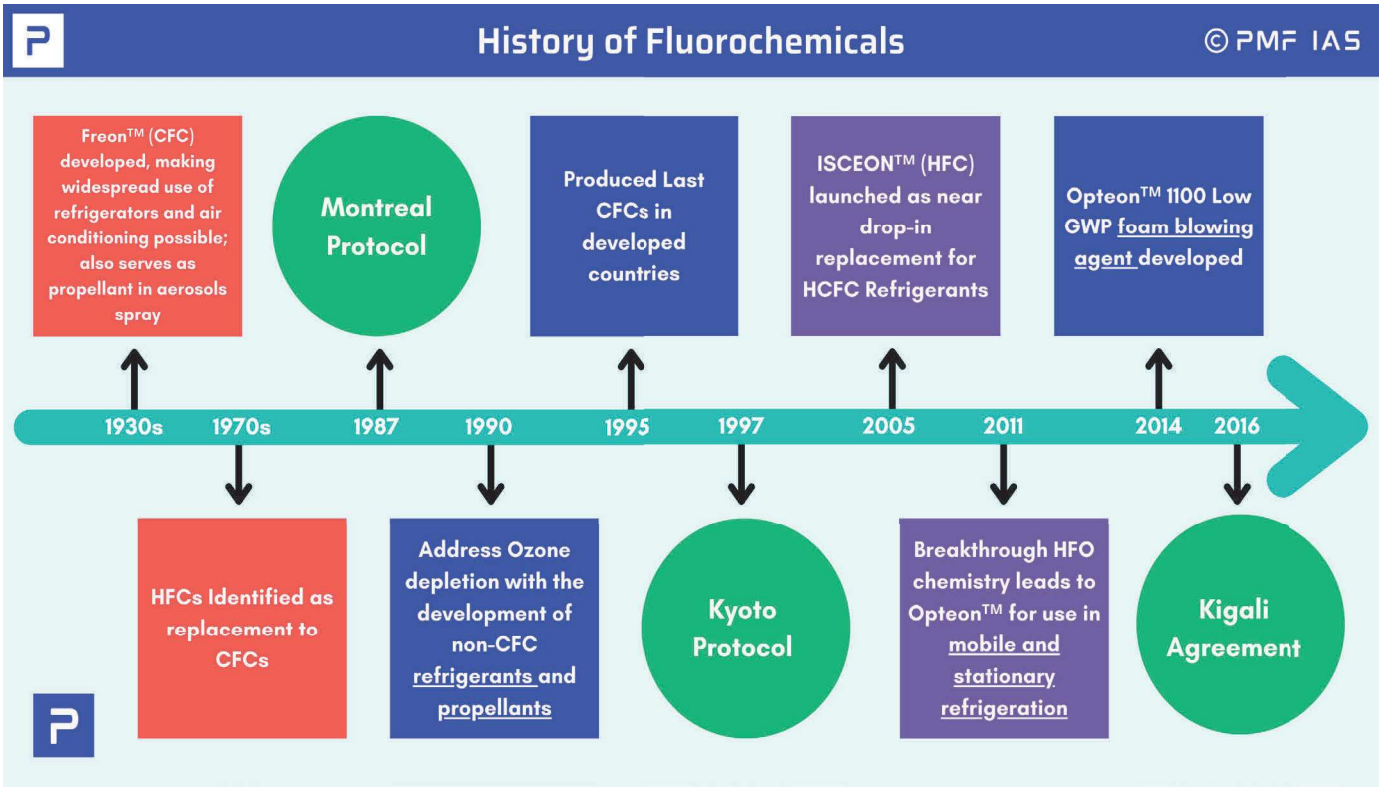
#### Quito Adjustment

- The **Quito Adjustment** was made to the **Montreal Protocol** in the **13th Meeting of the Parties** at **Quito**, **Ecuador**, **in 2018**. It aims to **avoid 1°C of future warming**.

#### Compliance

- Reduction in the atmospheric concentration of **CFC-11 (Trichlorofluoromethane)** has made the second-largest contribution to the decline in the total atmospheric concentration of **ozone-depleting chlorine** since the 1990s.

- CFC-11 is a **chlorofluorocarbon (CFC)**, which is outlawed for almost all uses by the 1987 **Montreal Protocol**. But this gas **(CFC-11) still contributes one-quarter of all chlorine reaching the stratosphere**. 40 to 60 per cent of total global **CFC-11** emissions are coming from **China**.
- As a signatory to the **Montreal Protocol**, China agreed to phase out production of CFC-11 in 2010. However, Chinese foam manufacturers have been using CFC-11 **illegally** to save on the higher cost of alternatives, such as **hydrochlorofluorocarbons (HCFCs)** like **HCFC-141b**, which is to be phased out in China by 2026.




**[UPSC 2015] Which one of the following is associated with the issue of control and phasing out of the use of ozone-depleting substances?**

a. Bretton Woods Conference
b. Montreal Protocol
c. Kyoto Protocol
d. Nagoya Protocol

**Explanation**

- **Bretton Woods Conference** established the **International Bank for Reconstruction and Development (IBRD)** and the **International Monetary Fund (IMF)**.
- **Montreal Protocol** is a **legally-binding** international treaty to protect the ozone layer by phasing out the production of ozone depleting substances.
- **Kyoto Protocol** implemented the objective of the UNFCCC to **fight global warming by reducing GHG concentrations** in the atmosphere to "a level that would prevent dangerous anthropogenic interference with the climate system". It is binding on the parties.

- **Nagoya Protocol** is an agreement to the 1992 **CBD** on "Access to Genetic Resources and the Fair and Equitable Sharing of Benefits".

***Answer: b)***

## Kigali Amendment to Montreal Protocol 2016

- In the 28th meeting of the Parties (2016) to the Montreal Protocol, negotiators from 197 nations signed an agreement to amend the Montreal Protocol in **Kigali (the capital city of Rwanda)**.
- The **Kigali Amendment to the Montreal Protocol** aims to **phase out** the use of **potent greenhouse gases** called **hydrofluorocarbons (HFCs)**, which are used widely in ACs. It is a **legally binding agreement** between the signatory parties with non-compliance measures. It came into effect on 1st January 2019. The parties are expected to **reduce the manufacture and use of Hydrofluorocarbons (HFCs) by 80-85%** from their respective baselines, **till 2045**.
- ACs greatly exacerbate the **Urban Heat Island effect**, making cities inhospitable, especially for the poor. The phase-down of HFCs is expected to arrest the global average temperature rise up to **0.5 °C by 2100**.

### Hydrofluorocarbons (HFCs)

- **Hydrofluorocarbons (HFCs)** are used as an alternative to **CFCs** and **HCFCs/HBFCs**. HFCs **do not contribute to ozone depletion**. However, they are **potent greenhouse gases** with **high global warming potential**.

### India's position

- India has agreed on a lenient schedule as it consumes only **3% of HFCs** compared to other nations like the **USA (37%)** and **China (25%)**. **India has to reduce its HFC use by 80 % by the year 2047**, while China and the **US** have to achieve the same target by the years 2045 and **2034**, respectively. India will complete its phase-down in 4 steps from 2032 onwards, with a cumulative reduction of 10% in 2032, 20% in 2037, 30% in 2042 and 85% in 2047.

### HFO Alternatives to HFCs

- **HFO** stands for **hydrofluoro olefin**. HFO refrigerants are composed of **hydrogen**, **fluorine and carbon atoms** but contain at least **one double bond** between the carbon atoms.

| Fluorochemical | Ozone Depleting Potential | Global Warming Potential |
|---|---|---|
| (ODS + GHG) Chlorofluorocarbons (CFCs) | High | High |
| (ODS + GHG) Hydrochlorofluorocarbons (HCFCs) | Low | High |
| (GHG) Hydrofluorocarbons (HFCs) | Zero | High |
| (GHG) Hydrofluoro Olefin (HFOs) | Zero | Very Low |

## The Ozone Depleting Substances (ODS) Rules

- The rules are framed under the jurisdiction of the **Environment (Protection) Act**. These Rules set the deadlines for **phasing out various ODSs**, besides **regulating the production**, **trade**, **import** and **export** of ODSs and the products containing ODS.

- These Rules **prohibit using CFCs** in manufacturing various products beyond 1st Ja 2003 except in **metered dose inhalers** and other medical purposes. Similarly, the **use of halons is prohibited** after 1st Jan 2001 except for essential use.
- Other ODSs such as **carbon tetrachloride methyl**, **chloroform**, and CFC for **metered dose inhalers** are prohibited after 1st January 2010. Further, **methyl bromide** was allowed up to 1st January 2015. Since **HCFCs** are used as an **interim substitute to replace CFC**s, these are **allowed up to 1st January 2040**.

## India phases out of ozone-depleting HCFC-141b

- **India has phased out Hydrochlorofluorocarbon (HCFC)-141 b**, which is used in foam manufacturing to produce rigid **polyurethane (PU) foams**. The **polyurethane foam sector** has links with important economic sectors related to buildings, cold storage and cold chain infrastructure, commercial refrigeration, etc.
- **HCFC-141b is prohibited from 1st January 2020** under **Ozone Depleting Substances (Regulation and Control) Amendment Rules**, **2019**, issued under the **Environment (Protection) Act**, **1986**.
- HCFC-141b is not produced in the country, and all the domestic requirements are **met through imports**. With the **2019 rules**, the import of HCFC-141 b is prohibited.
- India has previously **phased out chlorofluorocarbons**, **carbon tetrachloride**, **halons**, **methyl bromide** and **methyl chloroform** for controlled uses per the Montreal Protocol schedule.

## Closure of Hindustan Fluorocarbons Limited (HFL)

- Recently, the GOI approved the closure of Hindustan Fluorocarbons Limited (HFL), a subsidiary of Hindustan Organic Chemicals Ltd., which is under the Department of Chemicals and Petrochemicals.
- HFL is engaged in the manufacture of **Chloro Di Fluoro Methane (HCFC-22/CFM-22)** and also uses the same for conversion to **Poly Tetra Fluoro Ethylene (PTFE)**.
- Under the provisions of the Montreal Protocol on phasing out ozone-depleting substances, HFL's present production quota of HCFC-22 is insufficient for the plant to operate.

**---------- End of Chapter ----------**

# 14. Water Pollution – Causes, Effects and Control Measures

## 14.1. Water Pollution

- Water pollution is the presence of undesirable substances/pollutants in water, such as organic, inorganic, biological, **radiological** and **heat**, which degrade water quality so that it becomes unfit for use. Natural sources of water pollution are soil erosion, the **leaching of minerals** from rocks (due to natural solubility and solubility triggered by **acid rain**) and the decaying of organic matter.
- When pollutants are discharged from a **specific location**, such as a drainpipe carrying industrial effluents discharged directly into the water body, it represents **point source pollution**. In contrast, **non-point sources** include the discharge of pollutants from **diffused sources** or **a larger area**, such as runoff from agricultural fields, grazing lands, construction sites, abandoned mines and pits, etc.

### Measuring Pollution Load in Water

#### Dissolved Oxygen (DO)

- Optimum DO content in water is essential for the survival of aquatic organisms. The presence of **organic** and **inorganic** wastes **decreases** the **DO** content due to the **high decomposition rate** and **$O_2$ consumption**.
- Several factors, such as **surface turbulence**, **photosynthetic activity**, **$O_2$ consumption by organisms** and **decomposition of organic matter**, determine the amount of DO in water. Water with a DO content **below 8.0 mg/L** may be considered **contaminated**, and water **below 4.0 mg/L** is deemed to be **highly polluted**.

#### Biological Oxygen Demand (BOD)

- Water pollution by **organic wastes** is measured in terms of **Biochemical Oxygen Demand (BOD)**. BOD is the **amount of dissolved oxygen needed by bacteria to decompose** the organic wastes present in water. It is expressed in milligrams of oxygen per litre of water.
- The **higher value of BOD indicates high pollution due to biodegradable organic wastes** and low **DO content of water**. Since BOD is **limited to biodegradable materials**, it is **not a reliable method of measuring water pollution**.

| BOD Level in mg/liter | Water Quality |
|---|---|
| 1 - 2 | **Very Good:** There will not be much organic matter present in the water supply. |
| 3 - 5 | **Fair:** Moderately Clean |
| 6 - 9 | **Poor:** Somewhat Polluted - Usually indicates that organic matter present and microorganisms are decomposing that waste. |
| 100 or more | **Very Poor:** Very Polluted - Contains organic matter. |

### Chemical Oxygen Demand (COD)

- **Chemical oxygen demand (COD)** is a **slightly better** mode for measuring pollution load in the water. It measures the **amount of oxygen** in parts per million **required to oxidise organic (biodegradable and non-biodegradable)** and **oxidisable inorganic compounds** in the water sample.

**[UPSC 2017] Biological Oxygen Demand (BOD) is a standard criterion for**

a) Measuring oxygen levels in the blood
b) Computing oxygen levels in forest ecosystems
c) Pollution assay in aquatic ecosystems
d) Assessing oxygen levels in high-altitude regions

## 14.2. Causes of Water Pollution

### Industrial Wastes

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

### Heavy Metals in Surface Water

- According to the Central Water Commission report, **iron** is the most common contaminant. Other major contaminants include **lead**, **nickel**, **chromium**, **cadmium** and **copper**.
- Metals found in the Monsoon Period include **iron**, **lead**, **chromium**, **and copper**, **which** exceeded tolerance limits.
- Metals found in the Non-Monsoon Period include **lead**, **cadmium**, **nickel**, **chromium** and **copper**.
- The primary sources of heavy metal pollution are **mining**, **plating** and **surface finishing industries**. Long-term exposure may result in physical, muscular, and **neurological degenerative** processes that mimic **Alzheimer's and Parkinson's disease**, **muscular dystrophy** and **multiple sclerosis (a disease of the central nervous system)**.

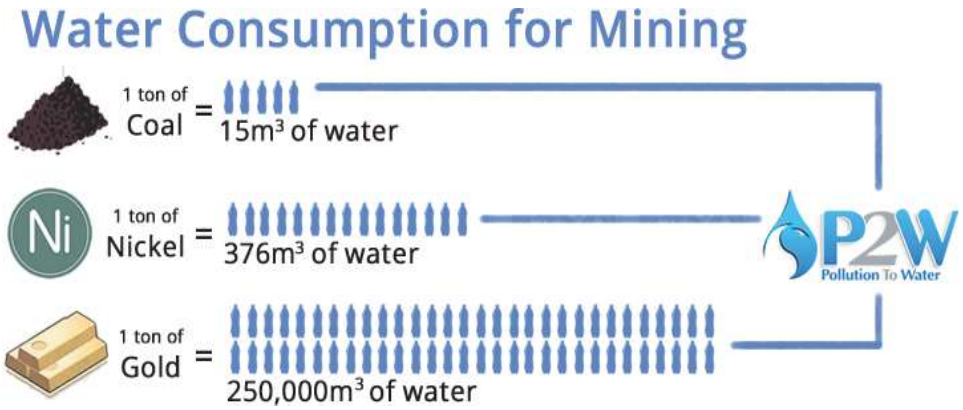
### Thermal and Radiation Pollution

- **Power plants** (thermal and nuclear), chemical plants, and other industries use a lot of water for **cooling purposes**. The used hot water is discharged into rivers, streams, or oceans, raising the water temperature by 5-15°C. This is **thermal pollution**. **An increase in water temperature decreases dissolved oxygen** in the water.
- Unlike terrestrial organisms, **aquatic organisms** are adapted to a **uniform**, **steady temperature**. A sudden rise in temperature kills fish and other aquatic animals.
- Nuclear accidents near water bodies or during natural calamities like tsunamis and earthquakes pose the risk of **radiation leakage (radiation exposure)** into water bodies. For e.g., the **Fukushima Daiichi nuclear disaster**.

- Radiation exposure causes **mutations in the DNA** of marine organisms. If those mutations are not repaired, the cell may turn **cancerous**.
- For e.g., **Radioactive iodine** tends to be absorbed by the thyroid gland and can cause **thyroid cancer**. **Radioactive radon** in air and water can cause lung cancer, and **uranium** in water can cause kidney cancer.

## Mining

- Much water is used in (open-pit and underground) mining operations (raw material processing, mine cooling, metal extraction, etc.) alongside chemicals such as **cyanide**, **sulphuric acid**, and **mercury**, increasing the potential for these chemicals to contaminate ground and surface water.
- Mine and mineral transportation exposes and disturbs a considerable amount of soil and rock. Erosion of these may carry substantial amounts of sediment and harmful chemicals into streams, rivers and lakes.




- **Acid Rock Drainage (ARD)** is a natural process whereby **sulphuric acid** is produced when **sulphides in rocks** are exposed to water. The produced acid accelerates the (chemical) weathering of rocks and causes the **leaching** of various minerals and metals.
- **Acid Mine Drainage (AMD)** is the greatly magnified version of ARD, which occurs when large quantities of rock containing **sulphide minerals** are excavated from an open pit or underground mine.
- When the water reaches a certain level of acidity, a naturally occurring type of bacteria called ***Thiobacillus ferrooxidans*** accelerates the oxidation and acidification processes, leaching even more trace metals from the wastes.

⇨ ***Thiobacillus ferrooxidans*** *is a highly* ***acidophilic*** *(pH 1.5 to 2.0) autotrophic bacterium that obtains its energy through the* ***oxidation of ferrous iron*** *or reduced inorganic* ***sulfur*** *compounds.*

- Heavy metal pollution is caused when metals such as **arsenic**, **cobalt**, **copper**, **cadmium**, **lead**, **silver** and **zinc** contained in excavated rock or exposed in an underground mine come in contact with water.
- Although metals can become mobile in neutral pH conditions, leaching is particularly accelerated in the **low pH conditions** created by processes like AMD.

## Groundwater and Drinking Water Contamination

- In India, in many places, the groundwater is threatened with contamination due to seepage from industrial and municipal wastes and effluents, and agricultural runoff. Pollutants like **fluorides**, **uranium**, **heavy metals** and nutrients like **nitrates** and **phosphates** are common.

- Among rural habitations in India, many face quality issues with drinking water. **Iron** is the most common contaminant, followed by **salinity**, **arsenic**, **fluoride**, etc.
- **Rajasthan** has the highest number of rural habitations affected by (salinity) contamination. In terms of **arsenic** and **iron pollution**, **WB** and **Assam** are the worst affected.

## Nitrates

- **Excess nitrate** in drinking water reacts with **haemoglobin** to form non-functional **methaemoglobin** and **impairs oxygen transport**. This condition is called **methemoglobinemia** or **blue baby syndrome**. High levels of nitrates may form carcinogens and can **accelerate eutrophication**.

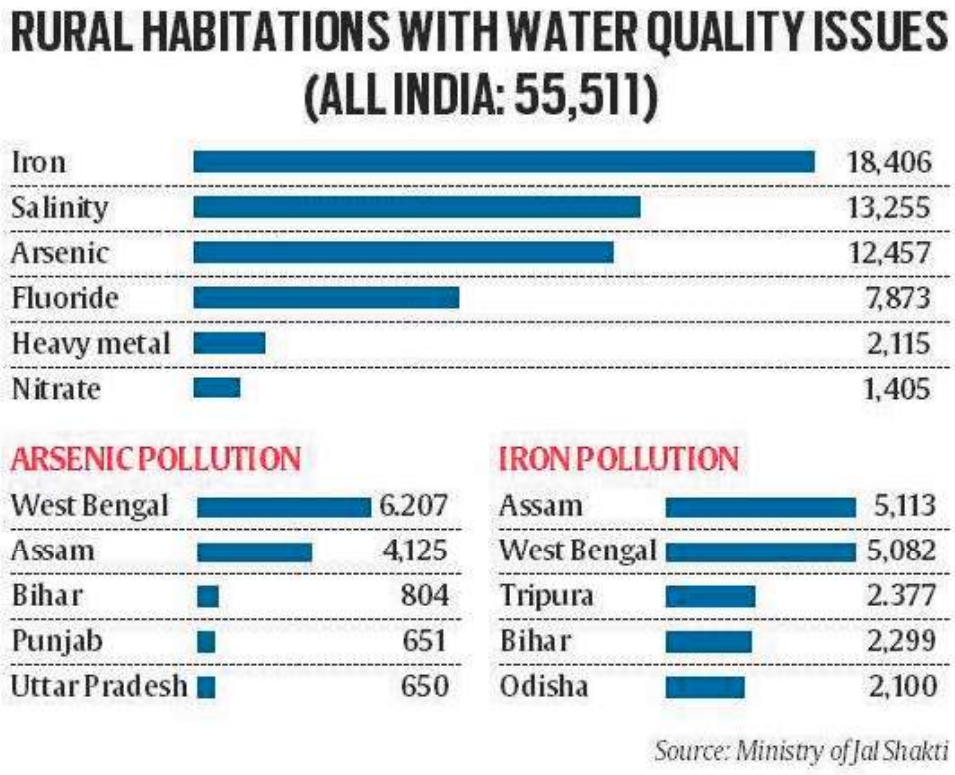
> ⇨ ***Methaemoglobin is a form of oxygen-carrying metalloprotein haemoglobin***. ***Methaemoglobin cannot bind oxygen***, ***unlike oxyhaemoglobin***.

## Trace metals

- Trace metals in water include **lead**, **mercury**, **cadmium**, **copper**, **chromium** and **nickel**, which can be carcinogenic.

## Arsenic

- Arsenic is a tasteless, odourless **carcinogen**. It is highly poisonous to humans. While arsenic is **naturally occurring**, it also comes in **inorganic** (or "**human-made**") formulas used in **agriculture**, **mining**, **and manufacturing**.




- Seepage of industrial and **mine discharges** and **fly ash ponds of thermal power plants** can lead to arsenic in groundwater. The **US**, **India**, **China**, and **Mexico** have the highest levels of arsenic in ground-water. Arsenic contamination is highest in the **Ganges Delta** (India and Bangladesh).

- Chronic exposure to arsenic causes **black foot disease** — a peripheral vascular disease (PVD), in which the **blood vessels in the lower limbs are severely damaged**, resulting in progressive gangrene. It also causes diarrhoea and also lung and skin cancer.
- Arsenic poisoning, or arsenicosis, occurs after the ingestion or inhalation of high levels of arsenic. It causes **melanosis** and **keratosis** (dark spots on the upper chest, back, and arms are known as melanosis, and the next stage is keratosis, in which palms become problematic).

## Fluoride

- Fluorosis is a common problem in India due to the intake of high fluoride content water. Excess fluoride intake causes **neuromuscular disorders**, **gastrointestinal problems**, **tooth deformity**, **hardening of bones** and **stiff** and **painful joints** **(skeletal fluorosis)**. Pain in bones and joints and outward bending of legs from the knees is called **Knock-Knee syndrome**.

## Uranium Contamination

- Uranium is weakly radioactive with a prolonged physical half-life (~4.5 billion years for uranium-238). The biological half-life (time taken by the human body to eliminate half the amount) is about 15 days.
- **Uranium concentrations** above **30 micrograms per litre** (WHO's guidelines) are prevalent in some of the localised pockets in India.
- In Rajasthan and other northwestern states, uranium occurs mainly in **alluvial aquifers**, while in southern states such as Telangana, crystalline rocks such as granite are the source. When groundwater is over-extracted from such soils, the uranium is exposed to air, triggering its release.
- Elevated uranium levels in drinking water may be associated with **kidney toxicity**. High rates of **chronic kidney disease** **(CKD)** in the **Srikakulam district in Andhra Pradesh** are thought to be due to groundwater uranium exposure.
- The Andhra Pradesh government has ordered an inquiry into complaints about groundwater pollution caused by **uranium mining** and processing at the Uranium Corporation of India Limited (UCIL) in the **Kadapa** district.

### Guidelines in India

- The Indian Standard **IS 10500: 2012 for Drinking Water specification** has specified the maximum acceptable limits for radioactive residues as alpha and beta emitters, values in excess of which render the water unsuitable.
- These requirements take into account **all radioactive elements**, including uranium. **No individual radioactive elements have been specifically identified**.
- The **Bureau of Indian Standards (BIS)** is working to incorporate the permissible limit of Uranium as **0.03 mg/l** **(WHO provisional guidelines)** in drinking water standards.

## Radioactive Radon

- Recently, high **radioactive radon** content has been detected in groundwater used for drinking in some areas in **Bengaluru**. It is found to be 50 to 100 times the permissible limit of **11.1 Bq per litre**.

- Radon emanates from **radioactive granites** and from **uranium** through radioactive decay to **radium** and **radon**.
- The **uranium content is also detected to be high** — 300 micrograms per litre in the water against the permissible limit of **30 µg/l**. It comes from minerals like **pitchblende**, **zircon**, and **monazite**, among others, in the region's rocks.
- **Radon in air and water** leads to damage of **lung tissues**, threatening **lung cancer**, while the presence of **uranium** affects the **urinary tract**, **leading to kidney cancer**.

## Freshwater Salinization Syndrome (FSS)

- FSS is the process of **salty runoff contaminating freshwater ecosystems**. Salts naturally occur in fresh waters, typically caused by rock weathering &naturally saline groundwater. However, **anthropogenic activities** are further increasing concentrations of salts in fresh waters.

### Causes

- **Oil and gas extraction and** other forms of **resource extraction**.
- **Road salts for de-icing (applying salt on snowy roads has a lower freezing temperature than the surrounding ice)**.
- Human-accelerated weathering of rocks and soils.
- **Sea-level rise and saltwater intrusion**.

**[UPSC 2013] Which of the following can be found as pollutants in the drinking water in some parts of India?**

1) Arsenic
2) Sorbitol
3) Fluoride
4) Formaldehyde
5) Uranium

***Select the correct answer using the codes given below.***

a) 1 and 3 only
b) 2, 4 and 5 only
c) 1, 3 and 5 only
d) 1, 2, 3, 4 and 5

### Explanation

- The most straightforward options are **Fluoride**, **Arsenic** and **Uranium**.
- The knowledge of either "Sorbitol" or "Formaldehyde" will give us the answer.
- We are more familiar with **formaldehyde (a carcinogen)** since it is a **volatile organic compound (VOC)**, **an air pollutant**.
- **Sorbitol (glucitol)** is a **sugar alcohol**. It contains about one-third fewer calories than sugar and is 60 per cent as sweet. It occurs naturally in berries and fruits.

***Answer: c) 1, 3 and 5 only***

## Sewage Water

- Sewage water includes discharges from houses and other establishments. It contains human and animal excreta, food residues, cleaning agents, detergents, etc. Domestic and hospital sewage contains many **pathogenic** microbes.

### Ammonia Pollution in Sewage

- Ammonia, a **colourless gas** with a distinct odour. It occurs **naturally** throughout air, soil, and water, as well as in plants and animals, including humans.
- The human body makes ammonia when the body breaks down foods containing **protein into amino acids** and **ammonia**, then converts the **ammonia into urea**.
- Ammonia is a basic building block for **ammonium nitrate fertiliser**, which releases **nitrogen**, an essential nutrient for growing plants, including farm crops and lawns.
- **Ammonium hydroxide**, commonly known as household ammonia, is an ingredient in many everyday **household cleaning products**. Ammonia has been used in **municipal treatment systems** for more than 70 years to **prolong the effectiveness of disinfection chlorine** added to water.
- The addition of ammonia **enhances the formation of chloramines** (creates a bad taste). It reduces the formation of chlorination by-products, which may be carcinogenic.
- The acceptable limit of ammonia in drinking water, as per BIS, is **0.5 ppm**. If its concentration in water exceeds **1 ppm**, **it is toxic to fish**. In humans, long-term ingestion of water having high ammonia levels (≥ **1 ppm**) is harmful.

## Agricultural Sources

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

### Nitrogen Pollution in India

- **Agriculture**, **sewage**, and **organic solid wastes** are the most significant contributors to nitrogen pollution in India. Only 33% of the nitrogen applied through fertilisers is used by plants, and the remaining **67% remains in the soil**.

## Invasive Aquatic Species

## Water hyacinth

- **Water hyacinth**, an aquatic plant **native to the Amazon basin**, is the world's most problematic aquatic weed. It is known as the **'Terror of Bengal'**, **'German Weed'** in Bangladesh, **'Florida Devil'** in South Africa and **'Japanese Trouble'** in Sri Lanka. Water hyacinths grow abundantly in **eutrophic (nutrient-rich) water bodies** and lead to an imbalance in the ecosystem. They cause havoc through their excessive growth, leading to the stagnation of polluted water and the **draining of oxygen** from the water bodies, resulting in the **devastation of fish stock**.

## Forked Fanwort

- In some places in Kerala, the widespread growth of **forked fanwort** has painted the water bodies **pink**. Forked fanwort is a submerged **perennial aquatic plant** that grows in stagnant to slow-flowing fresh-water. It is an **invasive species** that belongs to **Central and South America**. It requires a considerable amount of **oxygen** to grow, and that could badly affect freshwater biodiversity.

## Pollution in River Ganga

- Almost all wastewater and industrial effluents are generated by various urban and industrial centres, viz. **Haridwar**, **Kannauj**, **Kanpur**, **Allahabad**, **Varanasi**, **Patna and Kolkata** are disposed of into the river Ganga. **The primary industrial sector**, namely, **Tannery**, **Sugar and Distillery**, **Pulp and Paper mills**, contributes significantly to the pollution load on the Ganga River and its tributaries.
- Ganga is polluted by **faecal coliform bacteria** in its entire length. In contrast, the level of BOD, an indicator of organic pollution, vastly exceeds the criteria in the stretch that spans from **Kannauj** to **Tarighat**. **Diversion of river water** through Upper and Lower Ganga canals, leaving virtually very little flow in the main river stream, makes dilution difficult even for the treated sewage.
- Microplastics present in the Ganga:
  - **Ehylenevinyl** is particularly suited for **food**, **drugs** and **cosmetic packaging**.
  - **Polyacetylene** is used as a doping agent in the **electronics industry**.
  - **Polypropylene** is also used in **packaging**, **plastic sheets**, **fibre**, **fabrics**, **rope**, **etc**.
  - **Persistent Inorganic Pollutant (PIP)** is mainly used in **footwear** and **baby bottle nipples**.

- **Polyamide**, commonly known as nylon, is used as a natural fibre and **metal wire** in **clothing** and **industry**.

## Marine Pollution: Oil Spills and Plastic

- Marine pollution refers to the emptying of chemicals into the ocean and its harmful effects. The potentially toxic chemicals stick to tiny particles, and these are taken up by **plankton** and **benthos** animals, which are deposit or filter feeders concentrating upward within food chains. As animal feeds usually have a high fish meal or fish oil content, toxins can be found in consumed food items obtained from livestock and animal husbandry.

### Oil Spills

- The most common cause of oil spills is leakage during marine transport, leakage from underground storage tanks, and during offshore oil production.

#### Recent Incidents of Oil Spills

- An oil spill accident in the **East China Sea** in 2018 released more than 1,36,000 tonnes of volatile petroleum.
- The **Deepwater Horizon drilling accident** is the largest oil spill disaster in history. It took place in 2010, releasing 779 million litres of crude oil into the **Gulf of Mexico**.
- The recent MV Wakashio spill off **Mauritius** — about 1,000 tonnes of oil spilt into a sanctuary for rare wildlife after the Japanese ship struck a coral reef in 2020.

#### Impact of oil spill on marine life

- **Oil**, **being lighter than water**, covers the surface as a thin film, **cutting off oxygen** to floating plants and other producers. Within hours of an oil spill, the fish, shellfish, and plankton die due to suffocation and metabolic disorders. Birds and sea mammals that consume dead fish and plankton die due to poisoning.

> ⇨ *Oil spills in water can be cleaned with the help of **bregoli** — a by-product of the paper industry resembling sawdust, oil zapper, and microorganisms.*

### Marine plastic pollution

- Marine plastic pollution is said to cause ~$13 billion in economic damage to marine ecosystems yearly. It is estimated to outweigh fish by 2050.

- Exposure to chemicals leaching from plastic pollution interfered with the growth, photosynthesis and oxygen production of **Prochlorococcus**, the **ocean's most abundant photosynthetic cyanobacteria**.
- Plastic has been documented even in the deepest part of the ocean (Challenger Deep in Marana Trench).
- The most visible and disturbing impacts of marine plastics are the ingestion, suffocation and entanglement of hundreds of marine species.
- Marine wildlife, such as seabirds, whales, fish and turtles, mistake plastic waste for prey, and most die of starvation as their stomachs are filled with plastic debris.
- **Invisible plastic** has been identified in salt and is present in all samples from the world's oceans, including the Arctic!

## 14.3. Effects of Water Pollution

### Effects on the Human Health

- Domestic and hospital sewage contains many undesirable pathogenic microorganisms, and its disposal into the water without proper treatment may cause an outbreak of serious diseases, such as typhoid, cholera, etc.
- Metals such as **lead**, **zinc**, **arsenic**, **copper**, **mercury and cadmium** in industrial wastewaters adversely affect humans and other animals.
- Consumption of such **arsenic-polluted water** leads to accumulation of arsenic in the body parts like blood, nails and hairs, causing skin lesions, rough skin, dry and thickening of the skin and ultimately **skin cancer**.
- Mercury compounds in wastewater are converted by bacterial action into highly toxic **methylmercury**, which can cause numbness of limbs, lips and tongue, deafness, blurring vision and mental derangement. Mercury in water causes **Minamata (a neurological syndrome)** in humans.
- Lead causes **lead poisoning** (interferes with various body processes and is toxic). The lead compounds cause **anaemia**, loss of muscle power and a bluish line around the gum.
- Water contaminated with **cadmium** can cause **Itai Itai** disease, also called **ouch-ouch disease** (a painful **disease of bones and joints**) and cancer of the lungs and liver.

### Effects on the Environment

- Micro-organisms involved in the **biodegradation of organic matter** in sewage waste **consume much oxygen** and **make water oxygen deficient**, killing aquatic creatures.
- The presence of large amounts of nutrients in water results in **algal bloom** (**excessive growth of planktonic algae** — leads to **ageing of lakes**).
- A few toxic substances, often present in industrial wastewater, can undergo **biological magnification (Biomagnification) in the aquatic food chain**.
- This phenomenon is well-known for **mercury** and **DDT**. High concentrations of **DDT** disturb **calcium metabolism in birds**, which causes **thinning and premature breaking of eggshells**, eventually causing a **decline in bird populations**.

## Effects on Aquatic Ecosystem

- **Hot and polluted waters** discharged from industries **lower DO content** and eliminate sensitive organisms like plankton, molluscs, fish, etc. **Biocides**, **polychlorinated biphenyls (PCBs)** and **heavy metals** also eliminate sensitive aquatic organisms.

⇨ *A few tolerant species like **Tubifex (annelid worm)** and some insect larvae may survive in highly polluted water with low DO content. Such species are recognised as **indicator species** for polluted water.*

### Ocean warming increases methylmercury toxin in fish

- There has been a **decrease** in seawater concentration of **methylmercury** since the late 1990s. However, the amount of **methylmercury in fish is higher in the food chain**, and it has been **found to increase**. The increase is due to **ocean warming** and dietary shifts due to **overfishing** by humans.
- Due to overfishing, fish higher in the food chain relied more on larger fishes, which have higher concentrations of the toxin than other prey fish. **Fish metabolism is temperature-dependent**. So, as **ocean temperature increases**, fish experience **higher metabolism**, and more energy obtained from food is spent on **maintenance rather than growth**. This leads to more methylmercury concentration in predatory fish (fish higher in the food chain).
- Human exposure to the toxin through fish consumption is bound to increase due to **climate change**.

## Eutrophication and Ageing of Lakes

- Lakes receive their water from surface runoff and, along with it, various chemical substances and minerals. Over periods spanning millennia, ageing occurs as the lakes accumulate mineral and organic matter and gradually fill up.
- The **nutrient enrichment** of the lakes promotes the growth of **algae**, aquatic plants, and various fauna. This process is known as **natural eutrophication**. **Human activities** cause similar nutrient enrichment of lakes at an accelerated rate, and the consequent ageing phenomenon is known as **cultural eutrophication**.
- Based on their nutrient content, lakes are categorised as **Oligotrophic (very low in nutrients)**, **Mesotrophic (moderate nutrients)** and **Eutrophic (highly nutrient-rich)**. Most lakes in India are either **eutrophic** or **mesotrophic** because of the nutrients derived from their surroundings or the organic wastes entering them.

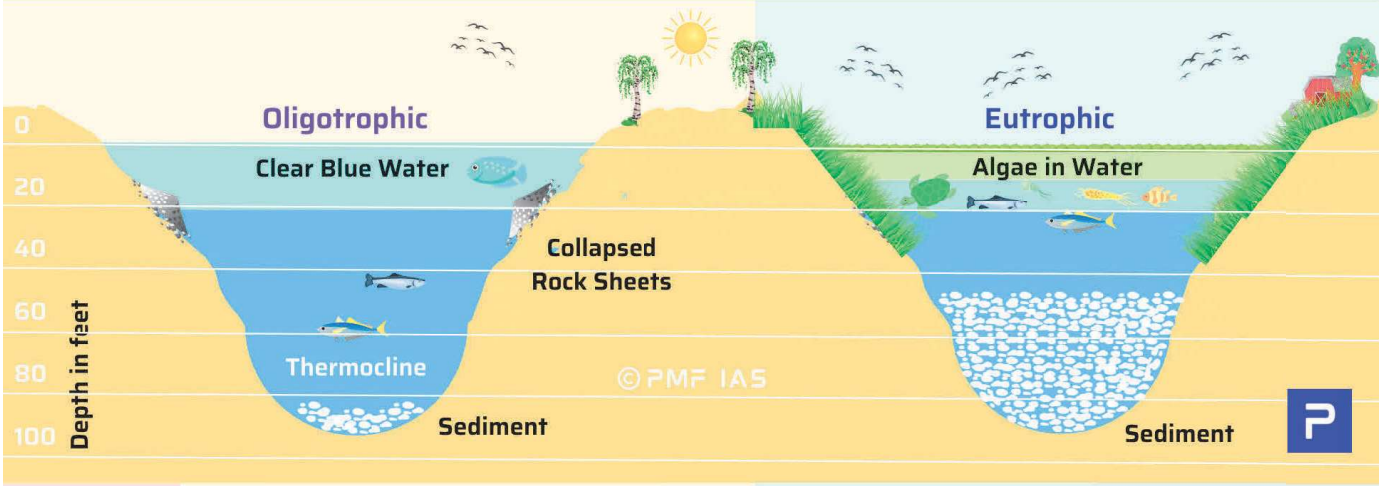
### Effects of Eutrophication

- **Collapsing food chains: Eutrophic water bodies (rich in nutrients)** support dense plant and phytoplankton populations, the death and **decomposition** of which kills animal life by **depriving water of oxygen**.
- **New species invasion:** Eutrophication may make the ecosystem competitive by transforming the normal limiting nutrient to an abundant level. This causes shifts in the species composition of the ecosystem.
- **Loss of freshwater lakes:** Eutrophication eventually creates a **detritus layer** in lakes and produces a successively **shallower** surface water depth. Eventually, the water body is **reduced into a marsh** whose

plant community is **transformed** from an aquatic environment to a recognisable **terrestrial** environment.

- **Loss of coral reefs:** Occurs due to decreased water transparency (**increased turbidity**).
- **Others:** Affects navigation due to increased turbidity; creates colour (yellow, green, red) and smell; increases biomass of **inedible toxic phytoplankton**, **benthic** and **epiphytic algae** and **bloom of gelatinous zooplankton**, **etc**.

## Difference Between Oligotrophic and Eutrophic Lakes




| | Oligotrophic | Eutrophic |
|---|---|---|
| Definition | It is a lake that has few nutrients present and also a low primary productivity | It is a lake that has abundant nutrients present and also a high primary productivity |
| Water Parameters | Low Turbidity, High Oxygenation at depth, and clear water | High Turbidity, Low Oxygenation at depth, and water often is brown or with a greenish tint. |

## Eutrophication and Algal Blooms

- **Eutrophication** is the response to the addition of nutrients such as **nitrates** and **phosphates** naturally or artificially, fertilising the aquatic ecosystem. **Phytoplankton** thrives on the excess nutrients, and their population explosion covers almost the entire surface layer, restricting the penetration of sunlight. This condition is known as an **algal bloom**. It results in the **death of aquatic plants** and hence **restricts the replenishment of oxygen**.

### Phytoplankton

- Phytoplankton are tiny microscopic **autotrophs** found in the ocean. They have **chlorophyll** to capture sunlight and use photosynthesis to turn it into chemical energy.
- **All phytoplankton photosynthesise**, but some get additional energy by consuming other organisms.
- Phytoplankton include **diatoms**, **dinoflagellates**, **cryptomonads**, **green algae**, **blue-green algae**, etc., which are at the base of the aquatic food web and are important **ecological indicators**. They contribute to more than half of the oxygen that we breathe. They influence our climate by **absorbing human-induced $CO_2$**.

**Phytoplankton Chlorophyll**

- Chlorophyll is **a green photosynthetic pigment** found in **plants**, **algae**, **and cyanobacteria**. It absorbs mainly in the **blue and**, **to a lesser extent**, **red portions** of the electromagnetic spectrum; hence it is in green colour.

1. Chlorophyll a: found in **all higher plants**, **algae** and **cyanobacteria**.
2. Chlorophyll b: found in **higher plants** and **green algae**.
3. Chlorophyll c: found in **diatoms**, **dinoflagellates** and **brown algae**.
4. Chlorophyll d: found only in **red algae**.

⇨ ***Algal blooms*** *can be any colour, but the most common ones are* ***red or brown****. These blooms are commonly referred to as* ***red or brown tides****.*

⇨ *Water temperature has also been related to the occurrence of algal blooms, with* ***unusually warm water being conducive to blooms*** ***(climate change will accentuate algal blooms)****.*

### Mechanism

- Phytoplankton are **photosynthetic during the daytime**, **adding oxygen to the aquatic ecosystem**. But **during the night**, **they consume far more oxygen as they respire aggressively**. Therefore, **algal blooms accentuate the rate of oxygen depletion** as the population of phytoplankton is exceedingly high.
- The primary consumers like **zooplankton** and small fish are killed due to **oxygen deprivation** caused by algal blooms, adversely affecting the food chain.
- Further, **more oxygen is taken up by microorganisms during the decomposition process** of dead algae, plants, and fishes. The new **anaerobic conditions** (absence of oxygen) promote the growth of bacteria such as **Clostridium botulinum**, which produces **toxins** that are **deadly to aquatic organisms**, **birds**, and **mammals**.

### Harmful Algal Blooms

- **Most algal blooms are not harmful**, but some **produce toxins (neuro and hepatotoxins)**, which can kill aquatic organisms (E.g., **Shellfish poisoning**) and pose a threat to humans and are known as **Harmful Algal Blooms (HABs)**. They adversely affect commercial and recreational fishing, tourism, and valued habitats.

## Eutrophication and Dead Zones

### The World's Oceans have Less Oxygen Today

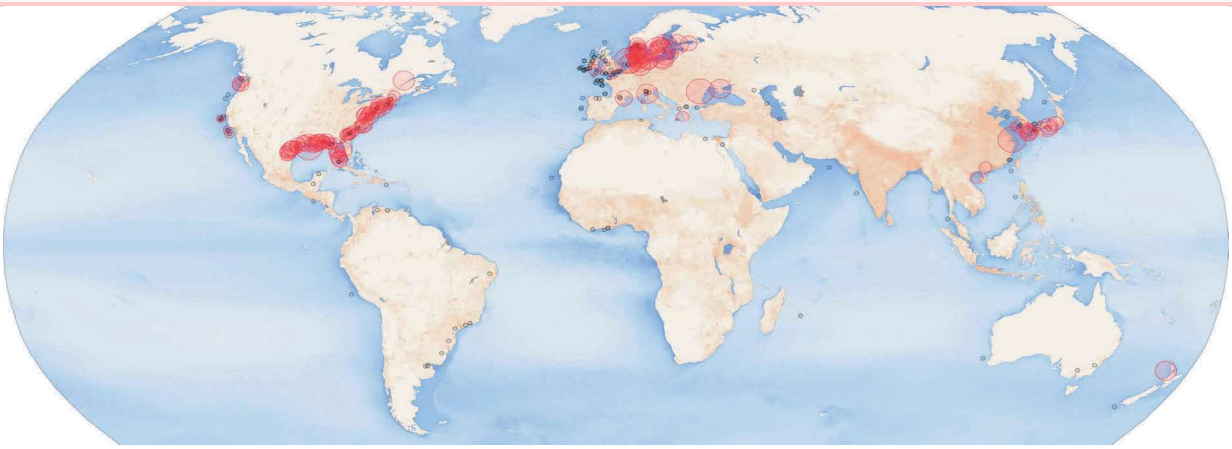
- According to a study by IUCN, the **fall in oxygen levels in the world's oceans** is around **2%** from 1960 to 2010. The primary causes of **deoxygenation** are **eutrophication** and **nitrogen deposition** from the burning of fossil fuels, coupled with the widespread impacts of **ocean warming**.
- **Warmer oceans** cause **deoxygenation**, both **because oxygen is less soluble in warmer water** and through **temperature-driven stratification**.

- Ice melt and glacial runoff result in a less salty and, therefore, **less dense layer that floats on top**. This **stratification inhibits the upwelling of nutrients** into the upper layer of the ocean. This decrease in nutrient supply is likely to decrease rates of photosynthesis in the surface ocean (where most of the oceanic photosynthesis (such as by phytoplankton) occurs).

## Dead zones

- **Dead zones (biological deserts** or **hypoxic zones)** are areas in the ocean with **very low oxygen concentrations (hypoxic conditions)**. They emerge when the **influx of excess chemical nutrients spurs algae growth (algal blooms)**. These zones usually occur 200-800 meters (in the saltwater layer) below the surface.
- **Hypoxic zones** can occur naturally (due to the upwelling of excess nutrients). They can be created or enhanced by human activity to form dead zones. Dead zones are **detrimental to animal life**. Most of the animal life either dies or migrates from the zone.
- **Dead zones** are increasing in the coastal delta and estuarine regions. One of the largest dead zones forms in the **Gulf of Mexico** every spring (farmers fertilise their crops, and rain washes fertiliser off the land into rivers). There's a dead zone in the Gulf of Oman, and it's growing.

⇨ *Dead Zone Formation: **1) Eutrophication**, **2) Algal Bloom** and **3) Hypoxic condition***



*Red circles show the size and location of dead zones in 2010. Dark blue regions indicate overly fertile water that may give rise to dead zones. (NASA Earth Observatory)*

**[UPSC 2018] What are the consequences of the spreading of 'Dead Zones' on marine ecosystems?**

## Blue Tide

- **Bioluminescent (light-emitting) tides** make occasional appearances along polluted coastlines where seawater has **low dissolved oxygen (climate change)** and a **high presence of nitrogen (eutrophication)**.
- The **blue tide** phenomenon appears when **luminescent dinoflagellates or other marine life make the sea appear deep blue** through **chemical reactions** in their proteins. While smaller tides may be harmless, **slow-moving larger tides impact deep-sea fishing**.

### Bioluminescence

- Bioluminescence is the property of a living organism to produce and emit light. It is an **antipredator response** (predator intimidation) through bioluminescence, which helps the organisms gather and make colonies.
- **Animals**, **plants**, **fungi**, and **bacteria** show bioluminescence. It is found in many marine organisms, such as bacteria, algae, **jellyfish**, crustaceans, sea stars, fish, sharks, etc. Luminescence is generally higher in deep-living and planktonic organisms than in shallow species.

## 14.4. Water Pollution Control Measures

### Bioremediation

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

#### In-situ (at the site) bioremediation

- **Bioventing:** supply of nutrients through wells to contaminated soil to stimulate the growth of bacteria.
- **Biosparging:** injection of air under pressure below the water table to **increase groundwater oxygen concentrations** and enhance the rate of biological degradation of contaminants by bacteria.
- **Bioaugmentation:** microorganisms are imported to a contaminated site to enhance the degradation process.
- Using bioremediation techniques, TERI has developed a mixture of bacteria called '**Oilzapper** and **Oili-vorous-S**', which degrades the pollutants of oil-contaminated sites, leaving behind no harmful residues.

**Recently, 'oilzapper' was in the news. What is it?**

a) It is an eco-friendly technology for the remediation of oil sludge and oil spills.
b) It is the latest technology developed for under-sea oil exploration.
c) It is a genetically engineered biofuel yielding maize variety.
d) It is the latest technology to control the accidentally caused flames from oil wells.

***Answer: a) Current Affairs-Based question. Keep track of similar developments.***

#### Ex-situ bioremediation

- Ex-situ — involves the removal of the contaminated material to be treated elsewhere.
- **Landfarming:** Contaminated soil is excavated and spread over a prepared bed and periodically tilled until pollutants are degraded. The goal is to stimulate indigenous biodegradative microorganisms and facilitate their aerobic degradation of contaminants.
- **Bioreactors:** These involve the processing of contaminated solid material (soil, sediment, sludge) or water through an engineered containment system.

- **Composting:** Composting is nature's recycling of decomposed organic materials into a rich soil known as compost.

### Bioremediation of Arsenic

- Using **arsenic (arsenate and arsenite are the toxic forms)** contaminated water for agricultural purposes can lead to increased concentration of arsenic in fruits and grains, proving toxic to humans. Arsenic can be removed from contaminated soil with the help of ***Bacillus flexus*** and ***Acinetobacter junii***. Both bacteria have a special gene that aids in **arsenic detoxification**. (*B. flexus* exhibited resistance to arsenate and *A. junii* to arsenite.)

### Advantages of bioremediation

- ✓ Destroys a wide variety of contaminants.
- ✓ The destruction of target pollutants is possible.
- ✓ Less expensive and environment-friendly.

### Disadvantages of bioremediation

- ➢ Bioremediation is **limited to biodegradable compounds**.
- ➢ Not all compounds are susceptible to biodegradation.
- ➢ It often takes longer than other treatment processes.

**[UPSC 2017] In the context of solving pollution problems, what is/are the advantage/advantages of bioremediation technique?**

1) It is a technique for cleaning up pollution by enhancing the same biodegradation process that occurs in nature.
2) Any contaminant with heavy metals such as cadmium and lead can be readily and completely treated by bioremediation using microorganisms.
3) Genetic engineering can be used to create microorganisms specifically designed for bioremediation.

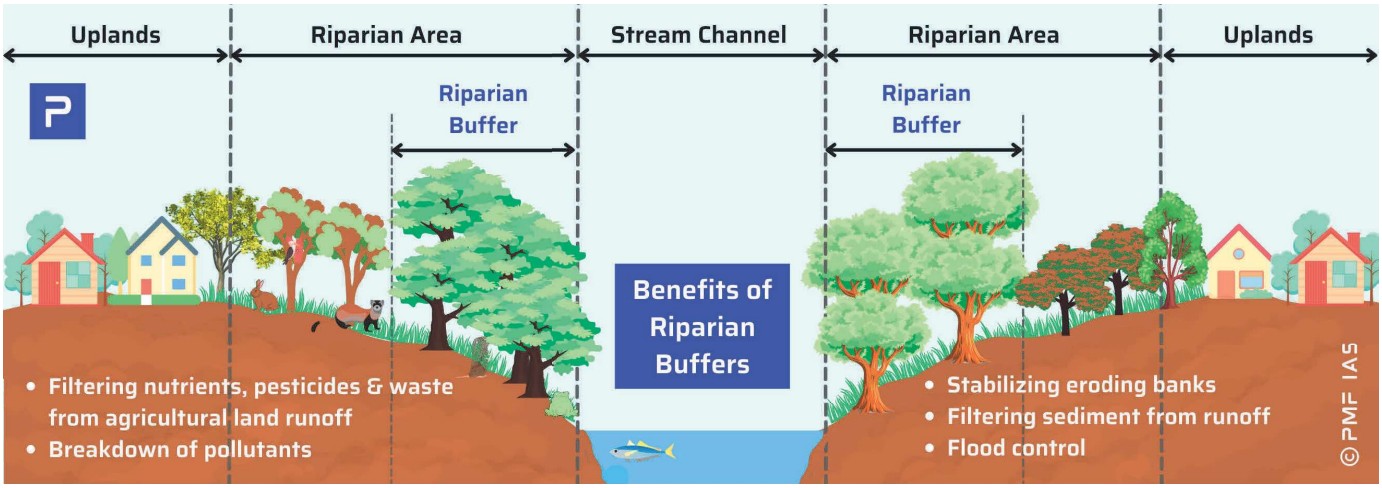
***Select the correct answer using the code given below:***

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

***Bioremediation is limited to biodegradable compounds. Answer: c) 1 and 3 only***

## Riparian buffers for Mitigation of Eutrophication

- **Riparian buffers** are interfaces (of vegetation) between a flowing body of water and land created near the waterways, farms, roads, etc., in an attempt to filter pollution. Sediments and nutrients are deposited in the buffer zones instead of deposition in water (**wetlands and estuaries are natural riparian buffers**). **Phytoremediation** plays a key role in filtering pollutants.




## Phytoremediation

- Phytoremediation is the use of **plants** to remove contaminants from soil and water. Mangroves, estuarine vegetation, and other wetland vegetation are used to carry out natural phytoremediation.
- **Phytoextraction/phytoaccumulation** is the accumulation of contaminants into the roots and aboveground shoots or leaves of plants. E.g., **Water hyacinth** (an **aquatic weed**, **invasive species**) can purify water by taking some toxic materials and several heavy metals from water.
- Planting **eucalyptus** trees all along sewage ponds is suggested. These trees absorb all surplus wastewater rapidly and release pure water vapour into the atmosphere.

# Sewage Water Treatment for Domestic Use

- Sewage water contains suspended solids, bacteria, algae, viruses, fungi, and minerals such as **iron** and **manganese**. The processes involved in removing these contaminants are described here.

## Coagulation / Flocculation

- During coagulation, **coagulants** like **aluminium sulfate (alum)**, **ferric sulphate** or **sodium aluminate** are added to untreated water. This causes the tiny particles of dirt in the water to thicken. Next, groups of dirt particles stick together to form larger particles called **flocs**. Flocs are easier to remove by **settling/filtration**.

## Filtration

- The filters are made of layers of sand and gravel and, in some cases, crushed anthracite (coal). Filtration collects suspended impurities in water and enhances the effectiveness of disinfection.

## Sedimentation

- As the water and the floc particles progress through the treatment process, they move into sedimentation basins, where the water moves slowly, causing the heavy floc particles to settle to the bottom as **sludge**.

## Disinfection

- Water is disinfected using chlorine before it enters the distribution system to ensure that pathogens are destroyed. **Chlorine** is used as it is a very effective disinfectant, and **residual concentrations** can be maintained to guard against possible biological contamination in the water distribution system.
- **Chlorination** is the addition of chlorine or chlorine compounds to drinking water. Chlorine can combine with particular naturally occurring organic compounds in water to produce **chloroform** and other potentially harmful by-products. The risk of this is minimal when chlorine is applied after coagulation, sedimentation, and filtration.
- **Ozone gas** may also be used to disinfect drinking water. However, since **ozone is unstable**, it cannot be stored and **must be produced on-site**, making it more **expensive** than chlorination.
- Ozone has the advantage of **not causing taste or odour problems**. It **leaves no residue** in the disinfected water.
- The lack of an ozone residue, however, makes it difficult to monitor its continued effectiveness as water flows through the distribution system.

## Fluoridation

- Fluoride is generally present in natural water. Its concentration up to a certain level is not harmful. Beyond that level, the **bones start disintegrating (fluorosis)**.
- Water fluoridation is the treatment of water supplies to adjust the concentration of the free **fluoride ion** to the optimum level sufficient **to reduce dental caries or cavities**.
- **Defluorination** at the domestic level can be carried out by mixing water for treatment with an adequate amount of **aluminium sulphate (alum) solution**, **lime** or **sodium carbonate** and **bleaching powder** depending upon its alkalinity (concentration of bicarbonates and carbonates in water) and fluoride contents.
- Many parts of our country have a fluoride problem. BIS prescribes **1.0 mg/l as the desirable limit** for drinking water and **1.5 mg/l as the permissible limit**.

## pH Correction

- **Lime** is added to the filtered water to adjust the pH and stabilise the naturally soft water **to minimise corrosion** in the distribution system and within customers' plumbing.

## Removal of iron

- In many parts of India, there is a problem of excess iron in drinking water, especially in **North-East regions**.
- Iron causes terrible taste and odour to the drinking water. BIS prescribes a desirable limit for iron as **0.3 mg/l**.
- A significant part of iron is oxidised. Then, the water is made to react with **oxidising media (lime)**. By aeration and further oxidation, the dissolved iron is converted to **insoluble ferric hydroxide**. The insoluble iron can thus be easily removed through filtration.

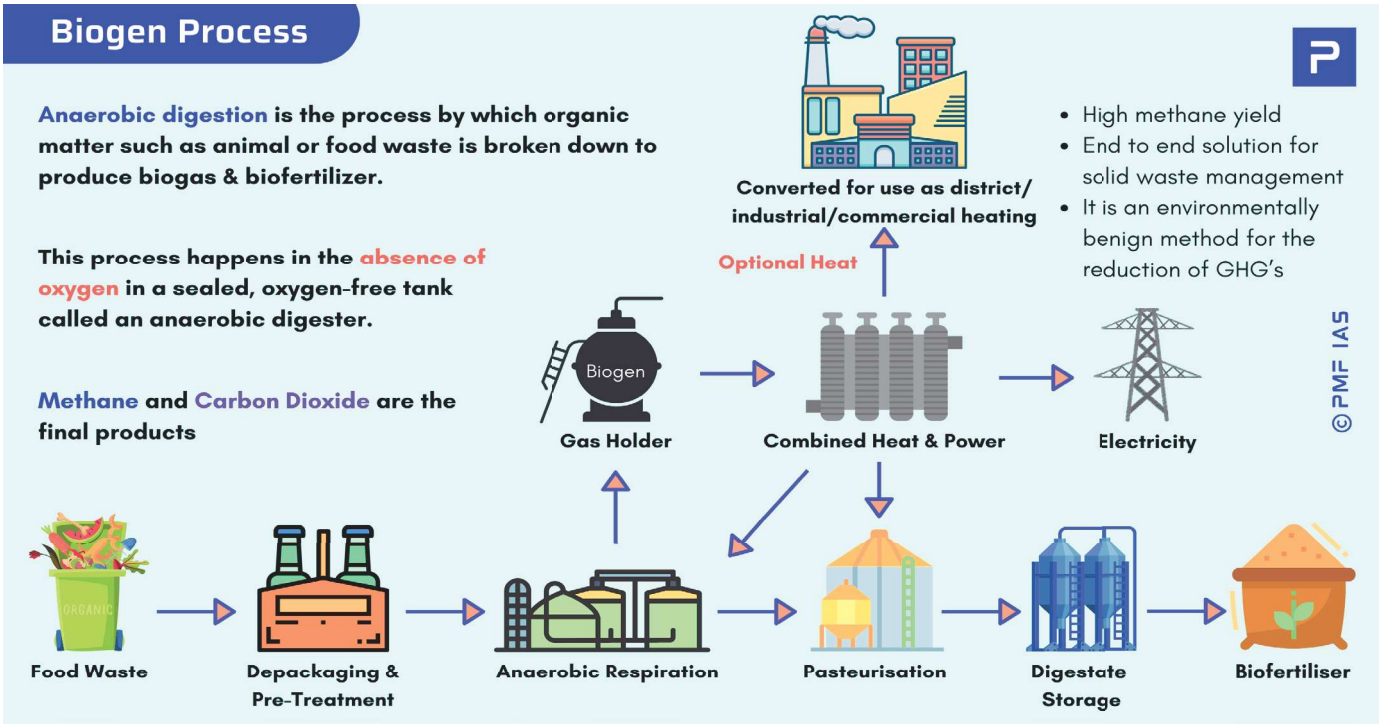
## Removal of arsenic

- BIS prescribes a desirable limit for arsenic as **0.05 mg/l**.
- **Bleaching powder and alum** are used for the removal.

## Bio-Toilets

### Terms associated with Bio-Toilets

- **Bio-digesters: shells of steel for the anaerobic digestion of human waste**.
- **Bio-tank:** tanks made of concrete for the **anaerobic digestion** of human waste.
- **Aerobic Bacteria:** bacteria that **flourish in the presence of free dissolved oxygen** in the wastewater and consume organic matter for their food, thereby oxidising it to stable end products.
- **Anaerobic Bacteria:** bacteria that **flourish in the absence of dissolved oxygen** and **survive by utilising the bounded molecular oxygen in compounds like nitrates ($NO_3$), sulphates ($SO_4$)**, etc, thereby reducing them to stable end products along with the evolution of foul-smelling gases like **$H_2S$ (hydrogen sulphide)** and **$CH_4$ (methane)**.




- **Facultative Bacteria:** bacteria that can operate **either** aerobically or anaerobically.
- **Anaerobic Microbial Inoculums:** a mixture of different types of bacteria responsible for the breakdown of complex polymers into simple sugars, further broken down into low-chain fatty acids and finally into **biogas**.

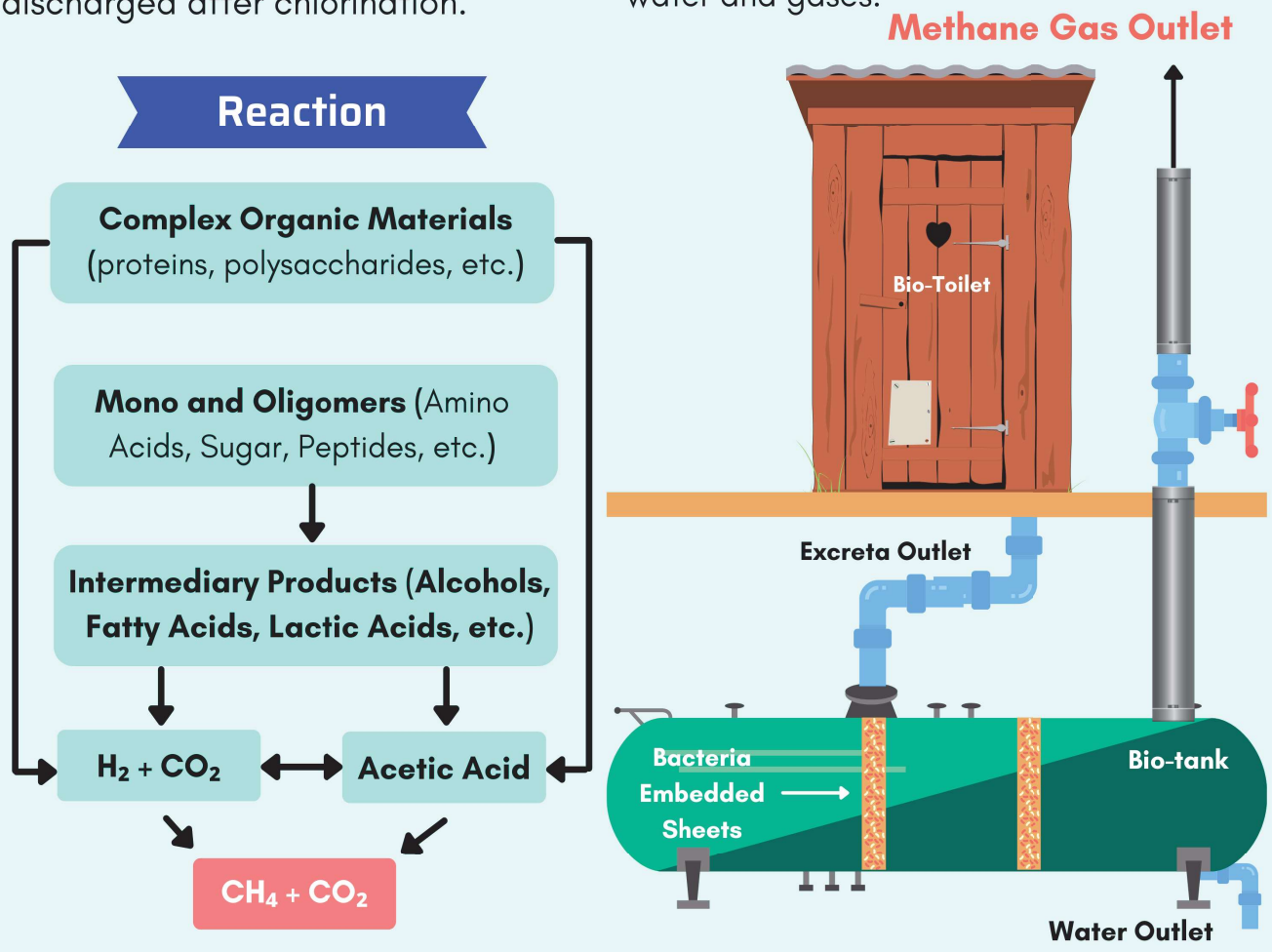
### Anaerobic (Digester) Biodegradation System

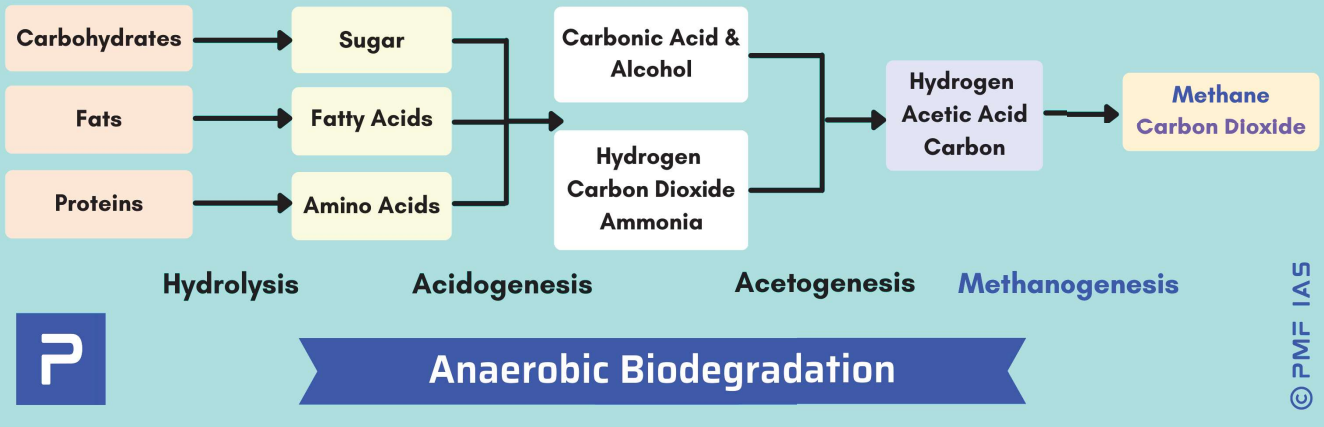
- Anaerobic digestion is a collection of processes by which microorganisms break down **biodegradable** material in the **absence of oxygen**. The final waste is **Methane** (biogas), **Carbon Dioxide** and **biofertiliser**. Every tonne of food waste recycled by anaerobic digestion as an alternative to landfill **prevents between 0.5 and 1.0 tonnes of $CO_2$** from entering the atmosphere, one of the many benefits of anaerobic digestion.

# Bio-Toilets and Anaerobic Biodegradation

The gases are released into the atmosphere and the water is discharged after chlorination.

Bio-Toilets have a colony of **anaerobic bacteria** that converts human waste into water and gases.




Anaerobic Biodegradation



**[UPSC 2015] With reference to bio-toilets used by the Indian Railways, consider the following statements:**

1) The decomposition of human waste in the bio-toilets is initiated by a fungal inoculum.
2) Ammonia and water vapour are the only end products in this decomposition which are released into the atmosphere.

***Which of the statements given above is/are correct?***

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

**Explanation**

- Anaerobic bacteria carry out the decomposition of human waste in bio-toilets. The final waste is **$CO_2$ and $CH_4$**.

***Answer: d) Neither 1 nor 2***

| Anaerobic Biodegradation | Aerobic Biodegradation |
|---|---|
| Complete anaerobic conditions. | Forced aeration is essential, which is energy intensive. |
| More than 99% pathogen inactivation. | Incomplete aeration leads to a foul smell. |
| Anaerobes **can even degrade detergents/phenyl**. | **Cannot tolerate detergents**. |
| Sludge generation is significantly less. | Generate a **large amount of sludge**. |
| One-time bacterial inoculation is enough. | Repeated addition of bacteria/enzymes is required. |
| Minimal maintenance and no recurring cost. | Maintenance and recurring costs are high. |

## EcoSan toilets

- **Ecological sanitation** is a sustainable system for handling human excreta using **dry composting toilets**. This is a practical, hygienic, efficient, and cost-effective solution to human waste disposal. With this composting method, human excreta can be recycled into a natural fertiliser.

## Bio-Toilets in Indian Trains

- Bio-toilets for the Indian trains were designed by **Indian Railways** in association with **DRDO**. The bio-toilets are fitted underneath the lavatories. The human waste discharged into them is acted upon by a particular kind of **bacteria** that converts it into non-corrosive **neutral water**. Direct discharge of human waste from the existing toilet system in trains causes **corrosion of the tracks**.
- Water Pollution Control Measures in India and Indian River Systems The Government of India has passed the **Water (Prevention and Control of Pollution) Act**, **1974** to safeguard our water resources.
- The **Central Pollution Control Board (CPCB)**, an apex body in the field of water quality management, in collaboration with the concerned State Pollution Control Boards (SPCB), has developed a concept of "**designated best use**". Accordingly, the water body is designated as A, B, C, D, and E based on **pH**, **dissolved oxygen**, **BOD**, **total coliform**, **free ammonia**, **electrical conductivity**, **etc**.

- The classification helps the water quality managers and planners to set water quality targets and identify needs and priorities for water quality restoration programmes. The **Ganga Action Plan** and, subsequently, the **National River Action Plan** are the results of such an exercise.

## Major River Conservation Initiatives

### Ganga Action Plan (GAP)

- **GAP** was the first river action plan taken up by MoEF in **1985** as a centrally sponsored scheme. The programme began with pollution abatement works in the river **Ganga**.
- Subsequently, **GAP Phase-II** was initiated, which included the works on the **major tributaries of the river Ganga**, namely, **Yamuna**, **Gomti** and **Damodar**.
- At the time of launching, the main objective of GAP was to improve the water quality of the Ganga to **acceptable standards**. However, it was later recast to the '**Bathing Class**' standard, which is as follows:

| Parameter | GAP Bathing Class |
|---|---|
| **Biochemical Oxygen Demand (BOD)** | **3 mg/l maximum** |
| **Dissolved Oxygen (DO)** | **5 mg/l minimum** |
| **Total Coliform** | **10,000 per 100 ml** |
| **Faecal Coliform** | **25,00 per 100 ml** |

- **Partially successful** GAP I was declared closed on 31st March 2000. It made a significant difference in water quality. However, in many places, the BOD levels were above the **permissible limit of 3.0 mg/l**.

### National River Conservation Plan (NRCP)

- In 1995, GAP was broad-based to cover **other national rivers** under the aegis of the **centrally sponsored scheme National River Conservation Plan (NRCP)**.
- NRCP is under implementation by the **Ministry of Jal Shakti** in **160 towns** along polluted stretches of **34 rivers** spread over **20 States**, **excluding those in the Ganga basin**.
- NRCP provides financial and technical assistance to the States/UTs on a cost-sharing basis. The objective is to implement the following pollution abatement schemes to bring the river to **bathing quality standards**:
  - ✓ Capture and **treatment of raw sewage** before flowing into the river (responsibility of the respective State Governments and Urban Local Bodies);
  - ✓ Prevention and control of **industrial pollution** (by the respective **Pollution Control Boards**).
  - ✓ **Low-cost sanitation** works to prevent open defecation on river banks;
  - ✓ **Electric crematoria** to ensure proper cremation of bodies brought to the burning ghat;
  - ✓ **Riverfront development** works such as improvement of bathing ghats, etc.

### National Ganga Council

- The National Council for Rejuvenation, Protection and Management of the River Ganga **(National Ganga Council)** was established by the River Ganga (Rejuvenation, Protection, and Management) Authorities Order, **2016**. It replaced the **National Ganga River Basin Authority (NGRBA)**.

- NGC has the overall responsibility of **preventing pollution** and **rejuvenating** the Ganga River Basin. **National Mission for Clean Ganga (NMCG – registered as a society under the Societies Registration Act 1860)** is the implementation wing of NGC, which is implementing the **Namami Gange Programme**.

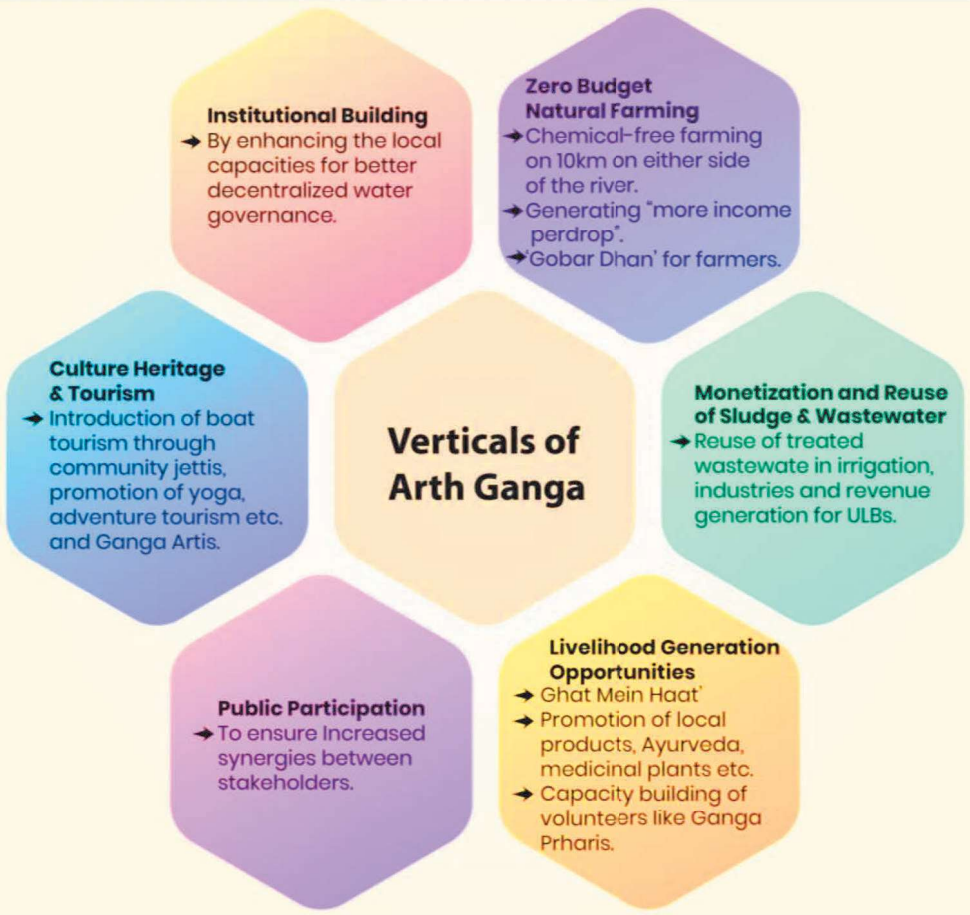
### Members of the National Ganga Council

- **Prime Minister – Chairperson**
- **Union Minister for Jal Shakti – Vice-Chairperson**
- **Union Minister for Environment**, **Finance**, **Power**, **Housing**, **Science and Technology**, **State for Tourism and Shipping**.
- **CMs of States** through which Ganga or its tributaries flow.
- **Vice Chairperson**, **Niti Aayog**

## National Ganga River Basin Authority (NRGBA)

- GOI established NGRBA in **2009** under Section 3 of the **Environment Protection Act**, **1986**. NGRBA declared the Ganges as the "**National River**" of India. **National Ganga Council** replaced it in 2016.

## Project Arth Ganga




- Project Arth Ganga is a **sustainable development model** focusing on channelising **river-related economic activities** along the banks of the Ganga River.

- It strives to contribute at least **3% of the GDP** from the Ganga Basin. The concept was introduced during the first **National Ganga Council** meeting in **2019**.
- The **Jal Marg Vikas Project (JMVP)** aimed to develop the river **Ganges as a safe mode of navigation** and is being implemented with the assistance of the **World Bank**. 'Project Arth Ganga' envisages re-engineering the JMVP by involving the local community with a focus on economic activities.
- Small jetty terminals (a structure that projects from land out into the water) will be set up along the banks to boost the economic activities at the community level, which will bring down the logistics cost for farmers in the movement of local produce.

## Namami Gange Programme

- In addition to the NRCP, the **Ministry of Jal Shakti** is implementing the central sector scheme of **Namami Gange**, an **Integrated Conservation Mission**, approved as a 'Flagship Programme' by GOI in 2014 with a budget outlay of **Rs**. **20,000 Crore** to accomplish the twin objectives of **abatement of pollution**, **conservation** and **rejuvenation** of Ganga.
- The main pillars of the programme are:
  - ✓ Sewerage Treatment Infrastructure
  - ✓ River-Front Development
  - ✓ River-Surface Cleaning
  - ✓ Bio-Diversity
  - ✓ Afforestation
  - ✓ Public Awareness
  - ✓ Industrial Effluent Monitoring
  - ✓ Ganga Gram.

## Clean Ganga Fund

- It was set up in **2014** as a trust under the **Indian Trust Act**, **1882**. It allows resident Indians, Non-Resident Indians (NRIs), Persons of Indian Origins (PIOs), Corporates (Public as well as private sector) to contribute towards the conservation of the river Ganga. The contributions to the Clean Ganga Fund fall within the purview of **Corporate Social Responsibility (CSR)**.

**[UPSC 2016] Which of the following are the key features of 'National Ganga River Basin Authority (NGRBA)'?**

1. River basin is the unit of planning and management.
2. It spearheads the river conservation efforts at the national level.
3. One of the Chief Ministers of the States through which the Ganga flows becomes the Chairman of NGRBA on rotation basis.

***Select the correct answer using the code given Below.***

a) 1 and 2 only
b) 2 and 3 only
c) 1 and 3 only

d) 1, 2 and 3

**Explanation**

- NGRBA is replaced by NGC, chaired by the Honorable Prime Minister.

***Answer: a) 1 and 2 only***

## Swachh Bharat Mission (SBM)

- SBM was Launched on 2nd October 2014. It is implemented by the **Ministry of Drinking Water and Sanitation (Ministry of Jal Shakti** since 2019**)**. SMB seeks to achieve **universal sanitation coverage** by making Gram Panchayats **Open Defecation Free (ODF)**.
- Under SBM, incentives are provided for all BPL and APL households restricted to SCs/STs, physically challenged, and women-headed households for the construction of household latrines.
- The incentives are provided by the Centre and States **(75%:25%)**. For the NE States, and the Special category States, the Central share will be 90%.

### Performance of the mission

- More than 10 crore individual toilets have been constructed since the mission's launch. **Rural areas in all the states were declared ODF on 2nd October 2019!** (In 2014, sanitation coverage was reported at 38.7 per cent.)

### Swachh Iconic Places

- Swachh Iconic Places (SIP) is an initiative of the **Ministry of Drinking Water and Sanitation (Ministry of Jal Shakti** since 2019**)** under SBM.
- SIP aims to take iconic places and surroundings to higher standards of Swachhata. It is a collaborative project with three other central Ministries: **Urban Development**, **Culture**, **Tourism** and concerned States.
- Initiatives taken up under the Swachh Iconic Places initiative include improved sewage infrastructure and sanitation facilities, water vending machines, solid and liquid waste management (SLWM), lighting arrangements, park beautification, road maintenance, and better transport facilities.

#### Places selected for implementation

- **Phase I:** Ajmer Sharif Dargah, CST Mumbai, Golden Temple, Kamakhya Temple, MaikarnikaGhat, Meenakshi Temple, Shri Mata Vaishno Devi, Shree Jagannath Temple, The Taj Mahal and Tirupati Temple.
- **Phase II:** Gangotri, Yamunotri, Mahakaleshwar Temple, Charminar, Church of St. Francis of Assissi, Kalady, Gommateswara, BaidyanathDham, Gaya Tirth and Somnath temple.
- **Phase III:** Raghavendra Swamy Temple (Kurnool, Andhra Pradesh), Hazardwari Palace (Murshidabad, WB), Brahma Sarovar Temple (Kurukshetra, Haryana), VidurKuti (Bijnor, UP), Mana village (Chamoli, Uttarakhand), **Pangong Lake (Leh-Ladakh)**, Nagvasuki Temple (Prayagraj), ImaKeithal market (Imphal, Manipur), Sabarimala Temple (Kerala) and Kanvashram (Uttarakhand).

### Swachh Bharat Mission II

- GOI has approved the second phase of the Swachh Bharat Mission (SBM II) to be implemented between **2020-21 and 2024-25**. The estimated central and state budget for SBM II is ~Rs 52,000 crore.
- The second phase will focus on **Open Defecation Free Plus (ODF Plus)**, which includes **ODF sustainability** and **solid and liquid waste management(SLWM)**.
- The ODF Plus will converge with MGNREGA, especially for **greywater** (wastewater from non-toilet plumbing systems such as hand basins, washing machines, showers and baths) management. It will complement the newly launched **Jal Jeevan Mission**.
- The fund-sharing pattern between the Centre and States will be 90:10 for North-Eastern States and the Himalayan States and UT of J&K; **60:40 for other States**; and 100:0 for other Union Territories.

## National Water Quality Monitoring Programme

- CPCBs, in association with the SPCBs, have been monitoring the water quality of rivers in the country through a network of monitoring stations under the **National Water Quality Monitoring Programme**. Based on water quality monitoring results, **pollution assessment of rivers** has been carried out by CPCB from time to time.
- In compliance with the orders of the **National Green Tribunal (NGT)** regarding polluted river stretches in the country, States/UTs are required to implement action plans approved by CPCB for restoration of the said stretches in their jurisdiction within the stipulated timelines.

### Parameters for National Water Quality Monitoring

**Core Parameters (9)**

| |
|---|
| pH |
| Temperature |
| Conductivity |
| Dissolved Oxygen |
| Biochemical Oxygen |
| Nitrate-N |
| Nitrite-N |
| Faecal Coliform |
| Total Coliform |

**Field Observations (7)**

| |
|---|
| Weather |
| Approximate depth of main stream/depth of water table |
| Colour and instensity |
| Odor |
| Visible efluent discharge |
| Human activities around station |
| Station detail |

**Bio-Monitoring Parameters (3)**

| |
|---|
| Saprobity Index |
| Diversity Index |
| P/R Ratio |

**General Parameters (19)**

| | |
|---|---|
| COD | Chloride |
| TKN | Sulphate |
| Ammonia | Total Alkalinity |
| Total Dissolved Solids | P-Alkalinity |
| Total Fixed Solids | Phosphate |
| Total Suspended Solids | Sodium |
| Turbidity | Potassium |
| Hardness | Calcium |
| Fluoride | Magnesium |
| Boron | |

**Trace Metals (9)**

| | | | | |
|---|---|---|---|---|
| Arsenic | Nickel | Copper | Mercury | Chromium Total |
| Cadmium | Zinc | Lead | Iron Total | |

**Pesticide (7)**

| | | | |
|---|---|---|---|
| BHC(Total) | Dieldrin | Carbamate | 2.4 D |
| DDT(Total) | Aldrin | Endosulphan | |

## 14.5. Measures to Curb Marine Pollution

- To curb marine pollution and regulate the use of the world's oceans by individual States, the nations of the world have come together to form two major conventions and an organisation:
  1. **Convention on the Dumping of Wastes at Sea (1972) (replaced by the 1996 Protocol)**
  2. **UN Convention on Law of the Sea (UNCLOS)**
  3. **International Maritime Organization (IMO)**

### Convention on Dumping of Wastes at Sea

- In **1972**, an intergovernmental conference on the **Convention on the Dumping of Wastes at Sea** met in London to adopt this instrument, the **London Convention**. The Convention has a global character and aims to control and **end marine pollution internationally**.
- The definition of dumping under the Convention relates to the deliberate disposal at sea of wastes or other materials from vessels, aircraft, platforms and other man-made structures. 'Dumping' here **does not cover** wastes derived from the **exploration and exploitation of sea-bed minerals**.
- **Dumping of low-level radioactive wastes** and **industrial wastes**, as well as **incineration of wastes**, were **earlier permitted by the Convention**. The 1978 amendment **banned the incineration of wastes at sea**.
- The 1993 amendment **banned the dumping of low-level radioactive wastes** into the seas. It **phased out the dumping of industrial wastes** by 1995.

#### 1996 Protocol

- The Protocol, which became effective in 2006, replaces the 1972 Convention. The 1996 Protocol is **much more restrictive** than the **1972 Convention**, which **allowed dumping provided certain conditions were satisfied**. The **International Maritime Organization (IMO)** is responsible for Secretariat duties concerning the Protocol.
- The 1996 Protocol calls for appropriate preventive measures to be taken when wastes thrown into the sea are likely to cause harm "even when there is no conclusive evidence to prove a relation between inputs and their effects."
- The Protocol states that "**the polluter should**, **in principle**, **bear the cost of pollution**", and the parties must ensure that the Protocol does not simply result in pollution being transferred from one part of the environment to another.
- The Protocol **prohibits the Contracting Parties from dumping** "**wastes or any other matter except those listed in Annex I — includes dredged material; sewage sludge; fish waste from industrial fish processing operations**, etc. for which the concern is mainly physical impact".
- The Protocol **prohibits the incineration of wastes at sea** (permitted by the 1972 convention but prohibited under the 1993 amendments). It states that "Contracting Parties **shall not allow the export of wastes or other matter to other countries for dumping or incineration at sea**".

#### 2006 Amendments to the 1996 Protocol

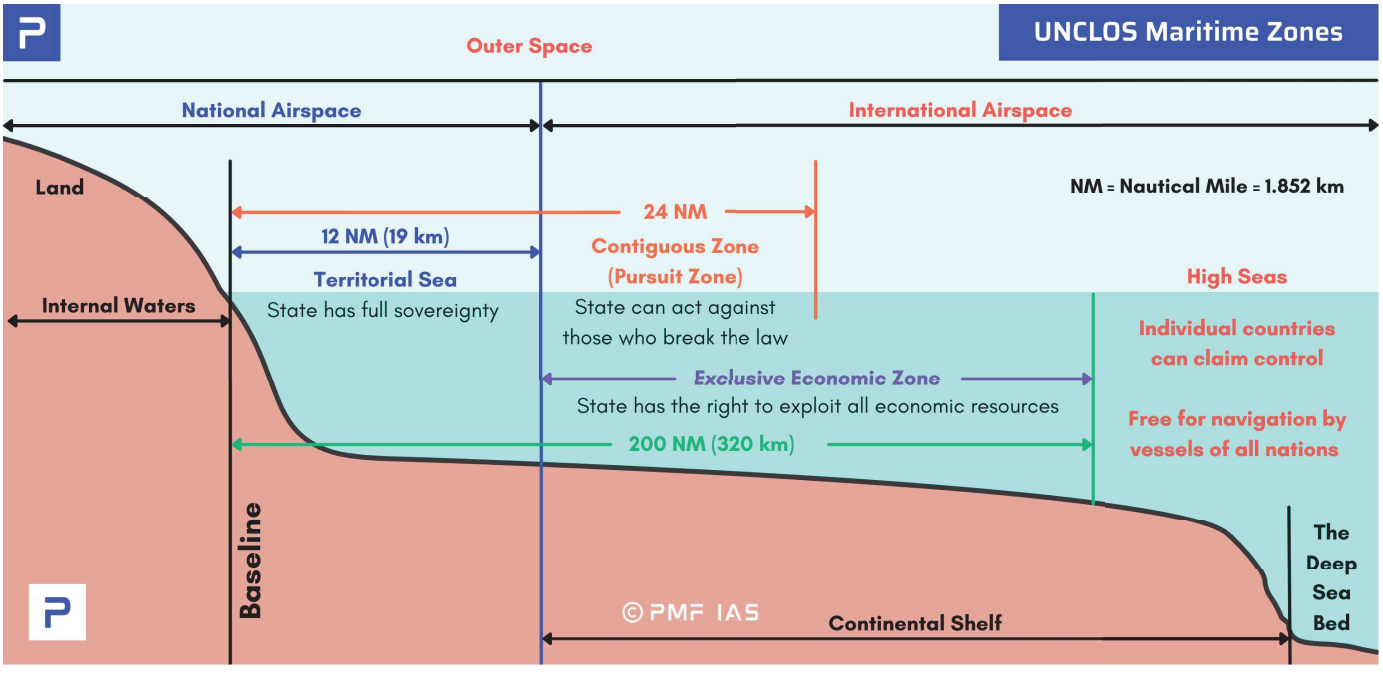
- Adopted in 2006, the amendments were enforced in 2007. They have created a basis in international environmental law to **regulate carbon capture and storage in the sub-sealed geological formation**. It is part of the measures to address **climate change** and **ocean acidification**.
- The amendments **allow the storage of carbon dioxide ($CO_2$) under the seabed** but **regulate the sequestration of $CO_2$ streams from $CO_2$ capture processes in sub-seabed geological formations**.

## The United Nations Convention on Law of the Sea (UNCLOS)

- UNCLOS establishes general obligations for **safeguarding the marine environment** and **protecting the freedom of scientific research** on the **high seas**. It can hold states liable for damage caused by violation of their international obligations through its three institutions:
  1) **International Tribunal for Law of Sea**
  2) **International Seabed Authority (ISA)**
  3) **Commission on the limits of the continental shelf**
- The convention clearly defines Internal Waters, Territorial Waters, Contiguous Zone, Exclusive Economic Zone and Continental Shelf. It **provides rights to landlocked states for access to and from the sea without taxation of traffic through transit states**.

### International Seabed Authority (ISA)

- UNCLOS creates a **legal regime** for controlling **resource exploitation** in **deep-seabed areas** beyond national jurisdiction through the **International Seabed Authority** (168 members; **India is a member**).
- ISA organises, regulates and controls all mineral-related activities in the international seabed area **beyond the limits of national jurisdiction**.




## International Maritime Organization (IMO)

- IMO is the **global standard-setting authority** for the safety, security and environmental performance of **international shipping**. Its headquarters is in the **UK (the only UN Special Agency to have its headquarters in the UK)**.
- IMO's objective is "**Improvement of maritime safety and prevention of marine pollution**". I
- IMO's **Maritime Environment Protection Committee** is responsible for coordinating the organisation's activities in the prevention and control of marine pollution. Its measures cover **accidental and operational oil pollution**.

### Ballast Water Management Convention (2004)

- This IMO convention aims to **prevent the spread of harmful aquatic organisms** from one region to another through **ballast water**, which is widely regarded as the most critical vector for spreading **potentially invasive alien species**.
- Ballast water is **water carried in a ship's ballast tanks** to improve its stability and balance. It is taken up or discharged when cargo is unloaded or loaded. Without special precautions, this practice causes a **massive spread of marine organisms** from their native habitats to areas where they do not naturally occur.

### Bunker Convention (2001)

- **Bunker Convention** ensures that adequate **compensation** is available to persons who suffer **damage caused by oil spills**. It applies to damage caused on the territory, including the **territorial sea** and **exclusive economic zone** of state parties. It is modelled on the **International Convention on Civil Liability for Oil Pollution Damage**, **1969**.

⇨ ***India has ratified both the conventions of IMO***

### Regional Oil Spill Contingency Plan

- It was jointly launched by South Asia Co-operative Environment Programme (**SACEP**) and **IMO** to facilitate international cooperation and mutual assistance in preparing and responding to major oil pollution incidents in the seas around **Bangladesh**, **India**, **Maldives**, **Pakistan and Sri Lanka**.

## High Seas Treaty (HST)

- The **UN** adopted the **Marine Biodiversity of Areas Beyond National Jurisdiction (BBNJ)** or the **High Seas Treaty (HST)** under the **UN Convention on the Law of the Sea (UNCLOS)**.
- **High Seas Treaty (HST/BBNJ)** is referred to as the **'Paris Agreement for the Ocean'**. It became the **third agreement approved under the UNCLOS** after the **1994** and **1995 treaties**, which established the **International Seabed Authority** and the **Fish Stocks Agreement**.

### What are High Seas (or Areas Beyond National Jurisdiction)?

- **High seas (open seas/international waters)** refer to ocean areas **beyond any national jurisdiction**. They exist **beyond the Exclusive Economic Zones (EEZ)**.

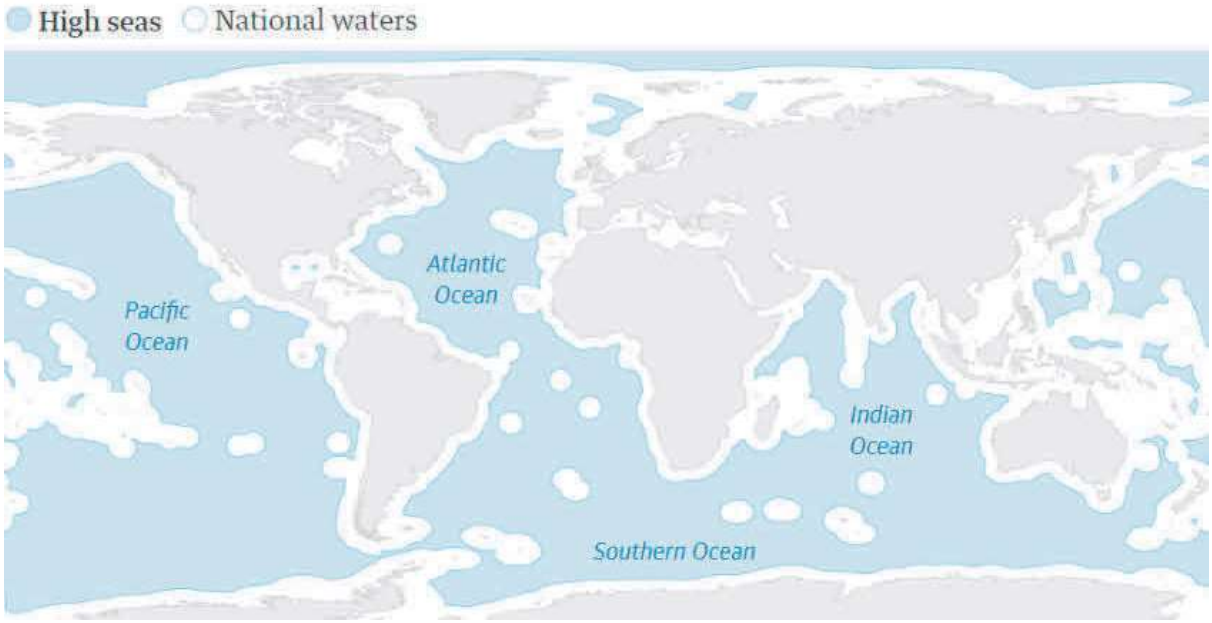
- High or open seas cover **almost 2/3rd of the world's oceans**. These waters are considered the **common heritage of humankind**, and all nations have the **freedom to navigate**, **fish**, **conduct scientific research**, and engage in other lawful activities in these areas.

## Need for BBNJ/HST

- ✓ Ocean ecosystems produce **half the oxygen** we breathe, represent **95% of the planet's biosphere** and soak up carbon dioxide, as the **world's largest carbon sink**.
- ✓ Though high seas cover the majority of ocean area, **only 1% of them are legally protected**.

## Aims of BBNJ/HST

- To **address critical issues** such as the increasing sea surface temperatures, overexploitation of marine biodiversity, overfishing, coastal pollution, and unsustainable practices **beyond national jurisdiction**.




## Key features of the High Seas Treaty

- **Marine Protected Areas (MPAs):** The treaty will provide a **legal framework** for establishing vast **MPAs** to protect against the loss of wildlife and share the **genetic resources** of the high seas.
- **Conference of the Parties (CoP):** It will establish a CoP that will meet periodically and enable member states to be held to account on issues such as governance and biodiversity.
- **Polluter-pays principle:** Those causing pollution in a particular region are responsible for its reduction.
- **Traditional Knowledge** associated with marine genetic resources in areas **beyond national jurisdiction** held by indigenous/local communities shall only be accessed with their free, prior, and informed consent.
- **Special Circumstances Nations:** The treaty acknowledges the special circumstances and needs of **small island developing states**, **least developed countries**, and **landlocked developing countries**.

## Achievement of '30×30'

- **30x30** is a worldwide initiative for governments **to designate 30% of Earth's land** and **ocean area as protected areas by 2030**.
- It was launched by the **High Ambition Coalition for Nature and People** in **2020**, which now has more than 100 countries, including **India**, the **US**, and the **UK**.
- **30 by 30** was agreed at the **COP15 meeting of the Convention on Biological Diversity** and became a target of the **Kunming-Montreal Global Biodiversity Framework**.

## Realizing the 2030 Agenda or SDGs

- The treaty will help achieve **SDG Goal 14: Life Below Water > "Conserve** and **sustainably use the oceans**, **seas**, and **marine resources for sustainable development"**. This goal entails:
  - ✓ Reducing **marine pollution** and **ocean acidification** and protecting and restoring ecosystems.
  - ✓ Supporting sustainable fishing and **small-scale fishers**.
  - ✓ **Ending subsidies contributing to overfishing**.
  - ✓ Increasing the economic benefits from the sustainable use of marine resources.

## Clear House Mechanism

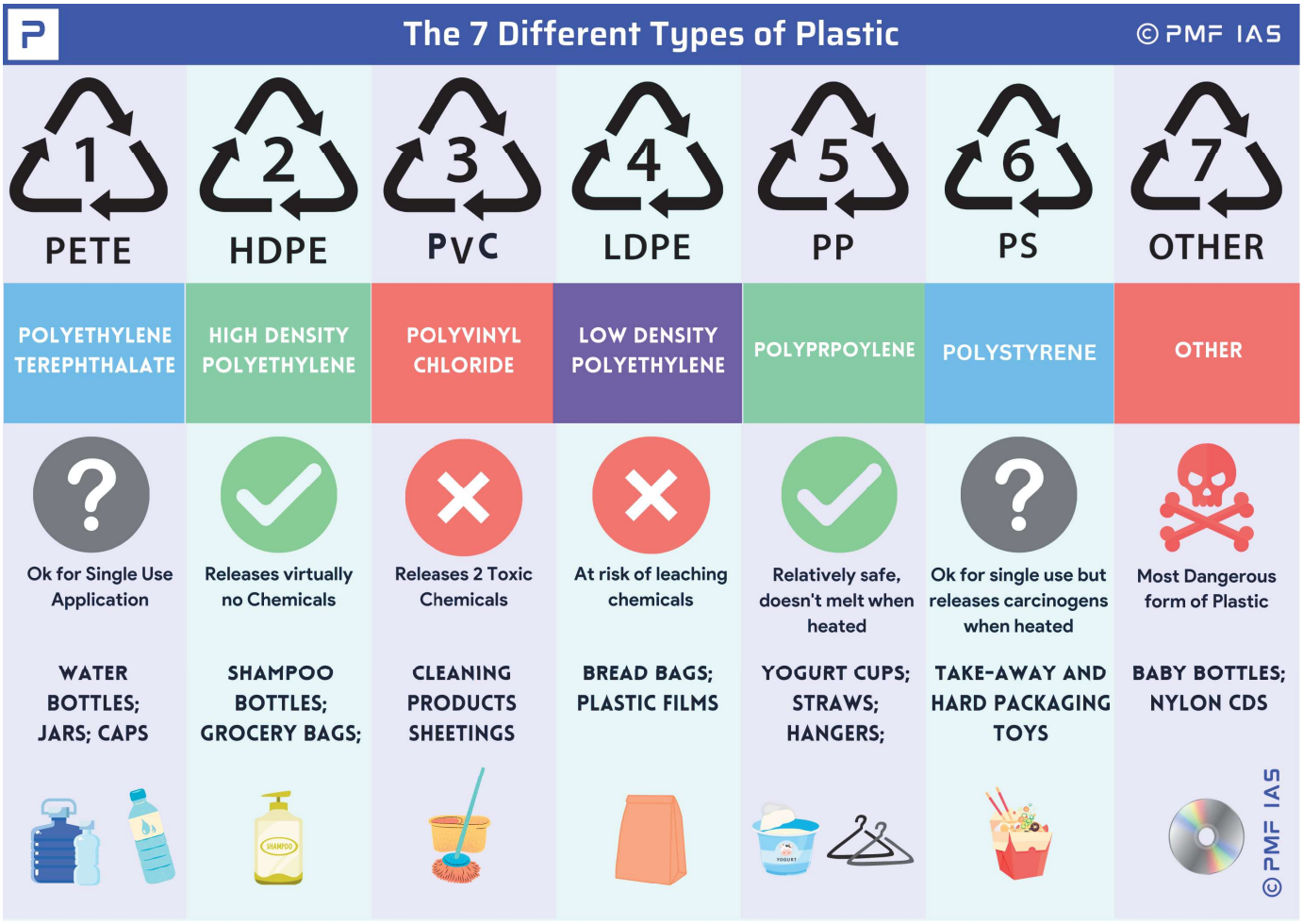
- For fair sharing of scientific information and monetary benefits, the treaty mandates installing a **clear house mechanism**. Through the mechanism, information on marine protected areas, marine genetic resources, and area-based management tools **will be open to access for all parties**.

## Opposition to the treaty

- Many **developed countries** opposed the treaty as they stand by private entities that are at the forefront of advanced research and development in marine technology. **Russia** and **China** are also not in favour of the treaty.

**---------- End of Chapter ----------**

# 15. Plastic Pollution, Solid, Hazardous and E-Waste




## 15.1. Plastic Pollution

- Plastic pollution is the accumulation of plastic objects and particles in the Earth's environment that adversely affects humans, wildlife and their habitat.
- Globally, **~270 million tons (mt) of plastic is produced**, and **~275 mt of plastic waste is generated yearly**. Up to **8-12 mt** of plastics are thought to enter the world's oceans yearly. Plastic fragments were found even in the guts of animals living more than **10 km below the ocean surface**.

### Microplastics, Microbeads and Nanoplastics

#### Microplastics

- **Microplastics** are shreds of plastic **less than 5 mm in length but larger than 1 micrometre**. They are often smaller than the tiniest grain of sand or a fraction of the width of a human hair. They come from various sources, including the breakdown of larger plastic debris.

- **Microplastics** are used in cosmetics, personal care products, industrial scrubbers, microfibers in textiles and virgin resin pellets used in plastic manufacturing processes.
- Several studies have established the presence of **microplastics in groundwater**. A study estimated that the average human ends up consuming at least 50,000 microplastics in food every year. Their **impact on tiny marine organisms is even more significant** since their injection leaves them starved and affects the marine food web.

## Microbeads

- **Microbeads** (>0.1 µm and < 5 mm) are very tiny pieces of plastic that are added to **health and beauty products**, such as in **some cleansers** and **toothpaste** (cooling crystals). However, one of the main contributors to microbead pollution is not manufactured microbeads but regular plastic waste, 90% of which is not recycled.

**[UPSC 2019] Why is there a great concern about the microbeads that are released into environment?**

a) They are considered harmful to marine ecosystem
b) They are considered to cause skin cancer in children
c) They are small enough to absorbed by crop plants in irrigated fields
d) They are often found to be used as food adulterants

### WHO: Microplastics in drinking water not a health risk

- In its first report into the effects of microplastics on human health, WHO said the level of microplastics in drinking water is **not yet dangerous for humans**. WHO said that microplastics **larger than 150 micrometres** are **not likely to be absorbed by the human body**, but the **chance of absorbing very small microplastic particles (nano-sized plastics) could be higher**.

### Microplastics in Human Blood

- For the **first time**, **microplastic pollution has been detected in human blood**. Blood samples contained **PET plastic**, **polystyrene** and **polyethylene**.
- The **particles can travel** around the body and may lodge in organs. It found that microplastics can latch onto the **outer membranes of red blood cells** and may **limit their ability to transport oxygen**. The particles have also been found in the **placentas of pregnant women**.

## Nanoplastics

- **Nanoplastics** are tiny plastic particles **smaller than 1,000 nanometres** (1 nm = one billionth of a metre). **They can pass through physiological barriers** and **enter organisms**.

✓ **Primary nanoplastics:** They are **intentionally produced** and used in various products, such as **cosmetics**, **washing powders**, research and diagnostics.

✓ **Secondary nanoplastics:** They are formed in the environment, especially in rivers and oceans, by fragmenting larger pieces of plastic.

### Nanoplastics in the Human Food Chain

- **Nanoplastics** can travel up the human food web through plants, insects and even fish. Nanoplastics from the soil were taken up the roots of the plants and accumulated in the leaves. In fishes and mammals, the **liver** contained the **highest concentration of nanoplastics**, indicating that the liver is the primary target tissue in vertebrates.

## Major Plastics in Use

### Polyethylene Terephthalate (PET Plastic)

- PET (**polyethylene terephthalate**), the chemical name for **polyester**. It is a **clear**, **strong**, **lightweight plastic** widely used for packaging foods and beverages, especially convenience-sized soft drinks, juices, water, cooking oils, etc.
- PET is **entirely recyclable**. They can easily be identified by the #1 in the triangular "chasing arrows" code, which is usually moulded into the bottom or side of the container. No other plastic carries the **#1 code**.


**[UPSC 2022] With reference to polyethylene terephthalate, the use of which is so widespread in our daily lives, consider the following statements:**

1. Its fibres can be blended with wool and cotton fibres to reinforce their properties.
2. Containers made of it can be used to store any alcoholic beverage.
3. Bottles made of it can be recycled into other products.
4. Articles made of it can be easily disposed of by incineration without causing greenhouse gas emissions.

***Which of the statements given above are correct?***

a) 1 and 3
b) 2 and 4
c) 1 and. 4
d) 2 and 3

**Explanation**

- Glass bottles are the safest for storing most liquids. Plastics contain certain chemical substances (**ethylene glycol** and **terephthalic acid**) that tend to leach if alcohol is stored for an extended period.

***Answer: a) 1 and 3 only***

### Polyethylene/Polythene (PE)

- **Polyethylene** is the most **common plastic** in use today. It is made from the **polymerisation of ethylene**. Ethylene ($C_2H_4$) is a gaseous hydrocarbon commonly produced by ethane cracking (a principal constituent of **natural gas**).
- Polyethylene is a polymer primarily used for packaging **(plastic bags**, **films**, **geomembranes**, **containers including bottles**, **etc.)**. It has **low strength**, **hardness**, and **rigidity** but has **high ductility**, **impact strength**, and **low friction**.
- Polyethylene is **not readily biodegradable** and thus accumulates in soil. However, several species of **bacteria can degrade polyethylene**. It can be read with **"PE"**.


### Polystyrene

- **Polystyrene** is a synthetic aromatic hydrocarbon polymer made from the monomer known as **styrene**. Polystyrene is a **hard**, **solid**, versatile plastic used to make various consumer products. It is often used in products that require clarity, such as food packaging and laboratory ware.
- When combined with various colourants, additives or other plastics, it is used to make **appliances**, **electronics**, **automobile parts**, **toys**, and **gardening pots**.

## Effects of Plastic Waste

### Impact on Health and Life

- Several chemicals used in producing plastic materials are known to be **carcinogenic**. They interfere with the body's **endocrine system**, causing developmental, reproductive, neurological, and immune disorders in humans and wildlife.
- **Dioxin** (**highly carcinogenic toxin**), the by-product of the plastic manufacturing process, is one of the chemicals believed to be passed on through **breast milk** to the infant.
- The burning of plastic waste releases **Polycyclic Aromatic Hydrocarbons (PAHs)** compounds, which, when inhaled, can lead to cancer, respiratory diseases, obesity, etc.
- Plastic **disturbs soil microbe activity** as it **takes several decades/centuries to decompose**. Terrestrial and aquatic animals misunderstand plastic garbage as food items, swallow it, and die.
- Presence of microplastics affect the soil health, water quality, nutrient cycling, and the organisms that inhabit these environments. These have **cascading effects** **on the entire food web**. They can accumulate in the tissues of organisms and transfer toxic chemicals through the food chain.

### Impact on the Environment

- Conventional plastics, right from their manufacture from toxic materials such as **benzene** and **vinyl hydrochloride** to their disposal, are a significant problem.
- Primary emissions from plastic production processes include **sulfur oxides**, **nitrous oxides**, **methanol**, **ethylene oxide**, and **VOCs**. Burning of plastics, especially **PVC**, releases **dioxin** and **furan** **(VOC)** into the atmosphere.

### Dioxins

- ⇨ ***Dioxins*** *belong to the so-called* ***"dirty dozen"*** *– a group of dangerous chemicals known as* ***persistent organic pollutants (POPs)***.
- ⇨ *The name "dioxins" is often used for the family of structurally and chemically related* ***polychlorinated dibenzo para dioxins (PCDDs)*** *and* ***polychlorinated dibenzofurans (PCDFs)***.

### Vinyl chloride

- ⇨ ***Vinyl chloride*** *is an artificially produced colourless gas that burns easily. It is used primarily to make* ***polyvinyl chloride (PVC)***, *a hard plastic resin used to make various plastic products, including pipes, wire and cable coatings, and packaging materials. (PVC is not a known or suspected carcinogen, but* ***vinyl chloride is****.)*
- ⇨ *Vinyl chloride is also produced as a combustion product in* ***tobacco smoke****. In the environment, the highest levels of vinyl chloride are found in the* ***air around factories*** *that produce vinyl products.*
- ⇨ *Vinyl chloride exposure is associated with an increased risk of liver* ***cancer****, brain and lung cancers, lymphoma, and leukaemia.*

- Plastics can contaminate foodstuffs due to **chemicals leaching** into foods or beverages. Some of the chemicals in plastic include **polycarbonate**, which leaches **bisphenol A** (induces infertility, obesity, heart disease, type II diabetes, and cancer); **polystyrene**, which leaches **styrene**; and **polyvinyl chloride**, which breaks down into **vinyl chloride**.
- Careless disposal of plastic bags chokes drains, blocks the porosity of the soil and hinders **groundwater recharge**.

## Plastic Waste Management Rules, 2016

- GOI has notified the 2016 rules in place of earlier **Plastic Waste (Management and Handling) Rules, 2011**. It extended the rules to **all villages**, which were earlier admissible up to municipal areas.
- The 2016 rules increased the **minimum thickness of plastic carry bags** from **40 to 50 microns** and stipulated a minimum thickness of **50 microns for plastic sheets**. Sachets made of plastic material used for storing, packing, or selling gutkha, tobacco or pan masala are prohibited.

### Extended Producer's Responsibility (EPR)

- **EPR** pins responsibility on producers, generators and brand owners in waste management and collect back systems.
- **Plastic waste management fee** collection through pre-registration of the producers, importers of plastic carry bags/multilayered packaging and vendors selling the same for establishing the waste management system.

### Responsibility

- The local bodies shall be responsible for **setting up**, **operationalisation and coordination** of the waste management system and for performing associated functions.
- Retailers or street vendors shall not sell or provide commodities in plastic sheet or multilayered packaging, or they are **liable to pay such fines**.

## Reuse of plastic waste

- Exploring options for the reuse of plastic in various applications, namely, road construction, waste-to-oil, and waste-to-energy, which will enhance plastic recycling.
- Phasing out **non-recyclable multilayered plastic**.

## 2018 Amendment

- The amended rules lay down that the **phasing out of Multilayered Plastic (MLP)** is now applicable only to MLPs that are **"non-recyclable**, or **non-energy recoverable**, or **with no alternate use"**.
- The amended Rules also prescribed an automated **central registration system** to be evolved by the **CPCB** for the registration of the producer/importer/brand owner.
- It **omitted Rule 15**, i.e. explicit pricing of carry bags mentioned in the 2016 rule.

## 2021 Draft Rules

- They will **extend the rules' applicability** to **brand owners** and **plastic waste processors**, including **recyclers** and **co-processors**.
- Draft proposes a **ban on specific single-use plastic** from Jan 1, 2022, and an increase in the thickness of carry bags made of **virgin plastic** to **120 microns from 50 microns**.

## Plastic Waste Management Amendment Rules 2021

- MoEF notified the 2021 rules, **prohibiting identified single-use plastic** (low utility and high littering potential) items from **July 2022**.
- The thickness of plastic carry bags increased from 50 to 75 microns from 30$^{th}$ September 2021 and to **120 microns** with effect from 31$^{st}$ December 2022.
- Guidelines for **EPR** are given **legal force**.
- Plastic packaging waste (not banned) must be collected and managed through the Extended Producer Responsibility of the Producer, importer, and Brand owner (PIBO), as per the 2016 rules.
- MoEF has constituted a national level taskforce for making coordinated efforts to eliminate identified single-use plastic items and effective implementation of **Plastic Waste Management Rules**, **2016**. The States/UTs have been asked to constitute a **Special Task Force** for the same.

## Banned Plastics

- Abiding by the rules, **CPCB** has announced a list of single-use plastic items that will be completely banned by the **end of June 2022**.

- ✓ **Plastic sticks** used in earbuds, balloons, candy and ice cream.
- ✓ **Plastic cutlery items** include plates, cups, glass, forks, spoons, knives and strays.
- ✓ **Plastic packaging/wrapping films** are used in sweet boxes, invitation cards, and cigarette packets.
- ✓ Other items: **polystyrene (thermocol)** for decoration, **PVC banners with less than 100 microns** and plastic stirrers.

## NITI Aayog's Report on Alternatives to Plastics

- NITI Aayog pushes waste minimisation drive in its report **'Alternative Products and Technologies to Plastics and their Applications'**.

### Major Findings of NITI Aayog's Report

- ➢ India produced **3.47 mt of plastic waste per annum**.
- ➢ Per capita waste grew from 700 grams to 2,500 grams over the last five years.
- ➢ The highest per capita plastic waste-generating states ➔ **Goa**, **Delhi** and **Kerala**.
- ➢ The Lowest per capita plastic waste-generating states ➔ **Nagaland**, **Sikkim** and **Tripura**.
- ➢ India collects only 60% of its plastic waste, and the remaining 40% remains in the environment.
- ➢ Globally, 97-99% of plastics are derived from **fossil fuel feedstock** while the remaining come from bio (plant) based plastics.

### Recommendations in the NITI Aayog Report

- ✓ Strengthen **waste minimisation** through **Extended Producer Responsibility (EPR)**, proper labelling and collection of **compostable** and **biodegradable plastics** (plat or fossil fuel-based plastics that do not leave toxic residue).
- ✓ **Develop** additives that can make **biodegradable plastic polyolefins** (a family of **thermoplastics** — that can be moulded by heat), such as **polypropylene** (the **rigid plastic** used to produce a wide range of plastic products) and **polyethene (the most common plastic in use)**.
- ✓ Use **bio-plastics (made from organic resources such as vegetable oils and starches)** as an alternative to plastics.
- ✓ Increase transparency in disclosing waste generation, collection, recycling or scientific disposal to bring accountability and **stop Greenwashing** (the process of conveying **misleading information** about how a company's products are more environmentally sound).

**[UPSC 2022] Which one of the following best describes the term "greenwashing"?**

a) Conveying a false impression that a company's products are eco-friendly and environmentally sound
b) Non-inclusion of ecological/environmental costs in the Annual Financial Statements of a country
c) Ignoring the disastrous ecological consequences while undertaking infrastructure development
d) Making mandatory provisions for environmental costs in a government project/programme

### Alternatives to Plastics

- **Glass:** safest for the packaging of food and liquid. Cost-effective, durable and recyclable.
- **Bagasse:** It is made from the pulp of sugarcane or beets (compostable and eco-friendly).
- **Bioplastics:** plant-based plastics used in food packaging.
- **Natural textiles:** examples are cotton, wool, hemp etc.
- **Edible seaweed cups:** seaweed can grow up to 60 times faster than land-based plants.
- **Algae-blended ethylene-vinyl acetate:** transforming air and water pollution (ammonia, phosphates, and carbon dioxide) into plant biomass rich in proteins.
- **Compostable plastics: plant** or **fossil fuel-based** plastics that undergo degradation by biological processes yielding $CO_2$, water, inorganic compounds and biomass and do not leave toxic residue. E.g. BASF's Ecoflex.

#### Plastic waste in road construction

- **Polyblend** is a fine powder of recycled and modified plastic waste. It can be used to make fabrics. It can be mixed with **bitumen** that is used to lay roads. It **enhances the bitumen's water-repellent properties** and helps to increase road life by a factor of three.

## Global Intiatives Against Plastics

### Global Partnership on Plastic Pollution and Marine Litter (GPML)

- It was launched at the **UN Conference on Sustainable Development (Rio+20)** in 2012 in response to the **Manila Declaration (protection of the marine environment from land-based activities)**.

### GloLitter Partnerships Project

- It is a project between **Norway**, **International Maritime Organization (IMO)** and **FAO** aiming to reduce marine litter. It will support developing countries in prevention and reduction of marine litter.

### International Convention for the Prevention of Pollution from Ships (MARPOL)

- It is a global treaty developed by the **International Maritime Organization (IMO)** to prevent pollution of the marine environment by ships from operational or accidental causes. It sets standards / regulations for preventing / controlling various types of ship-generated pollution.

### Plastics Pact

- It brings together businesses, governments and NGOs to reduce, reuse, and recycle plastics in their value chain. **U**.**K**. is the first country and **India** is the first Asian country to launch Plastics Pact.

### Un-Plastic Collective

- It is a voluntary initiative co-founded by the **UN Environment Program (UNEP)**, **Confederation of Indian Industry (CII)**, and **WWF-India**.

## 15.2. Solid Wastes

- Solid waste includes garbage, construction debris, sludge from waste treatment plants and other discarded solid materials. It can come from industrial, commercial, mining, and agricultural operations and from household and public activities. **Municipal solid waste** (trash/garbage) is a solid waste type consisting of everyday items like paper, food wastes, plastics, glass, metals, rubber, leather, textiles, etc., that are discarded by the public

### Sources of Soil Wastes

#### Industrial solid wastes

- Thermal power plants producing **coal ash/fly ash (fly ash in concrete increases the life of roads)**;
- The integrated iron and steel mills producing blast **furnace slag (can be used in portland cement concrete**, **road and railway construction**, and **soil conditioning);**
- Non-ferrous industries like aluminium, copper and zinc producing **red mud (**can be used as **construction material in bricks**, **lightweight aggregates**, **roofing tiles**, **etc.);**
- Sugar industries generating **press mud (can be used as a soil conditioner**, **soil fertiliser)**;
- Pulp and paper industries producing **lime mud (which can be used in bricks**, **cement**, **wastewater treatment**, **and agricultural soils)**;
- Fertiliser and allied industries producing **gypsum (can be used to treat soil alkalinity; used in portland cement** and **plaster of Paris (POP))**;

**[UPSC 2020] Steel slag can be the material for which of the following?**

1. Construction of base road
2. Improvement of agricultural soil
3. Production of cement

***Select the correct answer using the code given below:***

a) 1 and 2 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

***Answer: d) all***

#### Residential and Commercial Waste

- Garbage from residential and commercial places includes food waste, plastics, paper, glass, leather, household items such as electronics, tyres, batteries, old mattresses, used oil, wood, and cardboard.

#### Construction and Demolition Sites

- Construction sites include new construction sites for buildings and roads, road repair sites, building renovation sites and building demolition sites that produce solid wastes such as steel materials, concrete, wood, plastics, rubber, copper wires, dirt, glass, etc.

### Bio-Medical Waste

- This refers to solid waste such as **syringes**, **bandages**, **gloves**, **drugs**, **plastics**, **chemicals**, etc., from hospitals, biomedical equipment and chemical manufacturing.

## Treatment and Disposal of Solid Waste

- **Solid waste management** is the process of **collecting and treating solid wastes**. It also offers solutions for recycling items that do not belong in the trash.
- According to the 12$^{th}$ Schedule of the 74$^{th}$ Constitution Amendment Act of 1992, **urban local bodies (ULBs)** are responsible for keeping cities clean. However, most ULBs lack adequate infrastructure due to poor institutional capacity, financial constraints, and a lack of political will.

### Open dumps

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

### Landfills

- A landfill is a **pit** dug in the ground. Garbage is dumped, and the pit is **covered with soil** every day, thus preventing the breeding of flies and rats. After the landfill is full, the area is covered with a thick layer of mud, and the site can thereafter be developed as a parking lot or a park.
- **All types of waste** are dumped in landfills, and when water seeps through them, it gets contaminated and, in turn, pollutes the surrounding area. This contamination of groundwater and soil through landfills is known as **leaching**.
- Landfills are also not much of a solution since garbage generation, especially in the metros, has increased so much that these sites are turning into **mountains of garbage**. E.g. **Garbage mountain at Delhi's Ghazipur landfill**.

## Sanitary landfills

- Open burning reduces the volume of waste, although it is generally **not burnt to completion**. Sanitary landfills were adopted as substitutes for open-burning dumps and ordinary landfills. They are **more hygienic and built methodically** to solve the problem of **leaching**. These are lined with impermeable materials such as plastics and clay and built over impermeable soil. However, constructing a sanitary landfill is **very costly**.

## Incineration plants

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

## Pyrolysis

- **Pyrolysis** is a process of **combustion (burning)** of material in the **absence of oxygen** or under a **controlled atmosphere of oxygen**. It is an **alternative to incineration**. Pyrolysis of carbonaceous wastes like firewood, coconut, palm waste, corn combs, cashew shells, rice husk paddy straw and sawdust yields **charcoal** and products like **tar**, **methyl alcohol**, **acetic acid**, **acetone** and **fuel gas**.

## Plasma gasification

- **Plasma gasification** is an **extreme thermal process** (uses a combination of electricity and high temperatures) using **plasma** (**without combustion**) that converts **organic matter** into **syngas** **(synthesis gas** — made up of **hydrogen** and **carbon monoxide)**. The inorganic wastes are converted into **slag**, a solid waste.
- Plasma gasification is a **cleaner alternative to landfills**, reducing or eliminating toxicity while avoiding the landfilling of huge amounts of garbage.

**[UPSC 2019] In the context of which one of the following are the terms pyrolysis and plasma gasification mentioned?**

a) Extraction of earth element
b) natural gas extractions technologies
c) Hydrogen fuel-based automobiles
d) Waste to energy technologies

**Explanation**

- **Plasma gasification** is an extreme thermal process using plasma that converts **organic matter** into **syngas** (primarily made up of **hydrogen** and **carbon monoxide**).

***Answer: d)***

## Composting

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

### Vermiculture

- In this method, earthworms are added to the compost. These worms break the waste and the added excreta of the worms make the compost very **rich in nutrients**.

## Biomining for Recycling

- **Biomining** is the technique of **extracting metals (like copper**, **uranium**, **nickel and gold) from ores and solid wastes**, typically using **prokaryotes (bacteria)**, **fungi or plants**. These organisms **secrete different organic compounds** and bioleaching metals from the ores/wastes.

## Waste to Energy (WTE) Plant

- **Waste-to-Energy** is the process of generating **electricity** and/or **heat** from **waste**. The process starts with segregating biodegradable (wet) waste from dry waste at the source.
- Municipalities can use **wet waste** to produce **compost and biogas** in biomethanation plants. The **dry waste**, after removing recyclable elements, goes to WTE plants.
- The inorganic material (dry waste) is processed as **Refuse Derived Fuel** (RDF: calorific value: 2,500 kJ/kg), which can be burned to produce electricity.
- **RDF** is a **renewable energy source** that ensures waste is not thrown into landfills.

### Challenges associated with Waste-to-Energy plants

- The cost of operation is high because India is heavily dependent on foreign countries for technology.
- **Nature of Waste:** WTE plants require fine inorganic material with **less than 5% moisture and less than 5% soil content**, whereas the moisture and inert content in Indian Municipal Solid Waste is 15%-20%.
- **Segregation at Source**: Since segregation at source doesn't happen in the city, the collected waste material needs to be sieved, adding to the additional costs.
- **Low Calorific value for electricity generation**: silt and soil particles can reduce the calorific value.
- **Power tariff**: the tariff at which WTE plants purchase the power is around ₹7-8 KwH, which is higher than the ₹3-4 per KwH generated through coal and other means.

# 15.3. Measures to Manage Solid Waste

## Solid Waste Management Rules (2016)

- These replace the Municipal Solid Wastes (Management and Handling) Rules, 2000. They are now **applicable beyond Municipal areas** and extend to urban agglomerations, notified industrial townships, areas under the control of Indian Railways, airports, defence establishments, places of pilgrimage, etc.
- **Responsibilities of Generators** have been introduced to segregate waste into **3 streams** before handing it over to the collector:
  1) **Wet (Biodegradable)**
  2) **Dry (Plastic**, **Paper**, **metal**, **wood**, **etc.)**
  3) **Domestic hazardous wastes** (diapers, containers of cleaning agents, mosquito repellents, etc.)

## Segregation at Source

- **Source segregation** of waste has been mandated to channel **waste to wealth** by **recovery**, **reuse and recycling**. In the case of a **gathering** of more than **100 persons**, the organiser will have to ensure the segregation of waste at the source and handing over of segregated waste to the waste collector agency.
- **Hotels** and **restaurants** will also be required to **segregate biodegradable waste** and set up a collection system to ensure that such food waste is utilised for **composting/biomethanation**.
- All resident welfare and market associations and gated communities with an area above **5**,**000 sq m** will have to segregate waste at the source. They have to hand over recyclable material to authorised pickers and recyclers or the urban local body.

## Collect Back scheme for packaging waste

- **Brand owners** who sell or market their products in non-biodegradable packaging materials should have 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.
- As per the rules, the generator will have to pay a **"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**.

## Waste Processing and Treatment

- Bio-degradable waste should be processed and disposed of through **composting/biomethanation**.
- Rules have mandated bioremediation or capping of old and abandoned dump sites **within 5 years**. Waste processing facilities will have to be set up by **local bodies** within the stipulated time frame.

## Promotion of Waste to Energy

- All industrial units within **100 km of a solid waste-based Refuse-Derived Fuel (RDF) Plant** must make arrangements to replace at least 5 per cent of their fuel requirement with RDF so produced.
- **Ministry of New and Renewable Energy** should facilitate infrastructure creation for Waste to Energy plants and provide appropriate subsidies or incentives for such Waste-to-Energy plants.

### Revision of Parameters

- **Landfill site** shall be 100 meters away from a river, 200 meters from a pond, 500 meters away from highways, habitations, public parks and water supply wells and 20 km away from airports/airbases.
- **Emission standards** are completely amended for **dioxins**, **furans**, particulate matter, etc.
- The compost standards have been amended to align with the **Fertiliser Control Order**.

**[UPSC 2019] As per the Solid Waste Rules, 2016 in India, which one of the following statements is correct?**

a) Waste generator has to segregate it into 5 categories.
b) The Rules are applicable to notified urban local bodies, notified towns and all industrial township only.
c) The Rules provide for exact and elaborate criteria for the identification of sites for landfills and waste processing facilities.
d) It is mandatory on the part of waste generator that the waste generated in one district cannot be moved to another district.

***Answer: c)***

### Promoting the use of compost

- The **Ministry of Chemicals and Fertilizers** should provide market development **assistance on city compost**.
- The **Ministry of Agriculture** should provide flexibility in the Fertilizer Control Order for the manufacturing and sale of compost and propagating the use of compost on farmland.

### Constitution of Central Monitoring Committee

- A Central Monitoring Committee, under the **chairmanship of the Secretary**, **MoEFCC**, will monitor the **implementation of the rules**.

### Some other features

- Integration of **rag pickers** from the informal sector to the **formal sector** by the state government.
- **Zero tolerance** for throwing or burning the solid waste generated on streets, open public spaces outside the generator's premises, drain, or water bodies.
- The manufacturers or **brand owners** of sanitary napkins are responsible for **awareness** for proper disposal of such waste by the generator.
- Land for **sanitary landfills** in **hilly areas** will be identified within 25 km for construction in **plain areas**.

## Bio-Medical Waste (Management and Handling) Rules, 2016

- Bio-Medical Waste Management Rules 2016 is an improvement to the 1998 rules. Biomedical waste comprises human and animal anatomical waste and treatment apparatus like needles used in health care facilities (HCF – hospitals, laboratories, immunisation programmes, etc.).

### Salient features of BMW Management Rules, 2016

- ✓ **Phase out chlorinated** plastic bags, gloves and blood bags within two years.
- ✓ Pre-treatment of the laboratory waste, microbiological waste, and blood samples through **sterilisation on-site**.
- ✓ Establish a **bar-code system** for bags or containers containing bio-medical waste for disposal.
- ✓ Bio-medical waste has been classified into **4 categories** instead earlier ten to improve segregation at source.
- ✓ State Government to provide land for **common bio-medical waste treatment and disposal facilities**.
- ✓ No occupier shall establish an on-site treatment and disposal facility if a service of it is available at a distance of **seventy-five kilometres**
- ✓ Operator of a common bio-medical waste treatment and disposal facility to ensure the timely collection of bio-medical waste from the HCFs.
- ✓ **Vaccination camps**, **blood donation camps**, etc., will come under the ambit of these rules.

### Procedure to be followed

- The hospitals must put in place the mechanisms for effective disposal either directly or through common biomedical waste treatment and disposal facilities.
- The hospitals servicing 1000 patients or more per month must obtain authorisation and segregate bio-medical waste into categories as specified by the rules. For example, syringes, needles and blood-soiled bandages should be all disposed of in a **red-coloured bag or bin**, where they will later be incinerated (destroyed by burning). If body fluids are present, the material needs to be **incinerated**.

### Problems of unscientific Bio-medical waste disposal

- 85% of the hospital waste is non-hazardous, and 15% is infectious/hazardous. **Mixing hazardous and non-hazardous waste** makes the entire waste hazardous. It encourages the recycling of prohibited disposables and drugs, which will further spread infections. It also develops **resistant microorganisms (antimicrobial resistance)**.

## Other Measures

### Waste Minimization Circles (WMC)

- WMC helps small and medium industrial clusters minimise waste in their industrial plants. This is assisted by the **World Bank** and the **National Productivity Council**, **New Delhi**, with the MoEF as the nodal ministry.
- The initiative aims to realise the objectives of the Policy Statement for Abatement of Pollution (1992), which states that the **government should educate citizens** about environmental risks, the economic and health dangers of resource degradation and the **actual economic cost of natural resources**.

- The policy also recognises that **citizens** and **NGOs** play a role in **environmental monitoring**, therefore enabling them to supplement the regulatory system.

### Composite Waste Management Index: 2.0

- **NITI Aayog** released it in 2019. It is an attempt to **inspire states and UTs** towards efficient and **optimal utilisation of water**. It provides helpful information for states and also for concerned central ministries/departments.
- **Rankings:** 1) **Gujarat** and 2) Andhra Pradesh among states. **Puducherry** was declared the top ranker among UTs.

### Lakshya Zero Dumpsite

- The **Swachh Bharat Mission-Urban 2.0 (SBM-U 2.0)** was launched in 2021 with the vision of creating **Garbage-Free Cities by 2026**. Towards this end, the **Ministry of Housing and Urban Affairs** launched the **Lakshya Zero Dumpsite project** to remediate 16 crore metric tons (MT) of legacy waste dumpsites occupying nearly 15,000 acres of city land.

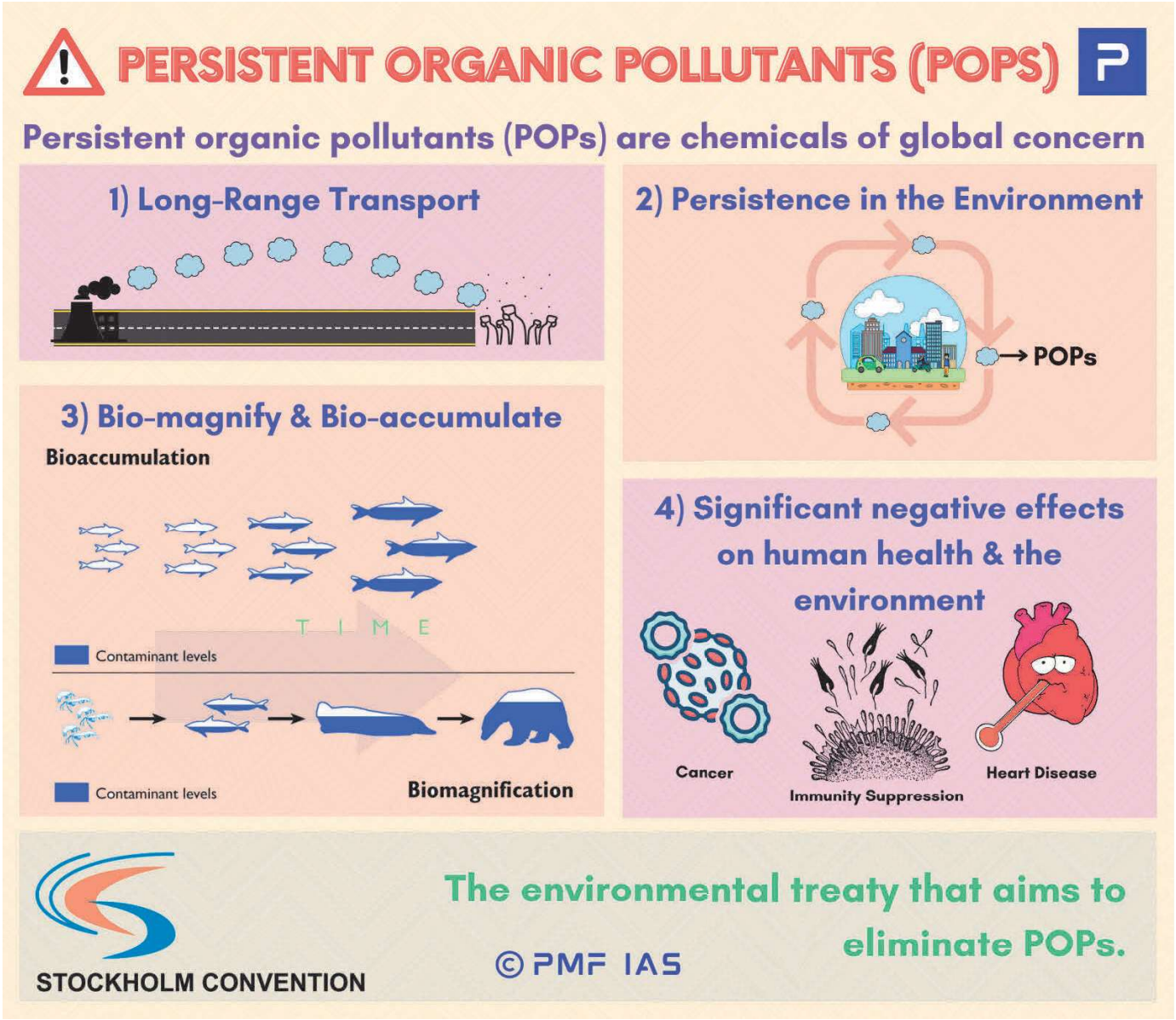
## 15.4. Hazardous Waste

- Any substance present/released in the environment that causes **substantial damage** to public health and the **environment's welfare** is called a **hazardous substance**.
- A hazardous substance could exhibit one or more of the following characteristics: **toxicity**, **ignitability**, **corrosivity or reactivity** (explosive). Thus, any waste that contains hazardous substances is called **hazardous waste**.

### Persistent Organic Pollutants (POPs)

- **POPs** are defined as "chemical substances that **persist in the environment**, **bioaccumulate** through the food web, and pose a risk of causing adverse effects to human health and the environment".
- They are chemicals of global concern due to their potential for **long-range transport** and ability to **biomagnify and bio-accumulate** **in ecosystems**.
- The most commonly encountered POPs are **organochlorine pesticides**, such as:
  - **Dichlorodiphenyltrichloroethane (DDT)**,
  - **Endosulfan**, **Chlordane**, **Endrin**, and **Heptachlor** **(were used as pesticides)**
  - **Hexachlorobenzene** **(fungicide)**,
  - **Polychlorinated biphenyls** **(PCB —** released from the **burning of plastics and electrical components; resistant to extreme temperature and pressure**, hence widely used in **electrical equipment** like capacitors and transformers),
  - **Dioxins** **(toxic by-products produced when organic matter is burned)**, **etc**.

- **DDT** was widely used a few decades ago as an effective pesticide and insecticide. It was later identified as a POP, and its usage was phased out in all developed countries and most developing countries.




- **DDT is banned for agricultural use in India**; however, it continues to be used for **fumigation against mosquitoes (disease vector control)** in several places in India.

## Chlorinated Hydrocarbons (Organochlorides)

- Chlorinated Hydrocarbons **(CHCs or Perfluoro Chlorides)** are **POP hydrocarbons** in which **one or more hydrogen atoms have been replaced by chlorine**. E.g., **DDT (dichlorodiphenyltrichloro-ethane)**, **endosulfan**, **chloroform**, **carbon tetrachloride**, etc.

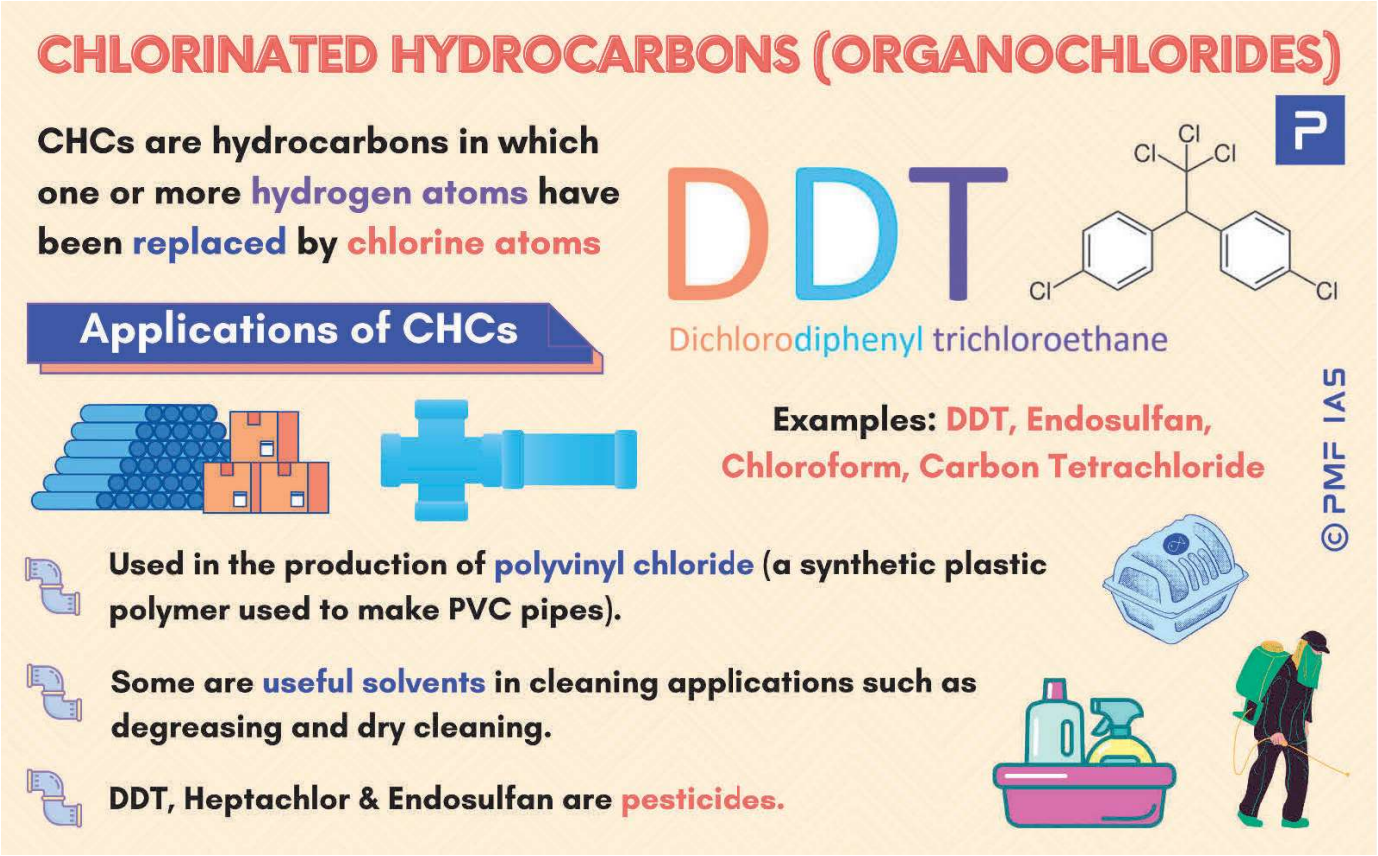
### Applications of Chlorinated Hydrocarbons

- CHCs are used to produce **polyvinyl chloride** (plastic polymer used to make PVC pipes).

- **Chloroform**, **dichloromethane**, **dichloroethane**, and **trichloroethane** are useful **solvents**. These solvents are immiscible with water and effective in cleaning applications like **degreasing and dry cleaning**. **DDT**, **heptachlor and endosulfan** were used as **pesticides**.

### Effects of Chlorinated Hydrocarbons (CHC)

- DDT accumulated in food chains and caused **eggshell thinning in certain bird species**.
- In India, traces of DDT spray used three decades ago can still be found on the walls of homes.
- DDT residues continue to be found in mammals across the planet. In Arctic areas, exceptionally high levels are found in **marine mammals**.
- The traces of POPs are found in the **breast milk of several mammals**. In females, the concentration is lower due to the transfer of the compounds to their offspring through **lactation**.



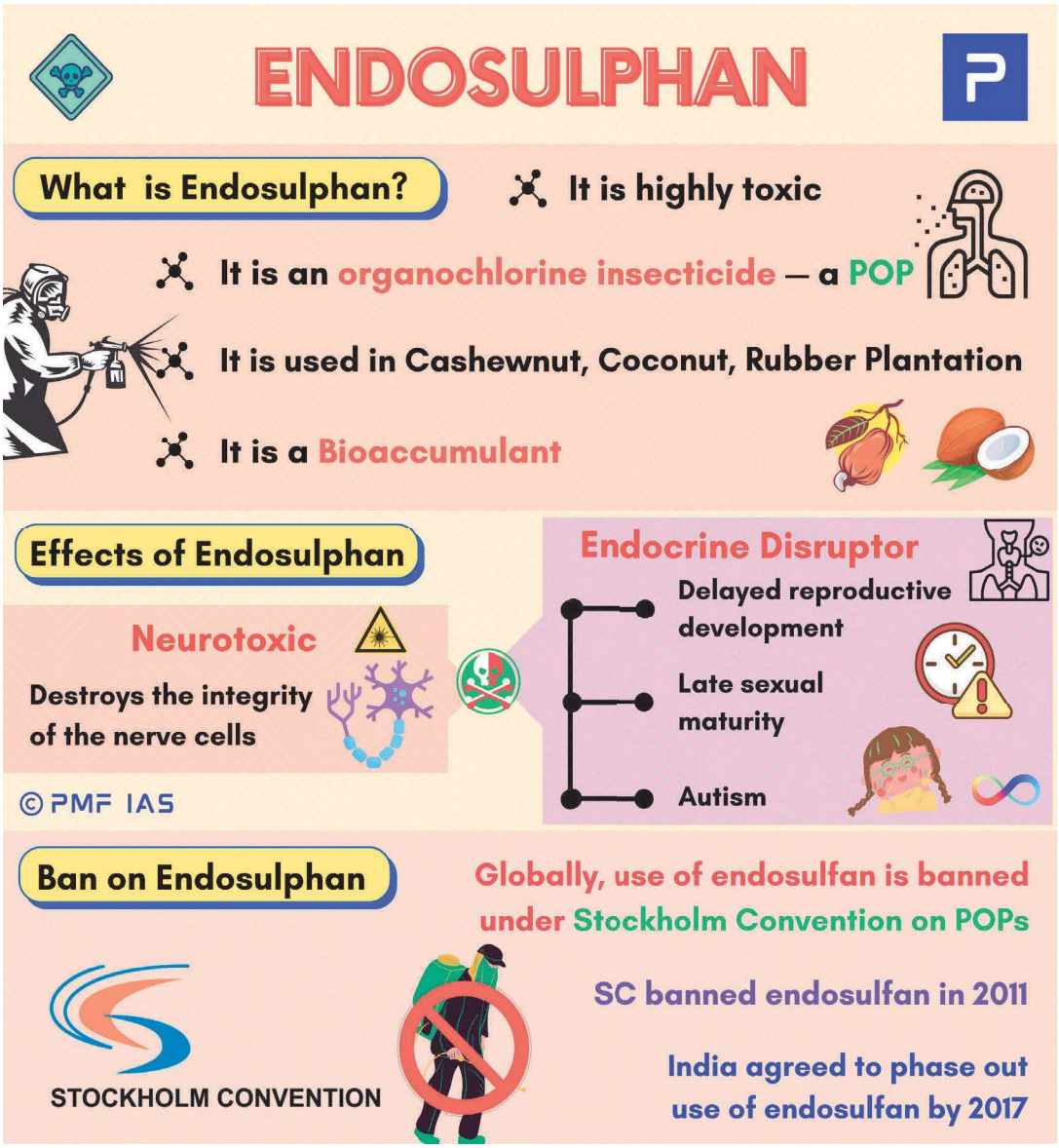

### Perfluoroalkyl Acids (PFAAs)

- **Perfluoroalkyl acids (PFAAs)** are emerging **POPs**. They are **different** from **Perfluoro Chlorides (organochlorines)**. PFAAs are used in water/stain-resistant coatings for clothing fabrics, leather, upholstery, and carpets and oil-resistant coatings for paper products approved for food contact, electroplating, electronic etching, etc.
- PFAAs have a **long life** and are one of the major pollutants **stored in the glaciers**. They **do not biodegrade** and are passed through several organisms and ecosystems.

- The glaciers are releasing PFAAs into lakes, which can lead to bioaccumulation of PFAAs in fish. The consumption of contaminated fish can prove fatal for humans.
- Himalayan glaciers may have higher levels of PFAAs than any other glaciers worldwide. This is because of their proximity to **South Asian countries** (the most polluted regions of the world).

## Endosulfan

- Endosulfan is an **organochlorine** insecticide — a **POP**. It is primarily used as an **insecticide** in agriculture and it is also used as a **wood preservative**.




### Ban on Endosulfan

- India was one of the biggest producers and consumers of endosulfan. After the toxicity of the pesticide came into the limelight in 2001 in Kasargod District, Kerala banned it. **In 2011**, **SC banned** **the production**, **distribution and use of endosulfan in India**. SC directed the Kerala government to pay Rs 500 crores to compensate over 5,000 victims.

- Globally, the use of **endosulfan is banned** under the **Stockholm Convention on Persistent Organic Pollutants**. Under pressure from pesticide firms, **India** sought remission on the ban for 10 years and agreed to **phase out the use of endosulfan by 2017**.

### Hazardous Effects of Endosulfan

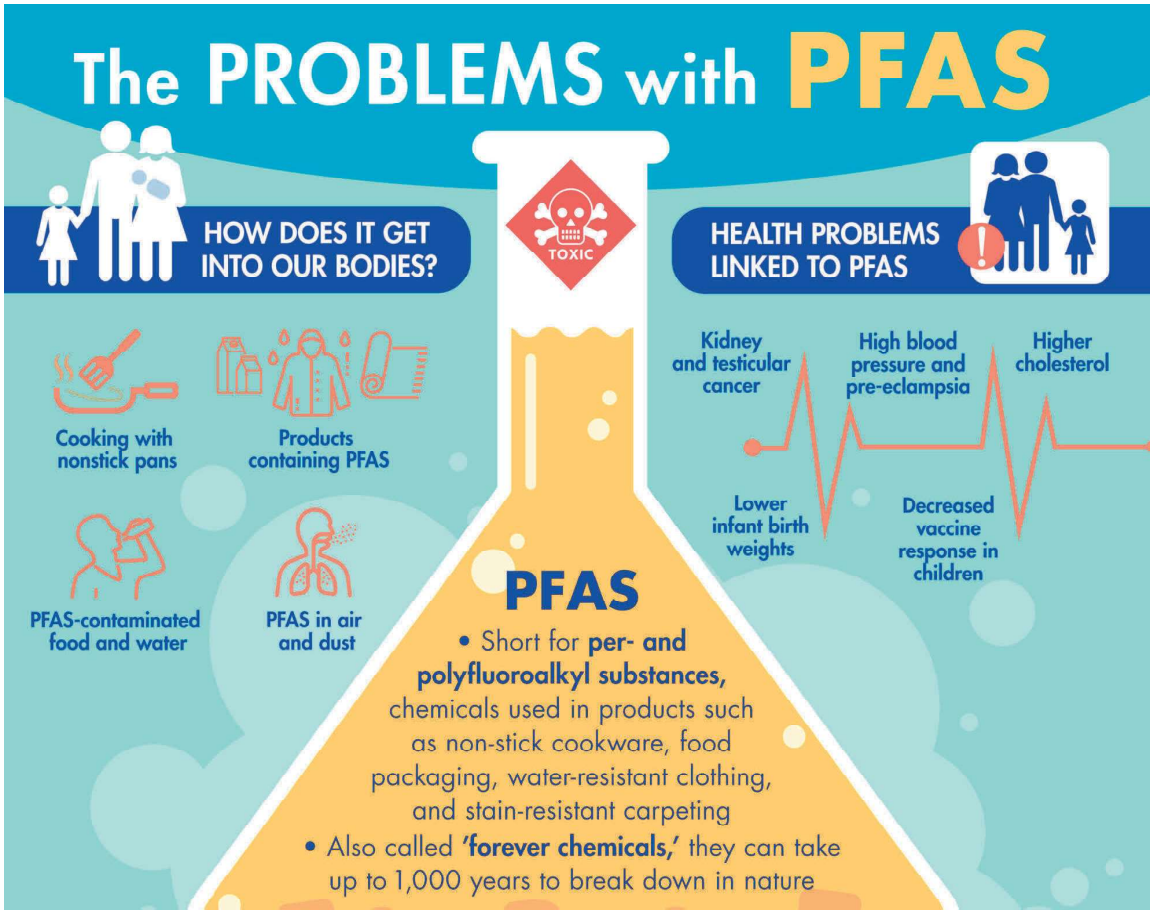
- It is **highly toxic** and has immense potential for **bioaccumulation (the substance does not leave the body)**.
- It has hazardous effects on **genetic and endocrine systems**.
- **Endocrine disruptor: enhances the effect of estrogens**, causing **reproductive and developmental damage** in both animals and humans.
- **Neurotoxic:** destroys the integrity of the nerve cells.

## Regulation of Persistent Organic Pollutants Rules, 2018

- MoEF has notified the **'Regulation of Persistent Organic Pollutants Rules**, **2018** under the provisions of the **Environment (Protection) Act**, **1986**.
- The rules prohibit the manufacture, trade, use, import and export of seven chemicals, namely:
  1. **Chlordecone**,
  2. **Hexabromobiphenyl**,
  3. **Hexabromodiphenyl ether** and **HeptaBromodiphenyl Ether (Commercial octa-BDE)**,
  4. **Tetrabromodiphenyl ether** and **Pentabromodiphenyl ether (Commercial penta-BDE)**,
  5. **Pentachlorobenzene**,
  6. **Hexabromocyclododecane**, **and**
  7. **Hexachlorobutadiene**.
- The ratification process would enable India to access the **Global Environment Facility (GEF)** financial resources.

## Polyfluoroalkyl Substances (PFAs)

- **Per- and Polyfluoroalkyl Substances (PFAs)** like **perfluorooctane sulfonic acid (PFOS)** and **perfluorooctanoic acid (PFOA)** are man-made chemicals used to make products **grease-proof**, **water-proof**, **stick-proof**, and **stain-resistant**.
- PFAs are used to make **nonstick cookware**, **water-repellent clothing**, **stain-resistant fabrics**, **cosmetics**, **fire-fighting forms**, etc.
- **Paper straws**, considered environmental friendly, have **more PFAs than plastic ones**. PFAs are used in paper straws to make them water-repellent.
- PFAs are called **forever chemicals** because they do not break down easily and accumulate in the environ-ment and in living organisms. They cause health issues like **cancer**, thyroid disorders, infertility, and developmental problems. They can interfere with body hormones and increase cholesterol levels.




## 15.5. Regulating Hazardous Waste

### Stockholm Convention on POPs

- **Stockholm Convention on Persistent Organic Pollutants (POPs)** is an **international treaty** enacted in 2004 to **eliminate or restrict the production and use of POPs**.

### Important Listed substances

- **Aldrin:** Used as an insecticide.
- **Heptachlor:** Uses as a **termiticide** (including in the structure of houses and underground) for organic treatment and underground cable boxes.
- **Hexachlorobenzene:** Use as a chemical intermediate and a solvent for pesticides.
- **Endrin:** Endrin has been used primarily as an agricultural insecticide on tobacco, apple trees, cotton, sugar cane, rice, cereal, and grains.
- **Polychlorinated biphenyl:** PCB's commercial utility was based largely on their chemical stability, including low flammability, and physical properties, including electrical insulating properties. They are highly toxic.
- **DDT:** DDT is the best-known of several chlorine-containing pesticides used in the 1940s and 1950s.

### Basel Convention on Hazardous Waste

- **Basel Convention** on the **Control of Transboundary Movements of Hazardous Wastes** and **Their Disposal** is an international treaty that entered into force in 1992. As of 2018, 190 members are parties to the Convention. The **United States** has signed the Convention but has **not ratified it**.
- Basel Convention was designed to:

✓ **Reduce the movement of hazardous waste between nations**.

✓ **Prevent the transfer of hazardous waste from developed to less developed countries (LDCs)**.

✓ Minimize the amount and toxicity of wastes generated.

✓ Assist LDCs in the environmentally sound management of the hazardous and other wastes they generate.

## Shortcomings of Basel Convention: Toxic colonialism in the name of recycling

- The Basel Convention focuses on **merely regulating the trade** in hazardous waste and **not on its complete ban**. It **merely requires a notification and consent** system known as **prior informed consent**. Basel Convention **does not prohibit waste exports** to any location **except Antarctica**. **It does not** address the **movement of radioactive waste**.
- Many waste traders ship hazardous waste in the guise of moving the waste to recycling destinations. Recycling involves stripping electronic waste, shipbreaking, etc., by desperate, unprotected workers.
- Further, wastes from shipping companies — old ships, **hazardous asbestos** and flammable gases and oils — end up on beaches in **South Asia**, where they create pollution and occupational diseases and hazards.

⇨ ***Alang Ship Breaking Yard in Gujarat*** *is one of the biggest ship-breaking yards in the world.*

⇨ *In the 2021 Budget speech, the Finance Minister spoke about* ***doubling the ship recycling capacity by 2024 and*** *attracting more ships to India from Europe and Japan.*

## Basel Ban Amendment to the Basel Convention

- Many believed a **complete ban on the shipment of hazardous waste** was needed, **including exports for recycling**. This led to the adoption of an **amendment to the Basel Convention** in **1995** termed the **Basel Ban Amendment**. It was hailed as a landmark agreement for **global environmental justice**.
- Basel Ban Amendment required ratification by **3/4** of the parties to the Convention to become a law. It finally **became international law** in **2019** after Croatia ratified it. It will become a new Article in the Convention and **enter into force in the 97 countries** after 90 days.
- Countries like the **US**, Canada, Japan, Australia, New Zealand, South Korea, Russia, **India**, Brazil, and Mexico are **yet to ratify the ban**, which will **stop the import/export** of hazardous waste.
- The US produces the most waste per capita but has actively opposed the Ban Amendment as the **amendment prohibits the export of hazardous waste (including electronic wastes) from a list of developed (mostly OECD) countries to developing countries**.

- The Basel Ban **applies to export for any reason**, **including recycling**. (India is the leader in the global ship recycling industry, with a share of over 30% of the market).

***Mains Practise: "There can be no excuse for using the developing world as the dumping ground for the toxic effluent of the affluent." Examine this statement in light of the Basel Ban Amendment. (250 Words)***

## Rotterdam Convention on Prior Informed Consent

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

## Joint meetings of Basel, Rotterdam, and Stockholm Conventions

- The joint meetings of the three **conventions on chemicals and waste** were held in **Geneva** in 2021.
  1. **COP9 to Stockholm Convention**
  2. **COP14 to Basel Convention**
  3. **COP9 to Rotterdam Convention**
- The theme of the meetings was "**Clean Planet**, **Healthy People: Sound Management of Chemicals and Waste**".

### COP9 to Stockholm Convention

- The COP decided to list "**Dicofol**" in Annex A without any exemption. The "**PFOA**" was also listed with some exemptions in Annex A of the Stockholm Convention.

#### Dicofol

- **Dicofol is an organochlorine pesticide** that is chemically related to **Dichlorodiphenyltrichloroethane (DDT)**. It has been used in a wide variety of industrial and domestic applications, including **non-stick cookware** and food processing equipment, as well as carpets, paper and paints.

#### Perfluorooctanoic acid (PFOA)

- **Perfluorooctanoic acid (PFOA)** is used in the process of making **Teflon (used in non-stick cookware)**.
- PFOA can stay in the environment and the human body for long periods of time. It is a **carcinogen**, a **liver toxicant**, **developmental** and **immune system toxicant**.

### COP14 to Basel Convention

- It amended the convention to **include plastic waste** in a **legally-binding framework**.

- The new amendment would empower developing countries to **refuse "dumping plastic waste"** by others (plastic waste included in the **Prior Informed Consent** procedure).
- Even though the **US and a few others have not signed the accord**, **they cannot ship plastic waste to countries on board with the deal**.
- **India** has already imposed a **complete prohibition on the import of solid plastic waste** into the country.

### COP9 to Rotterdam Convention

- Under the Rotterdam Convention, two new chemicals (**acetochlor**, **hexabromocyclododecane (HBCD)** and **phorate**) were added to the list for mandatory PIC (Prior Informed Consent) procedures in international trade.

## Hong Kong Convention on Recycling of Ships

- The **Hong Kong International Convention** for the **Safe and Environmentally Sound Recycling of Ships**, **2009**, was developed in cooperation with the **International Labour Organization** and the Parties to the **Basel Convention**.
- The Hong Kong Convention intends to address all the issues surrounding ship recycling, including the fact that ships sold for scrapping may contain hazardous substances such as asbestos and heavy metals.
- It also addresses concerns about the **working conditions** at many of the world's ship recycling locations.

# 15.6. Regulatory Measures by India

## Recycling of Ships Act, 2019

- The act seeks to ensure **Environmentally Sound Recycling of Ships** and adequate safety of the yard workers. The **Shipbreaking Code**, **2013** and the provisions of the **Hong Kong Convention** are present in this Bill.

### Recycling

- The act defines **ship recycling** as the dismantling of a ship at a facility to recover the components and materials for reuse and taking care of the hazardous material so produced.
- Ships will be recycled only in authorised recycling facilities. Each recycler must maintain adequate measures for emergency preparedness and the safety and welfare of workers.

### Requirements for ships

- Ships should **not use prohibited hazardous materials** as notified. The central government **may exempt** certain categories of ships from this requirement. These requirements will **not apply** to (i) **any warship** and (ii) ships with an internal volume of less than 500 tons.

### National Authority

- The National Authority will conduct periodic surveys to verify the prescribed requirements.
- The owner of every new ship must make an application to the National Authority to obtain a certificate on the inventory of hazardous materials.
- The Ship Recycler must prepare a **ship recycling plan**, which the National Authority should approve. Each ship will be recycled after obtaining written permission from the National Authority.

### Key Benefits of the bill

- ✓ The Increased number of global ships entering Indian shipyards for recycling.
- ✓ Recycling of Ships will boost business and employment opportunities.
- ✓ It will raise the value of our Ship Recycling Yards located at **Alang in Gujarat**, **Mumbai Port**, **Kolkata Port and Azhikkal in Kerala**.
- ✓ **10% of the country's Secondary steel needs** can be met eco-friendly from recycled ships.
- ✓ Ships Recycling facilities will become compliant with international standards.

## Hazardous Wastes (Management and Handling) Rules, 2016

- The 2016 Rules has been enacted to promote recycle and reuse of waste while reducing hazardous wastes.

### Other Wastes

- These rules have been made to distinguish between hazardous waste and **other wastes**.
- Other wastes include waste tyres, paper waste, metal scrap, used electronic items, etc. and are recognised as a **resource for recycling and reuse**.

### Standardisation of Steps of Waste Management by Occupier

- The 2016 Rules standardised the sequence of priority in which the occupier must manage waste.
- The sequence is **prevention > minimization > reuse > recycling > recovery**, **utilisation (including co-processing) > safe disposal**.

### Standard Operating Procedures (SOPs)

- The rules established the fundamental requirement of infrastructure and **SOPs** to protect human health and the environment from hazardous waste, specific to the waste type. These SOPs must be complied with by the stakeholders and verified by SPCB/PCC.

### Rules for the Import/Export of Waste

- **No country can export hazardous waste to India for final disposal**. This means that **India only imports hazardous wastes to recycle**, **reuse or for other utilisation**.
- The rules specify the procedure for importing and exporting hazardous waste to and from India.
- Exporters of silk waste have now been exempted from requiring permission from MoEF.

- Electrical and electronic components manufactured in and exported from India, if found defective, can now be imported back into the country without obtaining permission from MoEF.
- Industries that do not require consent under the **Water (Prevention and Control of Pollution) Act 1974** and the **Air (Prevention and Control of Pollution) Act 1981** are now exempted from requiring authorisation also under the Hazardous and Other Wastes Rules, 2016.

## Wastes Prohibited for Import

- Waste edible fats and oil of animals or vegetable origin
- Household waste
- Critical care medical equipment
- **Tyres for direct re-use purpose**
- Solid Plastic waste, including Pet bottles
- Waste electrical and electronic assemblies scrap
- Other chemical wastes, especially in solvent form

## Duties Assigned to State Governments for Waste Management

- **States** should establish/allocate industrial space or sheds for recycling, pre-processing, and other utilisation of hazardous or other waste and register the workers involved in recycling.
- States must undertake skill development activities and ensure the safety and health of workers.
- The state governments have to submit an annual report to the MoEFCC.
- SPCBs must prepare an annual inventory of the waste generated, recycled, recovered, and utilised (including co-processed) and submit it to the CPCB.

## Treatment, Storage and Disposal Facility for Hazardous Wastes

- 2016 rules give a clear direction of how the treatment, storage and disposal facility is to be established. Permission from the **SPCB** is required for the layout in this regard.

## Packaging, Labelling and Transport of Hazardous and Other Wastes

- CPCB provides extensive guidelines for packaging and labelling.
- If the waste is to be transported to a facility in a different state for its final disposal, a '**No Objection Certificate**' is required on the sender's part from the **SPCBs of both states**.

## Amendment of 2019

- Amendment has been made considering the "Ease of Doing Business" and boosting the "Make in India" initiative by simplifying the procedures under the Rules while simultaneously upholding the principles of sustainable development and ensuring minimal impact on the environment.

### No Rules for the Disposal of Cigarette Butts

- **Cellulose acetate** is a significant component (95%) of cigarette butts, along with **rayon**. In general, the **toxicity date is not available for cellulose acetate**. **Cellulose acetate will persist for a longer duration**.
- The MoEF had said that **cigarette butts were not listed as hazardous**, and the Health Ministry had maintained that they were **not biodegradable**. Hence NGT has directed the CPCB to lay down guidelines for the disposal of cigarette and beedi butts.

## Steel Scrap Recycling Policy

- Steel is most conducive to a **circular economy** as it can be used, reused and recycled infinitely. While iron ore remains the primary source of steel making, used or reused steel in the form of **scrap is the secondary raw material for the steel industry**.


### Steel Production Process

- Steel is principally made via two routes:
  1) **Basic Oxygen Furnace (BOF) route – Primary**
  2) **Electric Arc Furnace route (EAF) route – Secondary**

- The former is used to create new or 'virgin' steel, and the latter is often used to recycle steel scrap. The Electric Arc Furnace route (EAF), 100% scrap, is used. This is the re-melting of steel without the use of primary raw materials.

### Circular Economy

- In a linear economic model of production and consumption, natural resources are turned into products that are ultimately destined to become waste because of the way they have been designed and manufactured. This process is summarised by **"take**, **make**, **waste"**.
- By contrast, a circular economy employs **reusing**, **sharing**, **leasing**, **repairing**, **refurbishing**, **remanufacturing** and **recycling** to create a **closed-loop system**, minimising the use of resource inputs and the creation of waste, pollution and carbon emissions.

- **National Steel Policy (NSP) 2017** aims to develop a globally competitive steel industry by creating 300 mt per annum steel production capacity by **2030** with a contribution of **35-40% from the EAF route**.


- Although scrap is the main raw material for the secondary sector, the primary sector also uses Scrap in the **charge mix of Basic Oxygen Furnace (BOF)** to the tune of **15% to improve efficiency** and minimise the cost of production and other process needs.
- The availability of raw materials at competitive rates is imperative for the growth of the steel industry and to achieve the NSP-2017 target. Thus, the availability of the right quality of scrap in adequate quantity is one of the critical factors for the future growth of both the EAF/IF sector and primary sector.

- The **Ministry of Steel** is the **nodal ministry** to deal with all the issues arising from scrap.

## Key Features of National Steel Scrap Policy

- The policy provides a framework to facilitate and promote the establishment of **metal scrapping centres** in India for the **scientific processing and recycling of ferrous scrap** generated from various sources.
- It enumerates responsibilities for setting up collection, dismantling centre and scrap processing centres, and the roles of aggregators and responsibilities of the Government, manufacturer and owner. It **does not** envisage the setting up of scrap centres by the **government**. The role of government is to be an **enabler** to facilitate the eco-system of metal scrapping in the country.
- Entrepreneurs decide to set up scrap centres based on commercial considerations. The Scrapping Centres are **approved** and **monitored** by the authorised agencies of the **State/UTs**. The Policy does not envisage any additional monitoring mechanism, thereby ensuring no additional compliance burden.
- The policy framework provides standard **guidelines for collection**, **dismantling and shredding activities** in an organised, safe and environmentally sound manner.

## Scrap categories

- **Home scrap:** It represents scrap generated at various stages during the manufacturing of steel and steel products in steel plants.
- **New scrap/industrial Scrap:** It represents scrap generated in the **downstream processing** during manufacturing, fabrication, and making steel products, such as forming auto components, white goods, machining, and tool and equipment manufacture.
- **Old scrap/obsolete scrap:** The steel **discarded** when steel products (end-of-life vehicles, appliances, machinery, buildings, bridges, ships, cans, railway coaches, wagons etc.) have served their useful life.

## Objectives of the Policy

- To promote a formal and scientific collection, dismantling and processing activities for **end-of-life products** that are **sources of recyclable** (ferrous, nonferrous and other non-metallic) scraps, which will lead to resource conservation and energy savings and setting up of an environmentally sound management system for handling ferrous scrap.
- To create a mechanism for treating waste streams and residues produced from dismantling and shredding facilities in compliance with **Hazardous and Other Wastes (Management and Transboundary Movement) Rules**, **2016**.
- To promote the **6Rs principles** of **Reduce**, **Reuse**, **Recycle**, **Recover**, **Redesign**, **and Remanufacture** through scientific handling, processing and disposal of all types of recyclable scraps, including non-ferrous scraps, through authorised centres/facilities.

## Advantages of the Policy

- The use of every ton of scrap shall **save 1.1 tons of iron ore**, **630 kg of coking coal and 55 kg of limestone**. It helps to reduce **water consumption and GHG emissions** by 40% and 58%, respectively.
- There is a worldwide trend towards increasing steel production using scrap as the primary raw material as recycling of scrap helps conserve **vital natural resources** besides other numerous benefits.

## 15.7. Heavy Metals

- **Heavy (toxic) metals** are metallic elements with a **relatively high density compared to water**. They are **harmful (toxic/poisonous)** to the environment, humans and other organisms, even at **low concentrations**.
- Most of them are **not broken down** by **biological degradation**. They **bioaccumulate (build up in organisms)** and **biomagnify (move up the food chain)**, thereby posing the greatest danger to organisms at the **top of the food chain**.
- Water-soluble heavy metals include **arsenic**, **cadmium**, **lead**, **mercury**, **barium**, **chromium**, **platinum**, **palladium**, and **silver**. Some, such as **arsenic**, **cadmium**, **lead** and **mercury**, are particularly hazardous.
- Heavy metals are present in very small amounts in natural water. Significant quantities of toxic metals are dispersed in the environment through **metal smelting industrial emissions**, **burning of organic wastes**, **automobiles** and **coal-based power generation**.
- **Heavy metal poisoning (toxicity)** is the result of exposure to heavy metals that enter the human body systems and **bind to cells**, preventing the normal functioning of organs. It can cause irreversible damage and can be life-threatening in some cases.
- Heavy metals can be carried to places far away from their source of origin by winds when they are emitted in **gaseous form** or form of **fine particulates**. Rain ultimately washes the air, having metallic pollutants, and brings them to the land and water bodies.

### Lead

- **Major Sources:** Mining, **lead-acid batteries**, battery scrap recycling, paints and pigments (used for quick drying), **fly ash**, and **plastic toys (lead softens plastic)**.
- **Minor Sources:** Lead-soldered food cans, cosmetic lip products, lead in water (from leaded pipes), **leaded petrol (phased out worldwide)**, **glass** (added to melt them during manufacturing), ayurvedic medicines, etc.
- **E-waste Sources:** Lead rechargeable batteries, solar panels, transistors, **lithium batteries**, PVC, solder in PCBs, glass panels and gaskets in computer monitors, etc.

#### Lead Poisoning

- The recycling of **lead-acid batteries** is a leading contributor to lead poisoning in children in low-income countries.

#### Health Effects

- Lead is a **carcinogen** of the lungs and kidneys. It affects many organs, especially developing **fetuses**, causing **stillbirths** and **miscarriages**. It can cause irreversible **behavioural** and **neurological damage** and other **developmental problems** in children.
- It can get mixed up with water and food and create **cumulative poisoning**, causing **neurodegenerative diseases** and **dysfunctions of the central nervous system**.
- Maternal exposure to lead during pregnancy can cause developmental reprogramming, which can lead to higher risk and early onset of **Alzheimer's disease** in later life.

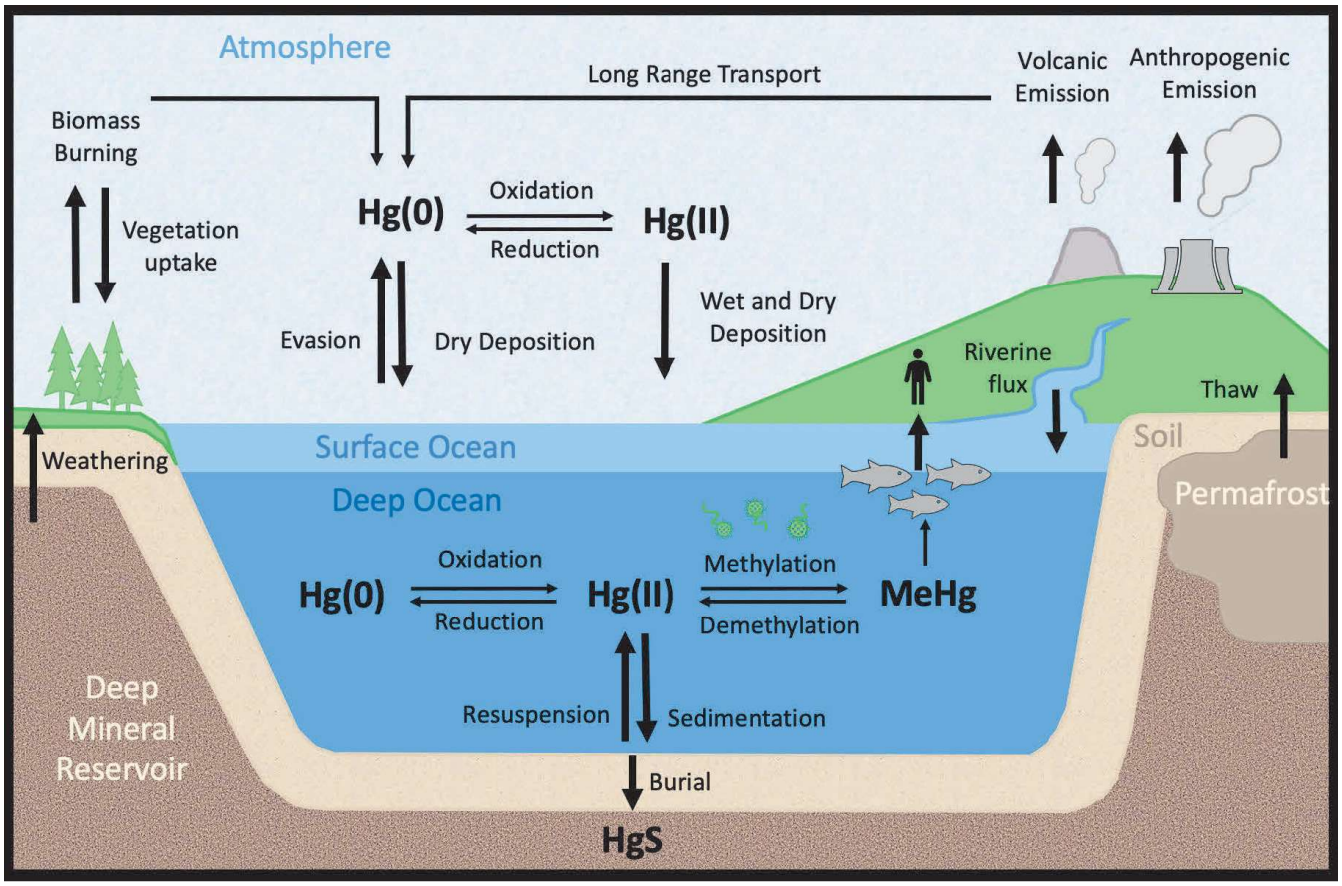
⇨ *India banned leaded petrol in 2000. By 2011, the UN announced that it had been successful in **phasing out leaded gasoline worldwide**.*

⇨ *Many ayurvedic medications contain overdoses of toxic metals such as **lead**, **mercury**, and/or **arsenic**. This is because of a lack of regulation/oversight.*

⇨ *Metals are a part of the ayurvedic practice of Rasa Shastra. Some metals are used intentionally, as the Ayurvedic tradition holds that lead, mercury, copper, gold, iron, silver, tin, and zinc may help restore good health and normal function to the human body.*

⇨ ***Alzheimer's** is the most common cause of **dementia (memory loss)** and loss of other cognitive abilities (mental abilities closely associated with learning and problem-solving).*

## Mercury



- Because elemental mercury has high surface tension, it forms tiny, compact, spherical droplets when released into the environment.
- Although the droplets themselves are stable, the **high vapour pressure of mercury** compared with other metals causes the mercury to evaporate. In an indoor setting, mercury can quickly become an inhalation hazard.
- Outdoors, elemental mercury vaporises and enters the atmosphere. In aquatic systems, naturally, present **microorganisms can transform mercury into methylmercury**, an organometallic compound that is more toxic at low doses than pure mercury.

## Sources

- **Natural: Volcanic eruptions**, **fossil fuels**, metal ores, and other minerals.
- **Human-made: Mining and refining of metals** such as copper, gold, lead, and zinc, coal burning, **manufacture of cement (present in limestone and/or coal)**, **caustic soda production**, **etc**.
- **E-waste Sources:** Most electrical and electronic goods contain significant quantities of mercury — **LCD screens**, **CFL bulbs**, **CRT monitors**, switches, printed solders (as an alloy with tin), batteries, mercury thermometers, thermostats, sensors, medical equipment, lamps, mobile phones, etc.

## Health Effects

- Mercury is known to cause severe and permanent damage to the **central nervous system**, **lungs** and **kidneys**. It can trigger depression and suicidal tendencies and cause paralysis, Alzheimer's disease, impotence, etc.
- Inhalation of mercury vapours is more dangerous than its ingestion. Methylmercury and metallic mercury vapours are especially harmful because mercury in these forms more readily reaches the brain.
- Repeated exposure has irreversible effects on the nervous system, particularly in children.

## Methylmercury

- **Methylmercury** is a very poisonous form of mercury. In the environment, methylmercury forms when bacteria react with mercury in water, soil, or plants.
- **Sources: Fluorescent (CFL) lights**, **batteries**, **polyvinyl chloride (PVC)**, **etc**.
- **Health effects:** Methylmercury (neuro-toxicant) poisoning leads to **brain** and **nervous system damage**. The developing **foetus** is highly vulnerable to mercury exposure.

### Minamata Convention

- In Japan, mass mercury poisoning (**Minamata disease**) was observed in the 1960s, caused by eating fish from Minamata Bay contaminated with **methylmercury (bioaccumulates and biomagnifies)**.
- Minamata disease patients complained of a **loss of sensation and numbness** in their hands and feet. They could not run or walk without stumbling, and they had difficulties seeing, hearing and swallowing. A high proportion died.

## Cadmium

### Sources

- **Major Sources:** Mining (especially of **zinc and copper**), metallurgical operations, **electroplating industries**, etc.
- **E-waste Sources:** Solar panels, batteries, solder, alloys, switches, **printed circuit boards (PCB)**, **computer batteries**, **cathode ray tube (CRTs) monitors**, surface-mount technology (SMT) chip resistors, infra-red detectors, **semiconductor chips**, UV stabilisers in older PVC cables, etc.

### Health effects

- **Cadmium (carcinogen)** enters the human body by inhalation or from aquatic sources, including fish. It may cause hypertension, liver and **kidney damage** and **lung cancer**.
- Long-term exposure causes **Itai-itai disease**, which causes **severe pain in the joints** and **spine**. It affects the **kidneys** and **softens bones**.
- The disease was first reported in Japan in 1965. It was attributed to **cadmium contamination** in **water** and **rice** caused by the discharge of effluents from a **zinc smelter**.

## Chromium

- **Sources: Chromium VI (hexavalent chromium)** is used as a **corrosion protector** of untreated and galvanised steel plates, **metal housings and plates in computers**, in chrome tanning (leather industry), and as a decorative or hardener for steel housings plastics (including PVCs).
- **Health effects:** Inhaling chromium or chromium 6 can damage the liver and kidneys and cause bronchial maladies, including asthmatic bronchitis and lung cancer. Chromium VI can cause damage to DNA.

## Other Heavy Metals

- Metals such as **zinc**, **chromium**, **antimony** and **tin** enter food from cheap cooking utensils.

### Arsenic

- **Sources:** Copper, iron and silver ores, **fly ash**, liquid effluents from **fertiliser plants**, semiconductors, diodes, microwaves, **LEDs (Light-emitting diodes)**, solar cells, etc.

*Health effects are mentioned in the 'Water Pollution' chapter.*

### Antimony

- Antimony is used to increase the hardness of alloys. **Antimony trioxide** is used in flame-retardant chemicals.
- **Sources:** Trace component of metal solders, lead alloys for batteries, lead/copper/tin alloys for bearings.
- **Health effects:** Antimony trioxide is a possible carcinogen.

### Tin

- **Sources:** Preserved foods stored in tin cans.
- **Health effects:** Tin is an irritant, and excess tin can cause damage to the **liver** and **kidneys**.

### Zinc

- Zinc is a nutrient found throughout your body, aiding the immune system and metabolism. Zinc is also essential for wound healing and a sense of taste and smell.
- **Sources:** Mining, metal smelting (like zinc, lead and cadmium), fly ash, steel, brass, alloys, disposable and rechargeable batteries, luminous substances, etc.
- **Health effects:** Excess zinc is a skin irritant and affects the pulmonary system.

### Barium

- **Sources:** Oil and gas industries (used to make drilling mud, which simplifies drilling through rocks by lubricating the drill), paint, tiles, **fireworks** (**barium nitrate** and chlorate for green colour), etc.
- **E-waste Sources:** Spark-plug electrodes, vacuum tubes (oxygen-removing agent), **CFL bulbs** (a spiral-shaped tube made of tungsten and coated with **barium**, **strontium** and **calcium oxides**), in computers in the front panel of a Cathode Ray Tube (CRT), to protect users from radiation.
- **Health effects:** Nausea, brain swelling, muscle weakness, irregular heartbeat, paralysis, etc.

### Beryllium

- **E-waste Sources: PCB motherboards** (copper-beryllium alloy is used to strengthen connectors while maintaining electrical conductivity).
- **Health effects:** Lung cancer and lung damage, poor wound healing, etc.

**[UPSC 2013] Due to indiscriminate disposal of old and used computers or their parts, which of the following are released into the environment as e-waste?**

1. Beryllium
2. Cadmium
3. Chromium
4. Heptachlor
5. Mercury
6. Lead
7. Plutonium

***Select the correct answer using the codes given below.***

a) 1, 3, 4, 6 and 7 only
b) 1, 2, 3, 5 and 6 only
c) 2, 4, 5 and 7 only
d) 1, 2, 3, 4, 5, 6 and 7

**Explanation**

- **Heptachlor** is a **Chlorohydrocarbon (CHC)** which is used as an insecticide.
- **Plutonium is a radioactive metal** and hence not used in computers.
- So, the answer should not contain either 4) or 7).

***Answer: b) 1, 2, 3, 5 and 6 only***

## 15.8. Electronic waste (E-Waste)

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

| Particulars | Source | Health Effects |
|---|---|---|
| Toners | Found in the plastic printer cartridge containing black and colour toners. | Respiratory tract irritant. **Carbon black** is a **carcinogen**. |
| Phosphor additives | The phosphor coating on cathode ray tubes contains toxic heavy metals, such as **cadmium**, and other rare earth metals, for example, **zinc** and **vanadium** , as additives. | |
| **PVC** | Plastics, cables, computer housings and mouldings, Chlorinated PVC (Chloro-benzenes) | **Dioxins** produced on burning are endocrine disrupters. |
| Phthalates | Used to soften plastics, especially PVC | Toxic to reproduction |
| **Lithium** | PVC stabilisers, lasers, LEDs, thermoelectric elements, circuit boards, etc. **Lithium-ion batteries** contain metals such as cobalt, nickel, and manganese, which are toxic. | |
| Acid | **Sulphuric** and **hydrochloric acids** are used to separate metals from circuit boards. Fumes contain **corrosive chlorine** and **sulphur dioxide**, which cause respiratory problems. | |
| Plastics | Found in circuit boards, cabinets and cables, they contain carcinogens. | |
| BFR | **Brominated Flame Retardants (BFRs)** are used in circuit boards (plastic), cables and PVC cables. BFRs give out carcinogenic brominated **dioxins** and **furans**. | |
| **PCB** | **Polychlorinated biphenyls (PCB)** are used in transformers and capacitors as softening agents for paint and plastics. | |
| Selenium | Photoelectric cells, pigments, photocopiers, fax machines | |
| Silver | Capacitors, switches (contacts), batteries, resistors | |
| Cobalt | Insulators | |

| Major E-waste component | Environmental hazards |
|---|---|
| **Cathode Ray Tubes (used in TVs, computer monitors, etc.)** | **Cadmium**, **lead**, **barium**, and **nickel** leach into the groundwater |
| **Printed Circuit Board (PCB) and switches** | Atmospheric release and discharge into rivers of **tin**, **lead**, **brominated dioxin**, **cadmium and mercury** due to desoldering/open burning |
| **Batteries** | **Cadmium**, **lead**, **lithium**, **mercury**, **nickel**, etc., depending upon the type of batteries. |

## E-Waste Generation and Recycling

- There was 53.6 mt (mt) of e-waste in 2019, a nearly 21 per cent increase in just five years. Globally, e-waste to increase by 38% in the decade between 2020 and 2030, according to the UN University (UNU) report.
- **Asia generated the greatest volume of e-waste in 2019 —** some 24.9 MT, followed by the Americas (13.1 MT) and Europe (12 MT). **Most e-waste in 2019 consisted of** small equipment (17.4 MT), large equipment (13.1 MT) and temperature exchange equipment (10.8 MT).
- Less than 18 per cent of the e-waste generated in 2019 was collected and recycled. E-waste consisting of **gold**, **silver**, **copper**, **platinum** and other high-value, recoverable materials worth several billion dollars was mostly dumped or burned rather than being collected for treatment and reuse.

### India

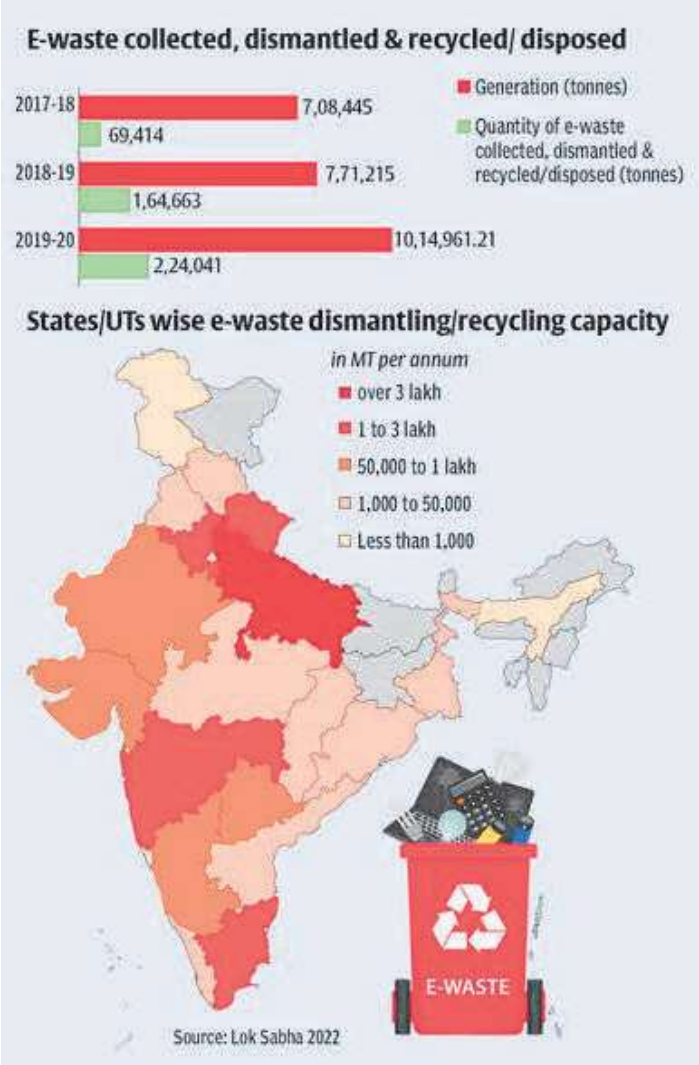
- The generation of e-waste has been increasing faster than plastic waste in India. In 2018-19, the plastic waste was **3.3 mt**, and in **2019-20**, it was **3.4 mt** (**an increase of 3%**). E-waste was **0.77 mt** in 2018-19 and **1.01 mt** in 2019-20 (**an increase of about 31%**).
- Among states, **Maharashtra**, **Tamil Nadu**, **Andhra Pradesh**, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh, etc., generate the most e-waste. Among cities, **Mumbai** is the top e-waste producer, followed by **Delhi**, Bengaluru, Chennai, and Kolkata.
- ~1.58 mt per annum of plastic waste is recycled, and 0.17 mt per annum is co-processed in cement kilns. For e-waste, there are **468 authorised dismantlers/recyclers in 22 states**, having a processing capacity of 1.38 mt.

### Issues

- India is only next to China and the US in e-waste generation. The informal sector handles more than 95 per cent of this waste. **Only 22.7%** of the e-waste out of the total **1.014 mt** generated in 2019-20 in India was **collected**, **dismantled**, **and recycled or disposed of**.
- Along with hazardous substances such as **lead**, **mercury**, **polychlorinated biphenyls (PCBs)**, **polybrominated biphenyls (PBBs)**, **polybrominated biphenyl ethers (PBDEs)**, **brominated flame retardants**

**(BFRs)**, etc. E-waste also contains valuable substances such as **gold**, **silver**, **copper**, **palladium**, **iron**, **steel**, **copper**, **aluminium** and **plastics**.

- While there is immense potential in augmenting e-waste recycling in the country, most of it ends up in landfills (**>75%**; **pollution**, **lost economic and employment opportunities**) due to a lack of enabling regulations and reforms.




### Unsound Solar Waste Management

- Manufacturing solar panels often requires using **several toxic chemicals** that contain **silver**, **copper**, **lead**, **arsenic**, **cadmium**, **hexafluoroethane**, **polyvinyl fluoride**, etc.
- Solar panels have an operating lifespan of around **20 to 30 years**. Since they were first introduced in the 2000s, tons of solar panels are reaching the end of their lifespan. There are no specific rules and mechanisms for collecting and safely disposing of discarded solar panels.
- India could generate over 34,600 tons of cumulative solar waste in India by 2030. With India's ambitious solar target of **280 GW by 2030**, it is time to formulate a sound **solar waste management policy**.

## 15.9. E-Waste Management Rules, 2016

- GOI passed the first law on **e-waste management in 2011**, based on **Extended Producer Responsibility (EPR)**, which put the onus on the producer to manage the final stages of the life of its product in an eco-friendly way by creating certain norms in tandem with SPCBs. **E-Waste Rules 2016 replaced 2011 Rules**.

**[UPSC 2019] In India, 'extended producer responsibility' was introduced as an important feature in which of the following?**

a) The Bio-medical Waste Rules,1998
b) The Recycled Plastic Rules, 1999
c) The e-Waste (Management and handling) rules, 2011
d) The food safety and standard regulations, 2011

***Answer: c) e-waste***

## Salient Features

- Over **21 products**, **including Compact Fluorescent Lamp (CFL)** and **mercury-containing lamps**, **were included** under the purview **(Schedule-I)** of the rules.
- The rules were also extended to components or consumables or parts or spares of **Electrical and Electronic Equipment (EEE)**, along with their products.

### EPR

- Manufacturers, dealers, refurbishes, and **Producer Responsibility Organisations (PRO)** have been introduced as additional stakeholders in the rules to strengthen EPR further.
- PRO, a professional organisation, would be authorised or financed collectively or individually by producers **to share the responsibility for collecting and channelising** e-waste generated from the '**end-of-life'** products to ensure environmentally sound management of such e-waste.
- The rules have provisioned the **target for the producers**, which was missing in the first version of the Rule. Now, manufacturers are mandated to take back their sold products with recommended mechanisms.
- The manufacturer is responsible for collecting e-waste generated during the **manufacture** of any EEE and channelise it for recycling or disposal and seeking authorisation from **SPCB**.
- **CPCB** shall conduct **random sampling** of EEEs placed on the market to monitor compliance with the law on **Restriction of Hazardous Substances (RoHS)**. The producer shall bear the cost of sampling.
- **Liability for damages** caused due to improper management of e-waste, including provision for levying financial **penalty for violation** of provisions of the rules, has also been introduced.

### Finance

- Option has been given for setting up of **e-waste exchange**, **e-retailer**, and **Deposit Refund Scheme** as an additional channel for implementing EPR by producers to ensure efficient channelisation of e-

waste. **Deposit Refund Scheme** is an additional economic instrument wherein the producer charges an additional amount as a **deposit at the time of sale** of EEE and returns it to the consumer along with interest when the end-of-life EEE is returned.

- The **e-waste exchange** as an option has been provided as an independent market instrument offering assistance for selling and purchasing e-waste generated from end-of-life EEE between agencies or organisations.

## Amendment in 2019

- The amendment in rules has been done to channelise **the E-waste** generated **towards authorised dismantlers and recyclers** to **formalise the e-waste recycling sector**.
- The collection targets under the provision of EPR in the Rules have been revised, and targets have been introduced for new producers who have started their sales operations recently.

### Salient Features

- The **phase-wise collection targets for e-waste** in weight shall be 10% of the quantity of waste generation as indicated in the EPR Plan during 2017-18, with a 10% increase every year until 2023. After 2023 onwards, the target has been made **70% of the quantity of waste generation** as indicated in the EPR Plan.
- **PROs** shall apply to the CPCB for registration to undertake activities prescribed in the Rules.
- Under the RoHS provisions, the **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, the cost of the test will be **borne by the Producers**.

## E-Waste Management Rules, 2022

- The new rules will come into force from the 1st of April, 2023. The rules widen the coverage of electronic goods from **21** to **106** — including all electrical devices and radiotherapy equipment, nuclear medicine equipment and accessories, Magnetic Resonance Imaging (MRI), electric toys, air conditioners, refrigerators, microwaves, washing machines, etc.
- The new rules **restrict the use of hazardous substances (such as lead**, **mercury**, **and cadmium)** in manufacturing EEE that have an adverse impact on human health and the environment.
- **EPR Certificates** (similar to carbon credits) will allow the offsetting of e-waste responsibility to a third party.

### Targets

- Producers of electronic goods have to ensure at least **60%** of their e-waste is collected and recycled by **2023**, with targets to increase them to **70% and 80% in 2024 and 2025**, respectively. '**Environmental compensation**' to be provided by the companies that don't meet their target.

### Responsibilities

- State Governments will earmark industrial space for e-waste dismantling and recycling facilities, undertake industrial skill development and establish measures for protecting the health and safety of workers.
- Manufacturers: making the end product recyclable and a component made by different manufacturers be compatible with each other.
- CPCB: shall conduct random sampling of EEE placed on the market to monitor and verify the compliance of reduction of hazardous substances provisions.

**---------- End of Chapter ----------**

# 16. Highly Polluting Industries (HPIs)

## 16.1. Highly Polluting Industries (HPIs) in India

- MoEF has classified **17 categories of Industries** as **Highly Polluting Industries (HPIs)**, which are to be closely monitored. These industries are **iron and steel**, **thermal power station**, **sugar**, **cement**, **distillery**, **dye and dyestuff**, **petrochemicals**, **refinery**, **pulp and paper**, **pharmaceuticals**, **fertiliser**, **pesticides**, **tannery**, **copper smelter**, **zinc smelter**, **aluminium** and **caustic soda**.
- *Pesticides, Pharmaceuticals, and Dye and Dye Stuff industries use a wide range of chemicals with far-reaching effects on water quality. Some of the pollutants released by these industries are persistent in nature.*

### Grossly Polluting Industries (GPIs)

- Grossly Polluting Industry (GPI) is defined as the industry that discharges wastewater of more than 100-kilo litres a day and/or hazardous chemicals used by the industry as specified under Schedule I, Part II of The Manufacture, Storage and Import of Hazardous Chemical Rules of 1989 under **Environment (Protection) Act**, **1986**.
- GIPs include fertilisers, petrochemicals, pesticides, pharmaceuticals, distillery, dairy, food and beverage, pulp and paper, sugar, tannery, textile, bleaching and dyeing, thermal power plants, slaughterhouses, cement, electroplating, metallurgical, automobile industry, etc.

#### Water Guzzlers

- Sectors such as **thermal power plants (70-80%)**, **engineering (5%)**, **paper and pulp (2.2%)**, **textiles (2%)**, **iron and steel (1.3%)**, **sugar (0.5%)**, **cement** and **fertilisers** are **water guzzlers**. Most water is used for filtration, cleaning, wet scrubbing, effluent discharge, etc.

### Industrial Emissions and Effluents Monitoring

- Every industry and its **effluent treatment plant (ETP)** outlets are connected to a central monitoring system that continuously reads and sends data to SPCB and CPCB. Since 2014, the monitoring has been done through the **Online Continuous Emissions/Effluents Monitoring Systems (OCEMS)**. All the **HPIs (17 categories of industrial units)** are required to have **OCEMS**.
- Five parameters are scrutinised for all industries: **BOD (Biological Oxygen Demand)**, **TDS (Total Dissolved Solids)**, **Ph value**, **COD (Chemical Oxygen Demand)** and **TSS (Total Suspended Solids)**.
- The emissions monitored include **particulate matter (PM)**, **carbon monoxide (CO)**, **nitrogen oxides ($NO_x$)**, **sulfur dioxide ($SO_2$)**, and **fluoride**. If the pollution control boards receive any number that exceeds the permissible limit, the industry is sent a notice and action is taken.

### Issues

- The data collected by OCEMS is largely inaccessible to the public; in the few cases that the data is accessible, it remains opaque. The OCEMS network is regulated by **CPCB**, which also monitors the **Continuous Ambient Air Quality Monitoring System (CAAQMS)**. However, in the OCEMS, the monitoring system is left to the same industries that are being monitored for their emissions! (The thieves have the keys!)

## 16.2. Pollutants From HPIs

### Thermal Power Plants (TPP)

- **Processes involved: fossil fuels such as coil**, **oil**, **and natural gas** are burnt to produce heat → Heat is used to produce high-pressure steam from water → High-pressure steam is used to drive a steam turbine → A generator attached to the steam turbine generates electricity.
- In India, most TPPs use **coal as fuel** (coal contains many toxic elements). Their **energy efficiency is very low** (20-45%). Most TPPs **do not employ pollution-reducing techniques** such as **flue gas desulphurisation (FGD)**, **electrostatic precipitation**, etc.

### Pollution

- **Fly ash** (electrostatic precipitator ash, dry fly ash, pond ash and mound ash) is a byproduct of coal combustion. It is discharged into air and **ash ponds** (fly ash + water). The collapse of ash ponds contaminates nearby farms, homes, **surface water bodies** and **groundwater** with **toxic heavy metals** and other elements.
- **Toxic heavy metals in fly ash: Mercury**, **cadmium**, **arsenic**, **lithium**, **zinc**, **iron**, **copper**, **nickel**, **boron**, **magnesium**, **lead**, **aluminium**, etc., are widely detected in the air as well as water bodies around TPPs.
- **Other toxic elements in fly ash:** Fluoride, sulphur, etc.
- **Gaseous Pollutants from TPP: Carbon Dioxide ($CO_2$)**, **Sulphur Dioxide ($SO_2$)**, **Oxides Of Nitrogen ($NO_x$)**, **Particulate Matter (PM)**, **Methane ($CH_4$)**, **Carbon Monoxide (CO — from incomplete combustion)**, **Volatile Organic Compounds (VOCs)**, etc.
- **Water Pollution:** Heavy metal pollution due to **acid mine drainage (AMD)** from open-pit and underground coal mines and TPP effluents (cooling tower blow down, ash handling wastewater, wet FGD system discharges, etc.).

**[UPSC 2023] Consider the following statements regarding mercury pollution:**

1. Gold mining activity is a source of mercury pollution in the world.
2. Coal-based thermal power plants cause mercury pollution.
3. There is no known safe level of exposure to mercury.

***How many of the above statements are correct?***

a) Only one

b) Only two
c) All three
d) None

**Explanation**

***Statement 1 is correct***

- During the gold extraction process, **mercury** is used to bind with gold particles, forming an amalgam. This technique, known as **amalgamation**. The amalgam is then heated to **evaporate the mercury**, leaving behind the gold.

***Statement 2 is correct***

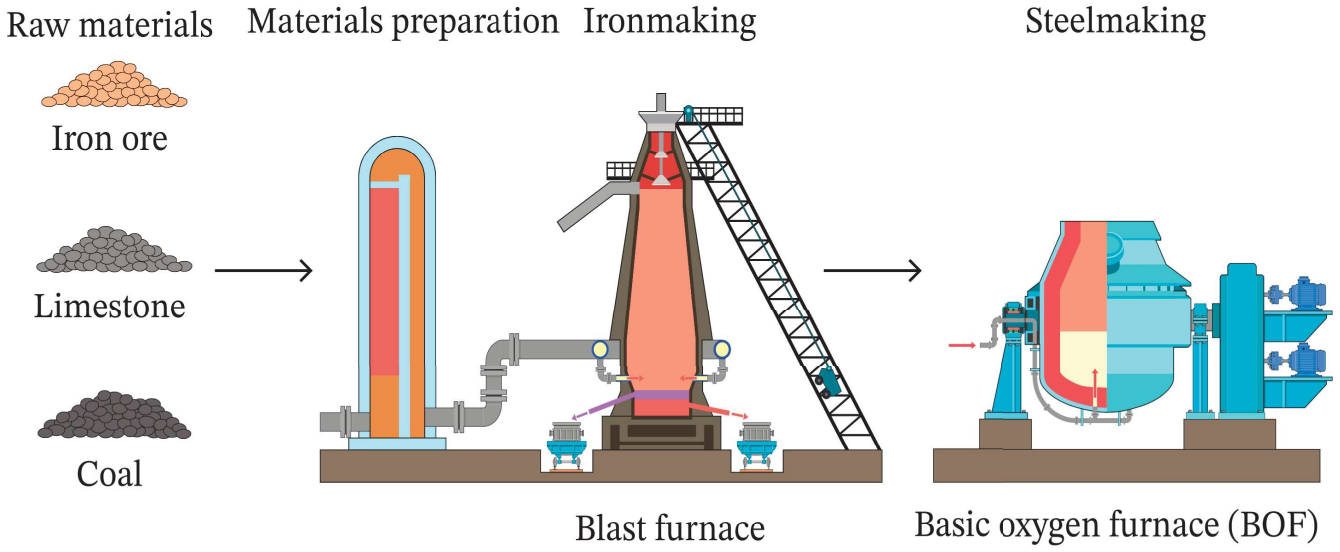
- When coal is burned to produce electricity in these power plants, **mercury** that **naturally occurs in coal** is released as a gas into the atmosphere.

***Statement 3 is correct***

- Mercury is a toxic substance, and there is no known safe level of exposure to it. Even low levels of mercury exposure can have adverse health effects, particularly on the nervous system.

***Answer: c) All***

## Iron and Steel Industry




### Processes involved

- **Unwanted impurities** are removed by **smelting iron ore in a blast furnace**. Major impurities include **sulphur** (which forms **iron sulphide**, which dramatically reduces the strength of steel), **lead** (improves the machinability of the steel when present in small quantities), **oxygen** (oxides make iron and steel weak), etc.
- In a blast furnace, **fuel (coke — has far fewer impurities than coal)**, **iron ore**, and **flux (limestone — removes sulphur and other impurities into slag)** are continuously supplied. The byproducts obtained are **liquid slag**, **liquid iron (pig iron — an intermediate product of smelting iron ore; has oxides)**

and gases. Oxygen in the iron oxides is reduced by a series of chemical reactions that produce **CO** and **$CO_2$**.

⇨ *Pig iron to steel ➔ **Liquid (pig) iron** → **Cast iron** (cooled liquid iron; brittle; carbon content greater than 2%; wrought iron (weak) = liquid iron + slag) → **Steel** (carbon content is up to 2.1%; it does corrode) → **Stainless steel** (steel + 10.5% **chromium** + **Nickel**, **manganese**, **molybdenum**, etc.; **it does not corrode**).*

## Byproduct – Slag

- **Slag ➔ full of impurities** such as calcium sulphide (CaS) and oxides of **silica**, **alumina**, **magnesia**, **calcium** (CaO), etc., that entered with the iron ore or coke. Only a small percentage of slag goes into **landfills**.
- **Cement** made with blast furnace slag has **lower permeability** and is **more durable** than Portland (regular) cement. It is used as an **aggregate** in concrete, cement clinker, asphalt concrete, asphalt and road bases.
- **Soil improvement:** The dissolution of slag generates **alkalinity** that can be used to precipitate out metals, sulfates, and excess nutrients (like nitrogen, phosphorus, and potassium) in wastewater treatment.
- **Soil conditioner:** Ferrous slags have been used to **rebalance soil pH** and as **fertilisers** (as sources of calcium and magnesium).

## Air Pollution

- The industry burns a lot of coal (thermal power; coke in the blast furnace), causing air pollution in the form of PM2.5 and PM10, **Carbon Dioxide**, **Sulphur Oxides (sulphur is eliminated as $SO_2$ in the blast furnace)**, **Nitrogen Oxides**, **Carbon Monoxide**, **Hydrogen Sulphide**, **Non-Methane Volatile Organic Compounds (NMVOC)**, etc.
- Coke ovens emit **naphthalene**, which is highly toxic and can cause cancer (carcinogenic).

## Magnetite Pollution

- Magnetite pollution refers to the presence of a magnetic mineral called Magnetite ($Fe_3O_4$) in the environment as a result of human activities such as mining, steel production and industrial processes.
- Magnetic particles can **interfere with the migratory patterns of birds** and the **operation of electronic equipment**, such as compasses and navigation systems.

**[UPSC 2021] Magnetite particles, suspected to cause neurodegenerative problems, are generated as environmental pollutants from which of the following?**

1) Brakes of motor vehicles
2) Engines of motor vehicles

3) Microwave stoves within homes
4) Power plants
5) Telephone lines

***Select the correct answer using the code given below***

a) 1, 2, 3 and 5 Only
b) 1, 2 and 4 Only
c) 3, 4 and 5 Only
d) 1, 2, 3, 4 and 5

**Explanation**

- **Magnetite** is an oxide of iron. It is the **most magnetic form of iron** with ~72% metallic iron. It is a **natural magnet** extensively sought out in the **electrical industry** for its **excellent magnetic properties**. Magnetite is used in brake pads as a solid lubricant.
- There are no conclusive sources mention the use of magnetite in microwave owens and telephone lines. However, magnets are used in a microwave oven to guide electrons to heat food.

***Answer: b) 1, 2 and 4 Only or d) all (tricky question)***

### Water pollution

- Heavy metal pollution occurs due to acid mine drainage (AMD) in slag dumps.
- Wastewater (used for filtering) from the **coking process** (heating coal in the **absence of oxygen (CO emissions)** to drive off VOCs, leaving behind high-carbon coke) is highly toxic and contains several carcinogenic organic compounds as well as cyanide, sulfides, ammonia, etc.
- Dissolution of **slags (full of oxides)** can produce **highly alkaline groundwater**. (oxides in slags react with water to produce a higher concentration of hydroxide ($OH^-$) in groundwater).

## Cement Industry

- **Processes involved:** blasting limestone quarries → crushing **limestone (75%)** and **clay (25%)** → (**calcination**) burning the prepared mix in a kiln (a large oven-like structure) at high temperature to form **calcium silicate clinker** (a mix of limestone and minerals transformed by heat) → grinding clinker with 3-5% **gypsum (regulates the setting time of cement)** → Portland Cement.
- Limestone (the most common form of **calcium carbonate**) is the most crucial **binder** in cement. It is heated in kilns to ~1,400 °C using **coal as fuel**.
- Carbon trapped in the limestone combines with oxygen and is released as **$CO_2$ (byproduct)** — a ton of cement yields at least half a ton of $CO_2$. A portion of limestone can be substituted by **blast furnace slag** and/or **fly ash** to reduce $CO_2$ emissions.

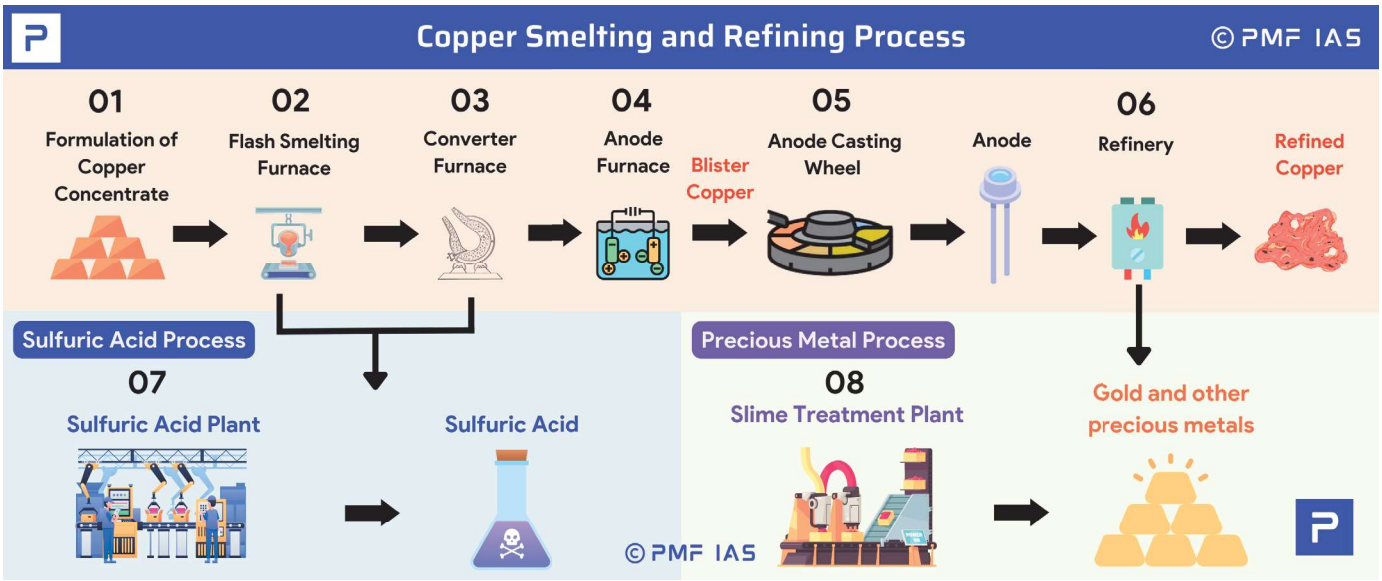
- Cement manufacturing requires water for cooling heavy equipment and exhaust gases, in emission control systems such as **wet scrubbers**, and for preparing slurry in kilns.

***Emissions and Effluents are the same as in TPP**, **as coal is the primary fuel source in kilns**.*

## Copper Smelting Industry

### Processes Involved

1. Mining of raw **chalcopyrite ore** ($CuFeS_2$ — **copper iron sulfide**; most abundant copper ore mineral; <1% Cu).
2. Improving chalcopyrite ore concentration (34.5% Cu, 30.5% Fe, and **35.0% S**) by crushing, grinding, and **flotation purification (oils are used as certain metals have an affinity to oils)** at the mine site.
3. Roasting of improved ore concentrate is performed in **copper smelters (mostly near ports)** to reduce impurities, including **sulfur**, antimony, arsenic, lead, etc. It eliminates 20-50% sulfur as highly concentrated **sulfur dioxide ($SO_2$)**. It is converted to concentrated **sulfuric acid** and transported to **fertilisers**, **pharmaceuticals**, **paper bleaching**, **petroleum refineries** and other industries.
4. Smelting of roasted ore concentrate produces **matte** (65% Cu), a molten mixture of **copper sulfide** ($Cu_2S$), iron sulfide (FeS), and slag consisting of iron oxide and **heavy metals**.
5. Converting the matte in a converter furnace yields high-grade **blister copper** (~99% Cu).
6. Blister copper is refined in an **anode furnace** and cast into anodes to remove oxygen (99.5% Cu).
7. **Electrolytic refining:** Copper from the anode plates is electrolytically deposited on the **stainless steel cathode plate**, resulting in copper with a grade of 99.99%.
8. **Slime** generated in electrolytic refining contains **precious metals** such as **gold**, **silver**, **selenium**, **tellurium**, etc. These metals are recovered in a **slime treatment plant**.




### Copper slag

- Copper slag is mainly used for **abrasive surface blast-cleaning** (used to shape the surface of the metal, stone, concrete, etc.). It can be used in **road construction** and the production of **cement**, **mortar**, and **concrete** as raw materials for **clinker**, coarse and fine aggregates.

## Pollution

- **Leaching of impurities from copper ore concentrate and slag:** **Radon** (emitted from the natural radioactive decay of **uranium** and **copper ores**), **iron**, **arsenic**, **antimony**, **mercury**, **lead**, **cadmium**, **selenium**, **magnesium**, **aluminium**, **cobalt**, **tin**, **nickel**, **manganese**, **nitrates**, **fluorides**, etc.
- As most copper ores are sulphur-based, the smelting process releases **Sulphur Dioxide**. When the concentration of sulphur dioxide is too high, the industries convert it into **sulphuric acid**, an irritant and water contaminant.

## Thoothukudi Sterlite Copper Plant Controversy

- **Vedanta's Thoothukudi Sterlite Copper Smelter** in **coastal TN** and **Hindalco's copper smelter in coastal Gujarat** produced more than 80% of India's copper.
- In 2018, massive protests erupted against the Thoothukudi plant over plans to increase the production capacity from 400,000 to 800,000 tonnes per year. The plant was subsequently closed.
- The plant was built 14 km from the **Gulf of Mannar Marine National Park**, while the mandated distance from an eco-sensitive zone for a hazardous industry like copper smelting should have been, as per **CSIR-National Environmental Engineering Research Institute (NEERI)**, **more than 25 km**. It was releasing toxic fumes of **Sulphur Dioxide** into the atmosphere and toxic effluents containing **heavy metals** into the nearby water bodies.
- The Thoothukudi plant contributed **36 per cent of the country's demand for refined copper**. It included a **sulphuric acid plant**, a **phosphoric acid plant** and a 160 MW coal-based power plant to power the copper smelter. The plant closure has affected many livelihoods.

### [UPSC 2021] Why is there a concern about copper smelting plants?

1) They may release lethal quantities of carbon monoxide into environment.
2) The copper slag can cause the leaching of some heavy metals into environment.
3) They may release sulphur dioxide as a pollutant.

***Select the correct answer using the codes given below.***

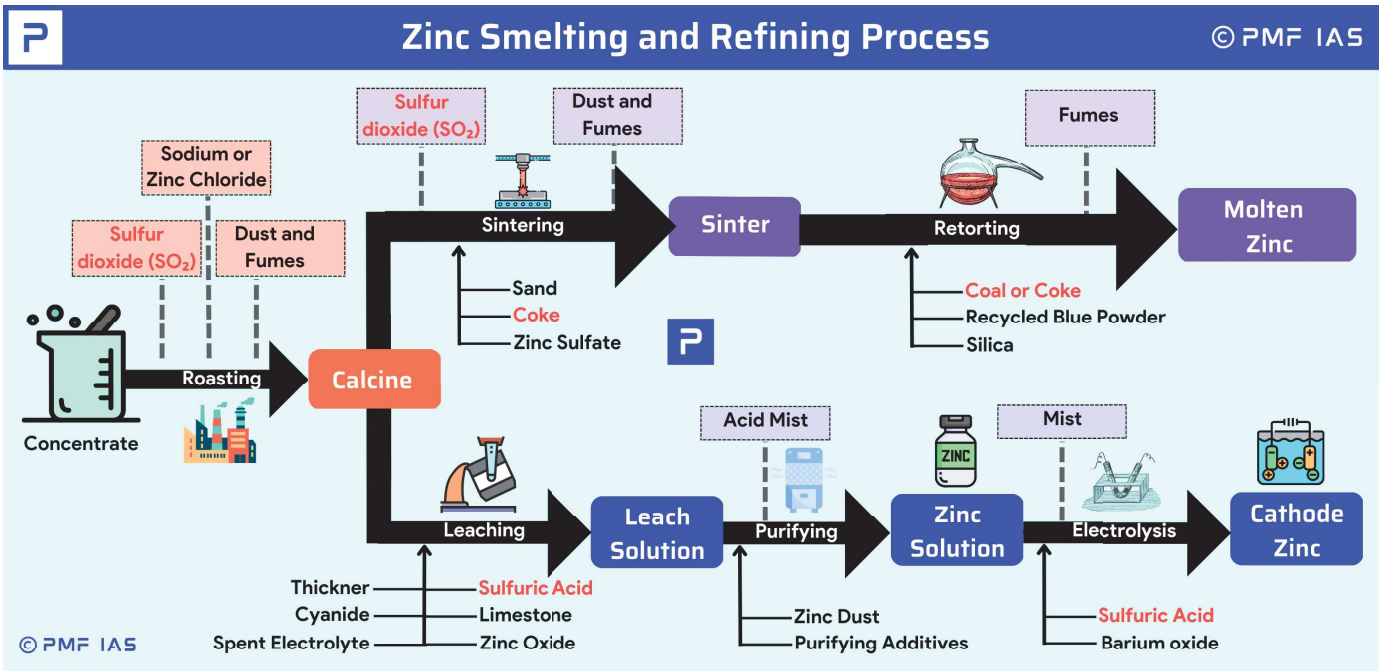
a) 1 and 2 Only
b) 2 and 3 Only
c) 1 and 3 Only
d) 1, 2 and 3

**Explanation**

- Some quantity of CO is produced in almost all combustion processes. Lethal quantities of CO are produced when there is **incomplete combustion** on an industrial scale.
- In the copper smelting process, the carbon monoxide produced reacts with the ore to produce carbon dioxide. Hence, it does not release a lethal quantity of CO in the environment.

***Answer: b) 2 and 3 Only***

## Zinc/Lead Smelting Industry




- **Zinc protects the steel from corrosion (galvanisation)**. Lead is used in batteries. **Zinc** and **lead** often occur together as sulphides.

1. **Raw materials:** Zinc sulfide (ZnS) and/or lead sulphide (PbS – galena) ore concentrate.
2. **Beneficiation:** Concentration of the zinc/lead in the recovered ore is done near the mine by crushing, grinding, and flotation process using oils (lead has an affinity to oils).
3. **Roasting:** Benefaction ore is burned in a blast furnace and turned into **calcine** (impure zinc oxide at high temperature), eliminating most of the sulphur as **$SO_2$**. Crude **molten lead (lead bullion)** is recovered similarly using **limestone flux** and **coke**.
4. **Leaching:** Calcine is dissolved in **sulphuric acid**.
5. **Purification:** Pure **zinc sulphate solution** is produced by separating metals such as lead, gold, etc.
6. **Electrowinning (specialised electrolysis process):** Zinc contained in the zinc sulphate solution is deposited onto aluminium cathodes. Similarly, lead is also extracted from lead bullion.

- **Byproducts:** Gold, silver and copper are collected as **slimes**.
- **Granulated lead–zinc slag** has suitable particle sizes for **sand replacement** in mortar and concrete.

## Pollution

- **Principal air pollutants: particulate matter (lead/zinc**, **arsenic**, **antimony**, **cadmium**, **copper**, **and mercury** and **metallic sulfates)** and **Sulfur Dioxide (**$SO_2$**)**.
- **Sources of wastewater:** spent electrolytic baths, slime recovery, spent acid from hydrometallurgy processes, cooling water, air scrubbers, etc.
- **Heavy metal leaching from discarded slag:** Cadmium, copper, lead, iron, bismuth, antimony, arsenic, copper, etc.

## Aluminium Smelting Industry

1) The **Bayer Process** separates **alumina (aluminium oxide)** from **bauxite ore near the mine**. The insoluble parts of the bauxite are removed by exposing the ore to very hot **caustic soda (sodium hydroxide)**.
2) The **Hall-Héroult Process** produces pure aluminium by **electrolysis** of alumina in an aluminium smelter. Due to the significant energy demand, the smelters must be set up close to a **power station**.

### Pollution

- Most of the emissions are related to thermal power and electrolysis processes — $NO_x$, $SO_2$, ammonia ($NH_3$) and polycyclic aromatic hydrocarbons (PAH — formed from incomplete combustion during electrolysis).

#### Red Mud

- The **highly alkaline** and **hazardous bauxite residue** from the Bayer process is known as **red mud**. It is composed mainly of **iron oxides** and various other various oxides and **heavy metals**.
- Historically, red was disposed of entirely in landfills. Of late, it is being used in **road construction**, and as a **source of iron**, in producing **iron-rich cement**, **low-cost concrete**, etc. It is applied to soils to improve phosphorus cycling, **amelioration of soil acidity**, carbon sequestration, etc.

## Petroleum Refining and Petrochemicals

- The petroleum industry is subdivided into **upstream**, **midstream**, and **downstream** segments. The upstream deals with the exploration and mining of crude oil, the midstream includes storage and transport of crude, while the downstream involves refining.

### Petroleum Refining

1) **Fractional distillation:** separation of different fractions (hydrocarbon compounds) of crude oil based on their boiling point differences.
2) **Conversion processes:** breaking down long chain molecules into more valuable smaller ones by heating.
3) **Treating:** separating the impurities such as **sulfur**, **nitrogen** and **heavy metals**.

### Pollution

- Air pollutants include **particulate matter (PM)**, **carbon dioxide ($CO_2$)**, **nitrogen oxides ($NO_x$)**, **carbon monoxide (CO)**, **hydrogen sulfide ($H_2S$)**, **sulfur dioxide ($SO_2$)**, **natural gas (methane)**, **lead**, **VOCs** including cancer-causing **benzene** pollutants, etc.
- Refineries use deep injection into underground wells and coastal waters to dispose of wastewater and **oil residues** generated inside the plants, and some of these wastes end up in aquifers and groundwater.


**[UPSC 2021] With reference to furnace oil, consider the following statements:**

1) It is a product of oil refineries.
2) Some industries use it to generate power.
3) Its use causes sulphur emissions into Environment.

***Which of the statements given above are correct?***

a) 1 and 2 Only
b) 2 and 3 Only
c) 1 and 3 Only
**d) 1, 2 and 3**

***Furnace oil is a residue of crude oil.***

## Petrochemicals

- Petrochemical industry comprises the manufacture of synthetic fibres, polymers (PVC, polystyrene, performance polymers, etc.) and intermediates (styrene), synthetic rubber (elastomers), synthetic detergent

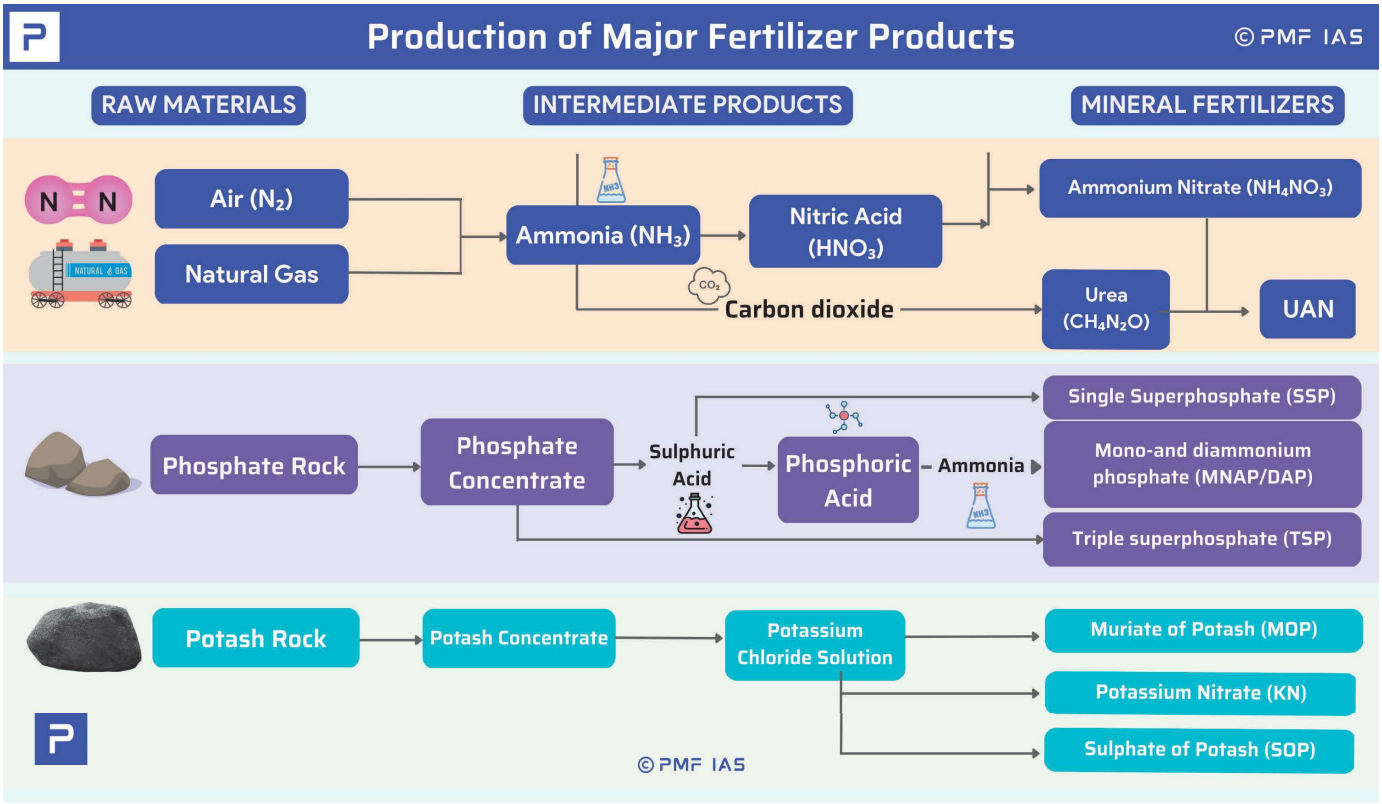
intermediates, performance plastics, etc., using **hydrocarbon feedstock** (**naphtha**, **ethylene**, **propylene**, **butadiene**, etc.) derived mainly from crude oil and natural gas processing.

### Pollution

- Organic pollutants primarily consist of complex **polycyclic aromatic hydrocarbons (PAHs)**. The wastewater effluents include toxic phenols, **cyanide**, and **formaldehyde**.

## Fertiliser Industry

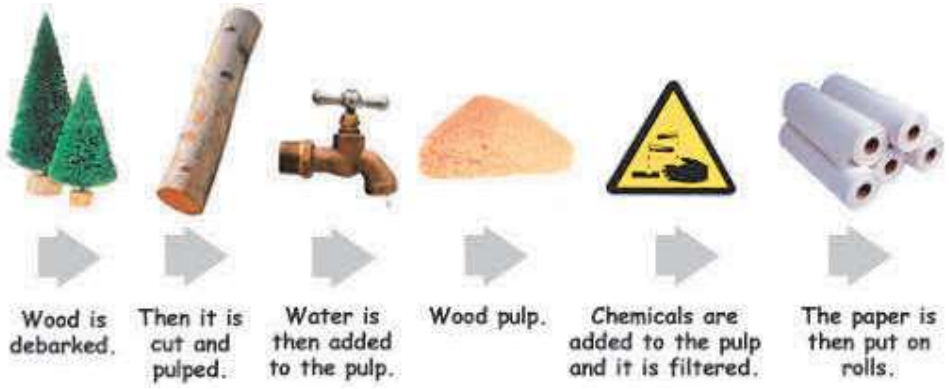
- Air Pollutants: Particulate matter, **ammonia ($NH_3$)**, **nitrogen oxides**, **sulphur** and **carbon dioxide**. Prilling towers, which manufacture urea prills, are a significant source of urea dust particulates.
- Water Pollution: Wastewater generated contains ammoniacal **nitrogen**, **phosphates**, **heavy metals (vanadium** and **arsenic** — used for **carbon dioxide removal** process in ammonia plant —and **Chromium** — used as a **corrosion inhibitor** in cooling towers) and fluorides in varied amounts.




## Distilleries

- The distillery industry uses **sugarcane molasses**, **cereals**, **fruits**, **sugar beet**, and other agro products to produce alcohol through fermentation and distillation. Alcohol is an essential material in the **chemical**, **pharmaceutical**, **cosmetics**, beverage, food, and perfume industries.
- Distilleries are among the most water-polluting industries because **ethanol fermentation** results in the discharge of high-strength liquid effluents with **high concentrations of organic matter (high BOD)** and nitrogen compounds (**eutrophication**), low pH, high temperature, high turbidity and high salinity.

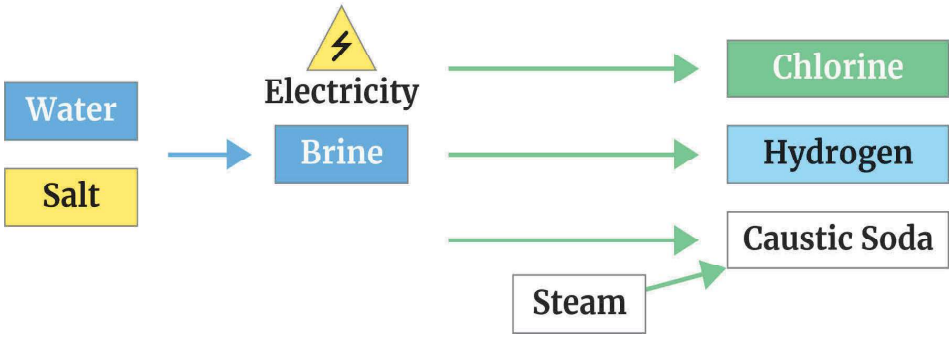
## Paper and Pulp Industry




- Pulp is a fibrous material prepared by separating cellulose fibres from wood, bagasse, fibre crops, waste-paper, etc. The pulp mills are energy intensive and use a lot of **unpolluted water** and **chemicals** (**sulfite salts**, **caustic soda**, **sodium sulfide**, **hydrogen peroxide**, **sulphonic acid**, etc.) for pulping the wood (to remove **lignin**) and bleaching the pulp to produce paper of various quality and finish.
- The released wastewater contains very **complex organic (high BOD)** and inorganic pollutants such as sodium hydroxide, sodium carbonate, sodium sulfide, chlorine dioxide, calcium oxide, hydrochloric acid, etc.
- The primary gaseous pollutants are hydrogen sulfides, sodium sulfide, **methyl mercaptan**, sulfur, etc.

## Caustic Soda

- Caustic soda (NaOH) is produced by **electrolysis of brine** (common salt dissolved in water; **chloralkali process**) using **mercury cell and membrane cell process**. It is a widely used industrial chemical in pulp and paper, detergents, packaging, agriculture, environmental protection, water treatment, textiles, etc.
- **Chlor-alkali industries** produce caustic **soda**, **soda ash**, **chlorine** and **hydrogen**, which are used as fuel or converted to HCl. These products are used to manufacture paper, soaps and detergents, chemicals, water treatment chemicals, textiles, PVC, glass, etc.
- Owing to the environmental risks associated with the **mercury** process and risks associated with handling chlorine, its vapours and hydrogen, the industry is classified among the 17 polluting industry categories.
- Wastewater is generated from drying chlorine using **sulphuric acid ($H_2SO_4$)**. Besides scrapped cell parts (membranes, anodes and cathodes) leach **heavy metals**.



## Tannery

1. **Beamhouse operations:** hides from slaughterhouses → soaking (removes dirt from hides) → liming (unhairing by chemical dissolution of the hair with an **alkaline medium** of **sulphide** and **lime**) → de-liming (alkaline hides are neutralised with **acid ammonium salts**) → bating or puering (to degrade proteins) → pickling (**increases the acidity** of the hide, enabling **chromium tannins to enter the hide**).
2. **Chrome tanning:** it is based on the **cross-linkage** of **chromium ions** with free carboxyl groups in the **collagen**. It makes the hide **resistant to bacteria** and temperature.

- The discharge of solid waste and wastewater containing **chromium** is the leading environmental problem.
- Wastewater with high **organic content (high BOD)** emanates from the beam house (pre-tanning) operations.
- Emissions into the air are primarily related to energy use and the use of organic solvents and dyes — **hydrogen sulphide ($H_2S$)** and **ammonia ($NH_3$)**.

## Sugar Industry

- **Processes involved:** sugar cane (tropical grass crop)/**sugar beet** (temperate root tuber crop) harvesting → juice extraction by crushing → filtration → crystallisation → drying of crystals → sugar.

### Byproducts

- **Press mud** is **waste produced during the filtration** of cane juice. **Applications:** used as **fertiliser**, **soil amendment** (any material added to a soil to improve its physical properties, such as water retention), **biosorbent** (effectively adsorb metal ions and contaminants), **animal feed**, etc.
- **Molasses** is a **dark viscous syrup** resulting from refining sugar cane juice into sugar. **Applications:** used to **sweeten and flavour foods**, in making **brown sugar for baking**, **ethanol production**, as animal feed, **soil amendment**, etc.
- **Bagasse** is a dry, pulpy, fibrous material that remains after crushing sugarcane. **Applications:** used as **fuel in sugar industries** and **raw material in paper**, **pulp**, **and packaging industries**.

### Air Pollution

- The burning of sugar cane leaves and residue and **bagasse** (used as a fuel in sugar industries) generates large quantities of **fly ash**, **sulfur dioxide**, **carbon monoxide**, **nitrogen oxides**, **nitrates**, **carbon compounds**, and **sulfates**.
- **Sulphitation (introduction of $SO_2$ into liquids)** and **carbonation (saturation of a liquid with $CO_2$ gas)** are used as a process of purification (lightning) of cane juice by employing **sulphur dioxide**, **carbon dioxide**, **lime (calcium hydroxide)** and **calcium carbonate (aids precipitation of impurities)** producing **$SO_2$** and **$CO_2$**.

#### GHGs

- The major part of the total GHG emission results from residue burning, the use of synthetic fertilisers, and fossil fuel combustion. The sugarcane residue burning results in not only **$CO_2$**, **$N_2O$** **(nitrous oxide)** and **methane** emissions but also other **GHG precursors**, including **carbon monoxide (CO)**, **non-methane volatile organic compounds (NMVOC)**, etc.

## Water Usage

- To mature in the field, one kilo of sugarcane requires 1,500-2,000 litres of water. After the harvest, crushing a single tonne of sugarcane requires another 1,500-2,000 litres of water, generating about 1,000 litres of wastewater.

## Water Pollution

- The sugar industry ranks third for the amount of wastewater produced, after the **pulp/paper** and chemicals sectors. The wastewater contains a high amount of **organic pollution load**, particularly in suspended solids, organic matter, press mud, bagasse, etc., raising the **Biological Oxygen Demand** (BOD — organic matter in water is decomposed by bacteria and other microbes consuming a lot of dissolved oxygen).
- **Coliform bacteria** (**indicator species** for pollution load) indicates a high presence of pathogen and total dissolved solids (TDS — inorganic salts such as **calcium**, **magnesium**, **sodium**, **nitrates**, etc.) in sugar industry effluents.

**---------- End of Chapter ----------**

# 17. Land Degradation

- **Soil/land degradation** is the **decline in soil quality** caused by improper use, usually for agricultural, pastoral, industrial, or urban purposes. It encompasses physical (soil erosion), chemical (salinity, alkalinity), and biological deterioration (pollution and deterioration of vegetal cover).

## 17.1. Major Causes for Land Degradation

### Deforestation

- **Roots of trees and plants bind the soil particles** and regulate the flow of water, thus saving soil from erosion. The population explosion has created pressure on forest land and resources, and this causes deforestation.
- Deforestation makes soil vulnerable and **accentuates soil erosion**. The large-scale damage to the soil in the **Shiwalik range**, the **Chos of Punjab**, and the **ravines of Chambal Valley** is due to deforestation.

#### Major Causes of Deforestation

##### Shifting cultivation

- In this practice, a patch of land is cleared, vegetation is burned, and the **ash** is mixed with the soil, thus adding nutrients to the soil. This patch of land is used for raising crops for two to three years, and when the yield is modest, it is abandoned and is **left to recover its fertility**, and the same practice is **repeated elsewhere** on a fresh piece of land. This agricultural practice has become **unsustainable** due to the rapid increase in **population pressure** in forests.

##### Raw Materials

- Wood is used as a raw material by various industries for making paper, plywood, furniture, match sticks, boxes, crates, packing cases, etc.
- Industries also obtain their raw materials from plants, such as drugs, scents and perfumes, resin, gums, waxes, turpentine, latex and rubber, tannins, alkaloids, and beeswax.

##### Other Causes

- **Mining:** opencast mining has resulted in deforestation all over the world.
- **Plantation Boom:** The increase in demand for **cocoa**, **coffee**, **tea**, **sugar**, **palm oil**, **rubber**, etc., has resulted in deforestation in the tropical rainforests.
- Deforestation also results from overgrazing, agriculture, urbanisation, flood, fire, pest, diseases, etc.

#### Effects of Deforestation

- **Closed forests (based on canopy level)** have diminished due to deforestation, leading to an **increase in degraded forests** (**carbon sink turning to carbon source**).

- Forests recycle moisture (natural motors) from the soil into their immediate atmosphere by transpiration where it again precipitates as rain.
- Deforestation results in **immediate lowering of groundwater levels** (low percolation due to the quick surface runoff on barren lands) and long-term reduction of precipitation. Due to deforestation, this natural reuse cycle is broken, and water is lost through rapid runoff.

## Soil Salinity and Soil Alkalinity

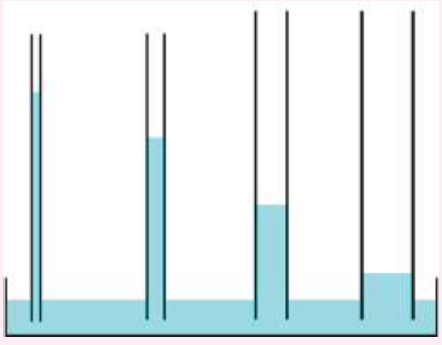
- In Saline and Alkaline Soils, the topsoil is **impregnated** (soaked or saturated with a substance) with **saline and alkaline efflorescences** (becomes covered with salt particles).
- Undecomposed rock fragments, on weathering, give rise to **sodium**, **magnesium and calcium salts**, **and sulfurous acid**. Some of the salts are transported in solution by the rivers.
- In regions with a **low water table** (due to over-irrigation in **canal-irrigated areas**), the **salts percolate into the subsoil**, and in regions with good drainage, the salts are wasted away by flowing water. But in places where the **drainage system is poor**, the **water with high salt concentration becomes stagnant** and **deposits all the salts in the topsoil once the water evaporates**.
- In regions with a high sub-soil water table, injurious salts are transferred from below by the **capillary action** because of evaporation in the dry season.
- In **canal-irrigated areas**, plenty of water is available, and the farmers indulge in **over-irrigation** of their fields. Under such conditions, the **groundwater level rises**, and **saline and alkaline efflorescences** consisting of salts of **sodium**, **calcium**, **and magnesium** appear on the surface as a layer of white salt.
- Vast tracts of **canal-irrigated areas** in Uttar Pradesh, Punjab, and Haryana; arid regions of Rajasthan; semi-arid areas of Maharashtra, Gujarat, Andhra Pradesh, Telangana, and Karnataka, etc. are facing this problem.
- Although the Indira Gandhi Canal in Rajasthan has turned the sandy desert into a granary, it has given birth to serious problems of salinity and alkalinity.

**[UPSC 2018] Which of the following is/are the possible consequence(s) of heavy sand mining in riverbeds?**

1) Decreased salinity in the river
2) Pollution of groundwater
3) Lowering of the water-table

***Select the correct answer using the code given below:***

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1 ,2 and 3



**Explanation**

- Water accumulates in the (pores) space between soil particles and can stay in these spaces dues to **capillary action**. Capillary action occurs because water is sticky and helps the water in the pores overcome gravity. It is because of the **capillary action** that water (water table) is available just a few feet below the topsoil.
- When the soil is removed the capillary action is lost and the water table falls. In places of the high-water table (near marshlands, wetlands, and river beds) when the topsoil is removed the water table is exposed to sunlight and evaporation increases salinity. Also, soil acts as a filter and when it is removed the pollutants manage to reach the groundwater more easily.

***Answer: b) 2 and 3 only***

### Effects of salinity and alkalinity

- Salinity and alkalinity have an adverse effect on soil and reduce soil fertility.
- Cultivation is not possible on saline soils unless they are flushed out with large quantities of irrigation water to **leach out the salts**.
- The choice of crops is limited to salinity-tolerant crops like cotton, barley, etc.
- The quality of fodder and food produced is of poor quality.
- Salinity and alkalinity create **difficulties in building and road construction**.
- Cause floods due to reduced percolation of water.

### Steps to treat salinity and alkalinity

- ✓ Providing outlets for lands to drain out excess water and lower the water table.
- ✓ Seal leakages from canals, tanks, and other water bodies by lining them.
- ✓ Making **judicious use of irrigation facilities**.
- ✓ Improve vegetal cover to avoid further degradation by planting salt-tolerant vegetation.
- ✓ Crop rotation.
- ✓ Liberal application of **gypsum to convert the alkalis into soluble compounds**.
- ✓ Alkali (base) can be removed by adding **sulphuric acid** or acid-forming substances like **sulfur and pyrite**.
- ✓ Organic residues such as rice husks and rice straw can be added to promote the formation of **mild acid** as a result of their decomposition.

## Desertification

- Desertification is the **spread of desert-like conditions in arid or semi-arid areas** due to man's influence or climatic change. A large part of the arid and semi-arid region lying between the Indus and the Aravalli Range is affected by spreading desert conditions.

- Desert soils suffer **maximum erosion by wind**. The sand carried by the wind is deposited on the adjoining fertile lands whose fertility dwindles, and slowly, the fertile land starts merging with the advancing desert. It has been estimated that the **Thar Desert is advancing** at an alarming rate of about 0.5 km per year.
- The process of desertification is attributed to **uncontrolled grazing**, reckless felling of trees, and growing population. Climate change has also contributed to the spread of deserts.

### Ecological implications of desertification

- Drifting of sand and its accumulation on agricultural land.
- Excessive soil erosion by wind and water.
- Deposition of sand in rivers and lakes decreases their water-containing capacity.
- **Lowering of water table** leading to acute water shortage.
- Increase in the area under wastelands.
- Decrease in agricultural production.
- Increase in frequency and intensity of droughts.

### Measures for Controlling Desertification

- ✓ Intensive tree plantation in the transition zones.
- ✓ **Mulching shifting sand dunes** in deserts with different plant species. Mulches serve as an effective physical barrier to the moving sand.
- ✓ Grazing should be controlled, and new pastures should be developed.
- ✓ Indiscriminate felling of trees should be banned.
- ✓ Alternative sources of fuel can reduce the demand for fuelwood.
- ✓ Sandy and wastelands should be put to proper use by judicious planning.

## Waterlogging

- The flat surfaces and depressions result in waterlogging. Waterlogged soils are soaked with water accumulated during the rainy season or due to leakage from various water sources. The extent of waterlogged soils is about 12 million hectares in India – half of which lies along the coast and the other half in the inland area.
- Waterlogging is believed to be one of the **chief causes of salinity**. Proper layout of drainage schemes is the only way to overcome the menace of waterlogging. The basic methods of removing excess water from waterlogged soils are:
- ✓ **Surface Drainage:** Surface drainage involves the disposal of excess water over the ground surface through an open drainage system with an adequate outlet.

- ✓ **Vertical Drainage:** Any bore or well from which the underlying water is extracted is defined as vertical drainage. It works well in the **Indo-Gangetic plain** where the pumped water is used for irrigating the neighboring regions.

## Faulty Methods of Agriculture

- Much of the soil erosion in India is caused by faulty methods of agriculture. Wrong ploughing, lack of crop rotation, and practice of shifting cultivation are the most adversely affecting methods of agriculture.
- If the fields are ploughed along the slope, there is no obstruction to the flow of water, and the water washes away the topsoil easily.
- In some parts of the country, the same crop (**mono crop**) is grown year after year, which spoils the chemical balance of the soil. This **soil is exhausted and is easily eroded by wind or water**.
- The removal of the forest cover by shifting cultivation leads to the exposure of the soil to rain and sun which results in heavy loss of topsoil, especially on the hill slopes.

## Wind Erosion

- Wind erosion or **aeolian erosion** is quite significant in **arid and semi-arid regions**. Winds usually blow at high speeds in deserts due to the absence of physical obstruction. These winds remove the fertile, arable, loose soils, leaving behind a depression devoid of topsoil.
- The depression formation in deserts is the first step in **Oasis formation**. Oasis forms in depressions when there is underground water that accumulates above rocks.
- Very fine and medium sands are moved by the wind in a succession of bounds and leaps, known as **saltation**. Small sand and dust particles are transported over long distances through the air by a process known as **suspension**.
- Coarse sand is not usually airborne but rather is rolled along the soil surface. This type of erosion is called **surface creep**. Very coarse sand and gravels are too large to be rolled by wind, so wind-eroded soils have surfaces covered with coarse fragments. This kind of arid soil surface is known as **desert pavement**.

## Water Erosion

- Running water is one of the main agents which carries away soil particles. Soil erosion by water occurs by means of raindrops, waves, or ice. Erosion by water is termed differently according to the intensity and nature of erosion: **raindrop erosion**, **sheet erosion**, **rill and gully erosion**, **stream bank erosion**, **landslides**, **coastal erosion**, and **glacial erosion**.

### Raindrop erosion or Splash Erosion

- A raindrop is approximately 5 mm in diameter and hits the soil at a velocity of 32 km/hr. Raindrops behave like tiny bombs when falling on exposed soil, displace soil particles and destroy soil structure.

- The **presence of vegetation** on land prevents raindrops from falling directly on the soil thus erosion of soil in areas covered by vegetation is prevented.

## Sheet erosion

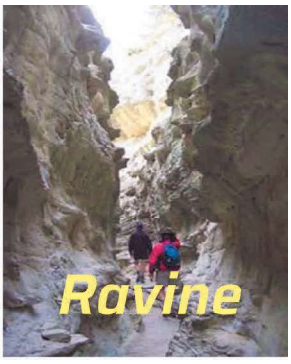
- With continued rainfall, the displaced soil particles fill in the spaces between soil particles and **prevent water from seeping into the soil**. This results in **surface runoff** and even more erosion. The detachment and transportation of soil particles by flowing rainwater are called **sheet/wash-off erosion**. Weathering and erosion tend to level down the irregularities of landforms and create a **peneplane**.

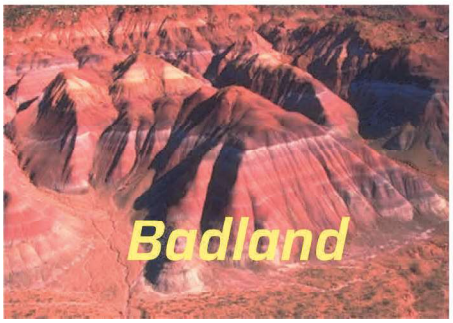
*Uluru (Ayers) Rock in Australia standing on a peneplane*

## Rill and gully erosion

- In rill erosion, finger-like rills appear on land after it has undergone sheet erosion. These rills are usually smoothened out every year while forming. Each year, the rills slowly increase in number and become wider and deeper.
- Gully erosion is the removal of soil along drainage lines by surface water runoff. When rills increase in size, they become gullies. Once started, gullies will continue to move by headward erosion or by slumping of the side walls. Gullies formed over a large area give rise to **badland topography** (**Chambal Ravines**).
- When a gully bed is eroded further due to headward erosion, the bed gradually deepens and flattens out, and a **ravine** is formed. The depth of a ravine may extend to 30 meters or more. Further erosion of ravine beds gives rise to **canyons**. Canyons are a few hundred meters deep and wide. E.g., the **Grand Canyon on the Colorado River**.








## Streambank erosion

- The erosion of **soil from the banks (shores)** of streams or rivers due to the flowing water is called bank erosion.
- In certain areas where the river changes its course, the river banks get eroded at a rapid rate.
- Streambank erosion damages the adjoining agricultural lands, high-ways, and bridges.

## Landslide

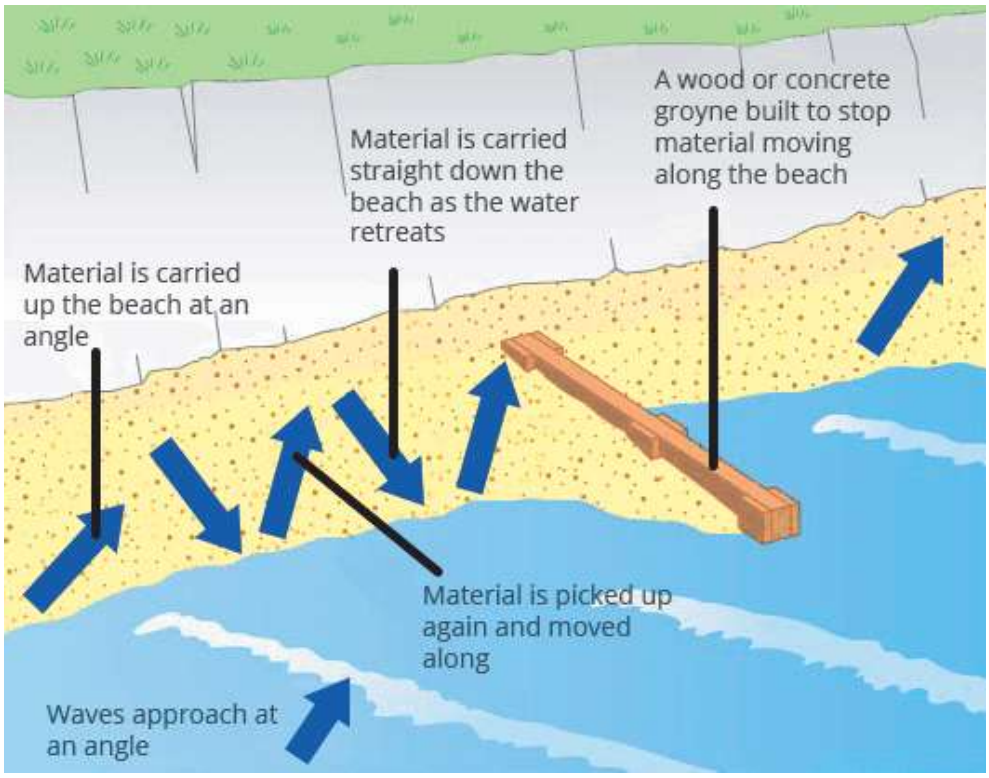
- The sudden mass movement of soil is called a landslide. Landslides occur due to instability or loss of balance of land mass with respect to gravity. The loss in balance occurs mainly due to excessive water or moisture in the earth's mass. **Gravity** acts on such an unstable landmass and causes the large chunks of surface materials, such as soil and rocks, to slide down rapidly.

## Coastal erosion

- In coastal areas, waves dash along the coast and cause heavy damage to the soil. During the landfall of cyclones, storm surges destroy beaches and wash away the top layer. In estuaries, tidal bores cause extensive damage to the surrounding banks.

### Groyne for coastal protection

- A **groyne** is a shore protection structure **built perpendicular to the shoreline** of the coast (or river), over the beach to reduce longshore drift and trap sediments. A **groyne** functions as a physical barrier by **intercepting sand moving along the shore**.




- Rock is often used as construction material, but wooden groynes, steel groynes, rubble-mound and sand-filled bag groynes, or groynes made of concrete elements can also be found. Rock groynes are generally preferred as they are more durable and absorb more wave energy due to their permeable nature.

### Glacial erosion

- In polar regions and high mountainous regions like the Himalayas, soil erosion is caused by **slowly moving glaciers**. This is called **glacial erosion**.

## Sea Erosion in India

- 32 % of India's coastline underwent sea erosion and 27% of it expanded between 1990 and 2018, according to a report by the **National Centre for Coastal Research (NCCR)**.

***[UPSC 2022] Explain the causes and effects of coastal erosion in India. What are the available coastal management techniques for combating the hazard? (Answer in 250 words)***

### Key Findings of the Report

- The **West Bengal coastline** has been particularly vulnerable among all, i.e. 60% of the coastline underwent erosion during the period. Erosion on Odisha's coast expanded by 51%. **More erosion was found on the eastern coast than on the western coast** (West Bengal, Puducherry, Tamil Nadu, Andhra Pradesh, etc.)

**Why was there more erosion on the Eastern Coast than on the Western Coast?**

- The Eastern coast showed more erosion because the Bay of Bengal witnesses **rougher seas and intense tide movement** in comparison to the Arabian Sea.
- Also, the Eastern coast **underwent more erosion due to frequent cyclonic activities from the Bay of Bengal in the past three** decades, compared to the western coast, which remained largely stable.
- Besides the southwest monsoon (June to September), the **Eastern coast also witnesses the Northeast Monsoon from October to December and** which brings rains to coastal Andhra Pradesh and Tamil Nadu and keeps the sea rough for most of the year.
- Apart from natural reasons, some anthropogenic factors also influence and intensify erosion, i.e.
  - ✓ Construction along coastlines. E.g. Ports.
  - ✓ Dredging in port areas and dumping of those sediments into deep seas (ideally, it should be dumped along the coast).
- 28.7% of the coastline in Andhra Pradesh is under varying degrees of erosion. About 28 km of coastline in Visakhapatnam (recently declared as the capital of AP) is prone to erosion. The erosion of beaches has been since the **construction of Visakhapatnam Port** in the 1930s.

## Erosion and Accretion

- Coastlines are **dynamic landforms** and are constantly subjected to erosion and/or accretion. Coastlines are modified by winds, waves, tides, currents, geomorphology, sediment supply to the coast, and anthropogenic activities.
- Accretion refers to an expansion of a coastal area through an increase in the width or length of the coastline. Although accretion is not considered inherently destructive like erosion, it can have **negative consequences in deltaic ecosystems** by reducing the flow of water inland.

## Measures to Check Sea Erosion

✓ Beaches are dynamic landforms and should be treated as part of the sea and not part of the land.

✓ The beaches act as cushions between the high wave action of the sea and the landmass. Continuous n**ourishment of beaches** is a must through the natural process and if disturbed, they will face severe erosion, which may lead to issues to the landmass like caving-in of roads.

- Construction of a submerged breakwater about 500 meters from the shoreline will break the energy of the waves and stop the erosion caused by the wave current. Measures such as **sea walls**, **revetments**, **groynes**, etc., will also help.

⇨ ***Beach Nourishment:*** *The basic principle involved is to dredge sand from the sea and deposit it on the beaches subject to erosion. The aim is to create a wider beach by artificially increasing the quantity of sediment on a beach experiencing sediment loss by dredging.*

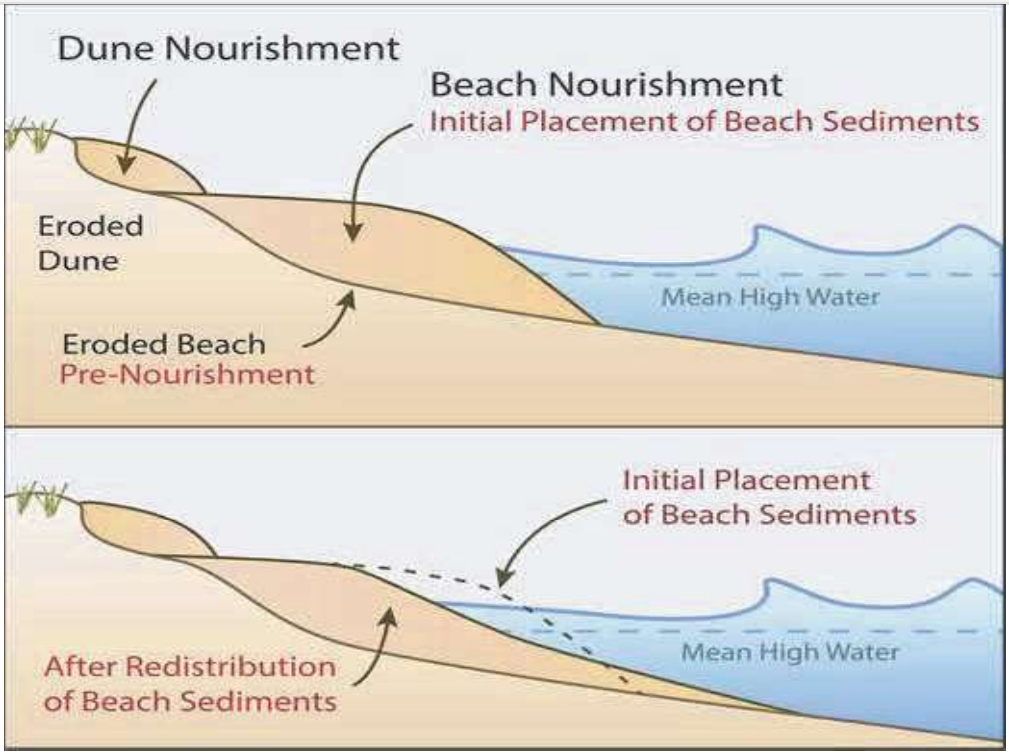
### National Centre for Coastal Research (NCCR)

- It is an attached office of the **Ministry of Earth Sciences**.

- It monitors shoreline changes along the Indian coast.

**National Centre for Sustainable Coastal Management**

- NCSCM is a research institute under the **Ministry of Environment**, **Forest and Climate Change (MoEF&CC)**.
- It is mandated to manage the Indian coast in a sustainable manner.




## Desertification Setting in Across a Quarter Of India


- According to **Desertification and Land Degradation of Selected Districts of India**, published by the **ISRO**, some **96.40 mha**, **or about 30 per cent** of the country's total area, is undergoing degradation.
- **Drylands** span **228.3 mha (70%)** of India's total land. **82.6 mha of drylands (~25% of total land area)** is under desertification.

## Regional causes behind desertification and degradation

- **Maharashtra:** The **timber mafia** is eating into already thin forests, leading to soil erosion.
- **Jharkhand and Odisha: Excessive mining** has triggered soil erosion and aggravated water scarcity.
- **Goa: Rampant mining** and expanding urbanisation have taken a toll.
- **Nagaland: Shifting cultivation (jhum cultivation)** and rising population are to blame for desertification.

- **Andhra Pradesh**, **Telangana**, **and Hyderabad Karnataka:** Droughts and **increased dependence on borewells** have led to soil aridity.
- **Himachal Pradesh:** Less snow and more rainfall have deepened the desertification crisis.
- **Gujarat: Overgrazing** and encroachment of grasslands for agricultural activities.

## Deforestation due to illegal mining

- Unscientific and illegal mining in Goa has led to severe degradation, according to **ISRO's Land Degradation and Desertification Atlas published in 2018**.
- The rush to export iron ore to China's 2008 Olympics building frenzy degraded large swaths of forests. SC had to stop mining in Goa in 2012, pointing to large-scale illegal mining.

### Apathy for environmental governance

- **Most of Goa's forests are outside recorded forest areas**, according to FSI's 2017 State of Forest Report. The total forest cover in the state was recorded at 2,229 sq km or 60. 21 per cent of the state. But the state forest department, in its own records, has only 1,224.46 sq km as government forest.
- Take the example of **Mopa**, where the Goa government wants to build an airport. The EIA for the airport **showed no tree cover**. But when the court case was filed, the forest department found 54,676 trees!

## Desertification in cold areas

- High altitude regions that get very little rainfall and are known as cold deserts. About 80 per cent of the cold desert region in India is in the **union territory of Ladakh**, while the rest is in Himachal Pradesh and Uttarakhand.
- There is clear evidence of desertification increasing in the trans-Himalayan regions in the form of **shifting tree lines**, migrating dunes, and changes in soil moisture levels.

## 31% of grassland and 19% of common lands lost in a decade

- The total area under **grasslands reduced by 31% — 12.3 mha** from **18 mha —** between 2005 and 2015. Grasslands in the **Aravalli Range** in Rajasthan underwent severe degradation.
- The country lost around 19 per cent of its common lands (90.5 mha to 73.02 mha) during the same period.
- Common lands include grazing grounds, some forest land, ponds, rivers, and other areas that all members of a rural community can access and use.

## State of India's Environment (SoE) Report 2019

- India has witnessed an increase in the level of desertification in 26 of 29 states between 2003-05 and 2011-13.
- India had committed to achieving land degradation neutrality by 2030. But it witnessed an **increase of 1.87 million hectares** undergoing the process of desertification between 2003-05 and 2011-13. More

than 80 per cent of the country's degraded land lies in just nine states: Rajasthan, Maharashtra, Gujarat, J&K, Karnataka, Jharkhand, Odisha, MP, and Telangana. The top three districts with the highest area under desertification or land degradation are **Jaisalmer (93%)**, **Lahaul and Spiti (80%)**, and **Kargil (78%)**.

## 17.2. Addressing Land Degradation and Desertification

- **SDG 15: Life on land:** "promote sustainable use of terrestrial ecosystems, sustainably manage forests, **combat desertification**, and **halt and reverse land degradation** and halt biodiversity loss."
- The pace of desertification has accelerated 30 to 35 times the historical rate in recent decades. At least one-quarter of the global land has degraded in the last two decades. Some 1,500 million people depend on this degrading land for their livelihood.

### Soil Conservation

- With soil conservation, people rise, and with its destruction, they fall. Neglect of soil is like killing the hen that lays the golden egg. Soil conservation is the **prevention of soil from erosion or reduced fertility caused by overuse**, **acidification**, **salinisation**, **or other chemical soil contamination**.

#### Crop Rotation

- Adopting sustainable agricultural practices is the most important measure to conserve soil. In many parts of India, a particular crop is sown in the same field year after year. This practice leads to the exhaustion of certain nutrients in the soil making it infertile.
- Crop rotation is a **practice in which a different crop is cultivated on a piece of land each year**. This helps to conserve soil fertility as different crops require different nutrients from the soil. Crop rotation will provide enough time to restore lost nutrients.
- For example, potatoes require much potash, but wheat requires nitrate. Thus, it is best to alternate crops in the field. Legumes such as peas, beans, and many other plants add **nitrates** to the soil by converting free nitrogen in the air into **nitrogenous nodules** on their roots. Thus, if they are included in the crop rotation **nitrogenous fertilisers** can be dispensed with.

##### Use of Early Maturing Varieties

- Early maturing varieties of crops take less time to mature and thus put less pressure on the soil. In this way, it can help in reducing soil erosion.

#### Strip Cropping

- **Crops may be cultivated in alternate strips parallel to one another**. Some strips may be allowed to lie fallow, while in others, different crops may be sown. Various crops are harvested at different intervals. This ensures that the entire area is not left bare or exposed at no time of the year.

- The tall growing crops act as **windbreaks**, and the strips, which are often parallel to the contours, help in increasing water absorption by the soil by slowing down runoff.


### Intercropping

- **Different crops are grown in alternate rows** and are sown at different times to protect the soil from rain wash.

## Contour Ploughing

- If ploughing is **done at right angles to the hill slope**, the ridges and furrows break the flow of water down the hill. This prevents excessive soil loss as gullies are less likely to develop and also reduces run-off so that plants receive more water.
- Ploughing the land in a direction **perpendicular to the wind direction** also reduces wind velocity and protects the topsoil from erosion.


## Checking Shifting Cultivation

- A very effective method of soil conservation is to check and reduce shifting cultivation by persuading the tribal people to switch to settled agriculture. This can be done by planning for their resettlement, which involves the provision of residential accommodation, agricultural implements, seeds, manures, cattle, and reclaimed land.

## Mulching

- The **bare ground (topsoil) between plants is covered with a protective layer of organic matter** like grass clippings, straw, etc.

## Benefits

- ✓ Protects the soil from erosion.
- ✓ Reduces compaction from the impact of heavy rains.
- ✓ **Conserves moisture** and reduces frequent watering.
- ✓ Maintains a more even soil temperature.
- ✓ **Prevents weed growth**.
- ✓ Organic mulches also improve the condition of the soil. As these mulches slowly **decompose**, they provide organic matter, which helps keep the soil loose.

## Contour barriers

- Stones, grass, and soil are used to **build barriers along contours**. **Trenches** are made in front of the barriers to collect water. They intercept downslope flowing water and soil particles. These barriers slow down the water movement and reduce its erosive force. They also filter out and trap many of the suspended soil particles, keeping them from being washed out of the field.

- A long-term advantage of barriers is that soil tends to **build up** behind them, creating a **terrace effect**. Barriers can be classified as live (strips of living plants), dead (rocks, crop residues), or mixed (a combination of the previous two).

## Rock Dam

- Rocks are piled up across a channel to slow down the flow of water. This prevents gullies and further soil loss.

## Terrace farming

- In terracing, a number of terraces are cut along the hill slope. These are made on steep slopes so that flat surfaces are available to grow crops. They can reduce surface run-off and soil erosion.

## Contour Bunding

- **Contour bunding involves the construction of banks along the contours**. **Terracing and contour bunding** divide the hill slope into numerous small slopes, check the flow of water, promote absorption of water by soil, and save soil from erosion. Retaining walls of terraces control the flow of water and help in reducing soil erosion.

## Shelterbelts or Windbreaks

- In the coastal and dry regions, rows of trees are planted to check the wind movement to protect soil cover.

## Sand fences

- **Sand fences** are barriers made of small, evenly spaced wooden slats or fabric. They are erected to reduce wind velocity and **trap blowing sand**. Sand fences can be used as perimeter controls around open construction sites to keep sediments from being blown offsite by the wind.

## Afforestation

- It includes the prevention of forest destruction along with growing new forests or increasing the area under forests. A minimum area of **20 to 25 per cent of forest land** was considered healthy for soil and water conservation for the whole country. It was raised to **33 per cent** in the second five-year plan – 20 per cent for the plains and 60 per cent for hilly and mountainous regions.

## Checking Overgrazing

- Overgrazing accentuates erosion. During the dry period, there is a shortage of fodder, and the grass is grazed to the ground and torn out to the roots by animals. The soil is **pulverised** (reduced to fine particles) by the hoofs of animals. All this leads to a weak top layer. So, overgrazing needs to be checked to prevent soil erosion. This can be done by creating **separate grazing grounds** and producing larger quantities of fodder.

## Dams

- Much of the soil erosion by river floods can be avoided by constructing dams across the rivers in proper places. This checks the speed of water and saves soil from erosion. However, indiscriminate dam construction can worsen the condition by creating floods and landslides, as it happens in the Himalayan region.

## Geotextiles

- **Geotextiles** are permeable synthetic/natural fabrics used in association with soil to reinforce and protect it. They are used to improve soils over which roads, embankments, and soil retaining structures are built.
- Synthetic geotextiles are typically made from **polypropylene** or polyester. Natural geotextiles are made from jute, coconut coir, etc. In 2020, GOI allowed the use of coconut coir-based geotextiles for the **construction of rural roads** under the Pradhan Mantri Gram Sadak Yojana.

**[UPSC 2020] In rural road construction, the use of which of the following is preferred for ensuring environmental sustainability or to reduce carbon footprint?**

1. Copper slag
2. Cold mix asphalt technology
3. Geotextiles

4. Hot mix asphalt technology
5. Portland cement

***Select the correct answer using the code given below:***

a) 1, 2 and 3 only
b) 2, 3 and 4 only
c) 4 and 5 only
d) 1 and 5 only

**Explanation**

- **Hot mix asphalt** involves **liquefying coal tar** by burning. 4) is eliminated
- Portland cement has **higher limestone content** (calcium carbonate). When limestone is heated in a cement or brick kiln it releases **$CO_2$**. 5) is eliminated ➔ a) is the answer
- **Cold mix asphalt** technology uses unheated mineral aggregate with foamed **bitumen**. It does not require any heating and causes less pollution.
- **Copper slag** is a key by-product in the manufacturing process of copper, with very similar physical properties to conventional sand. Globally, **copper slag** is used in cement manufacturing, cement concrete applications, bricks, etc.

***Answer: a) 1, 2, and 3 only***

## United Nations Convention to Combat Desertification (UNCCD)

- **UNCCD**, along with the **Convention on Biological Diversity (CBD)** and the **UNFCCC**, emerged from the **1992 Rio de Janeiro Earth Summit**. UNCCD was established in 1994 in Paris. It is ratified by 196 countries and European Union. **India** ratified the UNCCD Convention in 1996.
- UNCCD is an agreement for ensuring **global action against land degradation**. It is the **only legally binding** international agreement that **links environment and development to sustainable land management**.
- The Convention requires countries to draw up their **national action programmes (NAP)** using a bottom-up approach — from the local community up — to restore degraded lands.
- The **Global Mechanism (GM)** was established under UNCCD to assist countries in the mobilisation of financial resources to implement the Convention.

### COP of the UNCCD

- The CoP is the supreme decision-making body of UNCCD. It is held every **two years**. The CoP reviews the implementation of the Convention, formulates strategies, coordinates its work with other agencies and NGOs, and so on.
- Recent COPs under UNCCD:

- ✓ COP 13 – 2017 - Ordos City (China)
- ✓ **COP 14 – 2019 - New Delhi (India)**
- ✓ **COP-15 – 2022 - Abidjan (Côte d'Ivoire)**

- COP-15 of the **UNCCD** was conducted recently at **Abidjan**, **Côte d'Ivoire**. At COP-15, India reaffirmed its commitment to restoring **26 million ha of degraded land by 2030**.
- Future meetings of the **biennial** Conference of the Parties to the UNCCD and its subsidiary bodies will be held in **Saudi Arabia (COP16 in 2024) and Mongolia (COP17 in 2026)**.

## CoP-14 at New Delhi

- At CoP14, India was elected **president** until CoP 2015.
- "**Restore land**, **sustain future**" was the theme of COP14.

### Only 25% of nations include gender discussions in land degradation targets

- The UNCCD mandates **gender mainstreaming** in advancing the efforts of countries to achieve their Land Degradation Neutrality (LDN) targets.
- Gender mainstreaming provides additional benefits to advance **gender equality**, increase women's access to and control over land and natural resources, reduce poverty, restore ecosystems, and so on.

### Report on Soil Organic Carbon

- Soil Organic Carbon (SOC) is pivotal in providing multifaceted benefits. It combats droughts, reduces soil diseases and soil compacting, and helps in organic production. Because of its multifunctional roles and its sensitivity to land management, **SOC is one of the three global indicators of Land Degradation Neutrality (LDN)**.

## COP-15 at Abidjan

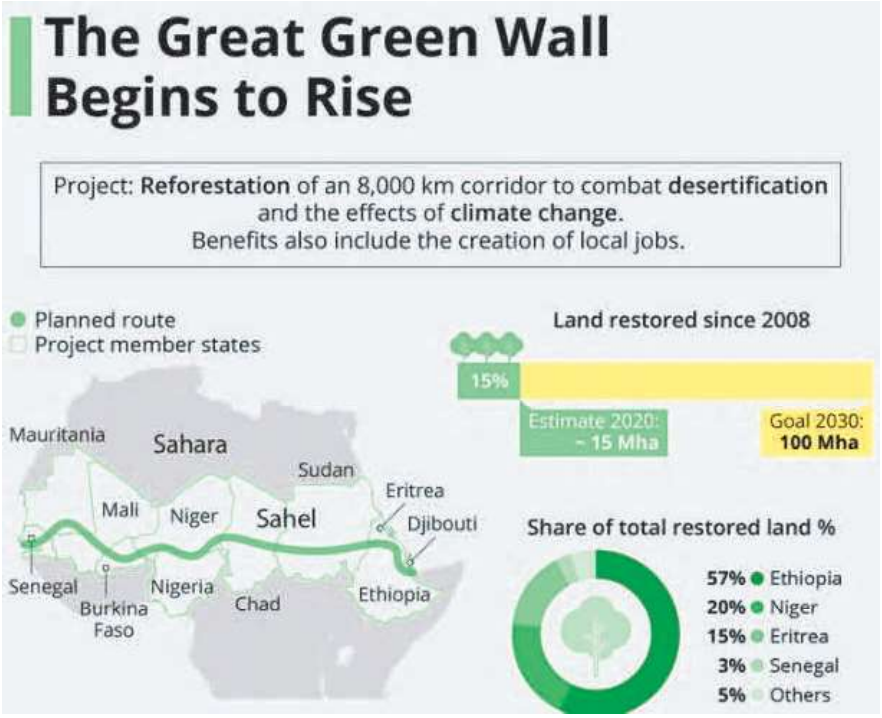
- The COP-15 theme "**Land**. **Life**. **Legacy: From scarcity to prosperity**" is a call to action to ensure land, the lifeline on this planet, continues to benefit present and future generations. The target is to **restore one billion hectares of degraded land between now and 2030**.
- The three key declarations of COP-15 included:
  1. **Abidjan Call** issued by the Heads of State and Government to boost long-term sustainability.
  2. **Abidjan Declaration** on achieving **gender equality for successful land restoration**.
  3. COP-15 "Land, Life and Legacy" Declaration, as a response to the findings of the UNCCD's flagship report, **Global Land Outlook 2** (second edition of the GLO).
- The **Global Land Outlook (GLO)** is a **UNCCD** publication that underscores land system challenges and showcases transformative policies and cost-effective pathways to scaling up sustainable land and water management.

### Major Concerns

- **40 per cent of our planet's land is degraded**, which will directly affect half of humanity and is a threat to about 50 per cent of global GDP or around $44 trillion. The world is slow on the **restoration of one billion hectares of degraded land by 2030**.

## UNCCD work and Impact

- ✓ UNCCD promotes practices that avoid, reduce and **reverse land degradation**.
- ✓ It is the driving force behind **Sustainable Development Goal 15** and **Land Degradation Neutrality (LDN)**.
- ✓ **The Drought Initiative:** Promotes a shift to proactive drought management.
- ✓ **The Great Green Wall Initiative:** It aims to **restore Africa's degraded landscapes** in the **Sahel**.




⇨ *The **Sahel** is a semiarid region that forms a **transitional zone between the Sahara to the north and tropical savannas to the south**.*

⇨ *It contains the fertile **delta of the Niger**. The Sahel's fertile land is rapidly becoming desert because of drought, deforestation, and intensive agriculture.*

## The Great Green Wall Initiative

- It was launched in 2007 by the **African Union**. This ambitious project is being implemented across 22 African countries and will revitalise thousands of communities across the continent.
- The GGW initiative's ambition is to restore 100 mha of currently degraded land, sequester 250 million tons of carbon and create 10 million green jobs by 2030.
- Barely 18 per cent of the Great Green Wall's objectives for 2030 have been achieved. Lack of communication, funds, and coordination are among the greatest challenges faced by GGW.

⇨ ***Communities have played a major role in China**, which has a quarter of its land under deserts. **China is a global leader in greening deserts because of successful community engagement**.*

## UNCCD Global Land Outlook Report

### Loss of cropland due to urbanisation

- Human settlements have historically developed in the **most fertile** and accessible lands. Their growing size is beginning to **displace fertile agricultural land** significantly.
- **Urbanisation** is projected to cause the loss of between 1.6 and 3.3 million hectares of prime **agricultural land** per year in the period between 2000 and 2030. (Between 48 and 99 million hectares in the period.) The loss of croplands translates into a **6 per cent production loss in Asia** and a 9 per cent drop in Africa.

### Increasing meat consumption across the world has put great pressure on land.

- Reducing the average meat consumption from 100 grams to 90 grams per person per day would significantly impact human health and **climate change**.
- The growing demand for meat and other land-intensive food (processed food using **soy** and **palm**) has led to crises like **land scarcity** and **food insecurity**.

### Water scarcity

- The demand for water is projected to outgrow extraction capacity by 40 per cent by 2030.
- Around two-thirds of the world's population will be living in water-stressed countries by 2025.
- Demand for water for **agricultural purposes** will **double by 2050** due to growing demands for food.
- The **most water-intensive crops per kg of production** are:
  1. **cotton (7,000 to 29,000 litres/kg)**,
  2. **rice (3,000 to 5,000 litres/kg)**,
  3. **sugar cane (1,500-3,000 litres/kg)**,
  4. **soya (2,000 litres/kg) and**
  5. **wheat (900 litres/kg)**.
- At present, two billion people and 40 per cent of irrigation are dependent on **groundwater**. **India (39 million hectares)**, China (19 mha) and the US (17 mha) were intensively using groundwater.

### Drought

- There is a strong nexus between land use and drought, and the management of both land and drought needs to be fundamentally linked.
- Drought was one of the **five 'Strategic Objectives'** of the UNCCD for 2018-2030. **UNCCD introduced the concept of 'drought-smart land management' (D-SLM)** within the broader group of SLM (sustainable land management)-based interventions.

### Cost

- An investment of **$1.8 trillion** in climate adaptation measures over the next decade will bring about concrete transformation on the ground.

### Desertification from a Conservation Perspective

- By desertification, we do not mean the natural expansion of existing deserts in the world. When we say desertification, we mean the **degradation of land** in arid, semi-arid and dry sub-humid areas. It is a gradual **loss of soil productivity —** which makes raising food grains and other crops impossible.

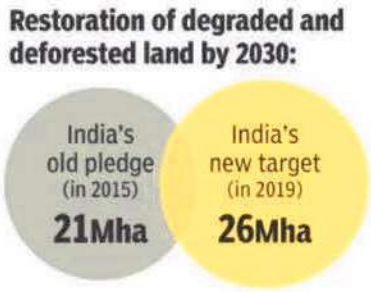
### Importance of reversing land degradation

- 34% of the earth's land surface and half of the farmlands are in drylands. Over 2 billion people and half of the world's livestock depend on these lands.

***[Mains 2020] The process of desertification does not have climatic boundaries. Justify with examples. (150 words).***

## Land Degradation Neutrality (LDN) Initiative

- The concept of LND emerged from the **UN Conference on Sustainable Development (Rio+20)** in 2012.
- In 2015, LDN became a target for the **SGD 15**, which is about sustaining life on land.
- **At COP12 to UNCCD**, **Parties adopted LDN** as a "strong vehicle for driving the implementation of UNCCD" and called on countries to set voluntary targets to achieve **"no net loss" by 2030**.
- **New Delhi Declaration**: **190+ countries** agreed to achieve **'land degradation neutrality' by 2030**. They vowed to ensure that their efforts in this direction **would not affect the land rights** of **forest dwellers** and **women**. The countries will, however, must mobilise a huge sum of **$300 billion** to step up the restoration exercise.
- **India's LND Targets: India will restore 26 million hectares of degraded land by 2030; earlier**, **the target was 21 mha**.

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# 18. Climate Change and Greenhouse Gases (GHGs)

## 18.1. Climate Change (CC) and Global Warming

- **Climate change** refers to long-term shifts in temperatures and weather (rainfall, snow, and wind) patterns attributed directly or indirectly to **human (anthropogenic) activity** that **alters the composition of the global atmosphere**, causing natural climate variability observed over comparable periods (hundreds of years).
- Climate change shifts may be natural, such as through variations in the **solar cycle**. But since the 1800s, **burning fossil fuels** like coal, oil and gas and **deforestation** (when forests are cut down or burned, they **can no longer store carbon**, and the carbon is released into the atmosphere) generated **greenhouse gas (GHG) emissions** that act like a blanket wrapped around the Earth, trapping the sun's heat and raising temperatures **— global warming due to greenhouse effect**.
- **Global warming** refers to **long-term warming (rise in global temperatures)** of the planet, which is only one aspect of climate change.
- Climate change encompasses global warming but refers to a broader range of changes (due to variability in temperature, rainfall, wind and water patterns), such as rising sea levels, shrinking mountain glaciers, accelerating loss of cryosphere (melting of ice caps of mountains and polar regions), ocean acidification, etc.
- Throughout its evolutionary history, earth has experienced episodic climate change events involving **global warming** and **global cooling (glaciation events)**. Global temperature has shown a well-documented rise (global warming) since the early 20$^{th}$ century and most notably since the late 1970s.

### How do we know about past CC events?

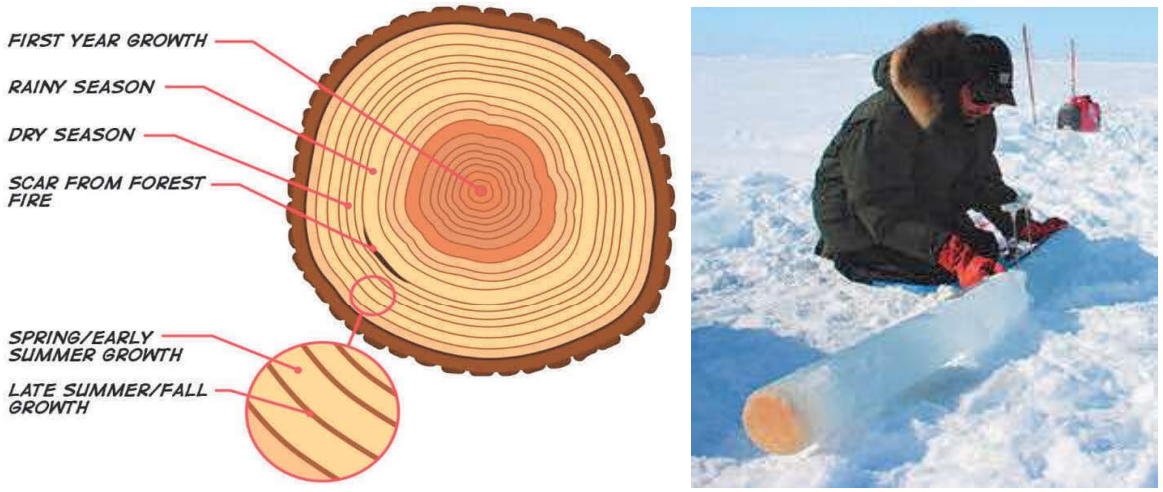
#### Tree rings record Earth's climate

- Trees record Earth's climate (hundreds or even thousands of years) in their rings. **Three rings** tell us **how old the tree is** and what the **weather** was like during each year of the tree's life. One light ring plus one dark ring equals one year of the tree's life. The light rings represent wood that grew in the early summer, while the dark rings represent wood that grew in the late summer. The **colour and width of these rings** can provide snapshots of past climate conditions. For example, tree rings usually grow wider during wet years, and they are thinner in dry years.

#### Ice cores from the cryosphere

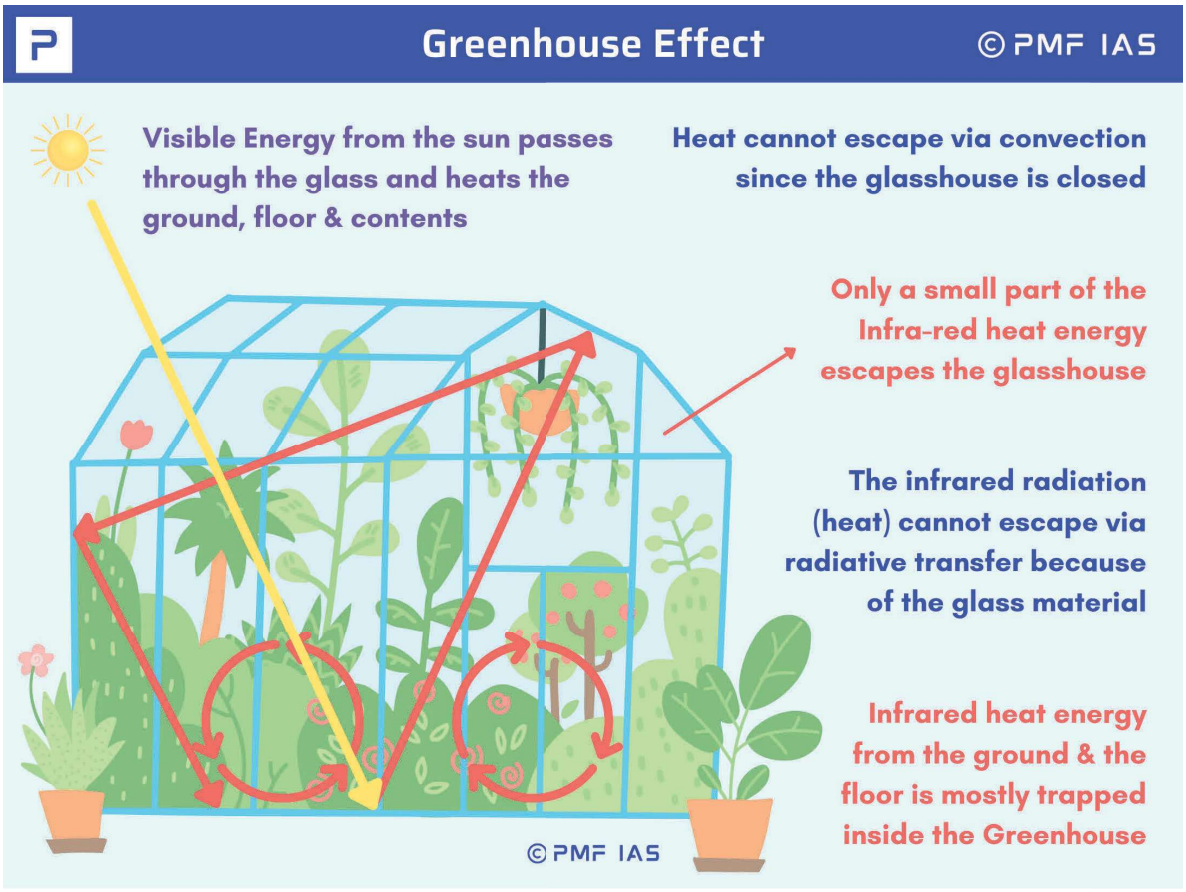
- Ice cores (ice columns) are extracted by drilling deeply into glaciers and ice sheets. They hold a **record of what our planet's climate was** like thousands of years ago.

- Ice sheets and glaciers near poles are formed from years and years of accumulating snowfall. Each layer of ice tells a story about what Earth was like when that layer of snow fell. The icy layers hold **air molecules**, **GHGs** and **aerosols** such as dust, ash, pollen, and sea salts of that time. These particles provide evidence of past global events, such as climate change, major volcanic eruptions, etc.




*The colour and width of tree rings indicate past climate conditions*

## Greenhouse Effect

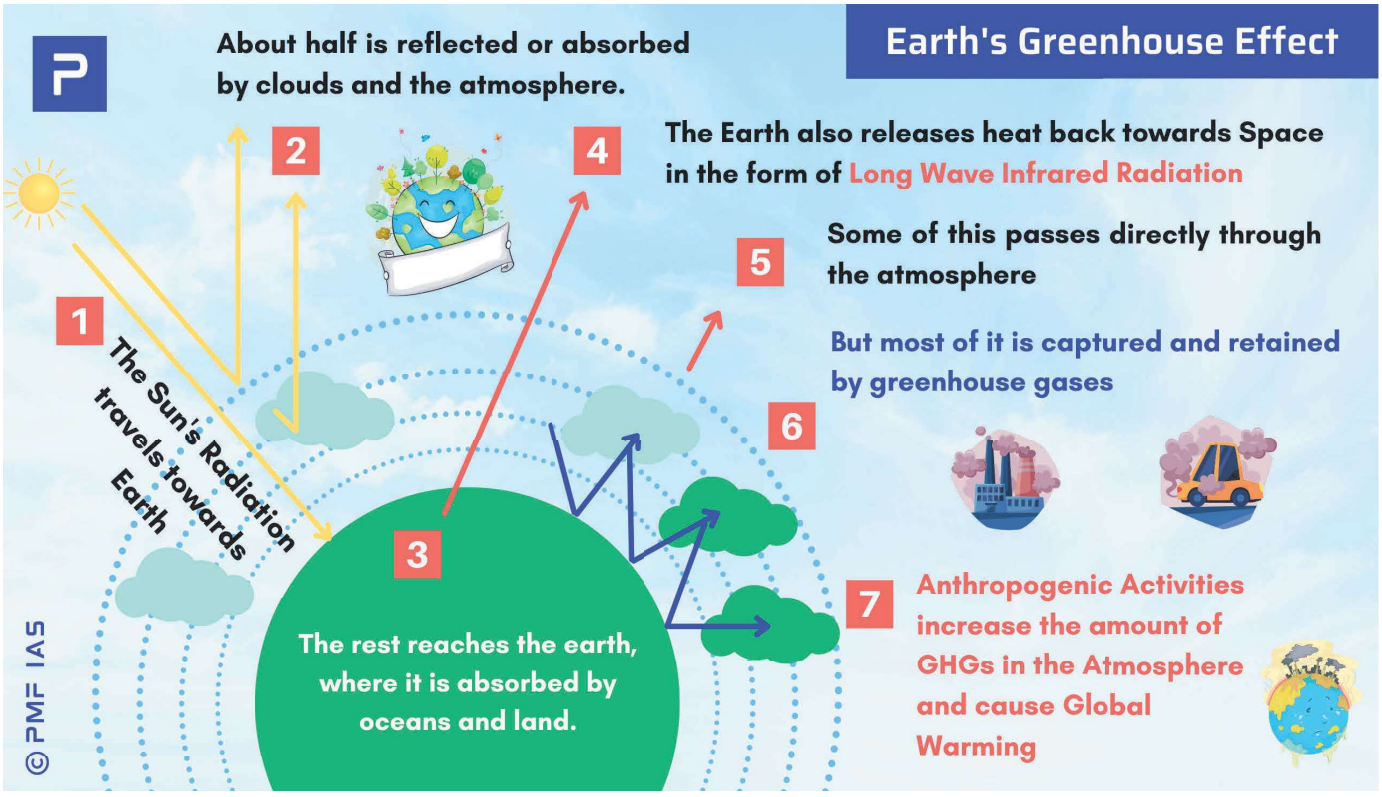



- A **greenhouse** is a structure whose roof and walls are made chiefly of **transparent** material, such as glass, in which **plants requiring regulated climatic conditions are grown**.

- In a greenhouse, the **incident solar radiation** (the **visible** and **adjacent portions** of the **infrared** and **ultraviolet** ranges of the spectrum) passes through the glass roof and walls. It is absorbed by the floor, earth, and contents, which become warmer and **re-emit the energy** as **longer-wavelength infrared radiation (heat radiation)**.
- Glass and other materials used for greenhouse walls **do not transmit infrared radiation**, so **infrared radiation cannot escape** via **radiative transfer**. As the structure is not open to the atmosphere, heat also **cannot escape via convection**, so the temperature inside the greenhouse rises. This is known as the **greenhouse effect**.

### Importance of Natural Greenhouse Effect

- The greenhouse effect is a **natural phenomenon** that has occurred for millions of years on the Earth. Life on the earth has been possible because of this **natural greenhouse effect** which is due to **water vapour** and **small particles of water** present in the atmosphere. Together, these produce more than **95 per cent of total greenhouse warming**.
- **Average global temperatures** are maintained at about **15°C** due to the **natural greenhouse effect**. Without this phenomenon, average global temperatures might have been around **-17°C**, and at such low temperatures, life would not be able to exist.

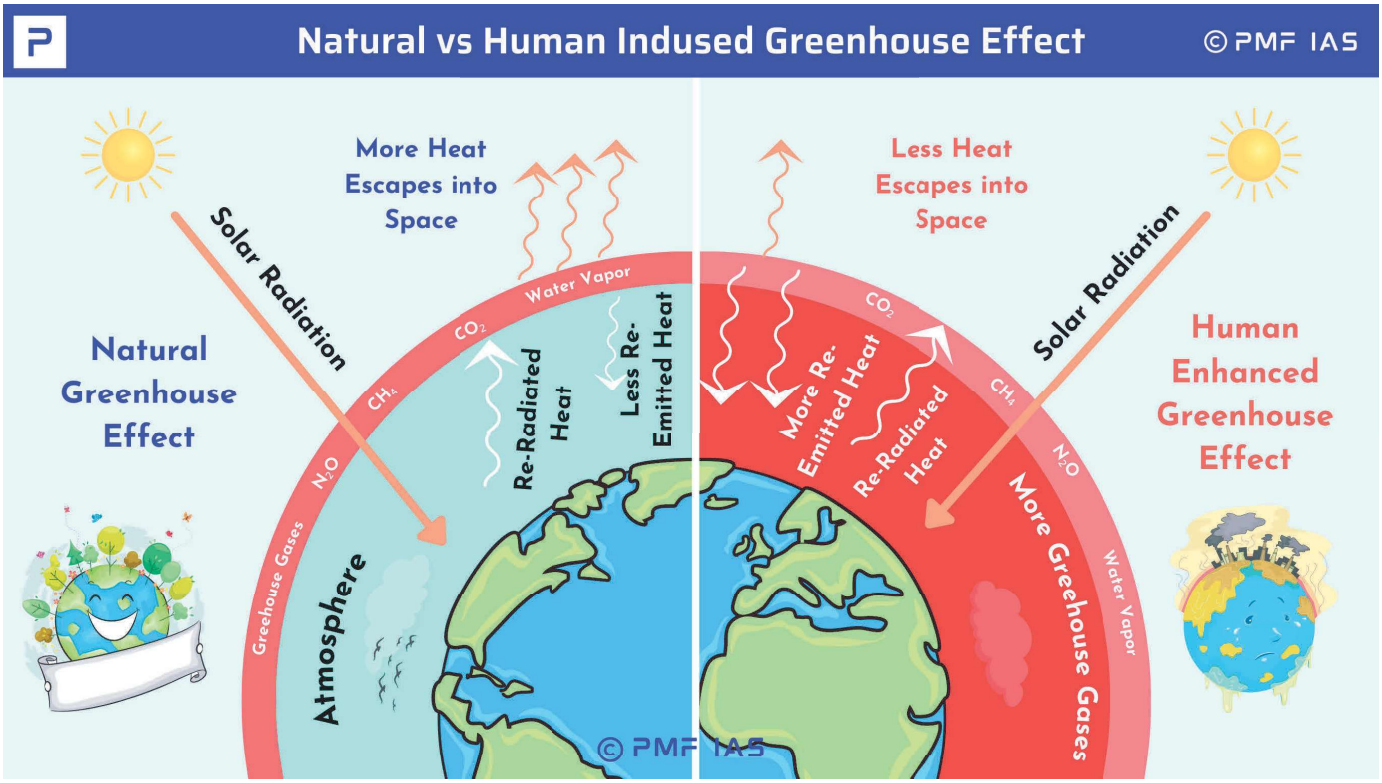



## 18.2. Greenhouse Gases (GHGs)

- Atmospheric gases like **Carbon Dioxide ($CO_2$)**, **Methane ($CH_4$)**, **Nitrous Oxide ($N_2O$)**, **Water Vapour**, And **Chlorofluorocarbons (CFCs)** can trap **the out-going infrared radiation** from the earth's surface.

Hence, these gases are known as **greenhouse gases (GHGs)**, and the heating effect is known as the **greenhouse effect**.

- Worldwide, since 1880, the average surface temperature has risen about **1°C**, relative to the mid-20th century baseline (1951-1980). This is on top of about an additional 0.15°C of warming from between 1750 and 1880. If greenhouse gases are not checked, by the turn of the century, the temperature may rise by **5°C**.
- Scientists believe that this temperature rise will lead to deleterious environmental changes and result in odd climatic changes (e.g., increased incidence of El Nino), thus leading to increased melting of the **cryosphere** (polar ice caps as well as other places like the Himalayan snow caps). Over many years, this will result in a rise in sea level that can submerge many coastal areas and lead to the loss of coastal areas and ecosystems like coral reefs, swamps and marshes (the most critical ecosystems from the point of ecological services), etc.



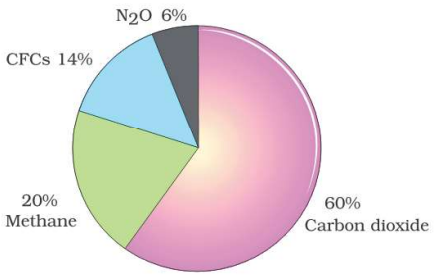

## Global Warming Potential and Lifetime of GHGs

- **Global warming potential (GWP)** is the heat absorbed by any GHG in the atmosphere as a multiple of the heat that would be absorbed by the same mass of $CO_2$.

| Greenhouse Gas | Sources and Causes |
|---|---|
| Carbon dioxide ($CO_2$) | **Burning of fossil fuels**, **deforestation**, **etc**. |
| Chlorofluorocarbons (CFCs) | **Refrigeration**, **solvents**, **insulation foams**, **aero propellants**, **industrial and commercial uses**. |

| | |
|---|---|
| **Methane ($CH_4$)** | **Growing paddy, excreta of cattle and other livestock, termites, burning of fossil fuel, wood, landfills, wetlands, fertiliser factories, etc.** |
| **Nitrous Oxide ($N_2O$)** | **Burning of fossil fuels, wood and crop residue; fertilisers.** |
| **Carbon Monoxide (CO)** | **Iron ore smelting, burning of fossil fuels, burning e-waste.** |

| Gas | GWP100 | Lifetime (years) |
|---|---|---|
| Carbon dioxide | 1 | 50-200 |
| Methane | 28 | 12 |
| Nitrous oxide ($N_2O$) | 265 | 120 |
| Hydrofluorocarbons (HFCs) | 140 -11,700 | 1-270 |
| Perfluorocarbons (PFCs) | 6,500-9,200 | 800-50,000 |
| Sulphur hexafluoride ($SF_6$) | 23,900 | 3,200 |




GWP100 measures the global warming potential of GHGs over a 100-year timeframe.

## GWP*

- GWP* measures the global warming potential of GHGs by considering their **varied lifetimes** in the atmosphere. GWP* was introduced in 2018 at **COP24** to the UNFCCC.

| Feature | GWP100 | GWP* |
|---|---|---|
| Timeframe | **100 years** | **Calculated over any specified time period** |
| Calculation | Compares the warming effect of a GHG to that of $CO_2$ over 100 years | Multiplies the GWP100 of a GHG by its expected lifetime in the atmosphere |
| Accuracy | **More accurate for long-lived gases** | **More accurate for short-lived gases** |
| Complexity | Simpler to calculate | More complex to calculate |
| Usage | Widely used | Not yet widely used |

### Concerns with GWP*

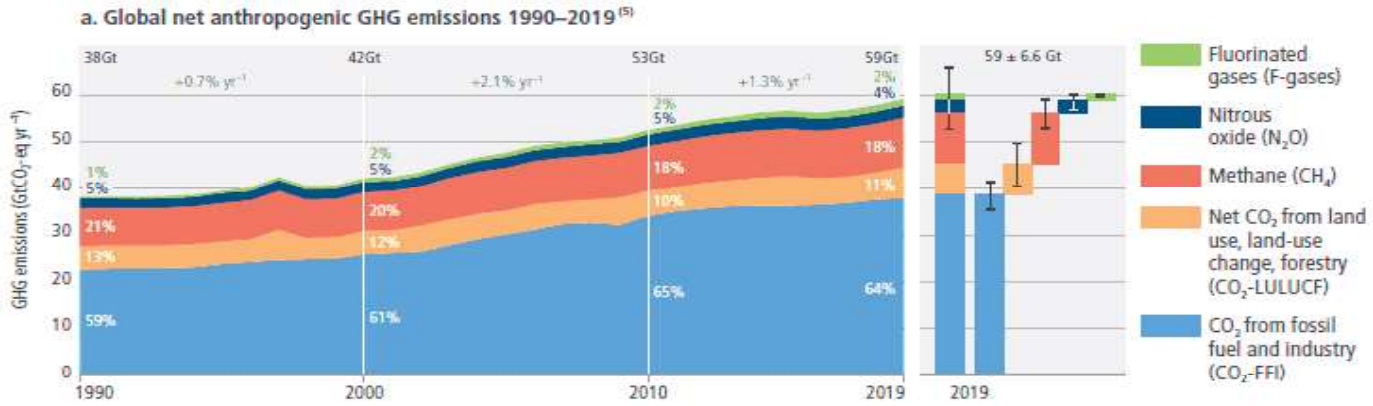
- **Omission of non-$CO_2$ effects:** GWP* doesn't consider non-$CO_2$ effects, such as the aerosol effects of black carbon or the impact of tropospheric ozone on methane lifetime.
- **Helps in greenwashing:** Depending on the choice of baseline year, the same volume of GHG emissions can be described as causing warming, no warming, or even cooling.

⇨ ***Greenwashing*** *refers to the process of making exaggerated or misleading claims about a product's or service's environmental benefits.*

⇨ ***Greenhushing*** *is tactic companies adopt to mislead consumers and regulators regarding their environmental friendliness by omitting crucial environmental information.*

## Super pollutants

⇨ *They are short-lived climate pollutants that have a **shorter atmospheric lifespan compared to $CO_2$**, they significantly impact climate change and air quality. It includes **methane**, **black carbon**, **hydrofluorocarbons** and **tropospheric ozone**.*




## Carbon Dioxide

- Carbon dioxide is a meteorologically important gas as it is **transparent to incoming solar radiation but opaque to outgoing terrestrial radiation**. Being an **efficient absorber of infrared radiation** (heat), it **absorbs** a part of terrestrial radiation and **reflects** some of it towards the earth's surface. It is **mainly responsible for the greenhouse effect** and **heat energy budget**.
- Its concentration is **greater close to the earth's surface** as it is **denser than air**. In May 2019, the global concentration of $CO_2$ in the atmosphere was measured to have crossed **415 parts per million (ppm)**. Atmospheric carbon dioxide measured at **NOAA's Mauna Loa Atmospheric Baseline Observatory** (Hawaii) peaked for 2021 in May at a monthly average of **419 ppm**.

⇨ *Currently, the aviation industry contributes around **2.5%** of total human-produced $CO_2$ emissions. If non-$CO_2$ emissions like water vapour are considered, the airline industry would contribute to nearly **5%** of historical global warming.*

### How much Carbon is there on the Earth?

- The US National Academy of Sciences has released a series of papers estimating the total carbon on Earth. This includes an analysis of the total $CO_2$ released by **volcanoes** contributing **much less than human activities**. Humanity's annual carbon emissions by burning fossil fuels and forests, etc., are **40 to 100 times greater than all volcanic emissions**.

| 1.85 Billion Gigatons (Gt) of total carbon on Earth | |
|---|---|
| **Below the Surface** | **Above the Surface** |
| • **1.845 Billion Gt** of the total carbon on Earth is below the surface.<br>• Of this, **315 Million Gt** of carbon is in continental and oceanic lithospheres. | **43,500 Gt** of the total carbon on Earth is above the surface.<br>1. **37,000 Gt in the deep ocean (85.1 %)**<br>2. **3,000 Gt in marine sediments (6.9%)**<br>3. **2,000 Gt in terrestrial biosphere (4.6%)**<br>4. **900 GT in the surface ocean (2%)**<br>5. **590 Gt in the atmosphere (1.4%)** |

## Ozone

- **Ozone** is another important greenhouse gas. But it is in **very small proportions at the surface**. Most of it is confined to the **stratosphere**, where it **absorbs harmful UV radiation**. At ground level, pollutants (**GHG precursors**) like **Carbon Monoxide (CO)**, **Nitrogen Dioxide ($NO_2$)** and **Volatile Organic Compounds (VOC) convert $O_2$ to tropospheric ozone ($O_3$) in the presence of sunlight**.

**[UPSC 2019] Consider the following:**

1. Carbon monoxide
2. Methane
3. Ozone
4. Sulphur dioxide

***Which of the above are released into the atmosphere due to the burning of crop/biomass residue?***

a) 1 and 2 only
b) 2, 3 and 4 only
c) 1 and 4 only
d) 1,2,3 and 4

**Explanation**

- $O_3$ is not released directly. It is a secondary pollutant.
- Burning of biomass releases CO, $CH_4$ and $SO_2$.

***Answer: d) all***

## Water Vapour

- Water Vapour is one of the most **variable** gaseous substances in the atmosphere – constituting between **0.02%** and **4%** of the total volume (in cold, dry and humid tropical climates, respectively). Water vapour is also a variable gas in the atmosphere, which decreases with altitude. 90% of moisture content in the atmosphere exists within 6 km of the earth's surface. Water vapour also decreases from the equator towards the poles.
- Like carbon dioxide, water vapour plays a significant role in the insulating action of the atmosphere. It **absorbs** not only the **long-wave terrestrial radiation** (**infrared radiation or heat emitted by the earth** during the night), but also a part of the **incoming short-wave solar radiation (visible and UV radiation)**.

**[UPSC 2011-12] The increasing amount of carbon dioxide in the air is slowly raising the temperature of the atmosphere, because it absorbs**

a) the water vapour of the air and retains its heat.
b) the ultraviolet part of the solar radiation.
c) all the solar radiations.

d) the infrared part of the solar radiation

**Explanation**

- Among GHGs, **only water vapour can absorb both incoming (UV) and outgoing (infrared) radiation**.

***Answer: d) the infrared part of the solar radiation (outgoing radiation).***

## Methane ($CH_4$)

- Methane is the **most important GHG after carbon dioxide**. The **20-year global warming potential** of methane is **84**, i.e., over a 20-year period, **it traps 84 times more heat per mass unit than carbon dioxide ($CO_2$) — it is a more potent GHG than $CO_2$**. However, **its lifetime** in the atmosphere is **much shorter** than **carbon dioxide (i.e., it is short-lived)**.

⇨ *Methane is the main constituent of **natural gas**. It is **odourless**, **colourless**, and **tasteless**, and it is **lighter than air**.*

⇨ *When methane burns in the air, it has a **blue flame (because of complete combustion)**. In the **presence of oxygen**, methane burns to give off **carbon dioxide ($CO_2$) and water ($H_2O$)**.*

### Excess Isoprene Elevating Methane Levels

- **Isoprene** is a colourless, volatile liquid hydrocarbon. It is the most abundant **non-methane VOC** emitted into the atmosphere.

**Sources**

- Most isoprene is produced by **plants** and by some algae and bacteria. It is also produced in small amounts by humans and other animals.
- **Isoprene** from plants is the second-highest emitted hydrocarbon after methane emissions from human activity. Due to global warming, plants like oaks and poplars are **emitting more isoprene**.
- Isoprene is also released by activities like the combustion of fossil fuels, production of petroleum products and synthetic rubber, etc.

**Uses**

- Isoprene is used in natural and synthetic rubber, adhesives, pharmaceuticals, and fragrances. It is the main component of **natural rubber**.

**Issues with excess Isoprene**

- **Ground-level ozone formation:** Ground-level ozone forms when sunlight reacts with nitrogen oxides and VOCs.
- **Secondary organic aerosol formation:** Isoprene also reacts with other atmospheric chemicals to form secondary organic aerosols, which reduces air quality and visibility.

- **Climate change:** Increased isoprene emissions raise **tropospheric ozone** and **methane** levels, which are significant **greenhouse gases**. Thus contributing to global warming.

### Methane emissions from Global Food Systems

- Currently, the **global food system** is responsible for **one-third of the world's GHG emissions**. Currently, a waste of food items is **one-third** of global food production. Much water, especially groundwater, and energy (coal electricity) go into food production. Rotting food, animal waste, biomass, etc., releases **Methane** (greater global warming potential than $CO_2$).
- Emissions from livestock mainly include carbon dioxide (from urea), nitrous oxide (from livestock dung and urine), and methane (from belching), among others.
- An IPCC research showed methane is responsible for **at least a quarter of today's global warming**. An assessment by the UNEP and **Climate and Clean Air Coalition** in 2021 found that cutting human or farming-related methane emissions by "45 per cent this decade" is vital in the global battle against climate change.
- In the livestock sector, popular belief says **cow flatulence (farts)** is a bigger source of methane than cow belching. However, according to NASA, **cow belching** releases more methane into the environment due to **enteric fermentation**, a digestive process where complex sugars are converted into simpler molecules to be absorbed into the bloodstream, producing methane as a by-product.

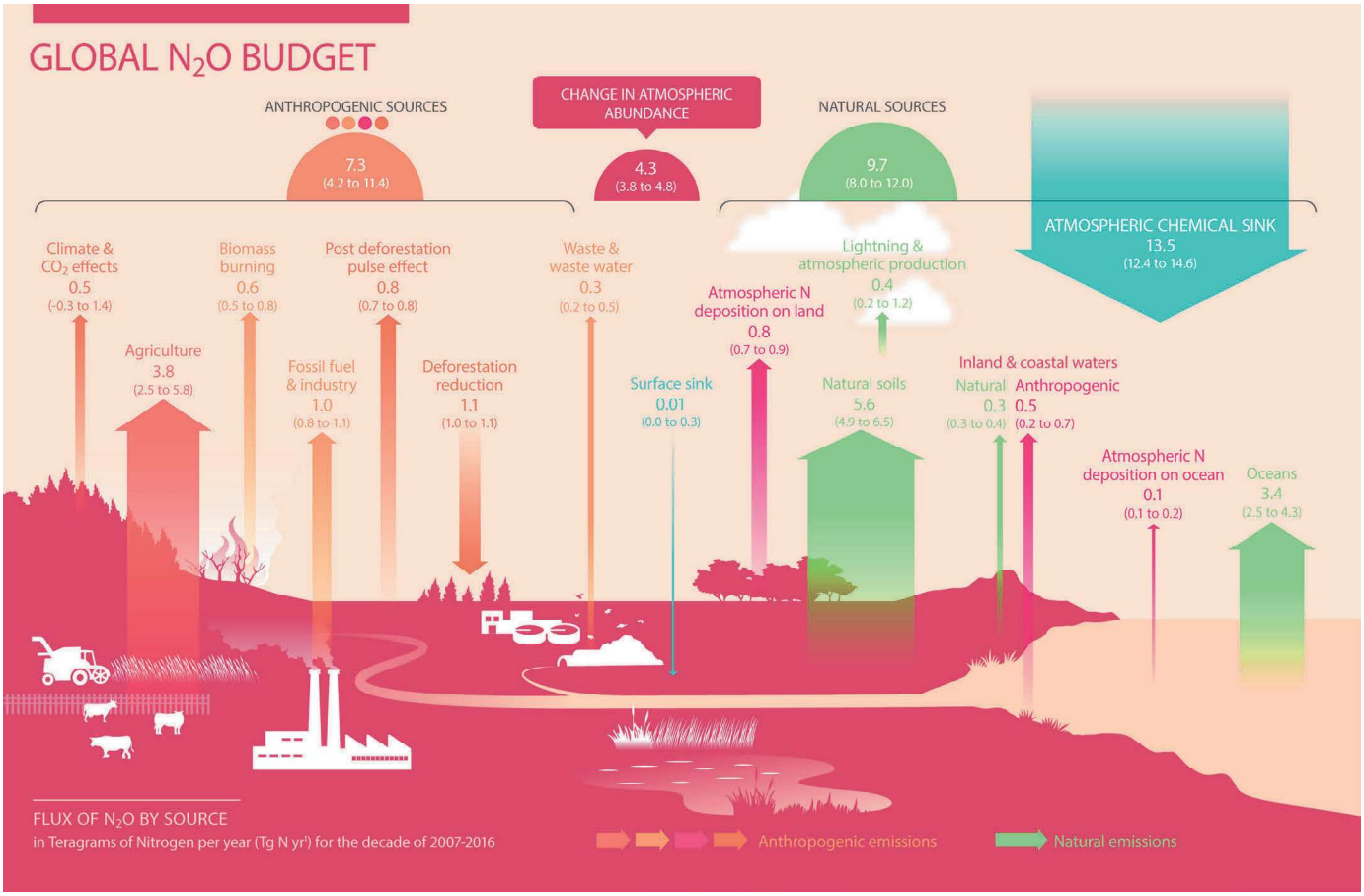
## Nitrous Oxide ($N_2O$)

- **Nitrous Oxide ($N_2O$)** is a **GHG (300 times more potent than carbon)**. It is also the only **remaining threat to the ozone layer** as it can live in the atmosphere for up to **125 years (long-lived, just like $CO_2$)**.
- **$N_2O$** emissions have increased by **30 per cent** between **1980 and 2016**. It has the **third-highest concentration after $CO_2$** and **methane** in our atmosphere among GHGs responsible for significant global warming.
- **43%** of the total emissions of $N_2O$ came from **human sources**, a significant portion of it from the **agricultural sector** (**nitrogen-based fertilisers)**.
- Most $N_2O$ emissions have come from emerging countries like **India**, **China and Brazil**. **Agriculture** accounts for over **70% of all nitrous oxide emissions** in the Indian environment, of which **fertilisers**, **mostly urea**, **contribute 77%**

⇨ ***Nitrogen Oxide (NO) and Nitrogen dioxide ($NO_2$) are global cooling gasses.***

⇨ ***Nitrous Oxide ($N_2O$) is a greenhouse gas.***

⇨ ***They all fall under the general formula for oxides of nitrogen ($NO_x$).***




## Black Carbon (Soot)

- Black carbon warms the earth by **reducing albedo** (the ability to reflect sunlight) when deposited on snow. It is the **strongest absorber of sunlight (a lot more than carbon dioxide)** and **heats the air directly**.
- Black carbon is said to be one of the **largest contributors to climate change after $CO_2$**. But unlike $CO_2$, which can stay in the atmosphere for years together, **black carbon is short-lived** and remains only for days to weeks before it descends as rain or snow.

## Fluorinated Gases

### Chlorofluorocarbons (CFCs)

- **CFCs** were **phased out via the Montreal Protocol** due to their part in **ozone depletion**. These anthropogenic compounds are also GHGs, with a **much higher potential to enhance the greenhouse effect** than $CO_2$.

### Hydrofluorocarbons (HFCs)

- HFCs are used as **refrigerants**, **aerosol propellants**, **solvents**, **and fire retardants**. These chemicals were developed as a **replacement for CFCs**. Sadly, HFCs are **potent GHGs with long atmospheric lifetimes**.

### Perfluorocarbons or Fluorocarbon (PFCs)

- **PFCs** are a group of human-made chemicals composed of **carbon** and **fluorine** only. They are produced as a by-product in **aluminium production** and the **manufacturing of semiconductors (as alternatives to CFCs)**. Like HFCs, PFCs generally have **long atmospheric lifetimes** and **high GWP**.

### Sulphur Hexafluoride ($SF_6$)

- **Sulphur hexafluoride** is also a **GHG**. It is used in **magnesium processing** and **semiconductor manufacturing**, as well as a **tracer gas for leak detection**. It is used in electrical transmission equipment, including **circuit breakers**.

### Carbon Monoxide

- **Carbon monoxide (less dense than air)** is a **short-lived**, **very weak direct GHG**. Through natural processes in the atmosphere, it is eventually **oxidised to carbon dioxide (GHG)**. It has an **indirect radiative forcing** effect by **elevating concentrations of methane (GHG)** and **tropospheric ozone (GHG)**.

## 18.3. Carbon Footprint

- **Carbon footprint** is a measure of the impact of one's activities on the amount of $CO_2$ produced through the burning of fossil fuels. It is expressed as the **weight of $CO_2$ emissions produced in tons**. It is measured during the course of a year and can be associated with an individual, organisation, product etc.

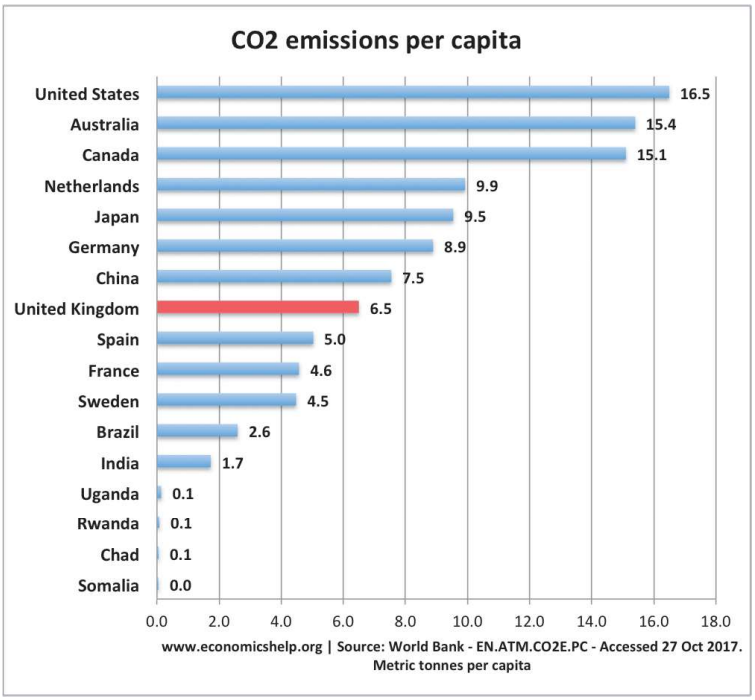
⇨ *India has pledged a **33-35% reduction** in its economy's **emissions intensity (carbon footprint)** by **2030 compared to 2005 levels**.*

### Carbon Footprint of various Sectors

- World Resources Institute (WRI) breaks down total global emissions from 2005 into the following headline sectors:

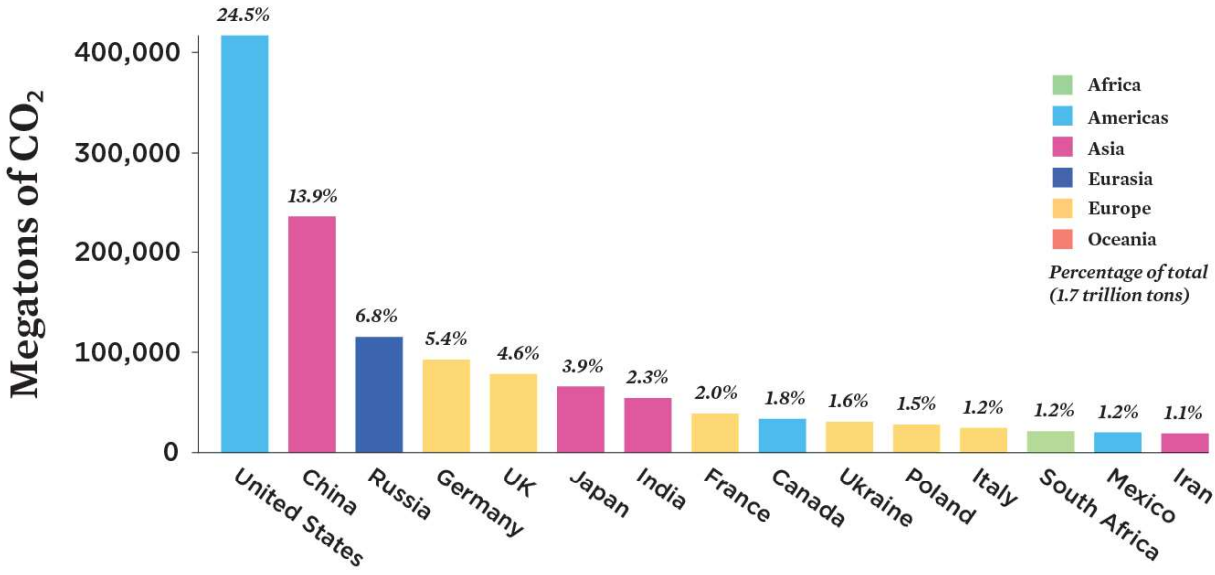
1. **Energy**
    1) **Electricity and heat (24.9%)**
    2) **Industry (14.7%)**
    3) **Transportation (14.3%)**
    4) **Other fuel combustion (8.6%)**
    5) **Fugitive emissions (4%)**
2. **Agriculture (13.8%)**
3. **Land use change (12.2%)**
4. **Industrial processes (4.3%)**
5. **Waste (3.2%)**

| Country | 2018 CO2 Emissions in Billion Metric Tons | Global Share | Change Since Kyoto Protocol |
|---|---|---|---|
| China | 9.43 | 27.8% | 54.6% |
| U.S. | 5.15 | 15.2% | -12.1% |
| India | 2.48 | 7.3% | 105.8% |
| Russia | 1.55 | 4.6% | 5.7% |
| Japan | 1.15 | 3.4% | -10.1% |
| Germany | 0.73 | 2.1% | -11.7% |
| South Korea | 0.70 | 2.1% | 34.1% |
| Iran | 0.66 | 1.9% | 57.7% |
| Saudi Arabia | 0.57 | 1.7% | 59.9% |
| Canada | 0.55 | 1.6% | 1.6% |




## Top $CO_2$ Emitting Countries, 1750-2020

(from fossil fuels and cement)



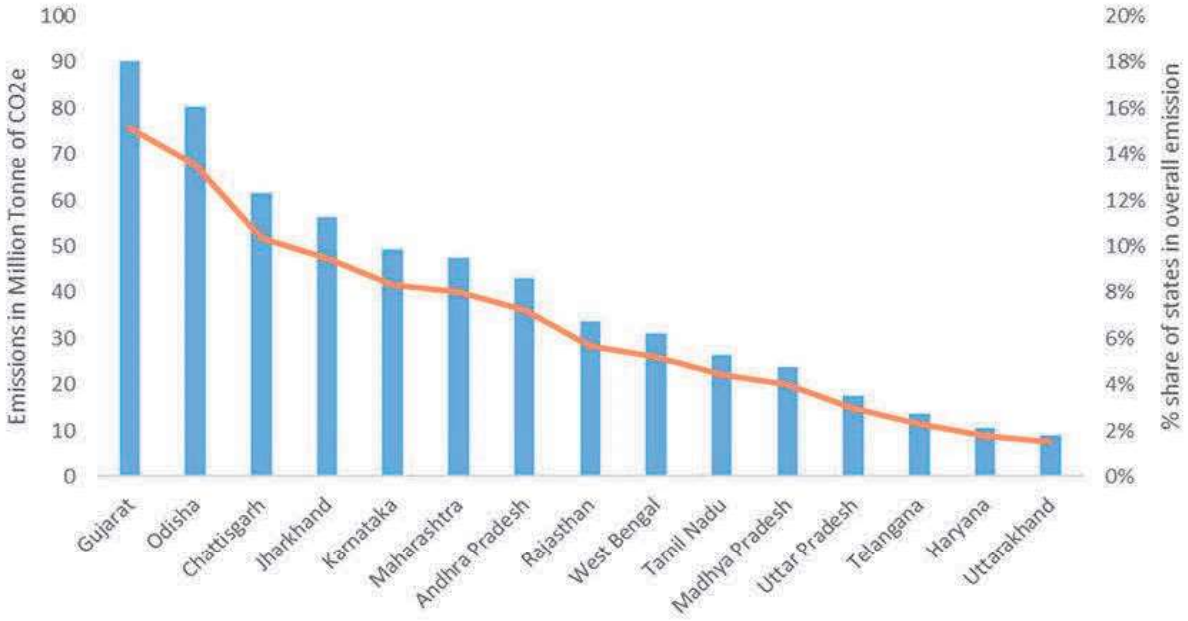
## Carbon Bombs

- A **Carbon Bomb** is "**a coal**, **oil or fossil gas project** with a **potential to emit over a Gigaton of $CO_2$ emissions over its lifetime**." A network named "**Leave It In the Ground Initiative (LINGO)"** has identified **425** of them around the world. According to LINGO, Carbon bombs' potential emissions exceed a 1.5°C carbon budget by a factor of two.
- China, the United States, Russia, and Saudi Arabia have the highest number of Carbon Bombs.
- Some listed carbon bomb projects include:
  - ✓ **Carmichael Coal Project** (coal mine in Queensland, Australia and owned by the Adani Group)
  - ✓ **Gevra Coal Mines** in Chhattisgarh by Coal India.
  - ✓ **Rajmahal Coal Mines** in eastern Jharkhand is owned by Eastern Coalfields.

### About "Leave It In the Ground Initiative (LINGO)"

- LINGO is a **think tank** with a mission to "**leave fossil fuels in the ground** and **learn to live without them**." It envisions a world powered by **100% renewable energy** and advocates a **circular economy**.
- LINGO aims to gain ground support for protesting such projects and challenge them through litigation.

## State Wise Carbon Emissions in India




- The largest contribution of $CO_2$ emissions comes from **Maharashtra**, **West Bengal** and **Gujarat**.
- **Electricity generation:** Contributed to **35.5% of total $CO_2$ emissions in 2010-2015**.
- **Road transport: Maharashtra's** annual contribution is the highest, followed by **Gujarat** and Uttar Pradesh.
- **Cement and steel industries**: Major sources of industrial $CO_2$ emissions are from **Rajasthan**, **Andhra Pradesh**, TN and MP which are the major producers of cement (57% of India's production). **Steel industries** are distributed in Chhattisgarh, Jharkhand, Maharashtra and Gujarat.

- **Agriculture:** Methane emissions from biomass are highest in **UP**, Punjab, WB, Madhya Pradesh and Andhra Pradesh.

## 18.4. Climate Sensitivity

- Climate sensitivity is defined as the **global temperature rise following a doubling of $CO_2$ concentration** in the atmosphere compared to pre-industrial levels. If we know what climate sensitivity is, it will help us estimate how much $CO_2$ we can emit and still stay **below 2°C of warming (as per the Paris Agreement)**.
- Pre-industrial $CO_2$ was about **260 ppm**, so a doubling would be at roughly **520 ppm**. The recent atmospheric concentration of $CO_2$ was found to be at **419 ppm (45% more)**. The **520 ppm threshold** is expected in the next 50-100 years, depending on future GHG emissions.

### Feedbacks Drive Uncertainty

- Climate sensitivity has been in the range of 1.5°C to 4.5°C. It is now moving to between 3°C and 7°C. The wide range of estimates of climate sensitivity is driven by **uncertainties in climate feedback**, including how **water vapour**, **clouds**, **and surface reflectivity (albedo)**.
- Climate feedback is a process that may **amplify (positive feedback)** or **diminish (negative feedback)** the warming effect from increased carbon dioxide ($CO_2$) concentrations or other **climate forcings**. **Cloud-related feedback** included in newer models is responsible for higher levels of predicted warming.

#### Permafrost

- Earth itself begins releasing stores of greenhouse gases **($CO_2$** and **Methane)** from **melting permafrost**. The melting of permafrost will raise the temperature, creating **positive feedback**.

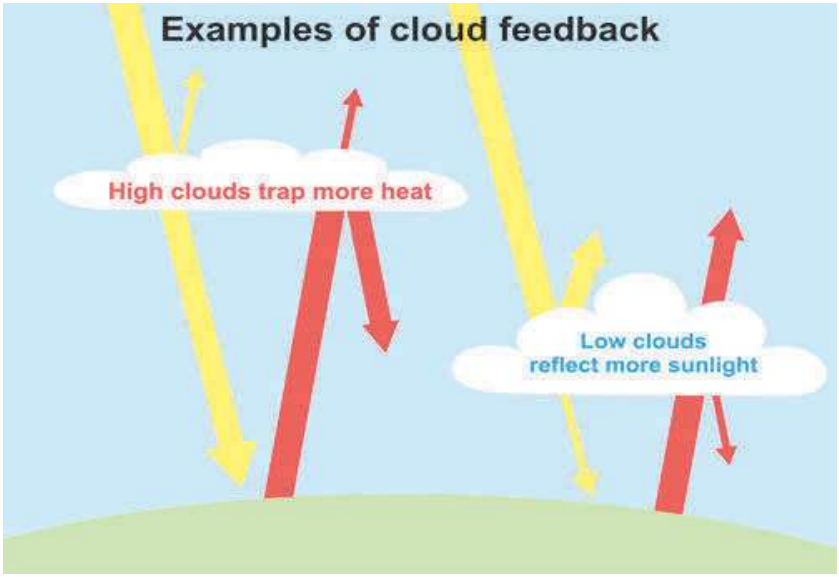
#### Water vapour

- As the world warms, the amount of water vapour in the atmosphere is expected to increase and, therefore, so too will the greenhouse effect.

#### Clouds

- Clouds have a **dual effect** on our climate: 1) they **reflect part of the sunlight back into space**, which decreases temperatures (**negative feedback**), and 2) they **trap part of the heat reflected from the earth's surface**, which increases temperatures (**positive feedback**). The net effect depends on the type of cloud.
- A warmer and wetter atmosphere will affect cloud cover. Clouds that contain **more water droplets** are **optically thicker** and **more effective at blocking sunlight than those composed mainly of ice crystals (cirrus clouds)**.

- For example, **thick**, **low clouds are "strong coolers"** since they reflect a large part of solar radiation (sunlight) and absorb little heat from the ocean and land. On the other hand, **very thin**, **high clouds such as cirrus clouds reflect little sunlight**, but they are very **efficient at absorbing thermal radiation (heat)**, **making them "strong warmers"**.




- Meanwhile, a **shift in sun-blocking clouds (due to global warming)** from the tropics towards the poles, where the incoming sunlight is less intense, would decrease their power to block sunlight. All this means the global net effect of cloud feedback is complex and hard for scientists to model precisely.

## 18.5. Current State of Emissions

- Global average temperature rise should not exceed 1.5°C if catastrophic climate change is to be avoided. To meet this goal, the IPCC has set a limit on how much carbon the world can emit in the future. This limit is called the **carbon budget or the emissions budget**.
- The IPCC had estimated the carbon budget to be **2900 gt** from the pre-industrial times to the end of the 21st century. But the world has already emitted **2,200 gt** by 2017!

### Climate Change Performance Index

- **CCPI** is an independent monitoring tool that compares the climate protection performance of **63 countries** and the **EU** — which account for **92% of global GHG emissions**.
- It has been published by **Germany-based Germanwatch**, the **New Climate Institute** and the **Climate Action Network annually** since 2005. CCPI assesses the performance of the countries based on 14 indicators in the following 4 categories:
  1. **GHG emissions (weighting 40%)**
  2. **Renewable energy (weighting 20%)**
  3. **Energy use (weighting 20%)**
  4. **Climate policy (weighting 20%)**

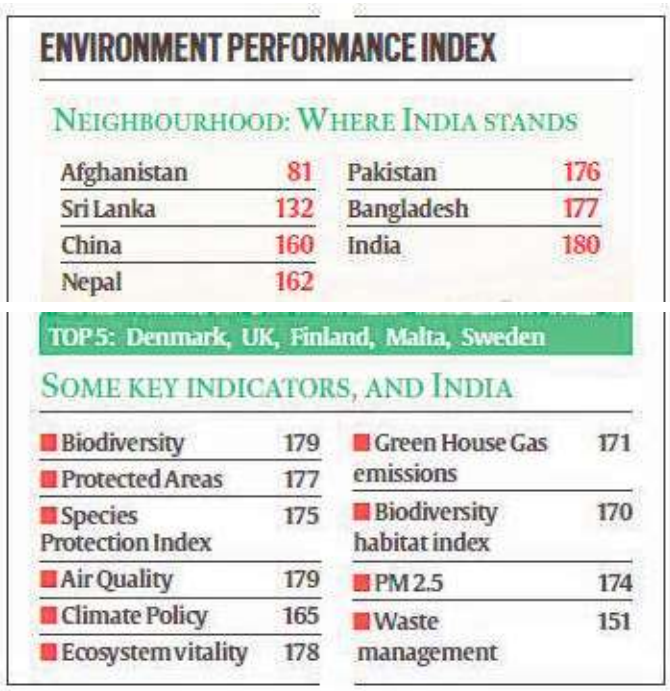
## Climate Change Performance Index (CCPI) 2023

- **India with 8th rank (10th in 2021)** is the **only G-20 country** in the top 10 rank.
- India received high ratings in all CCPI indicators **except renewable energy**.

## Climate Change Performance Index (CCPI) 2024

- **No country** performs well enough in all index categories to achieve an **overall "very high" rating** in the index. Therefore, the **first three ranks in the overall ranking remain empty (just like in 2023)**.
- India has been placed **7th** in the CCPI 2024. **Denmark** was ranked 4th.
- Bottom countries: Saudi Arabia, Iran and UAE.

## Environmental Performance Index (EPI)




- **EPI** is a **biennial index** that is a scorecard that ranks countries on their environmental performance. It was first started in 2002 as the **Environment Sustainability Index (ESI)**, as a collaboration between the **World Economic Forum**, **Yale and Columbia University**.
- The aim was to supplement the environmental targets of the United Nations Millennium Development Goals.

## Environmental Performance Index (EPI) 2022

- The 2022 index was published by **Yale and Columbia University**. It used 40 performance indicators across 11 categories to judge countries on **climate change performance**, **environmental health** and **ecosystem vitality**.

## EPI, 2022 and Performance of India

- **India ranked 180th in the EPI in 2022** (score: 18.9), while it was **ranked 168th in 2020** (score: 27.6).

- MoEFCC has **rejected** the findings of the EPI, 2022. The reasons cited for the same include:

✓ EPI does not consider several important indicators of **sustainable consumption and production**.

✓ Crucial **carbon sinks** that mitigate GHG have not been taken into account.

✓ **Low weightage is given to per-capita GHG emissions**.

✓ No indicator talks about **renewable energy**, **energy efficiency** and process optimisation.

✓ The index emphasises the extent of **protected areas** rather than the **quality of protection**.

✓ The **EPI assumes every country is in the same position (in contrast to Common But Differentiated Responsibilities (CBDR))** economically, developmentally and environmentally.

**---------- End of Chapter ----------**

# 19. Climate Change Impacts and IPCC Reports

## 19.1. Impact of Global Warming

### Increased Frequency and Severity of Heat Waves

- The unprecedented heatwave, which has claimed hundreds of lives in **British Columbia (South-Western Canada)** and neighbouring **Washington and Oregon states (North-Eastern US)** in 2021, is the latest in a growing list of extreme weather events that are attributed to global warming. **Australia (2019-20)**, **California (2020)**, and **Siberia** have all recently experienced deadly wildfires caused by extreme heat waves.

### Heat Wave

- A heat wave is a period of **excessively hot weather**. India Meteorological Department (IMD) declares heat waves when the **actual maximum temperature remains 45°C or more**, regardless of the normal maximum temperature.
- Heat waves are caused by the **shifting of Jet Streams (meandering Rossby Waves in the temperate region case Heat Domes —** explained in Physical Geography > Page 236**)**, **hot local winds like loo (affects Gangetic Plains Region)**, and **anthropogenic causes like global warming**.

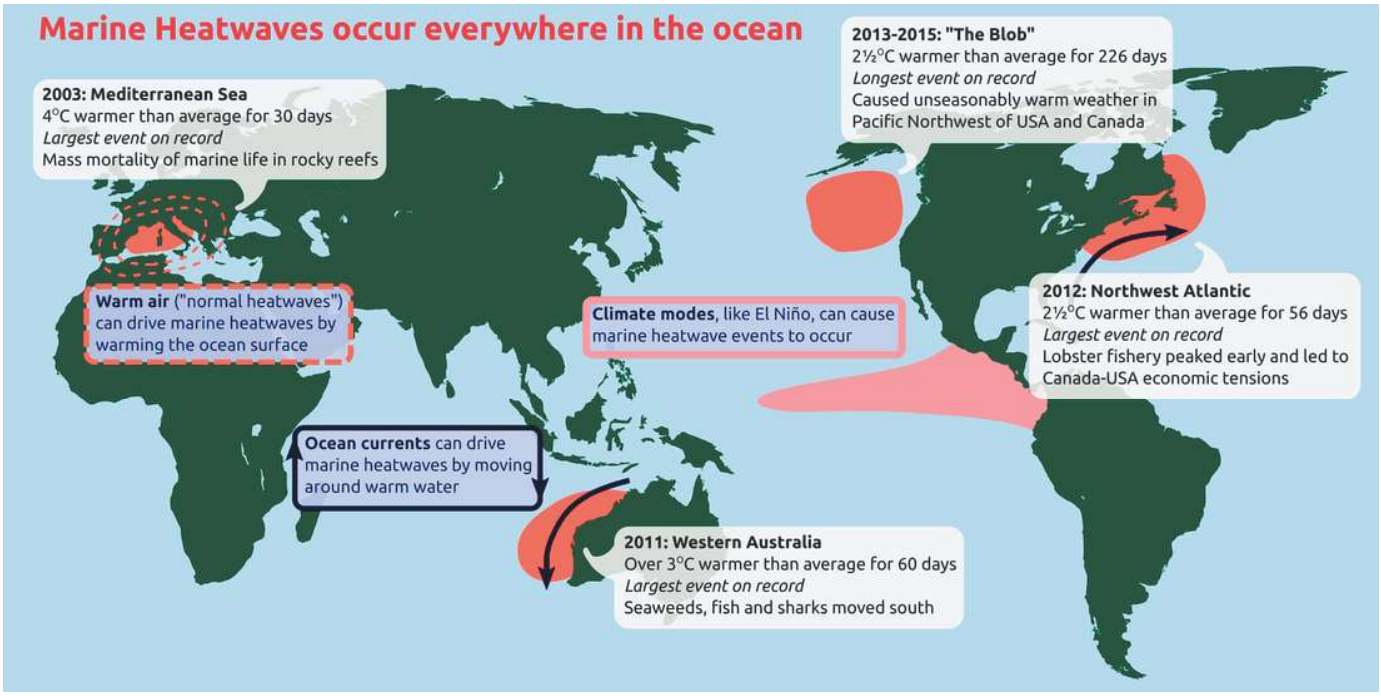
### Global Warming and Heat Waves

- The global average temperature increase since 1900 is around **1.3°C**, **in India**, **it has crossed 2°C**. As emissions continue to rise, India will suffer from heat waves more than the rest of the planet.
- IMD and the **Indian Institute of Tropical Meteorology (Pune)** have established that the **frequency and severity of heatwaves** have **risen** significantly in India over the last three decades. The impact of heatwaves is not limited to cities, but cities aggravate this phenomenon in the form of **Urban Heat Islands**.

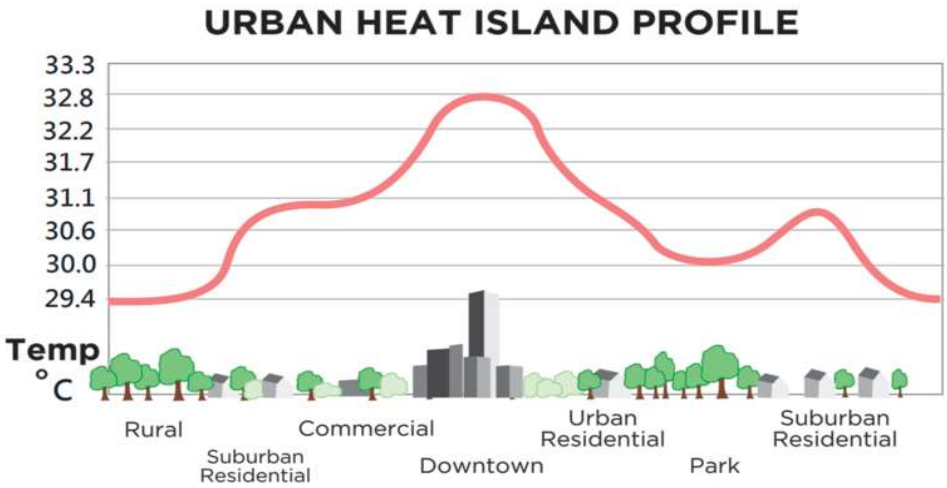
### Effects of Heat Waves

- **Sunstroke (results in body temperature >40°C) and vital organ failure:** In 2015, over 2,300 people died in India, reportedly due to heat waves. **A record heatwave in July 2021** killed more than 500 people in **western Canada**.
- **Reduced human output:** due to adverse effects on mental health (the body works best in a narrow range of body temperature — 36-37.5°C).
- **Economic cost:** Increased expenditure on cooling appliances (**creates a positive feedback mechanism** and enhances global warming; heat wave ➔ More cooling appliances ➔ More emissions ➔ Severe heat waves, and the cycle repeats).
- **Ecological damage:** Reduced biological activity and carbon sequestration.

- **Forest fires:** One of the worst consequence of heat waves in **temperate regions** are wildfires. This is evident in the **2019-2020 Australian Bushfires** and **July 2021 Western Canada Wildfires**.




## Urban Heat Islands




- An urban heat island is an urban or an industrial area that has temperatures **considerably higher than its surrounding rural areas** (both share the same climate) primarily due to anthropogenic reasons.

### Causes Behind Urban Heat Islands

- **Heat-trapping concrete** and **asphalt** (have **very low albedo** or **low reflectivity**) replace natural vegetation and water (reduced evaporation and evapotranspiration).
- High-rise buildings that offer **more surface area for heat absorption**.
- **High vehicle density** and heat released from their engines.
- **High pollution levels** and high concentrations of GHGs like **$CO_2$ (thermal power plants and vehicles)**.

- GHGs, aerosols, particulate matter, etc., are good at **absorbing outgoing infrared radiation**.
- Cooling appliances like **air conditioners** release heat into the surroundings.
- Bad monsoons because of less evaporation of water from vegetation (evapotranspiration) and soil.
- Heat islands at night: Cities used to cool down during the night, but nowadays, they are trapping this heat overnight. **ACs**, pollution and a close and dense network of buildings are the primary reasons for the Urban heat islands at night.

***[UPSC 2013] Bring out the causes for the formation of heat islands in the urban habitat of the world. (2013)***

### Albedo of different surfaces

- **Albedo** of a surface is the proportion of sunlight that the surface can reflect back into space.
- **Fresh snow** has the **highest albedo** (reflects back 80-90% of the incident sunlight). **Dark asphalt** used to road construction and in the roofing of buildings has very low albedo (~5%).

| Surface | Albedo |
|---|---|
| 1. **Fresh Snow** | **80-90%** |
| 2. **Thick cloud** (**low level clouds**) | **70-80%** |
| 3. Water near horizon | 50-80% |
| 4. **Old Snow** | **45-50%** |
| 5. **Desert** | **30-45%** |
| 6. **Light soil** | **20-45%** |
| 7. **Thin cloud** (**Cirrcus clouds**) | **25-35%** |
| 8. **Grasses** | **20-25%** |
| 9. **Soil** | **20-25%** |
| 10. **Crops** | **10-25%** |
| 11. **Forest** | **10-20%** |
| **Asphalt** (**used in road construction and roofing**) | **5%** |

## Marine Heat Waves

***[UPSC 2019]How do ocean currents and water masses differ in their impacts on marine life and the coastal environment? Give suitable examples. (Answer in 250 words)***

- **Marine heatwaves** occur when ocean temperatures for a particular oceanic location are **unusually extremely warm for an extended period** and time of year. They can occur in **summer or winter** and have a significant impact on marine ecosystems and world weather patterns.

### IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) on Marine Heat Waves

- Today's oceans are experiencing unprecedented conditions with **increased temperatures**, **further** ocean acidification, **marine heatwaves** and **more frequent extreme El Niño and La Niña events**.
- Communities close to coastal environments, **small island nations**, polar areas and high mountains are particularly vulnerable to changes, such as **rising sea levels** and **shrinking glaciers**. Communities in other areas are affected by **extreme weather events** exacerbated by ocean warming.

### Marine heat waves

- Marine heat waves have become **twice as frequent** in the past four decades and are lasting longer. The report finds that **human activities** are responsible for 84 to 90 per cent of the marine heat waves that occurred in the last decade. By 2081, the frequency of marine heat waves could jump by 20 to 50 times.

### Impact on marine productivity

- **Marine heat waves** have resulted in **large-scale coral bleaching**, which takes more than 15 years for corals to recover from.
- Marine heat waves **reduce the mixing between water layers** and, consequently, the **supply of oxygen and nutrients for marine life**.
- The Pacific Ocean, which had seen such unusually warm water, had **boosted the growth of toxin-producing algae** and **suppressed the growth of small organisms** at the **base of the ocean food chain**.

### Impact on weather patterns

- The direct cause of marine heat waves is **weak winds**. A more pronounced effect of marine heat waves would be on global wind circulation and ocean currents.
- The IPCC report indicates the **Atlantic Meridional Overturning Circulation (AMOC — explained in PMF IAS Physical Geography > Page 308)**, which ensures a **northward flow of warm**, **salty water in the upper layers** of the Atlantic and a **southward flow of colder**, **deep waters**, has already weakened.
- Any substantial weakening of the AMOC would cause:
  - A further **decrease in productivity in the North Atlantic**
  - More storms in Northern Europe
  - **Less Sahelian (southern part of Sahara Desert) summer rainfall** and **South Asian summer rainfall**
  - A reduced number of tropical cyclones in the Atlantic
  - An **increase in regional sea level** along the northeast coast of North America, the report warns.

### More severe cyclonic storms

- IPCC says there is emerging evidence of an annual increase in the percentage of category 4 and 5 storms. These storms sustain their strength further by feeding on the moisture over **warm ocean waters**.

## Increased Incidence of Wildfires

- Increased incidence of wildfire creates a **positive feedback loop** exacerbating global warming.

## Australia's Bushfires are Getting Severe

- Australia, where the summer starts around October, is known to be the **most fire-prone of all continents**. This is mainly because Australia is also the driest inhabited continent. Almost 70% of its area comprises arid or semi-arid land, with an average annual rainfall of less than 35 cm.
- Most of Australia's forest land is in the north and east. Bushfires are common every summer in this region. But the fires in recent times are getting more severe with each passing year due to **climate change**.
- In 2020, Australia witnessed its worst drought and subsequent heat waves in more than five decades. This caused catastrophic fires, and wildlife in Australia was severely hit with thousands of **koala deaths**.


### Criticism of Australia's climate policy

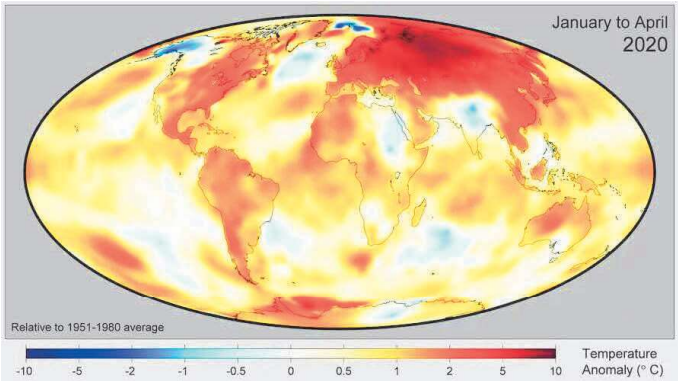
- **One-third of global coal exports come from Australia**, accounting for 7% of global carbon emissions. The country is the largest **exporter of coal** and liquefied natural gas in the world. The Australian government has defended the country's coal industry despite criticism from environmentalists. Australia has also invited criticism for counting carbon credits under the Kyoto Protocol instead of making new reductions to meet its emissions targets.

## Wildfires and Zombie Fires Have Reached the Tundra

- Wildfires on **permafrost in Siberia** south of the Arctic are **not uncommon**.
- But in 2020, burning occurred well above the Arctic Circle (tundra), a region **not commonly known to support large wildfires**. It is because of the unprecedented drying up of the tundra vegetation like moss, grass and dwarf shrubs.
- Also, the 'zombie fires' are becoming more frequent in the once-frozen tundra **—** north of the Arctic Circle.
- A **zombie fire** (**holdover fire**) is a **fire from a previous growing season** that can burn slowly with smoke but no flame under the ground made of **carbon-rich peat**.

## Concerns

- The fires and record temperatures have the **potential of turning the carbon sink into a carbon source**.




# Shrinking Cryosphere

- The areas of snow or ice, which are subject to **temperatures below 0°C for at least a part of the year**, compose the cryosphere. **Continental ice sheets** found in Greenland and Antarctica, ice caps, glaciers, areas of snow (glaciers of Alps, Himalayas) and **permafrost (Siberia)**, frozen parts of the ocean, rivers, lakes, etc., are all part of the cryosphere.
- Glaciers from almost half of natural World Heritage sites **—** such as the **Khumbu Glacier in the Himalayas —** may disappear entirely by 2100 if emissions continue at the current rate, an IUCN study warns.
- The study predicts glacier extinction in 21 of the 46 natural World Heritage sites with glaciers.

## Role of Cryosphere

- ✓ **Snow and ice (have the highest albedo)** reflect heat from the sun (**heat budget**).
- ✓ Glaciers and high snow-covered mountains supply freshwater to many parts of the world.
- ✓ The cryosphere is **most sensitive to climate shifts**. Hence, it acts as the **earth's black box** (ice accumulates layer over layer. **Studying the vertical ice column helps understand past global changes in climate**).

## Consequences of Shrinking Cryosphere (Glaciers)

- Water scarcity and water wars between nations.
- Loss of ecologically rich and important **coastal wetlands**.
- **Distress migration** of coastal inhabitants due to the submergence of major coastal cities.
- Submergence of **Small Island Developing States** (first to suffer the consequences of climate change).
- Disastrous changes in major weather patterns.
- Groundwater resources of the coastal regions will also be severely affected by salinisation.
- Reduced hydroelectric power generation due to the abnormal behaviour of glaciers will further increase dependence on fossil fuels.
- The widespread vanishing of animal populations due to habitat loss will add more species to the 'threatened' and 'extinct' list.

### Vegetation Change

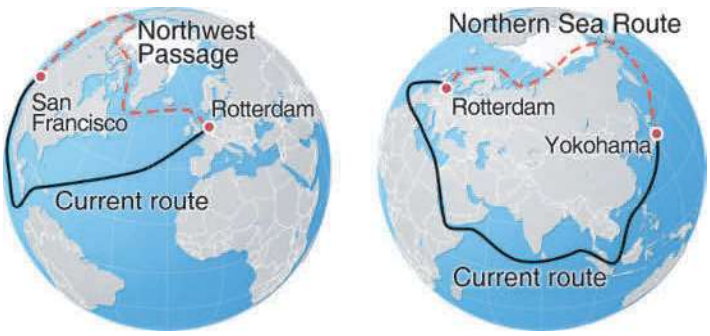
- As a result of the thawing of snow, the **amount of arable land in high-latitude regions is likely to increase** with the reduction of the amount of frozen land.
- At the same time, **arable land along the coastlines is bound to be reduced** as a result of rising sea levels and **saline water inundations**.
- The **tundra will return to swamps (→ loss of forest → loss of carbon sink)**, and the **permafrost is thawing (→ exposing the subsurface carbon sinks)**.

### Surge-Type Glaciers and Disasters

- Surge-type glaciers are glaciers that have shown advancement in volume and length over a period. They go against the normal trend of considerable reduction in the volume and length of most glaciers. Surging glaciers do not flow at a constant speed but rather are subjected to cyclical flow instabilities. These types of glaciers can give rise to catastrophic **glacial lake outburst** floods when they break due to **global warming**.

## New Sea Routes in The Arctic region

- The **Arctic Region is warming up twice as fast as the global average**. The **Northern Sea Route (NSR)**, which would connect the **North Atlantic** to the **North Pacific** through a short polar arc, is slowly opening due to ice melting. Models predict that this route could be ice-free in summer by 2050.



### New shipping routes

- The opening of the Arctic presents **huge commercial and economic opportunities**, particularly in shipping, energy, fisheries, and mineral resources.
- Commercial navigation through the NSR is the most tempting: The distance from **Rotterdam** to **Yokohama** will be cut by 40 per cent compared to the Suez route.

### Access to unexploited resources

✓ Unexplored oil and natural gas deposits are estimated to be **22% of the world's unexplored resources**, mostly in the **Arctic Ocean (Barents Sea Region)**.

✓ Mineral deposits, including **25 per cent** of the **global reserves of rare earths**, are buried in **Greenland**.

### Challenges associated with the new opportunities

- Mining and deep-sea drilling carry massive costs and **environmental risks**.
- **Unlike Antarctica**, **the Arctic is not a global common**. **No treaty governs it**; only the **UN Convention of Law of the Sea (UNCLOS) deals with it**. Large parts of it are under the sovereignty of the five littoral states **— Russia**, **Canada**, **Norway**, **Denmark (Greenland) and** the **US** and exploitation of the new resources is well within their rights and can trigger **fresh territorial conflicts**.

⇨ ***[UPSC 2017] How does the cryosphere affect global climate? (2017)***

⇨ ***[UPSC 2018] Why is India taking keen interest in resources of Arctic Region? (2018)***

⇨ ***[UPSC 2015] What is the economic significance of discovery of oil in the Arctic Sea and its possible environmental consequences? (2015)***

## Arctic (or Polar) Amplification (PA)

- The ratio of **warming differential** between the poles (polar warming) and the tropics (tropical warming) is known as **Arctic (or polar) Amplification**.
- Simply saying the **Arctic region is warming faster than other parts of the globe**. Arctic's average annual temperature rose by 3.1°C between 1971 and 2019, compared to 1°C for the planet.
- Arctic Amplification (AA) occurs whenever there is any change in the **Net Radiation Balance**, which is **slightly higher in the Arctic** compared to tropical areas. **Net Radiation Balance** is the balance between incoming and outgoing energy at the top of the atmosphere.

### Why is the Arctic warming more rapidly?

- **Change in Albedo:** Amplification is primarily caused by **melting polar ice**, which is increasing in the Arctic at a rate of 13% per decade. Ice is more reflective of sunlight (**high albedo**) than land or ocean. When ice melts, it typically reveals darker areas, and this results in **increased sunlight absorption (low albedo)** and associated warming.

- **Melting sea ice also releases greenhouse gases from thawing permafrost and frozen methane** from the ocean bottom and further intensifies Amplification.

### Why is PA much stronger in the Arctic than in Antarctica?

- This is because the Arctic is an **ocean covered by sea ice**, while Antarctica is an elevated continent covered in more permanent ice and snow. In fact, the Antarctic continent has not warmed in the past seven decades despite a steady increase in the atmospheric concentrations of GHGs.

### What are the possible effects of Arctic warming?

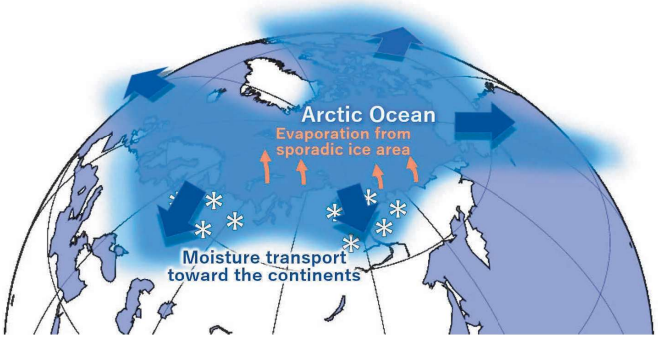
- The most obvious impact will be a **sea-level rise globally**. Arctic **permafrost thaw** has significant implications for global climate because the **thawing process releases carbon dioxide and methane**, which has the potential to cause even further warming (positive feedback). The most significant effect of Arctic amplification is its impact on **mid-latitude climate**, as well as the occurrence of extreme events. It affects mid-latitude climate by:

➢ **Weakening of the tropospheric Jet Stream** (will contribute to an increase in unusual and extreme weather in the mid-latitudes).

➢ **Weakening of the stratospheric polar vortex** (which results in extreme weather events in the mid-latitudes).

### Warming Arctic Ocean Increasing Snowfall in Siberia

- This is because the warming of the Arctic Ocean has enhanced the evaporation rate, and more moisture is deposited in the Arctic atmosphere. This increased moisture journeys towards northern Eurasia and caused increased snowfall there (particularly in Siberia).




***[UPSC 2021] How do the melting of the Arctic ice and glaciers of the Antarctic differently affect the weather patterns and human activities on the Earth? Explain. (250 words)***

## Sea Level Change

- Sea level change means the fluctuations in the mean sea level over a considerably long period of time. Commonly, seasonal variations of 5-6 cm are observed in a year.

### Processes that cause Change in Sea Level

1. **Eustatic changes** occur when the volume of seawater changes due to factors such as
   - ✓ **global warming and melting of ice sheets** (rise in sea level) or ice ages (fall in sea level) and
   - ✓ **changes in the volume of mid-oceanic ridges**.
2. **Tectonic changes** occur due to a change in land level
   - ✓ **Isostatic changes** take place due to the **addition or removal of load** — during ice ages, landmass subsided due to the load exerted by the glacial ice. On the other hand, **landmasses rise as the glacial ice is removed**.
   - ✓ **Epeirogenic movement** occurs due to the broad-scale tilting of continents, which may result in the rise of one part of the continent even as the other part may subside, causing an apparent rise in sea level.
   - ✓ **Orogenic movement (mountain building)** results in the formation of lofty mountains and an apparent fall in sea level.

## Short-term sea level change

- **Marine water density:** Temperature and salinity control the density of seawater. Low temperatures and **high salinity produce high-density seawater and lower sea levels**.
- **Atmospheric pressure:** Low pressure results in higher local sea levels and vice versa. E.g., **Storm surge**.
- **Velocity of ocean currents:** Fast-flowing ocean currents, when taking a curved path, cause a rise in sea level on their outer fringes. Generally, a difference of 18 cm in sea level is observed along the axis of a fast-flowing current.
- **Ice formation and fall in sea level:** During winter, ocean water trapped in the icecaps of the northern and southern hemispheres causes sea levels to fall.
- **Piling up of water along windward coasts:** A local rise of sea level occurs in the coastal region as water is driven towards the coasts by an air mass. For example, the sea level rises in south and east Asia during the monsoon months due to landward movement of the air mass.

## Long-term sea level change

- **Global warming** in the last century due to anthropogenic activities has resulted in the **thermal expansion** of ocean water. So, the sea level has risen by about 10 to 15 cm in the past 100 years.
- The **melting of Antarctica's ice sheets** by **about 3 per cent** of its total volume of ice has, to some extent, contributed to global sea level rise.
- Global sea level changes which exceed **100 m** are possible only if the **major ice sheets melt** or there are substantial changes in the volume of the world's mid-oceanic ridge.

## Importance of understanding Sea Level Changes

- ✓ It provides key evidence regarding past climate change.
- ✓ It helps in estimating the rates of tectonic upliftment in the past geological periods.

- ✓ It helps to assess the suitability of coastal locations for industrial and agricultural development.
- ✓ It helps in protecting low-lying countries by building **coastal dykes** and **embankments**.
- ✓ The task of mapping of areas likely to be affected by storm surges and periodic flooding becomes possible.
- ✓ By identifying the areas of possible submergence in the near future, it becomes possible to set up tidal power **generation plants** in suitable locations.

## Sea Level Rise and Coastal Flooding

- The IPCC report warns that sea level rise could reach **60 to 110 cm** if emissions continue to increase strongly. More than half the global population lives in cities, most of which are located on **low-lying islands and coasts** and economic losses due to extreme flooding will soar **166 times** more by 2050.
- **300 million people**, and **not 80 million as estimated earlier**, across the globe were currently living in areas that were below the annual coastal flood line. Almost 80 per cent of these 300 million people live in China, Bangladesh, India, Vietnam, Indonesia and Thailand. **China** alone accounted for 43 million.
- In each of several dozen major cities — including Bangkok, Hong Kong, Shanghai, Taizhou, Surabaya, Dhaka, **Mumbai**, Ho Chi Minh City and Osaka — millions will find themselves in flood zones.

### Vulnerable areas in India

- **36 million** people along the Indian coastlines currently live on land that will fall below the annual flood level by 2050, exposing them to risks of flooding.
- **Bhuj**, **Jamnagar**, **Porbandar**, **Surat**, **Bharuch** and **Mumbai** are much more susceptible to rising sea levels. On the eastern side, almost the entire coastline of **West Bengal** and **Odisha** have been found under threat.


***[UPSC 2017] 'Climate change' is a global problem. How India will be affected by climate change? How Himalayan and coastal states of India will be affected by climate change?***

***[UPSC 2023] The Intergovernmental Panel on Climate Change (IPCC) has predicted a global sea level rise of about one metre by AD 2100. What would be its impact on India and the other countries in the Indian Ocean region? (Answer in 250 words)***

## Small Island Developing States are the Biggest Losers

- Small Island Developing States (SIDS) are islands that are relatively **remote**, **vulnerable to environmental challenges**, **such as climate change**, and generally small in size.
- The SIDS were recognised as a distinct group of developing countries in June 1992 at the **UN Conference on Environment and Development (1992 Earth Summit)**. Most of the SIDS are **coral islands formed on shallow atolls**. Hence, they are **highly vulnerable to sea level rise**.

### Barbados Programme of Action (1994)

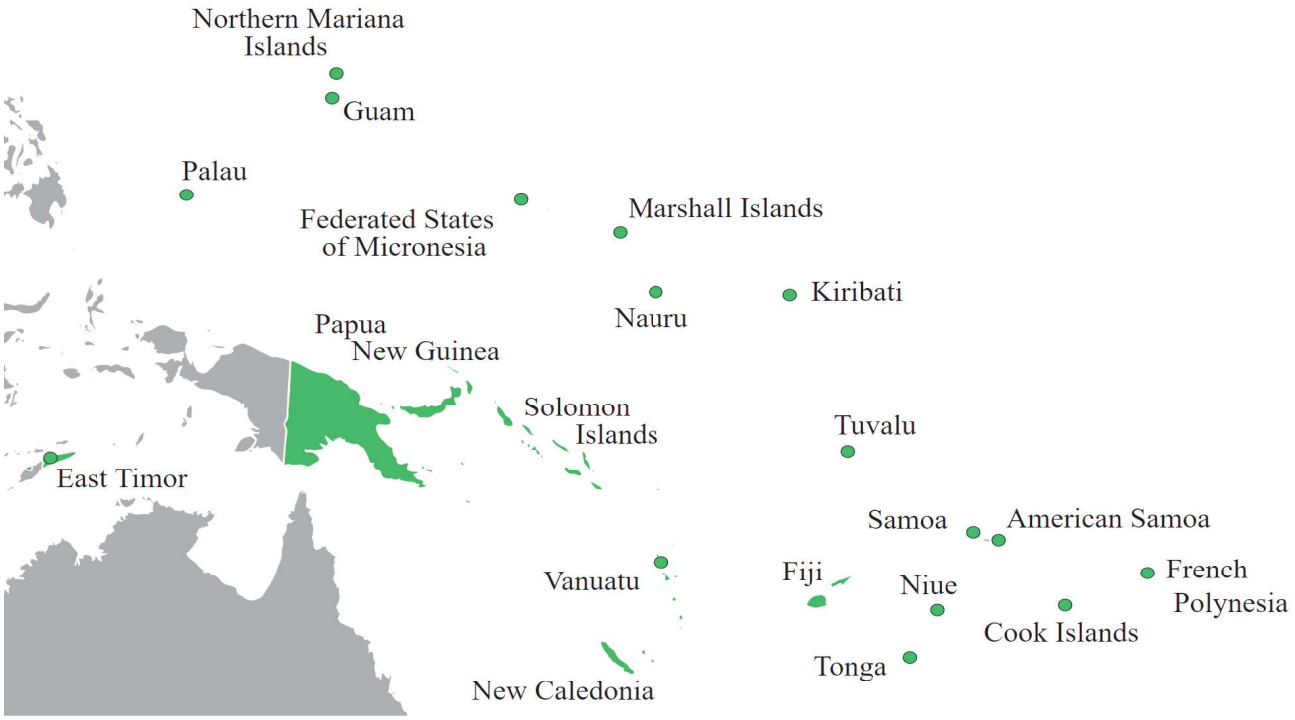
- The **United Nations Programme of Action** on the **Sustainable Development of Small Island Developing States** is popularly referred to as the **Barbados Program of Action (BPOA)**. It is a policy document that addresses the economic, environmental and social developmental **vulnerabilities facing islands** and outlines a strategy to mitigate those vulnerabilities. It remains the **only** internationally approved programme specific to **Small Island Developing States (SIDS)**.

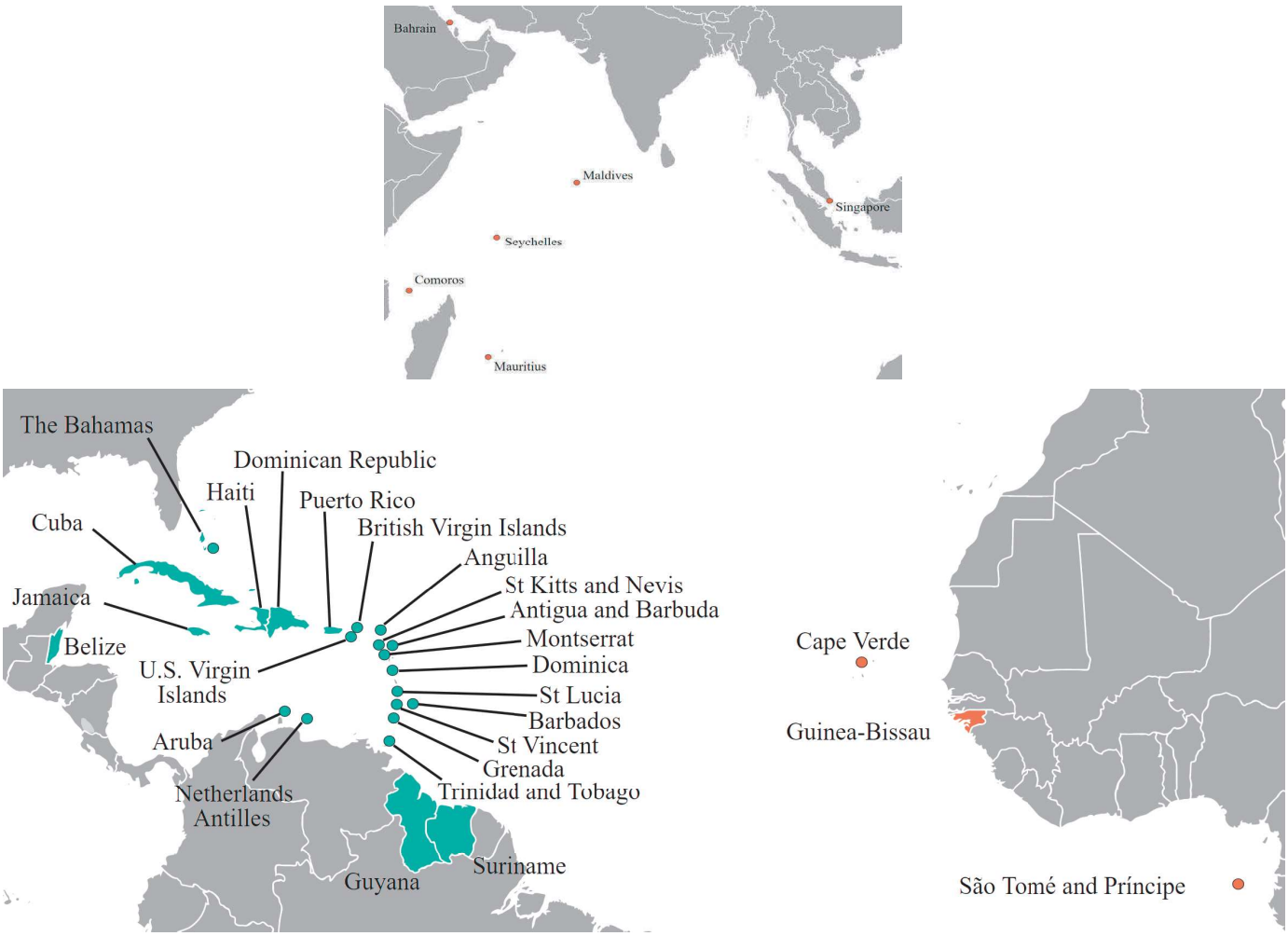
### *Mauritius Strategy (2005)*

- It is a 10-year comprehensive review of the Barbados Programme of Action (BPOA). The outcome was the adoption of the **Mauritius Strategy** for the further Implementation of the **BPOA**.

⇨ *In 2016, the **Marshall Islands** sued India, Pakistan and Britain in the International Court of Justice for **failing to halt the nuclear arms race**.*

⇨ *To check the phenomenon of sea level rise, the **'Oceans and Coastal Areas Programme Activity Centre'** was set up in 1987 under the aegis of the **United Nations Environment Programme (UNEP)** to identify the countries facing the maximum risk of submergence.*

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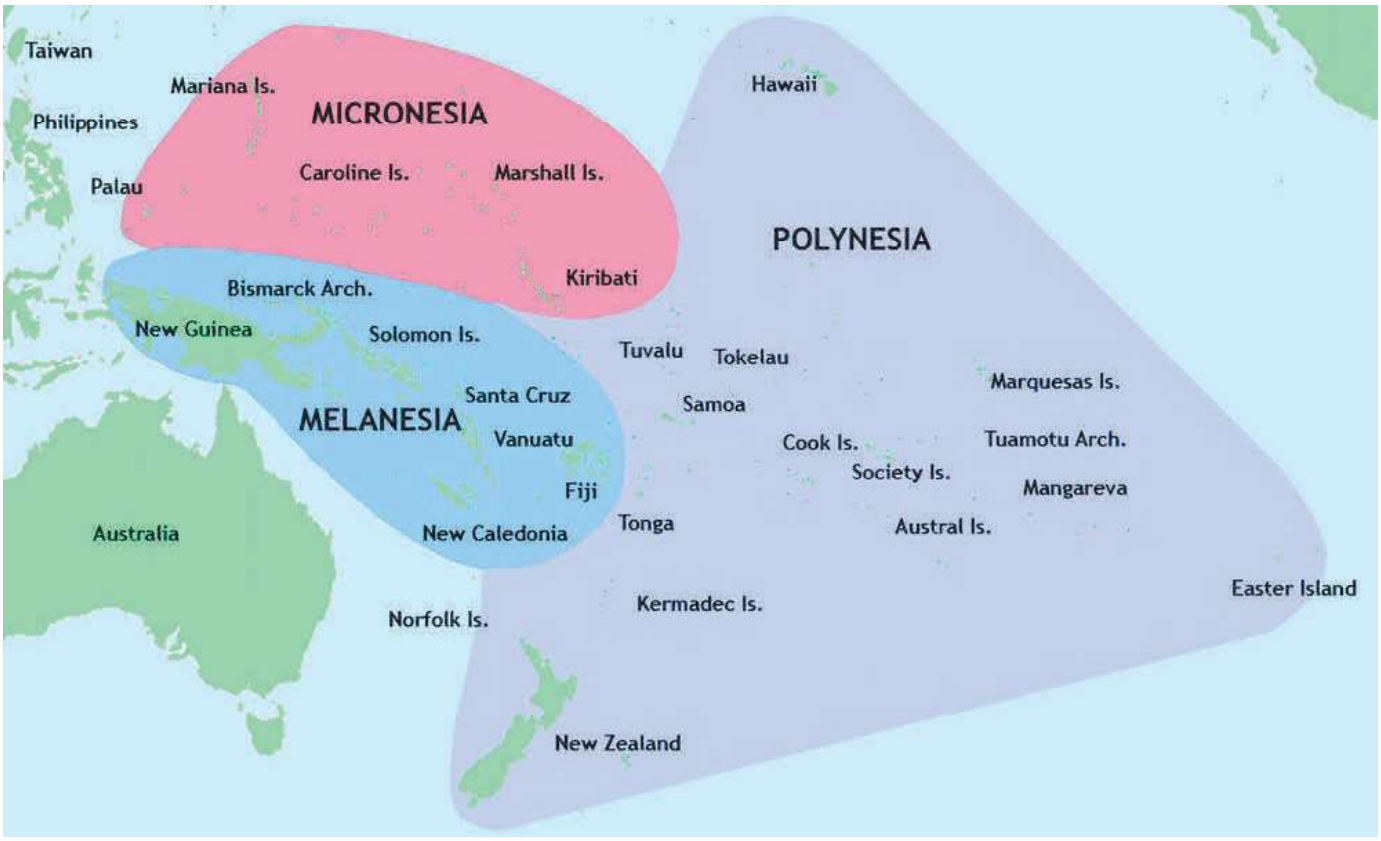
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New Zealand

## Regional Sea Level Rise (SLR)

- Globally, of the 68% area that is prone to coastal flooding, over **32 per cent can be attributed to Regional SLR**. **SLR is not uniform across the world**, for instance, the **gravitational pull of the polar ice sheets** has different effects on sea levels in different parts of the world, which means regional SLR can be higher or lower than the global SLR.

### How much of a threat is SLR?

- Cities that regularly feature in the lists endangered by climate change are **Guangzhou**, **Jakarta**, **Miami and Manila**.
- In 2019, Indonesia's President Joko Widodo announced that the country's capital would be relocated from **Jakarta** to the province of **East Kalimantan** on the **lesser populated island of Borneo**. The combination of climate change and heavy congestion continues to bury Jakarta, the **"world's fastest-sinking city"**, **by about 25 cm into the ground every year**.
- The situation looks grim for **Mumbai** as well. As per some projections, climate change is expected to inundate significant sections of Mumbai by 2050.

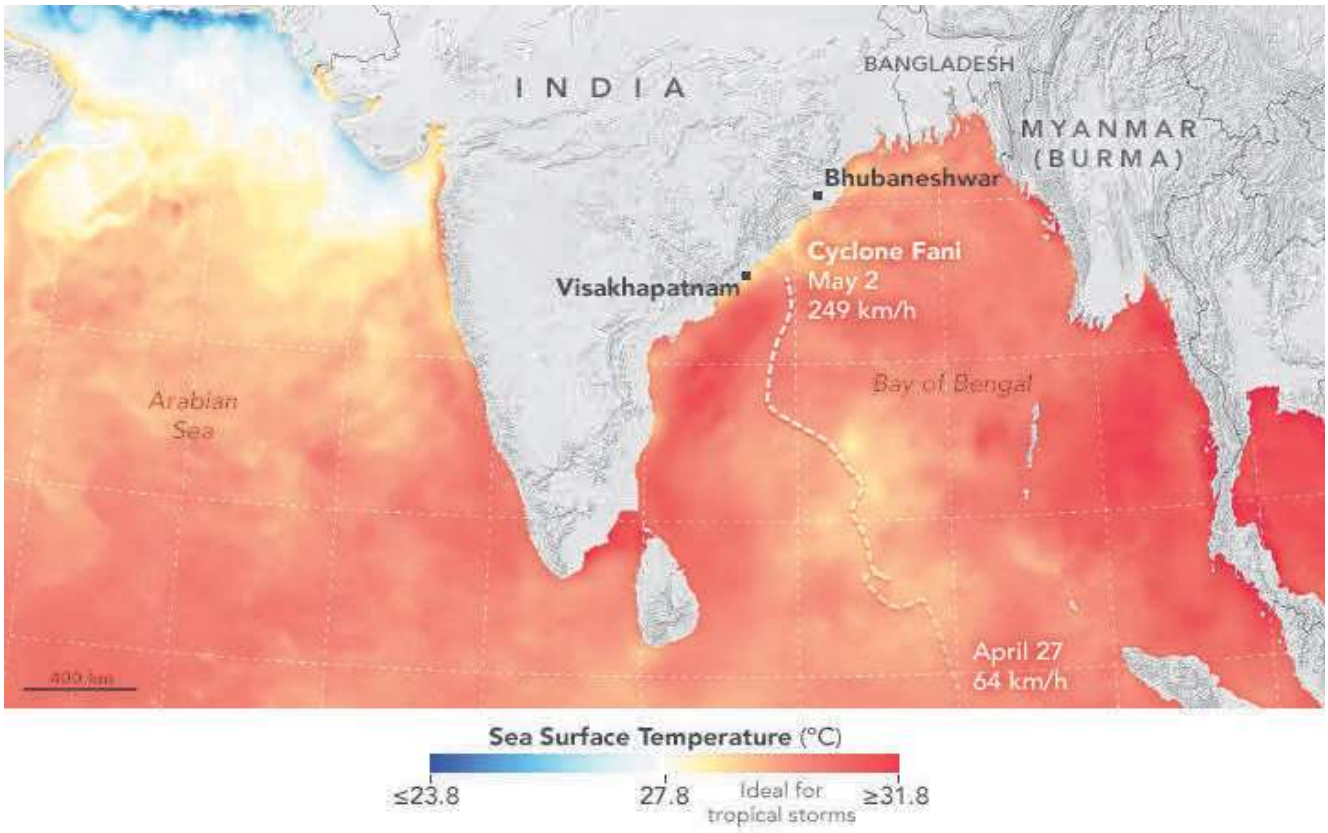
### Ways of protecting against SLR

- A **Special Report on the Ocean and Cryosphere in a Changing Climate**, published by the IPCC, noted that **"well-designed coastal protection"** could both "reduce expected damages" and "be cost efficient for urban and densely populated areas".
- Indonesia's government launched a coastal development project called a **Giant Sea Wall or "Giant Garuda"** (Garuda is the name of a bird from Hindu mythology and is Indonesia's national symbol) in 2014.
- **Northern European Enclosure Dam (NEED)**, enclosing all of the **North Sea**, is a planned measure to protect 25 million people and essential European economic regions from rising seas due to CC. The idea involved constructing two dams of a combined length of 637 km to protect Northern Europe against "unstoppable" SLR.


- It was identified that other regions such as the **Persian Gulf**, the **Mediterranean Sea**, the **Baltic Sea** and the **Red Sea** that could benefit from similar enclosures.

## Tropical Cyclones are Becoming More Severe

- Tropical cyclones require a sea surface temperature (SST) of **26.5°C** to form, while the highest intensity storms require much warmer sea surface temperature (SST) of **28-29°C**. The frequent high intensity storms have been tied to the **very warm SST (30°C+)**.




- The South Indian Ocean that previously experienced the temperatures of 26.5°C is now experiencing temperatures as warm as **30-32°C**. The increasing ocean temperatures gave rise to devastating **Idai cyclone in March 2019** (1300+ causalities) in the SW Indian Ocean basin (SE Africa).
- Regions further from the equator are more regularly experiencing the threshold temperature of 24-26°C **widening the range of formation of tropical cyclones**. These conditions are exacerbated by **global forcing mechanisms**, including **El Niño**, **Indian Ocean Dipole**, **Southern Annular Mode** and **Madden-Julian Oscillation** (these, in turn, are affected by global warming). (*Explained in PMF IAS Physical Geography > Climatology*)

## Unusual Timing and High Frequency

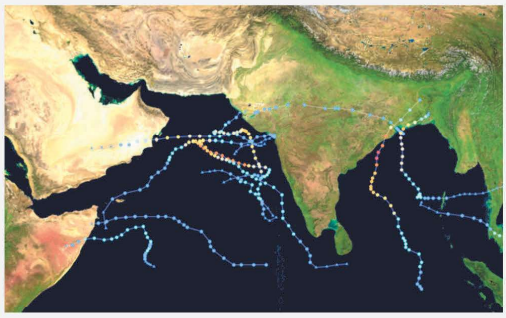
- **Extremely Severe Cyclonic Storm Fani (April 2019)** is India's **strongest April cyclone in 43 years**. The unusual timing (April) is attributed to **global warming** (unusual warming of the Bay of Bengal).
- The **severe cyclone frequency** in the north Indian Ocean has registered about a three-fold increase. About one severe cyclone was expected to form every year during the intense cyclonic period (May, October and November). The number has now gone up to about **three per year**.

## The number and intensity of tropical cyclones is increasing in the Arabian Sea

- Almost 50% of the storms do not sustain over the Arabian Sea since the west-central and north Arabian Sea (due to **Findlater/Somali Current that causes local upwelling**) have a relatively colder SST, which is not favourable for the development and sustenance of cyclonic storms. However, this is changing.

- The Arabian Sea is heating rapidly and **driving more cyclones** and **excessive rainfall (excessive rainfall in sea → less moisture in monsoon winds → less rainfall on the mainland)**. Climate models suggest that 64 per cent of the cyclone risk in the Arabian Sea was due to climate change.

2019 North Indian Ocean cyclone season



### Increased occurrence of Severe cyclonic storms

- In the usual course, there was an occurrence of **one extremely severe cyclone every four to five years**. Of late, the Arabian Sea started receiving tropical cyclones of high intensity quite frequently. For instance, from 1998 to 2013, five extremely severe cyclones originated in the Sea.

### Unusual timing

- In 2019, a Very Severe Cyclonic Storm, Vayu, occurred in the Arabian Sea in the month of June. This is unusual as the **conditions in June are not conducive for depressions to turn into severe cyclones (due to the outbreak of monsoons)**.

### Changing path

- Previously, tropical cyclones in the Arabian Sea were **restricted to Gujarat**. In the past decade, though, **Kerala** and **Karnataka** have also become more vulnerable to cyclones.

**Mains Practise: What are the consequences of Global Warming (anthropogenic impact) on the Indian weather conditions?**

- Answer must include El Nino, Tropical Cyclones, Hotter summers – devastating heat waves.
- Include examples like the 2018 Kerala floods, the 2015 Chennai Floods, Severe Cyclonic Storm Fani, etc.

## Deterioration of Carbon sinks

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

### Carbon Dioxide Fertilization

- Earth's vegetated lands have shown significant **greening (an increase in leaves on plants/trees)** largely due to **rising levels of atmospheric $CO_2$ (increases in photosynthesis)**.

- **Carbon dioxide fertilisation** contributes **70 per cent of the greening effect**. The second most important driver is **nitrogen**, at 9 per cent. The rest occurs due to land cover changes, precipitation, sunlight changes, etc.
- Plants acclimatise to rising $CO_2$ concentration, and the **fertilisation effect diminishes over time**. That is, raising $CO_2$ concentrations may be **beneficial in the short run**, but **in the long run**, **it is harmful due to climate change**.

**Carbon Fertilization is increasing carbon sink on land**

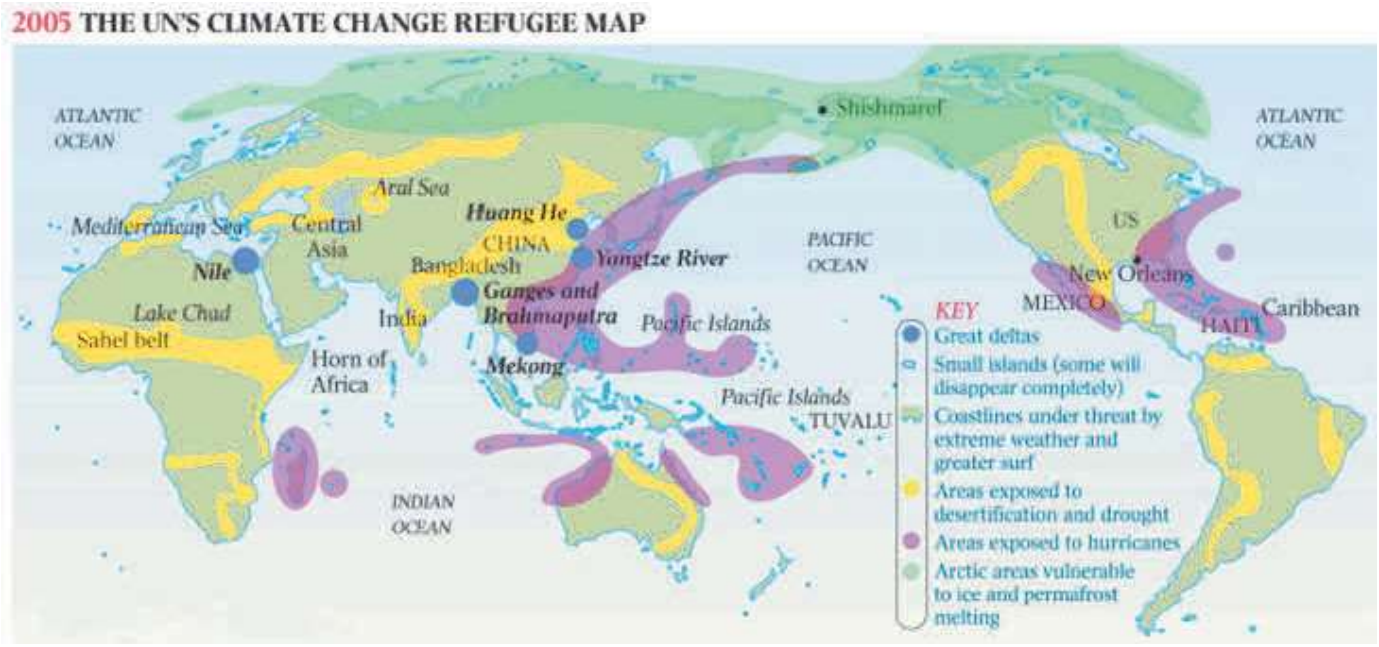
- Every year, about half of the **10 gt of carbon emitted** into the atmosphere from human activities remains **temporarily stored**, in about **equal parts**, in the **oceans and plants**. Studies have reported an **increasing carbon sink on land** since the 1980s, which is entirely consistent with the idea of a **greening Earth**.

**[UPSC 2018] Which of the following statements best describes "carbon fertilisation"?**

a) Increased plant growth due to increased concentration of carbon dioxide in the atmosphere
b) Increased temperature of Earth due to increased concentration of carbon dioxide in the atmosphere
c) Increased acidity of oceans as a result of increased concentration of carbon dioxide in the atmosphere
d) Adaptation of all living beings on Earth to the climate change brought about by the increased concentration of carbon dioxide in the atmosphere

***Answer: a)***

## Climate Migrants




- **Environmental Migrants** are people displaced due to adverse changes to their local environment. **Climate migrants** are migrants people displaced due to climate change impacts such as **sea level rise**

**(Sundarbans)**, **floods (Ganges**, **Brahmaputra basins)**, **drought (central India**, **Vidarbha**, **Telangana**, **Rayalaseema)**, etc.

- The National Sample Survey Office (NSSO) 2007-08 report titled 'Migration in India' identified natural disasters as one of the major reasons for migration (13/1,000 migrants). Displacement or rise in migration due to disasters has raised concerns about increasing human trafficking, conflicts and pressure on resources.

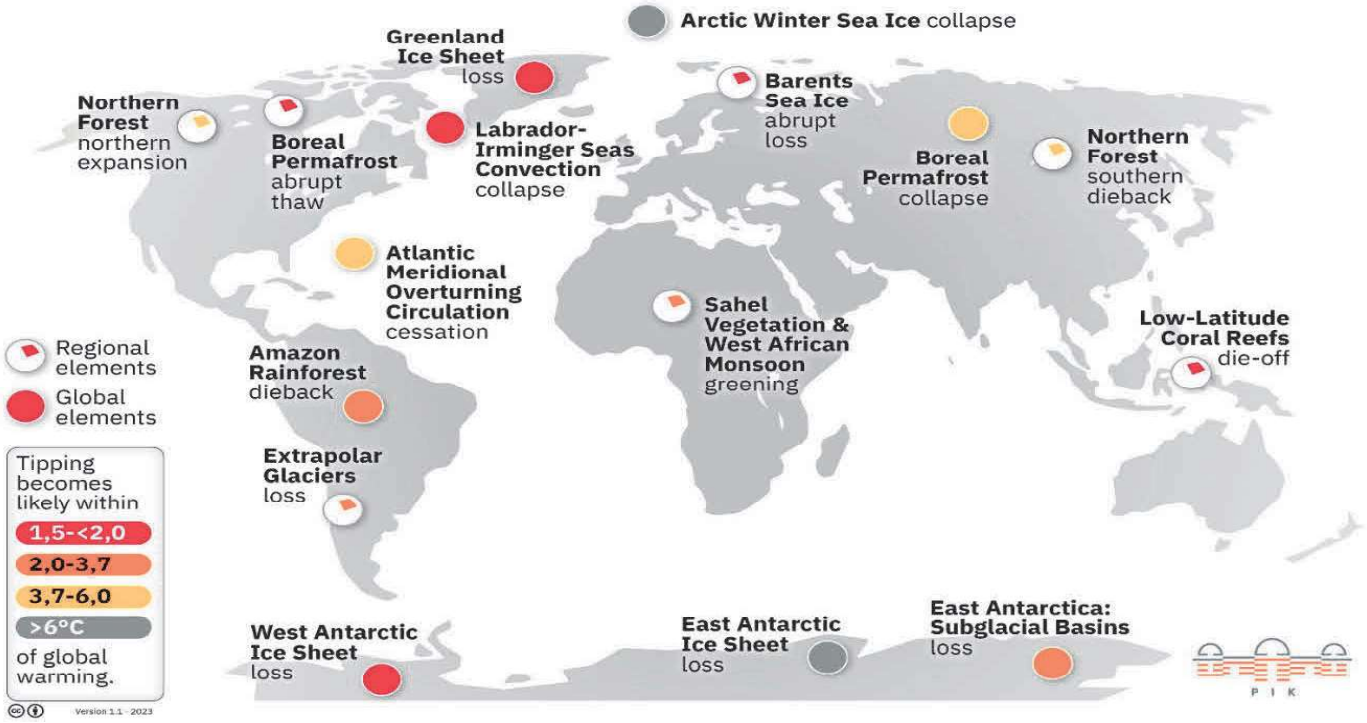
## World Risk Index (WRI) 2020

- India was 'poorly prepared' to deal with 'climate reality', due to which it was more vulnerable to extreme natural disasters, according to the **World Risk Index (WRI) 2020**.
- **India ranked 89th among 181 countries on the WRI 2020**. **The country was the 4th-most-at-risk in South Asia** on the index, after Bangladesh, Afghanistan and Pakistan. Sri Lanka, Bhutan and the Maldives fared better than India in their abilities to cope with extreme disasters.
- The report identified **Africa as a hotspot of vulnerability**. The **Central African Republic** was the most vulnerable country, followed by Chad, the Democratic Republic of Congo, Niger and Guinea-Bissau.

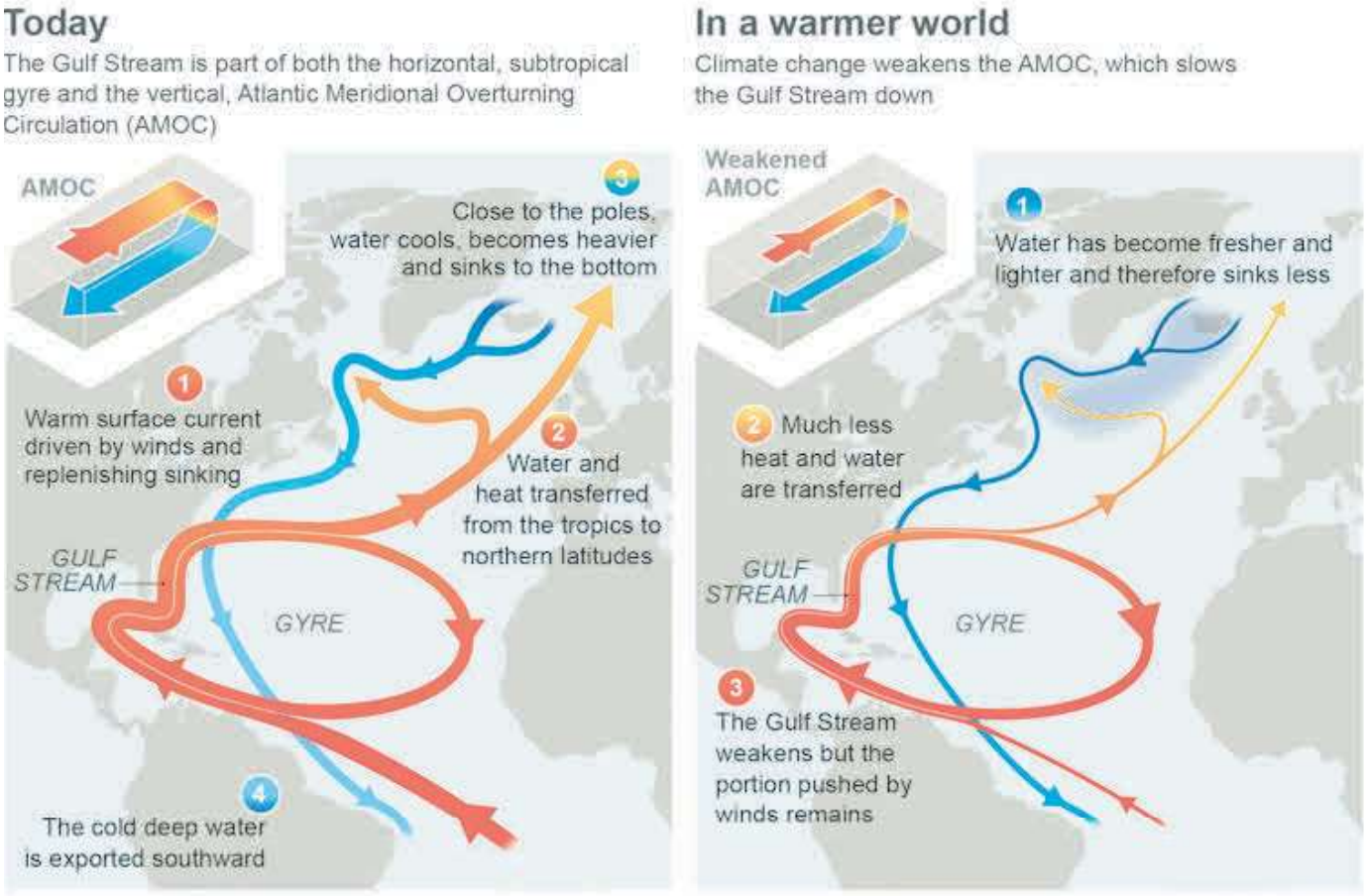
### High And Low-Risk Nations

- The index showed that **Oceania** **(Small Island Developing States** **(SIDS)** **are a part of Oceania)** was the continent most at risk, followed by Africa and the Americas. **Vanuatu** was the country with the **highest disaster risk** worldwide, followed by **Tonga** and **Dominica**. **Qatar** had the lowest risk (0.31) according to the global index.

## Climate Tipping Points



- **Tipping points** are '**critical thresholds** in a system that, when exceeded, can lead to a significant change in the state of the system, often with an understanding that the **change is irreversible**.' Such critical irreversible changes that might occur in the coming few decades due to climate change are the **weakening** of **Atlantic Meridional Overturning Circulation (AMOC)** and the **Gulf Stream**, t**hawing of permafrost** releasing vast amounts of **methane**, etc.




## Other Impacts

### Economic Losses

- Economic losses suffered involve money spent on
  - ✓ **adaptation to climate change** (costs involved in moving from submerging areas to higher ground)
  - ✓ rebuilding post-extreme climatic events
  - ✓ money spent on **climate change mitigation** (like carbon sequestration).
- The **economic losses suffered** due to the **emission of one ton of carbon dioxide into the atmosphere** is termed the **social cost of carbon**. It is expressed as the dollar value of the losses suffered. **India's country-level social cost of carbon emission** was estimated to be the **highest at $86 per ton of $CO_2$**. It means the Indian economy will lose $86 by emitting each additional ton of $CO_2$. India is followed by the US, where the economic damages would be $48 per ton of $CO_2$ emissions.

**[UPSC 2020] Which one of the following statements best describes the term 'Social Cost of Carbon'? It is a measure, in monetary value, of the**

a) long-term damage done by a ton of $CO_2$ emissions in a given year.
b) requirement of fossil fuels for a country to provide goods and services to its citizens, based on the burning of those fuels.
c) efforts put in by a climate refugee to adapt to live in a new place.
d) contribution of an individual person to the carbon footprint on the planet Earth.

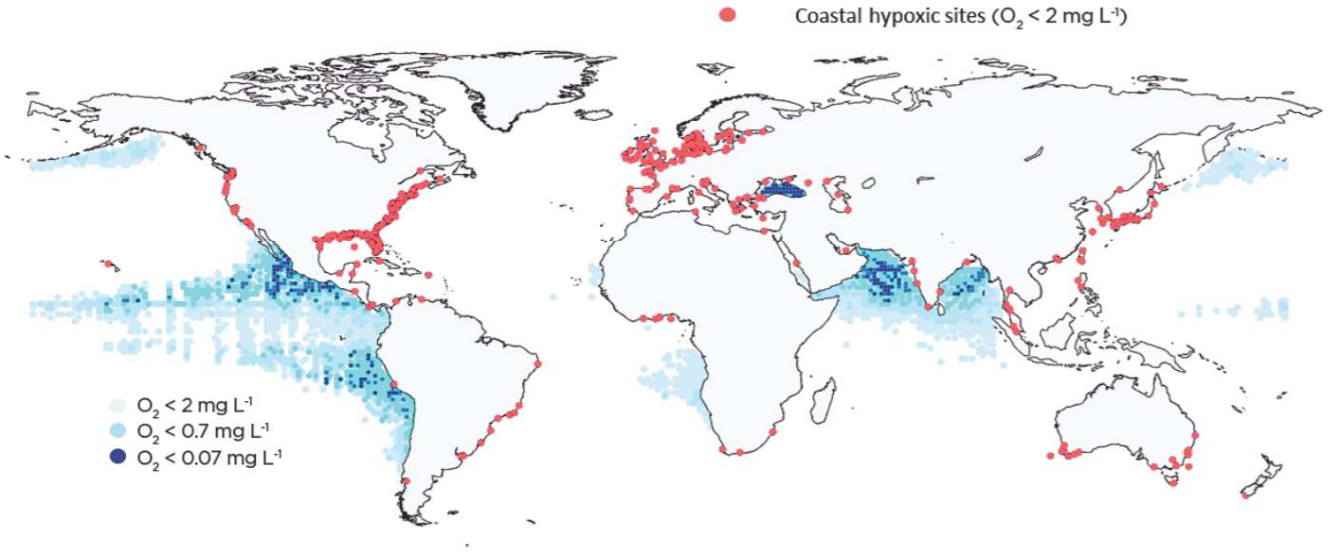
***Answer: a)***

## Ocean Deoxygenation

- Ocean deoxygenation is the expansion of **oxygen minimum zones (OMZs)** in the world's oceans as a consequence of anthropogenic emissions of carbon dioxide.
- OMZs are found in areas where an interplay of physical (**ocean stratification**) and biological (**less photosynthesis**) processes create a "pool" of water where oxygen concentrations fall (**anoxic zones**).
- Warmer oceans cause deoxygenation both **because oxygen is less soluble in warmer water**, and through temperature-driven stratification.

### Effects of deoxygenation of oceans

- As oceans lose oxygen, they become **more acidic** resulting in shellfish having their shells degraded.
- Reduction in the cycling of elements such as carbon, nitrogen and phosphorous, which are essential for lifeforms.
- Dying of fish in large numbers due to less phytoplankton to feed on.




### Biodiversity Loss

- **Bleaching of Coral Reefs** (ocean rain forests) and **loss of plankton** due to warming seas will adversely affect marine food chains, causing a great loss of marine biodiversity.

### Food and Health Security at Risk

- Climate Change affects crops by impacting irrigation, insolation as well as the prevalence of pests. Increased frequencies of droughts, floods, storms and cyclones are likely to increase agricultural production variability.
- Rising temperature would increase fertiliser requirement and result in **higher GHG emissions**, **ammonia volatilisation** and cost of crop production.
- Moderate warming (an increase of 1 to 3°C in mean temperature) is expected to **benefit crop yields in temperate regions**, while in lower latitudes the crops will take a hit. However, the natural calamities due to global warming can offset the benefits in temperature regions.
- Lack of freshwater during droughts and contamination of supplies during floods compromise hygiene, thus increasing rates of diseases like cholera and diarrhoea.
- The spread of diseases (like malaria, etc.) in the tropics will put more pressure on the healthcare sector.

## 19.2. Coral Bleaching or Coral Reef Bleaching

- **Coral reef bleaching** is a typical **stress response** of corals to various disturbances. However, in recent times, global warming and its associated phenomena (like **marine heat waves**, **changing rainfall patterns**, etc.) have resulted in **large-scale coral bleaching**, which takes more than 15 years for corals to recover from.

### Coral Reefs

- Coral reefs are made up of **calcareous skeletons** of thousands of tiny marine organisms called **coral polyps**. They belong to the **phylum cnidaria** and are related to **anemones** and **jellyfish** (**cnidarians**). Polyps occur in different forms and colours, depending upon the **nature of the salts** they are made of.
- Polyps are **shallow**, **warm-water organisms** with soft bodies covered by **calcareous skeletons**. The polyps extract calcium salts from seawater to form these hard, tubular skeletons. Small marine plants **(algae)** also deposit calcium carbonate, contributing to coral growth.
- Polyps live in colonies on the seafloor as a cemented calcareous rocky mass, collectively called **corals**. When the coral polyps die, they shed their skeleton (coral) on which new polyps grow. The cycle is repeated for millions of years, leading to the **accumulation of layers of corals**. The shallow layers of corals created by the depositions of corals are called **coral reefs**.
- The **2300-km-long Great Barrier Reef (GBR)** off the NE coast of Australia is the **world's largest reef**. The GBR is not a single reef but a large complex consisting of **many reefs**. India's major coral reef areas are in the **Andaman and Nicobar Islands**, **Lakshadweep**, the **Gulf of Mannar and** the **Gulf of Kachchh**. Some coral reefs, over a period of time, transform or evolve into **coral islands** (**e.g.**, **Lakshadweep**).

***For information on Types of Coral Reefs**, refer to PMF IAS Physical Geography > Page 132*

## Ideal Conditions for Coral Growth

- ✓ **Stable climatic conditions:** Corals are highly susceptible to quick changes. They grow in regions where the climate is **significantly stable for an extended period** (**equatorial oceans with warm ocean currents**).
- ✓ **Perpetually warm waters:** Corals thrive in **tropical waters** (30°N to 30°S latitudes; temperature around 20°C) where **diurnal and annual temperature ranges are very narrow**. (**Coral reefs are absent on the west coast of tropical continents because of Cold Ocean Currents**.)
- ✓ **Shallow water:** Corals require a relatively good amount of **sunlight** to survive. The ideal depths for coral growth are 45 m to 55 m below the sea surface, where enough sunlight is available.
- ✓ **Clear salt water:** Clear salt water is suitable for growth, while **freshwater and highly saline water are harmful**.
- ✓ **Abundant Plankton:** An adequate supply of **oxygen** and microscopic marine food (**plankton**) is essential for growth. As the **plankton is more abundant on the seaward side**, **corals proliferate on the seaward side**.
- ✓ **Little or no pollution:** **Corals are highly fragile and are vulnerable to climate change and pollution**, and even a minute increase in marine pollution can be catastrophic.

## Corals and Zooxanthellae

- Many invertebrates, vertebrates, and plants live in close association with corals, with **tight resource coupling and recycling**, allowing coral reefs to have **extremely high productivity and biodiversity**, such that they are referred to as the '**Tropical Rainforests of the Oceans**'.
- Scleractinian corals (stony, hard corals) build skeletons of calcium carbonate **sequestered** from the water. They receive their nutrient and energy resources in two ways.
    1. They use the traditional **cnidarian** strategy of **capturing tiny planktonic organisms** with their tentacles.
    2. Having a **symbiotic relationship** with a **single-cell photosynthetic alga** known as **zooxanthellae** (**autotrophic microalgae** belonging to various taxa in the **phylum Dinoflagellata**).

⇨ ***Coral Polyps***, ***Sea Anemones***, ***Jellyfish*** ➔ ***Cnidaria***

⇨ ***Zooxanthellae*** ➔ ***Phylum Dinoflagellata***

### Symbiotic Relationship Between Corals and Zooxanthellae

- **Zooxanthellae live symbiotically within the coral polyp tissues (as a patch of cells)** and **assist the coral in nutrient production through its photosynthetic activities**. These activities provide the coral with **fixed carbon compounds for energy**, **enhancing calcification** and **mediating elemental nutrient flux**. The host coral polyp, in return, provides zooxanthellae with a **protected environment** to live within and a **steady supply of carbon dioxide** for its **photosynthetic processes**.

- The symbiotic relationship allows the **slow-growing corals** to compete with the faster-growing multi-cellular algae. The corals feed by day through **photosynthesis (by zooxanthellae)** and by night through **predation**.
- **The tissues of corals are inherently clear**. The corals receive their **colouration** from the **zooxanthellae** living within their tissues.

## Causes for Coral Bleaching

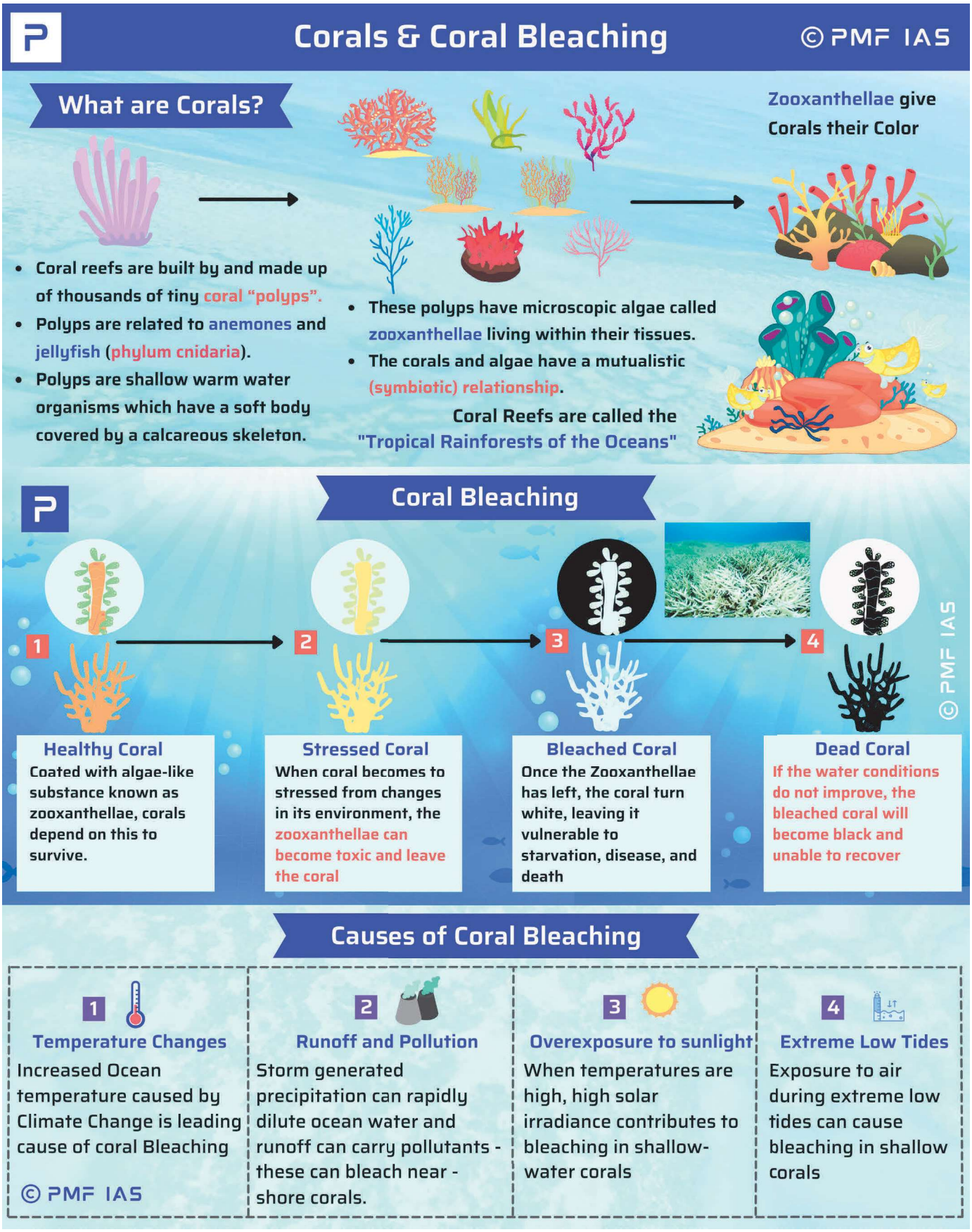
- Disturbances affecting coral reefs include anthropogenic and natural events. Recent accelerated coral reef decline is mainly related to **anthropogenic impacts (overexploitation**, **overfishing**, **increased sedimentation** and **nutrient overloading)**.
- Natural disturbances include **violent storms**, **flooding**, **high and low-temperature extremes**, **El Nino Southern Oscillation (ENSO) events**, **subaerial exposures**, **predatory outbreaks** and **epizootics (epidemics in animals)**.
- **Coral reef bleaching** is a typical **stress response** of corals to various disturbances mentioned above. Bleaching occurs when **the densities of zooxanthellae decline** and/or **the concentration of photosynthetic pigments within the zooxanthellae fall (no longer helpful for the corals**, **and the corals will bleach them)**.
- When corals bleach, they commonly **lose 60-90% of their zooxanthellae**, and each zooxanthella may **lose 50-80% of its photosynthetic pigments**. If the **stress-causing** bleaching is not too severe and decreases in time, the affected corals usually **regain their symbiotic algae within several weeks or a few months**. If zooxanthellae loss is prolonged, i.e., if the stress continues, zooxanthellae populations do not recover, and the coral host eventually dies.

### Ecological Causes of Coral Bleaching

#### Temperature Changes

- Coral species (similar to most marine species) **live within a relatively narrow temperature range**. Small temperature changes over many weeks or **anomalously large changes** (3-4 °C) over a few days will result in **coral dysfunction** and subsequent **coral bleaching**.
- Coral bleaching events have occurred mainly during the **protracted warming periods** (summer seasons). They are also reported to have occurred during **low wind velocity**, **clear skies**, **calm seas** and **low turbidity**. These conditions favour **localised heating** and **high ultraviolet (UV) radiation** — which readily penetrates clear sea waters. (The corals contain UV-absorbing compounds, but **rising temperatures** mean a reduction in their concentration.)
- Bleaching events also occur during **sudden temperature drops** accompanying **intense upwelling episodes (El-Nino)** and **seasonal cold-air outbreaks**.

#### Ocean Acidification




- While the rising temperatures have increased the frequency and intensity of bleaching, **acidification** has **reduced corals' calcifying ability**.

*[UPSC 2019] Assess the impact of global warming on the coral life system with examples.*

### Subaerial exposure

- Sudden exposure of corals to the atmosphere during **extreme low tides**, **ENSO-related sea level drops**, or **tectonic uplift** can potentially induce bleaching.
- The consequent exposure to high or low temperatures, increased solar radiation, desiccation, and **seawater dilution by heavy rains** could all play a role in **zooxanthellae loss**.

### Inorganic Nutrients

- Rather than causing coral reef bleaching, an increase in ambient elemental nutrient concentrations (e.g., **ammonia** and **nitrate**) **increases zooxanthellae densities** 2-3 times.
- Although **eutrophication** **(excessive nutrients that result in harmful algal blooms)** is not directly involved in zooxanthellae loss, it could cause secondary adverse effects such as **lowering corals' resistance to diseases**.

### Xenobiotics

- **Xenobiotics** are chemical substances that are foreign to animal life. When corals are exposed to high concentrations of chemical contaminants like copper, herbicides and oil, coral bleaching happens.

### Epizootics

- Most coral diseases cause patchy or whole colony death due to sloughing (shedding) of soft tissues, resulting in a white skeleton (not to be confused with bleached corals).

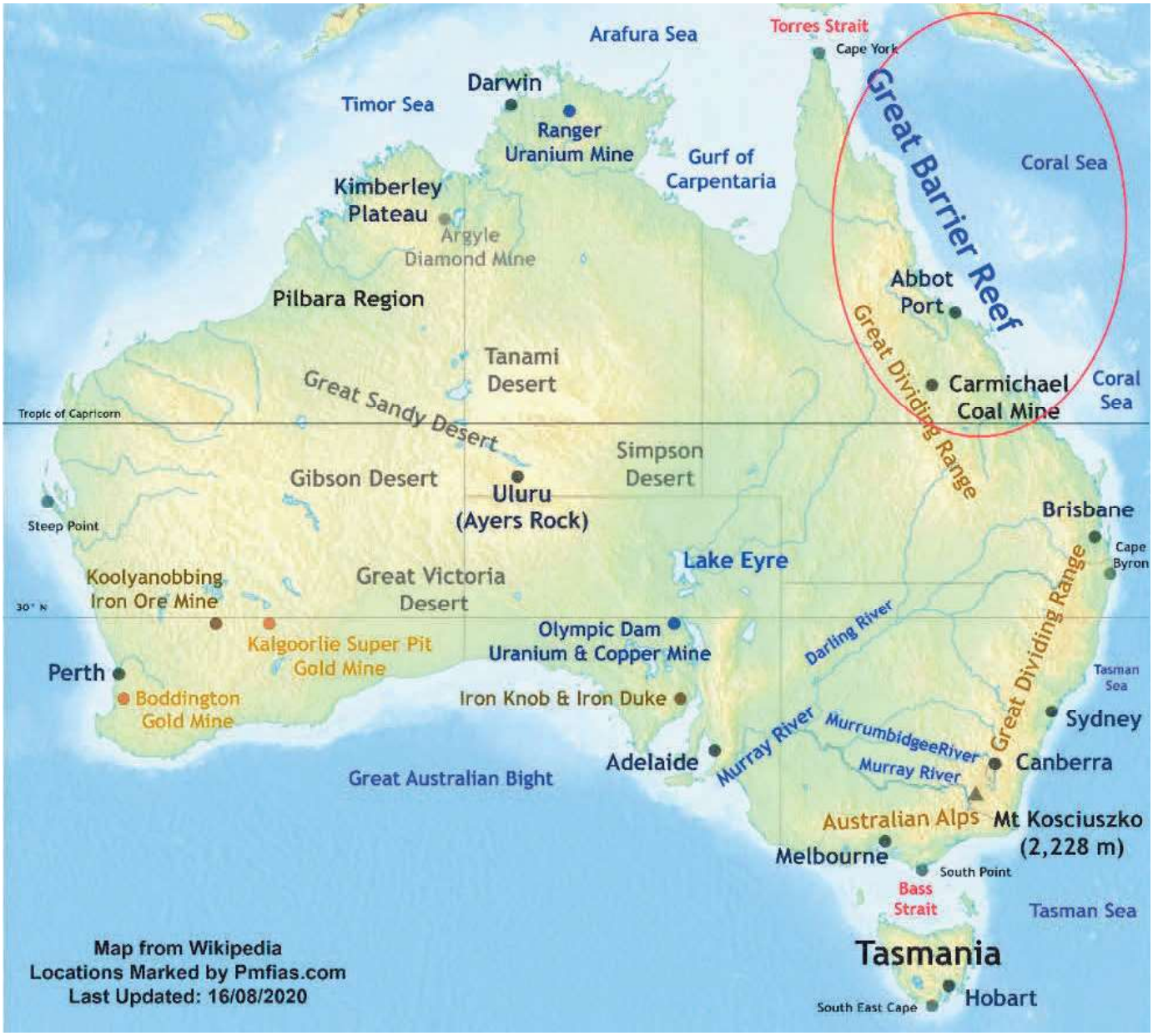
⇨ ***Bleaching may also be Beneficial:*** *Research has revealed that corals consistently exposed to lower stress levels may develop some resistance to bleaching.*

## Australia's Great Barrier Reef

- The **Great Barrier Reef**, with over 2900 individual coral reefs, is the **world's largest reef system**. It is located in the **Coral Sea**, off **Queensland**, Australia.
- It is the **world's most prominent single structure made by living organisms** and can be **seen from outer space**. The reef is a habitat of the **dugong (sea cow)** and **green turtle**. It was selected as a **World Heritage Site** in 1981.
- According to IUCN, Australia's Great Barrier Reef is in a **"critical state and deteriorating"** as **climate change warms up the waters** in which it lies. Its IUCN conservation status has been downgraded from **"significant concern"** to **"critical"** because of frequent mass bleaching events (four in the past six years). An UN-backed mission **recommended** that the Great Barrier Reef be added to the **list of endangered World Heritage sites (not yet)**.

### The Threat of Coal Mining

- Australia is one of the world's largest exporters of fossil fuels. The reef has been under threat due to coal mining, gas extraction and port construction for mining ships.
- In 2018, the Australian government approved Adani's $16.5 billion **Carmichael coal-mining project** in **Galilee Basin (one of the largest untapped coal reserves)** in Queensland, Australia. The mine will be connected to the **Abbot Port**, operated by Adani. The project produces thermal coal (coal for power generation; metallurgical coal (coke) is used in steel making). There were massive protests against the project.




- In February 2023, Australia (which is highly dependent on coal for electricity generation), for the first time, **rejected a new coal mining application**, citing the open-pit mine's potential harm to the nearby Great Barrier Reef. The project would have had unacceptable impacts on fragile **seagrass meadows** that feed **dugongs**.

### Biorock Technology for Coral Restoration

- The Zoological Survey of India attempted to restore coral reefs using **biorock** in the Gulf of Kachchh. If successful, biorock technology could potentially help to restore the degraded coral reefs.
- **Biorock** is the substance formed by **mineral accretion or electro-accumulation of minerals** on steel structures that are placed on the seabed and are connected to a power source like floating solar panels.
- The technology works by passing a small amount of electrical current through electrodes in the water. When electric current flows between the anode (+ve) and cathode (-ve) placed on the sea floor, **calcium ions** combine with **carbonate ions** and adhere to the cathode as **calcium carbonate ($CaCO_3$)**. This **electroaccumulated calcium carbonate** is termed **biorock**.
- Fragments of broken corals are tied to the biorock structure, where the coral larvae adhere to the $CaCO_3$ and **grow faster** as they need not spend their energy building their $CaCO_3$ skeletons.

## 19.3. Intergovernmental Panel on Climate Change (IPCC)

- The **IPCC** is the **UN body** for **assessing the science related to climate change**. It was established by the **United Nations Environment Programme (UNEP)** and the **World Meteorological Organization (WMO)** in 1988.
- The IPCC produces reports that support the **UNFCCC**. IPCC reports cover all relevant information to understand the risk of **human-induced climate change**, its potential impacts and options for adaptation and mitigation.

### IPCC Reports

- The IPCC **does not carry out its own original research**. Thousands of scientists and other experts contribute on a voluntary basis. The work is shared among **three Working Groups (WG)**, a **Task Force** and a **Task Group** of **IPCC**:
  1. WG I aims at assessing the physical **scientific basis** of the climate system and climate change.
  2. WG II assesses the **vulnerability** of socio-economic and natural systems to climate change.
  3. WG III focuses on climate change **mitigation**, assessing methods for reducing GHG emissions and removing greenhouse gases from the atmosphere.
- The research by the WGs is published by the IPCC at regular intervals as comprehensive **assessment reports** for the understanding of **human-induced climate change**, potential impacts and options for mitigation and adaptation.

#### IPCC Assessment Reports (ARs)

- After the IPCC had been founded in 1988, the AR1 was published in 1990 and received an Update in 1992. **In intervals of about 6 years**, new editions of the IPCC Assessment Report followed: AR2 in 1995, AR3 in 2001, AR4 in 2007, and AR5 in 2014.

- The IPCC is currently in its **6th Assessment Cycle**, during which the IPCC will produce the following reports:
  - ✓ **Assessment reports (ARs) of its three WGs**,
  - ✓ **Three special reports (SR1.5, SRCCL and SROCC)**,
  - ✓ **A refinement to the methodology report**, and
  - ✓ **The Synthesis report (the last of the AR6 reports**).
- Aug 2021: The WG I contribution to the AR6, **Climate Change 2021: The Physical Science Basis**.
- Feb 2022: The WG II to the AR6, **Climate Change 2022: Impacts, Adaptation and Vulnerability**.
- Apr 2022: The WG III to the AR6, **Climate Change 2022: Mitigation of Climate Change**.
- The **Synthesis Report** will be the **last of the AR6 products** and is scheduled to be released in **March 2023** to inform the 2023 Global Stocktake under the UNFCCC.

**AR1 (1990)**

- Global temperatures have risen by **0.3-0.6° C in 100 years**. In a business-as-usual scenario, it is likely to increase **by 2°C compared to pre-industrial levels by 2025** and **4° C by 2100**. Sea level likely to increase **65 cm by 2100**.

*This report formed the basis for **UNFCCC**, **1992**.*

**AR2 (1995)**

- It revised the previous projection for the global rise in temperature to **3°C by 2100** and **sea level rise to 50 cm**.

*This report formed the basis for the **Kyoto Protocol**.*

**AR3 (2001)**

- It revised the predicted temperatures to **1.4-5.8°C by 2100** compared to 1990.
- Rainfall to increase, **sea level** likely to rise by **80 cm** from 1990 by 2100.

**AR4 (2007)**

- It won the **Nobel Peace Prize for IPCC**.
- In the **worst-case scenario**, global temperatures could rise by **4.5° C by 2100** from pre-industrial levels; sea levels could be 60 cm higher than in 1990.

**AR5 (2014)**

- Temperatures rise by 2100 could be **4.8° C from pre-industrial times**.
- Atmospheric Concentrations of CO2, CH4 and N2O were at unprecedented levels in the last 800000 years.
- More frequent and longer heat waves **"virtually certain"**.
- A large fraction of species faces extinction.

*This report formed the scientific basis for the **Paris Agreement**.*

### WG I to AR6 (Feb 2021)

- The global average air temperature may rise by **more than 1.5°C** mark over pre-industrial levels between 2021 and 2040.
- For the first time, IPCC has said that the **1.5°C warming was inevitable even in the best-case scenario**.
- With 1.5°C of global warming, there will be **increased heat waves**, **longer warm seasons**, **and shorter cold seasons**.
- If GHG emissions **are halved by 2030 and net zero by 2050**, global warming can be stopped.
- The report supports India's argument that **historical cumulative emissions** are the source of the climate crisis the World faces today.
- Burgeoning air pollution has **reduced the intensity as well as the frequency of monsoon rains** in India and the rest of south Asia.
- **Urbanisation has pushed up intense rainfall (due to aerosols)** in cities across South Asia using scientific evidence generated in Indian cities.

### WG II to AR6 (Feb 2022)

- Cities, which house more than half of the world's population, are at the highest risk from climate change.
- The adverse impacts, as well as related losses, escalate with every increment of global warming.
- Up to **14% of species face a very high risk of extinction** at global warming of **1.5 °C over pre-industrial levels**. The risk increases to **29%** at 3 °C and **39%** at 4°C of global warming.
- Some climate change-driven losses, such as species extinction, are irreversible. Others are approaching irreversibility with accelerating climate change. These include the retreat of **glaciers and the thawing of permafrost**, particularly in the Arctic region.
- **Climate** change has conclusively affected the physical and mental health of people worldwide. As the crisis worsens, human society will increasingly face heat stress, water scarcity, threats to food security, and flood risks.

## WG III to AR6 (Apr 2022)

- GHG emissions from human activity reached **59 gt of carbon dioxide equivalent (GtCO2e)** in 2019, an increase of 54% from 1990. The **average annual growth rate slowed to 3% per year** in the period 2010-19, compared to 2.1% per year in the period 2000-09.
- At least **18 countries have reduced GHG emissions for longer than 10 years** continuously due to the decarbonisation of their energy system, energy efficiency measures and reduced energy demand.

### Emission by the Least Developed Countries

- **Carbon inequality** remains as pervasive as ever, with **Least Developed Countries (LDCs) emitting only 3%** of global emissions in 2019. Their average **per capita emissions** in the period 1990-2019 were only **1.7 tonnes CO2e**, compared to the global average of **6.9 tCO2e**.

- **LDCs** contributed **less than 0.4% of total historical $CO_2$ emissions** from fossil fuels and industry from 1850-2019.
- Globally, **41% of the world's population** lived in countries emitting **less than 3 tCO2e per capita** in 2019.

### Insufficient Pledges

- It is likely that **warming will exceed 1.5 °C in this century due to fossil fuels**, thereby failing the Paris Agreement's mandate. In its best-case scenario, known as the **C1 pathway**, global GHG emissions **must fall by 43% by 2030** to limit temperatures to 1.5°C, with limited or no 'overshoot'.

### Recommended Solutions

- Rapid shift towards **renewable energy**, **EVs**, and financial support for poor countries.
- Measures such as the removal of $CO_2$ from the atmosphere with natural or artificial means, even potentially risky technologies such as **pumping aerosols into the sky to reflect sunlight**.
- Aim at the "low-hanging fruit" — **methane emissions** from mines, wells and landfills.

### Low Emissions Technologies

- The costs of low emissions technologies have **fallen** continuously since 2010. On a unit cost basis, the cost of **solar energy** has dropped by **85%**, **wind** by **55%**, and **lithium-ion batteries** by **85%**. Their deployment, or usage, has increased multiplefold since 2010 **— 10 times for solar** and **100 times for electric vehicles**.

## Land use patterns and climate change

- IPCC has focused its attention solely on the **land sector** for its upcoming AR6 2022 report. The report presents the most recent evidence on how the different uses of land **—** forests, agriculture, urbanisation **—** are affecting and getting affected by climate change.

### The contribution of land use patterns to climate change

- Activities like agriculture and cattle rearing are major sources of **methane** and **nitrous oxide** **(GHGs)**.
- If pre-production activities like cattle rearing and post-production activities like transport and food processing are considered, then food production could contribute as much as **37% of all GHG emissions every year**.
- Overall, food system contribute ~50% **of global emissions:**
  - ✓ **agriculture (15%)**
  - ✓ **deforestation for food (18%)**
  - ✓ **transportation**, **storage**, **processing**, **waste**, **etc**. **(17%)**
- IPCC has appealed that access to coarse grains, legumes, fruits and vegetables, nuts, and seeds will have to be increased, and the **carbon footprint caused by meat has to be reduced**. Nearly **25% of all food produced is either lost or wasted**, the decomposition of which releases GHGs.

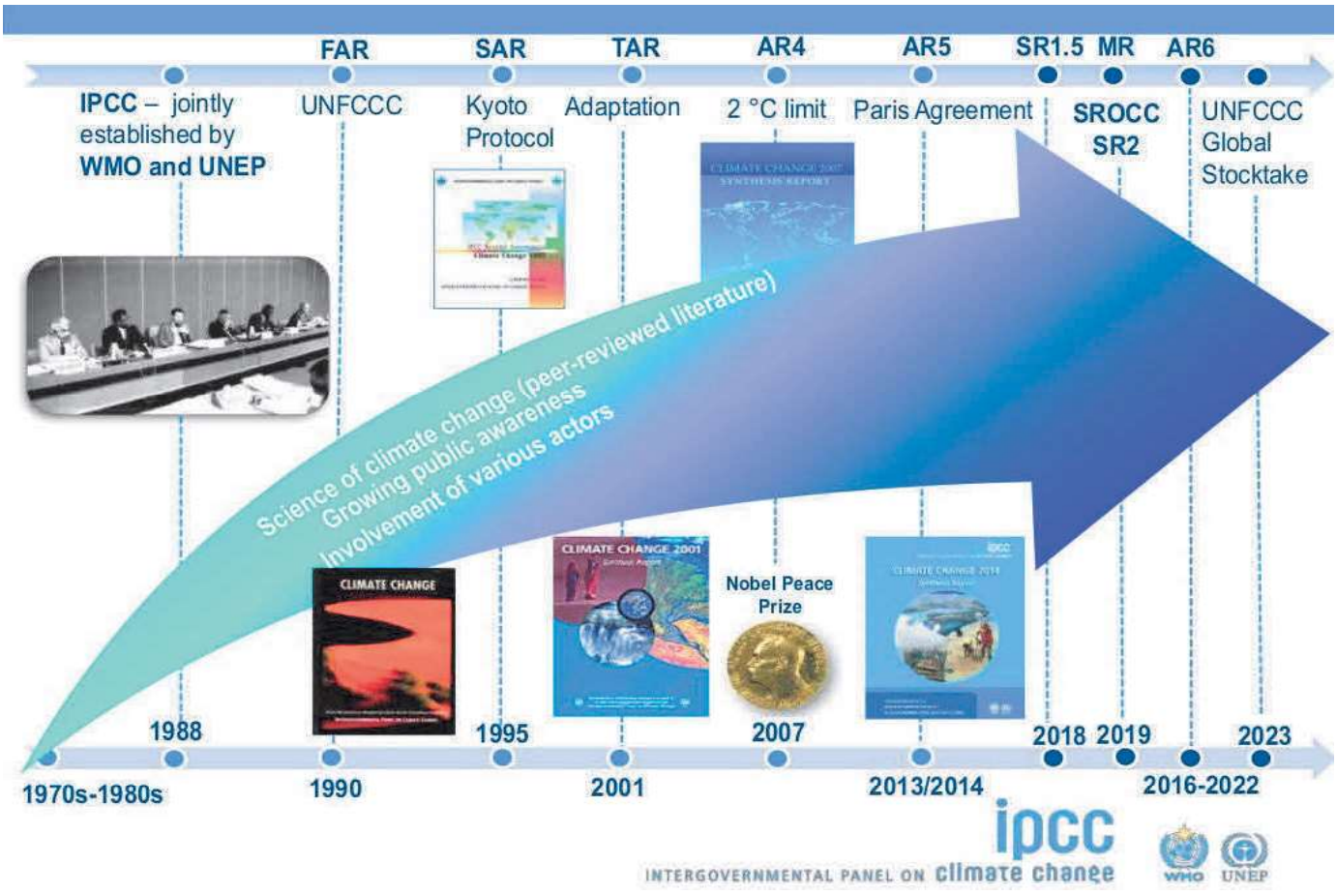
- At the same time, soil, trees, plantations, and forests absorb carbon dioxide for the natural process of photosynthesis, thus reducing the overall carbon dioxide content in the atmosphere. This is the reason why **land use changes**, **like deforestation or urbanisation**, or even a **change in cropping pattern**, have a direct impact on the overall emissions of GHGs.

## Synthesis Report of IPCC AR6

- IPCC released its fourth and final instalment of the 6th assessment report (AR6) named **Synthesis Report**. It is named so because it draws together the key findings of the preceding three main sections to make a comprehensive review of global knowledge of the climate.

### Key Findings for Synthesis Report of IPCC AR6

- **Human-induced Global Warming:** Due to human activities, the Earth's average temperature has **already risen by 1.1°C** since the industrial age. So, if not restricted then there is 50% chance that by **2030 global surface temperature will exceed 1.5°C** (the limit set in the 2015 Paris Agreement).
- **Maladaptation:** There are many examples of maladaptation which are making vulnerable communities more helpless. When actions or measures taken to adapt to the impacts of climate change have unintended negative consequences (which increase existing vulnerabilities) is called maladaptation.




## IPCC Special Reports

- Special Reports have been prepared on topics such as regional impacts of climate change, $CO_2$ capture and storage and on the relationship between safeguarding the ozone layer and the global climate system.
- IPCC decided in 2016 to prepare **three Special Reports**:
  1. **Special Reports on Global Warming of 1.5 °C (SR1.5 – October 2018)**
  2. **Special Report on Climate Change and Land (SRCCL – August 2019)**
  3. **Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC – September 2019)**

## Special Reports on Global Warming of 1.5 °C (SR1.5)

- SR1.5 said it was **possible** to keep the rise in temperature to **within 1.5 °C** if the world brings down its GHG emissions to **half of its 2010 levels by 2030 (45 per cent by 2030)**, and to **net zero by 2050**.

> ⇨ ***Net zero*** *is achieved when the* ***total emissions is balanced by the amount of absorption of $CO_2$ through natural sinks or the removal of $CO_2$*** *from the atmosphere through technological interventions.*
>
> ⇨ *Some countries have already announced their intention to achieve the net zero target, but the most prominent emitters* ***— China****,* ***the US****, and* ***India —*** *have so far not done so.*

- At the current rate of emissions, the world is set to breach the limit of 1.5 °C between 2030 and 2052.

## Special Report on Climate Change and Land (SRCCL)

- The land report said the various kinds of uses that land was being put to — forestry, agriculture, industries, urbanisation — had contributed about **5.2 Gt of $CO_2$ every year** between 2007 and 2016.
- During the same time, **trees and forests absorbed** almost **11.2 Gt of $CO_2$ annually** from the atmosphere. The sum total of these two processes meant that land, and the vegetation on it, was **removing** about **6 Gt of $CO_2$ from the atmosphere annually**.
- The land report also pointed out that the **global food system**, including agriculture, cattle-rearing, food processing, transportation and energy, could account for as much as **a third of all greenhouse gases**. It said nearly **25 per cent** of all food produced globally was either lost or wasted.

## IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC)

- IPCC SROCC report updates scientific literature available since 2015 (since the 5$^{th}$ Assessment Report). The SROCC report summarises the **disastrous impacts of warming** based on current projections of global GHG emissions.

### Ocean warming

- The global ocean has taken up **more than 90% of the excess heat in the climate system**. Since 1993, the rate of ocean warming has more than doubled. **Marine heatwaves** have very likely doubled in frequency since 1982 and are increasing in intensity.

- The ocean is warming, becoming **more acidic** and **losing oxygen**. The rising temperatures are starving the upper layers of the water of **oxygen**, suffocating marine life, creating growing **dead zones**, and **disrupting the circulation of ocean currents** (disruptive weather on land).
- **Long lag times** at work in oceans mean that some of these changes will **inevitably intensify over centuries —** even if the world stopped emitting all its GHGs tomorrow.

## Sea Level Rise

- The sea levels are rising because of the **thermal expansion of ocean waters** due to rising temperatures as well as **due to the melting of glaciers and polar ice**. 50% of coastal wetlands have already been lost over the last 100 years.
- Globally, sea levels are estimated to rise **1.1 metres by 2100** if countries are not able to restrict emissions "well below" **2°C above pre-industrial levels**, as stated in the **2015 Paris climate agreement**. But, even if countries are able to restrict emissions, it is still estimated to rise **30-60 cm by 2100**.

## Cryosphere

- The **cryosphere** is the frozen water part of the Earth's water system. **Polar regions** and **snow caps of high mountain ranges** are all part of the cryosphere.
- Between 2006 and 2015, the Greenland ice sheet lost ice mass at an average rate of **278 billion tons every year**, while the **Antarctic ice sheet lost a mass of 155 billion tons** on average every year.
- Snow over areas outside of these two regions, like the glaciers in the Himalayas, together lost an average of **220 billion tons of ice every year**. (**Loss in Arctic > Loss in Himalayas > Loss in Antarctic**)
- In the Himalayas, glaciers feeding 10 rivers, including the **Ganges** and the **Yangtze**, could shrink dramatically if emissions do not fall, hitting water supplies across Asia.
- **Thawing permafrost in places such as Alaska and Siberia** could **release vast quantities of greenhouse gases**, potentially unleashing feedback loops driving faster warming.

## Suggested Solutions

- A relatively straightforward solution to curbing biodiversity loss, especially in the face of climate change, is expanding the global network of **large-scale protected areas on land and ocean**.
- The report also highlights an even more challenging component of the solution: **Rapid reduction of greenhouse gas emissions** must be achieved across institutional boundaries. The report calls for a **five-fold increase** in nationally determined contributions (NDCs), volunteered by countries under the 2015 Paris Agreement.

**---------- End of Chapter ----------**

# 20. Climate Change Mitigation

## 20.1. Climate Change Mitigation Measures

- Climate change mitigation involves **avoiding** and **reducing** GHG emissions into the atmosphere or **removing** them from the atmosphere to prevent the planet from warming to more extreme temperatures.

### Clean coal technology to reduce $CO_2$ Emissions

- Half of the world's electricity is generated by burning coal, and coal will remain a dominant energy source for years to come. **Carbon dioxide ($CO_2$)**, **nitrous oxide ($N_2O$)** and **methane ($CH_4$)** are the major GHGs that are released during the burning of coal.
- Clean coal technology seeks to reduce these emissions by using multiple technologies. Some clean coal technologies **purify the coal before it burns**. Other systems control the coal burn to minimise emissions.

✓ Coal preparation, coal washing, **removes unwanted minerals** by mixing crushed coal with a liquid and allowing the impurities to separate and settle.

✓ **Electrostatic precipitators** remove particulates by charging particles with an electrical field and then capturing them on collection plates.

✓ **Coal Gasification avoids burning coal altogether**. With gasification, steam and hot pressurised air or oxygen combine with coal in a reaction that forces carbon molecules apart. The resulting **syngas**, **a mixture of carbon monoxide** and **hydrogen**, are then cleaned and burned in a gas turbine to make electricity.

✓ **Wet scrubbers**, or **flue gas desulphurisation** systems, remove **sulphur dioxide (GHG precursor)** by spraying flue gas with **limestone** and water.

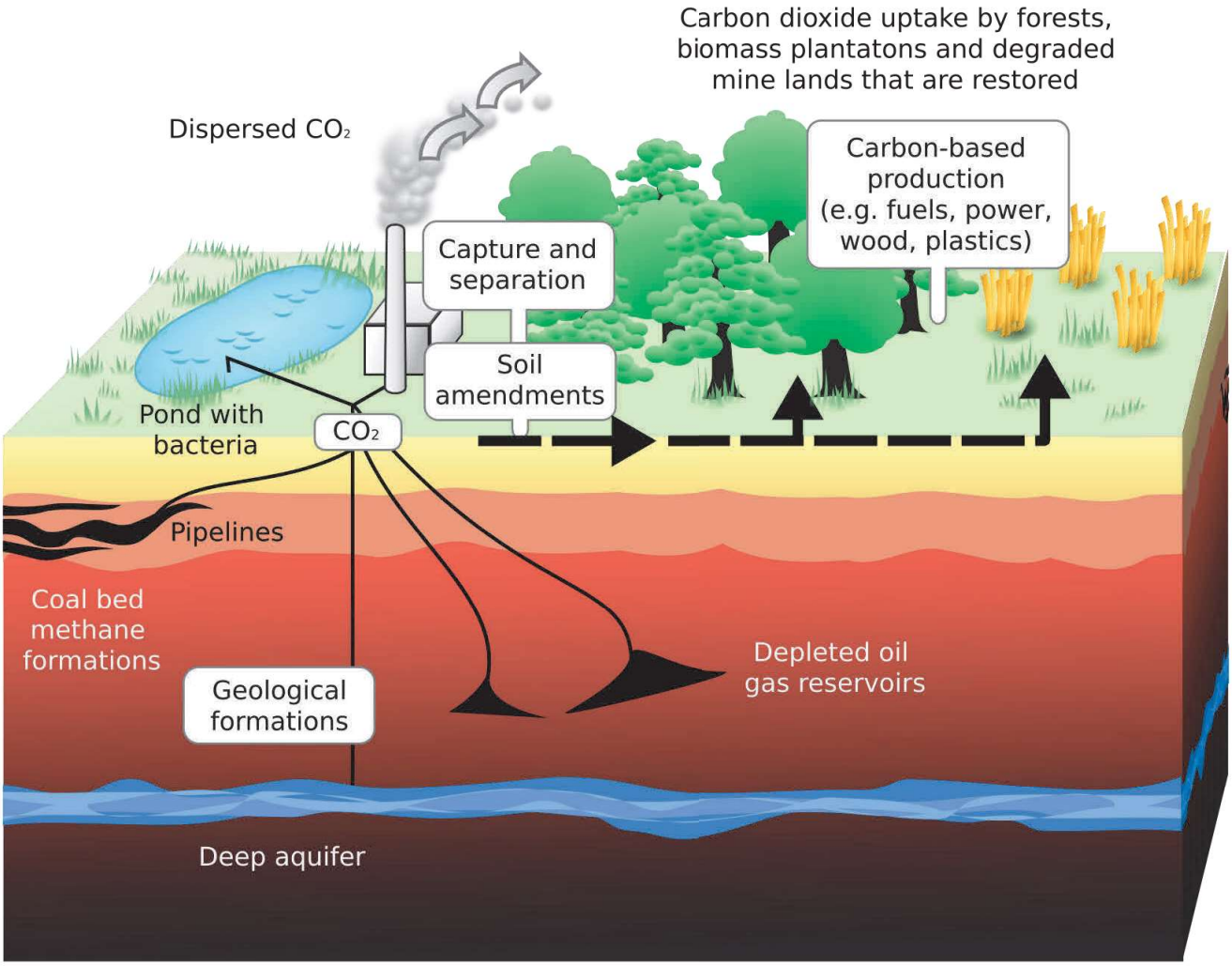
✓ Low-$NO_x$ (nitrogen oxides) burners reduce the creation of nitrogen oxides by restricting oxygen and manipulating the combustion process.

### India's coal

- Coal mined in India is poor-quality coal (India's coal is **not Carboniferous Coal**. It is **Gondwana coal**) with **less carbon**, **high ash** (hard to dispose of) and **high moisture content** (more gases; less fuel efficiency).
- To improve efficiency and reduce adverse effects, India should do away with its present sub-critical coal power plants and build more **super-critical and ultra-super-critical ones** (15-20% increase in efficiency).

### Carbon Capture and Storage

- 'Carbon capture and storage' **catches** and **sequesters (hides) $CO_2$** from stationary sources like power plants.
- Capturing by **flue-gas separation** removes $CO_2$ and condenses it into a concentrated $CO_2$ stream. After capture, secure containers sequester the collected $CO_2$ to prevent its re-entry into the atmosphere. The two storage options are **geologic (injecting $CO_2$ into the earth)** and **oceanic**.
- **Depleted oil or gas fields** and **deep saline aquifers safely** store $CO_2$ while **coal seams** absorb it.
- **Ocean storage**, a technology still in its early stages, involves injecting liquid $CO_2$ into waters 500 to 3,000 meters deep, where it **dissolves under pressure**. However, this method would slightly **decrease pH (acidification)** and **potentially harm marine habitats**.




## Carbon Capture Utilisation and Storage (CCUS)

- CCUS is the process of **capturing $CO_2$ emissions** and either using them to make useful things (**utilisation**) or **permanently storing** them thousands of feet below the surface (carbon sequestration). According to Niti Aayog, **CCUS** has a critical role to play in the country to **halve $CO_2$ emissions by 2050**. It will help India to achieve **net-zero $CO_2$ emissions by 2070** which **India pledged in COP 26**.

- CCUS will enable **sunrise sectors** such as **coal gasification** and the **hydrogen economy** in India. It will support the transition from **blue hydrogen to green hydrogen** by creating technologies and infrastructure for hydrogen production, storage and transportation.
- It will make valorisation (creating value) of the $CO_2$ by converting it into different value-added products like **green urea**, **green ammonia**, **concrete** and **aggregates**, **methanol** and **ethanol**, polymers like **bioplastics**, etc. This contributes towards a **circular economy** **(make**, **use**, **reuse**, **recycle**, **reduce)**.

⇨ ***Sunrise sector*** *is a new business or business sector showing potential for substantial and rapid growth.*

⇨ ***Blue hydrogen*** *is hydrogen produced from* ***fossil fuels*** *with* ***carbon sequestration****.*

⇨ ***Green hydrogen*** *is hydrogen produced from* ***renewable power sources****.*

## Carbon Sink and Carbon Sequestration

- A **carbon sink** is a **natural or artificial reservoir** that **accumulates and stores some carbon-containing chemical compound indefinitely**. The process by which **carbon sinks remove carbon dioxide ($CO_2$)** from the atmosphere is known as **carbon sequestration**.
- **Natural carbon sinks** include **forests**, **soil** and **oceans**. Unlike the other natural sinks, **ocean uptake of carbon dioxide results in acidification**, threatening species like **corals**.

### Carbon Sink vs Carbon Source

- A **carbon sink** is **anything that absorbs more carbon than it releases**, whilst a **carbon source is anything that releases more carbon than it absorbs**.
- **Forests**, **soils**, **oceans** and the **atmosphere** all store carbon, and this carbon moves between them in a continuous cycle (carbon cycle). This constant movement of carbon means that **forests**, **soils**, **atmosphere and oceans act as sources or sinks at different times**.

### Carbon sequestration

- **Carbon sequestration** is the **process of capture and long-term storage of atmospheric carbon dioxide**. It has been proposed as a way to slow the atmospheric and marine accumulation of GHGs.

### Forests as carbon Sinks

- Trees **absorb $CO_2$ during photosynthesis** thereby converting **atmospheric $CO_2$** into **biomass**. When this biomass is buried, the **carbon is trapped**, **forming a carbon sink**. When the carbon sink is exposed, the **biomass decomposes**, adding **methane** to the atmosphere. When **biomass is used as fuel** (coal, petroleum), it **releases $CO_2$** into the atmosphere **(carbon source)**.
- Forests are **carbon dioxide sinks when they increase in density or area** and **become carbon sources when they are degraded (forest degradation)**.

### Oceans as Carbon Sink

- **Blue carbon** is the term for carbon captured by the **world's ocean** and **coastal ecosystems** (seagrasses, mangroves, salt marshes, etc.).
- The coastal systems, though much smaller in size than the planet's forests, sequester carbon at a **much faster rate** and can continue to do so for millions of years. When these systems are damaged, an enormous amount of carbon is emitted back into the atmosphere.

**[UPSC 2017] In the context of mitigating the impending global warming due to anthropogenic emissions of carbon dioxide, which of the following can be the potential sites for carbon sequestration?**

1) Abandoned and uneconomic coal seams
2) Depleted oil and gas reservoirs
3) Subterranean deep saline formations

***Select the correct answer using the code given below:***

a) 1 and 2 only
b) 3 only
c) 1 and 3 only
d) 1, 2 and 3

**Explanation**

- From the figure it is clear that **abandoned coal seams**, **depleted oil** and **gas reservoirs** can be used for carbon sequestration.

***Answer: d) all***

**[UPSC 2014] The scientific view is that the increase in global temperature should not exceed 2°C above pre-industrial level. If the global temperature increases beyond 3°C above the pre-industrial level, what can be its possible impact/impacts on the world?**

1) Terrestrial biosphere tends toward a net carbon source
2) Widespread coral mortality will occur.
3) All the global wetlands will permanently disappear.
4) Cultivation of cereals will not be possible anywhere in the world.

***Select the correct answer using the code given below.***

a) 1 only
b) 1 and 2 only
c) 2, 3 and 4 only
d) 1, 2, 3 and 4

**Explanation**

- **Taiga and temperate forests act as an essential carbon sink**. **Global warming by 3°C will turn these forests into carbon source (because of the thawing of permafrost and wildfires)**.
- **Corals are overly sensitive to temperature changes**. 3°C rise in global temperature will lead to widespread coral mortality.
- It has been estimated that a sea-level rise of approximately 2.3 metres for each degree Celsius of temperature can occur within the next 2,000 years.
- 3°C rise in global temperature will lead to the submergence of many low-lying coastal wetlands like **Sundarbans**, **Chilika Lake**, etc., due to the rise in sea levels. Inland wetlands like **Keoladeo Ghana National Park**, **Kolleru Lake**, **etc**., will not be affected.
- Cultivation of cereals in the tropics will take a hit. But in temperate regions, **their production increases** in the short run.

***Answer: b) 1 and 2 only***

### [UPSC 2021] What is blue carbon?

a) Carbon captured by oceans and coastal ecosystems
b) Carbon sequestered in forest biomass and agricultural soils
c) Carbon contained in petroleum and natural gas.
d) Carbon present in atmosphere

### [UPSC 2023] Consider the following activities:

1. Spreading finely ground basalt rock on farmlands extensively
2. Increasing the alkalinity of oceans by adding lime
3. Capturing carbon dioxide released by various industries and pumping it into abandoned subterranean mines in the form of carbonated waters

***How many of the above activities are often considered and discussed for carbon capture and sequestration?***

a) Only one
b) Only two
c) All three
d) None

**Explanation**

***Statement 1 is correct***

- When basalt rock is exposed to air and water, it undergoes carbonation in which the rock reacts with $CO_2$ to form carbonate minerals, effectively capturing and storing the carbon.

***Statement 2 is correct***

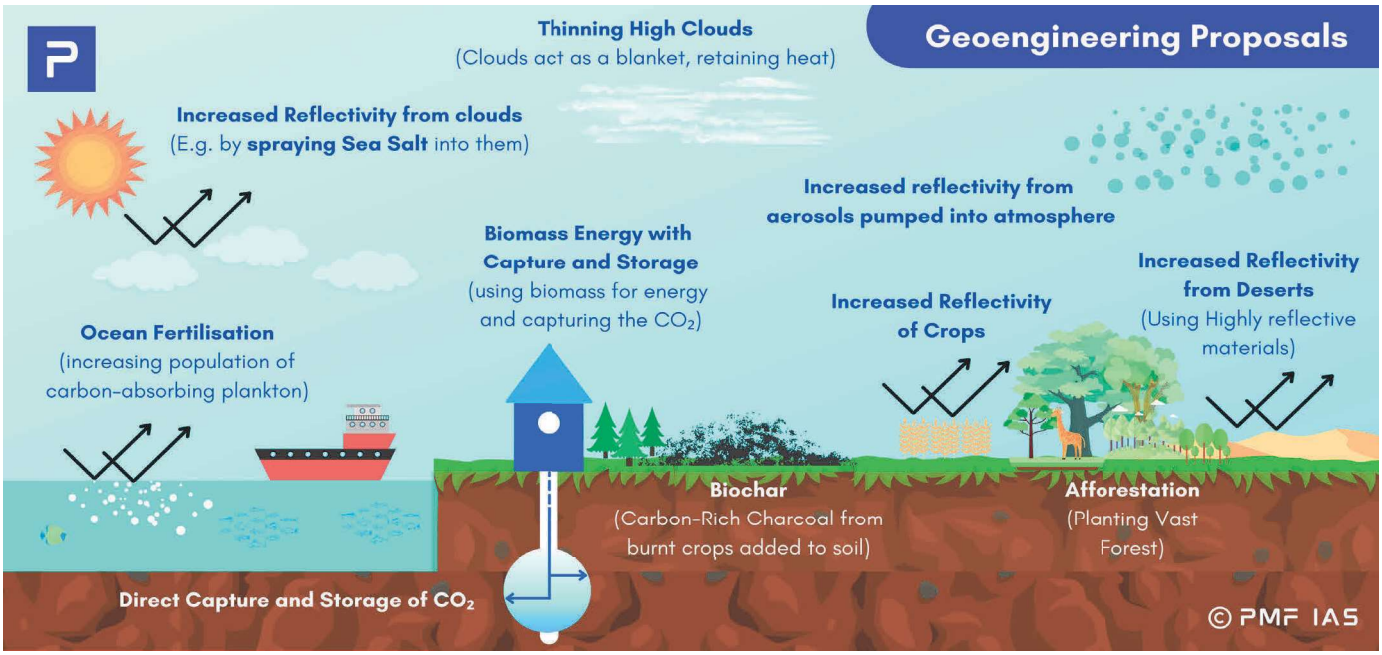
- When lime reacts with seawater, it increases the concentration of carbonate ions ($CO3^{2-}$), which helps to buffer the acidity and reduce the pH of the water. The carbonate ions can then react with $CO_2$ dissolved in the seawater to form bicarbonate ($HCO3^{-}$), effectively storing the carbon in a dissolved form.

***Answer: c) All***

## Geoengineering to Fight Climate Change

- The Oxford Geoengineering Programme defines geoengineering as "**the deliberate large-scale intervention in the Earth's natural systems to counteract climate change**".
- Geoengineering technologies include **managing solar radiation**, **removing carbon dioxide and other GHGs from the atmosphere**, **afforestation**, **protecting the cryosphere on a large scale**, etc.

### Solar Radiation (Geoengineering) Management (SRM)




- SRM techniques aim to **reflect a small proportion of the Sun's energy back into space** through:

✓ **Albedo enhancement** — **increasing the reflectiveness of clouds** or the land surface.

✓ **Space reflectors** — blocking a small proportion of sunlight before reaching Earth.

✓ **Stratospheric aerosols** — introducing small, reflective particles into the upper atmosphere to reflect some sunlight before it reaches the surface of the Earth.

**[UPSC 2019] In the context of which of the following do some scientists suggest the use of cirrus cloud thinning technique and the injection of sulphate aerosol into stratosphere?**

a) Creating the artificial rains in some regions

b) Reducing the frequency and intensity of tropical cyclones

c) Reducing the adverse effects of solar wind on the Earth

d) Reducing the global warming

**Explanation**

- Creating artificial rains in some regions ➔ **Cloud Seeding**
- Reducing the frequency and intensity of tropical cyclones ➔ **Sea Surface Temperature (SST)** should be reduced for this. Mitigating climate change is the solution.
- Reducing the adverse effects of solar wind on the Earth ➔ Earth's Magnetosphere will take care of this.

⇨ *Do you know why **Venus is the brightest planet in the solar system**? It is because of the thick dense atmosphere and thick clouds composed mainly of **highly reflective sulfuric acid droplets**.*

⇨ *These clouds reflect about 75% of the sunlight (**high albedo**) that falls on them. This makes optical imaging of the surface of Venus a very tough job.*

- **Injection of sulphate aerosol ➔ will increase the albedo of the atmosphere**.
- Very thin, high clouds such as **cirrus clouds reflect little sunlight**, they are very **efficient at absorbing thermal radiation (heat)**, **making them "strong warmers"**.
- **Cirrus cloud thinning ➔ will absorb less thermal radiation reflected by the earth**.

***Answer: d) reducing the global warming***

## GHG Removal (GGR) or Carbon Geoengineering

- **GGR** techniques aim to **directly remove carbon dioxide** or other GHGs from the atmosphere. These include:

✓ **Afforestation:** Engaging in a global-scale tree planting.

✓ **Biochar:** 'Charring' biomass and burying it so that its **carbon is locked up in the soil**.

✓ **Bio-energy with carbon capture and sequestration:** Growing biomass, burning it to create energy and capturing and sequestering the carbon dioxide created in the process.

✓ **Ambient Air Capture:** Building large machines that can remove carbon dioxide directly from ambient air (helps only if they are **carbon negative** ➔ more carbon is absorbed than released).

✓ **Ocean Fertilisation:** Adding nutrients to the ocean in selected locations to **increase primary production**.

✓ **Enhanced Weathering:** Exposing large quantities of minerals that will react with carbon dioxide in the atmosphere and storing the resulting compound in the ocean or soil.

## Forests for Carbon Geoengineering

- In boreal forests, as much as **80% of the total carbon** is stored in the **soils** as **dead organic matter (peat)**. Tropical forests absorb about 18% of all $CO_2$ added by fossil fuels.
- A lot of emphasis and hope has been put into the **ability of trees**, other plants and the **soil** to **temporarily sink the carbon** that **fossil fuel burning** releases into the atmosphere.

- The **Kyoto Protocol** suggests that the **absorption of carbon dioxide by trees and the soil** is just as valid a means to **achieve emission reduction commitments** as cutting carbon dioxide emissions from fossil fuels.

### Artificial snow

- Due to global warming, the West Antarctic Ice Sheet is expected to disintegrate from the Antarctic. The melting of the disintegrated sheet would trigger a global sea level rise of **at least 3 metres over centuries**.
- Last-ditch geoengineering project proposed to prevent disintegration is to blanket its surface with **artificial snow**.
- It involves using thousands of wind turbines to pump seawater 1,500 metres up to the surface, where it would be frozen into "snow" to try to weigh the sheet down enough to stop it from collapsing any further.

## Transition Away from Coal

- IPCC established that a 1.5°C-consistent trajectory **requires coal-powered electricity to drop to less than one per cent of the total electricity mix by 2050**!
- One proposal is to phase out the oldest coal plants first. This would phase out coal in developed (most of the coal power plants are old) and developing (some of the coal power plants are new and many are under construction) economies at a differentiated rate.

### Current phaseout efforts

- The UK plans to shut down all "unabated" coal-fired electricity by 2025. France and Italy have also made similar political commitments.
- Germany finalised a plan to shut down all coal power plants by 2038 (falling short of the ambition required to stay within 2°C).
- There is an international coalition coordinating the coal phase-out problem — the **"Powering Past Coal" Alliance** (currently not a formal organisation), announced at UNFCCC COP23 in Bonn.
- The Alliance is based on a commitment to phasing out coal in the **OECD (by 2030) and globally (by 2050)**.
- These political actions **ignore the largest consumers of coal —** the **US**, **Japan**, **China**, **and India —** and significant exporters such as **Australia**, **Indonesia**, **Russia** and **South Africa**.
- Also, over the next 20 years, coal going offline in Europe and OECD countries is offset by **increases in consumption in Africa and Asia**, **particularly India**. Global coal consumption hence **increases by five per cent between 2010 and 2040**. **Coal consumption in India is said to increase by 29 per cent until 2040!**

### Barriers to Phasing Out Coal Power

- The barriers to the transition are economic and political rather than technological.
- They generally take 4 forms **— stranded assets**, **livelihood loss**, **electricity prices**, and **irresponsible financing**.

### Livelihood impacts

- In India, around one million livelihoods depend directly or indirectly on coal power.
- **Coal royalties** constitute almost **50% of the earnings** of states like **Jharkhand** and **Odisha**.
- China employs about five million in coal industries. Most workers in China's coal sector are off-farm workers who have very limited job choices.
- In **Australia**, around 50,000 are employed in coal mining, representing 0.4% of the direct workforce. Coal workers are generally older. This limits the capacity for re-skilling.

### Stranded assets (Built-up infra)

- Since 2006, India has added 151 GW of new coal power, with about **75 per cent of this capacity being subcritical**. The present value of these assets is around **$100 billion**. A similar problem exists in China, with the electricity policy resulting in an **over-supply** of coal power capacity.
- Coal power capacity is less of a problem in **Europe and US** since coal plants are closer to the end of their life. Coal accounted for about **15% of Australia's total export value** in 2017. **Indonesia** is the world's fifth-largest producer of coal. Around 80 per cent of Indonesia's coal is exported.

### Electricity prices

- In India, the **cost of electricity** from recently built coal power plants is still **cheaper than that from renewables** (although new renewable power is cheaper than proposed new coal power).
- In addition, **investments in battery/storage technology** are required for renewable electricity to match the **continuous availability of coal-fired power**.
- Electricity tariffs for residential consumers are much lower than tariffs for industrial consumers, making residential consumers less likely to transition to renewable sources.

### Irresponsible financing

- The number of countries using coal power has risen from 66 in 2000 to 78 in 2018. This is driven by **larger economies providing finance** for fossil-based growth in the developing world. Moreover, G20 members provided **higher finance** for overseas coal projects than that for renewables.
- **Africa**, in particular, is witnessing a rise in coal plants being planned from 2018 onwards. These plants require more than eight times the region's existing coal capacity (**developed countries are shutting down their coal plants** and **finding newer markets for their coal in the developing world**).

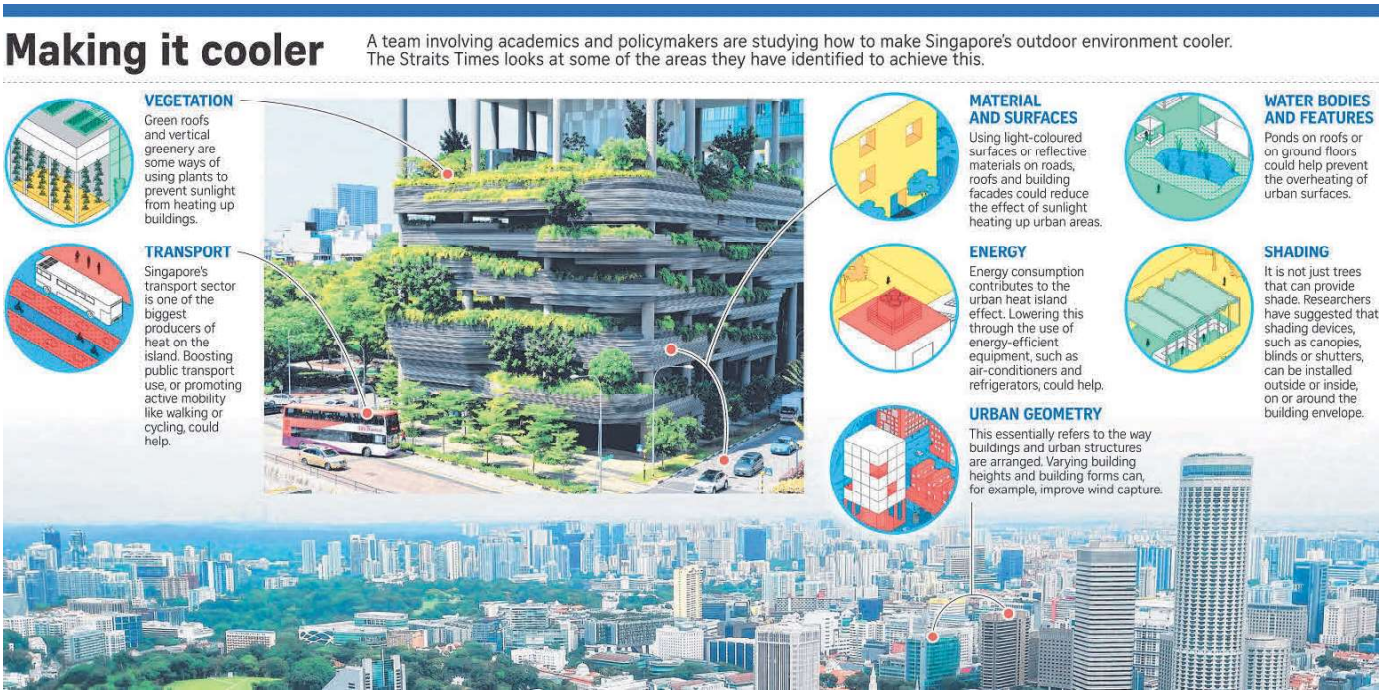
## Climate Smart Cities

- Climate-smart refers to an integrated approach to managing landscapes (urban centres) and ecosystems to address interlinked challenges of sustainable development and climate change. Making cities more

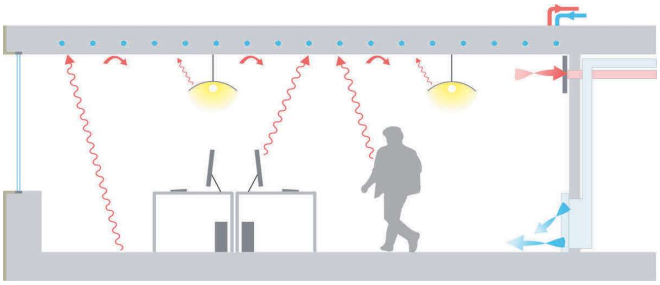
**resilient**, **sustainable**, **inclusive**, **and safe** is one of the **United Nations' Sustainable Development Goals** (**SDG 11**).

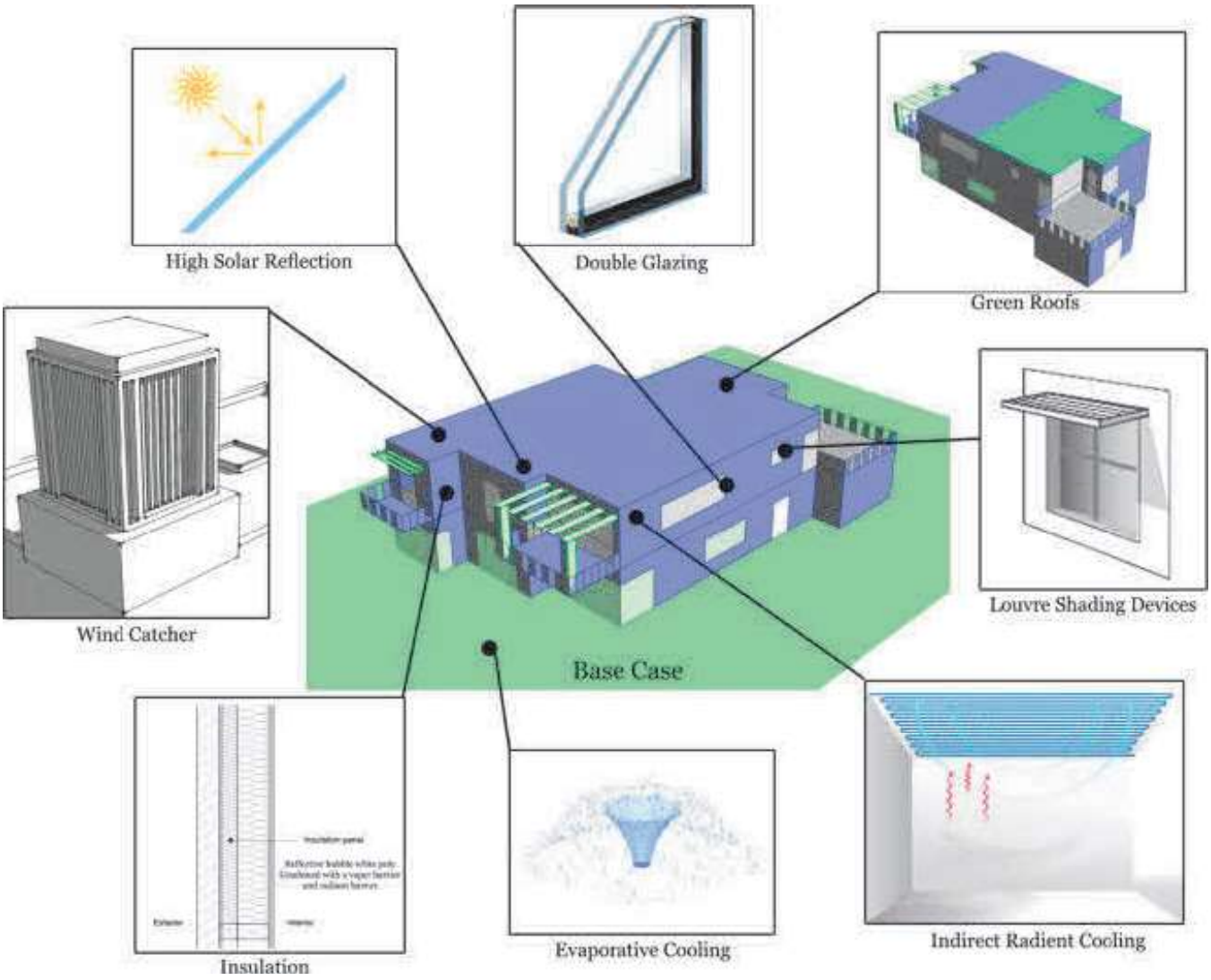
- **Cities are responsible for 70% of GHG emissions** (**UNDP report**) and face severe consequences because of it (**heat waves**, **urban heat islands**, **water crises**, **flooding**, **epidemics**, **conflicts**, etc.).
- Modifying the **heat-generating** and **heat-retaining** nature of cities is a critical part of making them resilient, sustainable, inclusive, and safe (**Climate Smart**), ultimately **reducing their carbon footprint** (lower emissions because of the **reduced electricity consumption**).

## Measures Required to Reduce the Heat-Retaining Nature




- ✓ Use **light asphalt** instead of dark asphalt in road construction and roofing.
- ✓ **Cool pavements** and **rooftops** designed to reflect more sunlight and absorb less heat.
- ✓ **Green roofing** — roofs covered with green vegetation (both the above methods reduce air conditioning).
- ✓ Transition away from heat-absorbent materials, towards alternative construction materials and technologies.
- ✓ **Decentralization of development** and building green cities (e.g., **Dholera Smart City Gujarat**).
- ✓ Relocate polluting industries away from cities.






Increasing tree and vegetation cover within cities.

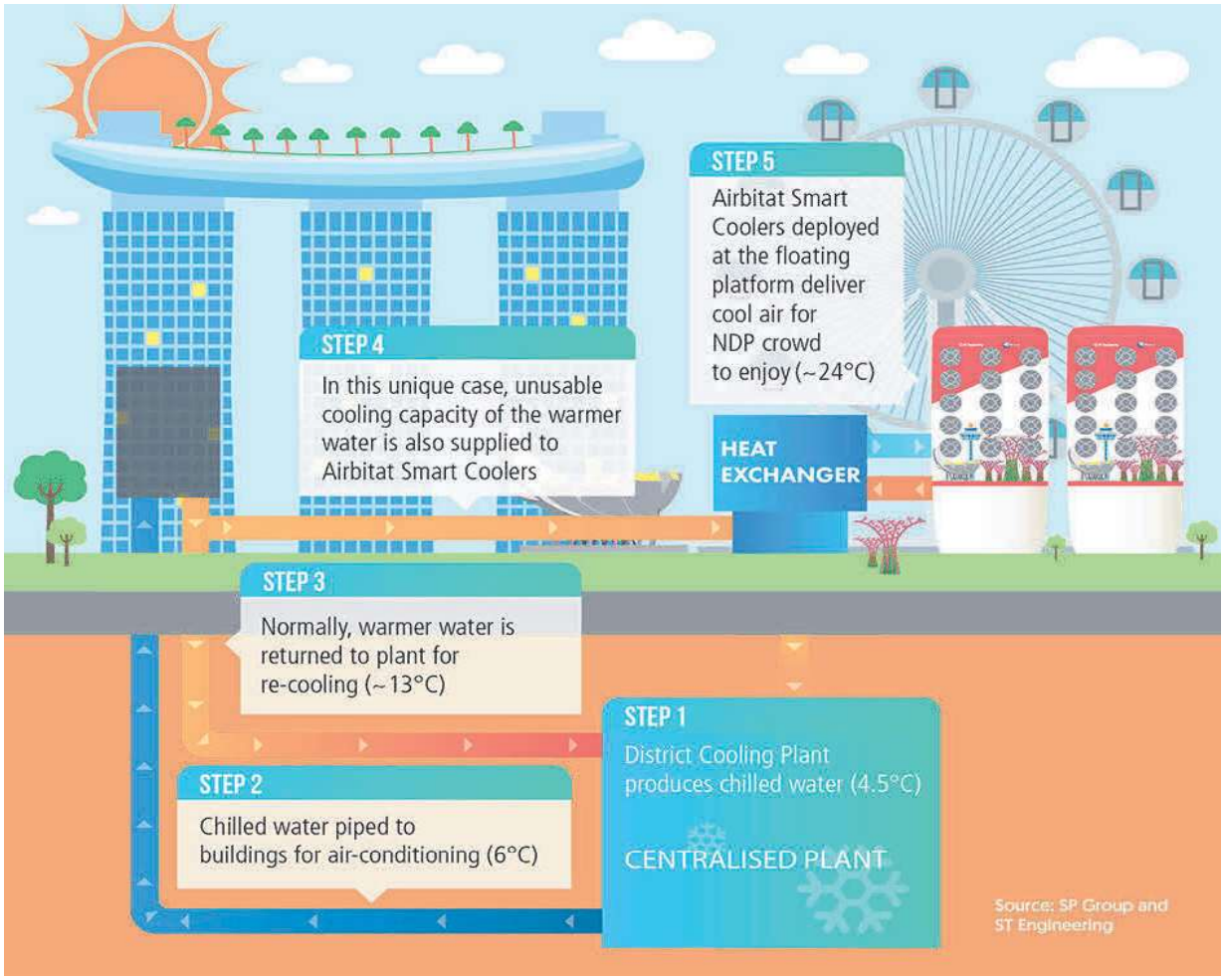
- ✓ Consider heat waves as natural disasters.
- ✓ Improve the overall ventilation of the cities.
- ⇨ *Stuttgart, Germany, which is located in a weak wind-flow region, has progressively implemented policies to improve ventilation.*
- ⇨ *In **Singapore**, the government is using urban environmental modelling to design and orient blocks of flats to maximise wind flow and shade in estates.*
- Develop a strategy to incorporate the **green belt concept in urban planning** and implement **building codes** that entail **passive cooling practices** (use energy from the environment to dissipate heat).
- ⇨ ***Double glazing:** reducing heat transfer by using two panes of glasses with space between them filled with heat-trapping gases like argon.*
- ⇨ ***Evaporative cooling via fountain:** heat is lost in the form of latent heat of evaporation.*
- ⇨ ***Indirect radiant cooling:** heat is transferred from low-conducting materials like humans and furniture to high-conducting materials like metals.*

## Cooling Singapore – A Case Study

- Multi-institute initiative called **Cooling Singapore** aims at developing a roadmap towards **reducing the urban heat island (UHI)** effect in Singapore and thereby also improving **outdoor thermal comfort (OTC)**.

### Components of 'Cooling Singapore'

- **Green Roofs/eco-roofs:** It involves the placing of a vegetative layer such as plants, shrubs, grass, and/or trees on rooftops.
- **Vertical Greenery**: It involves the growing of vegetative elements on the external facade of the building envelope. They are also called **living walls** and **vertical gardens**.
- **Vegetation Around Buildings:** It can provide shade to pedestrians, buildings and ground surfaces.
- **Green Pavements:** They reduce the amount of artificial material on urban pavements by replacing natural soil elements with grass.
- **Macroscale Urban Greening:** The large-scale vegetation increase in urban areas focusing on big urban parks, forests and natural reservoirs.
- **Urban Farming:** It involves producing food within urban areas.
- **Singapore District Cooling: Centralising the cooling plants saves 40% of electricity**.



## Measures Taken in India

- ✓ **Cool roof** and **Cool pavement** programmes, which are already a component of Indian cities' **heat action plans**, involve **lightening roof and pavement colours** to reduce heat absorption.
- ✓ The **National Mission on Sustainable Habitat** is aimed at transitioning away from heat-absorbent materials.
- ✓ The **Building Material and Technology Promotion Council (BMTPC)** under the **Union Ministry of Housing and Urban Affairs (MoHUA)** promotes many alternative materials and technologies.
- ✓ **Climate-Smart Cities Assessment Framework** for a **climate-sensitive approach to urban planning**.

### Climate-Smart Cities Assessment Framework (CSCAF)

- By 2030, 40% of India's population is expected to live in Cities. The **MoHUA** has initiated several missions to manage this growth. **Climate-Smart Cities Assessment Framework (CSCAF)** is one such measure.
- The CSCAF initiative intends to inculcate a **climate-sensitive** approach to **urban planning** and development. It is a step to adopt, implement, and disseminate the best practices adopted by our cities and further set standards compared to the international efforts towards sustainable, and resilient urban habitats.
- The **Climate Centre for Cities** under the **National Institute of Urban Affairs (NIUA)** is supporting **MoHUA** in the implementation of CSCAF.
- Other programmes like **Green India Mission (GIM)**, **National Clean Air Programme (NCAP)**, **Atal Mission for Rejuvenation and Urban Transformation (AMRUT —** providing basic amenities to improve urban life), **Swachh Bharat Mission**, **and Urban Transport** are supporting the cities in becoming **Climate Smart**.

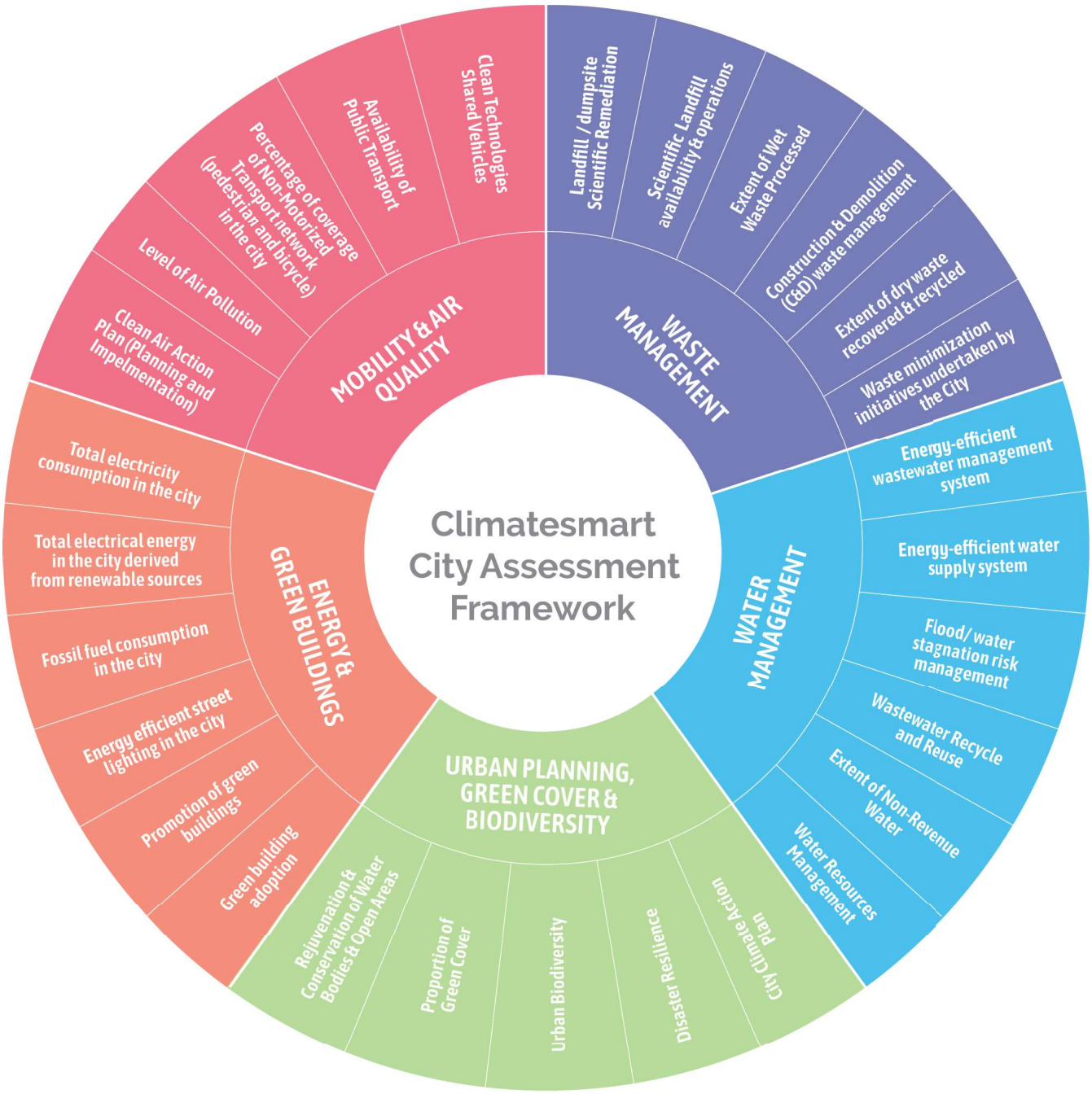
## Climate-Smart Cities Assessment Framework (CSCAF 2.0)

- **Climate-Smart Cities Assessment Framework (CSCAF 2.0)** has been launched by the **MoHUA**. The **objective of CSCAF** is to provide a **clear roadmap** for cities **towards combating Climate Change** while planning and implementing their actions.
- The framework has **28 indicators across five categories**:
  1) **Energy and Green Buildings**,
  2) **Urban Planning**, **Green Cover and Biodiversity**,
  3) **Mobility and Air Quality**,
  4) **Water Management and**
  5) **Waste Management**.

**[UPSC 2020] Account for the huge flooding of million cities in India including the smart ones like Hyderabad and Pune. Suggest lasting remedial measures. (250 words).**

- You must include the impact of aerosols (due to air pollution) on regional rainfall distribution.

- You must discuss issues like wetland encroachments, climate change, poor drainage (clogging by plastic), etc.




## Green Rating for Integrated Habitat Assessment (GRIHA)

- **GRIHA** is a **national rating tool** that assesses the performance of buildings against certain benchmarks. It evaluates the **environmental performance** of a building holistically, thereby providing a definitive standard for what constitutes a **green building**.
- **GRIHA** is developed by **The Energy and Resources Institute (TERI)** with support from the **Ministry of New and Renewable Energy (MNRE)**.

**Some of the benefits of a green building are**

- ✓ Reduced energy consumption without sacrificing comfort.
- ✓ Reduced destruction of natural areas, habitats, and biodiversity, and reduced soil loss from erosion etc.
- ✓ Reduced air and water pollution (direct health benefits).
- ✓ Reduced water consumption.
- ✓ Limited waste generation due to recycling and reuse.

## Transition to a Green Economy

- Three priorities in the transition of economy to a **green economy** are:
  - a) **Decarbonizing the economy**
  - b) **Commit the environmental community to justice and equity**
  - c) **Conserve the biosphere**

### Measures to Adapt Green Economy

- ✓ Energy audit can reduce your building's climate footprint.
- ✓ Sustainable fishing practices.
- ✓ Sustainably managed forests.
- ✓ Usage electronic files to reduce demand for paper.
- ✓ Support certified sustainable forest products.
- ✓ Car-pooling or taking public transport.
- ✓ Walking or riding a bike for short trips.
- ✓ Wise water use.
- ✓ Development of clean, renewable energy using solar, wind, tidal, etc., will contribute to a **green economy**.
- ✓ Recycling materials and composting food waste.
- ✓ Moving towards a green economy has the potential to achieve sustainable development.

### Green Contracts

- **Green Contracts** refer to **commercial contracts** that mandate that **contracting parties cut down GHG emissions at different stages of delivery of goods/services**.
- The process of implementing a green contract **may commence at the bidding stage itself** when various interested companies participate in the tender process.

### Green tender

- **Green tender** may prescribe necessary **Green Qualifications**, which can be considered when awarding the contract to a bidder. Once such a bidder is chosen, the **contracting agreement** between the parties can prescribe the **green obligations** in detail, thus making the obligations **binding and enforceable** in the eyes of the law.

### Advantages

- ✓ Decreased carbon emissions.
- ✓ Improved goodwill of the corporation in the market.
- ✓ Corporations can avail of tax rebates.

### Concerns

- ➢ There is **no effective audit mechanism for implementing** these contracts in letter and spirit.
- ➢ **Green contracts are more expensive** than **brown contracts** (**normal contracts that don't take the environment into account**).

**---------- End of Chapter ----------**

# 21. International Environmental Conventions and Laws – Part I

***Nature conservation***

- United Nations Conference on Environment and Development (UNCED)
- Convention on Biological Diversity (CBD)
- Ramsar Convention on Wetlands
- Convention on International Trade in Endangered Species of Fauna and Flora (CITES)
- The Wildlife Trade Monitoring Network (TRAFFIC)
- The Convention on the Conservation of Migratory Species (CMS)
- Global Tiger Initiative and Global Tiger Forum (GTF)
- Stockholm Convention
- Basel Convention
- Rotterdam Convention

***Land***

- United Nations Convention to Combat Desertification (UNCCD

***Marine environment***

- International Whaling Commission (IWC)

***Atmosphere***

- Vienna Convention and Montreal Protocol
- United Nations Framework Convention on Climate Change (UNFCCC)
- Kyoto Protocol

***These environmental protection and conservation measures are explained in relevant chapters***.

## 21.1. United Nations Conference on the Human Environment (1972)

- The 1972 **UN Conference on the Human Environment (Stockholm Conference)** was held in **Stockholm**, **Sweden**. It marked the **emergence of international environmental law**. The participants adopted the **Stockholm Declaration** and **Action Plan for the Human Environment**.

### Stockholm Declaration

- Stockholm Declaration is also known as **The Declaration on the Human Environment**.
- It set out the **26 principles** for the preservation and enhancement of the natural environment.

#### Principles of the Stockholm Declaration

1. **Right to environment** is one of the fundamental rights of every individual

2. **Natural resources must be safeguarded** for the benefit of the present and future generations
3. The **Earth's capacity to produce renewable resources** must be maintained
4. **Wildlife** must be safeguarded
5. **Non-renewable resources** must be shared and not exhausted
6. **Pollution must not exceed the environment's capacity to clean itself**
7. Marine pollution must be prevented
8. Create conditions on Earth conducive to human living and socio-economic development
9. Support by developed countries to tackle underdevelopment and natural calamities
10. Developed countries must maintain price stability and availability of raw materials for environmental management
11. **Environment policy must not hamper development**, especially in developing countries
12. Sufficient resources should be available to the developing countries for development
13. States should adopt an integrated and coordinated approach for their development to protect and improve the environment
14. **National planning** is vital for balancing development needs with environmental protection
15. Human settlements and urbanisation must be planned to avoid environmental problems
16. Appropriate population policies to balance environmental concerns and development needs
17. A national institution should manage environmental resources
18. Create awareness about environmental matters
19. States must promptly inform potentially affected parties about activities with significant adverse **cross-border environmental effects**
20. Promote scientific research and development on matters related to environmental problems
21. Urgent development in the legal control of acid rain, greenhouse effect and ozone depletion
22. Enhance **international laws on liability and compensation** for victims of environmental pollution
23. Implement international community standards that are not against the developing states' interests
24. States should take action for the protection and improvement of the environment on an equal footing
25. States should ensure the protection of the environment against pollution by appropriate means
26. **Weapons of mass destruction** must be destroyed

## Importance

- The **Stockholm Conference** motivated countries, including India, **to create environmental ministries and agencies**.
  - ❖ The **Department of Environment** was created in **1980**
  - ❖ **Ministry of Environment and Forests (MoEF)** in **1985**
  - ❖ In 2014, the MoEF was renamed to the **Ministry of Environment**, **Forest**, **and Climate Change (MoEFCC)**
- The Stockholm Conference led to the establishment of the **UN Environment Programme** (UNEP).

## 21.2. United Nations Environment Programme (UNEP)

- UNEP is an agency of the UN. It **coordinates** the **UN's environmental activities**. It **assists developing countries** in implementing environmentally sound policies and practices.
- It has **overall responsibility for environmental problems among UN agencies**.
- UNEP's activities cover various issues related to the atmosphere, marine and terrestrial ecosystems, environmental governance, and the **green economy**.
- Other specialised UN agencies like the **UNFCCC** and **UNCCD** oversee **climate change** or **combating desertification**.

### Agencies Established/Implemented by UNEP

- The **World Meteorological Organization** (WMO) and **UNEP** established the **Intergovernmental Panel on Climate Change** (IPCC) in 1988.
- UNEP is also one of the several implementing agencies for the **Global Environment Facility** (GEF) and the **Multilateral Fund for implementing the Montreal Protocol**.
- It is also a member of the **United Nations Sustainable Development Group** (UNSDG). It aims to help the world meet the **17 Sustainable Development Goals**.
- It has registered several successes, such as the **1987 Montreal Protocol** and the **2012 Minamata Convention** (treaty to limit toxic mercury).
- UNEP **hosts the secretariats** of several multilateral environmental agreements/research bodies, including:
  - **Convention on Biological Diversity (CBD)**
  - **Minamata Convention on Mercury (MCM)**
  - **Convention on Migratory Species (CMS)**
  - **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)**
- The **solar loan programme** sponsored by UNEP helped finance **solar power systems in India**.

#### Faith for Earth Initiative (FEI)

- FEI was launched in 2017 by UNEP. It aims to strategically engage with faith-based organisations and partner with them to **achieve the SDGs collectively**.
- It aims to create a global **"Coalition for Creation"** to facilitate policy dialogue on environmental issues that would encourage innovative approaches to finding long-lasting solutions.

### Global Environment Facility (GEF)

- GEF was established on the eve of the **1992 Rio Earth Summit** as an **independently operating financial organisation**.

#### Areas of Work

- The GEF provides grants for projects related to **biodiversity**, **REDD+ (Sustainable Forest Management)**, **climate change**, **land degradation**, **ozone layer**, **persistent organic pollutants**, etc.
- It unites countries, institutions, civil society, NGOs, and the private sector to tackle the earth's **most pressing environmental problems** while supporting national **sustainable development initiatives**.
- GEF runs a **Small Grants Programme** that provides financial support to projects that embody a **community-based approach**.

### The GEF Serves as Financial Mechanism for the Following Conventions:

- **Convention on Biological Diversity (CBD)**
- **United Nations Framework Convention on CC (UNFCCC)**
- **UN Convention to Combat Desertification (UNCCD)**
- **Stockholm Convention on Persistent Organic Pollutants**
- **Minamata Convention on Mercury**

- The GEF, although **not linked formally** to the **Montreal Protocol**, **supports the implementation** of the Protocol in **countries with economies in transition**.

### Multilateral Fund (MLF) for the Implementation of the Montreal Protocol

- The MLF, established by the **London Amendment to the Montreal Protocol** in 1990, provides **funds to help developing countries** comply with their obligations under the Montreal Protocol to **phase out the use of ozone-depleting substances** (ODS) at an agreed-upon schedule.
- Countries eligible for this assistance are those with **an annual per capita consumption of ODS of less than 0.3 kg/year**. These are referred to as **Article 5 countries** (including India).

### The GEF works with18 agencies. Notable ones are:

1) **United Nations Development Programme (UNDP)**
2) **United Nations Environment Programme (UNEP)**
3) **World Bank (WB)**
4) **Food and Agriculture Organization (FAO)**
5) **Asian Development Bank (ADB)**
6) **International Fund for Agricultural Development (IFAD)**
7) **World Wide Fund for Nature (WWF)**
8) **Conservation International (CI)**
9) **International Union for Conservation of Nature (IUCN)**

### [UPSC 2014] With reference to 'GEF', which of the following statements is/are correct?

a) It serves as financial mechanism for 'Convention on Biological Diversity' and 'United Nations Framework Convention on Climate Change'.

b) It undertakes scientific research on environmental issues at global level
c) It is an agency under OECD to facilitate the transfer of technology and funds to underdeveloped countries with specific aim to protect their environment.
d) Both (a) and (b)

**Explanation**

- GEF is an **independent financial organisation (not a research body)**. It may fund **scientific research** but is **not directly involved in it**.
- **IPCC takes care of most of the research work**.

***Answer: a)***

## Agencies Funded/Administered by GEF

### Special Climate Change Fund (SCCF) – 2001

- SCCF aims to help **developing countries** under the UNFCCC to adapt to climate change impacts and enhance resilience.
- It funds additional costs for climate change adaptation interventions. It is open to all **vulnerable developing countries** (Non-Annex 1 countries under the **Kyoto Protocol**).

### Least Developed Countries Fund (LDCF) – 2001

- LDCF was established to support the LDC work programme under the **UNFCCC**.
- LDCF funding helps recipient countries address their **short**, **medium and long-term resilience needs and** reduce climate change vulnerability in priority sectors and ecosystems. It is operated by the **GEF**.

### Global Wildlife Programme (GWP) – 2015

- GWP was launched to **combat trafficking in Wildlife**. It is a World Bank-led and GEF-funded partnership.

**Q. Consider the below statements about Global Wildlife Programme (GWP):**

1) GWP is a CITES led global partnership that promotes wildlife conservation and sustainable development by combating illicit trafficking in wildlife.
2) The GWP is funded by the Global Environment Facility.

**Which of the statements given above are correct?**

a) 1 only
b) 2 only
c) Both
d) None

***Correct Answer: b) 2 only***

## 21.3. UNCED/Earth Summit, Rio De Janeiro

- The **United Nations Conference on Environment and Development** (UNCED) is popularly known as **Earth Summit 1992**. UNCED succeeded in raising public awareness of the need to integrate environment and development.
- At UNCED, 190 countries pledged their commitment to achieving a significant reduction in the current rate of biodiversity loss at global, regional, and local levels by 2010.

### Landmark Agreements of the Earth Summit

- A major achievement of the Earth Summit was an agreement on the **Climate Change Convention (UNFCCC)**, which in turn led to the **Kyoto Protocol** and the **Paris Agreement**.
- Important **legally binding agreements** opened for signature under the aegis of the Earth Summit are:
  a) **Convention on Biological Diversity (CBD)**
  b) **United Nations Convention to Combat Desertification (UNCCD)**
  c) **United Nations Framework Convention on Climate Change (UNFCCC)**

### High-level Political Forum on Sustainable Development (HLPF)

- HLPF is a forum under the **UN Economic and Social Council (ECOSOC)** tasked with **overseeing the outcomes of the 1992 Earth Summit**. HLPF meets under the General Assembly **every 4 years** and under the ECOSOC **annually**. It is responsible for **reviewing the progress of implementation** of:
  - **Agenda 21**
  - **Johannesburg Declaration (Rio+10)**
  - **Rio+20**
  - **Barbados Programme of Action (Sustainable Development of SIDS)**
  - **LDC-IV (4th United Nations Conference on the Least Developed Countries)**
  - The relevant outcomes of other United Nations summits and conferences

## 21.4. The History of Sustainable Development Goals (SDGs)

### Brundtland Commission

- In 1983, the **United Nations** created the **World Commission on Environment and Development**, later known as the **Brundtland Commission**.
- It defined **sustainable development** as "**meeting the needs of the present without compromising the ability of future generations to meet their own needs**".

### UNCED or Earth Summit 1992, Rio De Janeiro Brazil

- The Earth Summit resulted in the following documents for sustainable development:
  - **Rio Declaration:** Principles intended to guide countries in future sustainable development.

- ❖ **Agenda 21: Non-binding action plan** of the United Nations regarding sustainable development.
- ❖ **Forest Principles: Non-legally binding document** on the Conservation and Sustainable Development of all types of forests.

⇨ **Rio+5 (1997):** In 1997, the UN General Assembly held a special session Rio+5 to appraise the status of **Agenda 21**.

**[UPSC 2016] With reference to 'Agenda 21', sometimes seen in the news, consider the following statements:**

1) It is a global action plan for sustainable development.
2) It originated in the World Summit on Sustainable Development held in Johannesburg in 2002.

***Which of the statements given above is/are correct?***

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

**Explanation**

- Agenda 21 came out as a part of Earth Summit 1992.

***Answer: a) 1 only***

## Post UNCED

- As a follow-up to **UNCED**, the **World Summit on Sustainable Development (Rio+10)** was held in **2002** in **Johannesburg**, **South Africa**.
- In 2012, the **United Nations Conference on Sustainable Development (Rio+20/Rio Earth Summit 2012)** was also held in **Rio**, **Brazil**.
- The issues touched on include:
  - ✓ checking production of **toxic components**, such as **lead in gasoline** and **radioactive chemicals**
  - ✓ **alternative sources of energy** to replace the use of fossil fuels
  - ✓ reliance on **public transportation**, congestion in cities
  - ✓ the health problems caused by **pollution**
  - ✓ the growing usage and limited supply of **water**

**[UPSC 2015] What is the Rio+20 Conference, often mentioned in the news?**

a) It is the UN Conference on Sustainable Development
b) It is a Ministerial Meeting of the WTO
c) It is a Conference of the IPCC
d) It is a Conference of the Member Countries of the CBD

**Explanation**

- ⇨ ***Earth Summit 1992 (Rio de Janeiro) ➔ UN Conference on Environment and Development***
- ⇨ ***Earth Summit 2002 (Rio+10) (Johannesburg) ➔ World Summit on Sustainable Development***
- ⇨ ***Earth Summit 2012 (Rio+20) (Rio de Janeiro) ➔ UN Conference on Sustainable Development***

***Answer: a)***

## Rio+10 (2002) or Earth Summit 2002

- Rio+10 affirmed the UN commitment to **Agenda 21** alongside the **Millennium Development Goals (MDGs)**.
- The ensuing **Johannesburg Declaration** pledged global commitment to sustainable development.

### Millennium Development Goals (MDGs) by 2015

- The MGDs were established following the **UN's Millennium Summit** in **2000**. In **2015**, the **Sustainable Development Goals (SDGs) replaced the MDGs**.

***Millennium Development Goals aimed to:***

1. Eradicate extreme poverty and hunger
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce child mortality
5. Improve maternal health
6. Combat HIV/aids, malaria, and other diseases
7. Ensure environmental sustainability
8. Develop a global partnership for development

## Rio+20 (2012) or Earth Summit 2012

- **Rio+20, or Earth Summit 2012**, was a **20-year follow-up to the Earth Summit 1992** and a **10-year follow-up to the Earth Summit 2002**. The **Sustainable Development Goals (SDGs)** were **born at Rio+20**. Since 2015, the SDGs have been included in the **Agenda 2030**.

### Partnership for Action on Green Economy (PAGE)

- PAGE, launched in 2013, is a direct response to the Rio+20 Declaration, The Future We Want. It seeks to **assist countries in achieving SDG** (Agenda 2030), especially **SDG 8: "Promote sustained, inclusive and sustainable economic growth, full and productive employment."**


**[UPSC 2016] Consider the following statements: (2016)**

1) The SDGs were first proposed in 1972 by a global think tank called the 'Club of Rome'.
2) The SDGs have to be achieved by 2030.

***Which of the above statements is/are correct?***

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

***Answer: b) 2 only***

**[UPSC 2018] The Partnership for Action on Green Economy (PAGE), a UN mechanism to assist countries in transition towards greener and more inclusive economies, emerged at (2018)**

a) The Earth Summit on Sustainable Development 2002, Johannesburg
b) The United Nations Conference on Sustainable Development 2012, Rio de Janeiro
c) The United Nations Framework Convention on Climate Change 2015, Paris
d) The World Sustainable Development Summit 2016, New Delhi

***Answer: b)***

## UN Agenda 2030 – Sustainable Development Goals

- SDGs are a collection of **17 global goals** and their **169 targets**, set by the **UN General Assembly (UNGA)** in 2015 for the year **2030 (UNGA resolution "2030 Agenda")**. They aim to eradicate poverty in all forms and "seek to realise the human rights of all and achieve gender equality".

### Goal 1: No Poverty

***"End poverty in all its forms everywhere"*** by

- ✓ Ensuring **equal rights** to ownership, essential services, technology, and economic resources.
- ✓ Building resilience to **environmental**, economic, and social **disasters**.

### Goal 2: Zero Hunger

***"End hunger**, **achieve food security and improved nutrition and promote sustainable agriculture"*** by

- ✓ **Doubling agricultural productivity** and incomes of small-scale food producers (women, tribals, etc.) by increasing access to land and eliminating wastage.
- ✓ Maintaining the **genetic diversity of seeds** and **improving land and soil quality**.
- ✓ **Preventing trade restrictions and distortions** in world agricultural markets.

### Goal 3: Good Health and Well-Being

***"Ensure healthy lives and promote well-being for all at all ages"*** by

- ✓ Reducing **maternal mortality** and ending all preventable **deaths under five years of age**.
- ✓ Reducing mortality from **communicable and non-communicable diseases**.
- ✓ Preventing and treating **substance abuse**.
- ✓ Promoting **mental health**.
- ✓ Reducing **road injuries and deaths**.
- ✓ Granting universal access to **sexual and reproductive care**, **family planning** and education.
- ✓ Achieving **universal health coverage**.
- ✓ Reducing illnesses and deaths from **hazardous chemicals and pollution**.
- ✓ Implementing the WHO framework on **tobacco control**.
- ✓ Supporting research, development and universal access to **affordable vaccines and medicines**.
- ✓ Increasing the health financing and workforce in developing countries.
- ✓ Improving **early warning systems for global health risks**.

## Goal 4: Quality Education

***"Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all"*** by

- ✓ Providing **free**, **equal access to pre-primary**, **primary and secondary education**, as well as **affordable technical**, **vocational**, **and higher education**.
- ✓ Expanding higher education scholarships and increasing the supply of qualified teachers in developing countries.

## Goal 5: Gender Equality

***"Achieve gender equality*** and ***empower all women and girls"*** by

- ✓ Ending all forms of **discrimination** against all women and girls everywhere.
- ✓ Ending **violence** and **exploitation** of women and girls.
- ✓ Eliminating harmful practices such as **child**, **early and forced marriage** and **female genital mutilation**.
- ✓ Increasing the value of unpaid care (domestic chores) and promoting **shared domestic responsibilities**.
- ✓ Ensuring full participation of **women in leadership and decision-making**.
- ✓ Ensuring universal **reproductive rights and health**.
- ✓ Fostering **equal rights** to economic resources, property ownership and financial services for women.
- ✓ Promoting **empowerment of women** through technology.
- ✓ Adopting and strengthening policies and enforcing legislation for **gender equality**.

## Goal 6: Clean Water and Sanitation

***"Ensure availability and sustainable management of water and sanitation for all"*** *by*

- ✓ Providing **safe and affordable drinking water**.
- ✓ **Ending open defecation** and providing access to sanitation and hygiene.
- ✓ Ensuring **equitable sanitation** for addressing the specific needs of women and girls, disabled, aged, etc.
- ✓ Improving **water quality**, **wastewater treatment** and r**euse**.
- ✓ Increasing **water-use efficiency** and **freshwater supplies**.
- ✓ **Integrated Water Resources Management (IWRM)**.
- ✓ Protecting and restoring water-related ecosystems.

> ⇨ ***IWRM*** *is a process that promotes the* ***coordinated development*** *and management of* ***water***, ***land and related resources*** *to maximise the resultant economic and social welfare* ***equitably*** *without compromising the* ***sustainability*** *of vital ecosystems.*

## Goal 7: Affordable and Clean Energy

***"Ensure access to affordable**, **reliable**, **sustainable and modern energy for all"** by increasing the share of renewables.*

### Goal 8: Jobs and Growth

***"Promote sustained**, **inclusive and sustainable economic growth**, **full and productive employment"*** by

- ✓ **Resource efficiency** in consumption and production.
- ✓ Providing full employment and decent work with **equal pay**.
- ✓ Promoting **youth** employment, education, and training.
- ✓ Ending **modern slavery**, **trafficking**, and **child labour**.
- ✓ **Labour rights** and promoting safe working environments.
- ✓ Promoting beneficial and **sustainable tourism**.
- ✓ Ensuring universal access to banking, insurance, and financial **services**.

### Goal 9: Industry, Innovation, and Infrastructure

***"Build resilient infrastructure**, **promote inclusive and sustainable industrialisation**, **and foster innovation"*** by

- ✓ Increasing access to **financial services** and **markets**.
- ✓ Supporting **domestic technology** development and **industrial diversification**.
- ✓ Ensuring universal access to **information and communications** technology.

### Goal 10: Reduced Inequality

***"Reduce income inequality within and among countries"*** by

- ✓ Promoting universal social, economic and political **inclusion**.
- ✓ Ensuring **equal opportunities** and **ending discrimination**.
- ✓ Improving regulation of financial markets/institutions.
- ✓ Enhancing representation for **developing countries** in financial institutions.
- ✓ Framing responsible and well-managed **migration policies**.
- ✓ Reducing transaction costs for **migrant remittances**.

### Goal 11: Sustainable Cities and Communities

***"Make cities and human settlements inclusive**, **safe**, **resilient**, **and sustainable"*** by

- ✓ Enabling **affordable** housing, transport systems, and sustainable urbanisation.
- ✓ Protecting the world's **cultural and natural heritage**.
- ✓ Reducing the adverse effects of **natural disasters**.
- ✓ Reduce **environmental impacts** and provide access to safe and inclusive **green and public spaces**.

### Goal 12: Responsible Consumption and Production

***"Ensure sustainable consumption** and **production patterns"*** by

- ✓ Achieving sustainable management and efficient use of **natural resources**.
- ✓ Reduce global **food waste** by half per capita at all levels and reduce food losses along supply chains.
- ✓ Achieving **environmentally sound management of chemicals** and wastes throughout their life cycle.
- ✓ Reducing waste generation through prevention, reduction, **recycling**, and **reuse**.
- ✓ **Removing market distortions**, **like fossil fuel subsidies**, that encourage wasteful consumption.

### Goal 13: Climate Action

***"Take urgent action to combat climate change and its impacts by regulating emissions and promoting developments in renewable energy"*** by

- ✓ Strengthening **resilience** and **adaptive capacity** to climate-related disasters.
- ✓ Integrating **climate change measures** into policies and planning.
- ✓ Building knowledge and capacity to meet climate change.
- ✓ Implementing the **UN Framework Convention on Climate Change (UNFCCC)**.

### Goal 14: Life Below Water

***"Conserve and sustainably use the oceans, seas and marine resources for sustainable development"*** by

- ✓ Reducing **marine pollution** and **ocean acidification** and protecting and restoring ecosystems.
- ✓ Supporting **sustainable fishing** and small-scale fishers.
- ✓ Ending **subsidies contributing to overfishing**
- ✓ Increasing the **economic benefits** from the **sustainable use of marine resources**.

### Goal 15: Life on Land

***"Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss"*** by

- ✓ Conserving and restoring **ecosystems**.
- ✓ Ending **desertification** and restoring **degraded land**.
- ✓ Conserving **mountain ecosystems**, **biodiversity**, and **natural habitats**.
- ✓ Reducing **urbanisation**.
- ✓ Protecting access to **genetic resources** and **fair sharing of the benefits**.
- ✓ Eliminating poaching and trafficking of **protected species**.
- ✓ Preventing **invasive alien species** in all ecosystems.
- ✓ Increasing financial resources to conserve and sustainably use ecosystems and biodiversity.
- ✓ Financing/incentivising **sustainable forest management**.

### Goal 16: Peace, Justice, and Strong Institutions

***"Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels"*** by

- ✓ **Protecting children** from abuse, exploitation, trafficking and violence.
- ✓ Promoting the rule of law and ensuring **access to justice**.
- ✓ **Combating organised crime** and illicit financial and arms flows.
- ✓ Substantially **reducing corruption** and bribery.
- ✓ Developing accountable, and transparent institutions.
- ✓ Ensuring inclusive, and representative decision-making.
- ✓ Providing **universal legal identity**.
- ✓ Ensuring **public access to information** and protecting fundamental freedoms.

### Goal 17: Partnership for the Goals

***"Strengthen the means of implementation and revitalise the global partnership for sustainable development"*** by

- ✓ Assisting developing countries in attaining **debt sustainability** and **investing** in least-developed countries.
- ✓ **Knowledge sharing** and cooperation for access to science, technology, and innovation.
- ✓ **Sustainable technologies** to developing countries.
- ✓ Promoting a **universal trading system** under the WTO.
- ✓ **Removing trade barriers** for least-developed countries.

**[UPSC Mains 2019] Define the concept of carrying capacity of an ecosystem as relevant to an environment. Explain how understanding this concept is vital while planning for sustainable development of a region.**

- **Carrying capacity of an ecosystem** refers to the maximum levels of the ecological/ecosystem services that an ecosystem can offer **sustainably**. Beyond the carrying capacity, the ecosystem is **severely constrained/degraded**. Examples:
  - ➢ Indian metropolitan cities have far exceeded their carrying capacity.
  - ➢ Agroecosystems in Punjab and Haryana are severely stressed due to rampant groundwater depletion and increased alkalinity.
  - ➢ Deforestation and plantation agriculture have exceeded the natural tolerance limits of the Western Ghats.
  - ➢ Poverty in the Indo-Gangetic plains can be attributed to excessive population stress.
  - ➢ Hydroelectric power projects and tourism in the Himalayas have exacerbated the disaster potential. (The recent case of **Joshimath's geological stresses** causing it to sink).
- Understanding the concept of the carrying capacity of an ecosystem is important for urban planning, sustainable resource extraction, development, population control, wildlife management, etc.

## 21.5. United Nations Framework Convention on Climate Change (UNFCCC)

- The **UNFCCC** is an **international environmental treaty** that was created under the UN's aegis. It was negotiated in New York in 1992 and signed in **1992** at the **Rio Earth Summit (UNCED)**.
- As of March 2024, the UNFCCC has **198 parties**.

✓ **Role: Provide a framework** for negotiating **specific international treaties (called "protocols")** that **aim to set binding limits on greenhouse gases (GHGs). (UNFCCC itself sets no binding limits)**

✓ **Objective: Stabilise GHG concentrations** in the atmosphere **at a level that would prevent dangerous consequences**.

✓ **Legal Effect:** it is considered **legally non-binding**.

## Conferences of the Parties (COP) to UNFCCC

- The COP is the UNFCCC's **decision-making body**. All States Parties to the Convention are represented at the COP. The COP **reviews the implementation of any legal instruments** it adopts and promotes the effective implementation of the Convention.
- The parties to the convention met **annually** from 1995. The 2020 COP was rescheduled to 2021.

### List of Major UNFCCC Summits

❖ **1995: COP 1**, **Berlin**, **Germany** — The **Berlin Mandate** calls to establish **specific**, **legally binding targets** and **timetables** for **reducing GHG emissions** by **developed countries**.

❖ **1997: COP 3**, **Kyoto**, **Japan** — The **Kyoto Protocol** established **legally binding obligations for developed countries to reduce their GHG emissions**.

❖ **2002: COP 8**, **New Delhi**, **India**

❖ **2005: COP 11/CMP 1**, **Montreal**, **Canada** — **Kyoto Protocol was ratified**

❖ 2009: COP 15/CMP 5, Copenhagen, Denmark

❖ 2011: COP 17/CMP 7, Durban, South Africa

❖ 2012: COP 18/CMP 8, Doha, Qatar

❖ 2013: COP 19/CMP 9, Warsaw, Poland

❖ 2014: COP 20/CMP 10, Lima, Peru

❖ **2015: COP 21/CMP 11**, **Paris**, **France** — **concluded the Paris Agreement**

❖ 2016: COP 22/CMP 12, Marrakech, Morocco

❖ 2017: COP 23/CMP 13, Bonn, Germany

❖ 2018: COP 24/CMP 14, Katowice, Poland

❖ 2019: COP 25/CMP 15, Madrid (Spain)

❖ **2021: COP 26 (Oct-Nov 2021)/CMP 16**, **Glasgow** **(hosted by the UK in partnership with Italy)**.

❖ **2022: COP 27 (Nov 2022)/CMP17**, **Sharm El Sheikh**, **Egypt**

❖ **2023: COP 28 (Nov-Dec 2023)/CMP18**, **Dubai**, **UAE**

⇨ ***COP: Conference of the Parties to the UNFCCC***

⇨ ***CMP: COP serving as the Meeting of the Parties to the Kyoto Protocol***

### Criticisms of the UNFCCC

- Nothing **except the Kyoto Protocol** made any binding limits on GHG emissions.
- **Never achieved its stated goals** of reducing the emission of carbon dioxide.
- It **does not cover developing countries** that now include the **largest $CO_2$ emitters**.
- Negotiations are governed by consensus, and a small group of countries often block the negotiations.
- It is easy for developed countries to escape from their responsibility — the **United States**, one of the biggest polluters, **never ratified the Kyoto Protocol**. **Canada pulled out of the Kyoto Protocol**, citing **wealth transfers** out of the country due to binding limits. **Japan and Russia did not sign the second Kyoto term** because it would impose restrictions on them that are **not faced by their main economic competitors** — China, India, and Indonesia.

## 21.6. Kyoto Protocol (COP 3; UNFCCC 1997)

***[UPSC 2022] Discuss global warming and mention its effects on the global climate. Explain the control measures to bring down the level of greenhouse gases which cause global warming, in the light of the Kyoto Protocol, 1997. (250 words)***

- The **Kyoto Protocol** was adopted in **Kyoto**, **Japan**, in **1997** and came into force in **2005**. It is the **only global treaty with binding limits on GHG emissions**. There are currently 192 Parties to the Kyoto Protocol. **India ratified it in 2002**, the USA never ratified it, and Canada withdrew in 2012.
- **Goal: Fight global warming by reducing GHG concentrations** in the atmosphere to "a level that would prevent dangerous anthropogenic interference with the climate system."
- The Kyoto Protocol is based on the principle of **common but differentiated responsibilities**.
- It aimed to cut GHG emissions across the **developed world** by about **5% by 2012 compared with 1990 levels**.

### The Kyoto Protocol Emission Target GHGs

1. **Carbon dioxide ($CO_2$)**
2. **Methane ($CH_4$)**
3. **Nitrous oxide ($N_2O$)**
4. **Sulphur hexafluoride ($SF_6$)**
5. **Groups of hydrofluorocarbons (HCFs)**
6. **Groups of perfluorocarbons (PFCs)**

### Common but Differentiated Responsibilities

- **CBDR (Kyoto Protocol) puts the obligation on developed countries to reduce current emissions** on the basis that they are **historically responsible** for the current levels of GHGs in the atmosphere. CBDR divides countries into two categories:

1. **Historically**, **the biggest polluting developed countries** are the **US**, **UK**, **France**, **Japan**, **Russia**, etc. (They have been polluting the earth since the Industrial Revolution).
2. **Recently polluting developing countries** like **China**, **India**, **Brazil**, etc. (polluting since the 1950s).

❖ **"Common"** ➔ Every country (developing and developed) must participate in the fight against climate change.

❖ **"But Differentiated Responsibilities"** ➔ Historically, the biggest polluters should do more than the recent polluters, i.e., **responsibilities proportional to the pollution caused**.

- Thus, under CBDR, **developed countries** like the US, UK, Russia, etc., **must contribute more to reducing GHGs by accepting certain binding limits on GHG emissions**. They must **contribute funds** towards reducing GHG emissions to **developing and least developed countries (LDCs)**.
- Meanwhile, **developing countries and LDCs** should do everything they can to reduce their GHG emissions. However, **nothing is binding on them**, **and every initiative is voluntary**.

## Climate Reparation

- According to a recent report by the **UN Office for the Coordination of Humanitarian Efforts (UNOCHA)**,
  - ❖ **Economic Losses:** The unavoidable annual economic losses from climate change were projected to reach somewhere between $ 290 billion and $ 580 billion by the year 2030.
  - ❖ **Non-economic Losses:** There are non-economic losses also, which include loss of lives, displacement and migration, health impacts, and damage to cultural heritage.
- **Climate reparations** refer to the **monetary compensation that developed countries give to developing countries** to compensate for the historical contributions that the developed countries have made towards climate change.
- It is an extension of the universally acknowledged **"Polluter Pays" principle**. The "Polluter Pays" principle is enacted **to make the pollution-producing party responsible for paying for the damage done to the natural environment**.

### Historical Emissions Argument: Who is Responsible for Climate Change?

- Developed countries have contributed most of the GHG emissions since the beginning of the Industrial Revolution in the 1850s, which has led to global warming.
- **The US**, **the UK**, **and the EU** accounted for **over 50% of all emissions** during this time. When Russia, Canada, Japan, and Australia are included, their contribution is above 65%.
- Even though developing countries are currently emitting high amounts of $CO_2$, their contribution since 1850 is not so high. **India**, **the third largest emitter of $CO_2$ at present**, accounts for **only 3% of historical emissions**, and **China**, **the biggest emitter of $CO_2$ at present**, has contributed about **11% of historical emissions** since 1850.

- Historical responsibility is important because **$CO_2$ remains in the atmosphere for hundreds of years**, and it is **this cumulative accumulation of $CO_2$ that causes global warming**.

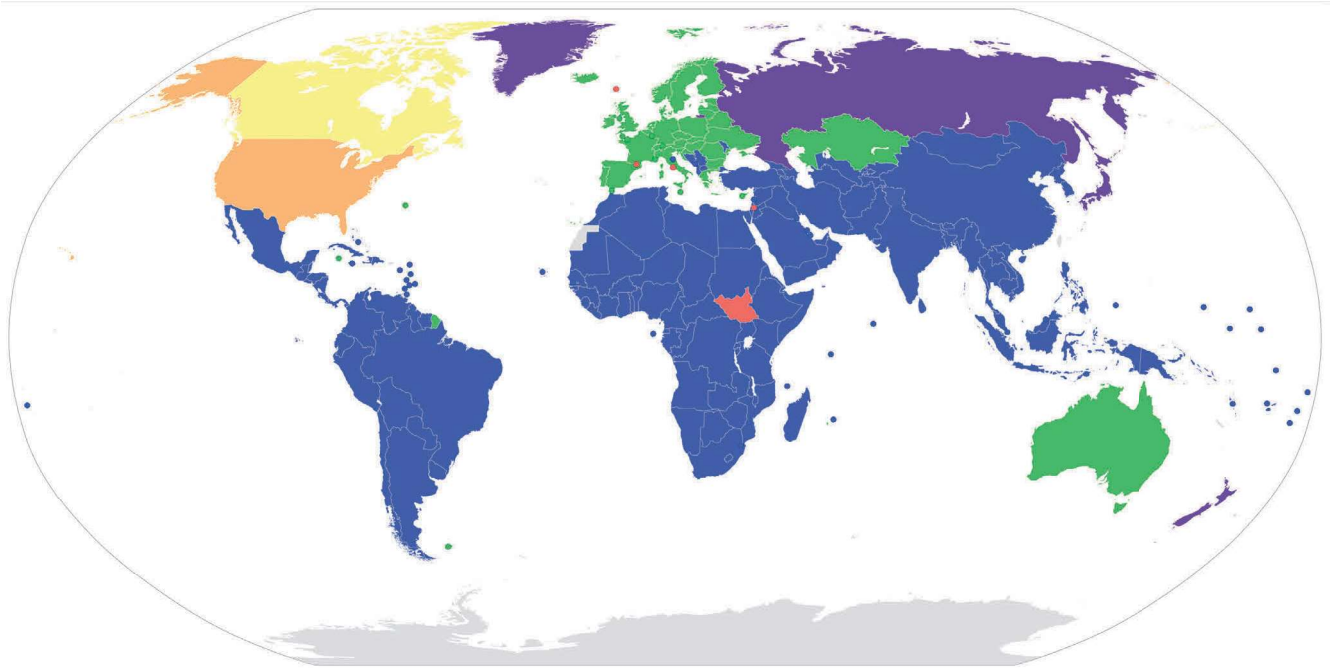
**UNFCCC' Stand**

- UNFCCC explicitly **acknowledges the differentiated responsibility of nations**. It makes it clear that rich countries must provide both finance and technology to developing nations to help them tackle climate change. Based on this mandate of UNFCC, the rich countries agreed to provide **$100 billion every year** to the developing world (yet to be fulfilled).

**Initiatives for Climate Reparations**

- The **Warsaw International Mechanism for Loss and Damages**, created in 2013, is the **first formal recognition to compensate developing countries hit by climate disasters**.

## Classification of Parties under the Kyoto Protocol



**Annex B parties with binding targets in the second period**
**Annex B parties with binding targets in the first period but not the second**
**Non-Annex B parties without binding targets**
**Annex B parties with binding targets in the first period but which withdrew from the Protocol**
**Signatories to the Protocol that have not ratified**
**Other UN member states and observers that are not party to the Protocol**

| | |
|---|---|
| **Annex I** | • **Developed countries** (US, UK, Russia, etc.) + **Economies in transition** (EIT) [Ukraine, Turkey, some eastern European countries] |
| **Annex II** | • **Developed countries** (**Annex II is a subset of Annex I**)<br>• Provide **financial and technical support** to **EITs** and **developing countries** to reduce GHG emissions. |

| | |
|---|---|
| **Annex B** | • **Annex I Parties with first or second-round Kyoto GHG emissions targets** (**Annex B is a subset of Annex I**)<br>• **Compulsory binding targets** to reduce GHG emissions<br>• The **first-round Kyoto targets** applied over the years **2008-2012**<br>• The **second-round Kyoto targets** applied from **2013-2020** |
| **Non-Annex I** | • The parties to the UNFCCC that are **not listed in Annex I** (mostly low-income developing countries)<br>• **No binding targets** to reduce emissions |
| **LDCs** | • Least-developed; **No binding targets** |

- **Developing countries may volunteer to become Annex I countries** when they are sufficiently developed.

## Doha Amendment to Kyoto Protocol

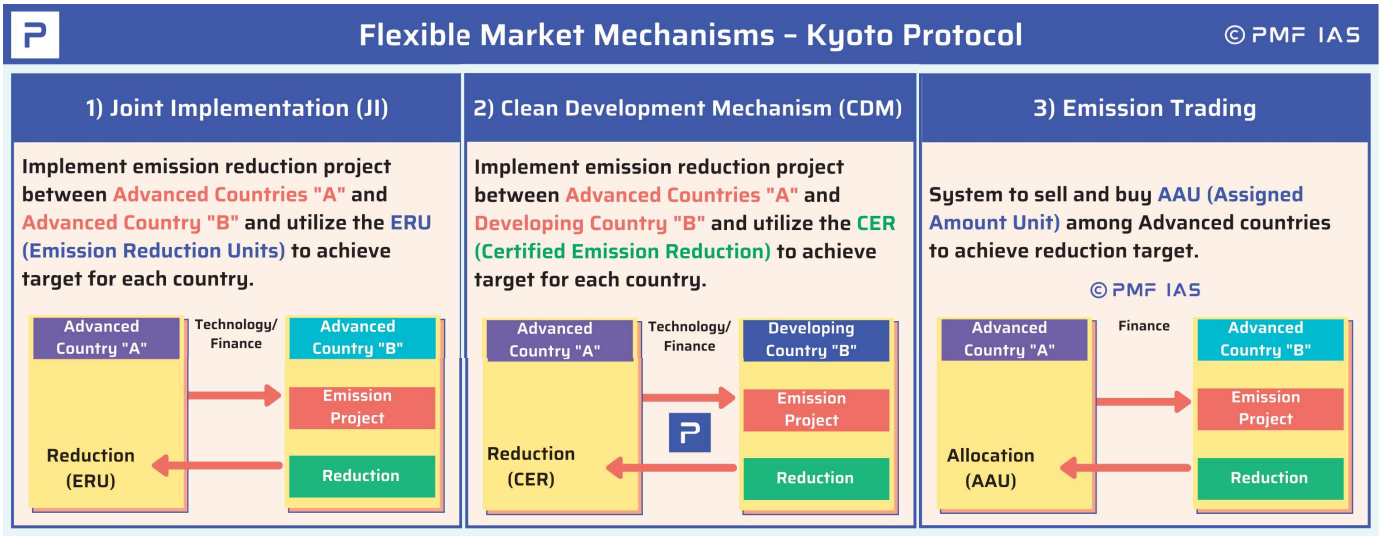
- Under the Kyoto Protocol, there are two commitment periods, **2008-2012** and **2013-2020**. The **second commitment period** was agreed on in 2012, known as the **Doha Amendment**.
- **Each commitment period has its binding targets set for developed countries**. During the first commitment period (2008-12), more than 35 countries had binding targets. Nations that missed their Kyoto target in 2012 **incurred a penalty of an additional third** added to whatever cut they agreed under a new treaty.
- **Canada withdrew in 2012** after the first commitment period. Japan, New Zealand, and Russia participated in Kyoto's first round but did not take on new targets in the second commitment period.
- The Doha Amendment needed acceptance by at least 144 states to enter into force. As of October 2020, **147 states had accepted the Doha Amendment**. It **entered into force on 31st December 2020 and ended on the same day!** Thus, the **second commitment period is an abject failure**.
- Negotiations were held in Lima in 2014 to agree on a post-Kyoto legal framework. **China**, **India**, **and the US (three big villains)** have all signalled that they will not ratify any treaty that legally commits them to reducing $CO_2$ emissions.

## Flexible Market Mechanisms Under the Kyoto Protocol

- Countries bound to Kyoto targets have to meet them largely **through domestic action — that is**, **to reduce their emissions onshore**. But they can meet **part of their targets** through **three "market-based mechanisms"**:
  1. **Clean Development Mechanism (CDM)**
  2. **Emission Trading**
  3. **Joint Implementation (JI)**

### Expected Benefits of Flexible Market Mechanisms

- ✓ Stimulating **green investment in developing countries**.
- ✓ The **private sector** is included in this endeavour to cut and hold steady GHG emissions at a safe level.
- ✓ It also makes **"leap-frogging"** — the possibility to skip older, dirtier technology for newer, cleaner infrastructure and systems, with obvious longer-term benefits.




## Clean Development Mechanism (CDM)

- CDM allows a country with an emission-reduction commitment under the Kyoto Protocol (Annex B Party like Australia) to **implement an emission-reduction project** in **developing countries** (like India).
- Such projects can earn **certified emission reduction (CER) credits**, **each equivalent to one tonne of $CO_2$**, which **can be counted towards meeting Kyoto targets**.
- In simple terms, developed countries emit more and lose carbon credits. They provide financial assistance to developing countries and LDCs to create clean energy and gain some carbon credits, thereby meeting their Kyoto Quota (Kyoto units) emissions without violations.
- Suppose a developed country has a Kyoto Quota of 100 Carbon Credits; then it can emit 100 tonnes of $CO_2$. Due to negligence, it emits 110 tonnes of $CO_2$, i.e., 10 carbon credits are lost (Kyoto Quota violation). The country must compensate for its lost carbon credits to avoid penalties. So, it invests some money (equal to 10 carbon credits) in developing countries and LDCs to build clean energy infrastructure like solar plants, wind farms, etc. and will make up for its 10 lost carbon credits and avoid penalties.

## Carbon Credits Trading (Carbon/Emission Trading)

### Carbon credit

- A carbon credit (a **carbon offset**) is a **tradable certificate or permit**. **One carbon credit is equal to one tonne of $CO_2$**. Carbon credits can be acquired through **afforestation**, **renewable energy**, **$CO_2$ sequestration**, **methane capture**, **buying from an exchange (carbon credits trading)**, etc.

### Carbon trading

- Carbon trading is the name given to the **exchange of emission permits (carbon credits)**. This exchange may take place within the economy or may take the form of an international transaction.
- Under the Carbon Credits Trading mechanism, **countries that emit more carbon than the quota allotted to them buy carbon credits from those that emit less**.
- In Carbon trading, one credit gives the country or a company the right to emit one tonne of $CO_2$. A developing nation, such as **India**, **turns out to be a seller of such credits**.
- Carbon credits are traded at various exchanges across the world. **The Multi-Commodity Exchange of India** launched futures trading in carbon credits in 2009.

### Types of Carbon Trading

1. **Emission trading**
2. **Offset trading**

***Emission Trading/Cap-and-Trade***

- **Sell/purchase:** emissions trading **allows countries to sell unused emission units to countries that have exceeded their targets**.

***Offset Trading/Carbon Project/'baseline-and credit'***

- **Create:** a country can earn a carbon credit by **investing some amount of money** in projects, known as **carbon projects**, which will emit a lesser amount of GHGs into the atmosphere.

## Joint Implementation (JI) – Kyoto Protocol

- The mechanism known as "**joint implementation**" **allows a country with an emission reduction commitment** under the Kyoto Protocol **(Annex B Party)** to earn emission reduction units (ERUs) from **an emission-reduction project in another Annex B Party**, each equivalent to one tonne of $CO_2$.
- Joint implementation offers Parties a **flexible** and **cost-efficient** means of fulfilling a part of their Kyoto commitments, while the host Party benefits from **foreign investment** and **technology transfer**.

**[UPSC 2011-12] Regarding "carbon credits", which one of the following statements is not correct?**

a) The carbon credit system was ratified in conjunction with the Kyoto Protocol.
b) Carbon credits are awarded to countries or groups that have reduced GHGs below their emission quota.
c) The goal of the carbon credit system is to limit the increase of carbon emission quota.
d) Carbon credits are traded at a price fixed from time to time by the United Nations Environment Programme.

**Explanation**

- Carbon credit prices are traded on an exchange. So, their prices are never fixed.

***Answer d)***

### Issues with the Flexible Market Mechanisms (Carbon Markets)

- There are no measurable reductions in GHG emissions that can be attributed to carbon markets.
- The two most important carbon markets so far – the **EU Emissions Trading System (EU-ETS)** and the **UN's carbon offsetting scheme**, **Clean Development Mechanism (CDM)** – are failures.
- The EU-ETS power stations and factories have been allocated **more allowances (higher quota)** than they actually need due to intense industry lobbying.
- The influx of **cheap CDM carbon credits**, **particularly from China and India**, has driven down the price of carbon significantly, making it a negligible cost to industries. Consequently, there is **little incentive for investments in low-carbon technologies**.
- The carbon markets have been infested by **corruption and non-transparency**. In fact, carbon markets have created much income for consultants, carbon brokers, NGO professionals, etc.

### Non-compliance of Kyoto and Penalties

- If a country does not meet the requirements for measurements and reporting, the **country loses the privilege of gaining credit through joint implementation projects**.
- If a country exceeds its emissions cap and does not try to make up the difference through any of the available mechanisms, it must make up the difference plus an **additional 30% during the next period**. The country could also be **banned** from participating in the **'cap and trade'** programme.

## Criticism of the Kyoto Protocol

- Under the Kyoto Protocol, **Annex 1** countries **can meet their targets by cutting emissions** or **buying unused allowances (carbon credits**, **carbon trading)** from other countries. This approach neglects long-term socio-economic costs, akin to only making half-hearted commitments.
- Kyoto Protocol is based on the "common but differentiated responsibility" approach to global warming. **Under CBDR**, **many countries were allowed to increase pollution**.
- It excluded most polluting countries, such as China and India, which have since become the world's largest and fourth-largest polluters, respectively.

## Proposed: Carbon Tax as An Alternative to Carbon Trading

- A **carbon tax imposes a tax on each unit of GHG emissions** and **gives countries an incentive to reduce pollution whenever doing so would cost less than paying the tax**. A carbon tax is proposed in many developed and developing countries. The proposal has faced severe political resistance (politician – corporate nexus; people fear more burden).

### (Proposed) Differential Global Carbon Tax (DGCT)

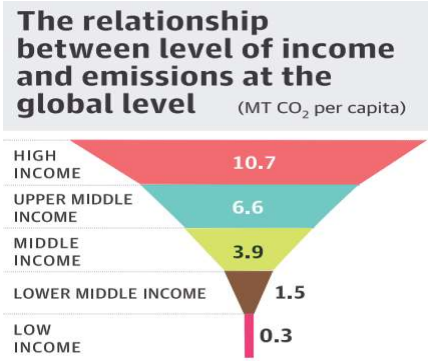
- Similar to **"**Common but Differentiated Responsibilities" under the Kyoto Protocol, **DGCT would put higher obligations on countries with higher per capita emissions**.
- Those countries that emit more than the global per capita average would pay a **transition fund** as part of the energy transition to those who are below this average.
- Thus, **those who suffer from climate injustice are duly compensated**, and the entire world transitions to a greener earth as a result of this carbon tax sharing process.

## (Proposed) Finance Energy Transition (FET – similar to DGCT)

- Currently, the global average of carbon emissions is **4.97 metric tonnes per capita**. All the countries with emissions above this level (**~68 in all**) are **payers** to **Finance Energy Transition (FET)** for **beneficiary countries** (135 in number) that are emitting below this level.
- The total amount of **carbon compensation** made by the payer nations would be **around $570 billion**. The distribution of the amount across the **payer countries** is based on their distance from the global average (i.e., based on how high their emissions are in comparison to the global average). In the case of **compensated countries**, the distribution of this fund across them is based on how much they lower their emissions in comparison to the global average.

## The Need for A Differential Global Carbon Tax

- If the emission targets are not met, **tropical regions** (mainly concentrated in the **global South**) are likely to be most negatively affected because of their pre-existing high temperatures. Some impact of this was already felt during the **Tamil Nadu water crisis in 2019**.
- The **global South**, **whose historical and present per capita emissions are much lesser than the global North**, happens to be at the receiving end of the **lifestyle choices made by the global North**. Thus, **the burden of adjustment cannot be equal** when the underlying relationship between the two worlds has been unequal (**climate injustice funnel**).
- A just approach would involve **global responsibility sharing among countries according to their respective shares in global emissions** (**similar to CBDR)**.
- Currently, the most accepted model of mitigating strategy has been the **carbon trading process**. However, the carbon trading process has its limitations, and hence, there is a need for an **alternate approach**, such as a **differential global carbon tax**.



## Is Differential Global Carbon Tax a Globally Just Policy?

- The **top 'payer' countries** in terms of absolute amounts of transfers are the **U.S**. and **China** since their emissions are higher than the global average. In terms of **'compensated' countries**, India comes at the top due to its population size and distance from the global emissions average (**India has per capita emissions of 1.73 metric tonnes**). The other prospects are all countries from the global South.
- The list includes a few surprises, such as **France**, **Sweden**, and **Switzerland**, which means that even **high-income countries that have kept their per capita emissions low are beneficiaries of this (globally just) policy**.
- With China on the first list and some of the first-world countries on the second, DGCT wants all nations to climb down the emissions ladder. **It is a global green Robin Hood tax!**

***[UPSC 2014] Should the pursuit of carbon credit and clean development mechanism set up under UNFCCC be maintained even through there has been a massive slide in the value of carbon credit? Discuss with respect to India's energy needs for economic growth.***

## Carbon Tax vs. Carbon Trading (Cap-and-Trade): Which is Better?

| Carbon Tax (price instrument) | Carbon Trading (quantity instrument) |
|---|---|
| A pure carbon tax **fixes the price of carbon** but allows the **amount of carbon emissions to vary**. | A pure carbon cap **places a limit on carbon emissions**, letting the **market price of carbon credits vary**. |
| A carbon tax directly establishes a price on GHGs. (**One has to pay for every ton of emissions**) | The Carbon Trading program issues a set number of **emissions "allowances"** each year. (**One has to pay only after they exceed their emissions quota**) |
| Carbon tax provides **certainty about the price being paid** for each unit of carbon dioxide emitted, but **uncertainty remains about the actual quantity of emissions**. | Cap-and-trade provides **certainty about the quantity of emissions** (it cannot exceed the cap) but **uncertainty about the cost** of achieving these reductions. |
| It offers **stable carbon prices** so energy producers and entrepreneurs can make investment decisions without fear of fluctuating regulatory costs. | The **regulatory costs always fluctuate**, and hence, making investment decisions is fraught with risks. |
| • Both policies encourage investors and entrepreneurs to develop **new low-carbon technologies**. Both policies **generate government revenue** that can be used productively. Some economists **recommend a hybrid model** that may offer the best of both worlds. This tends to comprise a cap on emissions (**to regulate the quantity of pollution**) but with adjustments, such as a carbon price floor or ceiling, **to keep the price of a permit within acceptable bounds**. | |

## India has a Sort of Carbon Tax

- Budget of 2010-11 introduced a **Clean Energy Cess of Rs. 50 per tonne** on **both domestically produced and imported coal**. Later, it was increased to **Rs. 100**. With the introduction of the Goods and Service Tax (GST), the **Clean Energy Cess was abolished**. A new cess on coal production, called the **GST Compensation Cess of Rs. 400 per tonne**, is put in place. This cess is used to raise revenues for the **National Clean Energy Fund**.

**National Clean Energy Fund (NCEF)**

- NCEF is a fund created in 2010-11 to **allocate Clean Energy Cess (later GST Compensation Cess)** for funding research and innovative projects in **clean energy technologies** of public or private sector entities, **up to the extent of 40% of the total project cost**.
- Assistance is available as a loan or viability gap funding, as deemed fit by the Inter-Ministerial group. These projects include innovative schemes like the **Green Energy Corridor** to boost the transmission sector and the **Jawaharlal Nehru National Solar Mission** (JNNSM).
- The Fund is designed as a **non-lapsable fund under Public Accounts** and with its secretariat in the Department of Expenditure, Ministry of Finance.

**[UPSC 2023] Consider the following statements:**

1. Statement-I: Carbon markets are likely to be one of the most widespread tools in the fight against climate change.
2. Statement-II: Carbon markets transfer resources from the private sector to the State.

***Which one of the following is correct in respect of the above statements?***

a) Both Statement-I and Statement-II are correct and Statement-II is the correct explanation for Statement-I
b) Both Statement-I and Statement-II are correct and Statement-II is not the correct explanation for Statement-I
c) Statement-I is correct but Statement-II is incorrect
d) Statement-I is incorrect but Statement-II is correct

**Explanation**

***Statement 1 is speculative and not definitive and it is correct***

- By the end of 2021 more than 21% of the world's emissions were covered by some form of carbon pricing, up from 15% in 2020. Since the prospects of carbon tax looks elusive, carbon trading will remain a crucial instrument.

***Statement 2 is correct but is not the right exaplanation for statement 1***

- In any kind of a market transaction, resources are transferred from the private sector to the states by the means of tariffs. Since there are no definitive worlds like "only", the statement remains open-ended.

***Answer: b)***

## 21.7. UNFCCC Summits Post Kyoto

- After the Kyoto Protocol, parties to the Convention have agreed to further commitments.

***CCC ➔ Climate Change Conference***

***CMP ➔ Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol***

| UNFCCC Summits Post Kyoto |
|---|
| 1. Montreal (Canada) CCC 2005 (COP 11; CMP 1) |
| 2. Nairobi (Kenya) CCC 2006 (COP 12; CMP 2) |
| 3. Bali (Indonesia) CCC 2007 (COP 13; CMP 3) |
| 4. Poznan (Poland) CCC 2008 (COP 14; CMP 4) |
| 5. Copenhagen (Denmark) CCC 2009 (COP 15; CMP 5) |
| 6. Cancún (Mexico) CCC 2010 (COP 16; CMP 6) |
| 7. Durban (Denmark) CCC 2011 (COP 17; CMP 7) |
| 8. Doha (Qatar) CCC 2012 (COP 18; CMP 8) |
| 9. Warsaw (Poland) CCC 2013 (COP 19; CMP 9) |
| 10. Lima (Peru) CCC 2014 (COP 20; CMP 10) |
| 11. **Paris (France) CCC 2015 (COP21; CMP11) or The Paris Summit** |
| 12. Marrakech (Morocco) CCC 2016 (COP22; CMP12; CMA1) |
| 13. Bonn (Germany) CCC 2017 (COP23; CMP13; CMA1-2) |
| 14. Katowice (Poland) CCC 2018 (COP24; CMP14; CMA1-3) |
| 15. Madrid (Spain) CCC 2019 (COP25; CMP15; CMA2) |
| 16. **Glasgow (UK) CCC 2021 (COP26; CMP16; CMA3)** |
| 17. **Sharm el-Sheikh (Egypt) CCC 2022 (COP27; CMP17; CMA4)** |
| 18. **Dubai (UAE) CCC 2023 (COP28; CMP18; CMA7)** |

## 21.8. Major Summits Before the 2015 Paris Summit

### Montreal (Canada) CCC 2005 (COP 11; CMP 1)

- The rulebook of the Kyoto Protocol was adopted.

### Bali (Indonesia) CCC 2007 (COP 13; CMP 3)

- The **Bali Road Map**, a two-year process aimed at finalising a binding agreement at COP 15 (2009), was adopted.
- The Bali Road Map includes the **Bali Action Plan**, guiding a new climate change negotiation process.
- The Bali Action Plan aims for full, effective, and sustained Convention implementation through **long-term cooperative action**, extending beyond 2012. The Plan is divided into five main categories: shared vision, mitigation, adaptation, technology and financing.

### Poznan (Poland) CCC 2008 (COP 14; CMP 4)

- It launched the **Adaptation Fund** under the Kyoto Protocol. The Fund is financed partly by the government and private donors and also from a **2% share of proceeds of Certified Emission Reductions (CERs)** issued under **Clean Development Mechanism** projects.

## Copenhagen (Denmark) CCC 2009 (COP 15; CMP 5)

- The **Copenhagen Accord** included the **goal of limiting the maximum global average temperature increase to no more than 2°C above pre-industrial levels**, subject to review in 2015.
- Developed countries promised to provide US$30 billion for the period 2010-2012 and to mobilise long-term finance of a further **US$100 billion a year by 2020**.

## Cancún (Mexico) CCC 2010 (COP 16; CMP 6)

- Parties **agreed to commit to a maximum temperature rise of 2°C above pre-industrial levels** and **to consider lowering that maximum to 1.5°C** in the near future.
- Parties agreed to establish a **Green Climate Fund (GCF)** to finance projects, programmes, policies and other activities in developing countries via thematic funding windows.
- They also agreed to include **carbon capture and storage (CCS)** in the projects under the **Clean Development Mechanism (CDM)**, subject to technical and safety standards.

### Green Climate Fund (GCF)

- GCF has been designated as an operating entity of the **financial mechanism of the UNFCCC**.
- The decision to set up the GCF was taken at **COP 16 in Cancun (2010)**.
- It was operationalised in **COP 17 in Durban (2011)**.
- It is headquartered in **Songdo**, **Incheon City**, **Republic of Korea**.
- It is a mechanism to **redistribute money from the developed to the developing world**. GCF will help developing countries financially in adapting mitigation practices to counter climate change. It is intended to be the centrepiece of efforts to raise **Climate Finance of $100 billion a year by 2020**.

## Durban (Denmark) CCC 2011 (COP 17; CMP 7)

- Decided to adopt a universal legal agreement on climate change no later than 2015.
- The **second phase of the Kyoto Protocol was secured**.
- Approved the Governing Instrument for the **Green Climate Fund (GCF)**.

**[UPSC 2015] Which of the following statements regarding 'Green Climate Fund' is/are correct?**

1) It is intended to assist the developing countries in adaptation and mitigation practices to counter CC.
2) It is founded under the aegis of UNEP, OECD, Asian Development Bank and World Bank

***Select the correct answer using the code given below.***

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

**Explanation**

- GCF is founded under the aegis of **UNFCCC COP**

***Answer: a) 1 only***

## Doha (Qatar) CCC 2012 (COP 18; CMP 8)

- COP18 reached an **agreement to extend the life of the Kyoto Protocol**, which had been due to expire at the end of 2012, until 2020 (**second commitment period 2013-20**).
- The extension of the Kyoto Protocol until 2020 **limited in scope to only 15% of the global $CO_2$ emissions**. This was due to the lack of participation of **Canada**, **Japan**, **Russia**, **Belarus**, **Ukraine**, and **New Zealand** (they refused to join the second commitment period of the Kyoto Protocol) and the **US (never ratified the Kyoto Protocol)**. Also, **developing countries** like **China**, **India** and **Brazil** are **not subject to emission reductions** under the Kyoto Protocol.

## Warsaw (Poland) CCC 2013 (COP 19; CMP 9)

- The term **Intended Nationally Determined Contributions (INDC)** was coined in Warsaw.
- The **Warsaw Mechanism** was proposed, which would provide expertise, and possibly aid, to **developing nations to cope with loss and damage from natural extremities** such as heatwaves, droughts and floods and threats such as rising sea levels and desertification.

### Intended Nationally Determined Contributions (INDC)

- During the **Warsaw Summit 2013 (COP 19)**, countries agreed to publicly outline **what actions they intended to take** under a global agreement well before the Paris Summit 2015. These country commitments are known as Intended Nationally Determined Contributions (INDCs).
- **Drawback:** Since the INDCs are **'nationally determined'** and **voluntary**, the **level of ambition in making 'contributions' is likely to be low**.

## Lima (Peru) CCC 2014 (COP 20; CMP 10)

- The conference's overarching goal is to reduce GHGs and **limit the global temperature increase by 2030 to 2°C above the 1850 baseline or pre-industrial era**.
- The agreement **urged parties to take national pledges by finalising their INDCs by 2015** (before the Paris Summit).

## India's INDC Objectives

- **India's three INDC objectives** were announced in **2015** (ahead of COP21).
  1. **Reduce the emissions intensity of its GDP by 33-35% by 2030**, below 2005 levels.
  2. Achieve **40%** of its **total electricity capacity from renewables**.
  3. Create an **additional carbon sink of 2.5 to 3 billion tonnes of $CO_2$ through afforestation** by 2030.

### Money required to meet India's INDC

- At least **USD 2.5 trillion** is required between 2015-30 to implement all planned actions.
- **Cess on coal** is being used to fund clean energy projects through the **National Adaptation Fund**.
- **Tax-free infrastructure bonds** were introduced to fund renewable energy projects.

***Tax-free infrastructure bonds***

- A bond is an instrument to borrow money. Infrastructure bonds are borrowings to be invested in government-funded infrastructure projects. Governments, authorised infrastructure companies, or non-banking financial companies issue them. Investments up to Rs. 20000 are eligible for income tax deduction under the Income Tax Act.

***National Adaptation Fund on Climate Change (NAFCC)***

- Budget 2015 introduced the central sector scheme "**National Adaptation Fund**" for climate change. **Money obtained from coal cess** goes into NAFCC.
- **Objective: Assist States and UTs** that are **particularly vulnerable to the adverse effects of climate change** in meeting the cost of adaptation.
- The **National Bank for Agriculture and Rural Development (NABARD)** is the National Implementing Entity responsible for the implementation of adaptation projects under the NAFCC.

⇨ ***National Clean Energy Fund (NCEF) ➔ Funds technology***

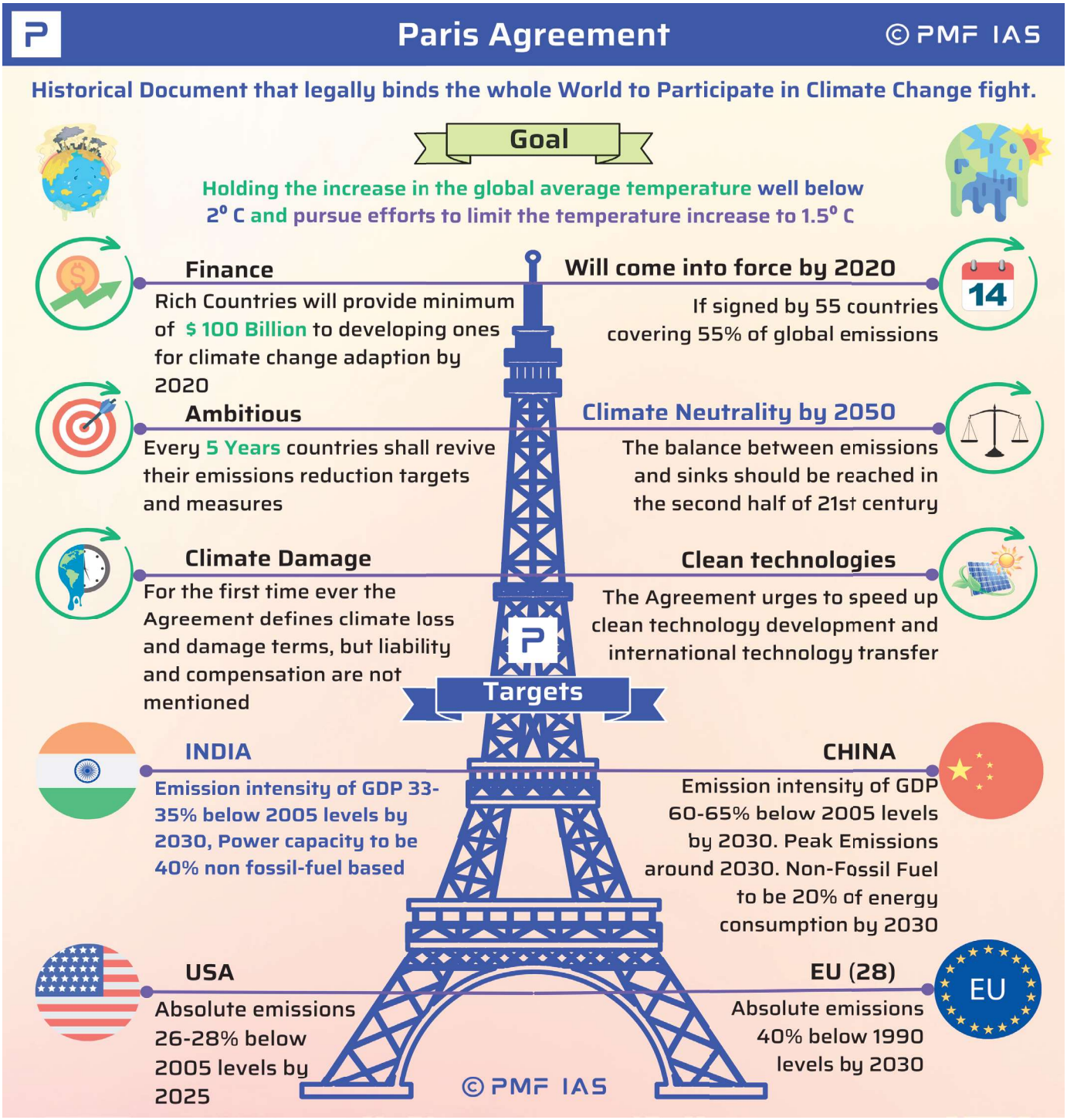
⇨ ***National Adaptation Fund ➔ Funds adaptation***

## Developed vs. Developing

- The US and EU urge developing countries to make deeper emission cuts, citing rising emissions. India accuses them of diluting the earlier envisioned CDR principle.
- India maintains that developed countries should bear a larger burden, given their initial responsibility for the issue. India confirmed that poverty alleviation would continue to be its primary concern, so it will not compromise with its share of carbon credits.

**---------- End of Chapter ----------**

# 22. International Environmental Conventions and Laws – Part II




## 22.1. Paris CCC 2015 (COP 21; CMP 11)

- The Paris Summit 2015 is the most crucial conference post-Kyoto because of the **INDC commitments made by major polluters**. The conference's objective is to achieve a **legally binding and universal agreement on climate change that will be implemented by 2020**.

- Before the conference, 146 national climate panels presented draft INDCs. Unlike the Kyoto Protocol, the Paris Agreement **didn't include detailed timetables or country-specific emission goals**.

## Paris Agreement

- The Paris Agreement is a **legally binding** **international treaty on climate change**.
- It was adopted by 196 Parties at the COP21 in Paris (France) in **2015**.
- It entered into force in **2016** after ratification by 55 countries that account for at least 55% of global emissions **India signed and ratified in 2016**.

> ⇨ ***Ratification:*** *Once the treaty has been signed, each state will deal with it according to its own national procedures. After approval has been granted under a state's own internal procedures, it will notify the other parties that* ***they consent to be bound by the treaty****. This is called ratification.*

- The agreement set a **goal of limiting global warming to well below 2°C compared to pre-industrial levels**. The agreement calls for **zero net anthropogenic GHG emissions** to be reached during the second half of the 21st century.
- The parties will also **pursue efforts to limit the temperature increase to 1.5 °C**. This **will require zero emissions sometime between 2030 and 2050**.
- The developed countries reaffirmed the commitment to mobilise **$100 billion a year** in climate finance by 2020 and agreed to continue it further **until 2025**.
- In 2017, the **US announced its withdrawal from the Paris Agreement**, and it remained a signatory until November 2020.

## Climate Neutral Now

- **Climate Neutral Now** was launched by the UNFCCC secretariat in 2015.
- It aims to encourage and support all levels of society to take climate action **to achieve a climate-neutral world** by the mid-century, as enshrined in the **Paris Agreement**.
- Climate neutrality is a three-step process, which requires individuals, companies and governments to:
  1. Measure their climate footprint
  2. Reduce their emissions as much as possible
  3. Offset what they cannot reduce with UN-certified emission reductions

**[UPSC 2016] With reference to the Agreement at the UNFCCC Meeting in Paris in 2015, which of the following statements is/are correct?**

1) The Agreement was signed by all the member countries of the UN and it will go into effect in 2017.
2) The Agreement aims to limit the greenhouse gas emissions so that the rise in average global temperature by the end of this century does not exceed 2 °C or even 1.5 °C above pre-industrial levels.
3) Developed countries acknowledged their historical responsibility in global warming and committed to donate $ 1000 billion a year from 2020 to help developing countries to cope with climate change.

***Select the correct answer using the code given below.***

a) 1 and 3 only
b) 2 only
c) 2 and 3 only
d) 1, 2 and 3

**Explanation**

- Paris Agreement entered into force in **November 2016**.

***Answer: b) 2 only***

**[UPSC 2018] Momentum for Change: Climate Neutral Now" is an initiative launched by**

a) The Intergovernmental Panel on Climate Change
b) The UNEP Secretariat
c) The UNFCCC Secretariat
d) The World Meteorological Organisation

**[UPSC 2016] The term 'INDC' is sometimes seen in the news in the context of**

a) pledges made by the European countries to rehabilitate refugees from the war-affected Middle East
b) plan of action outlined by the countries of the world to combat climate change
c) capital contributed by the member countries in the establishment of Asian Infrastructure Investment Bank
d) plan of action outlined by the countries of the world regarding Sustainable Development Goals

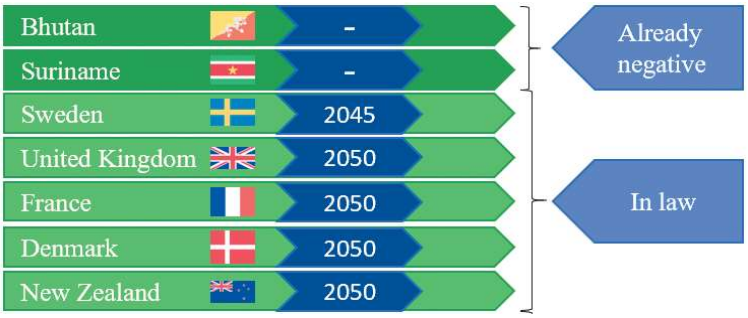
## China-U.S. Deal on Emission Cuts

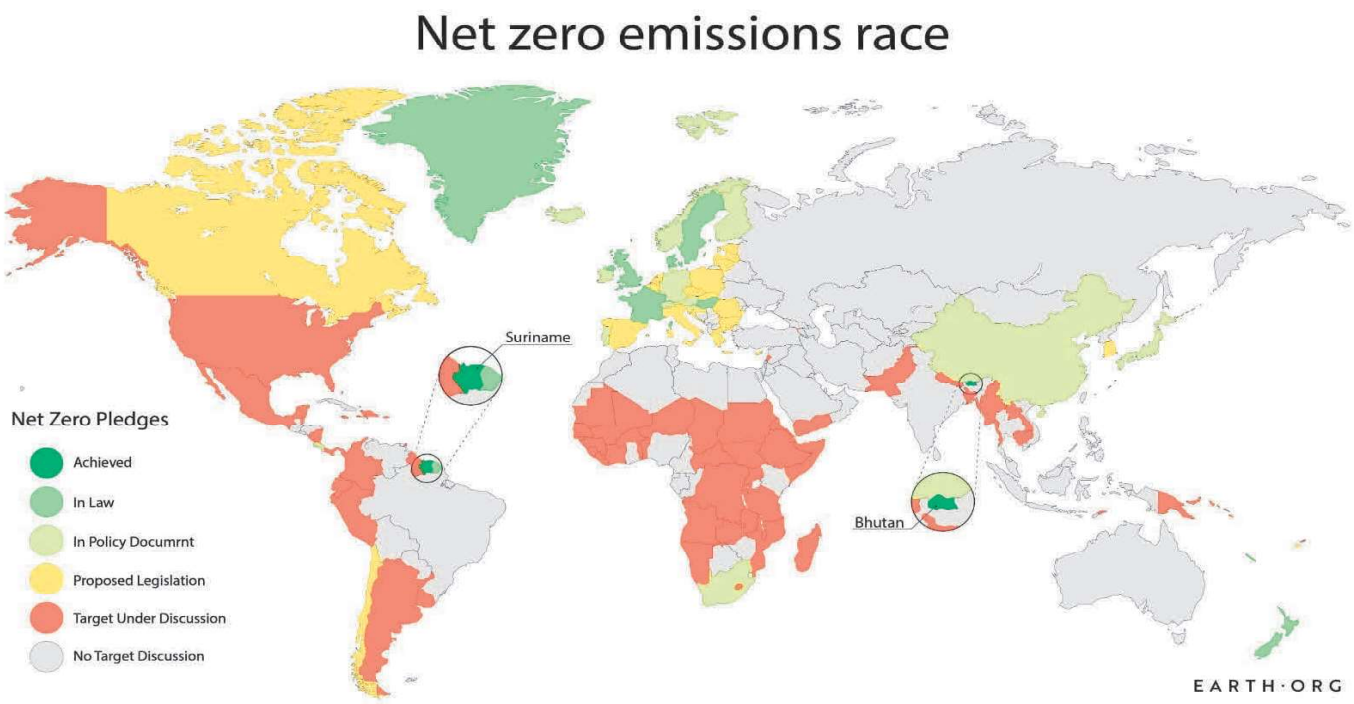
- Before the summit, China and the US agreed on a **timetable to limit GHG emissions**. The US agreed to reduce its emissions by 2025 by 26- 28% below their 2005 level. China stated its intent to peak $CO_2$ emissions in 2030 (from 2030, it will start reducing its emissions).
- It also agreed to raise the **share of non-fossil fuels to 20% in the next 16 years**.
- **India's per capita emissions** are estimated at **1/10$^{th}$ of the US** and **1/4$^{th}$ of China**. China-US deal has imposed **fresh pressure on India to make a voluntary commitment**.

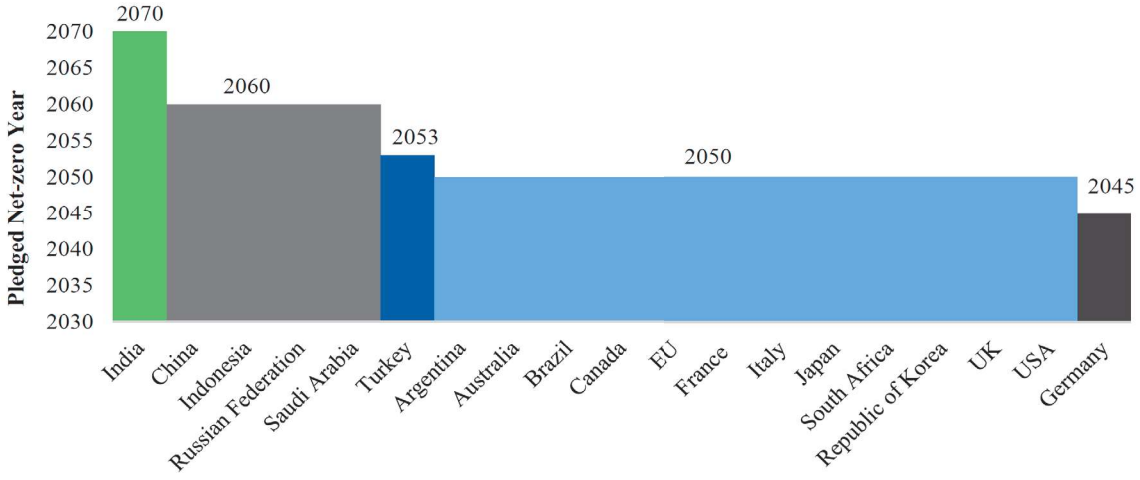
## Net Zero Emissions and Carbon Neutrality

- **Net zero** means the amount of **GHGs emitted into the atmosphere is less than the amount taken out**. **Carbon Neutrality (Net Zero Carbon Footprint)** refers to **achieving net zero $CO_2$ emissions**.
- Global GHG emissions need to be **cut by 45% by 2030** and **become net zero by 2050 to keep warming below 1.5°C**. For this, the world **must stop using coal** for its energy needs and shift completely towards **renewables**.

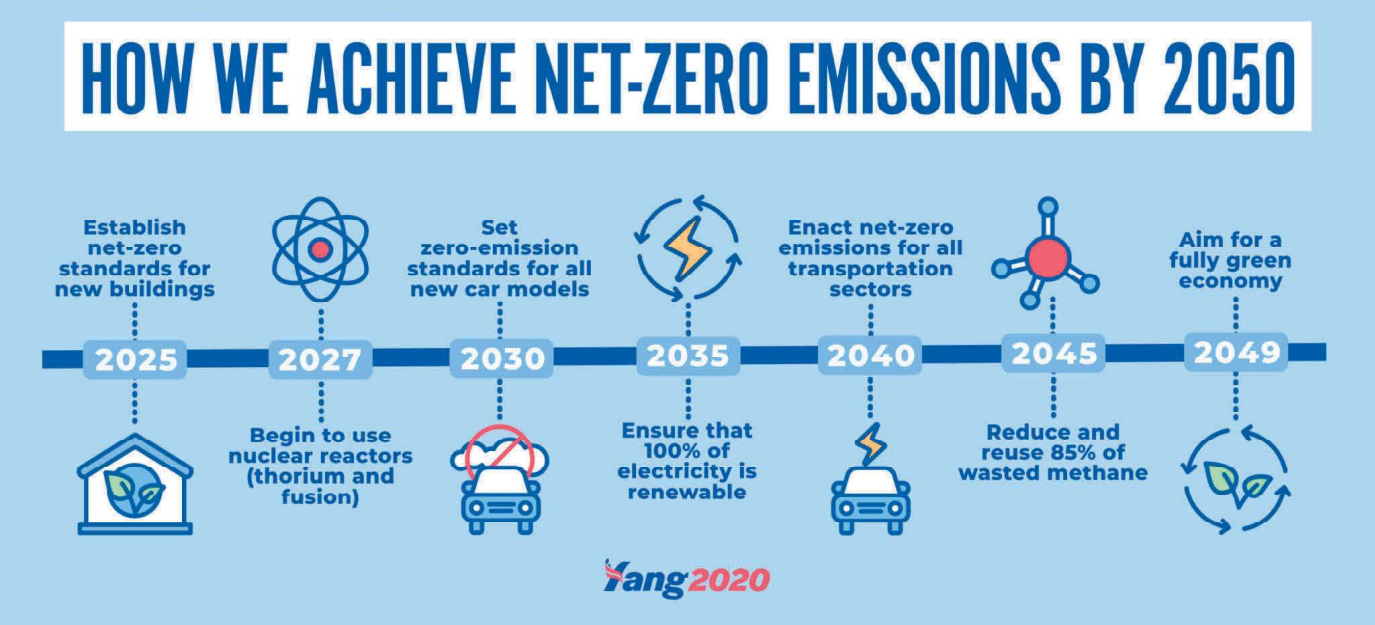
- Some countries have already announced their intention to achieve the net zero target, but the most prominent emitters—**China**, **the US**, and **India**—**have not yet done so**.
- Of the five developed countries with **national net zero legislation** — **Sweden**, **Norway**, **UK**, **France** and **New Zealand** — **only Sweden aims to become net zero before 2050**.
- **Suriname** and **Bhutan** are the only countries that have achieved **Carbon Neutrality** **(Net Zero Carbon Footprint — GHGs emitted into the atmosphere is less than the amount taken out**).



## How can Net Zero Emissions be Achieved?




- ✓ **Clean coal technology** to reduce $CO_2$ in the atmosphere (short-term measure)
- ✓ **Carbon sequestration** (long-term sustainable measure)
- ✓ **Afforestation**: Forests as carbon Sinks (long-term sustainable measure)
- ✓ **Geoengineering** to fight climate change (last resort superhuman options)
- ✓ **Electric Mobility** and **Renewable Energy** (prevention is better than cure option)
- ✓ **Carbon Trading and Carbon Tax** (long-term measure)
- ⇨ To contain carbon emissions, UNFCCC summits have arrived at the **"polluter pays" principle** by **placing a price on carbon dioxide and other greenhouse gas emissions**.
- ⇨ The "polluter pays" principle can be implemented through a **Carbon Tax** or **Carbon Trading**.

## European Green New Deal

- In its climate action plan declared under the **Paris Agreement**, the **EU** committed to **reducing its emissions by 40% by 2030** compared to 1990 levels.
- Through the **European Green New Deal**, the EU has promised to increase the 2030 emission reduction target to at least 50% (climate neutrality or zero emissions by 2050) and work towards 55%.
- Even at 40%, the EU had the most ambitious reduction targets among the developed countries.

## India's Objection to Net Zero

- India's basic argument is that **net zero goals do not figure in the 2015 Paris Agreement**. The Paris Agreement **only requires every signatory to take the best climate action it can (INDC)**.
- India argues that instead of opening up parallel discussions on net zero targets outside the Paris Agreement, **countries must focus on delivering what they have already promised**.

- India, as a developing country, needs to **achieve higher economic growth**. Most **carbon removal technologies** are **unreliable or very expensive**. With an increase in India's growing energy demands, **net zero emissions in the immediate future is impossible**.
- **India** is already **well on its way to over-achieve its 3 targets** under the **Paris Agreement**.


## UNEP Emissions Gap Report

- The UNEP releases the **Emissions Gap Report (EGR) annually**.
- The UNEP Copenhagen Climate Centre manages the flagship report.

- EGR measures the **gap** **between what we need to do and what we are actually doing** to tackle climate change and keep the earth's temperature within the **Paris Agreement**.

## Findings from the EGR 2022

- Current policies point to a 2.8°C temperature rise by the end of the century. Implementation of the current pledges will only reduce this to a 2.4-2.6°C temperature rise by the end of the century.
- The NDC pledges only to reduce the emissions by 1% by the decade's end.
- While other sectors dominate the global climate action plans, food systems are neglected.
- In 2020, the top seven emitters (China, the EU27, India, Indonesia, Brazil, the Russian Federation, and the US), plus international transport, accounted for 55% of global GHG emissions.
- Collectively, G20 members are responsible for 75% of global GHG emissions.
- The global average per capita GHG emissions was 6.3 tonnes of CO2 equivalent ($tCO_2e$) in 2020.
- India remains far below the world average at 2.4 $tCO_2$.

## Findings of the EGR 2023

### Temperature Rise

- With current climate policies, the world will become **warmer by 3°C** by the **end of the century**.
- There is only a 14% chance of limiting global warming to 1.5°C even in most optimistic scenarios.

### Global GHG emissions

- Global GHG emissions increased by 1.2% from 2021 to 22, setting a new record of 57.4 gigatons of CO2 equivalent ($GtCO_2e$).
- The primary contributor to this increase is emissions from **fossil fuels** and **industrial processes**.
- Except for transport, all sectors have **recovered from the emission decline** caused by the **COVID-19 pandemic** and have now surpassed 2019 levels.

### Unequal Emission Across Countries

- **China**, the **US**, and the **EU** are the **largest emission contributors**, while the **least developed countries** contributed only **3 to 4%**.
- Globally, **10% of the population** with the highest income accounted for **48% of emissions**.

### Lack of Commitment

- There has been negligible movement on Nationally Determined Contributions (NDCs), with only nine countries having submitted new or updated NDCs since COP 27.
- The number of net-zero pledges is increasing, but confidence in their implementation remains low.
- India has an **8% implementation gap** between **current policies** and **NDC pledges**.

## Suggestions by the Emissions Gap Report 2023

- **Low-Carbon Development:** Low-income countries should be supported in their clean energy transition while they strive for development.
- **Climate finance: Local**, **national**, or **transnational funding** from various sources (public, private, and **alternative**) to support actions addressing climate change through mitigation and adaptation efforts.
- **Exploring carbon dioxide removal (CDR) strategies:** It will be necessary, given that Net Zero emissions will be impossible without residual emissions being balanced out through removals.

## 22.2. Major Summits Post 2015 Paris Summit

### Marrakech (Morocco) CCC 2016 (COP22; CMP12; CMA1)

- COP22 was called "Action COP" or "**Agriculture COP**." The **Adaptation of African Agriculture** (AAA) was launched at COP 22, and FAO and various governments (esp. African) promoted it.

## 22.3. COP 26

***[UPSC 2021] Describe the major outcomes of the 26th session of the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC). What are the commitments made by India in this conference? (Answer in 250 words)***

- The 26th meeting of UNFCCC COP was held in 2021 in **Glasgow**, **UK**.
- It is the 3rd meeting of the parties to the 2015 Paris Agreement (**CMA3**) and the 16th meeting of the parties to the Kyoto Protocol **(CMP16**).
- Its main task was to **finalise the rules and procedures for implementing the Paris Agreement**.
- The Paris Agreement states that **every 5 years**, **parties must set out increasingly ambitious climate action**. This meant that, by 2020, countries needed to submit or update their plans for reducing emissions, known as **Nationally Determined Contributions (NDCs)**.

### The Glasgow Climate Pact

- The **Glasgow Climate Pact** is an agreement reached at COP26. It recognises the enormous **importance of the IPCC's latest reports**. It reaffirms the Paris Agreement's goal of keeping the global average temperature **well below 2°C above pre-industrial levels** and pursuing efforts to **limit the temperature increase to 1.5 °C above pre-industrial levels**.
- To secure **global net zero emissions by mid-century (2050)**, it has asked countries to strengthen their 2030 climate action plans, or **NDCs**, by 2022.
- It asked countries to reduce the usage of coal as fuel, i.e., **Phase Down of Coal**, **not Phase Out**.
- It has also asked countries to **abolish "inefficient" subsidies on fossil fuels**.
- It has asked the developed countries to fulfil their past commitments and arrange **$100 billion every year till 2025**.

- It has established a **"Glasgow Dialogue"** to discuss funding arrangements in accordance with the **loss and damage provision** in the Paris Agreement, which seeks to address climate change disasters.
- It welcomed the **operationalisation** of the **Santiago network** to avert, minimise, and address loss and damage associated with the adverse effects of climate change.

## Carbon Markets

- A **carbon market existed under the Kyoto Protocol** but is no longer there because the Protocol itself **expired in 2020**. A new market under the Paris Agreement is yet to be functional.
- Developing nations like India, China, and Brazil hold significant surplus carbon credits due to decreased demand, as many countries have abandoned their emission reduction targets.
- **Developing nations** sought to **transition their unused carbon credits to the new market**, which is opposed by developed nations, causing a deadlock in finalising Paris Agreement procedures.

### What Does the Glasgow Pact Say?

- The **Glasgow Pact** has **allowed unused carbon credits to be used to meet countries' first NDC targets**. However, these credits **cannot be used to meet targets in subsequent NDCs**. That means if a developed country wants to buy these credits to meet its targets, it **can do so until 2025**.

## Major Outcomes of COP26

- **COP26 finalised the Paris 'rulebook'**, resolving the critical outstanding political decisions needed for Parties to begin implementing the Paris Agreement.
- It signalled the start of a vital **stock-taking process** to assess the Parties' progress against the Paris goals on implementation over the **next two years**. It will **culminate in 2023 at the Global Stocktake**.

### Collaboration

- It recognises the vital role of non-party stakeholders, including civil society, indigenous peoples, nature, local communities, youth, children, etc.

#### Action for Climate Empowerment and Youth

- It agreed to a new 10-year **Glasgow work programme on Action for Climate Empowerment (ACE)**. It focused on advancing climate education, training, public awareness, etc. The most notable outcome is its **recognition of youth as critical agents of change**.

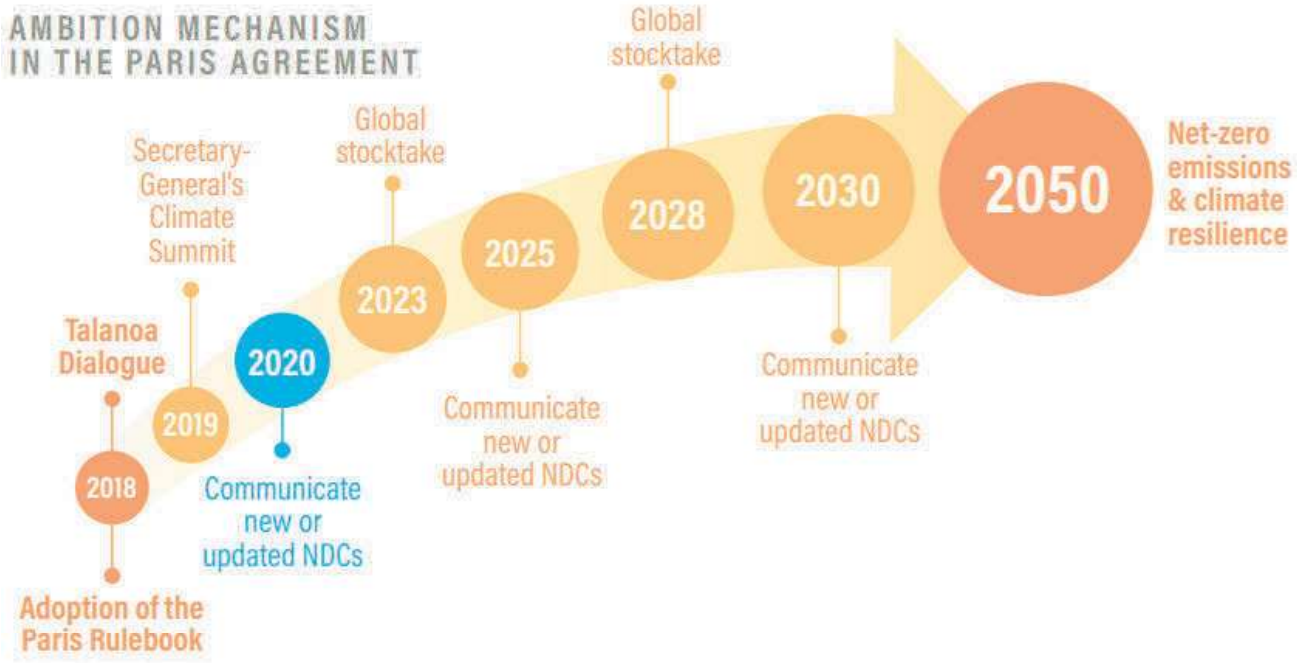
#### Gender

- At **COP25**, Parties agreed on a **5-year** enhanced **Lima work programme** on gender and its gender action plan. At COP 27, parties agreed to review the **Gender Action Plan** for 2022. The plan encourages Parties to increase women's meaningful and equal participation in climate action.

#### Marrakech Partnership

- At COP26, the **High-Level Champions** launched their five-year plan for the Improved Marrakech Partnership for Enhancing Ambition.
- The **Marrakech Partnership** is the space within the UN Climate Change body for **collaboration** between Parties, businesses, local governments, investors, and civil society.

## Paris Rulebook




- One of the key achievements of COP26 includes the finalisation of the "Paris Agreement rulebook".
- This set of rules lays out **how countries are held accountable for delivering on their climate action promises and self-set targets under their Nationally Determined Contributions** (NDCs).

### Article 6

- **Article 6.2** regulates bilateral and mini-multilateral markets by setting up conditions under which **carbon credits can be used to achieve a country's NDCs**.
- **Article 6.4** creates a centralised, global market — the **Sustainable Development Mechanism (SDM)**, which effectively succeeds the **Clean Development Mechanism (CDM)** under the **Kyoto Protocol**.
- With the introduction of SDM, the consensus was finally reached on the major political issues that had divided parties for many years: **how to avoid double-counting emissions reductions**, how to use unused Clean Development Mechanism (CDM) credits and adaptation finance.

## Global Methane Pledge

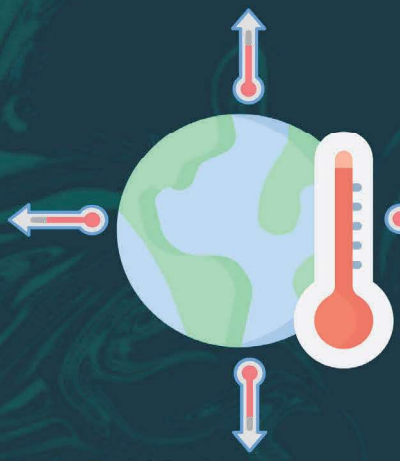
- Nearly 100 countries signed a **voluntary pledge**, the **Global Methane Pledge**, to cut methane emissions by **at least 30% by 2030 compared to 2020 levels**.
- **India is not a signatory** to this pledge.

13 CLIMATE ACTION

# COP 26

**26th COP** to the United Nations Framework Convention on Climate Change (**UNFCCC**)

16th Meeting of the Parties to the Kyoto Protocol (**CMP16**)



3rd Meeting of the Parties to the 2015 Paris Agreement (**CMA3**)

The **Glasgow Climate Pact** is an agreement reached at the COP26, adopted by **197 Countries**

## Outcomes

### Science & Urgency

ipcc
INTERGOVERNMENTAL PANEL ON climate change

- Parties wishes to fully **embed science** in the decision making.
- It recognizes the enormous importance of the **IPCC's Latest Report.**

1.5º

### Mitigation

- To secure Global Net-Zero Emissions by **Mid-Century (2050).**
- **Phase Down of Coal not Phase Out** (1st Climate Agreement explicitly planning to Reduce Unbated Coal Usage)
- Reaffirms the **Paris Agreement Temperature Goal.**
- To **strengthen their 2030 Climate Action Plans, or NDCs by 2022.**
- To **abolish "inefficient" subsidies on fossil fuels.**

## Adaption



- At least double the money for adaption by 2025 from the 2019 Levels.
- Two-Year work program to define a global goal on adaption.

## Finance


$100 Billion in Every year till 2025

## Loss and Damage


- Established a " Glasgow Dialogue" to discuss arrangements for funding.
- Operationalization of Santiago Network.

## Carbon Markets



Countries allowed to use Old carbon credits under Kyoto protocol mechanism to achieve their emissions on target till 2025

## Collborations


- Agreed a new 10-Year Glasgow Work Program on Action for Climate Empowerment (ACE)
- Review of Gender Action Plan launched in COP 25.
- 3 year workplan of Local Communities and Indigenous People Platform (LCIPP).
- High Level champions launched Marrakech Partnership.

## Implementation

COP26 finalized the Paris 'rulebook', resolving the key outstanding political decisions needed for Parties to begin implementing the Paris Agreement.

# What is Parallel Processes?

- It is not a part of the officials COP Discussions.
- They do not form part of the Final Agreed Outcome.

## India's Commitment - 5-Fold Strategy

**Panchamrit**

- 50% of India's Energy will be sourced from renewable energy sources.
- Reduction in Carbon Emissions until 2030 by a Billion Tonnes.
- To achieve a net zero emissions target by 2070.
- 500 GW of Renewable Energy to be installed by 2030.
- India shall also reduce its emissions intensity per unit GDP by less than 45%.

## Global Methane Pledge

- This pledge, if achieved, is estimated to avoid about 0.2 degree Celsius temperature rise by the middle of the century.
- Over 100 countries pledged to **reduce methane emissions by at least 30%** from present levels by 2030.
- India is not a signatory to this pledge.

## Enhanced Climate Actions by Other Countries

- Brazil, for example, said it would advance its net-zero target year from 2060 to 2050.
- China promised to come out with a detailed roadmap for its commitment to let emissions peak in 2030, and also for its 2060 net-zero target.
- Israel announced a net zero target for 2050.

## Glasgow Breakthrough Agenda

- Agenda endorsed by 42 countries (including India).
- To accelerate the development and deployment of clean technologies and sustainable solutions.

- A 30% reduction in methane emissions by 2030 is expected to avoid a **0.2° C** rise in temperature by 2050. It is essential to keep the temperature increase below the **1.5° C target** (Paris Agreement target).

### Enhanced Climate Actions by Other Countries

- Over 30 countries signed a declaration promising to work towards a **transition to 100% zero-emission cars by the year 2040**, at least in the world's leading markets.
- Brazil, for example, said it would advance its net-zero target year from 2060 to 2050. China promised to develop a detailed roadmap for its commitment to letting emissions peak in 2030 and for its 2060 net-zero target. Israel announced a net-zero target for 2050.

### Glasgow Breakthrough Agenda

- This agenda is endorsed by **42 countries (including India)**. This **cooperative effort** aims to speed up the adoption of **clean technologies** and sustainable solutions in areas like clean power, road transport, steel, and hydrogen.

#### Glasgow Finance Alliance for Net Zero (GFANZ)

- It brings together over 160 firms for leading **net zero initiatives** across the financial system to accelerate the transition to net zero emissions by 2050 at the latest. **The UN Race must accredit all GFANZ member alliances to the Zero campaign**. They must use science-based guidelines to reach net zero emissions, cover all emission scopes, include 2030 interim target setting, and commit to transparent reporting and accounting in line with the UN Race to Zero criteria.

## India at COP26

### India's Commitment – Five-Fold Strategy

- India announced the **five-fold strategy** termed **Panchamrit** to fight climate change at the COP26:
- **Two were upward revisions of existing NDC targets**, i.e., **emissions intensity** and **non-fossil fuel-based energy** targets.
- India revised its NDC targets as it was on its way to meeting existing goals before the 2030 deadline.
- Now, in 2023, both old NDC targets have been surpassed.
  1. ***50% of India's energy will be sourced from renewables* (previous NDC goal was 40%)**
  2. ***Reduction in carbon emissions by a billion tonnes by 2030***
  3. ***Reduce emissions intensity per unit of GDP by less than 45%* (previous NDC goal was 35%)**
  4. ***500 Gigawatt of renewable energy to be installed by 2030***
  5. ***To achieve a net zero emissions target latest by 2070***
- India has also given the slogan of **One LIFE**, **One World**, at Glasgow. The PM also called upon developed economies to make **$1 trillion** available for climate financing.

⇨ *India has **already achieved its target of 40%** installed electric capacity from non-fossil fuels ahead of 2030. It has advanced the **target to 50%**. The **National Hydrogen Mission** and **Green Hydrogen Policy** have been introduced to enable India to be **energy-independent by 2047**.*

⇨ *The 50% target will be achieved with the help of the transfer of technology and low-cost international finance, including from the **Green Climate Fund (GCF)**.*

### "Phase Down of Coal not Phase Out"

- The **Glasgow Climate Pact** states that the use of "**unabated coal should be phased down**", **not phase out**. Several countries had criticised India for making the wording weaker than the initial proposals, with the final text calling for only a **"phase down"** and not a **"phase out"** of coal.
- India adopted phased-down because coal phase-down will help expand the commercial viability of new technologies needed to **scale up renewable capacities**.

## Leader's Declaration on Forests and Land Use

- On the sidelines of COP26 climate negotiations, a declaration on Forests and Land Use was adopted.
- The declaration, **initiated by the UK**, aims to **"halt deforestation**" and **land degradation** by **2030**.
- In the plan, global leaders affirmed forests' role in balancing GHG emissions and removals, adapting to climate change impacts, and maintaining healthy ecosystem services.
- The declaration has over 105 signatories, including the **UK**, the **US**, **Russia** and **China**.
- **India**, **Argentina**, **Mexico**, **Saudi Arabia**, and **South Africa** are the only G20 countries that **did not sign the declaration**.

### Why didn't India sign the declaration?

- The declaration **interlinks trade to climate change and forest issues**. **Trade falls under the WTO and should not be included in climate change declarations**. India asked other nations to remove the word "trade," but other countries didn't agree, so India didn't sign the declaration.

## LiFE (Lifestyle for Environment)

- PM Modi launched **'Mission LiFE' (Lifestyle for Environment)** at **COP26**.
- Mission LiFE is an **India-led global initiative** to help the world in its fight against climate change and lead to a sustainable way of life to achieve sustainable development goals.
- It will encourage **individual and collective action** to protect and preserve the environment. It aims to **replace the 'use and dispose' economy with a circular economy of 'reduce**, **reuse**, **and recycle'**.
- The mission's basic principle is '**Lifestyle of the planet**, **for the planet and by the planet**'. Mission LiFE emboldens the spirit of the **P3 model**, i.e., **Pro Planet People**.

# 22.4. COP27

- The 27$^{th}$ meeting of UNFCCC COP was held in 2022 in **Sharm El-Sheikh**, **Egypt**.

- It is the 4th meeting of the parties to the 2015 Paris Agreement (**CMA4**) and 17th meeting of the parties to the Kyoto Protocol (**CMP17**).

## Global Shield Against Climate Risks Initiative

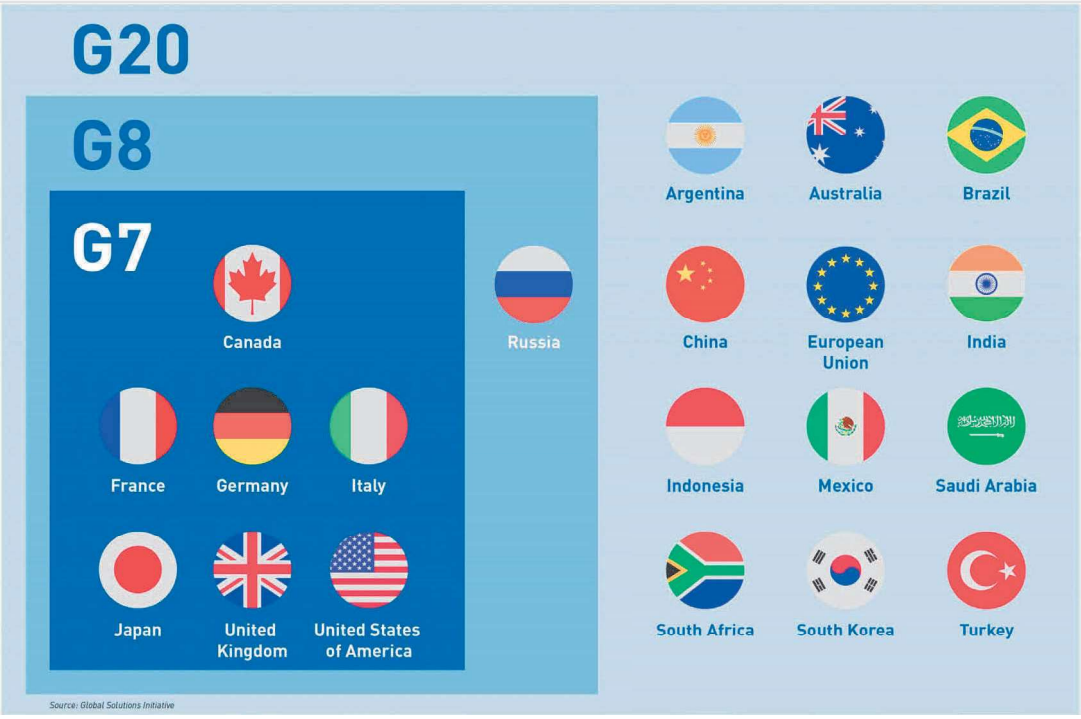
- The **Global Shield Against Climate Risks initiative**, launched at COP27, is a collaboration between the **V20 Group** and the **G7 countries**.
- The initiative will provide pre-arranged **financial support** designed to be **quickly deployed in times of climate disasters**, such as the devastating Pakistan floods in 2022.
- **Pakistan**, **Bangladesh**, Costa Rica, Fiji, Senegal, Philippines and Ghana will be the first countries to receive assistance from this initiative.

### Vulnerable Twenty (V20) Group

- **Vulnerable Twenty (V20) Group** of **Ministers of Finance** of the Climate Vulnerable Forum is a dedicated cooperation initiative of economies systemically **vulnerable to climate change**.
- V20 was established in Lima, Peru, in 2015. Its members are **58 climate-vulnerable countries**.

### Group of Seven (G7)

- G7 is an intergovernmental political forum consisting of **Canada**, **France**, **Germany**, **Italy**, **Japan**, **the UK** and the **US**. It is **not based on a treaty** and has no permanent secretariat. It is organised through a presidency that **rotates annually** among the member states. It meets annually to discuss issues of common interest like global economic governance, international security and energy policy. G7 countries account for over **half of global net wealth**, 32 to 46% of global GDP and 10% of the world's population.



## Illegal Wildlife Trade (IWT) and Climate Change

- The UN Office on Drugs and Crime (UNODC) released a paper during **COP27**. The paper stated that policymakers had overlooked the effects of **illegal wildlife trade (IWT)** on ecosystem services related to climate change (especially on carbon sequestration and storage).
- Trees belonging to the genus **Dalbergia** (e.g., **Indian Rosewood**) play a significant role in carbon sequestration and storage. Despite being protected in many countries, they are trafficked globally.
- **Ecosystem Engineers**, **African Forest Elephants** (declined by 86% in the last 30 years), **white rhinos** and **pangolins** **(the most trafficked animals globally)** are all in grave danger due to IWT.

⇨ Ecosystem Engineers are species that modify, create, and maintain habitats. They modify their habitats through their biology (autogenic engineers) or by physically changing biotic and abiotic factors in the environment (allogenic engineers).

- ✓ African forest elephants **reduce above-ground carbon** through grazing and disturbance. They influence nutrient transport and plant communities and can increase carbon stocks.
- ✓ White rhinoceros affect the carbon cycle through **soil compaction and disturbance** (**bioturbation**).
- ✓ Pangolins feed on **termites** and regulate their population. Termites, while decomposing things, release 1-3% of **natural** global annual emissions.

**Conservation Status of Ecosystem Engineers**

| Ecosystem Engineer | Conservation Status |
|---|---|
| **African Forest Elephants** | • IUCN Red List: **CR**<br>• CITES: **Appendix I** |
| **White Rhinoceros (Southern Africa)** | • IUCN Red List: **NT**<br>• CITES: **Appendix II** |
| **Pangolins**<br>• CITES: **Appendix I**<br>• WPA, 1972: **Schedule I** | • IUCN Red List:<br>• **Chinese Pangolin (CR)**<br>• **Indian Pangolin (EN)** |

## Long-Term Low-Emission Development Strategy (LT-LEDS)

- India submitted its **Long-Term Low Emission Development Strategy (LT-LEDS)** to the UNFCCC during COP27. LT-LEDS are **qualitative requirements** **emanating from** the **2015 Paris Agreement**.
- Under the 2015 Paris Agreement, countries must explain how they will transition their economies beyond achieving **near-term** **NDC targets** and work towards the larger climate objective of **cutting emissions by 45% by 2030** and **achieving net zero around 2050**.
- The Paris Agreement's signatories were obliged to submit the long-term document by 2022.

### India's Long-Term Low Emission Development Strategy (India's LT-LEDS)

- India's LT-LEDS is based on the following four considerations:

1. India's historical contribution to cumulative global GHG emissions is minuscule despite having a share of ~17% of the world's population.
2. India has significant energy needs for development.
3. India is committed to pursuing low-carbon strategies and is actively pursuing them.
4. India needs to build climate resilience.

- India's focus will be on the **rational utilisation** of resources with due regard to **energy security**. The transition from fossil fuels will be undertaken in a just, smooth, sustainable and inclusive manner.
- The strategy is to increase the use of **biofuels**, especially **ethanol** **blending in petrol (20% by 2025)**, **electric vehicles**, a **three-fold increase in nuclear capacity by 2032**, and **green hydrogen** to achieve low-carbon development in the transport sector.
- **Smart city initiatives**, which enhance efficiency, effective green building codes, and innovative waste management, will drive future sustainable and climate-resilient urban development.
- The focus will be on improving energy efficiency through the **Perform, Achieve and Trade (PAT) scheme**, the **National Hydrogen Mission**, the circular economy, and exploring options for hard-to-abate sectors (such as steel, cement, aluminium and others).

⇨ ***Ethanol blending in petrol:*** *Ethanol contains* ***oxygen*** *which* ***aids in complete combustion****. So, when petrol is blended with ethanol, the vehicle uses less fuel and releases less emission.*

⇨ ***Green hydrogen*** is hydrogen produced from **renewable power sources**.

⇨ ***Hard-to-abate sectors*** *are sectors where decarbonisation options are limited and more expensive in comparison to other sectors of the economy.*

## Loss and Damage Fund

- COP27 decided to establish and operationalise the **Loss and Damage Fund**. This fund will **assist poor and developing countries** that are **vulnerable to the adverse effects of climate change**. COP established this fund to **address the issue of climate reparations**.

### History of Loss and Damage

- Establishing liability and compensation for loss and damage has been a long-standing goal for vulnerable countries in the **Alliance of Small Island States (AOSIS)** and the **Least Developed Countries Group**.
- In 2009, developed countries agreed to provide **US$ 100 billion every year** starting in **2020** to help developing nations fight climate change. However, they are struggling to fulfil this promise.
- The **Warsaw International Mechanism** (WIM), established in 2013, is the **first formal recognition of compensating developing countries affected by climate disasters**.

## Methane Alert and Response System (MARS)

- **Methane Alert and Response System (MARS)** was launched during COP27. MARS is a **satellite-based monitoring system** for tracking **methane emissions** and alerting governments and corporations. It is an initiative to accelerate the implementation of the **Global Methane Pledge**.
- MARS is a platform set up as part of the **UNEP's International Methane Emissions Observatory (IMEO)**. It will be the **first publicly available global system** to provide methane emissions notification. It will be implemented with partners, including the **International Energy Agency** and the **UNEP**-hosted **Climate and Clean Air Coalition**.

### International Methane Emissions Observatory (IMEO)

- IMEO creates a **global public dataset of methane emissions** and interconnects this data with actions on research and regulation. It collects methane data from various public and private sources.
- **UNEP** launched it with support from the **European Union** at the **G20 Summit** in 2021.

### New Zealand to Tax Agricultural Emissions

- New Zealand recently planned to **tax agricultural emissions**, which includes those from **livestock** burps and waste, in an attempt to fulfil its promise "to price agriculture emissions from 2025".
- New Zealand is one of the world's largest exporters of dairy and meat products and is responsible for significant **biogenic methane and nitrous oxide emissions**; hence, a pricing mechanism will be introduced to achieve the emissions reduction target by 2050.

## Carbon Border Tax

- A carbon border tax is **a duty on imports based on the amount of carbon emissions resulting from the production of the product in question**.
- From 2026, the EU **plans to tax carbon-intensive products** like iron, steel, cement, fertiliser, aluminium, and electricity generation. This aims **to create fair competition for EU firms** against those operating in countries with lax environmental regulations.
- At COP27, the **BASIC group**, comprising **India**, **China**, **Brazil** and **South Africa**, **opposed carbon border tax** as it goes **against the principle of Common But Differentiated Responsibility (CBDR)** enshrined in the Paris Agreement.

# 22.5. COP28

- The 28th meeting of the UNFCCC COP was held in November 2023 in **Dubai**, **UAE**. **It was the 5th meeting of the parties to the 2015 Paris Agreement (CMA5)** and the **18th meeting of the parties to the Kyoto Protocol (CMP18)**.

## Key Highlights of the COP28

### Global Stocktake

- COP 28 marked the conclusion of the **first-ever global stocktake**.
- **Global Stocktake** (GST) is an **evaluation process established by** the **Paris Agreement** (2015) **to assess the collective progress made by countries in achieving their goals**.
- Under the Paris Agreement, nations pledged to limit global warming to well below 2°C above preindustrial levels, with an aspirational target of 1.5 °C.
- **Starting in 2023**, the agreement mandates a GST **every five years** to ensure accountability and encourage increased efforts.
- The **fifth iteration of the GST text** was released at COP28 and adopted with no objection.
- The text proposes eight steps to keep the global temperature rise within the ambit of 1.5 °C.
  1. **Triple global renewable energy capacity** and double the annual energy efficiency rate by 2030
  2. **Rapidly phasing down unabated coal** and restrict new coal power generation permits
  3. Accelerate global efforts for net zero emissions energy systems, **using zero and low carbon fuels** by mid-century
  4. Accelerate **zero and low emissions technologies**, including renewables, nuclear, carbon capture, and low carbon hydrogen, to replace fossil fuels in energy systems
  5. **Transitioning away from fossil fuels** in energy systems fairly and equitably to achieve net zero emissions by around 2050, aligned with scientific findings
  6. Accelerate and significantly **reduce global non-$CO_2$ emissions**, **mainly methane**, by 2030
  7. Accelerate **emissions cuts in road transport** through infrastructure development and swift deployment of zero and low-emission vehicles
  8. **Phase out inefficient fossil fuel subsidies** that promote wasteful consumption, addressing neither energy poverty nor just transitions, as soon as possible

## Global Renewables and Energy Efficiency Pledge

- Signatory countries of the pledge have agreed to:
  1. **Triple installed global renewable energy capacity** to a minimum of 11,000 gigawatts
  2. **Double the global annual energy efficiency** improvement rate to over 4% by 2030
- **India refrained from signing** the Global Pledge on Renewable Energy and Energy Efficiency.

### Share of Fossil Fuel in Emissions

- Fossil fuels account for **80%** of all **greenhouse gas (GHG) emissions**.
- To address GHG emissions, we must significantly reduce fossil fuel use. Yet, influential nations in climate talks **pursue emissions cuts without tackling their source**.
- The current focus is on reducing energy consumption or enhancing energy efficiencies.

### Phase Down vs Phase Out of Fossil Fuels

- There has been **growing pressure** for the **phase-out of fossil fuels** in the global scenario.

- But countries like **India** do not favour it; instead, it is pitching for the **phase-down of fossil fuels**.
- In the **2021 Glasgow meeting**, India, at the last minute, altered the final draft outcome by changing the "phase-out" of coal to "phase-down".

### Arguments of India for Not Phasing Out Fossil Fuels

- **Low per capita emissions:** India, the **third-largest emitter of GHGs**, has low per capita emissions. This suggests it has limited access to energy, reduced consumption, and comparatively lower living standards.
- **India is not a historical contributor:** Developed nations grew at the expense of the global climate and sought to transfer the responsibility of climate change mitigation to developing countries. This is **against the Common But Differentiated Responsibilities and Respective Capabilities (CBDR-RC) principle**, enshrined in the **Earth Summit 1992**.
- **Lack of infrastructure for a complete renewable energy switch**
- **Detrimental for economic growth**

## Global Cooling Pledge

- Sixty-three countries, including the US, have committed to the **world's first-ever Global Cooling Pledge** at COP28. **India is not a signatory**.
- The Global Cooling Pledge **mandates countries to cut cooling emissions by at least 68% by 2050**.

- **Cooling emissions** are generated from **refrigerants** (used in appliances like ACs and refrigerators) and the **energy used for cooling**.
- Currently, cooling emissions account for only **7% of global greenhouse gas (GHG) emissions**.

## Declaration to Triple Nuclear Energy

- At COP28, 22 countries, led by the US, including France, the UK, Japan, Canada, S. Korea, and Ukraine, pledged to **triple global nuclear capacity by 2050 to achieve a net-zero emissions goal**.
- **India abstains** from the nuclear energy commitment, **aligning with its position not to join alliances outside the COP process**.
- Commitments under the pledge:
  - ❖ Mobilise investment and urge financial institutions like the World Bank to back nuclear power
  - ❖ Efforts to extend the life of existing plants
  - ❖ Support for new technologies like **small modular reactors** (SMRs)

⇨ ***Small Modular Reactors (SMRs)*** *are smaller, simpler, and more affordable than traditional nuclear reactors. They typically have a power capacity of up to* ***300 MW(e)****, which is about* ***1/3rd of the generating capacity of traditional nuclear power reactors****.*

## Loss and Damage Fund

- On COP 28, member countries **agreed to operationalise a Loss and Damage (L&D) Fund**.
- The L&D fund was **first announced** at the conclusion of **COP 27 in Sharm El-Sheikh**, **Egypt**.
- The **World Bank** will oversee the L&D fund in the beginning.
- Funding will come from **developed nations** like the US, UK, EU, and **some developing countries**.
- The scale or the replenishment cycle of the fund remains unclear.

## Declaration on Climate and Health

- The Declaration on Climate and Health was signed at COP28. It aims to **promote sustainable practices within the health sector** to contribute to broader climate goals.
- The COP28 summit marks the **first time** in 28 years that the **climate-health nexus** will be a **focal point in negotiations**.
- **India refrains from signing it** because the declaration included **reducing GHGs in healthcare cooling applications**. This may impede meeting India's growing medical demands, especially in remote areas and underserved areas.

### First Health Day at a COP

- COP28 is the **first COP to host a Health Day** and climate-ministerial at a COP.
- At the first-ever Health Day, participants tried progress solutions to reduce carbon emissions, limit air pollution, and prevent premature deaths.

## Global Goal on Adaptation (GGA)

- The **Paris Agreement (2015)** **established the Global Goal on Adaptation** (GGA) to enhance adaptative capacity, strengthen resilience and reduce vulnerability to climate change.
- GGA aims to contribute to keeping temperature rise to a maximum of 2°C or 1.5°C.
- The **first draft text** on the Global Goal on Adaptation (GGA) was **released in COP28**.
- Draft adaptation text lists seven targets, which include actions focusing on **food and water security**, **climate-resilient infrastructure**, **health**, **ecosystems**, **poverty reduction and cultural heritage**.

## Climate Finance

- **Climate finance** refers to large-scale investments required for actions aimed at **mitigating or adapting** to the consequences of climate change.
- At **COP21**, the COP, serving as the meeting of the Parties to the Paris Agreement (CMA), **decided to set a New Collective Quantified Goal** (NCQG) from a floor of $100 billion per year before 2025.
- As the 2024 deadline to adopt the new climate finance goal, NCQG approaches, the **UN Conference on Trade and Development** (UNCTAD) released estimates of what wealthy nations owe developing countries in COP28. The UN agency calculated that **$500 billion** should be channelled to developing countries in 2025 under the new finance goal to support climate action.

# COP28 UAE

13 CLIMATE ACTION

## KEY HIGHLIGHTS FROM COP 28

### Signalling the "beginning of the end" for fossil fuel era

- Introduction of language targeting fossil fuel reduction in the agreement.
- A global call to **cut greenhouse gas emissions by 43% by 2030** compared to 2019.
- Goals to **triple renewable energy capacity** and **double energy efficiency by 2030.**
- Nations urged to set ambitious emission reduction targets by early 2025.

### New Funding for Loss and Damage

- Historic **agreement on loss and damage fund operationalisation at COP 28's start.**
- Over USD 600 million in commitments received.
- Builds on COP 27's decision to establish a climate change impact fund.
- Total commitments reached USD 661 million.
- Symbolises global solidarity and advances international climate justice.
- Santiago network for loss and damage secretariat hosted by UN agencies.

### Enhancing global efforts to strengthen resilience

- **Global Goal on Adaptation (GGA)** targets set for climate resilience in key sectors.
- Green Climate Fund (GCF) replenishment hits USD 12.8 billion.
- Over USD 362 million pledged to climate funds at COP 28.
- **'Global stocktake' shows large climate finance gap.**
- Talks on **new climate finance goal of USD 100 billion per year by 2025**.

### Linking Climate Action with nature conservation

- COP 28 connects climate and biodiversity crises.
- Calls for ecosystems, biodiversity inclusion in climate plans by 2025.
- Stresses nature's role in meeting Paris Agreement, seeks deforestation halt by 2030.
- Highlights need for more support, investment in climate, biodiversity.
- Aligns with **Kunming-Montreal Framework, including "30x30" pledge**.

### Ramping up Practical Climate solutions

- COP 28's **Global Climate Action** space promoted climate solution collaborations.
- **Marrakech Partnership's 2030 roadmap** targets halving emissions, boosting resilience.
- 125 countries backed **UAE's Climate and Health Declaration**, securing USD 1 billion.
- 137 leaders pledged to transform food systems, mobilizing USD 2.6 billion.
- EU commits EUR 175 million for methane reduction.

### Looking Ahead

- COP 28 advances the Paris Agreement with new transparency tools for June 2024.
- **Azerbaijan to host COP 29 in 2024; Brazil for COP 30 in 2025**.
- COP 29 to establish new climate finance goal; COP 30 to update national contributions aligned with 1.5°C goal.
- Emphasises urgency of actions matching 1.5-degree target by 2025.

# WHAT IS GLOBAL STOCKTAKE?

- COP 28 marked the **conclusion of the first-ever global stocktake**.
- The **fifth iteration** of the **GST** text was released at COP28 and adopted with no objection.

## WHAT IS GLOBAL STOCKTAKE?

- Global Stocktake (GST) is an **evaluation process** established by the **Paris Agreement (2015)** to **assess the collective progress made by countries in achieving their goals.**
- Starting in 2023, the agreement mandates a GST **every five years** to ensure accountability and encourage increased efforts.

**The text proposes eight steps to keep the global temperature rise within the ambit of 1.5 °C.**

**Triple global renewable energy capacity** and double the annual energy efficiency rate by 2030



**Rapidly phasing down unabated coal** and restrict new coal power generation permits

Accelerate global efforts for net zero emissions energy systems, **using zero and low carbon fuels by mid-century**



Accelerate **zero and low emissions technologies**, including renewables, nuclear, carbon capture, and low carbon hydrogen, to replace fossil fuels in energy systems

**Transitioning away from fossil fuels** in energy systems fairly and equitably to achieve net zero emissions by around 2050, aligned with scientific findings


Accelerate and significantly **reduce global non-CO2 emissions, mainly methane,** by 2030

Accelerate **emissions cuts in road transport** through infrastructure development and swift deployment of zero and low-emission vehicles


**Phase out inefficient fossil fuel subsidies** that promote wasteful consumption, addressing neither energy poverty nor just transitions, as soon as possible

# GLOBAL RENEWABLES AND ENERGY EFFICIENCY PLEDGE

**1** Signatory countries of the pledge have agreed to

**Pledge 1**

**Triple installed global renewable energy capacity** to a minimum of 11,000 gigawatts.

**Pledge 2**

**Double the global annual energy efficiency** improvement rate to over 4% by 2030.

**2** **India refrained from signing the Global Pledge on Renewable Energy and Energy Efficiency**

# GLOBAL COOLING PLEDGE

## PLEDGE

63 countries, including the US, have committed to the **world's first-ever Global Cooling Pledge** at COP28. **India is not a signatory.**

The Global Cooling Pledge mandates countries to **cut cooling emissions by at least 68% by 2050.**

**WHAT ARE COOLING EMISSIONS?**

- Cooling emissions are generated from refrigerants (used in appliances like ACs and refrigerators) and the energy used for cooling.
- Currently, cooling emissions account for **only 7% of global greenhouse gas (GHG) emissions.**

# DECLARATION TO TRIPLE NUCLEAR ENERGY

- 22 countries, led by the US, including France, the UK, Japan, Canada, S. Korea, and Ukraine, pledged to **triple global nuclear capacity by 2050** to achieve a **net-zero emissions** goal.
- **India abstains from the nuclear energy commitment,** aligning with its position **not to join alliances outside the COP process.**

# LOSS AND DAMAGE FUND

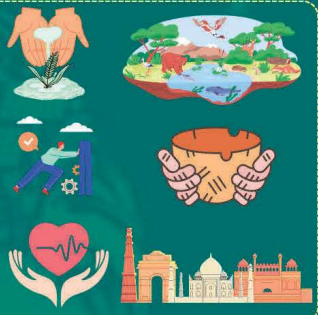
- The L&D fund was **first announced at the conclusion of COP 27** in Sharm El-Sheikh, Egypt.
- On COP 28, member countries **agreed to operationalise a Loss and Damage (L&D) Fund.**
- The **World Bank** will oversee the L&D fund in the beginning.
- Funding will come from developed nations like the US, UK, EU, and some developing countries.

# DECLARATION ON CLIMATE AND HEALTH

- **COP28 is the first COP to host a Health Day and climate-ministerial at a COP.**
- The Declaration on Climate and Health was signed at COP28 to promote sustainable practices within the health sector to contribute to broader climate goals.
- It is the **first time** in 28 years that the **climate-health nexus** is a focal point of COP negotiations.
- **India refrains from signing** it because the declaration included reducing GHGs in healthcare cooling applications.

# GLOBAL GOAL ON ADAPTATION (GGA)

- The **first draft text on the GGA** was released in COP28 which lists **seven targets,** which include **food and water security, climate-resilient infrastructure, health, ecosystems, poverty reduction and cultural heritage.**



## WHAT IS GLOBAL GOAL ON ADAPTATION (GGA)?

- The Paris Agreement (2015) established the Global Goal on Adaptation (GGA) to enhance adaptative capacity, strengthen resilience and reduce vulnerability to climate change.
- GGA aims to contribute to keeping temperature rise to a maximum of 2°C or 1.5°C.

# CLIMATE FINANCE

- The **UN Conference on Trade and Development (UNCTAD)** calculated that wealthy nations owe $500 billion to developing countries under **New Collective Quantified Goal (NCQG).**

## NEW COLLECTIVE QUANTIFIED GOAL (NCQG)

- At COP21, the COP, serving as the meeting of the Parties to the Paris Agreement (CMA), decided to set a NCQG (a new climate finance goal) from a floor of $100 billion per year before 2025.

→ **Climate finance** refers to large-scale investments required for actions aimed at mitigating or adapting to the consequences of climate change.

COP28 UAE

UNITE. ACT. DELIVER.


## Other Highlights of the COP28

### Santiago Network

- **Santiago Network for Loss and Damage** is a technical assistance network established at the **COP25 (Spain)**. It focuses on **coordinating technical assistance** from organisations, bodies, networks, and experts to implement strategies addressing climate change-induced loss and damage in vulnerable developing countries at local, national, and regional levels.
- In COP28, countries finally agreed to host the Santiago Network.

### Coal Transition Accelerator

- **France**, in collaboration with various countries and organisations, has launched the new initiative, **Coal Transition Accelerator**.
- Its goal is to leverage expertise, develop policies, and secure funding to facilitate just transitions from coal to clean energy.

### Coalition for High Ambition Multilevel Partnership (CHAMP) for Climate Action

- 65 national governments signed CHAMP commitments to enhance cooperation with subnational governments in the planning, financing, implementation, and monitoring of climate strategies.

## India at COP28

### Global River Cities Alliance (GRCA)

- **Global River Cities Alliance** (GRCA) was launched at COP28 of UNFCCC.
- It will be **led by** the **National Mission for Clean Ganga** (NMCG), which is under the Ministry of Jal Shakti.
- GRCA is a unique alliance covering 275+ global river cities, international funding agencies, and knowledge management partners.
- Its member countries are **India**, **Egypt**, **Netherlands**, **Denmark**, **Ghana**, **Australia**, **Bhutan**, **Cambodia**, **Japan**, **and Hungary**.
- The international funding agencies in the alliance are the **World Bank**, **Asian Development Bank (ADB)**, and **Asian Infrastructure Investment Bank (AIIB)**.
- It is the **first global river conservation effort and sustainable water management**.
- The alliance activities will include knowledge exchange, capacity development, high-level advocacy, and bilateral interactions among member cities.
- It will widely **expand the reach of the existing River Cities Alliance** (RCA).

#### River Cities Alliance (RCA)

- RCA is a **joint initiative** of the **Ministry of Jal Shakti** (MoJS) and the **Ministry of Housing and Urban Affairs** (MoHUA), which aims to link river cities and promote sustainable river-centric development.
- Launched in **2021** with 30 member cities, the alliance has expanded to **109 river cities across India** and **one international member city from Denmark**.

### Green Credit Initiative

- **India co-hosted** the **Green Credit Initiative** at the COP-28 summit **along with the UAE**.
- It is a pro-planet, proactive and positive initiative that **goes beyond the commercial mindset associated with carbon credits**.
- It focuses on creating carbon sinks through people's participation.
- This initiative **mirrors** the **Green Credits Programme** launched by GoI this year.

#### Green Credits Programme (GCP)

- GCP was **launched by** the **Ministry of Environment**, **Forest and Climate Change** (MoEFCC).
- It is an initiative within the GoI's broader **Lifestyle for Environment (LiFE) Movement** (an India-led initiative launched at COP26).
- It is an effort to create a **market-based incentive for various environment-positive actions**, not just for carbon emission reductions.
- It incentivises **voluntary environmental actions** of individuals, communities, and private industries.

- It will allow an individual or entity to **earn Green Credit and trade it on a dedicated exchange**.
- This programme will cover eight types of activities:
  1. Tree plantation
  2. Water management
  3. Sustainable agriculture
  4. Waste management
  5. Air pollution reduction
  6. Mangrove conservation and restoration
  7. **Ecomark**
  8. Sustainable building and infrastructure
- In its initial phase, the GCP will focus on **two key activities**: **water conservation** and **afforestation**.
- The **Indian Council of Forestry Research and Education** shall administer GCP.

### Ecomark

- **Ecomark (or Eco Label)** is a **voluntary labelling scheme** for consumer products meeting Indian environmental criteria and quality standards. GoI launched the Eco Mark Scheme in 1991.
- The Ecomark Scheme is administered by the **Central Pollution Control Board** (CPCB) in partnership with the **Bureau of Indian Standards** (BIS) (the national body for standards and certification).

### Phase II of the Leadership Group for Industry Transition (LeadIT 2.0)

- **India**, **along with Sweden**, co-launched the Phase II of the **LeadIT 2.0** at COP-28.
- LeadIT 2.0 will focus on inclusive and just industry transition, co-development and transfer of low-carbon technology, and financial support to emerging economies for industry transition.
- India and Sweden co-launched LeadIT at the UN Climate Action Summit in New York in 2019.

## 22.6. Others

### UN-REDD and REDD+

| UN-REDD | REDD+ |
|---|---|
| • The **UN Programme** on **Reducing Emissions from Deforestation and Forest Degradation (UN-REDD)**.<br>• Headquarters: Geneva, Switzerland.<br>• Membership: 64 Partner Countries. | • **Reducing emissions from deforestation** and **forest degradation**<br>• **Role: conservation**, **sustainable management of forests** and **enhancement of forest carbon stocks** in **developing countries** |
| • It is a multilateral **collaborative programme** of **FAO**, **UNDP** and **UNEP** | • **Voluntary climate change mitigation approach developed by Parties to the UNFCCC**. |

| | |
|---|---|
| • It was created in 2008 in response to the **UNFCCC** decisions on the **Bali Action Plan** and REDD. | |
| • It partners with **developing countries** to support them in establishing the technical capacities needed to implement **REDD+** and meet UNFCCC requirements for REDD+ results-based payments. | • REDD+ goes beyond deforestation and forest degradation and aims to incentivise **developing countries** to reduce emissions from deforestation and forest degradation, **conserve forest carbon stocks**, sustainably manage forests and enhance forest carbon stocks. |

⇨ *The **United Nations Development Programme (UNDP)** is a UN agency tasked with helping countries eliminate poverty and achieve sustainable economic growth and human development. Headquartered in New York City, it is funded entirely by voluntary contributions from UN member states.*

⇨ *In addition to the **UN-REDD Programme**, other initiatives assisting countries that are engaged in REDD+ include the **World Bank's Forest Carbon Partnership Facility**, the **Global Environment Facility**, the **Green Climate Fund** etc.*

**[UPSC 2016] Proper design and effective implementation of UN-REDD+ can significantly contribute to**

1) Protection Of Biodiversity
2) Resilience Of Forest Ecosystems
3) Poverty Reduction

***Select the correct answer using the code given below.***

a) 1 and 2 only
b) 3 only
c) 2 and 3 only
d) 1, 2 and 3

**Explanation**

- Poverty reduction is nowhere mentioned in the REDD+. But the question is not asking for specific details, "UN-REDD+ Programme **can significantly contribute to?**"
- **Conservation**, **sustainable management of forests** and **enhancement of forest carbon stocks** in developing countries will certainly contribute to employment opportunities and help in poverty reduction.
- According to FAO, REDD+ can also contribute to achieving other SDGs – including those which address **poverty reduction**, **health and well-being**, **hunger alleviation**, and improving institutions"

***Answer: a) 1, 2 and 3 (UPSC Official Key)***

## Forest Carbon Partnership Facility

- It is a **global partnership** of governments, businesses, civil society, and Indigenous Peoples focused on reducing emissions from activities commonly referred to as **REDD+**:
  - ✓ **deforestation and forest degradation**,
  - ✓ **forest carbon stock conservation** and **the enhancement of forest carbon stocks in developing countries**.
  - ✓ **the sustainable management of forests**, **and**
- The **World Bank** assumes the functions of trustee and secretariat. The **World Bank**, the **Inter-American Development Bank** and **UNDP** are delivery partners under the **Readiness Fund** and are **responsible for providing REDD+ readiness support**.

### Objectives

- ❖ To assist **countries** in their REDD+ efforts by providing them with **financial** and **technical assistance**.
- ❖ To pilot a **performance-based payment system** for REDD+.
- ❖ To test ways to sustain or enhance the livelihoods of local communities and to conserve biodiversity.
- ❖ To disseminate broadly the knowledge gained in Emission Reductions Programs (ERPs).

## Climate and Clean Air Coalition (CCAC)

- In 2012, a few nations, along with the **UNEP**, formed the **Climate and Clean Air Coalition**.
- It is a **partnership** of governments, public and private sectors, scientific institutions, civil society organisations, etc., committed to protecting the climate through actions to **reduce short-lived climate pollutants**.

### Short-lived climate pollutants (SLCPs)

- SLCPs have relatively short lifetime in the atmosphere – **a few days to a few decades**. Though short-lived, **their potential to warm the atmosphere can be many times greater than $CO_2$**. SLCPs are responsible for up to **45% of current global warming**, only next to $CO_2$. SLCPs include **black carbon**, **methane**, **tropospheric ozone**, and **hydrofluorocarbons (HFCs)**.

#### Benefits of Reducing SLCPs

- ✓ Reducing methane and black carbon will prevent crop losses.
- ✓ Reducing SLCPs could slow down the warming expected by 2050 by about 0.5 °C and play an important role in achieving the **2°C target set by the Paris Agreement**.

## Other Minor Initiatives

### BioCarbon Fund Initiative

- **BioCarbon Fund Initiative for Sustainable Forest Landscapes (ISFL)** is a **multilateral fund** supported by **donor governments** and **managed by the World Bank**.

- It seeks to **promote reduced GHG emissions** from the l**and sector**, **from deforestation and forest degradation** in developing countries (**REDD+**), and sustainable agriculture, as well as smarter land-use planning, policies, etc.
- It promotes reducing GHG emission from the land sector, including efforts to reduce deforestation and forest degradation in developing countries (REDD+), sustainable agriculture, as well as smarter land-use planning, policies and practices.

## Cool Coalition

- It aims to inspire ambition and accelerate action on the transition to **clean and efficient cooling**. It was launched at the first **Global Conference on Synergies** between the 2030 Agenda and the Paris Agreement in 2019.
- It is a global effort led by:
  1. **UNEP**
  2. **Climate and Clean Air Coalition**
  3. **Kigali Cooling Efficiency Program**
  4. **Sustainable Energy for All (SEforALL)**

## Global Climate Change Alliance + (GCCA+)

- **GCCA+** is a **European Union** initiative. It helps **vulnerable countries** on the front line of climate change.
- GCCA+ initiatives help mainly **Small Islands Developing States (SIDS)** and **Least Developed Countries (LDCs)** increase their resilience to climate change. It also supports these group of countries in implementing their commitments resulting from the **2015 Paris Agreement** (COP21).

## Global Alliance for Climate-Smart Agriculture (GACSA)

- GACSA is promoted by **FAO** along with various governments. Its vision is to improve food security, nutrition and resilience in the face of climate change. GACSA works towards three aspirational outcomes to:
  1. **Improve farmers' agricultural productivity and incomes in a sustainable way;**
  2. **Build farmers' resilience to extreme weather and changing climate;**
  3. **Reduce greenhouse gas emissions associated with agriculture**, **when possible**.

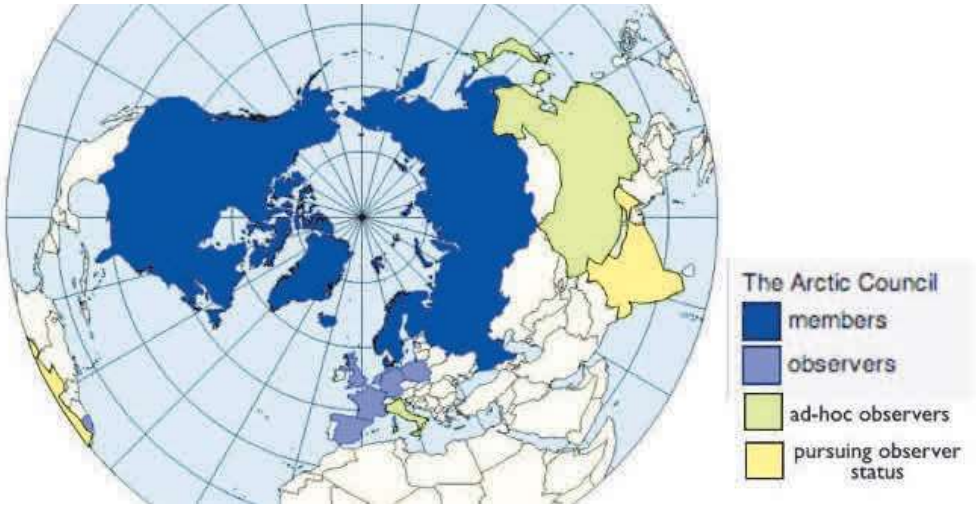
## GHG Protocol

- GHG Protocol is developing standards, tools and online training that helps countries, cities and companies track progress towards their climate goals.
- GHG Protocol establishes frameworks to measure and manage greenhouse gas (GHG) emissions from private and public sector operations, value chains and mitigation actions.

- GHG Protocol arose when **World Resources Institute (WRI)** and **World Business Council for Sustainable Development (WBCSD)** recognized the need for an international standard for **corporate GHG accounting** and reporting in the late 1990s.

## Arctic Council

- Arctic Council is an **intergovernmental forum** promoting cooperation, coordination and interaction among the Arctic states, Arctic Indigenous communities and other Arctic inhabitants on **common Arctic issues**, in particular on issues of sustainable development and environmental protection in the Arctic.
- The Arctic Council consists of the **eight Arctic States**: **Canada**, **the Kingdom of Denmark (including Greenland and the Faroe Islands)**, **Finland**, **Iceland**, **Norway**, **Russia**, **Sweden** and the **United States**.




**[UPSC 2015] With reference to 'Forest Carbon Partnership Facility', which of the following statements is/are correct?**

1) It is global partnership of governments, businesses, civil society and indigenous peoples.
2) It provides financial aid to universities, individual scientists and institutions involved in scientific forestry research to develop eco-friendly and climate adaptation technologies for sustainable forest management.
3) It assists the countries in their 'REDD+ (Reducing Emission from Deforestation and Forest Degradation+)' efforts by providing them with financial and technical assistance.

***Select the correct answer using the code given below***

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

***Explanation***

- It provides financial incentives to countries in their REDD+ efforts. There is no mention of assistance to universities, scientists…

***Answer: c) 1 and 3 only***

**[UPSC 2015] 'BioCarbon Fund Initiative for Sustain-able Forest Landscapes' is managed by the**

a) Asian Development Bank
b) International Monetary Fund
c) United Nations Environment Programme
d) World Bank

**[UPSC 2017] Regarding 'Global CC Alliance', which of the following statements is/are correct?**

1) It is an initiative of the European Union.
2) It provides technical and financial support to targeted developing countries to integrate climate change into their development policies and budgets.
3) It is coordinated by World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD).

***Select the correct answer using the code given below:***

a) 1 and 2 only
b) 3 only
c) 2 and 3 only
d) 1, 2 and 3

***Answer: a) 1 and 2 only***

**[UPSC 2014] Consider the following countries:**

1) Denmark
2) Japan
3) Russian Federation
4) United Kingdom
5) United States of America

***Which of the above are the members of the 'Arctic Council'?***

a) 1, 2 and 3
b) 2, 3 and 4
c) 1, 4 and 5

d) 1, 3 and 5

***Answer: d)***

**[UPSC 2016] What is 'Greenhouse Gas Protocol'?**

a) It is an international accounting tool for government and business leaders to understand, quantify and man-age greenhouse gas emissions
b) It is an initiative of the United Nations to offer financial incentives to developing countries to reduce GHG emissions and to adopt eco-friendly technologies
c) It is an inter-governmental agreement ratified by all the member countries of the UN to reduce GHG emissions to specified levels by the year 2022
d) It is one of the multilateral REDD+ initiatives hosted by the World Bank

***Answer: a)***

**[UPSC 2018] With reference to the 'Global Alliance for Climate Smart Agriculture (GACSA)', which of the following statements is/are correct?**

1) GACSA is an outcome of the Climate Summit held in Paris in 2015.
2) Membership of GACSA does not create any binding obligations.
3) India was instrumental in the creation of GACSA.

***Select the correct answer using the code given***

a) 1 and 3 only
b) 2 only
c) 2 and 3 only
d) 1, 2 and 3

***Answer: 2) only***

**---------- End of Chapter ----------**

# 23. National Environmental Legislation – Part I

- After the **1972 United Nations Conference on Human Environment** in **Stockholm**, **India amended its constitution to include provisions for protecting the environment**, which were initially absent.
- The **42nd amendment to Article 51A(g) (Fundamental Duties)** of the Indian constitution states, "*It shall be the **duty of every citizen of India** to **protect and improve the natural environment** including forests, lakes, rivers and wildlife and **have compassion for living creatures**.*"
- **Directive Principles of State Policy** through **Article 48A**, which states, "***The State shall endeavour** to **protect and improve the environment** and to **safeguard the forests and wildlife** of the country*".
- **Article 21** of the Indian Constitution assures the citizens of India the **right to a healthy environment**. In this regard, the **Department of Environment** was established in **1980**. This later became the Ministry of Environment and Forests (**MoEF**) in 1985. It is now the Ministry of Environment, Forests and Climate Change (**MoEFCC**) since **2014**.
- Environment-related legislation came very late with the **Wild Life Protection Act 1972**. The **Environment Protection Act of 1986 (EPA)** came into force soon after the **Bhopal Gas Tragedy** and is considered **umbrella legislation** as it fills many lacunae in the existing legislation.

## 23.1. Pollution Related Laws

### The Water (Prevention and Control of Pollution) Act of 1974 and its Amendments

- The Water (Prevention and Control) Act, 1974, aimed to **prevent and control water pollution** and ensure the maintenance of water wholesomeness.
- The **Central Pollution Control Board (CPCB)** and **State Pollution Control Boards (SPCBs)** have been constituted under this Act.
- The Act also confers powers to the CPCB and SPCBs to control pollution of the water bodies.
- The Act was amended in **1978** and **1988** to clarify certain ambiguities and to vest more powers in the Pollution Control Board.
- Salient obligations for industries and local bodies include:
  - **Prior consent from SPCBs is required for establishing any industry or local body discharging sewage or effluent** into water, streams, wells, sewers, or land.
  - After obtaining consent to establish and install required facilities, the industry must **apply for consent to operate**.
  - Similar provisions of application and grant of consent exist for **industries discharging the trade/effluent waste prior to enactment of the Act**.

#### Central Pollution Control Board (CPCB)

- It is a **statutory organisation** under the Ministry of Environment, Forest and Climate Change (**MoEFCC**).
- It was constituted in **1974** under the **Water (Prevention and Control of Pollution) Act**, **1974**.
- It was given powers and functions under the **Air (Prevention and Control of Pollution) Act**, **1981**.
- It also offers technical services to the MoEFCC under the **Environment (Protection) Act**, **1986**.
- Principal functions of the CPCB are:
  (i) To **prevent**, **control**, **and abate water pollution** to promote the cleanliness of streams and wells
  (ii) To improve the quality of air and **prevent**, **control**, **and abate air pollution**
- It oversees the **National Air Monitoring Programme** (NAMP) and **Water Quality Monitoring** (WQM).

## Main Provisions of Water (Prevention and Control of Pollution) Amendment Bill, 2024

### Decriminalisation of Minor Offences

- The Act also has imprisonment provisions for several violations, along with fines.
- The Bill **replaces imprisonment provisions with fines** to **decriminalise minor offences**.
- It is done to ensure that citizens, businesses and companies operate without fear of imprisonment for minor, technical or procedural defaults.

### Exemption for Certain Industrial Plants

- As per the Act, **prior consent of the SPCB is mandatory** to establish any industry or treatment plant likely to discharge sewage into water bodies, sewers, or land.
- The Bill specifies that the **GOI**, **in consultation with the CPCB**, **may exempt certain industrial plants** from obtaining such consent.
- The Bill also states that the **GOI may issue guidelines for granting**, **refusing**, **or cancelling the consent of the SPCB**.

### Chairman of SPCB

- Under the Act, the SPCB chairman is nominated by the state government.
- The Bill specifies that the GOI will prescribe the nomination process and terms of service for the SPCB chairman.

## The Water Cess Act of 1977

- The Water (Prevention and Control of Pollution) Cess Act, enacted in 1977, **levies and collects a cess on water consumption by certain industrial activities**.
- **Every local authority**, including municipal corporations, councils, cantonment boards, and other bodies **responsible for supplying water**, is also **liable to pay the cess**.
- **Objective:** To augment the resources for the **CPCB** and the **SPCBs** for the prevention and control of water pollution, as mandated under the Water (Prevention and Control of Pollution) Act, 1974.

- To encourage capital investment in pollution control, the Act gives a polluter a **70% rebate of the applicable cess upon installing effluent treatment equipment**.

### The Air (Prevention and Control of Pollution) Act of 1981 and its Amendment

- The Air (Prevention and Control of Pollution) Act of 1981 was enacted to implement decisions made at the **UN Conference on the Human Environment** (**Stockholm**, **1972**).
- **Objective of the Act:** To improve air quality and prevent, control and abate air pollution.

#### Important Provisions of the Act

- The Act entrusted powers and functions to the **CPCB** and **SPCBs** to prevent and control air pollution.
- It allows for the **constitution of SPCBs** in states where they are not formed.
- CPCB will exercise the same powers and perform as an SPCB in the UTs.
- All industries operating within designated **air pollution control areas** must obtain **consent (permit) from the SPCBs**.
- The **SPCBs** are required to prescribe **emission standards** for industry and automobiles **after consulting the CPCB** and noting the state's ambient air quality standards.

#### Amendment of 1988

- The 1987 Amendment Act **empowered SPCB and CPCB to close a defaulting industrial plant**. Prior to this, the Act was enforced through criminal prosecutions initiated by the Boards.
- It introduced a **citizen suit provision** into the Air Act. Citizen suits allow individuals or NGOs to approach the court to address environmental wrongs, serving as a tool for **environmental activism**.
- It extended the Air Act to include **noise pollution**.

## 23.2. Environment (Protection) Act of 1986

- The Environment (Protection) Act of 1986 (EPA 1986) was enacted in the backdrop of the **UN Conference on the Human Environment** (**Stockholm**, **1972**) and the **Bhopal Gas Tragedy of 1984**.
- The Act was passed by the GOI under **Article 253** of the Constitution of India.
- The objective of the Act is to provide protection and improve the environment.
- EPA 1986 serves as an **umbrella legislation**, coordinating central and state authorities established under the **Water (Prevention and Control) Act**, **1974**, and **Air (Prevention and Control) Act**, **1981**.

⇨ ***Article 253 of The Constitution of India: (Legislation for giving effect to international agreements)*** *Parliament has the power to make any law for the whole or any part of the territory of India for implementing any treaty, agreement or convention with any other country or countries or any decision made at any international conference, association or other body.*

### Definitions under the EPA 1986

- **"Environment"** is defined to include water, air and land and the inter-relationships that exist among water, air and land and human beings and other living creatures, plants, micro-organisms and property.
- "**Environmental pollution**" is the presence of a pollutant, defined as any solid, liquid or gaseous substance present in such a concentration as may be or may tend to be injurious to the environment.
- "**Hazardous substances**" include any substance or preparation that may harm human beings, other living creatures, plants, microorganisms, property, or the environment.

## Major Provisions of the EPA 1986

- **Powers of the Central Government:** Through the EPA 1986, the **Central Government gets full power** for the purpose of protecting and improving the quality of the environment. The powers include:
  1. **Co-ordination** of actions by the State Governments, officers and other authorities
  2. **Planning** and **execution** of nationwide programmes
  3. Laying down **emission or discharge standards** of environmental pollutants from various sources
  4. Placing **restrictions on the location of industries**, operations or processes
  5. **Closure**, **prohibition or regulation of any industry**, operation or process
  6. Stoppage or regulation of the **supply of electricity or water** or any other service
  7. Establish procedures and safeguards to **prevent accidents that may cause environmental pollution** and implement remedial measures for such incidents.
  8. Laying down procedures and safeguards for the **handling of hazardous substances**
  9. **Inspection of any premises**, plant, equipment, machinery, manufacturing or other processes, materials or substances
  10. Establishment or recognition of **environmental laboratories** and institutes
  11. Preparation of codes, guides and manuals
  12. The GOI may make rules through Official Gazette notifications to fulfill the Act's purposes
  13. Other matters as the **central government deems necessary** for effective implementation of the Act **(this provision truly makes the EPA 1986 an umbrella legislation)**.
- **Protection of action taken in good faith:** No legal action can be taken against the Government, its officers, employees, or any authority constituted under this Act for actions done in good faith under the provisions of the Act.
- **Cognisance of offence:** No court shall take cognisance of any offence under this Act except on a complaint made by:
  (a) the Central Government or any authority or officer authorised on this behalf by that Government
  (b) any person who has given notice of not less than 60 days of the alleged offence to the Central Government or the authority or officer authorised (**Citizen suit**)
- **Bar of jurisdiction: No civil court has jurisdiction** over suits or proceedings concerning actions, orders, or directions issued by the Central Government or any authority or officer under this Act.

**[UPSC 2019] Consider the following statements: The Environment Protection Act, 1986 empowers the Government of India to**

1. State the requirement of public participation in the process of environmental protection, and the procedure and manner in which it is sought.
2. Lay down the standards for emission or discharge of environmental pollutants from various sources.

***Which of the statements given above is/are correct?***

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

***Answer: b) 2 only***

## Environmental Impact Assessment (EIA)

- EIA is a tool for **predicting the likely environmental impacts** that may arise from the proposed developmental activities and suggesting mitigation measures and strategies.
- It was **introduced in India in 1976-77** for assessing river valley projects, later enhanced to include other developmental sections.
- Till **1994**, **environmental clearance** (EC) from the GOI was an administrative decision and **lacked legislative support**. In 1994, under the **Environmental (Protection) Act 1986**, the Ministry of Environment and Forests (MEF) **made EC mandatory** for expansion, modernisation, or establishment of new projects listed in Schedule 1 of an EIA notification.
- EIA is now mandatory for 30 categories of projects, and these projects are granted EC only after the EIA requirements are fulfilled.
- **EC** or the **'go ahead'** signal is granted by the **Impact Assessment Agency** in the **MoEF**.
- The important aspects of EIA are:
  - ✓ **Risk assessment**
  - ✓ **Environmental management**
  - ✓ **Post product monitoring**

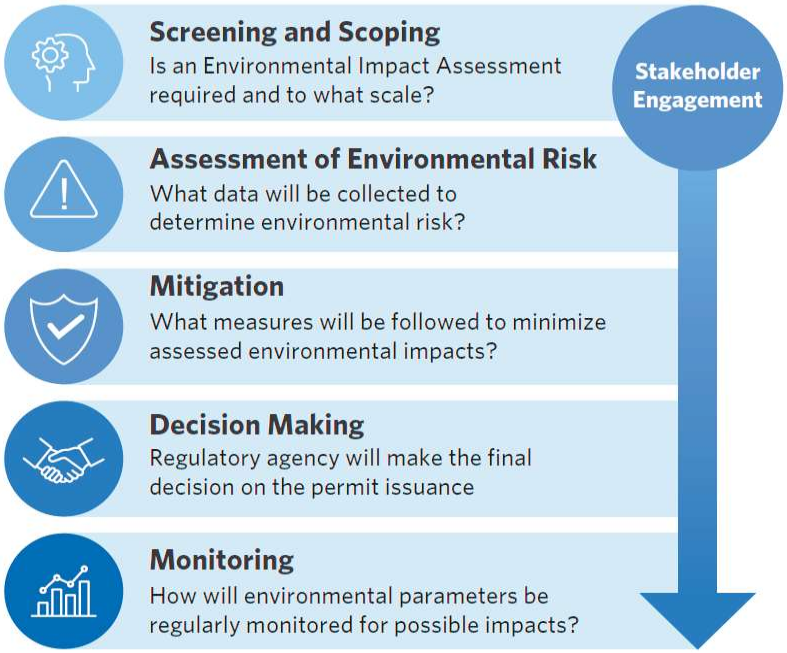
### Classification of Projects that Require EIA Clearance

- Expert Committees are formed for diverse sectors to ensure multidisciplinary input in the environmental appraisal of development projects:
  1. Mining Projects
  2. Industrial Projects
  3. Thermal Power Projects

4. River Valley, Multipurpose, Irrigation and H.E. Projects
5. Infrastructure Development and Miscellaneous Projects
6. Nuclear Power Project

## EIA Process and Procedures

- ***Steps in the EIA process (EIA process is cyclical with the interaction between the various steps):***
  - **Screening:** The project plan is screened for investment scale, location, development type, and statutory clearance requirements.
  - **Scoping:** Identifying potential impacts, impact zones, mitigation options, and monitoring needs.
  - **Collection of baseline data:** Baseline data refers to the environmental status of the study area.
  - **Impact prediction:** Predictions must be made for positive/negative, reversible/irreversible, and temporary/permanent impacts.
  - **Mitigation measures:** The EIA report should outline actions to prevent, minimise, or compensate for environmental impacts.
  - **Public hearing:** After completing the EIA report, nearby public and environmental groups may be informed and consulted.
  - **Decision making:** The **Impact Assessment Authority**, with expert input, consults the project-in-charge to make decisions, considering the EIA and **Environment Management Plan** (EMP).
  - **Monitoring and implementation of EMP**
  - **Assessment of Alternatives**, **Delineation of Mitigation Measures and EIA Report**
  - **Mitigation plan:** After reviewing alternatives, a mitigation plan is developed for the chosen option, supplemented by an Environmental Management Plan (EMP).
  - **Risk assessment:** Inventory analysis and hazard probability and index are integral to EIA procedures.



### Environment Management Plan

- It involves outlining mitigation measures for each environmental component, including prevention and control, as well as a rehabilitation and resettlement plan.

### Environmental Appraisal

- The MoEF's **Appraisal Committee** reviews a project based on data provided by project authorities. The MoEF may also consult with investors and experts on specific issues as needed.
- After reviewing all aspects of a project, EC is granted subject to the implementation of the specified environmental safeguards. If project proponents provide complete information, a decision is reached **within 90 days**.

### EIA of Coasts

- Coastal states or UTs prepare **Coastal Zone Management Plans (CZMPs)** according to CRZ notification rules. These plans categorise coastal areas for various activities before submission to the MoEF for approval.

### Single Window Clearance

- Projects requiring **both EC** and **approval under the Forest (Conservation) Act, 1980** must submit proposals for both simultaneously. Processing for clearance or rejection is done concurrently. If the project doesn't involve forestland diversion, it's processed solely for EC.

⇨ ***Single window clearance = Environmental clearance (EC) + Forestry clearance***

### The Main Participants Of EIA

2) The Project Proponent
3) The Environmental Consultants
4) The State Pollution Control Board / Pollution Control Committees (PCCs)
5) The Public
6) The Impact Assessment Agency

## Benefits of EIA

✓ EIA connects the environment with development for **sustainable development**, offering a cost-effective way to reduce adverse impacts of projects.

✓ EIA promotes **mitigation strategies** and ensures development within **capacity of assimilation and regeneration of the ecosystem**.

## Shortcomings of EIA

- **Applicability:** Several projects with significant environmental impacts are **exempted** if they are **not listed in Schedule I of EPA** or if their **investments fall below** the notification threshold.

⇨ ***Schedule I of EPA 1986*** *specifies emission or discharge standards for pollutants from industries, processes, or operations, along with their maximum allowable concentration limits.*

- **Composition of expert committees:** EIA teams often lack field experts such as environmentalists, wildlife experts, anthropologists, and social scientists.
- **Public hearing:** Problems with public hearings are:
  - Public comments are **not considered at the early stage**, which leads to conflict at a later stage
  - Several projects with significant environmental and social impacts have been **excluded from the mandatory public hearing process**
  - Documents to which the public is entitled are seldom available on time
  - Data collectors often **disregard the indigenous knowledge** of local people
- **Quality of EIA Reports:** EIA reports are often **incomplete**, with **false data** and reliance on single-season data. The documents are **overly technical** and cumbersome to understand.
- **Lack of credibility:** The project proponent funds the EIA preparation, aiming to secure project clearance, which raises concerns about potential bias. Moreover, the lack of accreditation for EIA consultants also undermines the credibility of the assessment.

## Recommendations to Improve the EIA Process

- **Independent EIA Authority** and **sector-wide EIAs**
- **Transparency:** Full disclosure of project information from notification to clearance to the public.
- **Applicability:** All projects causing major ecosystem alteration must undergo the EC process.
- **Public hearing:** Public hearings should apply to all previously exempt project categories.
- **Easy to understand:** EIA reports must clearly outline the adverse impacts of proposed projects in a separate chapter, distinct from technical details.
- **Avoid conflict of interest:** Independence of EIA preparation from the project proponent is crucial.
- **Composition of expert committees:** Replace current executive committees with experts from diverse stakeholder groups renowned in environmental and related fields.
- **Stringent punishments:** The EIA notification should incorporate automatic clearance withdrawal for violations and enforce stricter penalties for noncompliance.

## Salient Features of the 2006 Amendment to the EIA Notification

- The 2006 EIA Notification **decentralises environmental clearance (EC)** by categorising developmental projects into two groups.
  1. **Category A (national-level appraisal)**
  2. **Category B (state-level appraisal)**.
- After the 2006 Amendment, the **EIA cycle comprises four stages**:
  1) Screening
  2) Scoping

3) Public hearing
4) Appraisal

- **Category A projects require mandatory EC**, and thus, they **do not undergo the screening process**.
- **Category B projects undergo the screening process**, and they are classified into two types:
  1. **Category B1 projects (Mandatorily requires EIA)**.
  2. **Category B2 projects (Do not require EIA/EC)**.

### Amendment to EIA Notification 2006 in Respect of Bulk Drugs and Intermediates

- During the **COVID-19 crisis**, MoEF amended the EIA Notification 2006, **re-categorizing projects** related to **bulk drugs and intermediates** from **Category 'A' to 'B2'**. This **exempts them from EIA**, baseline data collection, EIA studies, and public consultation.

### Amendment to EIA Notification 2006 for EC Waver for Oil and Gas Exploration

- In 2019, GOI relaxed rules to incentivise oil exploration in less-explored fields, allowing companies to retain more revenue from viable hydrocarbon blocks.
- This sparked interest in exploration, but stringent EIA processes have become a hurdle.
- So, MoEF amended the 2006 EIA Notification, **exempting both onshore and offshore drilling explorations by oil and gas firms from EIA** by downgrading exploratory projects from **'Category A' to 'B2'**.
- **Criticism:** Offshore exploration, with well digging and seismic surveys, is ecologically intensive. It can impact fish, increase water contaminants, disorient marine life, and raise the risk of oil spills.

## Draft EIA 2020 Notification (Expired)

- The EIA 2020 Notification Draft aimed to amend the EIA Notification 2006, defining three project categories, **A**, **B1**, and **B2**, based on their social and economic impact and geographical extent.
- The notification envisages two kinds of approval:
  1. **Prior environment clearance (EC) with the approval of expert committees**
  2. **Environmental permission or provision (EP) without the approval of expert committees**.
- Nearly 40 projects, including clay and sand extraction, well digging, solar thermal power plants, and effluent treatment plants, are exempted from prior environmental clearance.
- Projects such as **B2 projects**, irrigation, halogen production, chemical fertilisers, acids, biomedical waste treatment facilities, building construction, elevated roads, highways, and expressways are **exempted from public consultation**.

### Issues with Draft EIA 2020

i) **Ex-Post Facto Clearance of Projects:** Under this provision, all industrial units and projects **operating illegally without EC** have the opportunity to become legal units by **submitting a remedial plan**. In a previous case, the Supreme Court ruled that **post facto clearances are against environmental law principles** and harmful to the environment.

ii) **Exclusion of Projects from Prior EC**

iii) **The validity period of EC increased for mining**, **river valley**, **and other projects** (this section does not sync with the object of the notification or the parent act)

iv) **Exclusion of Projects from Public Consultation**

### Rules Similar to Draft EIA 2020 Notification

- Although the draft 2020 notification expired, MoEF introduced some contentious rules separately through individual notifications.
- MoEF issued a notification stating that **highway projects near the country's borders are sensitive and need to be exempted** from the requirement of seeking an EC.
- MoEF's new guideline authorises its **regional offices to expedite forest clearances** for critical **infrastructure projects in districts affected by Maoist insurgency** and **defence-related projects in border areas**, **bypassing the forest advisory committee**.
- ECs granted to hydropower projects were made valid for 13 years, 15 years for nuclear projects and 50 years for mining projects. Whereas, under EIA 2006, the validity of prior EC was 10 years for river valley projects, a maximum of 30 years for mining, and 7 years for other projects.
- MoEF issued a notification stating that **state environment authorities will consider all airport expansion projects**, including airstrips for commercial use.
- The notification has also delegated environmental appraisal of **non-coal mining**, **river valley**, and **thermal power projects** to the state appraisal body.
- The notification has also **delegated environmental appraisal of various non-coal mining**, **river valley and thermal power projects to the state appraisal body**. EIA 2020 had said the same thing.
- MoEF is working on creating a **single-window process to grant environment**, **forest**, **and wildlife clearances**, which will standardise and expedite clearances further.

***[UPSC 2020] How does the draft Environment Impact Assessment (EIA) Notification, 2020 differ from the existing EIA Notification, 2006? (250 words)***

## 23.3. Wild Life (Protection) Act of 1972 (WPA 1972)

- The **WPA1972** provides a **legal framework** for protecting various species of **wild animals and plants**, managing their **habitats**, and regulating **trade** in them and their **products**.
- Originally extended to the whole of India except J&K, but after the abrogation of Art 370, the WPA1972 now covers J&K as well.

### Salient Features of WPA 1972

#### Schedules

- Wildlife species are given **varying levels of protection** under different schedules within the act: **Schedule I**, **II**, **III**, **IV**, **V**, and **VI**.
- **GoI can declare any wild animal not listed in Schedules I and II** as **vermin** through notification. Vermin are small wild animals that carry disease and destroy plants and food.
- GoI can **modify Schedules** by **adding**, **deleting**, or **transferring** entries between them.

## Prohibition of Hunting

- Wild animals specified in **Schedules I**, **II**, **III**, and **IV** are prohibited from hunting.

### Exceptions

- Wild animals listed under these schedules can **only be hunted or killed with permission** from the **state's Chief Wildlife Warden (CWLW)** if:
  1. A **Schedule I**-listed wild animal poses a **threat to human life** or is **irreversibly disabled or diseased**
  2. A wild animal listed in **Schedules II**, **III**, **or IV** is a **threat to human life or property** or is **irreversibly disabled or diseased**
- Killing or injuring a wild animal in **self-defence** or **defence of others**.

## Establishment of Protected Areas

- Five kinds of protected areas can be notified under this Act. They are:
  1. **Wildlife Sanctuaries:** The **State or Central Government** may, by notification, declare its intention to constitute any area as a sanctuary for protecting wildlife and the environment. The **government decides the rights of individuals** over the land within the sanctuary.
  2. **National Park:** The **State or Central Government** may declare an area, whether inside a sanctuary or not, a national park (NP) to protect wildlife and its environment. The **State Government cannot alter NP boundaries without the National Board's recommendation**. All rules applicable to sanctuaries also apply to NPs. **No human activity is permitted inside an NP except for ones permitted by the Chief Wildlife Warden** of the State.
  3. **Conservation Reserve: After consultation with local communities**, the **State Government** can declare **government-owned areas**, especially those near national parks or sanctuaries, as conservation reserves.
  4. **Community Reserve:** The **State Government**, **in consultation with individuals or communities volunteering to conserve wildlife**, can designate **private or community land** as a community reserve for wildlife conservation.
  5. **Tiger Reserve:** The **State Government** can notify an area as a tiger reserve on the recommendation of the **Tiger Conservation Authority**.

## Other Salient Features of the WPA

- **Regulation of Trade and Commerce:** The act controls trade and commerce in wildlife and its products via **permits** and **licenses**.
- **Authorities Appointed Under the Act:** The **State Government** appoints the **Chief Wildlife Warden**, and the **Central Government appoints directors and assistant directors**.
- **Penalties:** The act imposes severe penalties, including imprisonment and fines, for illegal activities such as hunting, trade, and commercial exploitation of wildlife.

## Bodies Constituted under the WPA

### National Board for Wildlife (NBWL)

- Due to the rapidly declining wildlife population, the GoI formed the **Indian Board for Wildlife** (IBWL) in 1952, chaired by the Prime Minister.
- The **Wildlife (Protection) Amendment Act of 2002** replaced the IBWL with the **National Board for Wildlife** (NBWL), a **statutory** body.
- Members of NBWL include:
  - The **Prime Minister** is the **Chairperson**
  - The **Minister in charge of the MoEF** in GOI is the **Vice-Chairperson**
  - **Three MPs** (two from Lok Sabha and one from Rajya Sabha)
  - Five persons representing **NGOs**
  - Ten **eminent ecologists**, **conservationists**, **and environmentalists**
  - The **Chief of the Army Staff**

#### Duties of NBWL

- It acts as the **apex body for reviewing wildlife matters and approving projects** within national parks and sanctuaries.
- The board **advises the GoI and state governments** on wildlife conservation policy-making.
- Prepare and publish a **status report** on wildlife in the country **at least once every two years**.
- **No alternation of boundaries in national parks and wildlife sanctuaries** can be done **without the approval of the NBWL**.

### State Board for Wildlife (SBWL)

- The **Wildlife (Protection) Amendment Act of 2002** provided for the constitution of the **State Board for Wildlife** (SBWL). (WPA 2002 amendment substituted "**Wild Life Advisory Board**" with SBWL).
- Members of SBWL include:
  - The **Chief Minister** is the **Chairperson**
  - The **Minister in charge of Forests and Wild Life** is the **Vice-Chairperson**
  - Three members of the **State Legislature** or, in the case of a UT with Legislature, two members of the **Legislative Assembly of that UT**

- ❖ Three persons representing **NGOs**
- ❖ Ten **eminent ecologists**, **conservationists**, **and environmentalists**, including at least two **representatives of the Scheduled Tribes**
- ❖ a representative of the Armed Forces **not below the rank of a Brigadier** nominated by the GoI

- It shall be the duty of the SBWL to advise the State Government
  - ✓ in the selection and management of areas to be declared as **protected areas**
  - ✓ in the **formulation of the policy** for the protection and conservation of wildlife
  - ✓ in any matter relating to the **amendment of any Schedule**
  - ✓ in **balancing the needs** of forest-dwelling tribes and other residents with wildlife conservation
  - ✓ in any other wildlife protection matter referred by the State Government

## Central Zoo Authority (CZA)

- **WPA 1972** provided for the constitution of the **Central Zoo Authority** by the Central Government.
- Accordingly, CZA was established as a **statutory body** under the **Ministry of Environment**, **Forest**, **and Climate Change** (MoEFCC).
- Authority shall consist of:
  - ❖ **Chairperson (Environment Minister)**
  - ❖ **Ten members**
  - ❖ Member secretary
- **Functions:**
  - ✓ It can **recognise or derecognise any zoo in the country**
  - ✓ It **regulates the zoos** across the country
  - ✓ It sets minimum standards for housing, upkeep, and veterinary care of zoo animals
  - ✓ It sets rules for **national and international animal transfers/exchanges among zoos**
  - ✓ It **identifies endangered species** of wild animals for purposes of **captive breeding** and assigning responsibility in this regard to a zoo.
  - ✓ It **identifies endangered wild animal species** for **captive breeding** and assigns responsibility to a zoo for this purpose.

## National Tiger Conservation Authority (NTCA)

- NTCA is a **statutory body** under the **MoEFCC**, established under the **WPA 1972**, **as amended in 2006**, to enhance tiger conservation efforts.
- It provides **statutory authority to Project Tiger** to ensure legal compliance with its directives
- **State Governments notify Tiger Reserves** under WPA 1972 **on the advice of the NTCA**.
- NTCA consists of the **Minister in charge of the MoEFCC** (as Chairperson) and the **Minister of State in the MoEFCC** (as Vice-Chairperson).

### Wildlife Crime Control Bureau (WCCB)

- WCCB is a **statutory multidisciplinary body** under the MoEFCC **that combats organised wildlife crime** in the country. It is constituted under the **WPA 1972**, **as amended in 2006**.
- The Bureau has its headquarters in New Delhi.
- It is mandated to:
  - ❖ **Collect and collate intelligence related to organised wildlife crime activities** and disseminate the same to the State to apprehend the criminals
  - ❖ Establish a **centralised wildlife crime data bank**
  - ❖ Assist State Governments to ensure success in prosecutions related to wildlife crimes
  - ❖ Advise the GoI on wildlife crimes with national and international implications, relevant policies and laws

## WPA Amendments till 2021

- The act has been **amended seven times:** 1982, 1986, 1991, 1993, 2002, 2006, and 2013, till 2021.
- **WPA amendment 1982:** Introduced a provision permitting the **capture and transportation** of wild animals for the **scientific management** of the animal population.
- **WPA amendment 2002:** Provision for **National Board for Wildlife**.
- **WPA amendment 2006:** Provision for **National Tiger Conservation Authority** and **Wildlife Crime Control Bureau**.
- **WPA amendment 2013:** Protects hunting rights of Scheduled Tribes in Andaman and Nicobar Islands.

## Wild Life (Protection) Amendment Act, 2022

- The **Wild Life (Protection) Amendment Act**, **2022** addresses the following objectives:
  - ❖ Give effect to India's **obligations under the Convention on Endangered Species of Wild Fauna and Flora (CITES)**
  - ❖ **Rationalise schedules** that list out species under the Wildlife Protection Act, 1972 (WPA, 1972)
  - ❖ **Strengthen the protection of species** (especially endangered species)
  - ❖ Conserve and protect wildlife through **better management of protected areas**
  - ❖ Benefit the **local tribal communities**

## WPA 1972 vs. WPA 2022

### Aspects of 'Conservation' and 'Management' of Wild Life

#### WPA 1972

- The1972 Act provided for the **protection of wild animals**, **birds**, and **plants** to ensure the nation's ecological and environmental security.

#### WPA 2022

- The words 'protection of wild animals, birds and plants' have been **substituted** with '**protection**, **conservation**, and **management of wildlife**'.

## Invasive Alien Species

### WPA 1972

- The1972 Act **did not have any provision for invasive alien species**.

### WPA 2022

- The 2022 Act **defines invasive alien species** as non-native animals or plants in India that could harm wildlife or its habitat **through** their **introduction or spread**.
- It **empowers** the **Central Government to regulate or prohibit** the import, trade, possession, or proliferation of invasive alien species

## Non-prohibited Activties in a Sanctuary

### WPA 1972

- No one can harm or take wildlife or alter their habitat in a **sanctuary**, or change the flow of water into or outside the sanctuary **without a permit** from the **Chief Wildlife Warden**.
- Permits can be issued **only for local residents' personal bona fide needs**, **not for commercial use**.
- **Non-prohibited activities: Grazing or movement of livestock**.

### WPA 2022

- The 2022 Act **increased non-prohibited activities** in a sanctuary. Now, it includes:
  - Grazing or movement of livestock
  - **Hunting of wild animals** without violating the conditions of the permit
  - **Exercise of land rights** whose continuance is permitted within the sanctuary
  - **Bona fide use of drinking and household water** by local communities

## Wild Animals, etc., to be Government Property

### WPA 1972

- The **state government owns hunted wild animals**, **their parts**, **hunting equipment**, and **wild animals kept or bred in captivity**.
- If hunted in a National Park or Sanctuary declared by the GoI, they **belong to the GoI**.

### WPA 2022

- When government property is a **live animal** that **cannot be released to its natural habitat**, the **State Government must house** and **care for it** in a **recognised zoo** or **rescue centre**.
- **Hunted wild animal parts** (including meat) **must be disposed** of by the concerned State Government or GoI as prescribed by the GoI. Such **disposal shall not include any commercial sale**.

## Regulation of Transfer of Animal

### WPA 1972

- **A person with a certificate of ownership** for a captive animal or an animal article **cannot sell** or **offer them for commercial purposes**.
- **Exemptions:**
  - **Tail feather of peacock** and articles made from it
  - **Transfer of captive animals between recognised zoos** or **amongst zoos and public museums**

### WPA 2022

- The 2022 Act **allows people with valid certificates of ownership to transfer or transport captive elephants for religious or other purposes**, subject to GoI terms and conditions.

### Criticism

***Dilution of elephant protection***

- The provision for the transfer of elephants for religious and other purposes has **legalised the misuse of elephants**. This 'other purpose' term is **broad** and **vague**.
- Though the WPA **still prohibits** the **commercial trade of elephants**, this new provision **dilutes** the former. Now, elephants can be acquired by any malicious individual or institution.

## Regulation of International Trade in Endangered Species of Wild Fauna and Flora as per CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora)

### WPA 1972

- The1972 Act **did not have any provision** for obligations under CITES.

### WPA 2022

- The 2022 Act provides for **proper implementation of the provisions of the CITES in India**. It provides for the GoI to designate a:
  1. **Management Authority (MA):** Grants export or import permits for trade of specimen
  2. **Scientific Authority:** Provides advice on how trade affects the survival of traded species
- Traders of scheduled specimens must report details of transactions to the Management Authority. As per CITES, the Management Authority can **use an identification mark for specimens**. The Act **forbids altering or removing a specimen's identification mark**.
- Possessors of **live scheduled animals** must **obtain a registration certificate** from the MA. Breeders and artificial propagators of **Appendix I Schedule IV species** must **apply for a license**.

### Criticism

***No clear connection between endangerment and conservation***

- The 1972 Act aimed to **regulate species use**, including hunting, and control trade and trafficking. The 2022 Act **extends this** by aligning with **CITES** and including its appendices.
- But **nowhere** in the Act is there **a clear connection between endangerment and conservation**.

## Rationalisation (Amendment) of Schedules

### WPA 1972

- The 1972 Act has **six schedules**, which are given varying degrees of protection

| Schedules | Protected Species | Protection |
|---|---|---|
| Schedule I | Critically endangered animals | Hunting and trade are prohibited throughout India |
| Schedule II | Less endangered than Schedule I | Hunting and trade are prohibited throughout India |
| Schedule III | Big game species | Hunting is prohibited, but penalties are less severe |
| Schedule IV | Small game species | Hunting is prohibited, but penalties are less severe |
| **Schedule V** | **Vermin** | **Hunting without restriction** |
| Schedule VI | Plants | Prohibited from cultivation and planting |
| ***Vermin*** *are small wild animals that carry disease and destroy plants and food.* | | |

### WPA 2022

- The 2022 Act **reduces** the **number of schedules to four** by:
  - **Reduced** the **schedules for specially protected animals** to **two** (one for greater protection level)
  - **Removed the schedule for vermin species**
  - Inserts a **new schedule** for **specimens listed in the Appendices under CITES**

1. **Schedule I:** Animal species that receive the **highest level of protection**, including critically endangered species
2. **Schedule II:** Animal species that receive a **lower level of protection**
3. **Schedule III:** Protected **plant species**
4. **Schedule IV:** Specimens listed in the Appendices under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (**CITES**)

### Criticism

***No rationale behind the listing of species in schedules***

- The main motive for scheduling of species is **prioritisation for conservation**. However, the new Act has **placed numerous species under the same schedule without any justification**. For e.g., the **same level of protection** is given to tigers, jackals, great Indian bustards, and barn owls.
- All these will **create confusion while allocating resources** for conservation.

***Help propagate invasive species***

- The 2022 Act has placed the species in schedules **without regard to their ecological roles**, potentially **aiding the spread of invasive species**. For e.g., the **spotted deer (chital)** is now in **Schedule I** despite being **invasive in the Andaman Islands**, **hindering legal culling** or **removal**.

## Control of Sanctuaries

### WPA 1972

- The1972 Act entrusts the **Chief Wild Life Warden** to **control**, **manage** and **maintain all sanctuaries in a state**. The Chief Wild Life Warden is **appointed by** the **state government**.

### WPA 2022

- The 2022 Act states that Chief Wardens must act **in accordance** with **sanctuary management plans** developed following GoI's guidelines and the Chief Warden's approval.
- **Sanctuary management plans in special areas** must be prepared **after consulting** the **Gram Sabha**.

⇨ ***Special areas*** *include:*

1. ***Scheduled Areas*** *(Economically backward areas with a predominantly tribal population, notified under the 5th Schedule to the Constitution).*
2. *Areas where the* ***Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act***, ***2006*** *is applicable.*

## Conservation Reserves

### WPA 1972

- The1972 Act **empowered state governments** to declare **adjacent areas of national parks and sanctuaries as conservation reserves** for protecting flora and fauna and their habitat.

### WPA 2022

- The 2022 Act **empowers** the **GoI** to **notify a conservation reserve**.

## Surrender of Captive Animals

### WPA 1972

- The1972 Act had **no provision for surrender of captive animals**.

### WPA 2022

- The 2022 Act allows for the **voluntary surrender of captive animals** or **animal products** to the Chief Wild Life Warden. **No compensation** will be paid for surrendering such items. The surrendered items become the **property of the state government**.

## Other Issues with WPA 2022

### Impact on people

- **Various Schedule I species**, like crocodiles in the Andamans, leopards in specific areas, and elephants in many regions, **cause significant physical**, **mental**, and **economic harm** to people. Moreover, the new Act **raises wild pigs** and **nilgai** to **Schedule I**, **barring states from limited culling of these problematic animals**.
- Thus, the WPA 2022 serves the elite conservationists' view that **people should learn to 'co-exist'** while utterly **disregarding the plight of marginal cultivators**. The WPA 2022 has missed the opportunity to address important issues relating to Human-Wildlife conflict, Eco-sensitive Zone rule, etc.

### Research

- The **research permit process** is **lengthy** and **burdensome**, potentially hindering research efforts due to the extensive species listing. Environmental NGOs will face greater challenges obtaining permits, **negatively affecting species conservation efforts**.

### Against the federal structure of the Constitution

- Protection of wild animals and birds is a subject under the **Concurrent List** of the Constitution. However, many provisions of the WPA 2022 have increased the power of the Central government in this regard and reduced the state's involvement.

> ⇨ *The **42nd Constitutional Amendment Act**, **1976**, transferred Forests and the **Protection of Wild Animals and Birds** from the **State** **to a** **Concurrent List**.*

## 23.4. Wildlife (Protection) Licensing Rules, 2024

- **Wildlife (Protection) Licensing (Additional Matters for Consideration) Rules**, **2024** were notified by MoEFCC. It aims to **replace** Wildlife (Protection) Licensing (Additional Matters for Consideration) Rules, 1983.
- It introduces fresh **guidelines for licenses** in **snake venom**, **captive animals**, **trophy animals**, and **stuffed animals**.
- The previous rules prohibit licences for **Schedule I or Part II of Schedule II animals** under the **Wildlife Protection Act 1972**. The licences were granted in **exceptional cases** with previous approval of the central government.

### New guidelines vs Old guidelines

| Notification | Rules | Details |
|---|---|---|
| **1983 Rules** | Prohibit licences for **Schedule I** and **Part II of Schedule II** | Licences are granted in exceptional cases with the **previous approval of the GoI** under the **WPA 1972**. |
| **2024 Rules** | Prohibit licences for **Schedule I** only. | **Restrictions on Schedule II species are lifted**. |

| | | |
|---|---|---|
| | It can be **provided** if there is a **prior consultation with the GoI**. | New guidelines consider capacity, source of supplies, and implications on hunting or trade. |

## 23.5. Forest Rights and Forest Conservation

### Indian Forest Act 1927 (IFA 1927)

- The IFA 1927 was largely based on previous Indian Forest Acts implemented under the **British**. The most famous one was the IFA 1878.
- It provides the legal framework for **the protection and management of forests** and **duty leviable on timber and other forest products**. It provides for the procedure to be followed for **declaring an area to be Reserve/Protected/Village Forest (Degree of protection: Reserved forests > Protected forests > Village forests)**
- The **Indian Forest (Amendment) Act, 2017** amended the definition of tree to **remove the word bamboo**. It means that **bamboo grown outside forest areas can be felled** or **transported for economical use without needing permission**.

#### Reserve Forest (RF)

- **State governments** can designate **any forest land or wasteland** as reserved forest **belonging to the government** and **can sell their produce**. Before official notification, a **Forest Settlement Officer** (with **powers of a Civil Court**) must be appointed **to inquire and settle the claims** of local residents.
- **All activities are prohibited unless permitted in RFs**.

#### Protected Forest (PF)

- **State government** may constitute **any forest land or wasteland not included in Reserve Forest** as **Protected Forest**. Protected forests are of **2 kinds**:
  1. **Demarcated** protected forests
  2. **Undemarcated** protected forests
- **All activities are permitted unless prohibited in PFs**.

#### Village Forest

- **State governments** can grant **village communities rights over government land designated as reserved forest**. They can also establish rules for managing village forests, including conditions for community access to timber, forest produce, or pasture.

#### Criticism

- The 1927 act primarily **served British interests**, granting **states control over tribal rights** without aiming to protect the nation's forests. Its focus was on regulating and taxing forest produce, which became a key revenue source for the government.

## Forest (Conservation) Act 1980 (FCA, 1980)

- FCA, 1980 was enacted **to protect India's forests** and **regulate forest resource extraction** by **industries** and **forest-dwelling communities**.
- The Act deals with the four categories of forests, namely **reserved forests**, **village forests**, **protected forests** and **private forests**.

### Features of the FCA, 1980

#### Restriction on Dereservation

- The Act **restricts the states** and **other authorities** from **allowing dereservation (i.e., use of forest land for non-forest purposes) without permission from the central government**.

> ⇨ ***Non-forest purposes*** *include using land for cultivating horticultural crops or for any purpose other than reafforestation.*

#### Appeal to National Green Tribunal

- The Act provided that any **aggrieved person** may file an **appeal** to the **National Green Tribunal** against the decision of the State Government or any authority.

#### Constitution of Advisory Committee

- The Act empowered the **Central Government** to constitute a **committee to advise** the Government regarding forest conservation.

#### Penalties

- The Act levies penalties in case of violations of the provisions of FCA.

#### Power to Make Rules

- The Act empowers the **Central Government** to make rules for carrying out the provisions of this Act.

### 1992 Amendment

- It provisioned for **allowing some non-forest activities in forests**, without cutting trees or limited cutting with prior approval of the Central Government.

### FCA Includes Forests That are Not Notified Protected

- The **SC Order of 1996** (**TN Godavarman Thirumulkpad vs the Union of India**) had observed that the Forest (Conservation) Act, 1980, aimed to prevent deforestation and stated that **conservation provisions must apply to all forests**, **regardless of ownership or classification**.
- The court also specified that **forests encompass not only areas officially recorded as such in government records** but **also any areas resembling the dictionary definition of a forest**.

#### The Responsibilities and Powers of States

- Under the **Godavarman order**, the **states are supposed to identify and notify forests**. The **Forest Advisory Committee (FAC) of MoEF**, the **apex body that deliberates on granting permission to fell forests**, said, "**criteria finalised by a state need not be subject to approval by MoEFCC**".

## Forest Conservation (Amendment) Bill, 2003

- The Bill **renames** the Forest (Conservation) Act, 1980, to **Van (Sanrakshan Evam Samvardhan) Adhiniyam** or **Forest (Conservation and Augmentation) Act**. The new name reflects a **new focus** on **afforestation** and **reforestation** activities.

### Objectives of the 2023 Bill

- To broaden the horizons of the Act **to boost India's forest cover to 33%** and **to create a carbon sink of additional 2.5-3.0 billion tons of $CO_2$ by 2030** as part of its Pari Agreement commitments.
- To **balance industrial development** and the **conservation** of forests.
- To clarify the **applicability of the Forest (Conservation) Act**, **1980** on various lands.

## Key Provisions of the Forest (Conservation) Amendment Bill, 2023

### Restrictions on Activities in the Forest

***FCA, 1980***

- FCA, 1980 **specifies activities** that will be **excluded from restriction on dereservation**. These activities include **conservation**, **forest development**, **wildlife-related works**, **etc**. GoI may **exclude any survey** (exploration, seismic survey) from restrictions on dereservation.

***2023 Bill***

- The 2023 Bill **adds more activities to the restriction on dereservation list**, such as:
  - **zoos and safaris** under the Wild Life (Protection) Act, 1972, **owned by the government or any authority**, **in forest areas other than protected areas**
  - **eco-tourism facilities**
  - **silvicultural operations (enhancing forest growth)**
  - **any other purpose specified by the central government**

### Land under the Purview of FCA

- The 2023 Bill provides that two types of land will be under the purview of the FCA:
  1. **Land notified as a forest** under the **Indian Forest Act**, **1927 or under any other law**
  2. **Land not covered in the first category** but **notified as a forest on or after 25th October 1980** in a **government record**.

***25th October 1980:*** *The day when the Forest (Conservation) Act of 1980 came into effect.*

***Criticism: Limits Scope of the FCA***

- SC in **T.N. Godavarman vs. Union of India** held that the **provisions of the FCA will apply beyond 'notified forests' to all areas 'recorded' as forest in any government record**.
- But the 2023 Bill proposes that the **FCA will apply ONLY to lands recorded as forest on or after 25th October 1980**, thus **restricting the scope of the Godavarman judgement**. This is a significant exclusion because it will **exclude 28% of India's forests outside Recorded Forest Areas** from the **purview of the FCA**, which can be **easily diverted for commercial use**.

### Land Exempted from the Purview of FCA

- The 2023 Bill **exempts certain types of land** from the provisions of the FCA. They include:
  - Forest land **along a rail line or a public road** maintained by the government providing access to habitation or a rail and roadside amenity **up to 0.10 hectares (ha)**.
  - Forest land situated within **100 km along the international borders** proposed to be used for the construction of **strategic projects** of **national importance or security**.
  - Forest land **up to 10 ha**, proposed to be used for **construction of security-related infrastructure**.
  - Forest land proposed for construction of **defence and paramilitary projects** or **public utility projects** as specified by the GoI (**not exceeding 5 ha in left-wing extremism-affected areas**).
  - **Land changed from forest use to non-forest use on or before 12th December 1996** by any authority authorised by a state/UT.

#### *Criticism: Endangers Ecologically Sensitive Bio-geographic Regions and Biodiversity Hotspots*

- This exemption provision of the Bill is problematic as **forests in the Himalayan**, **Trans-Himalayan** and **North Eastern regions**, which are **rich with endemic biodiversity**, **will be exempted**. Clearing these forests without any assessment and mitigation plan will lead to **biodiversity loss** and **increase the vulnerability** of the ecologically and geologically sensitive areas.

### Incentiving Private Agro-Forestry and Tree Plantation Activities

#### *FCA, 1980*

- It allowed **private plantations** or **reforested land** to be **retrospectively earmarked as forest**. This provision **disincentivised the private parties**.

#### *2023 Bill*

- The 2023 Bill **incentivises private parties** by **allowing the diversion of private forests for commercial or other uses without the need for acquiring forest clearance**.

#### *Criticism: Incentivise Afforestation for Commercial Ends*

- The Bill allows the **diversion of private forests for afforestation activities**. This **may not help create a permanent carbon stock**, as the forests can be used as **carbon credits**.

⇨ ***Carbon Credits*** *(or carbon offsets) are permits that allow the owner to emit a certain amount of carbon dioxide or other greenhouse gases. They are awarded to organisations based on the quantities of greenhouse gases that they keep out of the air or remove from it. The* ***carbon credit owner can sell them to organisations that have exceeded their limit****.*

### Assigning of Land through a Lease or Otherwise

***FCA, 1980***

- State government or any authority **requires prior approval of the GoI** for assigning forest land to **any organisation** (**private person**, **authority**, **corporation**) **not owned by the government**.

***2023 Bill***

- The 2023 Bill provides that the **state government or any authority** do this assigning to **any organisation subject to terms and conditions prescribed by the GoI**.

### Power to Issue Directions

- The 2023 Bill adds that the **GoI may issue directions** for implementing the FCA to any other authority/organisation under or recognised by the centre, state, or UT.

### Other Criticisms of the 2023 Bill

- **Diluted the Power of FCA:** The 203 Bill used terms like 'proposed', 'ecotourism facilities', and 'any other purposes', which are **too vague** and can be exploited or **misused for commercial purposes**.
- **Biodiversity Loss:** Though the 2023 Bill proposes to ease the land transfer for **compensatory afforestation**, it will not serve the ecological purpose until fundamental changes are made. Generally, **monoculture** is practised in **compensatory afforestation**, which leads to biodiversity loss.
- **Violation of Constitutional Rights:** The provision of exemptions without the consultation of local individuals **violates the Forest Rights Act**, **2006 (FRA 2006)**, **the Panchayat Act**, **and constitutional provisions for the STs**. Requiring consent for forest land diversion **legally acknowledges the rights of forest dwellers**, which is recognised by the **FRA 2006**.

## FCA 2023 and the NE States

- The Mizoram Assembly passed a resolution opposing the **Forest (Conservation) Amendment Act (FCA)**, **2023**, "to **protect the rights** of the people of Mizoram".

### What are the Concerns of Northeast Against Amended FCA?

### Land Exempted from FCA Clearance

- The amended FCA **allows the diversion of forest land** for **strategic projects** of national importance and security **within 100 km of India's international borders without a forest clearance** under the **Forest (Conservation) Act (FCA) 1980**. **Most of NE falls in this 100 km range**.

### Land Deprived of FCA Protection

- The amended FCA **protects only notified forests**:
- **Land notified as a forest** under the **Indian Forest Act**, **1927**, or **under any other law** or
- **Land not covered in the first category** but **notified as a forest on or after 25th October 1980** in a **government record**. (FCA 1980 came into effect on 25 October 1980).
- This goes against the **SC judgment** in the **Godavarman Case (1996)**, which says **FCA will apply beyond 'notified forests' to all areas 'recorded' as forests** in government records **irrespective of ownership**. Thus, this judgment **brought unclassed forests under the purview of FCA**.

| NE State | Recorded Forest Area (in %) | Unclassed Forests (in %) |
|---|---|---|
| Arunachal Pradesh | 62 | - |
| Assam | 34 | 33 |
| Manipur | 78 | 76 |
| Meghalaya | 42 | 88 |
| **Mizoram** | **35** | **15** |
| Nagaland | 53 | 97 |
| Tripura | 60 | 42 |
| **Sikkim** | **82** | **0** |

- **More than 50%** of the **Northeast** is **Recorded Forest Area (RFA)**. Of this, **53% are unclassed forests** controlled by individuals, clans, and village councils according to customary law and procedures.

***Recorded Forest Area:*** *It refers to all geographic areas* ***recorded as 'Forests' in government records***.
***Notified Forest:*** *Any forest area notified under the provisions of the* ***Indian Forest Act 1927*** *or* ***state forest acts***.
***Unclassed Forests:*** *These are recorded forests but* ***not notified*** *as forests.*

## Is FCA applicable to the Northeast?

- **Special constitutional protections**, such as **Article 371A** for **Nagaland** and **Article 371G** for **Mizoram**, **prohibit** the **application of any law enacted by Parliament** that **impinges**:
  - On **Naga** and **Mizo customary law** and procedure
  - **Ownership** and **transfer of land** and its **resources**
- Such laws can be **extended only if** their **Legislative Assemblies decide so** through a resolution.

| Article | Added by |
|---|---|
| **Article 371A** | 13th Amendment Act, 1962 (it created the State of Nagaland) |
| **Article 371G** | 53rd Amendment Act, 1986 (it created the State of Mizoram) |

### Nagaland

- In 1986, Nagaland extended the application of the FCA to government forests. However, in 1997, the **Home Ministry** confirmed that the FCA **did not** apply to Nagaland. Later, in **1998**, the **MoEF informed** the Nagaland government that **FCA applies to the State**. Nevertheless, **since 1980**, the **MoEFCC** has **not granted an FCA clearance** to forests in Nagaland.

#### Mizoram

- In 1986, the UT of Mizoram became a **State** with the **53rd Amendment of the Constitution**. It stipulated that **all Central Acts in force** before 1986 be extended to the State, **including** the FCA.
- Moreover, the powers of the **Autonomous District Councils** in the **6th Schedule areas** in Mizoram do not extend to reserved forests. So, **FCA covers 85% of forest areas** that are **notified forests**.

#### Rest of Northeast India

- **FCA applies to the rest of the Northeast**, including the 6th **Schedule areas of Assam**, **Meghalaya**, **and Tripura**.

***Top NE States in FCA clearance: 1st Arunachal Pradesh*** *> 2nd Tripura > 3rd Mizoram >4th Assam*

## 23.6. FCA 2023 and Odisha's Deemed Forest Issue

- Following the **FCA 2023**, the Odisha government has directed that the **diversion of forest land for non-forestry purposes** should now **conform with the amended Forest Act** and that **'deemed forests' as a category would cease to exist**.

### What are Deemed Forests?

- Deemed forest is a land that **conforms to the 'dictionary' meaning of forest** but is **not notified as forest land by the Centre or the state government**. The concept of deemed forests has **not been clearly defined in any law**, including the Forest Conservation Act 1980 (FCA 1980).

### TN Godavarman vs Union of India (1996)

- In **TN Godavarman vs UoI (1996)**, the **SC** held that the **'forest'** must be **understood by its dictionary meaning**. It **entrusted States** to **identify lands "that conformed to the dictionary meaning of forest irrespective of ownership"** and **expand protections under the FCA to them**.

### What the FCA 2023 Says About Deemed Forests?

- FCA 2023 has **not directly addressed** the concept of deemed forest. But it provided that the **FCA will apply only to lands recorded as forest on or after 25th October 1980**.
- FCA 2023 also provided that **forest land officially diverted by the government for non-forestry purposes between 1980 and 1996** will also **not be protected**.
- Thus, FCA 2023 **restricted the scope of the Godavarman judgment** and **lifted the FCA protection from deemed forests**.

### Clarification by the Environmental Ministry

- The Environment Ministry clarified to a Joint Parliamentary Committee that the amendments **did not fall afoul** of the **1996 Supreme Court judgment**. **Deemed forest lands identified by the Expert Committee of the State have been taken on record**, and hence, the **provisions of the Act will be applicable in such lands**.

### Issue: After the Clarification

- States were expected to form **expert committees** and **identify land** encapsulated **under the definition of forest** given by the **1996 SC Judgement**. However, **not all states submitted these reports**, **leaving considerable leeway for States** to define or leave out large parcels of land from the definition of forest.

### Issues with the Odisha Government's Order Regarding Deemed Forests

- **Nearly half of Odisha's forest land is 'deemed forest'**. So, the Odisha government's interpretation of the FCA 2023 will end up **accelerating the razing of forests**.
- The Odisha government's order **conflicts** with the **Environment Ministry's assurance** that **'deemed forest' will continue to be protected**.

### Present Position of Odisha Government

- It has **withdrawn the order** stating that **'deemed forests' as a category would cease to exist**. It has put the decision on hold till the issuance of **final guidelines by the Forest Ministry**.

## Forest Rights Act, 2006 (FRA 2006)

- The **Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006**, provides for the **restitution of deprived forest rights** across India. It **integrates conservation** and **people's livelihood rights** and **strengthens local self-governance**.
- For the first time, FRA recognises and secures:
  - **Community Rights in addition to their Individual Rights**
  - Right to **protect**, **conserve**, or **manage** any community forest resource **traditionally safeguarded by communities** for sustainable use
  - Right to **intellectual property** and **traditional knowledge** related to biodiversity and cultural diversity
  - Rights of **displaced communities** and rights over **developmental activities**

### Salient Features

- This Act applies to **tribal** and **other traditional forest-dwelling communities**. The **Ministry of Tribal Affairs** (MoTA) is the nodal agency for its implementation.

- The Act recognises the **right of ownership** and access to **collect**, **use**, and **dispose** of **minor forest produce** **by** **tribals** (FRA defines **Minor Forest Produce** as **all non-timber forest produce of plant origi**n and includes bamboo, canes, Tusser, cocoon, honey, waxes, tendu leaves, medicinal plants, etc.).
- The **rights conferred** under the Act shall be **heritable** but **not alienable or transferable**.
- **National Parks and Sanctuaries**, along with **Reserve Forests** and **Protected Forests**, are included for the recognition of rights. FRA **recognises** **pre-existing rights exercised by eligible persons** in NPs and Sanctuaries, securing the tenure of existing forest dwellers **without creating new rights**.

**[UPSC 2021] At the national level, which ministry is the nodal agency to ensure effective implementation of the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006?**

a) Ministry of Environment, Forest and Climatic change.
b) Ministry of Panchayat Raj
c) Ministry of Rural Development
d) Ministry of Tribal Affairs

## The FRA Act Identifies 4 Types of Rights

1. **Title rights:** Grants **land ownership rights** to forest-dwelling farmers, **capped at 4 hectares**.
2. **Use rights:** The **dwellers' rights** extend to **extracting Minor Forest Produce**, **grazing areas**, etc.
3. **Relief and development rights:** Right to **rehabilitation** in case of illegal eviction or forced displacement and to **basic amenities**, subject to restrictions for forest protection.
4. **Forest management rights:** Right to protect, regenerate, conserve or manage **any community forest resource** **traditionally safeguarded by communities** for sustainable use.

## Criteria to Claim Rights Under FRA

- **Criteria and evidence for Forest Dwelling Scheduled Tribes (FDST) to claim rights under FRA:**
  - Must be **ST** in an area.
  - Primarily resided in forest or land prior to **December 2005**
  - Depend on forest or forest land for **livelihood needs**
- **Criteria for Other Traditional Forest Dwellers (OFTD) to claim rights under FRA:**
  - Primarily resided in the forest for **3 generations** (75 years) prior to December 2005
  - Depend on forest for **livelihood needs**
- If an OTFD village establishes its eligibility under the act, there is no need for every individual to establish its eligibility separately.

## Gram Sabha

- As per the Act, the **Gram Sabha** has been designated as the **competent authority** for initiating the process of determining the **nature and extent of individual or community forest rights**.

- The decision of the Gram Sabha to reject or allow a claim **can be appealed before the court**.

***[UPSC 2016] Rehabilitation of human settlements is one of the important environmental impacts which always attracts controversy while planning major projects. Discuss the measures suggested for mitigation of this impact while proposing major developmental projects.***

### Community Forest Resources Guidelines

- **Community forest resource (CFR) rights** are given under the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 (**FRA 2006**).
- In community forestry, the **local community plays a significant role** in **forest management** and **land use decision-making** by facilitating the support of government and NGOs. It gained prominence in the mid-1970s in countries like Nepal, Indonesia, Korea, Brazil, India, and North America.

#### Forest Rights Act in Northeast

- In the **FRA 2006**, **"forest land" includes unclassified forests**, **un-demarcated forests**, **existing or deemed forests**, **protected forests**, **reserved forests**, **Sanctuaries**, and **National Parks**.
- This complied with the **1996 Supreme Court redefinition** of forest.
- However, **none of the Northeast States have implemented FRA except for Assam** and **Tripura**.

**Reasons why FRA is being 'irrelevant' in the Northeast:**

- **Communities**, clans, etc., own most forest lands and **already enjoy the rights**.
- A lack of forest-dwellers who are totally forest-dependent.

## Critical Wildlife Habitats (CWH)

- The **Critical Wildlife Habitats** (CWH) have been envisaged in the **Forest Rights Act of 2006**. CWH are defined under the act as the "**areas of national parks and sanctuaries** which are **required to be kept as inviolate** (human settlement and usage) **for the purpose of wildlife conservation**". FRA identifies **MoEF** as the **agency to notify the guidelines** related to Critical Wildlife Habitats (CWH).

### 2011 Guidelines by MoEFCC

- To notify a CWH, the FRA requires **state governments** to establish that the **presence of right-holders** is **causing irreversible damage to wildlife and their habitats**.
- **Gram Sabha's free**, **informed consent must be given** before any relocation of right-holders is carried out. **Forest rights are settled** under the FRA **before a CWH can be declared** in an area.
- An expert committee (members of the gram sabha, an ecologist, a tribal welfare NGO, a social scientist, and the Forest Department's officers) will take the main responsibility for determining the habitats.
- After more than a decade of FRA's existence, **not a single CWH had been notified**.

### 2018 Guidelines by MoEFCC

- The **Chief Wildlife Warden** of a state will notify a **7-member expert committee** chaired by a chief conservator of forest in charge of a national park or sanctuary for the purpose of identification of **CWH in an NP or sanctuary**. The Expert Committee will identify areas based on scientific and objective criteria relevant to the protected area.
- The Expert Committee shall issue a **public notice 15 days in advance** on the intention to notify CWH. The public notice shall include details of areas required to be kept **inviolate**, criteria adopted for CWH identification, implication of the notification, and options for resettlement and rehabilitation schemes.
- The Expert Committee shall carry out open consultations with all stakeholders, and the proceedings and objections will be documented appropriately. The committee will submit the CWH proposal to the **Chief Wildlife Warden**.
- The **Standing Committee** of the **National Board for Wildlife** will make the **final decision**. The committee will invite a MoTA representative to discuss the proposal. Following the committee's recommendation, CWH will be notified in the **official gazette**.

**How do the Guidelines Dilute FRA?**

- Guidelines have **replaced prior consent of the gram sabha** with a **public hearing** of all stakeholders.
- There is **no mechanism** in the guidelines **to address the objections** raised (by MoTA representatives) during consultations. It is also not clear whether there would be single or multiple consultations for an entire Protected Area.
- In the existing guidelines, **CWH notification is not subject to public scrutiny once 'open consultations' have been carried out (in the contract, the draft notification of every Eco-sensitive Zone** (ESZ) is put up in the **public domain for at least 60 days** before its finalisation).
- The guidelines are **silent on the issue of settlement of rights before notifying CWHs**.

**[UPSC 2018] Consider the following statements:**

1) The definition of "Critical Wildlife Habitat" is incorporated in the Forest Rights Act, 2006.
2) For the first time in India, Baigas have been given Habitat Rights.
3) MoEF officially decides and declares Habitat Rights for Primitive and Vulnerable Tribal Groups in any part of India.

***Which of the statements given above is/are correct?***

a) 1 and 2 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

**Explanation**

- 2016: **Baiga tribe (living in sal forests of Maikal Hills) in Madhya Pradesh** is the **first to get habitat rights in India** under the Forest Rights Act of 2006.
- Baiga community is one of the **75 particularly vulnerable tribal groups**, or PVTGs, who are eligible to get habitat rights under FRA.
- The definition of the **habitat rights** was incorporated **through an amendment in the FRA in 2012**.
- As per the amendment, the district level committee shall ensure that all PVTGs receive habitat rights, in consultation with these groups, after filing claims before the gram sabha.
- **It is MoTA that decides habitat rights**.

***Answer: a) 1 and 2 only.***

## National Forest Policy 1988

- India has had a forest policy since 1894. The policy was revised in 1952 and again in 1988. The **principal aim** of the 1988 policy was to ensure **environmental stability and maintenance of ecological balance**, including **atmospheric equilibrium**. The derivation of direct economic benefit must be subordinated to this principal aim.
- For the first time, the policy considered **forest land or land with tree cover as a national asset**. The diversion of forest land for any non-forest purpose should be subject to the most careful examination. It **mandates** that **33% (1/3$^{rd}$)** of the GA of India **should be under forest or tree cover**.

### Other Aims and Objectives of 1988 Policy

- **Conservation of natural heritage** and checking soil erosion and denudation in catchment areas
- **Checking extension of sand dunes** in desert areas of Rajasthan and along coastal tracts
- Increasing forest/tree cover through massive **afforestation and social forestry programmes**
- Ensuring the **symbiotic relationship between tribal people and forests** and including tribal people closely in the protection, regeneration and development of forests
- Taking steps to meet requirements of fuel, wood, fodder, minor forest produce, soil and timber of rural and tribal populations
- Taking steps to **create a massive people's movement with the involvement of women** to achieve the objectives and minimise pressure on existing forests.
- Greater impetus for **Forestry Education and Research**

### Draft National Forest Policy 2018

- It's an update to the **National Forest Policy of 1988**, which has been pending.

#### Aims and Objectives of 2018 Policy

- **Reverse the degradation of forests** and contribute towards achieving forestry-related **Nationally Determined Contribution Targets (NDCs)**.

- ❖ Maintenance of the health of forest vegetation and forest soils for augmenting water supplies through **recharge of underground aquifers** and **regulation of surface water**.
- ❖ Manage protected and other wildlife-rich areas with the primary objective of **biodiversity conservation** and enriching other ecosystem services.
- ❖ Include **green accounting**, **ecosystem service valuation**, and **climate change** considerations in planning and managing forests and protected areas.
- ❖ Integrate climate change mitigation/adaptation measures in forest management through the **mechanism of REDD+** so that the impacts of climate change are minimised.
- ❖ **Sustainable use of Non-Timber Forest Produce (NTFP)** such as medicinal and aromatic plants, oil seeds, resins, wild edibles, fibre, bamboo, grass etc.
- ❖ Expanding and managing **green spaces in urban and peri-urban areas** to enhance citizen well-being.
- ❖ **Credible certification process** to enhance the value of forest products harvested sustainably.
- ❖ Greater emphasis on protecting **forests of the North-East**.
- ❖ Establishing a **National Board of Forestry** (headed by the Environment Minister) and **State Boards of Forestry** (headed by the State Environment Minister) to ensure convergence, and conflict resolution.
- ❖ Integration and assimilation of **international multilateral agreements and commitments**.
- ❖ **Private intervention** for maintaining the forest quality.

## Afforestation Programmes

- The MoEFCC implements afforestation schemes in the forest areas with a **participatory approach**. **Plantation species** are selected by **Joint Forest Management Committee** (JFMC) members based on needs, ecological conditions, etc. **Native forest species** with multiple uses are encouraged.
- The ministry is implementing three significant schemes for the development of forest areas:
  1. **National Afforestation Programme (NAP) scheme:** For the afforestation of **degraded forest lands**.
  2. **National Mission for a Green India (GIM) (Green India Mission):** To **improve the quality of forests and increase forest cover**.
  3. **Forest Fire Prevention and Management Scheme (FFPM):** For forest fire prevention and management measures.
- For **scientific forest management**, the states prepare a Working Plan, which MoEFCC approves. The funds collected under the **Compensatory Afforestation Fund Management and Planning Authority (CAMPA)**, as compensatory levies from states, are used in plantation activity.

### National Afforestation Programme (NAP)

- NAP aims to **restore degraded forests** with **people's participation**. It is a **centrally sponsored scheme** with a **60:40** fund-sharing ratio between the **Centre and States** and **90:10** for **NE and hilly States**. A three-tier institutional setup implements NAP:

1. **State Forest Development Agency (SFDA)** at the state level
2. **Forest Development Agency (FDA)** at the forest division level
3. **Joint Forest Management Committees (JFMCs – registered societies)** at the **village level**

### Joint Forest Management (JFM)

- GoI introduced **Joint Forest Management** (JFM) through the **National Forest Policy**, **1988**, which is a forest management **partnership** between **forest departments** and **local communities**. The communities are required to organise a Forest Protection Committee (FPC), village forest committees, etc.
- Each body has an executive committee for daily management. A women's sub-committee in the JFMC ensures gender balance. Communities **benefit from using minor non-timber forest produce in return for their services**.

#### *Examples of Joint Forest Management (JFM)*

- The controlled grazing of cattle by the **Gaddi and Gujjar tribes** in the **Himalayan states** prevents the widespread growth of wild grass, thus contributing to the conservation of biodiversity.
- The **Bishnoi community** (**Rajasthan** and **Punjab**) play a major role in conserving **blackbuck (LC)**.
- **Maldharis** in the vicinity of **Gir National Park** contributed to the improvement of the lion population.

#### *Issues with Joint Forest Management (JFM)*

- Implementation of JFM afforestation programmes is **expensive** (Rs 20,000 per ha).
- **Inadequate remuneration** for local communities from JFM activities.
- **Lack of legal status and financial and executive powers** for the Forest Protection Committee (FPC).
- Forest Departments in certain States are vested with **arbitrary powers to dissolve FPCs**.
- **Absence of participation by women** despite their formal representation in management committees.
- **Inter-intra-community conflicts** hamper FPC functioning.
- **Denial of local communities' rights to dispose** of valuable non-timber forest products (NTFPs).

## Social Forestry

- The **National Commission on Agriculture**, GoI, first used the term **'social forestry'** in **1976**. Social forestry is the **management and protection of forests** and **afforestation of barren and deforested lands** with the help of **local communities**.
- Social forestry aimed to **reduce pressure on forests** by **using unused and fallow land**. With this scheme, the government **formally recognised local communities' forest resource rights**.

### Components of Social Forestry

- **Farm forestry:** Commercial and non-commercial farm forestry promote **individual farmers planting trees on their land**.
- **Community forestry:** Communities raising **trees on community land** for **collective benefit**. The government has the responsibility of providing seedlings and fertiliser.

- **Extension forestry:** Planting **trees along roads**, **canals**, **railways**, and **wastelands** is called extension forestry. It involves creating wood lots on **common village lands**, **government wastelands**, and **panchayat lands**.
- **Agroforestry:** Planting trees on **agricultural boundaries**, **marginal private lands**, and **alongside crops** is called agroforestry.

⇨ *Social forestry suffers from similar issues as those faced by Joint Forest Management.*

## Compensatory Afforestation (CA)

- Under the **Forest (Conservation) Act**, **1980**, whenever forest land is diverted for non-forestry purposes, **an equal area of non-forest land (revenue land)** or **twice the area of degraded forest land** has to be **planted over as CA**.
- The project proponent identifies land for CA and proposes it to the state forest department. Upon approval, the **proponent pays for the land (Net Present Value)**, which is then **transferred to the state forest department for plantation work**.
- **Until 2019**, **CA on degraded forest land was permitted only when revenue land was unavailable**. A notification by **MoEFCC now allows CA on forestland with crown density below 40%**.

### Compensatory Afforestation Fund (CAF) Act, 2016

- **Compensatory Afforestation Fund Management and Planning Authority (CAMPA)** is a **National Advisory Council** headed by the **Union Minister of Environment**. CAMPA and State CAMPA were established on an ad hoc basis in 2006 after the Supreme Court intervened.
- CAMPA and state CAMPAs **promote afforestation** and regeneration activities **to compensate for forest land diverted to non-forest uses**. The CAMPA National Advisory Council makes recommendations to the state CAMPA, which receives funds collected from user agencies for CA.
- The **CAF Act 2016** was enacted **to manage the funds collected for CA by CAMPA**. The law established the **National Compensatory Afforestation Fund** under the **Public Account of India** and the **State Compensatory Afforestation Fund** under the **Public Account of each state**. These Funds will receive payments for (i) compensatory afforestation, (ii) net present value of forest (NPV), and (iii) other project-specific payments.
- **Distribution of funds:** **The National Fund receives 10%** of payments, while the **State Funds receive the remaining 90%**.
- **Use of funds:** The funds are used for the treatment of catchment areas, assisted natural generation, forest management, wildlife protection and management, relocation of villages from protected areas, managing human-wildlife conflicts, training and awareness generation, supply of wood-saving devices and allied activities.

⇨ ***Net Present Value (NPV) of forests:*** *The Act acknowledges that newly afforested land cannot immediately start delivering the range of goods and services (like fuelwood, timber, bamboo, carbon sequestration, soil conservation, water recharge, etc.) that the diverted forests were providing. So, project developers need to pay for the NPV of the forests being cleared.*

**[UPSC:2019] Consider the following statements:**

1. As per law, the Compensatory Afforestation Fund Management and Planning Authority exists at both National and State levels.
2. People's participation is mandatory in the compensatory afforestation programmes carried out under the Compensatory Afforestation Fund Act, 2016.

***Which of the statements given above is/are correct?***

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

**Explanation**

- The act stresses on the participation of people and social audit. However, they are **not mandatory**. So the answer is a) 1 only

## Problems with Compensatory Afforestation

- **Greenwashing:** Critics believe compensatory afforestation has **legitimised forest clearing** and see it as an example of '**greenwashing**'. Greenwashing is the act of making a product, policy, activity, etc., appear to be more environmentally friendly or less environmentally damaging than it really is.
- **Low Utilization of Funds:** The money collected for compensatory afforestation remains unutilised.
- **Land Non-Availability:** The biggest problem for compensatory afforestation remains the lack of suitable land. Often, the land provided is unsuitable for growing plantations.
- **Fragmented Land:** Generally, the forest cleared is a large continuous stretch of land. But rarely the land provided for compensatory plantations is a contiguous stretch of land; it is always distributed over numerous locations.
- **Monoculture Plantations:** Generally, the compensatory plantations are **monocultures**, meaning they contain only one species of plants. This is **insufficient for biodiversity and carbon capture stability**.
- **Biotic Pressure:** It refers to the challenge the compensatory plantations face from nearby human habitations and cattle.
- **Negative edge effects:** CAMPA-funded projects endanger landscape connectivity and "biodiversity corridors" and expose **forest patches to "edge effects"**. The edge effect refers to the changes in population or community structures that occur at the **boundary of two habitats** (ecotone).

⇨ ***Carbon storage** is **highest** in species-rich **evergreen forests**. **Eucalyptus plantations** had relatively **lower carbon storage**, while **teak plantations** stored nearly as much carbon as **deciduous forests**.*

## Green Credit Scheme

- The **Forest Advisory Committee (FAC)**, an **apex body** under **MoEFCC** that **adjudicates requests to raze forest land for commercial purposes**, has approved the **Green Credit Scheme**, which **allows forests to be traded as commodities**. FAC has recommended that **private players** be allowed to **raise plantations** to be later **used towards CA**.
- If implemented, it allows the **Forest Department to outsource its responsibilities of reforesting** to non-government participating agencies — private companies, village forest communities, etc.
- After **three years**, if they meet the Forest Department's criteria, the plantations would be eligible to be considered compensatory forest land. The participating agency can trade its plantation parcels with project proponents needing forest land. The land is then transferred to the Forest Department and recorded as forest land (RFA).
- If plantations meet the criteria **after three years**, they can be **considered compensatory forest land**. The participating agency **can trade these parcels with project proponents**, transferring the land to the Forest Department as **recorded forest land (RFA)**.

### FAC's Arguments for the Green Credit Scheme

- FAC recommended accepting such plantations in non-forest areas to **encourage individual planting** and **meet international commitments like SDGs and NDCs**.
- The **Green India Mission** aims **to sequester 2.523 billion tonnes of carbon by 2030**, adding 30 million hectares of forest. The Green Credit Scheme could help achieve this.

### Criticism of the Green Credit Scheme

- The scheme would **privatise forests**, **promote their destruction**, and fail to address core compensatory afforestation issues.
- Forests are **treated as mere commodities without any social or ecological character**.
- If the economic value of these plantations becomes lucrative, it could **threaten agricultural land by diverting it to plantations**.
- Private companies might **grow fast-maturing**, **invasive species** like **eucalyptus** to trade plantations after three years.

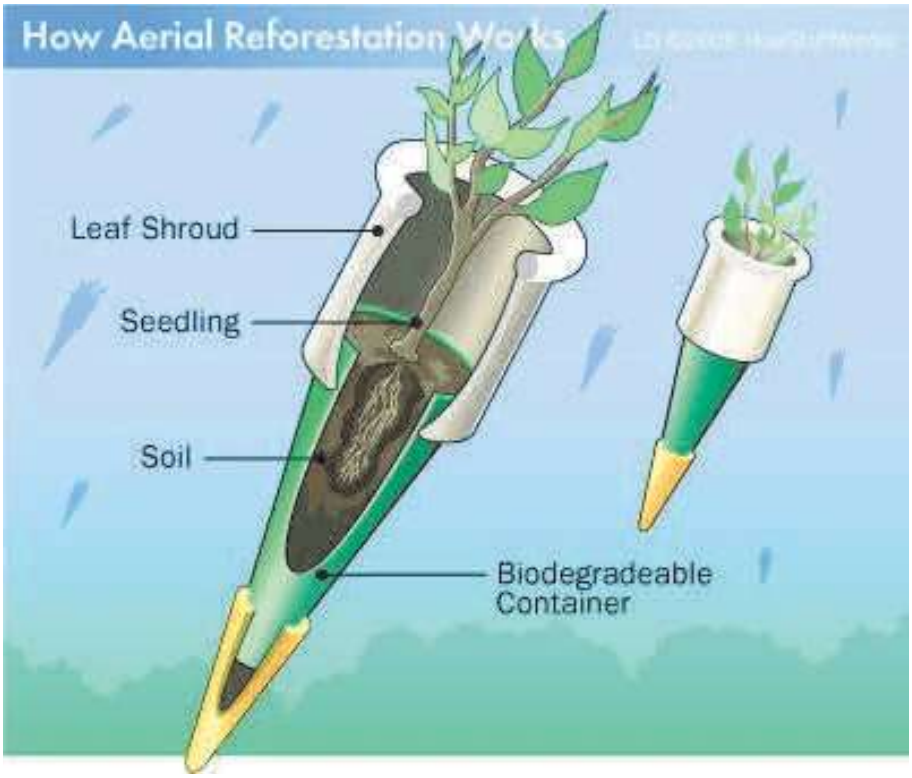
## Aerial Seeding for Reforestation

- The Delhi High Court asked about using dart shots from helicopters to plant seeds. The Forest Department concluded this technology is unnecessary for accessible areas.

- **Aerial seeding (aerial reforestation)** is a **reforestation technique** in which seeds or seed balls (**seed bombs** made of **compost**, **clay**, and **seeds**) are **sprayed using aerial devices** like helicopters, drones, etc. Seeds planted through this procedure **have a success rate of 50%**.
- Aerial seeding can spread grasses and plants to large areas **after wildfires**. It is adopted because it is **quicker** and **more effective** than planting manually. It also allows access to difficult areas like **rocky terrain and high elevation**.

## Dart Seeding

- Dart seeding is used with the same broad objective as aerial seeding. The process involves throwing **darts containing seeds** onto open ground.
- In aerial seeding, many seeds fail to germinate. If dart plantation is done from a low-flying helicopter, seeds have a relatively better chance of survival as they reach deeper into the ground.
- Plantation with both aerial and dart plantations is carried out **close to the onset of monsoon**.




**---------- End of Chapter ----------**

# 24. National Environmental Legislation – Part II

## 24.1. Biodiversity Act 2002 (BDA 2002)

- The **BDA 2002** was enacted in **response to India's commitments under the Convention on Biological Diversity (CBD),1992**. It **regulates access to biological resources** to ensure **equitable sharing of benefits** arising from their use.
- **Aim:** to **safeguard India's biodiversity and knowledge** from **exploitation by foreign entities** without sharing resulting benefits, thus **preventing biopiracy**.

> ***Biopiracy*** *is the* ***unethical or unauthorised commercial exploitation*** *of* ***biological resources***, ***traditional knowledge***, *or* ***genetic resources*** *from indigenous or local communities* ***without*** *prior informed* ***consent*** *or* ***fair compensation***.

### Three Tier Structure

- BDA 2002 established a **three-tier structure** to regulate India's biodiversity and associated knowledge:
  1. **National Biodiversity Authority (NBA)** at the national level
  2. **State Biodiversity Boards (SBBs)** at the state level
  3. **Biodiversity Management Committees (BMCs)** at the local level

### National Biodiversity Authority (NBA)

- NBA is an **autonomous statutory body** established under the provisions of BDA, 2002. It enjoys the **power of a civil court**. It is **headquartered in Chennai**.
- **Objective of NBA:** To **regulate access** to **biological resources** and associated **traditional knowledge for research**, **commercial utilisation**, and other purposes.

### Functions of NBA

#### Regulation of Access to Biological Resources

- Approval of the **NBA** (regulator) is a **must** to carry out biodiversity-related activities.

| Biological Activity | Requires Prior Approval | Exempted |
|---|---|---|
| Obtaining biological resources and associated knowledge for any use | **All foreign nationals or organisations** | **Indian citizens/entities/local people** (including **AYUSH practitioners**) |
| **Transferring research results** of biological resources to **foreign nationals/organisations** | **Most Indian individuals/entities** require approval from the NBA | **Collaborative research projects** and exchange of knowledge and resources (conducted according to the policy guidelines of the GoI) |

| | | |
|---|---|---|
| Applying for **Intellectual Property Rights (IPRs)** (in or outside India) for an **invention based on research on an Indian biological resource** | **Everyone** | **None** |

### Benefit-Sharing

- The NBA establishes mechanisms to **ensure fair and equitable sharing of benefits** from using biological resources and traditional knowledge.

### Conservation and Sustainable Use

- The **monetary benefits**, **fees**, and **royalties** from NBA approvals are deposited in the **National Biodiversity Fund (NBF)**. NBF is used to conserve and develop areas where the resource has been accessed in consultation with the **local self-government** concerned.

### People's Biodiversity Registers (PBRs)

- NBA facilitates the **preparation** and **maintenance** of **PBRs at the local level**, which **document the local biological resources** and **associated traditional knowledge**.

### Biodiversity Heritage Sites (BHS)

- NBA has the authority to **declare areas of biodiversity importance as Biodiversity Heritage Sites**. These sites are critical for biodiversity conservation, and the NBA takes measures to protect them.

### Advisory Role

- **NBA** advises the **GoI** on biodiversity conservation and sustainable use.

**[UPSC 2011-12] How does National Biodiversity Authority (NBA) help in protecting the Indian agriculture?**

1) NBA checks the biopiracy and protects the indigenous and traditional genetic resources.
2) NBA directly monitors and supervises the scientific research on genetic modification of crop plants.
3) Application for intellectual Property Rights related to genetic / biological resources cannot be made without the approval of NBA.

***Which of the statements given above is/are correct?***

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

**Explanation**

- The top **biotech regulator** in India for **Genetically Modified Organisms** is **Genetic Engineering Appraisal Committee** (**GEAC under functioning under the aegis of EPA**, **1986**).

***Answer: c) 1 and 3 only***

**[UPSC 2023] Consider the following statements:**

1. In India, the Biodiversity Management Committees are key to the realisation of the objectives of the Nagoya Protocol.
2. The Biodiversity Management Committees have important functions in determining access and benefit sharing, including the power to levy collection fees on the access of biological resources within its jurisdiction.

***Which of the statements given above is/are correct?***

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

**Explanation**

***Statement 1 is correct***

- As per the Biological Diversity Act 2002, Biodiversity Management Committees (BMCs) are created for promoting conservation, sustainable use and documentation of biological diversity by local bodies. They are key to the realisation of the objectives of Nagoya Protocol (Access and benefit sharing).

***Statement 2 is correct***

- The BD Act grants BMCs the independent powers to levy charges by way of collection fees from persons collecting biological resources from their territorial jurisdiction.

***Answer: c)***

## Biological Diversity (Amendment) Bill 2021

### Objectives of Biological Diversity (Amendment) Bill 2021

- Encourage the **Indian system of medicine** and cultivation of **wild medicinal plants**
- Facilitate **fast-tracking of processes** for research, patent application, and transfer of research results
- **Decriminalise offences**
- Encourage **foreign investment** in the sector
- To include references to the **Nagoya Protocol**

### Key Features of the Biological Diversity (Amendment) Bill 2021

#### Access to Biological Resources and Associated Knowledge

***BDA 2002***

- The Act mandates obtaining **prior approval from regulatory authorities**, namely the **National Biodiversity Authority** (NBA) and **State Biodiversity Boards** (SBB), **for accessing biological resources or associated knowledge in India**.

***2021 Bill***

- The 2021 Bill amends the classification of **entities** and **activities** requiring **prior approval** while **introducing exemptions** to certain cases.
- It **exempts registered AYUSH practitioners** and **people accessing codified traditional knowledge** from getting prior approval from **SSBs** for accessing biological resources for certain purposes.
- It provides that **only foreign-controlled companies** will **need permission to use** biodiversity resources. (It **exempts all domestic companies**).

***Criticism: Ambiguity Regarding Codified Traditional Codified Knowledge***

- Though the 2021 bill exempts people accessing codified traditional knowledge from getting prior approval from SSBs, it has **not defined the term 'codified traditional knowledge'**. So, this ambiguity can be used by **exploiters** of biological resources for their benefit.

***Criticism: Exemption for Domestic Companies***

- The **exemption for all domestic companies** from seeking permission to use biological resources will create a **loophole for domestic companies with foreign shareholding**.

**Approval for Intellectual Property Rights (IPR)**

***BDA 2002***

- The Act specifies that **approval of NBA is required before applying for IPR involving biological resources obtained from India**.

***2021 Bill***

- The 2021 Bill provides that **approval of NBA** will be **required before the grant of** IPR instead of before the application itself.

**Benefit Sharing**

***BDA 2002***

- The Act **mandates benefit sharing** with benefit claimers and local people. The **terms of benefit sharing are decided by the NBA** during approval. The Act provides that the terms of benefit sharing are **mutually agreed** between the **applicant**, **local bodies concerned**, and the **benefit claimers**.

***2021 Bill***

- It **removes the applicability of benefit sharing** from **research**, **bio-survey**, and **bio-utilisation**.

- It also **gives SBBs the authority to determine terms of benefit sharing while granting approvals to domestic entities**. It provides that the benefits-sharing terms are **mutually agreed** upon between the **applicant** and the **Biodiversity Management Committee (BMC) represented by NBA**.

***Criticism***

- The 2021 Bill **removes the direct role of local bodies and benefit claimers in determining mutually agreed-upon terms**. These bodies and benefit claimers are the **actual preservers** of biodiversity.

### Offences and Penalties

***BDA 2002***

- Under the Act, offences include **failing to take approval** or **providing prior intimation** for various activities. These **offences are punishable** with **imprisonment**, **or a fine**, **or both**.

### 2021 Bill

- The 2021 Bill **decriminalises the offences** and makes offences **punishable only with a penalty**.

***Criticism***

- Decriminalising offences will make the **exploitation of biological resources will become easier**.

## 24.2. National Green Tribunal Act, 2010 (NGT Act 2010)

- The **NGT Act 2010** enables the **creation of the NGT** to handle the **expeditious disposal of cases pertaining to environmental issues**. It was enacted under **Article 21** of the Indian constitution, which assures the citizens of India the **right to a healthy environment**.
- The NGT's specialised architecture ensures **fast-track resolution of environmental cases**, boosting **sustainable development**. It must **dispose of cases within 6 months of appeals**.
- The NGT's Principal Bench has been established in New Delhi, with regional benches in Pune (Western Zone Bench), Bhopal (Central Zone Bench), Chennai (Southern Bench), and Kolkata (Eastern Bench).

### Members of NGT

- The tribunal's **sanctioned strength** is **10 expert** and **10 judicial members**, though the **act permits up to 20 each**. Each bench must include **at least one expert and one judicial member**.
- The **Chairman** must be a **serving or retired Chief Justice of a High Court** or a **Supreme Court judge**. The Chairman also serves as a judicial member.

### Jurisdiction

- The Tribunal has **original jurisdiction** on matters of "**substantial question relating to environment**" (like a community at large is affected, damage to public health at a broader level) and "**damage to the environment due to specific activity**" like pollution.
- **Drawback:** The term **"substantial" is not clearly defined** in the Act.

## Powers

- The Tribunal's **orders are binding**. It has the **power to grant relief** in the form of compensation and damages to affected persons. It can hear **all civil cases** related to **environmental issues** and **implementation of laws listed in Schedule I of the NGT Act**. These include the following:
  1. The Water (Control of Pollution) Act, 1974
  2. The Water (Control of Pollution) Cess Act, 1977
  3. The Forest (Conservation) Act, 1980
  4. The Air (Prevention and Control of Pollution) Act, 1981
  5. The Environment (Protection) Act, 1986
  6. The Public Liability Insurance Act, 1991
  7. The Biological Diversity Act, 2002
- NGT has **not been vested with powers to hear any matter relating to:**
  - **Wildlife (Protection) Act, 1972**
  - **Indian Forest Act, 1927**
  - Various laws enacted by states relating to forests, tree preservation, etc.

## Principles of Justice adopted by NGT

- The NGT **follows principles of natural justice** and is **not bound by** the **Civil Procedure Code, 1908**.
- Further, the NGT is **not bound by the rules of evidence** in the **Indian Evidence Act, 1872**.
- When passing Orders/decisions/awards, the **NGT will apply** the **principles of sustainable development**, the **precautionary principle**, and the **polluter pays principle**.
- Conservation groups can more easily present facts and issues, identify technical flaws, and propose alternatives before the NGT compared to a court.

### Review and Appeal

- Under Rule 22 of the NGT Rules, the Tribunal has **powers to review its own decisions**. **If this fails**, an NGT Order **can be challenged before** the **Supreme Court within 90 days**.

## Success of NGT

- ✓ Since its inception, the NGT has **protected vast acres of forest land** and **halted polluting construction activities** in metros and smaller towns.
- ✓ It has **penalised negligent officials** and **held large corporations accountable**.
- ✓ It has **protected tribal rights** and **enforced the "polluter pays" principle**.

## Challenges Faced by NGT

- **Issue of 'tribunalisation'** (government appointing members, leading to potential conflicts of interest).
- The government attempts to **dilute appointment criteria for the NGT** and other tribunals, similar to changes made to the Right to Information Act.

**[UPSC 2011-12] The National Green Tribunal Act, 2010 was enacted in consonance with which of the following provisions of the Constitution of India?**

1) Right to healthy environment, construed as a part of part of Right to life under Article 21.
2) Provision of grants for raising the level of administration in the Scheduled Areas for the welfare of Scheduled Tribes under Article 275(1)

***Which of the statements given above is/are correct?***

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

***Answer: a)***

**[UPSC 2018] How is the National Green Tribunal (NGT) different from the CPCB**

1) The NGT has been established by an Act whereas the CPCB has been created by an executive order of GOI.
2) The NGT provides environmental justice and helps reduce the burden of litigation in the higher courts whereas the CPCB promotes cleanliness of streams and wells and aims to improve the quality of air in the country.

***Which of the statements given above is/are correct?***

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

**Explanation**

- **CPCB is a statutory organisation under the MoEF**.
- It was established under the **Water (Prevention and Control of Pollution) Act**, **1974**.

***Answer: b) 2 only***

## Development vs Conservation

- Sustainable development is often a misnomer as most projects cannot be completed without harming the environment. In India, limited resources make balancing environment and development dire.
- Projects incur **high environmental** or **financial costs**. **Complex legal and regulatory processes** (SC, NGT, NTCA, National Board for Wildlife) stall development, causing project costs to skyrocket.

### A Web of Regulation

- In 2019, the **SC halted** road construction through the **critical corridor** between **Rajaji** and **Corbett Tiger Reserves** for violating the Forest Conservation Act. The road **lacked approval from the National Board for Wildlife** and **advice from the NTCA**.

### High Financial Costs

- In 2018, nine **'animal underpasses'** were built under **NH 44** (**Srinagar to Kanyakumari**; **India's longest highway**) between **Kanha** and **Pench tiger reserves** to prevent roadkill and reduce the **'barrier effect**.' This followed an SC order to the NHAI for wildlife corridor mitigation. Similar measures are needed in most of India's protected areas.

**Prelims Practice: Statements:**

1. NH 44 passes through Pench Tiger Reserve.
2. Kashmir-Kanyakumari NH passes through Pench TR.
3. Pench Tiger reserve is spread across the borders of Maharashtra and Madhya Pradesh.

***Which of the above statement(s) are false?***

a) 2 only
b) 2 and 3 only
c) 3 only
d) None

**Explanation**

- All the statements are true.
- NH 44 (3700+ km) also known as Kashmir-Kanyakumari highway, is the longest highway in India.

***Answer: D) None***

## 24.3. Coastal Regulation Zone (CRZ) Rules

- In 1991, **coastal areas influenced by tidal action** (seas, bays, estuaries, creeks, rivers and backwaters) were declared "**Coastal Regulation Zone**" (CRZ). The 1991 CRZ rules by MoEF define this zone as an **area up to 500 m from the high-tide line**.
- The **National Coastal Zone Management Authority (NCZMA)** and **State Coastal Zone Management Authority (SCZMA)** were created to enforce and monitor CRZ rules, with powers under the **Environmental Protection Act**, **1986**. **State governments** implement these rules through SCZMA and must develop their **own coastal zone management plans** per central guidelines.

### Coastal Regulation Zone (CRZ) Rules 2011

- Despite amendments, the **1991 CRZ Rules** were **seen as too restrictive** by states and **hindered infrastructure projects** like Navi Mumbai.

- Some concerns are addressed with the **new CRZ Rules in 2011**. Exemptions were made for constructing the **Navi Mumbai airport** and projects by the **Department of Atomic Energy** near the coast.

## Coastal Regulation Zone (CRZ) Classification (based on changes by CRZ Rules 2011)

### CRZ-I

- CRZ-I includes:
  A. **Ecologically sensitive areas** (such as national parks, marine parks, sanctuaries, reserve forests, wild habitats, mangroves, coral reefs, breeding grounds for marine life, areas of natural beauty, historical and heritage sites, regions rich in genetic biodiversity, and areas vulnerable to sea level rise).
  B. Area between **High Tide Line (HTL)** and **Low Tide Line (LTL)**.
- **Regulation: No new construction is permitted within 500m of the HTL**
- **Exceptions:**
  - Projects relating to the **Department of Atomic Energy**
  - Pipelines, conveying systems, including transmission lines
  - Facilities that are essential for activities permissible under CRZ-I
  - Installation of **weather radar for monitoring of cyclones** by the Indian Meteorological Department
  - Construction of **trans harbour sea link without affecting the tidal flow of water** between LTL and HTL
  - Development of green field airport already approved at only Navi Mumbai
  - Exploration and extraction of **natural gas**
  - Construction of **amenities for traditional inhabitants in biosphere reserves** after approval from the concerned CZMA
  - **Salt harvesting** by **solar evaporation of seawater**
  - **Desalination plants**
  - Storage of **non-hazardous cargo** such as edible oil, fertilisers and food grain

### CRZ-II

- Area that has already been **developed up to or close to the shoreline**. "Developed Area" refers to **municipal or legally designated urban areas** with substantial infrastructure, including drainage, roads, water supply, and sewerage mains.
- **Permitted activities:**
  - Buildings are permitted only on the landward side of the existing road or authorised structures
  - Permitted structures are subject to the existing local town and country planning regulations
  - Reconstruction of authorised building to be permitted subject to the existing Floor Space Index or Floor Area Ratio Norms and without change in present use
  - Facilities for **receipt and storage** of **petroleum products** and **liquefied natural gas**
  - Facilities for **regasification** of **Liquefied Natural Gas**

- ❖ **Desalination plants** and associated facilities
- ❖ Storage of **non-hazardous cargo**, such as edible oil, fertilisers and food grain
- ❖ Facilities for generating power by **non-conventional power sources** and associated facilities

## CRZ-III

- Areas that are **relatively undisturbed** and **not part of CRZ-I or II** include **rural coastal zones** (developed and undeveloped) and **urban areas not substantially built up**.

### Areas up to 200 metres from HTL

- The area up to 200m from the HTL on the seafront and 100m along tidal-influenced water bodies or the width of the creek, whichever is less, is designated as a "**No Development Zone (NDZ)**."**No construction is permitted within this zone** except for repairs to the existing structures.
- However, the NDZ **does not apply** to **areas within notified port limits**.
- Also, the following activities may be **permitted in NDZ** –
  - ❖ **Agriculture**, **horticulture**, gardens, pasture, parks, playfield, and **forestry**
  - ❖ Projects relating to the **Department of Atomic Energy**
  - ❖ **Mining** of **rare minerals**
  - ❖ **Salt manufacturing** from seawater
  - ❖ Facilities for **receipt and storage** of **petroleum products** and **liquefied natural gas**
  - ❖ Facilities for **regasification** of **liquefied natural gas**
  - ❖ Facilities for generating power by **non-conventional energy sources**
  - ❖ **Desalination plants** and associated facilities
  - ❖ **Weather radars**
  - ❖ Construction of **amenities required by local inhabitants**
  - ❖ Construction of **domestic sewage treatment** and **disposal units** with the prior approval of the concerned Pollution Control Board or Committee
  - ❖ **Facilities required for local fishing communities**, such as fish drying yards, ice plants, etc.
  - ❖ Development of green field airport already permitted only at Navi Mumbai

### Area between 200 metres to 500 metres

- The following activities shall be **permissible** in the above areas;
  - ❖ Construction of **hotels** or **beach resorts** for tourists or visitors subject to specific conditions
  - ❖ Facilities for **receipt and storage** of **petroleum products** and **liquefied natural gas**
  - ❖ Facilities for **regasification** of **liquefied natural gas** subject to conditions
  - ❖ Storage of **non-hazardous cargo**, such as edible oil, fertilisers, food grain, etc., in notified ports
  - ❖ **Desalination plants** and associated facilities
  - ❖ Facilities for generating power by **non-conventional energy sources**

- ❖ **Construction or reconstruction of dwelling units** is **allowed within the scope of traditional rights and customary uses**, such as existing fishing villages and goathans (such construction or reconstruction will be subject to the local town and country planning rules with an overall height of construction, not exceeding 9m with two floors (ground + one floor))
- ❖ Construction of **amenities by CZMA**. CZMA may also permit schools and dispensaries for local inhabitants if no other area is available within CRZ panchayats
- ❖ Development of green field airport already permitted only at Navi Mumbai

## CRZ-IV

- It includes:
  A. The water area from the **LTL to 12 nautical miles on the seaward side**
  B. **Tidal-influenced water area** from the mouth of the water body to the point where tide influence is five parts per thousand during the driest season
- **Permitted activities:** No restriction on the **traditional fishing and allied activities** undertaken by local communities
- **Restriction: No untreated sewage**, **effluents**, ballast water, ship washes, fly ash, or solid waste **from any activities**, including aquaculture, shall be discharged or dumped.

### Prohibited Activities Within CRZ

- The following activities **shall be prohibited**, **in general**, **within the entire CRZ** (Exceptions to these and other permissible activities in CRZ categories I, II, III, and IV will be governed by provisions of CRZ Rules).
  - ❖ Setting up of **new industries** and **expansion of existing** industries, operations or processes
  - ❖ Manufacture or handling of **oil**, storage or disposal of **hazardous substances**
  - ❖ Setting up of **new fish processing units**
  - ❖ **Land reclamation**, bunding or **disturbing the natural course of seawater**
  - ❖ Discharge of **untreated waste and effluents** from industries, cities or towns and other human settlements
  - ❖ **Dumping of city or town wastes** (including construction debris, industrial solid wastes, and fly ash) **for the purpose of landfilling**
  - ❖ Port and harbour projects in high-eroding stretches of the coast
  - ❖ **Mining** of sand, rocks and other sub-strata materials
  - ❖ Dressing or **altering active sand dunes**
  - ❖ **Disposal of plastic** into the coastal waters
  - ❖ **Drawal of groundwater**

## Critical Vulnerable Coastal Areas (CVCA)

- **Sundarban region** of West Bengal and other **ecologically sensitive areas** identified under the **Environment (Protection) Act**, **1986**, such as the **Gulf of Khambat** and **Gulf of Kutchh** in Gujarat, **Malvan**, **Achra-Ratnagiri** in Maharashtra, **Karwar** and **Coondapur** in Karnataka, **Vembanad** in Kerala, **Gulf of Mannar** in Tamil Nadu, **Bhaitarkanika** in Odisha, **Coringa**, **East Godavari** and **Krishna** in Andhra Pradesh shall be treated as CVCA.
- They shall be managed with the involvement of **coastal communities including fisher folk** who depend on coastal resources for their sustainable livelihood.

## Coastal Regulation Zone (CRZ) Rules 2019

- In 2019, GOI notified new CRZ Rules, the salient features of which are:

### New Sub-Categories

- Two separate categories have been proposed for **CRZ - III areas**.
  A. **CRZ-III A:** CRZ-III areas with a population density over 2161 per sq km (2011 census) shall be designated as CRZ-III A. Here, the area up to **50m from the HTL** on the landward side is designated as the **No Development Zone** (NDZ), as against the 200 m stipulated in CRZ Rules 2011.
  B. **CRZ-III B:** CRZ-III areas with a population density below 2161 per sq km (2011 census) are designated as CRZ-III B. Here, the area up to **200m from the HTL** on the landward side is designated as the **No Development Zone** (NDZ).


### No Development Zone

- The new Rules propose a **20-m no-development zone** for **all islands close to the mainland coast** and for **all backwater islands on the mainland**.

### Streamlining of CRZ Clearance

- The CRZ clearance process has been streamlined with multiple delegation levels for recommending and granting approvals.

### Floor Space Index (FSI) Norms Eased

- In the CRZ 2019 Notification, the government decided to **de-freeze the Floor Space Index** and permit FSI for construction projects.

### Tourism Infrastructure Permitted in Coastal Areas:

- The new norms permit **temporary tourism facilities** such as shacks, toilet blocks, change rooms, drinking water, etc.

## Integrated Coastal Zone Management Plan (ICZMP)

- The ICZMP is an integrated approach to managing the coast, considering all geographical and political aspects to achieve sustainability.
- In India, the **MoEFCC** launched an **ICZMP**, a **World Bank-assisted project**, by establishing a **Society of Integrated Coastal Management** (SICOM). The project aims to improve coastal community livelihoods and conserve the coastal ecosystem. **SICOM** implements ICZMP at the national and state levels.
- The **National Centre for Sustainable Coastal Management** (NCSCM), Chennai, provides the scientific and technical inputs required for the project.
- So far, three coastal States, namely **Gujarat**, **Odisha**, and **West Bengal**, have prepared ICZMP with support from the World Bank.
- Under the ICZMP, SICOM would be implementing the **four components**, namely,
  1. National Coastal Management Programme
  2. ICZM-West Bengal
  3. ICZM-Orissa
  4. ICZM-Gujarat
- National component of ICZMP includes:

(a) **Demarcation of hazard line** for mapping the entire coastline of the mainland of the country

(b) A **National Centre for Sustainable Coastal Management** (NCSCM) established within the campus of Anna University, Chennai, with regional centres in each of the coastal States/UTs to promote R&D for coastal management, including addressing issues of coastal communities

### Draft Integrated Coastal Zone Management

- The draft **Environmental and Social Management Framework (ESMF)** for **Integrated coastal management** was prepared by the **SICOM**. The document lays out guidelines for coastal States to adopt when they approve projects in coastal zones.

- The key activities proposed for coastal zone development are **mangrove afforestation**, **habitat conservation activities** (such as sea-grass meadow restoration), **eco-restoration of sacred groves**, **development of hatcheries and rescue centres**, **tourism infrastructure**, **water body restoration**, **beach cleaning**, and small infrastructure facilities.
- Livelihood improvement projects include **climate-resilient agriculture**, **water harvesting**, **eco-tourism infrastructure**, **community-based mariculture**, **seaweed cultivation**, **aquaponics**, and value addition to other livelihood activities.
- The plan describes how "environmental and social aspects" ought to be integrated into the planning, design, and implementation of projects.

### Society of Integrated Coastal Management (SICOM)

- It is established **under the aegis of MoEF**. It aims for vibrant, healthy and resilient coastal and marine environment. It is the **nodal agency** for implementation of **Integrated Coastal Zone Management (ICZM) practices** and **ENCORE project** in all the 13 Coastal States/UTs. It acts as **secretariat** to the **National Coastal Zone Management Authority (NCZMA)**.

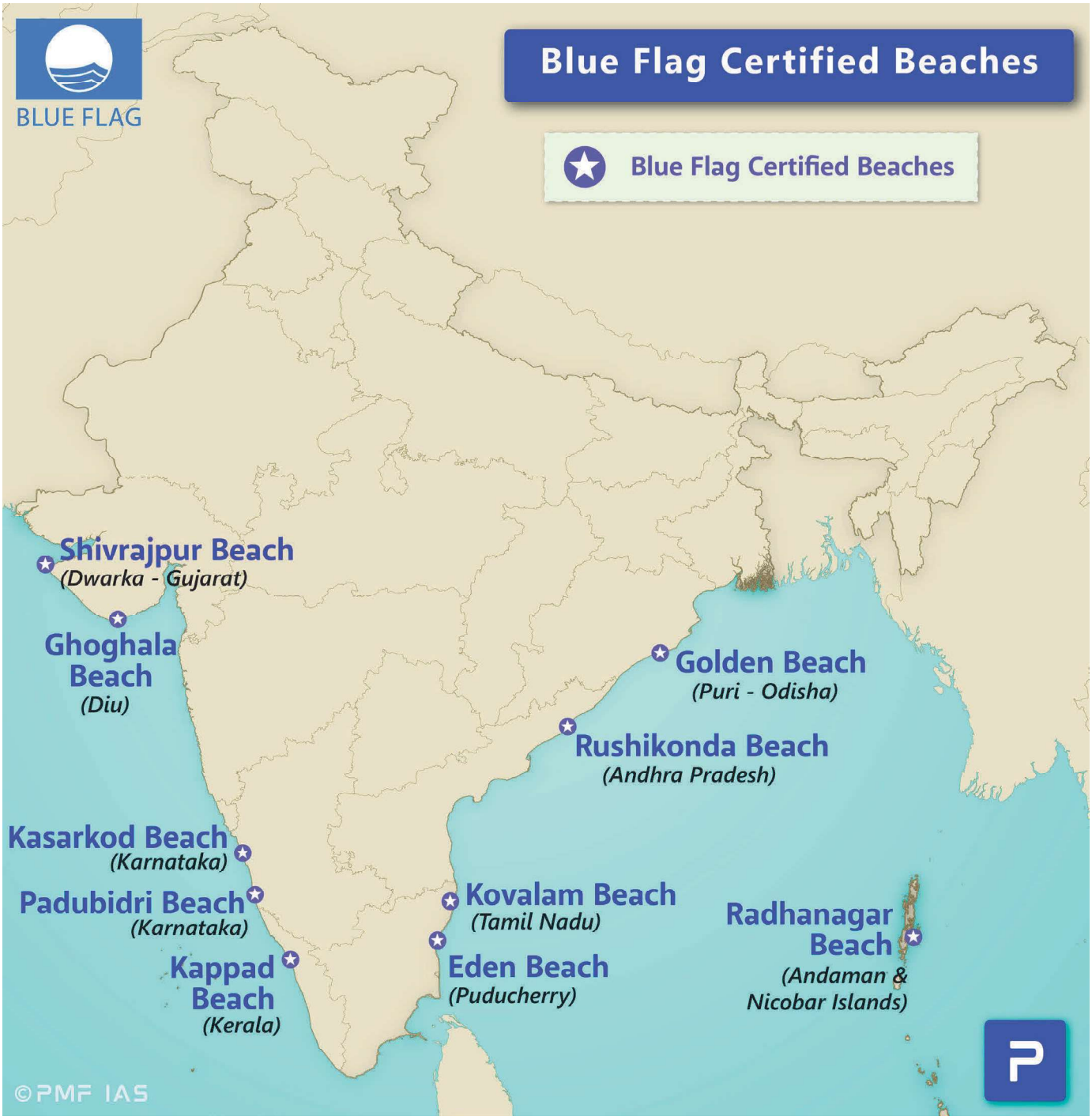
#### Enhancing Coastal and Ocean Resource Efficiency Program (ENCORE)

- ENCORE is a **World Bank funded** program to help India enhance its coastal resources, protect coastal populations from pollution, erosion, and sea level rise, and improve livelihood opportunities for coastal communities.

## Blue Flag Beaches

- **'Blue Flag' annual certification** is an **eco-label certification** that a beach, marina, or sustainable boating tourism operator can obtain. It was started in **France in 1985** and in areas out of Europe in 2001. It is awarded by **Denmark based Foundation for Environment Education (FEE)**.
- Blue Flag Beaches are selected based on **33 parameters** that are divided into 4 major heads, namely,
  1. **Water quality**
  2. **Environmental management**
  3. **Environmental Education**
  4. **Safety**
- The jury that selects Blue Flag beaches comprises members of the:
  - **United Nations Environment Programme (UNEP)**
  - **UN World Tourism Organization (UNWTO)**
  - **Foundation for Environmental Education (FEE)**
  - **International Union for Conservation of Nature**
- **Spain** has the **highest number of Blue Flag beaches** (729).

### Blue Flag Beaches of India




- There are **10 Blue Flag certification beaches** in India. **Chandrabhaga beach (or the Golden beach)** in **Odisha** is the **first beach in India as well as in Asia** to win the Blue Flag certification. The **Minicoy Thundi beach** and **Kadmat beach** in **Lakshadweep Islands** are **recent reveivers** of 'Blue Flag' tag.

## BEAMS (Beach Environment and Aesthetics Management Services)

- Under the **ICZMP**, the **MoEFCC** has piloted **BEAMS Programme**. It aims to:
  - ❖ Abate pollution in coastal waters
  - ❖ Promote sustainable development of beach facilities

- ❖ Protect coastal ecosystems and natural resources
- ❖ Promotes local authorities and stakeholders to maintain high standards of cleanliness, hygiene and safety
- ❖ Promotes beach recreation in harmony with nature

### Activities Permitted in the CRZ of Certain Beaches

- The MoEFCC has **relaxed CRZ rules** restricting construction near beaches to help states build infrastructure and receive **'Blue Flag' certification**. The following activities and facilities are **permitted in the CRZ of beaches**, **including islands**, subject to **maintaining a minimum distance of 10m from the High Tide Line** (HTL):
  - ❖ Portable toilets, change rooms and shower panels
  - ❖ Grey water treatment plant
  - ❖ Solid waste management plant
  - ❖ Purified drinking water facility
  - ❖ Other associated facilities or infrastructure, as per requirements of Blue Flag Certification

## Issues with the Way the CRZ Rules are Executed

- State governments and local bodies often **overlook CRZ rules** to facilitate construction. **CZMAs** are **limited by existing laws** and **can only file cases**, **not take direct action**. Power is delegated to the principal secretary or additional chief secretary of the environment, chairman or member secretary of the pollution control board, and the district collector.

### Maradu Apartments Demolition Order

- In 2007, Maradu panchayat issued a show-cause notice to builders for high-rise structures violating CRZ norms near **Vembanad Lake**. The Local Self Government directed the panchayat to revoke the permits, but it **only issued the show cause notice**.
- The **Kerala HC** granted a stay order **allowing builders to continue construction**, ruling they couldn't be penalised for **lacking a 'No-Objection Certificate' from KCZMA** (a mandatory clearance). KCZMA petitioned the SC against this order.
- Under the **1991 CRZ notification**, the **area was classified as CRZ-III**. Maradu became a municipality in 2010, **reclassified as CRZ-II** in the **2011 CRZ notification**, with MoEFCC approval in 2019.
- The **SC ordered the demolition** of the apartments, **as they fell within CRZ-III during construction**. The Kerala government razed the buildings in 2021.

#### Implications

- **Ecological Implications: Lake contamination** from debris and **air pollution** from the demolition posed severe health hazards to nearby residents.

- **Economic Implications:** Explosions of illegal structures can damage neighboring buildings. The poor and middle class are generally the primary victims of such demolitions.
- **Moral implications:**
  - **Municipal Authorities:** Maradu civic authorities ignored KCZMA reminders. It was the **municipality's responsibility**, not the project proponents', **to seek clearance**.
  - **Builders:** The builders conspired with panchayat officials and never applied for CRZ clearance.
  - **Buyers:** Bought flats, knowing similar constructions were challenged in court, driven by the desire to own a home in land-hungry India, where owning a house is an ultimate dream for many.
  - **Judiciary:** Kerala HC allowed construction, holding permit holders not liable. SC ignored local government permissions and ordered demolition based on bureaucratic categorisation, placing liability solely on apartment owners.
- **Legal implications:** SC ordered the demolition as the apartments fell within CRZ-III at construction time. But **new buildings can now be constructed under CRZ-II rules**.

### Mains Practise

**Q**. "Demolishing illegal structures comes with a baggage of moral, constitutional (legal), ecological and humanitarian implications." Examine this statement with examples.

**Q**. "**Environmental governance** is a victim of pathologies of the executive and the judicial decision-making on environment and urban development in India." Examine.

**Q**. "For **environmental justice**, India needs a strong **environmental governance** system that enables all stakeholders to prevent violations instead of the court becoming India's new demolition man." Elaborate this statement.

## 24.4. Rules for Hazardous Microorganisms/Genetically Engineered Organisms or Cells 1989

- The aim of 'Rules 1989' is **to protect the environment**, **nature**, and **health (biosafety)** in connection with the application of **gene technology** and **microorganisms**.
- These rules **govern research and large-scale applications of GMOs**, including **field trials** and **seed production**. They also define competent authorities and their composition.

### Presently There are Six Committees

1. **Recombinant DNA Advisory Committee (RDAC):** Its functions are **advisory**, recommending safety regulations for recombinant research and applications.
2. **Review Committee on Genetic Manipulation (RCGM):** Established under the **Department of Biotechnology**, **Ministry of Science and Technology**, to **monitor the safety aspects of ongoing research projects**.

3. **Genetic Engineering Appraisal Committee (GEAC):** it is the **statutory body** constituted in the **MoEFCC** under 'Rules 1989', under the **Environment Protection Act**, **1986**.
4. **State Biotech Coordination Committee (SBCC):** It has powers to inspect, investigate and take punitive action in case of violations of statutory provisions.
5. **District Level Committees (DLCs):** Monitors the safety regulations in installations engaged in the use of GMOs/hazardous microorganisms and their applications in the environment.
6. **Institutional Biosafety Committee (IBSC):** The **National Institute of Environmental Health Sciences** (NIEHS) has **established IBC** to review **projects involving recombinant DNA**, **RNAi**, **pathogens**, **human materials**, and **transgenic animals**.

**[UPSC 2015] The Genetic Engineering Appraisal Committee is constituted under the**

a) Food Safety and Standards Act, 2006
b) Geographical Indications of Goods (Registration and Protection) Act, 1999
c) Environment (Protection) Act, 1986
d) Wildlife (Protection) Act, 1972

## 24.5. Protection Against Chemical Disasters

- **Environment (Protection) Act of 1986 (EPA 1986):** At the time of the Bhopal gas tragedy, the Indian Penal Code was the only relevant law. In the wake of the **Bhopal gas tragedy**, GoI enacted the **Environment Act of 1986**. It gives **powers to the GoI** to undertake measures for improving the environment and set standards and inspect industrial units.
- **Bhopal Gas Leak (Processing of Claims) Act, 1985:** It gives powers to the GoI to secure the claims arising out of or connected with the Bhopal gas tragedy.
- **The Public Liability Insurance Act, 1991:** It is an insurance act providing **relief for accidents involving hazardous substances**.
- **The National Environment Appellate Authority Act, 1997:** The National Environment Appellate Authority hears **appeals on restricted industrial activities** under the **EPA 1986**.
- **National Green Tribunal Act, 2010:** It established the **National Green Tribunal** for **efficient and swift resolution** of environmental protection and forest conservation cases.

### Strict Liability Principle vs Absolute Liability Principle

- The **Styrene gas leak** at an LG plant in Visakhapatnam killed several people. NGT found LG Polymers liable under **strict liability principle**, though lawyers argue it should be **absolute liability principle**.
- **Strict Liability Principle:** A party is **not liable and need not pay compensation if a hazardous substance escapes** its premises **by accident** or **by an 'act of God'** among other circumstances.
- **Absolute Liability Principle:** A party in a hazardous industry **must mandatorily pay compensation regardless of whether or not the disaster was caused by its negligence**.

- The **National Green Tribunal Act of 2010 mandates** applying the **absolute liability principle even if the disaster is an accident**.

**Major Industrial Gas Leak Disasters in India**

| | When? | Where? | Cause? | Casualties |
|---|---|---|---|---|
| **Bhopal Gas Tragedy** | December 2-3, 1984 | Union Carbide India, Pesticide Plant, Bhopal, MP | Methyl isocyanate (MIC) Gas Leak | Nearly 5000 were Killed and more than 5,00,000 were affected |
| **GAIL Pipeline Blast** | June 27, 2014 | GAIL Plant, Nagaram, East Godavari, A.P. | Underground Natural gas Pipeline Rupture | Over 18 People were Killed and Over 40 People were Injured |
| **Bhilai Steel Plant Gas Leak** | June 12, 2014 | Bhilai Steel Plant, Durg, C.G. | Methane Gas Leak | 6 People were Killed and over 40 people were injured |
| **Tughlaqabad Gas Leak** | May 6, 2017 | Container Depot. Tughlaqabad, E-E delhi | Chemical gas Leakage from a Container Truck | Over 400 School Children were Hospitalised |
| **Kanpur Ammonia Gas Leak** | May 15, 2017 | A Cold Storage Facility at Shivrajpur, Kanpur, U.P. | Ammonia gas Leak | 5 People were Killed and 9 were injured. |
| **Belur Chlorine Gas Leak** | May 16, 2017 | A Water Treatment plant at Gandehalli, Belur, Karnataka | Chlorine gas Leak | More than 10 people fell Sick. |
| **Bhilai Steel Plant Blast** | Oct 9, 2018 | Bhilai Steel Plant, Durg, C.G. | Explosion in a Gas Pipeline Connected to the Coke Oven | 9 People were Killed and 14 were Injured |



**What happened in Vishakapattanam?**

| What Leaked? | What Is It?? | How Dangerous Is it? | What is it used for? |
|---|---|---|---|
| **Styrene** | It is also called ethenylbenzene, vinylbenzene and phenylbenzene. It is an organic compound derieved from benzene | Sustained exposure affects the central nervous system. Studies have shown that it causes cancer. | Manufacturing polystyrene, plastics, fibreglass, rubber and latex. |

### The Supreme Court's Intervention

- In the 1987 **M.C. Mehta vs Union of India case**, the **Supreme Court replaced** the **strict liability principle with the absolute liability principle**, following the 1986 **Oleum gas (fuming sulfuric acid) leak case** in Delhi. Following 1984 Bhopal gas tragedy, the SC sought to hold corporations fully liable.
- The SC found that strict liability offered companies exemptions, whereas **absolute liability**, provides no exemptions and is **part of Article 21 (Right to Life)**.

### Issue: Lack of Accountability and Burden of Proof on Victims

- **Sterlite**, **operating a copper smelter in TN**, **shifted the burden of proof** onto those affected by its pollutants. The tobacco industry, asbestos manufacturers, and many other MNCs have done the same.
- **Dow Chemical** and **Union Carbide** deny any link between **Methyl Isocyanate**, the **Bhopal gas tradegy**, and the lasting health effects on those exposed to the 1984 gas leak.
- **Unilever** denies that **mercury** caused health issues (**nervous disorders**, **memory loss**, **dental issues**, and **kidney failures**) among workers at its closed **thermometer factory in Kodaikanal**.
- **Petroleum companies** delayed legislation to curb the addition of **heavy metal lead** to petroleum, despite knowing its major role in **impaired brain development among children**.

## 24.6. Pesticide Regulatory Regime in India

- In India, pesticides are **registered by** the **Registration Committee (RC)**. The **Central Insecticides Board (CIB)** acts as an **advisory body**.
- The **Insecticides Act**, **1968**, and the **Insecticides Rules**, **1971**, **govern two regulatory bodies** tasked with overseeing the import, manufacture, sale, transport, distribution, and use of insecticides. Their goal is to prevent risks to human beings or animals from these substances.
- The **CIBRC** (as they are together called) **registers pesticides based on** applications and data provided by companies, covering **efficacy**, **toxicity**, and **safety**. The **Ministry of Agriculture can cancel registrations**, **allow continued use**, or **ban pesticides** based on the RC's recommendations.

## Pesticides Management Bill 2020

- Union Cabinet has approved the **Pesticide Management Bill 2020**. The bill aims **to promote the use of organic alternatives** to chemical pesticides.
- The bill will **provide farmers** with comprehensive **digital information on pesticides**, including their strengths, weaknesses, risks, alternatives, and potential environmental effects.
- The bill aims to **regulate pesticide-related advertisements to prevent misleading claims** by industries and **compensate farmers for losses caused by spurious pesticides**.
- Under the new bill, those **involved in pesticide import**, **manufacture**, **or export must register** and **provide detailed information** on claims, efficacy, safety, and storage.

### Need for a Fresh Law

- The **current regulations** under the Insecticides Act, 1968 and 1971, **lack effectiveness in addressing scientific evidence regarding pesticide harm**. There's a pressing need to address pesticide-related deaths and hospitalisations among farmers, as well as the poisoning of wildlife and livestock.

### Pesticide Usage in India

- **India** is the **world's fourth-largest producer of pesticides**. The recent increase in pesticide use is due **higher use of herbicides** like **glyphosate** (**many countries have banned it)** as cost of manual weed control has risen due to increase in agricultural wages.
- Eight states consume more than **70% of the pesticides used in India**. Total pesticide consumption is the **highest in Maharashtra**, followed by **UP**, **Punjab** and **Haryana**. Amongst the crops, **paddy accounts for the maximum share (26-28%)**, followed by **cotton (18-20%)**.

### Recommendations

#### States must be empowered to ban certain pesticides

- State governments' insufficient authority are significant concerns. Instances like Punjab and Kerala wanting to ban glyphosate within their states but being prevented from doing so highlight this issue.

#### Pesticide promotion must not be allowed

- **Advertisements for pesticides should be banned** in India due to their hazardous nature. **Interactions between pesticide companies/dealers and farmers should be deemed illegal**.

### Class I pesticides should be banned

- Based on acute toxicity, WHO classifies certain pesticides as **extremely hazardous (Class Ia)** and **highly hazardous (Class Ib)**. Provisions should be made to ban sale and use of Class I pesticides.
- In 2018, the **Ministry of Agriculture banned 18 Class I pesticides**. But it **left out two heavily used Class I pesticides**: **Monocrotophos** and **Carbofuran**.

### Personal protective gear

- The bill should make it illegal to sell pesticides without providing personal protective equipment.

### Polluter Pays

- The **Polluter Pays' principle** should be the **basis for fixing liability and compensation** from the company. Any pesticide registration must follow a transparent assessment procedure.

### Give powers to Union Ministry of Health

- **Legislative powers to regulate pesticides** should be **transferred to** the **Ministry of Health and Family Welfare** from the Ministry of Agriculture and Farmers' Welfare **to address health-related concerns without conflict of interest**.

## There is a collapse of pesticide regulation

### 2020 Notification on Draft ban order

- In 2020, the **Ministry of Agriculture and Farmers' Welfare proposed a ban on 27 pesticides in India**, including WHO Class I pesticides and probable human carcinogens, due to their hazardous nature and documented toxicity on bees and fish.
- 24 of the 27 pesticides are banned in other countries. Many of these have been part of 2015 **Anupam Verma Committee** reviewed 66 "bannable" pesticides. The **Department of Chemicals and Petrochemicals** cited Covid-19 pandemic situation as an excuse in proceeding with the draft ban order.

### Notable Pesticides in the List of 27 Proposed-To-Be-Banned Pesticides

- **Carcinogenic: Oxyflourfen**, **Pendimethalin (causes Thyroid follicular cell adenoma)**
- **Endocrine disruption: Dicofol**, **Carbofuran**, **Oxyflourfen**
- **Eco-toxic: Carbofuran**, **Monocrotophos**, **Carbofuran**, **Oxyflourfen**

**[UPSC 2019] In India, the use of carbofuran, methyl parathion phorate and triazophos is viewed with apprehension. These chemicals are used as**

a) pesticides in agriculture
b) preservatives in processed foods

c) fruit-ripening agents

d) moisturising agents in cosmetics

***Answer: a)***

### Deemed to be Registered Pesticides or DRPs

- **DRPs** are **pesticides used prior to the Insecticides Act of 1968**, with the **expectation of registration once efficacy and toxicity data are available**.
- There are at least 51 such DRPs. Six of these have been withdrawn, eight have been banned and five are to be phased out by the end of 2020.
- There are at least **51 DRPs**, with **six withdrawn**, **eight banned**, and **five to be phased out by the end of 2020**. Also, **17 of the 27 proposed-to-be-banned pesticides are DRPs**.
- The **list of DRPs is not readily available** on any government website (**lack of transparency**).
- The **biosafety** (safety to human health and environment) of these DRPs was never assessed, and their data submissions are secretive, even denied under RTI. Yet, they are being considered for registration regardless of the submitted data.

## 24.7. E-Waste Management Rules, 2022

- **MoEFCC revised** the **E-Waste (Management) Rules**, **2016**, and notified the **E-Waste (Management) Rules**, **2022**. Under these rules, the **collection** and **processing of e-waste can be carried out only by registered producers**, **recyclers and refurbishers**.

### Salient Features of the New Rules

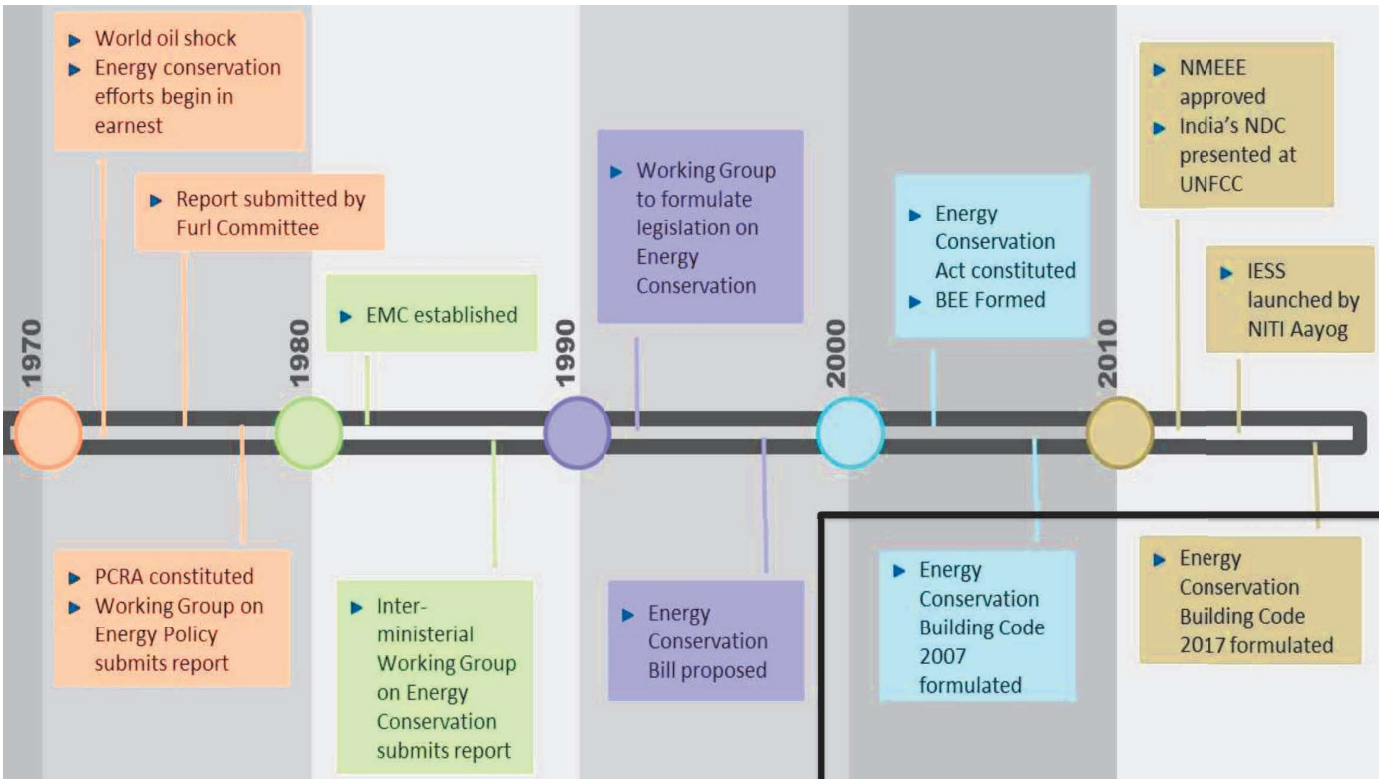
- They apply to **every** manufacturer, producer, refurbisher, dismantler and recycler.
- All manufacturers, producers, refurbishers and recyclers **must register** on the **Central Pollution Control Board (CPCB) portal**. No entity shall carry out any business without registration and not deal with any unregistered entity.
- **Authorisation** has now been replaced by **registration** through the online portal, and **only** manufacturers, producers, refurbishers, and recyclers require registration.
- **Schedule I is expanded**, and now **106 Electrical and Electronic Equipment (EEE)** have been included under the **extended producer responsibility (EPR)** regime.
- **Producers of notified EEE** have been given **annual E-Waste Recycling targets** based on the generation from the previously sold EEE or based on sales of EEE, as the case may be. Target may be made stable for 2 years, starting from 60% for the years 2023-2024 and 2024-25, 70% for the years 2025-26 and 2026-27, and 80% for the years 2027-28 and 2028-29 and onwards.
- Management of **solar PV modules/panels/cells** is added to new rules.
- The **quantity recycled** will be **computed based on end products** to avoid any false claims.

- Provision for generation and transaction of **EPR Certificate** has been introduced.
- Provisions for **environmental compensation**, **verification** and **audit** have been introduced.
- There is a provision for the constitution of a **Steering Committee** to **oversee** the overall **implementation** of the rules.
- The **provision for reducing hazardous substances in the manufacturing of EEE mandates** that every producer of EEE and its components ensure that their **products do not contain lead**, **mercury**, and **other hazardous substances beyond** the **maximum prescribed concentration**.
- It also provides recognition and registration, skill development, monitoring and ensuring the **safety and health of workers** involved in dismantling and recycling e-waste.

### Advantages of the amendments

- The new provisions would facilitate and channelise the **informal sector to the formal sector** for doing business and ensure recycling of E-waste in an **environmentally sound manner**.
- It will promote a **circular economy** through the EPR regime and scientific recycling/disposal of e-waste.
- Provisions for environmental compensation, verification and audit will improve **accountability**.

## 24.8. Energy Conservation Building Code 2017




- The **ECBC** was released by the **Bureau of Energy Efficiency (BEE – Ministry of Power)** in **2007** and was updated in **2017**. The code sets **minimum energy standards** for **commercial buildings (private and govt)** with a connected load of **100 kW or more** or contract demand of **120 kVA or more**, like hospitals, shopping complexes, etc. It is applicable for **both** new and retrofitted existing buildings.

- It includes **incremental**, **voluntary** **energy efficiency performance levels: ECBC**, **ECBC Plus**, and **Super ECBC**. Each level offers increased energy savings compared to conventional buildings.
- While the code acts as a **National Standard**, the **states can modify** it per their regional needs.
- It aims to achieve **25-50% energy savings** in compliant buildings.
- The code focuses on the following building **design components**: Envelop (walls, roofs, and windows)
- Lighting systems, HVAC (heating, ventilation, and air conditioning) systems, and Electric power systems.
- Currently, **23 Indian states** have notified rules to enforce ECBC compliance, while large states like Maharashtra and Gujarat are **still** drafting rules.

### Bureau of Energy Efficiency (BEE)

- It is a **statutory body** established in 2002 under the **Energy Conservation Act**, **2001**. It works under the supervision of the **Ministry of Power**.
- Its function is to **develop programs** to enhance the conservation and **efficient energy use** in India.

### International Energy Agency (IEA)

- It is an **autonomous** **intergovernmental organisation** established in 1974 in **Paris**, **France**.
- It was set up under the framework of the Organisation for Economic Co-operation and Development (**OECD**) in the aftermath of the **1973 oil crisis**.
- **Mandate:** Tracking and analysing key **global energy trends**, **promoting sound energy policy**, and encouraging multinational energy technology cooperation.
- **3 E's of IEA:** Economic Development, Energy Security and Environmental Protection.
- **Members: 31 member states (mostly developed economies)** and **11 Associate countries**.
- **India** became an **Associate member** of IEA in 2017.
- **Criteria for membership:** A candidate country to the IEA **must be a member of the OECD**.

## Energy Conservation (Amendment) Act, 2022

- It amended the **Energy Conservation Act 2001**. The Energy Conservation Amendment Act 2022 expands ECBC into the **Energy Conservation and Sustainability Building Code (ECSBC)**.

### Objectives

- To promote **efficient use of energy** and **carbon-neutral technologies**.
- To support India's commitments to combat climate change and achieve **net-zero emissions by 2070**.

### Key Provisions of the Amendment Act

- It **empowers GoI** to specify a **carbon credit trading scheme**, which allows entities to trade permits for emitting greenhouse gases.

⇨ *A **carbon credit** is a tradable permit that permits the holder to emit **1 tonne of Carbon Dioxide** or other GHGs. It represents the right to emit a measured amount of GHG.*

- It **mandates** using **renewable energy** and **carbon-neutral technologies** by **designated consumers** (entities that consume a specified amount of energy or more in a year).
- It introduces the concept of **Energy Service Companies (ESCOs)** (entities that provide energy efficiency or conservation services to consumers).
- It **expands the scope of ECBCs**. GoI may prescribe ECBCs for different types of buildings, such as **residential**, **commercial**, **industrial**, or **public**.
- The Act expands the scope to include **vehicles** (as defined under the Motor Vehicles Act, 1988) and **vessels** (including ships and boats).
- It enhances the penalties for non-compliance with the provisions/rules of the act.

### Energy Conservation Initiatives in India

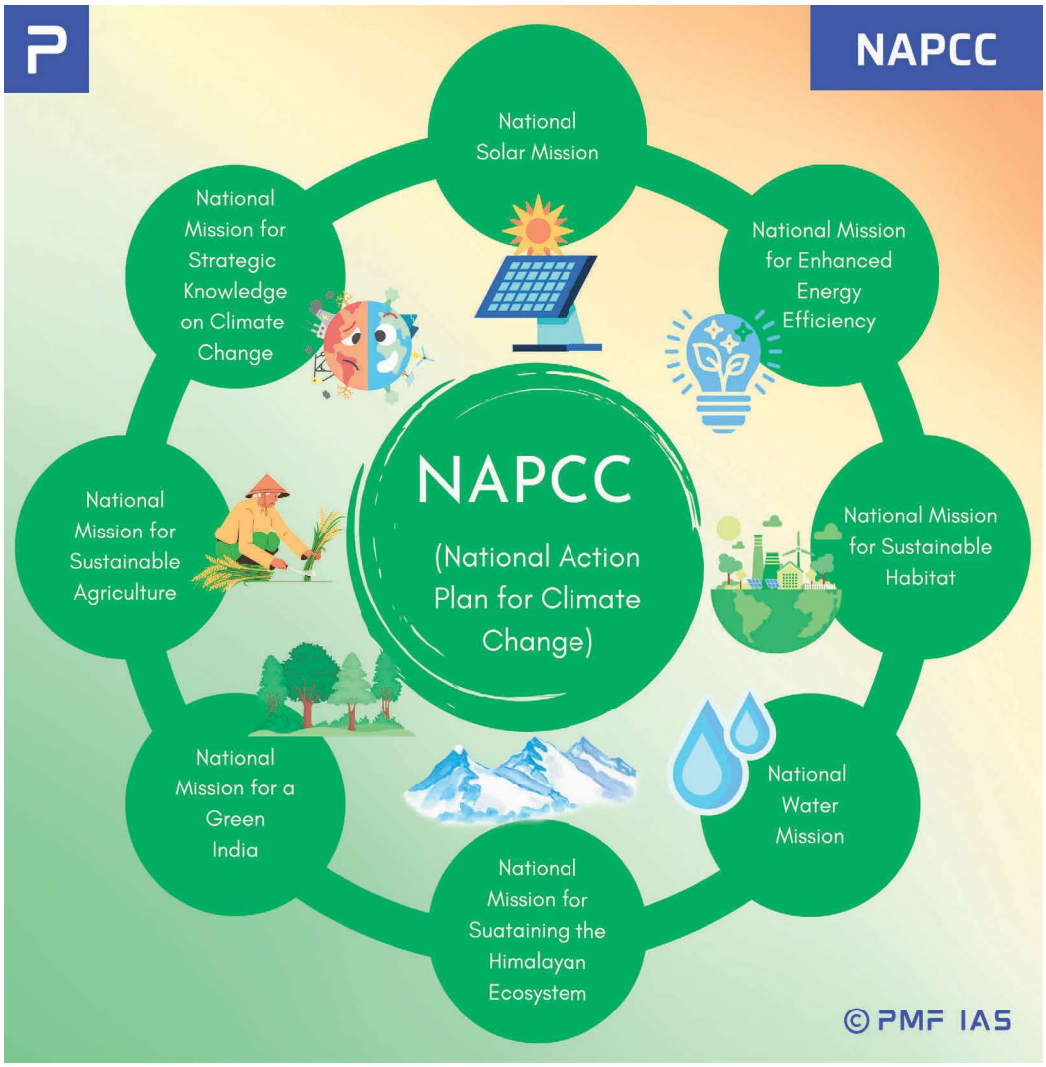
- **Standards and Labelling (S&L) Programme:** This programme was announced in 2006 for **equipment and appliances**. Its aim is to provide the consumer with an **informed choice** about energy savings and, thereby, the **cost-saving potential** of the relevant marketed product.
- **National Mission for Enhanced Energy Efficiency (NMEEE):** It is one of the eight missions under the **National Action Plan on Climate Change (NAPCC)** *(discussed ahead)*.
- **Unnat Jyoti by the Affordable LED for All (UJALA) Yojana:** It was launched in **2015**. Under it, **LED bulbs**, **LED Tube lights** and **Energy-efficient fans** are being **provided to domestic consumers** to **replace** conventional and inefficient variants.

## 24.9. India's National Action Plan on Climate Change (NAPCC)

- The **NAPCC**, published in **2008** by the Prime Minister's Council on Climate Change, emphasises the **development and use of new technologies**.
- The plan involves **public-private partnerships** and **civil society action**, emphasising awareness of **climate change**, **adaptation**, **mitigation**, **energy efficiency**, and **natural resource conservation**.
- There are **eight National Missions** which form the core of the **National Action Plan**.
  1. **National Solar Mission** (approved in 2010)
  2. **National Mission for Enhanced Energy Efficiency** (2009)
  3. **National Mission on Sustainable Habitat** (2011)
  4. **National Water Mission**
  5. **National Mission for Sustaining Himalayan Ecosystem**
  6. **National Mission for A Green India** (approved in 2014)
  7. **National Mission for Sustainable Agriculture** (2010)
  8. **National Mission on Strategic Knowledge for Climate Change**

⇨ ***National Bio-Energy Mission*** *(approved in 2017 but not yet legally included under NAPCC)*

⇨ ***National Coastal Mission*** *(under consideration)*




## National Solar Mission (JNNSM)

- Also known as the **Jawaharlal Nehru National Solar Mission (JNNSM)**, it was inaugurated in 2010. Objectives are to **establish India as a global leader in solar energy** and to **promote sustainable growth** while addressing India's energy security challenges.

### Targets are Set for three phases

1. **First phase 2010-13**
2. **Second phase 2013–17**
3. **Third Phase 2017–22**

- Total target of **100,000 MW (100 GW) by 2022**. MNRE has proposed to achieve it through
  1. **40 GW through Rooftop Solar Projects**
  2. **60 GW through Large** and **Medium Scale solar projects**

**[UPSC 2016] 'Net metering' is sometimes seen in the news in the context of promoting the**

a) production and use of solar energy by the households/consumers

b) use of piped natural gas in the kitchens of households
c) installation of CNG kits in motor-cars
d) installation of water meters in urban households

**Explanation Net Metering**

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

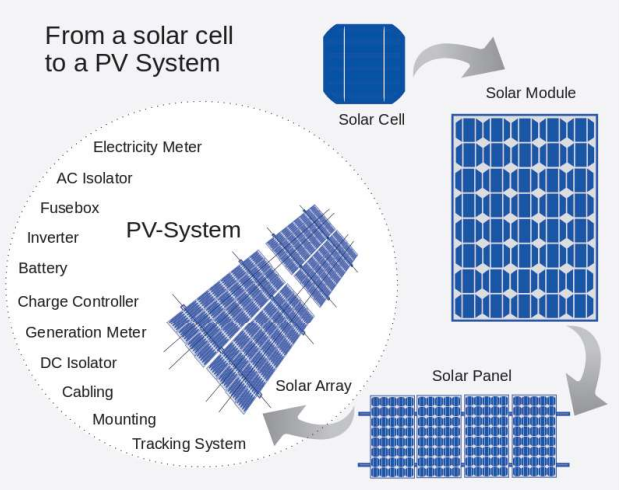
## Domestic Content Controversy

***[2015] To what factors can the recent dramatic fall in equipment costs and tariff of solar energy be attributed? What implications does the trend have for the thermal power producers and the related industry?***

- Guidelines for the solar mission **mandated Indian manufacturing for crystalline silicon PV cells and modules**. This represents over 60% of system costs. For solar thermal, guidelines mandated **30% project to have domestic content**.
- Conflicts arose between power project developers, who prefer sourcing modules globally for better pricing and technology, and Indian solar PV manufacturers, who want developers to buy locally to support the growing industry.
- **US Trade Representative** filed a **complaint** at World Trade Organisation challenging India's domestic content requirements citing discrimination against US exports. **WTO ruled in favor of USA**.

### Types of PV Modules

- **Crystalline Silicon (Semiconductor) PV Module**: **Costly** and **High Conversion Efficiency**
- **Amorphous Silicon (Semiconductor)PV Module**: **Low-cost** and **Low Conversion Efficiency**



## National Mission for Enhanced Energy Efficiency

- **Objective:** Promote energy efficiency through **innovative policies** and **market instruments**.
- The 2010 NMEEE mission document identified India's energy efficiency potential at Rs. 74,000 crores. A recent World Bank study estimates India's energy efficiency market at Rs. 1.6 lakh crores.

### NMEEE Includes Four Efficiency Initiatives Under its Umbrella

#### 1) Perform Achieve and Trade (PAT)

- Assigning **energy reduction targets** to large energy-intensive industries and distributing **Energy Saving Certificates (ESCerts)** on achievement of the targets. (These **ESCerts can be traded**. Consumers who are not able to meet their energy savings targets will buy the ESCerts.)

#### 2) Market Transformation for Energy Efficiency (MTEE)

- Promoting the **adoption of energy-efficient equipment and appliances** through innovative business models. Programs that were developed under this scheme include:
  - **Domestic Efficient Lighting Program: Unnat Jeevan by Affordable LEDs for All (UJALA)** program to promote the use of **LED lighting for households**.
  - **Super-Efficient Equipment Program (SEEP):** Under this program, the manufacturers are incentivised by GOI to elevate the efficiency standards of the equipment.
  - **Bureau of Energy Efficiency (BEE – Ministry of Power):** Launched in the XII five-year plan, the program **focused on ceiling fans** due to their widespread use and significant impact on domestic energy consumption.

#### 3) Energy Efficiency Financing Platform (EEFP)

- Increasing the confidence of financial institutions and investors to support energy efficiency initiatives.
- The EEFP initiative aims to **catalyse energy efficiency financing** by addressing market and implementation challenges and providing a platform for financial institutions, investors, and project developers.

#### 4) Framework for Energy Efficiency Economic Development (FEEED)

- Promoting energy efficiency initiatives by **hedging against investment risks**. **BEE institutionalised two types of funds** in order to protect the confidence of banks and investors in energy efficiency projects and to avoid the stalling of projects:
  1. **Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE):** The fund guarantees risk cover for banks and investors up to 50% of the loan amount or INR 10 crore per project, whichever is less.
  2. **Venture Capital Fund for Energy Efficiency (VCFEE):** This fund promotes equity financing in the energy efficiency sector, reducing the impact of unavailable debt financing for small companies and projects, with equity support up to INR 2 crore or 15% of total equity.

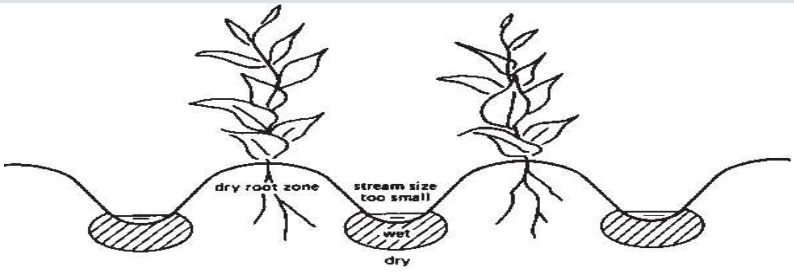
## National Mission on Sustainable Habitat

- The National Mission on Sustainable Habitat was approved in **2010**. It seeks to promote:
  - ❖ **Improvements in energy efficiency in buildings** by extending **energy conservation building codes** to new and large commercial buildings.
  - ❖ **Better urban planning** and **efficient and convenient public transport** to facilitate the growth of medium and small cities.
  - ❖ **Improved management of solid** and **liquid waste** like recycling and urban waste management.
  - ❖ **Improved ability of habitats to adapt to climate change** and measures for **improving advance warning systems** for extreme weather events.
  - ❖ Conservation through appropriate **changes in the legal and regulatory framework**.
- The Mission is being implemented through the following programmes of the **Ministry of Urban Development**:
  1) **Atal Mission on Rejuvenation and Urban Transformation (AMRUT)**
  2) **Swachh Bharat Mission**
  3) **Smart Cities Mission**
  4) **Urban Transport Programme**

## National Water Mission (NWM) Mission

- **Objective:** To ensure **integrated water resource management** helping to conserve water, minimise wastage and ensure **more equitable distribution** both across and within states.
- The Mission is in line with the **National Water Policy**, which aims to
  - ❖ **increase water use efficiency by 20%**
  - ❖ ensure that a considerable share of the **water needs of urban** areas are **met through recycling**
  - ❖ ensure that the **water requirements of coastal cities** are met through modern **desalination technologies**
  - ❖ ensure **basin level management strategies** by working with states to deal with variability in rain
- The Mission aims to achieve its objectives through:
  - ❖ Increasing efficiency through **regulatory mechanisms** (differential entitlements and pricing).
  - ❖ **Enhanced storage** both above and below ground, **rainwater harvesting**.
  - ❖ **Incentivising water-neutral or water-positive technologies** and adoption of large-scale irrigation programmes that rely on sprinklers, drip irrigation and ridge and furrow irrigation.

⇨ *Ridge and furrow irrigation: The crops are grown on the ridges, and the furrows are used to irrigate.*



## National Mission for Sustaining the Himalayan Ecosystem (NMSHE)

- The primary objective of the Mission is to:
  - ❖ develop a sustainable model to assess the health status of the Himalayan Ecosystem continuously
  - ❖ enable policy bodies in policy formulation as also to assist States in the Indian Himalayan Region with the implementation of actions for sustainable development
- The NMSHE will attempt to address a variety of issues:
  - ❖ **Himalayan glaciers** and associated consequences
  - ❖ Prediction and management of natural hazards
  - ❖ **Biodiversity conservation** and protection
  - ❖ **Wildlife conservation** and protection
  - ❖ **Traditional knowledge** societies and their livelihood
- The effect of climate change on Himalayan glaciers and associated hydrological consequences:
  - ➢ Increased **drought-like situations** due to an overall decrease in the number of rainy days.
  - ➢ Increased **flood events** due to an overall increase in the rainy day intensity.
  - ➢ Effect on **groundwater quality** in alluvial aquifers due to increased flood and drought events.
  - ➢ Influence on **groundwater recharge** due to changes in precipitation and evaporation.
  - ➢ Increased **saline intrusion** of coastal and island aquifers due to rising sea levels.

## National Mission for A Green India

- The **Green India Mission** aims to **sequester 2.523 billion tonnes of carbon by 2020-30**, and this involves adding **30 million hectares** in addition to existing forest. It aims at:
  - ❖ Protecting, restoring, and **enhancing India's diminishing forest cover**
  - ❖ **Responding to climate change** by a combination of adaptation and mitigation measures.
  - ❖ **Enhanced annual $CO_2$ sequestration** by 50 to 60 million tons in the year 2020
- The mission will be **implemented on public and private lands**. Local communities will participate in planning, decision-making, implementation, and monitoring.

### The Intended Major Outcomes of the Project

- ✓ Improved ecosystem services
- ✓ Reversal of land degradation
- ✓ Improvement in forest cover quality and ecosystem services of forests, degraded grassland and wetlands
- ✓ Eco-restoration of shifting cultivation areas, cold deserts, mangroves, ravines, and abandoned mining areas
- ✓ Improvement in forest and tree cover in urban lands
- ✓ Improvement in tree cover on agricultural and other non-forest lands (**agroforestry/social forestry**)

### National Mission on Seabuckthorn

- The MoEF and DRDO have launched the initiative for **seabuckthorn cultivation** in the **cold deserts**. It is a part of the **Sub-Mission on Cold Desert Ecosystems** under the **Green India Mission**.
- Seabuckthorn, popularly known as **Leh berries**, is also called the **"Wonder plant"** and **"Ladakh gold."** Its uses are:
  - ❖ It has multi-purpose **medicinal and nutritional properties**.
  - ❖ The plant can **fix atmospheric nitrogen**.
  - ❖ It is **tolerant to extreme temperatures**.
  - ❖ It has an extensive root system, making it **ideal for controlling soil erosion and desertification**.

**[UPSC 2016] Which of the following best describes/describe the aim of 'Green India Mission' of the Government of India?**

1) Incorporating environmental benefits and costs into the Union and State Budgets thereby implementing the `green accounting'
2) Launching the second green revolution to enhance agricultural output so as to ensure food security to one and all in the future
3) Restoring and enhancing forest cover and responding to climate change by a combination of adaptation and mitigation measures

***Select the correct answer using the code given below.***

a) 1 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

***Answer: c) 3 only***

**[UPSC 2011-12] Government of India encourages the cultivation of 'sea buckthorn'. What is the importance of this plant?**

1) It helps in controlling soil erosion and desertification.
2) It is a rich source of biodiesel.
3) It has nutritional value and is well-adapted to live in cold areas of high altitudes.
4) Its timber is of great commercial value.

***Which of the statements given above is /are correct?***

a) 2, 3 and 4 only
b) 1 and 3 only
c) 1, 2, 3 and 4
d) 1 only

***Answer: b) 1 and 3 only***

## National Mission for Sustainable Agriculture

- NMSA has been formulated for enhancing agricultural productivity especially in **rainfed areas**. **60% of India's net sown area is rainfed**, and it accounts for **40% of the total food production**.
- Focus areas are **integrated farming**, **water use efficiency**, **soil health**, and **resource conservation**.
- Stated dimensions of NMSA:
  1. Improved crop seeds, livestock and fish cultures
  2. Water Use Efficiency
  3. Pest Management
  4. Improved Farm Practices
  5. Nutrient Management
  6. Agricultural insurance
  7. Credit support
  8. Markets
  9. Access to Information
  10. Livelihood diversification

## Soil Health Management (SHM)

- **Soil Health Management (SHM)** is one of the components of **NMSA**. SHM aims at
  - ❖ Promote **Integrated Nutrient Management** (INM) using **chemical fertilisers**, **organic manures**, and **bio-fertilisers**
  - ❖ Fertiliser testing facilities to improve **soil test-based recommendations** to farmers

### Soil Health Card (SHC) Scheme

- Implemented in 2015, the SHC scheme provides farmers with a **Soil Health Card every two years**. The card shows **soil nutrient status** and **recommends dosages** for better soil health.
- Village youth and farmers under 40 years old can set up **soil health laboratories**. The cost is up to Rs 5 lakhs, and the central and state governments fund 75% of the costs.
- A study conducted by the National Productivity Council (NPC) says the application of Soil Health Card recommendations has led to a **decline of 8-10% in the use of chemical fertilisers**.

### What does a Soil Health Card Contain?

- It contains the status of soil with respect to **12 parameters**:
  - ❖ **N-P-K** (**Macro-nutrients**)
  - ❖ **Sulphur** (**Secondary-nutrient**)
  - ❖ **Zn**, **Fe**, **Cu**, **Mn**, **Bo** (**Micro-nutrients**)
  - ❖ **pH**, **EC**, **OC** (**Physical parameters**)
- Based on this, the SHC will provide fertiliser and soil amendment recommendations for the farm.

## National Mission on Strategic Knowledge for Climate Change (NMSKCC)

- NMSKCC seeks to build a knowledge system that supports national policy and action for **effectively responding to climate change challenges while preserving the nation's growth goals**.
- **Mission objectives:**
  - ❖ Formation of knowledge networks engaged in R&D relating to climate science
  - ❖ Development of national capacity for modelling the regional impact of climate change
  - ❖ Establishing research networks and promoting studies on climate change impacts on important socio-economic sectors like agriculture, health, ecosystems, biodiversity, and coastal zones.

## Indian Network on Climate Change Assessment (INCCA)

- Launched by **MoEFCC** in an effort **to promote domestic research on climate change**.
- Reports prepared by the INCCA will form a part of India's **National Communication (NATCOM)** to the UNFCCC.

### National Communication (NATCOM)

- In pursuance of the implementation of the provisions of UNFCCC, India's Initial National Communication (NATCOM) was initiated in 2002 and funded by the **Global Environment Facility**.

**---------- End of Chapter ----------**

# 25. Green Revolution and Sustainable Agricultural Practises

## 25.1. Green Revolution

### India's First Green Revolution

- **Rapid growth in food grain production** from using **seeds of high-yielding varieties (HYV)** is termed as **Green Revolution**. The use of **HYVs**, **fertilisers**, **pesticides**, **irrigation** and **mechanisation** are the major aspects of the Green Revolution.
- The high-yielding varieties of **wheat** and **rice** have been the key elements in the **Indian green revolution**. Though the term "green revolution" refers to wheat and rice, some agricultural scientists include maize and soyabean, where spectacular gains in yield have occurred.

### Introduction of High-yielding Varieties (HYV)

- In the 1960s, the yield of wheat was very low compared to the yields of advanced countries. **MS Swaminathan**, former Director General of the Indian Council of Agricultural Research (ICAR) stressed the need for reorientation of the entire breeding programme of tall varieties.
- On the request of Indian breeders **Norman E. Borlaug** was invited from Mexico in 1963 by the Government of India to assess the possibilities of using **dwarf varieties** in India.
- Mr Borlaug recommended the feasibility of using **semi-dwarf wheat of Mexican origin** as the **agro-climatic conditions prevailing in India are similar to Mexico**.
- On Mr. Borlaug's recommendation, two semi-dwarf varieties, namely, **Lerma Rajo** and **Sonora-64**, were chosen and released for cultivation in irrigated fields. These varieties gave high yields and revolutionised wheat production. Norman E. Borlaug was awarded the **Nobel Prize** in 1970 for the **"Green Revolution"**, which also helped India.
- Through extensive wheat breeding programmes carried out during 1970-80, new amber-seeded, high-yielding dwarf wheat varieties were developed. These HYVs responded favourably to **fertiliser** and **irrigation**.

### Use of Chemical Fertilizers and Pesticides

- Pesticides are chemicals which have been developed to control organisms called pests.
- **Nitrogenous fertilisers: Ammonium sulphate**, **ammonium nitrate** and **urea** ➔ **promotes plant growth**.
- **Phosphate fertilisers: Ammonium phosphate**, **calcium dihydrogen phosphate (superphosphate)** ➔ helps in **root development**, **plant maturation** and **seed development**.

- **Potassium fertilisers: Potassium sulphate** and **potassium nitrate ➔ improves plants' abilities to resist disease**. It also **protects the plant when the weather is cold or dry**, **strengthening its root system and preventing wilt**.

## Mechanisation of Agriculture

- The increase in productivity on large areas of land brought the idea of farm mechanisation. To cope with the shortage of agricultural labour, farm mechanisation was the obvious choice for completing agricultural operations.
- The machines that perform various jobs at the farm are water pumps, ploughs, combine harvesters, land levellers, cultivators, power-operated tractor sprays, reapers, threshers, trolleys, mechanical pickers, etc.

## Irrigation

- HYVs **require a lot of water** and hence, irrigational facilities were a prerequisite for the green revolution.
- **Wells:** There are two types of wells, namely **dug wells** and **tube wells**. This kind of irrigation is widely practised in **plain regions of India**. Overexploitation of wells is well observed in the **Punjab-Haryana region**.
- **Canals:** This is usually an elaborate and extensive irrigation system. In this system, canals receive water from one or more reservoirs or rivers. Canal irrigation is well suited for **regions with clayey soil**, as **clayey soil prevents water percolation**. It is mostly practised in **south India** and the **Ganga-Yamuna region**.
- **River Lift Systems:** In areas where canal flow is insufficient or irregular due to inadequate reservoir release, the lift system is more rational. Water is directly drawn from the rivers to supplement irrigation in areas close to rivers. This system is mostly practised in **South India**.
- **Tanks:** These are small storage reservoirs that intercept and store the run-off of smaller catchment areas.

***[UPSC 2023] From being a net food importer in the 1960s, India has emerged as a net food exporter to the world. Provide reasons. (Answer in 250 words)***

## Bringing Green Revolution in Eastern India (BGREI)

- Green Revolution turned India from a **'begging bowl'** to a '**grain bowl**'. BGREI is about binging similar benefits to **eastern India**, which largely remained untouched.
- BGREI is the flagship programme under the **Rashtriya Krishi Vikas Yojana (RKVY**). It was announced in the Union Budget, 2010-11. It is intended to address the constraints limiting the productivity of "rice-based cropping systems".
- BGREI focuses on bringing the **Green Revolution (second) to** Seven northeastern states with rich water resources: **Assam**, **Bihar**, **Chhattisgarh**, **Jharkhand**, **Odisha**, **Eastern UP**, and **WB**.
- Objective: **yield maximisation of rice and wheat** per unit area by improving agronomy, **water harvesting and conservation**, and water utilisation.

### Government Initiatives to Strengthen BGREI

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

## Second Green Revolution for Sustainability

- The first Green Revolution was to ensure **food security**, as there was severe food scarcity in the country. The second Green Revolution aims at creating **sustainable agriculture** by leveraging advancements in technology.

### Need for the Second Green Revolution

- With the growing population and over-exploitation of land resources, the **pressure on food security** will continue and rise. 65% of the population is still living in the villages and over 70% of the rural people are dependent on agriculture for their livelihood.
- The **Green Revolution**, launched in the **mid-1960s**, was mainly **confined to well-irrigated areas**. It was **not successful in rain-fed areas**, which contribute significantly to the total food-grain production.
- The Green Revolution has made us **self-sufficient in food grains**, but the **environmental consequences** and ecological costs are offsetting the progress made. The **groundwater is depleted and polluted**. The lakes and ponds are becoming lifeless due to **eutrophication – a direct consequence of the Green Revolution**.
- Growth in the agricultural sector has been almost stagnant. **GM Crops** are marred in various controversies related to **intellectual property**, **ecological consequences**, **health consequences** etc. **Global warming** is said to **engulf productive coastal lands** due to the rise in sea levels. This creates an urgent need to raise and diversify agriculture.

⇨ ***[UPSC 2020] What are the major factors responsible for making rice-wheat system a success? In spite of this success how has this system become bane in India? (150 words).***

⇨ ***[UPSC 2019] How was India benefited from the contributions of Sir M. Visvesvaraya and Dr. M. S. Swaminathan in the fields of water engineering and agricultural science respectively?***

### What We Want from the Second Green Revolution

- ✓ Improving agricultural production while generating gainful self-employment for the small farmers and weaker sections of the society.
- ✓ Scaling up food production **without disturbing the ecological balance**.
- ✓ Boosting agricultural development, women empowerment, and environmental protection. (Women are the major power in agriculture as about 65-70% of the labour in crop production is contributed by women).
- ✓ **Reclaiming degraded and low fertile lands** and **lands deprived of irrigation**.

### Making Second Green Revolution a Success

#### Precision Agriculture

- ✓ The **wealth of data** if harnessed appropriately, can help farmers make the most efficient use of vital inputs such as water and fertilizer by applying them in precise amounts.
- ✓ Testing of samples of soil from agricultural fields is vital for achieving **nutrient stewardship**.
- ✓ Mobile-based applications for farmers will form an important part of the **data-driven precision approach**.

### Efficient Use of Water

- ✓ **Laser levelling** is a technology that can grade an agricultural field to a flat surface by using a laser-guided scraper.
- ✓ Laser levelling has been shown to **improve crop yields**, **reduce labour time spent weeding**, and reduce **water use for irrigation by up to 20-25 per cent**.
- ✓ Developing additional water sources through tube wells, dug wells and farm ponds.
- ✓ Promotion of Flood, Drought, and Salinity tolerant rice varieties and use of Drum seeders for timely planting of direct seeded rice.

### Sustainable Agricultural Practices

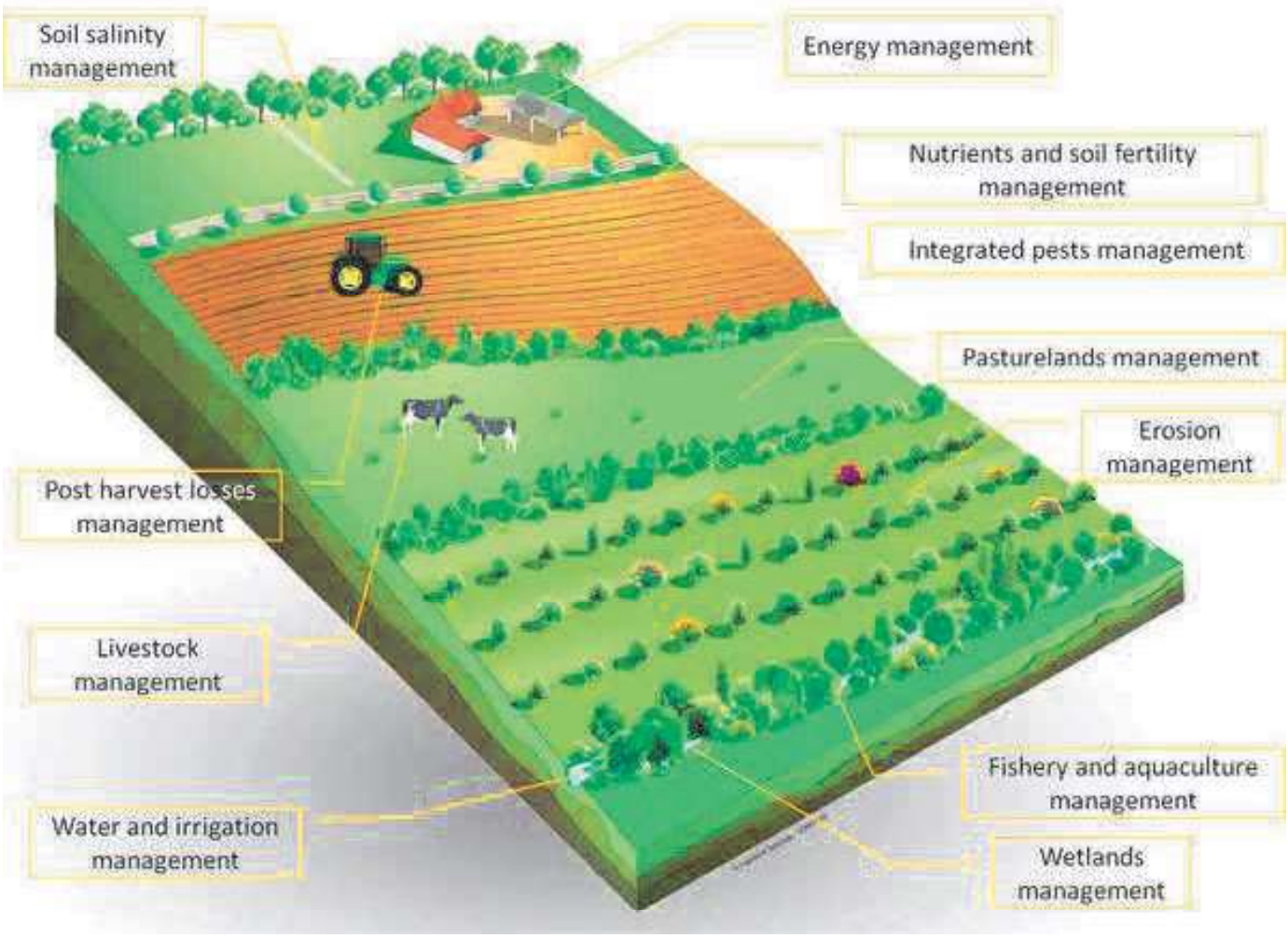
- ✓ Selection of improved varieties to suit the need and cultivation practices to increase ecological and economic stability.
- ✓ Soil management by proper method of tillage.
- ✓ **Organic farming** and **natural farming**

***[UPSC 2017] Explain various types of revolutions, took place in Agriculture after Independence in India. How have these revolutions helped in poverty alleviation and food security in India?***

## 25.2. The Concept of Sustainable Agriculture

- Agriculture is a broad term encompassing all aspects of crop production (food and fibre), livestock farming, fisheries, forestry, etc. Food and fibre productivity has increased due to new technologies, mechanisation, increased use of fertilisers and pesticides, and expansion of irrigation facilities. These changes reduced the labour demand to produce the majority of the food and fibre.
- Although these changes have had a positive effect, they also caused **some serious environmental and social problems**, such as **erosion of topsoil**, **depletion and pollution of groundwater** and other water resources, and unemployment of farm labourers due to mechanisation.
- In view of the growing negative consequences of modern agriculture there is growing demand to promote "sustainable agriculture". Sustainable agriculture is the production of food, fibre, plant or animal

products using **farming techniques that protect the environment**, **public health**, **human and animal welfare**.




- Sustainable agriculture incorporates many **environmentally safe agricultural practices** and offers economically viable opportunities for farmers, labourers, consumers, and others in the entire food system. Sustainable farming systems are those that are **least toxic and least energy intensive** and yet maintain productivity and profitability. E.g., **Organic farming** and, to an extent, **precision farming**.
- Thus, sustainable agriculture is one that,
  - ✓ **supports profitable production**
  - ✓ **protects environmental quality**
  - ✓ **uses natural resources efficiently**
  - ✓ **provides affordable**, **high-quality products**
  - ✓ **decreases dependency on non-renewable resources**
  - ✓ **enhances the quality of life for rural communities**
  - ✓ **will last for generations to come**

## Sustainable Practises for Natural Farming and Agriculture in General

## Mixed cropping or Diverse cropping

- In **mixed/diverse cropping** **two or more crops are grown all at the same time in a field**. If, by chance, one crop fails, the other crops cover the risk of total crop failure.
- Usually, a long-duration crop is grown with a short-duration one, so both get **sufficient nutrition** at the time of maturity. Generally, a **leguminous crop** is grown along with the **main crop** (**intercropping**).
- The various plans followed in mixed cropping:
  - Polyvarietal cultivation, where **several genetic varieties** of the same crop are planted.
  - **Intercropping** is where two or more different crops are grown simultaneously, like carbohydrate-rich cereal that uses soil nitrogen and nitrogen-fixing legume that puts the nitrogen back in the soil.
  - Polyculture, in which different **plants maturing at various times** are planted together.

### Advantages of Mixed cropping

- ✓ This practice has many advantages because the fertiliser and water requirements of plants are different, so there is less need for these inputs.
- ✓ Pests are controlled naturally because their natural predators find multiple habitats to survive.
- ✓ It has been found that this practice produces a much higher yield per hectare than monoculture.

### Monoculture

- Large-scale mechanisation has led to the spread of **monoculture**, i.e., **only one crop variety is sown in the entire area**. It uses a lot of fertiliser, pesticides, water, etc. It may be productive for some time but causes environmental and economic problems later on. E.g. wheat and paddy cultivation in the Punjab-Haryana belt.

### Strip Farming

- This involves planting the main crops in **widely spaced rows** and **filling the spaces** with another crop to ensure complete ground cover. It retards water flow which thus soaks down into the soil, consequently **reducing erosion problems**.

## Crop Rotation (Multiple Cropping or Multi-Cropping)

- It is the practice of growing **two or more different crops in regular succession** in the same field within a year. This practice controls insects and diseases, increases soil fertility, and decreases soil erosion. This practice can not continue for long as the land cannot sustain fertility.
- Generally, soil cannot sustain continuous cropping (**monocropping**) with a high-yielding single crop because certain nutrients required by the crop get exhausted totally. In contrast, others remain unutilised, leading to a severe nutrient imbalance and encouraging certain diseases and pests.
- Sowing a leguminous crop (e.g., green gram) as a **rotational crop** is very useful because **legumes enhance nitrogen levels in the soil** and reduce the need for chemical nitrogen fertiliser.

### Best Practises in Crop Rotation

- ✓ Leguminous crops should precede non-leguminous crops.
- ✓ Crops that require less water (irrigation) should be grown after those that require more water.
- ✓ Crops requiring less manure should be sown after one that requires more manure.

## Mixed Farming

- **Mixed farming** involves **mixed crops along with livestock operations**. It has several advantages:
- ✓ Optimum diversity may be obtained by integrating **crops and livestock** in the same farming operation.
- ✓ Growing crops only on more level land and pastures or forages on steeper slopes will reduce soil erosion.
- ✓ Pasture and leguminous forage crops in rotation enhance soil quality and reduce erosion; livestock manure, in turn, contributes to soil fertility.
- ✓ Livestock can buffer the negative impacts of low rainfall periods by consuming crop residue, which in "plant only" systems would have been considered crop failure.
- ✓ Feeding and marketing are flexible in animal production systems. This can help cushion farmers against price fluctuations and make more efficient use of farm labour.

## Soil Management

- ✓ Healthy soil produces crops less susceptible to pests and diseases. Accordingly, the soil must be protected and nurtured to ensure long-term productivity. Methods of protection include using **cover crops** and **compost**, **reducing tillage**, and **conserving soil moisture with dead mulches**.

## Vermicomposting (Palekar opposes the use of vermicompost in ZBNF)

- ✓ Vermicomposting is an appropriate technique for **efficiently recycling** animal wastes, crop residues, and agro-industrial wastes with the help of **earthworms**.
- ✓ Vermicompost can be prepared from all sorts of organic residues – animal waste, sericulture residues, dairy and poultry residues, bagasse from sugarcane factories, **weeds** (particularly *Parthenium hysterophorus* or Congress weed before flowering), etc.

## Integrated Pest Management (IPM)

- In this approach, each crop and its pests are evaluated as parts of an **ecological system**. Then, farmers develop a control programme that includes **cultivation**, **biological** and **chemical** methods applied in **proper sequence** and timing.
- The aim of IPM is **not to eradicate the pest population completely** but to keep the crop damage to an economically tolerable level. Farmers monitor the field, and when they find the pest level to be high enough, they first use biological methods and cultivation practices to control and then use **small amounts of insecticides**, mostly derived from plants, as a **last resort**.

### Biological control

- Natural predators, parasites, and pathogens of the pests are used. For example, a Pest on cucumber plants called the red spider mite is controlled by using a predatory mite that feeds on it.

### Cultivation practices

- A variety of cultivation practices like **crop rotation**, **polyculture**, **inter-cropping**, etc., can be used to get rid of the pests. Some amounts of insecticides, mostly of plant origin (e.g. **Pyrethrum** and **Rotenone neem** product) are applied as a last resort.
- Pest and disease-resistant crop plants can be produced by **genetic engineering**. An example is **Bt cotton**, insecticidal for the bacterial gene (**Bacillus thuringinesis**) introduced into cotton plants, making the cotton plants resistant to pests.

### Disadvantages of Integrated Pest Management (IPM)

- Farmers should have expert knowledge about each pest.
- It acts more slowly than conventional pesticides.
- Methods developed for a crop in one area might not apply to areas with even the slightest different growing conditions.
- Initial cost may be higher.

## 25.3. Nutrient Management

- **17 elements** act as essential plant nutrients. **Nine** of these are **macronutrients** (required by plants in **large amounts)**, and the other **eight** are **micronutrients** (required in **trace amounts**). Macronutrients are generally present in plant tissues in significant amounts, while micronutrients constitute less than 1% of the dry weight of most plants.

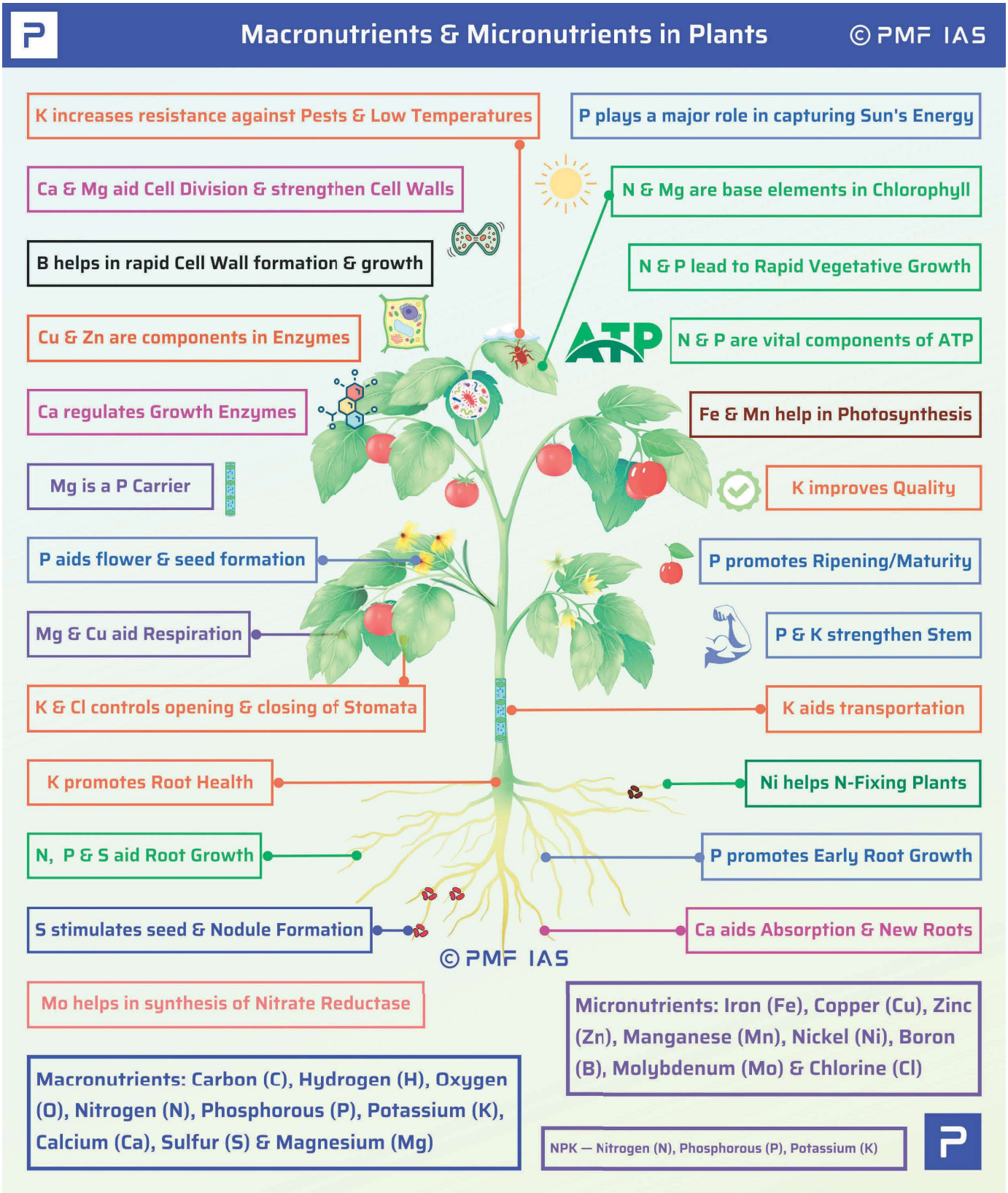
### Macronutrients for Plants

- **Macronutrients (9):** Carbon (C), Hydrogen (H), Oxygen (O), **Nitrogen (N)**, **Phosphorous (P)**, **Potassium (K)**, **Calcium (Ca)**, **Sulfur (S)**, and **Magnesium (Mg)**.
- Of the ten micronutrients, carbon, hydrogen and oxygen are obtained mainly from **carbon dioxide ($CO_2$)** and **water ($H_2O$)**, while the others are absorbed from the **soil** as mineral nutrition.
- **NPK — Nitrogen (N)**, **Phosphorous (P)**, **and Potassium (K)** are the most significant macronutrients.

### Carbon (C), Hydrogen (H) and Oxygen (2)

- Carbon and hydrogen are the major constituents of most **biomolecules**, including proteins, starches and cellulose.
- Photosynthesis converts carbon dioxide into carbohydrates. Hydrogen, obtained from water, is also used in photosynthesis. **Plants require oxygen for cellular respiration during nighttime**.

### Nitrogen (N)




- Of NPK, nitrogen has received the maximum attention as it gets easily converted to soluble forms (nitrite) from various fertilisers.

**Function of Nitrogen in Plants**

- Nitrogen is a base element in all cells, **proteins (chain of amino acids)**, **hormones**, and **chlorophyll**.
- It produces the **most significant yield response** in crop plants by promoting **rapid vegetative growth** and **healthy green colour**.

### Sources of Nitrogen for Plants

- **Organic matter** in soil is rich in nitrogen. Plants take up nitrogen from the soil as **$NH_4^+$ (ammonium/ammonium ions)** and **$NO_3^-$ (nitrate)**. Some plants, such as Legumes, fix atmospheric nitrogen.
- Atmospheric nitrogen is used to make fertilisers like ammonium sulfate, ammonium nitrate and **urea/carbamide**. When applied to soil, nitrogen is converted to an **easily absorbable mineral form**, **nitrate**.

⇨ ***Urea (carbamide;*** *molecular formula: $CH_4N_2O$; chemical formula $CO(NH_2)_2$)* ***has the highest nitrogen content*** *of all solid nitrogenous fertilisers. Therefore, it has a* ***low transportation*** *cost per unit of nitrogen nutrients. Urea breaks down in the soil to give* ***ammonium ($NH_4^+$)***.

### Nitrogen Deficiency

- Nitrogen deficiency occurs when soil organisms use much nitrogen to break down harmful **carbon** sources in the soil. It leads to slow growth, small plant parts and **leaves with less chlorophyll**.

## Phosphorus (P)

- **Functions:** Phosphorus plays a significant role in **capturing and converting the sun's energy (photosynthesis)**. **Adenosine triphosphate (ATP)**, the energy unit of plants, is formed during photosynthesis.
- Phosphorus stimulates **early root and plant growth** and the **nitrogen-fixing capacity of legumes**. It **hastens ripening/maturity**, **improves the quality of fruit/grain** and **strengthens the plant stalk and stem**.
- **Phosphorus deficiency** leads to slow growth and weak and stunted plants.
- **Source: Superphosphate** (a mixture of **calcium phosphate** and **calcium sulfate**), made from **rock phosphate** and **sulfuric acid**. All manures contain phosphorus.

## Potassium (K)

- **Functions:** Potassium increases **resistance in plants against diseases**, **pest attacks**, **climate stresses**, etc. It helps to form and move starch, sugars and oils in plants and **improves fruit quality and quantity**.
- It increases the efficiency of the uptake of nutrients, strengthens straw and root systems in cereals, and **reduces lodging**. It also **controls the opening/closing of the stomata**.
- Plants deficient in potassium 'lodge' or bend over at ground level, making them difficult to harvest.
- It is involved in processes that ensure **carbon assimilation and transportation** throughout the plant for growth and storing sugars and proteins. The potassium ion is essential for **water regulation and uptake (osmosis)**.

- **Source: Potassium chloride** (KCl – obtained from ancient dried lake deposits) and **potassium sulphate** (sulfate of potash/$K_2SO_4$ – found mixed with various salts/ores).

### Calcium (Ca)

- **Functions:** Calcium is essential for **cell division**, the **growth** **of seeds**, **plant tissues**, **new roots**, **root hairs**, etc. It is also vital for pollen growth and preventing leaf fall.
- **Sources:** Lime, gypsum, dolomite and superphosphate.

### Magnesium (Mg)

- **Functions:** **Magnesium** and **nitrogen** are base elements of **chlorophyll**. Magnesium is essential in **activating enzymes** involved in respiration, photosynthesis and nucleic acid synthesis. It serves as a **carrier of phosphate** compounds throughout the plant.
- **Source: Dolomite (calcium magnesium carbonate)**, **magnesite (magnesium oxide)**, **epsom salt (magnesium sulfate)**, etc.

### Sulfur (S)

- **Functions:** Sulfur is a constituent of **amino acids** in plant proteins. It is also found in vitamin B1 and several enzymes. It is responsible for **odour compounds** in plants. It stimulates **root growth** and **seed** and **nodule formation**.
- **Source:** Superphosphate, gypsum, elemental sulfur and sulfate of ammonia, soil organic matter, etc.

## Micronutrients for Plants

- **Micronutrients (8): Iron (Fe)**, **Copper (Cu)**, **Zinc (Zn)**, **Manganese (Mn)**, **Nickel (Ni)**, **Boron (B)**, **Molybdenum (Mo)** and **Chlorine (Cl)**. They occur as **trace elements** in soil.

| Micronutrient | Function |
|---|---|
| **Iron (Fe)** | Constituent of many compounds that regulate and **promote growth and development**. It is essential for the formation of **chlorophyll** and the **synthesis of proteins**. |
| **Manganese** | Mn helps in **photosynthesis** and growth. |
| **Copper (Cu)** | An essential constituent of plant **enzymes**. Regulates respiratory activity. |
| **Zinc (Zn)** | Helps in the production of **hormones** responsible for stem and leaf expansion. |
| **Boron (B)** | Helps with the **formation of cell walls** in rapidly growing tissue. Deficiency reduces calcium uptake and inhibits the plant's ability to use it. |
| **Molybdenum (Mo)** | Required for the synthesis of the enzyme **nitrate reductase (reduces nitrate ($NO_3^-$) to nitrite ($NO_2^-$))**, helping N-fixing soil bacteria in legumes. |

| | |
|---|---|
| **Nickel (Ni)** | Required in small amounts for N-fixing plant species. Without nickel, **toxic levels of urea can accumulate**. |
| **Chlorine (Cl)** | It helps in plant growth and development, **osmotic and stomatal regulation** and disease resistance. |

## Fertilizer Subsidies and Consequences

### Urea Subsidy Scheme

- **Urea** is sold at **statutorily notified uniform MRP**. It is being provided to the farmers at an MRP of Rs. 242 per 45 kg bag of urea (exclusive of neem coating charges and applicable taxes). The difference between the delivered cost of urea to the farmer and net market realisation by the urea units is **given as a subsidy to the urea manufacturer/importer** by the **Centre**.

### Nutrient Based Subsidy (NBS) Scheme

- The **NBS scheme** has been implemented since 2010 by the **Department of Fertilisers**, **Ministry of Chemicals and Fertilisers**. Under the scheme, fertilisers are provided at subsidised rates based on the nutrients contained, namely **Nitrogen (N)**, **Phosphate (P)**, **Potash (K)** and **Sulphur (S)**. Moreover, fertilisers fortified with secondary nutrients and **micronutrients (sulphur**, **zinc**, **boron**, **iron**, **manganese**, and **copper)** are given additional subsidies. A fixed rate of subsidy (in ₹per Kg basis) is announced on nutrients (N, P, K and S) by the government annually. NBS **does not include urea-based fertilisers**.

#### How Is The NBS Fertilizer Subsidy Paid and Who Gets It?

- Farmers buy **non-urea fertilisers** at MRPs **below** their standard supply-and-demand-based market rates or what it costs to produce/import them. The **Centre** foots the difference as a **subsidy**. **The subsidy under NBS goes to fertiliser companies** through a **Direct Benefit Transfer (DBT)**, although its **ultimate beneficiary is the farmer** who pays MRPs less than the market-determined rates.

### Issues With Fertilizers Subsidy Schemes

#### Increase in Imbalanced Use of Fertilisers due to NBS

- **Urea is not included in the NBS scheme** and **remains under price control** (**MRP is officially fixed**). On the other hand, the MRPs of non-urea fertilisers under the **NBS scheme** are **decontrolled (fixed by the companies)**. Thus, **they retail way above urea** while attracting **lower subsidies**. This has **led the farmers to use more urea**, worsening the **fertiliser imbalance**.

#### Environmental and Economic Cost

- Fertilizer subsidy is the **second-biggest subsidy** after food subsidy. Schemes like NBS promote the **injudicious** use of fertilisers, which are the major emitters of **nitrous oxide (**$N_2O$ – **a potent GHG** and **ozone-depleting substance)**, damaging the soil health and the **fiscal health** of the economy.

- The current ratio of **NPK (desirable ratio of 4:2:1)** in agricultural soil in several states is skewed towards nitrogen. This imbalance causes widespread deficiency of secondary nutrients and micronutrients and soil alkalinity and salinity.

### Measures Required

- The government must bring reforms to promote the balanced use of fertilisers and make efforts to do away with fertiliser subsidies in the coming years.
- To begin with, it must introduce a **decontrol measure (don't fix the MRP**; **leave it to the market)** in the **urea** sector. Gradually, fertiliser subsidies must be replaced with **Direct Benefit Transfers** to farmers.
- Efforts must be made to promote **organic manure**, **bio-fertilisers**, and **city compost** as they come with a much lower environmental footprint than synthetic fertilisers. They increase organic soil carbon and support microbial life. They also promote more efficient use of synthetic fertilisers.

## 25.4. Organic Farming

- Organic farming **avoids the use of synthetic fertilisers**, **pesticides**, **growth regulators**, and **livestock feed additives**. It relies on **crop rotation**, **crop residues**, **animal manures**, **legumes**, **green manure**, **off-farm organic wastes**, **bio fertilisers**, **mineral-bearing rocks for soil fertility**, etc.


- Organic farmers build **healthy soils** by nourishing the **microbial inhabitants** that release, transform, and transfer nutrients. They **feed soil biota** and **build soil organic matter** with cover **crops**, **compost**,

and **biologically based soil amendments**. This contributes to good soil structure and **water-holding capacity**.

- Organic farmers' primary strategy in controlling pests and diseases is prevention through good **plant nutrition and management**. They use **cover crops** and sophisticated **crop rotations** to change the field ecology, effectively **disrupting the habitat for weeds**, **insects**, and **disease organisms**.
- They rely on a diverse population of soil organisms, beneficial insects, and birds to keep pests in check. When pest populations get out of balance, growers implement a variety of strategies, such as the use of insect predators, mating disruption, traps and barriers.
- Weeds are controlled through **crop rotation**, **mechanical tillage**, and **hand-weeding**, as well as through **cover crops**, **mulches**, **flame weeding**, and other management methods.

## Bio-Fertilizers are a Key Aspect of Organic Farming

- For a sustainable agriculture system, it is essential to use **renewable inputs** that can benefit the plant and **cause no or minimal damage to the environment**.
- One of the energy-efficient and pollution-free methods is to exploit the ability of certain microorganisms like bacteria, algae and fungi to fix atmospheric nitrogen, solubilise phosphorus, decompose organic material or oxidise sulphur in the soil.
- When they are applied in the soil, they **enhance the growth and yield of crops**, **improve soil fertility** and **reduce pollution**. They are known as "**bio-fertilisers**". Thus, **bio-fertilisers** are **living or biologically active products or microbial inoculants of bacteria**, **algae and fungi** (separately or in combination) that are able to enrich the soil with nitrogen, phosphorus, organic matter etc.

### Rhizobium biofertilizer

- **Rhizobium** is a **symbiotic bacterium forming root nodules in legume plants**. These nodules act as miniature nitrogen production factories in the fields. The nodule bacteria **fix more nitrogen ($N_2$)** than is needed by the legume plant and the bacteria. The surplus fixed nitrogen is then secreted and fertilised in the soil. Rhizobium is more efficient than free-living nitrogen-fixing bacteria.

### Azotobacter bio-fertiliser

- Azotobacter are **aerobic**, **free-living nitrogen fixers**. They grow in the **rhizosphere (around the roots)**, **fix atmospheric nitrogen non-symbiotically**, and make it available to particular cereals. These bacteria produce **growth-promoting** hormones which help in enhancing the growth and yield of the plant.

### Azospirillium bio-fertiliser

- These are **aerobic living nitrogen fixers** that live in **associative symbiosis**. In this type of association, bacteria live on the root surface of the host plant and **do not form any nodules** with roots of grasses. It increases crop yield and its inoculation benefits crop. They also benefit the host plants by supplying

growth hormones and vitamins. These bacteria are commonly used for the preparation of commercial inoculants (vaccines, culture medium).

### Blue green algae

- **Blue green algae (cyanobacteria)** like **Nostoc** and **Anabaena** are free living photosynthetic organisms also **capable of fixing atmospheric nitrogen**. In the flooded rice fields blue green algae serves as a nitrogen biofertilizer.

**[UPSC 2013] Consider the following organisms**

a) Agaricus
b) Nostoc
c) Spirogyra

***Which of the above is / are used as biofertilizer / biofertilizers***

a) 1 and 2
b) 2 only
c) 2 and 3
d) 3 only

***Answer: b) 2 only***

### Azolla bio-fertilisers

- Azolla is a water fern inside which grows the **nitrogen-fixing blue-green algae Anabaena**. It contains 2-3% nitrogen when wet and also produces organic matter in the soil. The Azolla-Anabaena combination type bio fertiliser is used all over the world. The only constraint in Azolla is that it is an **aquatic plant**, and water becomes a limiting factor in growing it, particularly in summer.

### Phosphorus solubilising bio-fertiliser

- Phosphorus is an important element required for plant growth. This element is also needed for nodulation by rhizobium. Some microorganisms are capable of solubilising immobilised phosphorus making it available to plants for absorption.

### Mycorrhizal fungi bio-fertiliser

- **Mycorrhizal fungi** act as bio-fertilisers and are known to **occur naturally on roots of forest trees** and crop plants. They **resist disease** in plants. The plants also **show drought and salinity resistance**. Plants can tolerate **adverse soil**, **pH**, **high temperature** and **heavy metal toxicity**.
- In soils low in available nutrients there is an increased absorption of nutrients by plants infected with Mycorrhiza. The fungus has the ability to dissolve and absorb phosphorus that plant roots cannot readily absorb.

**[UPSC 2013] Mycorrhizal biotechnology has been used in rehabilitating degraded sites because mycorrhiza enables the plants to**

1) resist drought and increase absorptive area
2) tolerate extremes of pH
3) Resist disease infestation

***Select the correct answer using the codes given below:***

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

***Answer: d) all***

## Compost Tea

- Compost tea is a liquid fertiliser. It is an **aerobic (in the presence of oxygen)** water solution that has extracted the microbe population from **compost (dead and decaying matter)** along with the nutrients. In simple terms, it is a **concentrated liquid** created by a process to **increase the number of beneficial organisms (bacteria**, **fungi**, **protozoa**, **nematodes)** as an organic approach to plant/soil care.
- The concentrated liquid can be **sprayed directly** onto the leaf surface. The liquid fertiliser occupies the infection sites on the leaf surface. It is held there by simple sugars that the plant puts out that work as a glue to keep the beneficial microorganisms thriving and protecting the plant.

## Bio char

- **Natural bio char** is found in soils around the world as a result of **vegetation fires** and historic soil management practices. An intensive study of biochar-rich dark earth in the Amazon (**terra preta**) has led to a wider appreciation of biochar's unique properties as a **soil enhancer**.
- **Bio char** is charcoal that is used as a soil amendment (minor improvement). It is created using a p**yrolysis process** (decomposition brought about by high temperatures), **heating biomass in a low-oxygen environment**.
- Once the **pyrolysis** reaction has begun, it is self-sustaining, requiring no outside energy input. By-products of the process include **syngas (**$H_2$ **+ CO)**, minor quantities of methane ($CH_4$), organic acids and excess heat. Once it is produced, **bio char** is spread on agricultural fields. The **syngas** and **excess heat** can be used directly or employed to produce a variety of **biofuels**.

### Agricultural Benefits

✓ It increases crop yields, sometimes substantially, if the soil is in poor condition.
✓ It helps to prevent fertiliser runoff and leeching, allowing the use of less fertilisers.

- ✓ It retains moisture, helping plants through periods of drought more easily.
- ✓ It replenishes marginal soils with organic carbon.
- ✓ It fosters the growth of soil microbes essential for nutrient absorption, particularly mycorrhizal fungi.
- ✓ It can increase soil fertility of acidic soils (reduces acidity). (The **most fertile soils are slightly acidic**. However, **friendly microbes** prefer slightly alkaline/basic medium).
- ✓ It protects the plants from diseases and promotes the growth of friendly microorganisms.

### Environmental Benefits

- The use of crop residues for **bioenergy production** reduces the carbon stocks in cropland. Further, the dedication of cropland to biofuel production increases the area of cultivated land and, thus, carbon loss from soils and vegetation.
- **Soils contain 3.3 times more carbon than the atmosphere**. This makes soils an important source of greenhouse gases but also a **potential sink** if the right management is applied. **Bio char** remains stable for millennia, providing a simple means to **sequester carbon emissions**. If bio char is returned to agri-cultural land, it can increase the soil's carbon content permanently and would establish a carbon sink for atmospheric $CO_2$.

## The Present Status of Organic Farming in India

- **India ranks first in number of organic farmers** and **eighth in terms of area under organic farming!** In January 2016, **Sikkim became India's first "100% organic" State**. **Lakshadweep** is the **first UT to become 100% organic**. **The NE** has traditionally been organic, and the consumption of chemicals is far less than in the rest of India.
- About 2.78 million hectares of farmland are under organic cultivation. This is **2%** of the 140.1 million ha **net sown area** in the country. **MP** tops the list with 0.76 million ha of area under **organic cultivation** — that is over **27% of India's total organic cultivation area**. The top three states — **MP**, **Rajasthan**, and **Maharashtra** — account for about half the area under organic cultivation.
- Flax seeds, sesame, soybeans, tea, medicinal plants, rice, and pulses are India's major organic exports. The major exporting states are Assam, Mizoram, Manipur, and Nagaland.

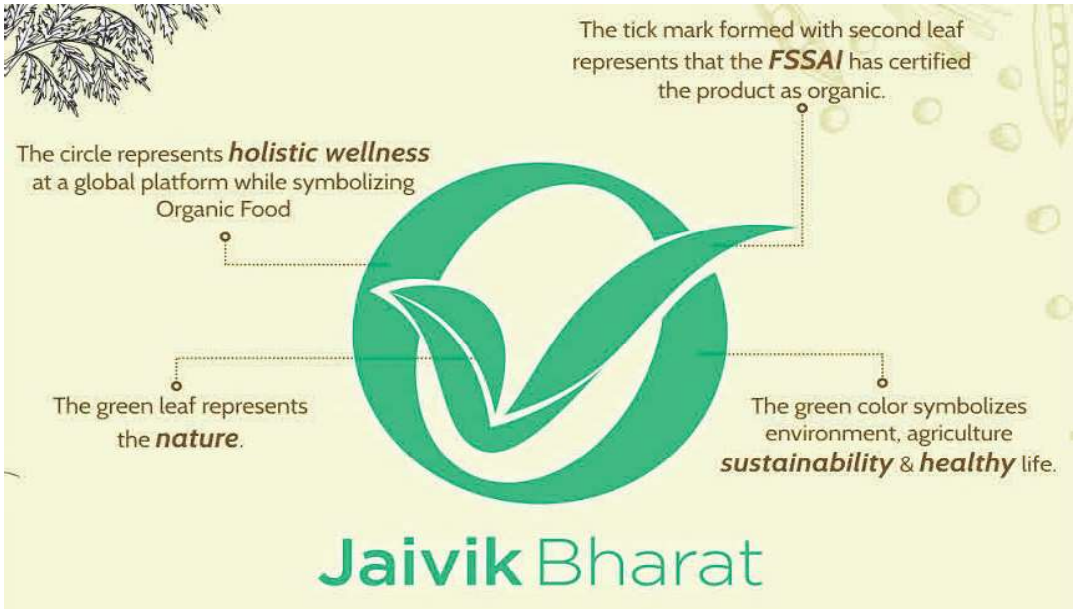
***[UPSC 2017] Sikkim is the first 'Organic State' in India. What are the ecological and economic benefits of Organic State?***

## Initiatives to Promote Organic Farming in India

- Schemes launched to promote organic farming:
  1. **Mission Organic Value Chain Development for North East Region (MOVCD)**
  2. **Paramparagat Krishi Vikas Yojana (PKVY)**
- Both PKVY and MOVCD are promoting certification under the **Participatory Guarantee System (PGS)** and **National Program for Organic Production (NPOP)**, respectively, targeting domestic and export

markets. The Food Safety and Standards (Organic Foods) Regulations, 2017 are based on the standards of NPOP and PGS.

- The consumer should look for the logos of FSSAI, **Jaivik Bharat/PGS Organic India** on the produce to establish the organic authenticity of the produce. **PGS Green** is given to chemical-free produce under transition to 'organic', **which takes 3 years**.




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

- MOVCD-NER is a **Central Sector Scheme**. It is a sub-mission under **National Mission for Sustainable Agriculture**. It was launched by the **Ministry of Agriculture** and **Farmers Welfare** for implementation in all the **North-Eastern states**, including Sikkim, during the 12$^{th}$ plan period.
- The scheme **aims to develop certified organic production** in a value chain mode to link growers with consumers. The scheme supports the development of the **entire value chain**, starting from inputs, seeds, and certification to the creation of facilities for collection, aggregation, processing, marketing and brand building initiatives.

## Paramparagat Krishi Vikas Yojna (PKVY)

- PKVY is a sub-component of the **Soil Health Management (SHM) scheme under** the National Mission of Sustainable Agriculture. It is a **centrally sponsored scheme** launched in 2015. It aims at the development and **promotion of organic farming by cluster approach** and PGS Certification.
- The objectives of the scheme are:
  - ✓ To **promote commercial organic production** through **certified organic farming**
  - ✓ To produce pesticide residue-free harvests that will improve the health of the consumer
  - ✓ To raise farmers' income and create a potential market for traders
  - ✓ To ensure long-term soil fertility, resource conservation and climate change adaptation and mitigation.

- Under this scheme, **50 or more farmers** will form a cluster having **50 acres of land** to take up organic farming. Every farmer will be provided Rs. 20,000 per acre in three years for seeds for the harvesting of crops and transporting of the produce to the market.

## National Programme for Organic Production (NPOP)

- The **Ministry of Industries** and **Commerce** is implementing the NPOP since 2001 with the following objectives:
  1. To provide the means of **evaluation of certification programmes for organic agriculture** and products.
  2. To accredit certification programmes of Certification Bodies seeking accreditation.
  3. To facilitate the certification of organic products in conformity with the prescribed standards.
  4. To facilitate **organic certification** in conformity with the importing countries' organic standards.
  5. To encourage the development of organic farming and organic processing.
- The **Agricultural** and **Processed Food Products Export Development Authority (APEDA)** is the implementation agency for the NPOP. APEDA is providing assistance to the exporters of organic products under various components of its export promotion scheme.

## Participatory Guarantee Scheme (PGS)

- **Union Agriculture Ministry** introduced PGS to incentivise more farmers to grow organic food. PGS is an **Operational Manual for Domestic Organic Certification** published by the **National Centre of Organic Farming**, **Ghaziabad**.
- PGS is a process in which small producers assess, inspect, and verify the production practices of each other and take decisions on organic certification. **PGS operates outside the framework of third-party certification**.

### Advantages of PGS over third-party certification

- ✓ Procedures are simple, documents are basic, and farmers understand the local language used.
- ✓ As all members are practising organic farmers themselves, they understand the processes well.
- ✓ Because peer appraisers live in the same village, they have better access to surveillance and the **costs are low**.
- ✓ Mutual recognition between regional PGS groups ensures better networking for marketing.
- ✓ Unlike the grower group certification system, PGS offers every farmer an **individual certificate**, and the **farmer is free to market his own produce independent of the group**.
- ✓ PGS ensures traceability until the product is in the custody of the PGS group, which makes PGS **ideal for local direct sales** and **direct trade between producers** and **consumers**.

### Limitations of PGS

- PGS certification is **only for farmers that can organise as a group** and are applicable only to activities such as crop production, processing, and livestock rearing, and off-farm processing by PGS farmers of their products.
- **Individual farmers or groups of farmers smaller than five members are not covered under PGS**.
- PGS is not ideal for furthering organic exports due to **apprehensions over peer-based certification**.

## Large Area Certification

- Department of Agriculture under its scheme of **Paramparagat Krishi Vikas Yojna (PKVY)** has launched a **quick certification programme** "**Large Area Certification**" (LAC) **to harness potential organic areas**.
- Under LAC, each village in the area is considered as one cluster/group. All farmers with their farmland need to adhere to the standard requirements and can get certified en-mass. Certification is **renewed on annual basis** by a process of **peer appraisals** as per the process of PGS-India.
- Under the scheme, **individual farmers can avail of financial assistance** for certification under any of the prevailing certification systems of NPOP or **PGS-India**.

### LAC vs. Old Certification Process

- **As per the established norms**, the areas having **chemical input usage history** are required to undergo a **transition period of minimum 2-3 years** to qualify as organic.
- During this period, farmers need to adopt standard organic agriculture practices and keep their farms under the certification process. On successful completion, such farms **can be certified as organic after 2-3 years**. The process also requires elaborate documentation and time to time verification by authorities.
- Whereas under **LAC**, **requirements are simple** and **the area can be certified almost immediately**. LAC is a **quick certification process that is cost-effective**, and **farmers do not have to wait for 2-3 years for marketing** PGS organic certified **products**.

### Car Nicobar and Nancowry group of Islands certified LAC

- The government has certified 14,491 ha of area of **Car Nicobar** and **Nancowry group of islands** in UT of A&N Islands under the **'Large Area Certification' (LAC) scheme** of the PGS-India (Participatory Guarantee System) programme.
- **Car Nicobar** and **Nancowry group of Islands have been traditionally organic for ages**. GOI has also banned the sale, purchase and usage of any chemical inputs or GMO seeds in these islands. An expert committee has verified their organic status and recommended for declaration of the area as certified organic under the PGS-India programme.

**[UPSC 2018] With reference to organic farming in India, consider the following statements:**

1) The National Programme for Organic Production' (NPOP) is operated under the guidelines and directions of the Union Ministry of Rural Development.
2) The Agricultural and Processed Food Products Export Development Authority' (APEDA) functions as the Secretariat for the implementation of NPOP.
3) Sikkim has become India's first fully organic State.

***Which of the statements given above is/are correct?***

a) 1 and 2 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

***Answer: b) 2 and 3 only***

## 25.5. Natural Farming

- The **Green Revolution** led to extensive water consumption and aggravated groundwater loss. According to the Central Water Commission, the agriculture sector has already **consumed over 83% of the available water resources**. Hence, there is a demand to shift to sustainable natural farming systems, such as **Zero-Budget Natural Farming (ZBNF)**.
- **Natural Farming** is a **chemical-free traditional sustainable** farming method. It largely **avoids the use of manufactured inputs and equipment**. Masanobu Fukuoka established this ecological farming approach in his 1975 book '**The One-Straw Revolution**'. It was referred to as the **Fukuoka Method** or **do-nothing farming**.

### Benefits of Natural Farming

- ✓ **Low cost of production**: Minimal use of the equipment and no use of chemical fertilizer and pesticides.
- ✓ **Good for health**: Food produced has **higher nutrition density** and is chemical-free.
- ✓ **Environment Conservation:** Fewer chemical residues and carbon emissions. In this **agroecology-based** diversified farming system, crops, trees, and livestock are **integrated** with functional **biodiversity**.
- ✓ **Efficient Use of Water:** Modern commercial farming leads to the over-extraction of groundwater. But natural farming leads to more efficient use of soil moisture.

### Promotes Soil Health

- ✓ **Conventional chemical-based farming depletes macro-nutrients** (**nitrogen**, **phosphorus**, **potassium**, etc.), **micro-nutrients** (iron, manganese, zinc, copper, etc.), organic carbon, and **rhizosphere microbiome (for nitrogen fixing)** in the soil. This does not happen in natural farming.
- ✓ Natural farming, on the other hand, helps in the growth of **beneficial organisms** like earthworms and increases soil enzymes and microbial biomass. All these help in soil restoration.

## Challenges of Natural Farming

- **The Decline in Yields:** Sikkim, the first organic state in India, has seen a decline in yield following conversion to organic farming. Many farmers have switched back to conventional farming after this decline.
- **Shortage of Natural Inputs:** Lack of readily available natural inputs is a barrier to converting to chemical-free agriculture. For profitable farming this delay and shortage in natural inputs are detrimental.
- **Resistance from Chemical Inputs Industry:** It is a well-built-up capital-intensive industry. It naturally discourages any efforts towards natural farming.

## Zero-Budget Natural Farming (ZBNF)

- India introduced **ZBNF** in its **Budget 2019-20**. It was first propagated by **Subhash Palekar** (who was conferred with Padma Shri in 2016) as a movement for farmers who were in debt due to the Green Revolution.
- ZBNF is **neither chemical-loaded nor organic**. It seeks to **reduce input costs to ZERO** by **avoiding chemical and manufactured inputs** and encouraging farmers to rely upon **natural products available locally**.
- It is considered a 'zero budget' because there is not much need to spend money on inputs and the **costs of raising the main crop are offset by the income that farmers earn from intercrops**.

### Components of ZBNF

- ZBNF promotes:
  - ✓ **Soil aeration**,
  - ✓ **Minimal watering (saves electricity)**,
  - ✓ **Intercropping**,
  - ✓ **Bunds and topsoil mulching and**
- ZBNF **discourages intensive irrigation and deep ploughing**. It **opposes the use of vermicompost**. Instead, it recommends the **revival of local deep soil earthworms** through increased organic matter. In ZBNF, chemical fertilisers and pesticides make way for **locally available cow dung**, **cow urine**, **jaggery**, etc., and treat seeds with natural ingredients **made on the farm** by the farmer himself.
- ZBNF promotes the application of

✓ **Jivamrita/jeevamrutha:** it is a **fermented microbial culture**. It provides **nutrients** and promotes the activity of **microorganisms** and **earthworms** in the soil. It also helps to prevent fungal and bacterial plant diseases.

✓ **Bijamrita**: Bijamrita effectively protects **young roots from fungus** and soil-borne and seed-borne diseases. Jeevamrutha and Bijamrita are prepared from a mixture of **desi cow dung** and **urine**, **jaggery**, etc.

✓ **Acchadana/Mulching**: a protective biomass layer on soil.

- ✓ **Whapasa/Moisture**: Whapasa is the condition where there are **both air molecules and water molecules present in the soil**. It involves reducing irrigation, irrigating only at noon in alternate furrows.
- Also, ZBNF includes three methods of insect and pest management: **Agniastra**, **Brahmastra**, **and Neemastra** (preparations using cow urine, cow dung, tobacco, fruits, green chilli, garlic, and neem).

## Bharatiya Prakritik Krishi Paddhati (BPKP) Scheme for Natural Farming

- BPKP Scheme is launched by the Ministry of Agriculture and Farmers Welfare in 2020-21. It is a **sub-scheme** of **Paramparagat Krishi Vikas Yojana (PKVY)**. It is launched for the promotion of **traditional indigenous practices**.
- It mainly emphasises on:
  - ✓ **Exclusion of all synthetic chemical inputs**
  - ✓ **On-farm biomass recycling** with significant stress on **biomass mulching**
  - ✓ Use of **cow dung-urine formulations**
  - ✓ **Plant-based preparations**
  - ✓ Time to time working of soil for **aeration**
- Under BPKP, **financial assistance of Rs 12200/ha for 3 years** is provided for cluster formation, capacity building and continuous handholding by trained personnel, certification, and residue analysis.

## Organic Farming vs. Natural Farming (ZBNF)

### Similarities

- ✓ **Both** organic and natural farming are sustainable agricultural practices. They focus on **producing chemical-free foods by avoiding the application of synthetic fertilisers and chemical pesticides**. They encourage farmers to use **local breeds of seeds and plants** and **non-chemical homemade pest methods**.

### Differences

- ➢ Natural farming is described as "**the natural way of farming**" or "**do nothing farming**". Organic Farming, on the other hand, is a **holistic system** designed to **optimise the productivity of diverse communities** (plants, livestock) within the agroecosystem.
- ➢ Organic farming doesn't discourage basic practices like ploughing, tilting, applying bulk organic manures (compost, vermicompost, etc.), weeding, etc. In natural farming, the **natural agroecosystem is preserved** by **avoiding** ploughing, tilling of the soil, weeding, application of bulk organic manures, etc.
- ➢ Organic farming **can be capital-intensive** due to the requirement of bulk organic manures, modified agroecosystems, etc. In contrast, natural farming is **extremely low-cost** (in the case of ZBNF it is almost zero) with locally made preparations.

# 25.6. Modern Agricultural Practices

- Modern agriculture includes animal husbandry, poultry farming, apiculture, fisheries, mushroom culture, etc., to provide additional food supplements like milk, meat, fish, egg, mushroom, etc. In addition to providing nutritional food for the masses, it also reduces the load on the consumption of cereals and pulses.

## Precision Farming for Productivity and Sustainability

- India's agriculture is focused on production, which **isn't necessarily translating into productivity** and **profitability**. **Shrinking land** and **depleting water and other related resources in agriculture** are serious causes of concern. Hence, there is a need for promoting **farmer friendly location specific**, **high-tech production systems** like **precision farming** to achieve vertical growth in agriculture with **judicious and efficient use of natural resources**.
- The high-tech and farmer-friendly interventions under precision farming include **fertigation**, **green-house**, **soil and leaf nutrient-based fertiliser management**, **mulching for moisture conservation**, **micro-propagation**, **high-density planting**, **drip irrigation**, etc.

### Micropropagation

- Micropropagation is the practice of **rapidly multiplying** a selected plant to produce **a large number of progeny plants** using modern plant **tissue culture methods**.

#### High-density planting

- **High density planting** technique is a modern method of **horticulture** involving planting of trees densely, allowing dwarf trees with **modified canopy** for better light interception and distribution and ease of mechanised field operations.
- Control of pests and diseases, weeds and pruning of tree canopy is mostly mechanised. Irrigation and fertigation are automatically controlled. Such a system has low labour requirements and produces high and regular yields of good-quality fruits.

- **Precision farming** uses **information-based farm management** for optimum profitability, sustainability and resource utilisation. The required information is obtained with the help of technologies like **geographic information systems (GIS)**, **Global Positioning Systems (GPS)**, **remote sensing (RS)**, etc.

## Geoinformatics for Precision Farming

- **Geoinformatics** deals with integrating computer science and geosciences to solve complex scientific questions. It is the science of **gathering**, **analysing**, **interpreting**, **distributing** and **using geographic information**. It encompasses **surveying** and **mapping**, **RS**, **GIS**, **and GPS**.

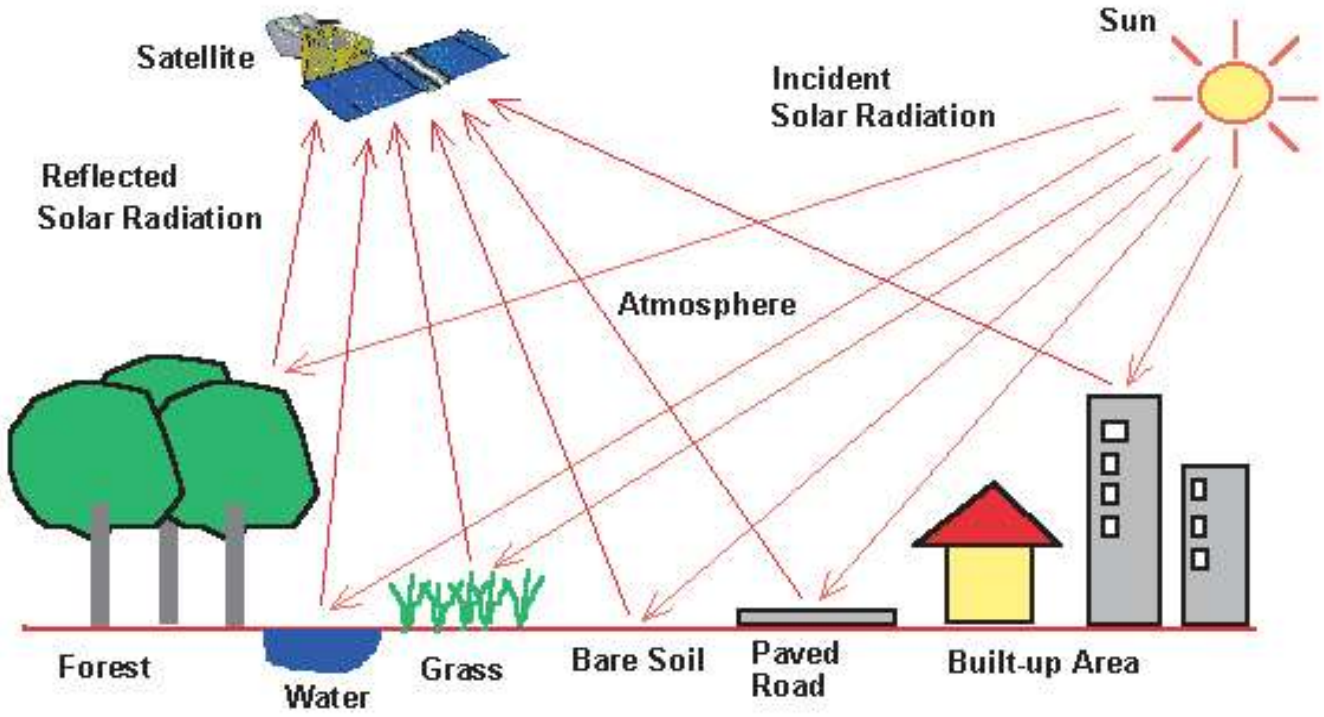
## Global Positioning System (GPS)

- GPS-based applications in precision farming are being used in farm planning, **field mapping**, **tractor guidance**, **variable rate applications** (**automated**, **precise application of pesticides**, **fertilisers**, **etc**.,

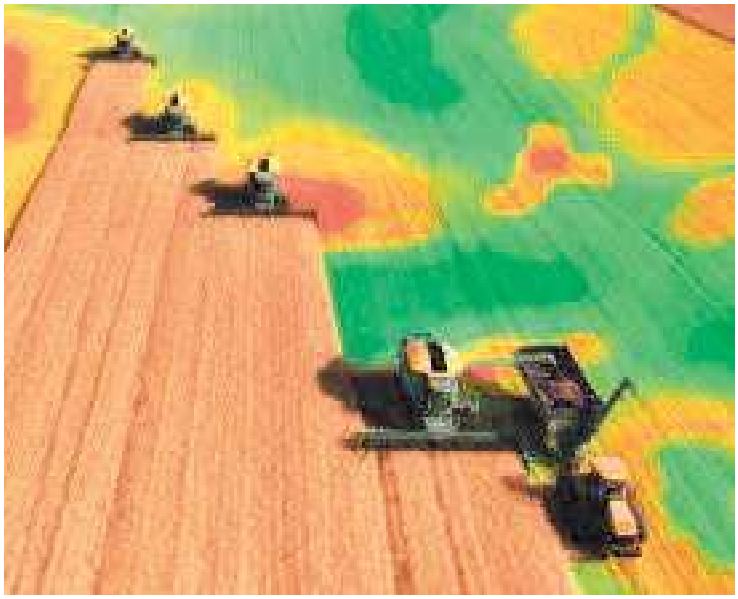
based on data that is collected by sensors, maps, and GPS) and yield mapping. GPS allows farmers to work during **low-visibility field conditions** such as rain, dust, fog, and darkness.

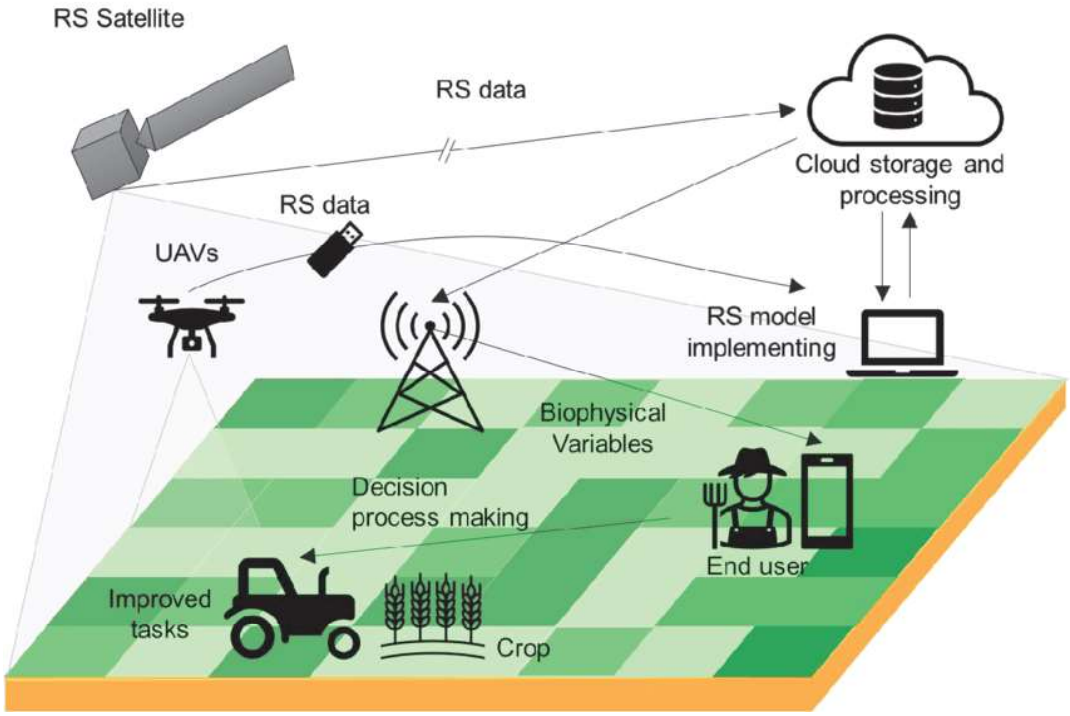
## Remote Sensing (RS) Technique

- RS is the science of making inferences about material objects from measurements made at a distance **without coming into physical contact** with the objects under study. The RS system consists of a sensor to collect the radiation and a platform (a drone, aircraft, balloon, rocket, satellite) on which a sensor can be mounted.




- Remote sensing is precision farming is used for crop yield modelling, **identification of pests** and disease **infestation**, **soil moisture estimation**, **irrigation monitoring**, **assessment of crop damage**, etc.






**[UPSC 2019] For the measurement/estimation of which of the following are satellite images/remote sensing data used?**

1) Chlorophyll content in the vegetation of a specific location
2) Greenhouse gas emissions from rice paddies of a specific location
3) Land surface temperatures of a specific location

***Select the correct answer using the code given below:***

a) 1 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

**Explanation**

- Various sensors can be used in remote sensing. Sensors may use a wide range of frequencies from radio waves to visible light.
- Methane Sensor for Mars (Mars Orbiter Mission) is a radiometer. It was remotely able to measure columnar **methane ($CH_4$)** in the Martian atmosphere at several parts per billion (ppb) levels.
- Forest Survey of India uses remote sensing to identify canopy density (uses thermal and HD imaging).
- Thermal sensors (uses infrared radiation) can detect GHGs as they trap heat.

***Answer: d) all***

## Geographic Information System (GIS)

- The GIS is a **computerised data storage and retrieval system** that can be used to manage and analyse spatial data relating to crop productivity and agronomic (study of crops and the soils) factors. It can integrate all types of information and interface with other decision-support tools.
- **GIS can display analysed information in maps** that allow a better understanding of interactions among yield, fertility, pests, weeds and other factors, and decision-making based on such spatial relationships.

### Internet of things

- The computers and low latency internet (5G) are the most important components in precision farming as they are main source of information processing and gathering.

### Future strategy

- Precision farming is practised in developed countries and it not yet practically adoptable in developing countries like India. Future strategy for adoption should consider the problem of **land fragmentation**, **lack of highly sophisticated technical centres for precision agriculture**, **specific software for precision agriculture**, **poor economic condition of the farmers**, etc.

## Protected Cultivation of Horticulture Crops

- Protected cultivation practices are cropping techniques wherein the **microenvironment** is controlled partially/ fully as per plant need during their period of growth to maximise the yield and resource saving.

### Green House

- Greenhouses are climate-controlled with cooling and heating systems. It is mainly used to grow exotic vegetables, off-season growing of vegetables, floriculture, planting material acclimatisation and plant breeding and varietals improvement under adverse agro-climatic conditions. The degree of sophistication of greenhouses includes fully automated systems with polycarbonate sheet roofing (double-walled), heating and cooling systems, etc.

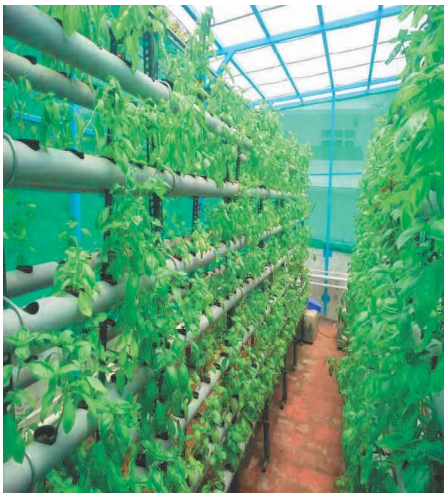
### Polyhouse

- **Polyhouse** is **less sophisticated version of green house** with **naturally ventilated climate controlled as against the fully climate controlled green houses**. The usage of poly houses is similar to greenhouses.

### Hydroponics

- Hydroponics is a method of **growing plants without soil**, using water enriched with **balanced mineral nutrients** essential for plant growth and yield. The nutrients and pH level are maintained as per the crop for better growth.
- With increasing water scarcity due to frequent droughts and declining land availability for farming, government agencies are promoting hydroponics for growing vegetables, fruits and fodder.

## Advantages of hydroponics



***More yield in a smaller patch of land***

- Hydroponics supports **vertical farming** (plants are grown on raised beds) and is ideal to grow crops in congested urban environments. The increase in output happens because the **cropping cycle is reduced**, **and the plants don't have to grow long roots in search of nutrients**.

***Significantly reduced water usage yet superior yield***

- In conventional farming, water and nutrients are lost in soil. This leads to groundwater contamination. In hydroponics, the nutrient solution is mixed into the water and is supplied directly to the roots. Hence it requires 90% less water compared to conventional farming.

***Better quality control and better environment***

- Hydroponics reduces transportation costs and emissions. It makes the **application of organic farming techniques very simple**. Sticky pads and a solar-powered insect trap can be used to trap insects. This reduces the use of insecticides. Soil-borne diseases and pests are also low as the crops are grown in a closed environment free of soil. Also, natural ingredients such as neem oil can be used more effectively to control pests (reduces the use of pesticides).

***Better nutritional value of crops***

- Fodder produced through hydroponics is more nutritional than the regular fodder. As food production is closer to the consumer, time is not lost in logistics and hence there is no loss of nutrients.

***Better cultivation techniques and application of sci and tech***

- The farms can be indoors or outdoors (a greenhouse). Each hydroponic crop can be given a favourable and individual climatic condition through an automated temperature and humidity-controlled greenhouse.
- The farm can be managed remotely using the **Internet of Things** (IoT – schedule a fertigation session, actively monitor the plants remotely, automated humidity and temperature control, nutrient and input control, etc.). The crop can use natural light or artificial lighting (day and night – 24/7 growth period).

## Disadvantages of Hydroponics

***Capital-intensive***

- Though hydroponics is typically much cheaper over time, it does require a substantial upfront cost to establish any larger system.

***Needs uninterrupted power supply***

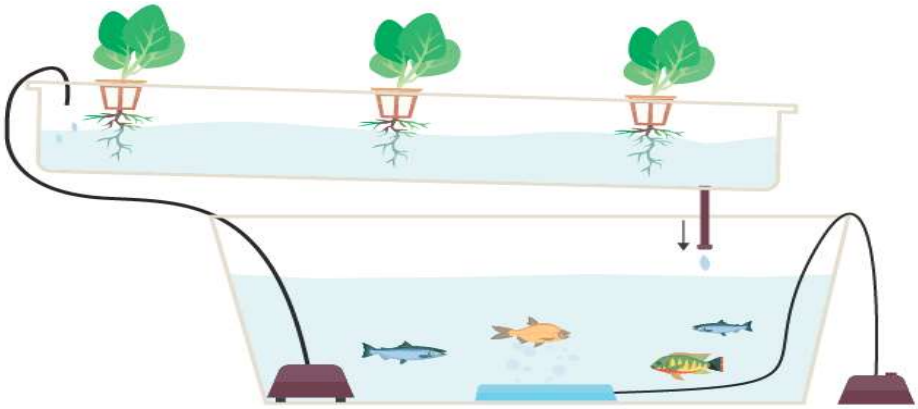
- Power failure can cause pumps to stop working.

***Lack of awareness***

- Many people fear that hydroponics requires substantial know-how and research when, in fact, it's very similar to traditional gardening.

## Aquaponics

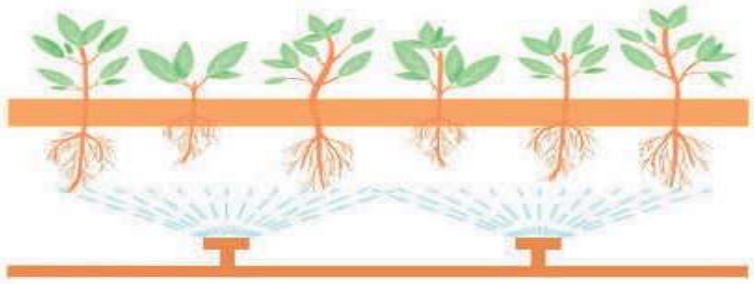
- The method combines **aquaculture** (cultivating fish and other aquatic animals in tanks with organic inputs) with **hydroponics**, where plants are cultivated in water. The difference between aquaponics and hydroponics is that **synthetic fertilisers are used in hydroponics for providing nutrients to plants and hence**, **cultivation of fish is not possible in hydroponics**.



- The water from the fish tank is pumped onto the beds where plants grow. While the **fish excretions provide nutrients for the plants** (hence, no chemical fertilisers are needed), the clean water is recirculated back to the fish tank. While the initial cost to set up the facility would be high, the recurring cost is low in aquaponics.

## Aeroponics

- Aeroponics has been implemented as an alternative to water-intensive hydroponic systems worldwide. Unlike in hydroponics, the **roots of plants grown in an aeroponic system are suspended in the air** and **the spraying of water and nutrients leads to an oxygen-rich**, **misty environment**.



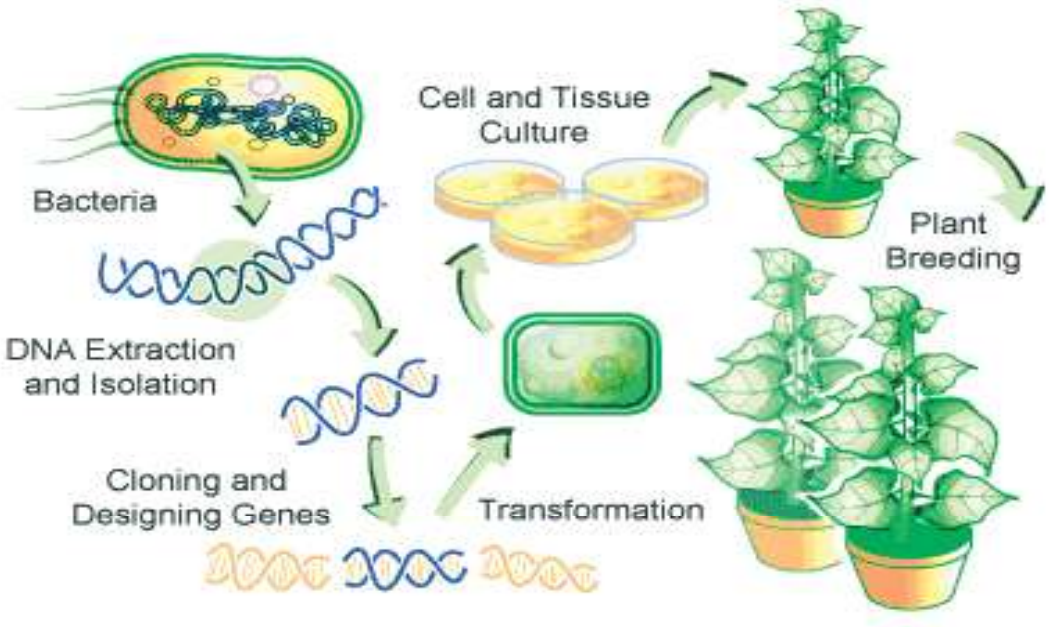
### Advantage of aeroponics over hydroponics

- ✓ **Aeroponics can limit disease transmission** since plant-to-plant contact is reduced.
- ✓ The enhanced oxygen availability at the root zone leaves disease-causing pathogens dormant.

- ✓ Helps in faster and better growth of plants with a **plentiful supply of oxygen**, **water and nutrients**.
- ✓ Plants in a true aeroponic condition have **100% access to the $CO_2$ concentrations** for photosynthesis. This leads to a multi-fold increase in plant metabolism, which in turn results in an **increase in production**.
- ✓ Any species of plants can be grown in a true aeroponic system because the microenvironment of an aeroponic can be **finely controlled**.
- ✓ Aeroponically grown plants have high dry-weight biomass (essential minerals).
- ✓ Aeroponically grown plants **require 1/4$^{th}$ the nutrient input** compared to hydroponics.
- ✓ Unlike hydroponically grown plants, aeroponically grown plants **will not suffer transplant shock (new stresses induced by transplantation)** when transplanted to soil.

## Genetically Modified Organism (GMO)

- In GMO, **genetic material (DNA)** is **altered or artificially introduced** using genetic engineering techniques. Genetic modification involves the **mutation**, **insertion**, or **deletion of genes to induce a desirable new trait which does not occur naturally** in the species. Inserted genes usually come from a **different organism** (e.g., In Bt cotton, Bt genes from bacterium ***Bacillus thuringiensis*** are induced).
- GM techniques are used in:
  - ✓ Biological and medical research
  - ✓ Agriculture (e.g., **golden rice**, **Bt cotton** etc.)
  - ✓ Production of biofuels from some GM bacteria
  - ✓ GM bacteria to produce the **protein insulin**
  - ✓ Production of pharmaceutical drugs and experimental medicine (e.g. gene therapy)




### GM Crops

- They are the plants used in agriculture whose DNA has been modified to induce a desired **new trait**. The new trait might help in:
  - ✓ Controlling certain pests and diseases
  - ✓ Resistance against certain environmental conditions
  - ✓ Reduction of spoilage
  - ✓ Inducing resistance to chemical treatments (e.g. Resistance to a herbicide)
  - ✓ **Improving the nutrient profile** of the crop
  - ✓ Atmospheric nitrogen fixation by cereal crops
  - ✓ Inducing tolerance to high salt and flooding in crops
  - ✓ Inducing drought resistance in crops
  - ✓ Prolonging shelf life and commercial value of fruits and vegetables

## Major GM Crops

### Bt Cotton

- Bt cotton is an insect-resistant cotton variety. Strains of the **bacterium Bacillus thuringiensis** produce different **Bt toxins**. Bt toxins are insecticidal to the larvae of moths, bollworms, etc., but are harmless to other forms of life. In 2002, a joint venture between Monsanto and Mahyco introduced Bt cotton to India.

#### *Advantages*

- ✓ Increases yield of cotton due to effective control of three types of bollworms.
- ✓ Reduction in insecticide use in the cultivation of Bt cotton in which bollworms are major pests.
- ✓ Potential reduction in the cost of cultivation (depending on seed cost versus insecticide costs).

#### *Problems with Bt Cotton*

- ➢ High cost of GM seeds as compared to non-GM seeds.
- ➢ Ineffective against sucking pests like whitefly rampant in Punjab, Haryana and elsewhere.
- ➢ The costs of Bt seed and insecticide increase the risk of farmer bankruptcy in low-yield rain-fed settings.

#### *Pink Bollworm*

- It is an insect known for being a pest in **cotton** farming. It is native to Asia but has become an invasive species in most of the world's cotton–growing regions. It is now **resistant to Bt cotton** in India.

### Bt Brinjal

- Bt brinjal is created by inserting a **crystal protein gene** from ***Bacillus thuringiensis***. The Bt brinjal has been developed to give resistance to Brinjal Fruit and Shoot Borer (FSB). The insecticide requirement for Bt brinjal is far less than its non-Bt counterpart for the control of FSB.

- **Mahyco** has developed the Bt brinjal variety. Mahyco's Bt brinjal is **commercially grown in Bangladesh**. The **Genetic Engineering Appraisal Committee (GEAC)** cleared Bt Brinjal for commercialisation in 2009. Following concerns raised by some scientists, the GOI has imposed a moratorium on its commercial use (not a permanent ban).

### Golden rice

- **Golden rice** is a variety of rice **(Oryza sativa)** produced to biosynthesise **beta-carotene**, a precursor of **Vitamin A**, in the edible parts of rice. It is mostly consumed in areas with a shortage of dietary vitamin A.

## Benefits of GM Crops

### Crops

✓ Enhances taste and quality.
✓ Reduces maturation time.
✓ Increases nutrients, yields, and stress tolerance.
✓ Improves resistance to disease, pests, and herbicides.

### Animals

✓ Increases resistance, productivity, and feed efficiency.
✓ Better yields of meat, eggs, and milk.
✓ Improves animal health and diagnostic methods.

### Environment

✓ Production of friendly bioherbicides and bioinsecticides.
✓ Reduces the use of pesticides and insecticides
✓ **Conservation** of soil, water and energy.
✓ **Bioprocessing (production of a value-added material from a living source)** for forestry products.
✓ Better natural waste management.

## Issues Surrounding GM Crops

### Safety

➢ The adverse impacts of genetically modified food are not evident immediately.
➢ **Potential human health impact:** allergens, transfer of antibiotic resistance markers, unknown effects.
➢ **Potential environmental impact:** unintended transfer of transgenes through cross-pollination, unknown effects on other organisms (e.g., soil microbes) and loss of flora and fauna biodiversity.
⇨ ***Criticism against the Anti-GM lobby:*** *Instead of evaluating the risks, costs and benefits of hybrids on a case-by-case basis, they propose a blanket ban on genetic modification.*

### Access and Intellectual Property

- Domination of world food production by a few companies.
- Increasing dependence on industrialised nations by developing countries.
- **Biopiracy**: The unethical or unlawful appropriation or commercial exploitation of biological materials (such as medicinal plant extracts) that are native to a particular country or territory without providing fair financial compensation to the people or government of that country or territory.

### Ethics

- Violation of natural organisms' intrinsic values.
- Tampering with nature by mixing genes among species.

### Labelling

- Not mandatory in some countries (e.g., United States).
- Mixing GM crops with non-GM confounds (confuses) labelling attempts.

### Illegal Cultivation

- There is a grave danger to the environment and health from the illegal cultivation of GM crops.

## Issues with banning GM crops

- The ban on GM crops is also promoting an illegal market to flourish in India. Bangladesh is reaping the benefits of Bt Brinjal while its cultivation is banned in India.

### GMOs have already entered the food chain

- Cotton seed oil extracted from Bt cotton plants is being consumed in Gujarat and Maharashtra. Soybean oil is extracted from imported seeds, which are produced from GM crops abroad.

### Illegal cultivation (Farmer's rights vs. Government Regulation)

- A farmers' group in Maharashtra marked its protest against the government ban on GM crops by planting Bt brinjal and HT cotton. There is a grave danger of illegal genetically modified brinjal cultivation proliferating.

## FSSAI's New Draft for GM Food Regulations

- FSSAI (Food Safety and Standards Authority of India) releases a new draft for GM (Genetically Modified) food regulations. The proposed draft regulation will be applicable to **genetically modified organisms (GMOs)** for food use.

### Highlights of the New Draft for GM Food Regulations

- **Labelling:** FSSAI proposes that food products **having individual GM ingredient of 1% or more** should be labelled as **'Contains Genetically Modified Organisms (GMO)'** on the front-of-the-pack.

- **Prior approval:** The draft regulation stated that "**no person shall manufacture**, **pack**, **store**, **sell**, **market**, **distribute or import any food product produced from GMOs without the prior approval of the FSSAI**".
- Moreover, a clearance from the **Genetic Engineering Appraisal Committee (GEAC)**, **the national competent authority for environmental risk assessment**, is required.
- If GMO is to be used as seeds for cultivation, an application to the GEAC for compliance with Rules 1989 (Environment Ministry notified rules) needs to be submitted.

## Various Agricultural Activities and Revolutions in Agriculture

| Revolution | Economic Activity |
|---|---|
| Green | Food grain Production |
| Golden | Horticulture, Fruit, Honey Production |
| Golden fiber | Jute cultivation |
| Grey | Fertilizer Production |
| Blue | Fish Production |
| Black | Petroleum Production |
| Brown | Leather production |
| Pink | Prawn Production / Onion production |
| Round | Potato Production |
| Red | Meat / Tomato Production |
| Silver | Egg / Poultry Production |
| White | Milk Production |
| Yellow | Oil seeds Production |

### Various Agricultural Activities

| Name | Agricultural Activity |
|---|---|
| Silviculture | cultivating forest trees |
| Sericulture | rearing of silkworms for the production of raw silk |
| Apiculture | maintenance of honey bee colonies, commonly in hives, by humans |
| Olericulture | science of vegetable growing, non-woody (herbaceous) plants for food |
| Viticulture | science, production and study of grapes |
| Floriculture | flowering and ornamental plants for gardens |
| Arboriculture | cultivation and study of individual trees, shrubs, and other woody plants |
| Pomology | focuses on the cultivation, production, harvest, and storage of fruit, etc. |
| Aeroponics | growing plants in a mist environment without the use of soil medium |
| Hydroponics | growing plants using mineral nutrient solutions in water, without soil. |

| | |
|---|---|
| **Geoponic** | refers to growing plants in normal soil |
| **Aquaponics** | symbiotic environment of aquaculture and hydroponics |

## Mushroom culture

- **Mushrooms are a kind of fungus** with a short stem and a cap that opens like an umbrella later. They grow on organic matter or waste materials from farms or factories.
- Out of a large number of mushroom species, only some are edible. They are a good source of high-quality proteins and are rich in vitamins and minerals.

**---------- End of Chapter ----------**

# 26. Energy Sources, Renewables and Energy Conservation

## 26.1. Conventional and Non-Conventional Sources of Energy

| Conventional (commonly used energy sources) | | Non-Conventional |
|---|---|---|
| Conventional Non-Renewable | Conventional Renewable | Renewable |
| **Mostly fossil fuels found under the ground.**<br>✓ **Coal**<br>✓ **Oil**<br>✓ **Natural Gas**<br>✓ **Coalbed Methane** | **Non-fossil fuels are mostly seen above the ground.**<br>✓ **Firewood**<br>✓ **Cattle Dung**<br>✓ **Vegetable Waste**<br>✓ **Wood Charcoal** | **Solar Energy**<br>**Hydro Power**<br>**Wind Energy**<br>**Nuclear Energy**<br>**Hydrogen Energy**<br>**Geothermal Energy**<br>**Biogas**<br>**Tidal Energy**<br>**Biofuel** |

### Major Energy Sources

| Fuel | Production | Advantages | Limitations |
|---|---|---|---|
| **Nuclear energy** | **Nuclear fission** and **Nuclear Fusion** | ✓ No air pollution<br>✓ Fuel efficient<br>✓ **No nuclear waste in a nuclear fusion reactor.** | ➢ High cost of construction of nuclear plant.<br>➢ Security and nuclear accidents.<br>➢ **The problem of safe disposal of nuclear waste in the case of nuclear fission reactors.**<br>➢ **Nuclear Fusion Reactor** technology remains a hard nut to crack as it is **technologically very challenging.** |
| **Hydropower** | Dams built on rivers for electricity generation | ✓ The world's hydroelectricity potential is high.<br>✓ It is a relatively cheap and clean source of energy. | ➢ Ecosystems behind dams disturbed.<br>➢ **Human settlements uprooted.**<br>➢ **Habitat loss and biodiversity loss.**<br>➢ **Development costs are high.**<br>➢ Fertile farmland is lost. |

| | | | |
|---|---|---|---|
| | | | ➢ The amount of nutrient-rich silt to the downstream of the dam is reduced. |
| **Solar energy** | From natural sunlight | ✓ Environment friendly<br>✓ Unlimited | ➢ Limited capacity for storage of sunlight.<br>➢ Diurnal and Seasonal variations and grid management. |
| **Wind energy** | Windmills were in use for long for irrigating crops | ✓ No pollution<br>✓ Available for free | ➢ Intermittently available.<br>➢ Fans of windmills are visual hazards for flying birds and aeroplanes (visual pollution). |
| **Tidal energy** | Harnessing tidal power by suitable structures | ✓ Free and clean | ➢ Structures (plants) used for harnessing energy are expensive.<br>➢ Structures (plants) **disrupt the natural flow of the estuary** and concentrate pollutants in the area. |
| **Geothermal energy**<br>Steam from hot springs and geysers is naturally produced underground | Wells are drilled to trap steam, which powers electrical generators. | ✓ Environment friendly | ➢ Steam contains **Hydrogen Sulphide** ($H_2S$), having the odour of rotten eggs.<br>➢ Minerals in the steam are **corrosive** to pipelines and equipment, causing maintenance problems.<br>➢ Minerals in the water are toxic to fish. |
| **Biomass** | Cutting trees for fuel wood and burning them straight away | ✓ Cheap and hence popular in underdeveloped and developing countries | ➢ Comparatively low level of energy.<br>➢ Bulky, so difficult to transport.<br>➢ Burning wood causes **air pollution**.<br>➢ Destruction of forests and desertification.<br>➢ Releases a lot of **fly ash**. |
| **Biomass conversion**<br>Burned directly for cooking or to produce electricity | Obtaining energy from chemical energy stored in biomass (or live material). | ✓ Renewable energy | ➢ This may lead to food shortage because nutrients are not returned to the soil from biomass.<br>➢ Growing maize for **ethanol** requires more energy expenditure |

| | | | |
|---|---|---|---|
| converted to ethanol or methane (biogas) | | | than the amount of energy in the form of alcohol retrieved.<br>➢ Land for growing food is used for growing biomass for conversion into fuel. |
| **Solid waste** | Waste is sorted, and combustible material is separated | ✓ Decreases cost of fresh disposal<br>✓ Reduces the need for landfills | ➢ Causes air pollution.<br>➢ Waste such as bleached paper and plastics have **chlorine containing compounds** that form **dioxins** (carcinogenic). |

## Biomass

- Biomass is a **renewable energy** resource derived from **plant** and **animal waste**. The energy from biomass (biomass conversion) is released by **breaking the chemical bonds of organic molecules** formed during photosynthesis.

### Advantages of biomass energy

- **The burning of biomass does not increase atmospheric carbon dioxide (carbon neutral)** because, to begin with, biomass was formed by atmospheric carbon dioxide and the same amount of carbon dioxide is released on burning.

## Petro Crops (Plants)

- **Hydrocarbon-producing plants** can become alternative energy sources. These plants called **petroplants/petrocrops** can be grown on land which are unfit for agriculture and not covered with forests.
- **Jatropacurcas** is an important petro plant. **Biocrude** can be obtained by tapping the latex of Jatropacurcas. Hydrocracking of biocrude can convert it into several useful products like **gasoline** (automobile fuel), gas oil and kerosene. Some other potential Petro-crop species belong to the family **Asclepiadaceae** and **Euphorbiaceae**.

## Geothermal Energy

- Geothermal energy is natural heat from the interior of the earth that can be used to generate electricity as well as to heat buildings. In some countries, such as the USA, water is pumped from underground hot water deposits and used for heating houses.

### Geothermal energy in India

- In India, North-western Himalayas and the western coast are considered geothermal areas. The **Puga Valley in the Ladakh region** has the most promising geothermal field.

### Environmental impact of geothermal energy

- The steam contains **hydrogen sulphide gas**, which has the odour of rotten eggs and causes air pollution. The minerals in the steam are also toxic to fish, and they are corrosive to pipes and equipment, requiring constant maintenance.

### Tidal energy

- The tidal power is harnessed by building a dam **across the entrance to a bay or estuary**. As the tide rises, water is initially prevented from entering the bay. Then, when tides are high, and water is sufficient to run the turbines, the dam is opened, and water flows through it, turning the blades of the turbines.
- Again, when the reservoir (the bay) is filled, the dam is closed, stopping the flow and holding the water in the reservoir. When the tide falls (ebb tide), the water level in the reservoir is higher than that in the ocean. The dam is then opened to run the turbines (which are reversible), and electricity is produced as the water is let out of the reservoir.

## Cleaner (Alternative) Energy Sources

- Cleaner fuels emit relatively lower emissions than the most widely used fuels like coal, petrol and diesel.

### Methanol

- Methanol and ethanol can be produced from **coal**, **petroleum**, **natural gas** and **biomass waste**. It is currently produced by breaking down **natural gas (methane)** at high pressure and temperatures into **hydrogen gas** and **carbon monoxide** before reassembling them (an expensive process).
- **$CO_2$** can be converted into **methanol** (treating $CO_2$ with hydrogen ($H_2$)) or **methane**. The **methanol economy** will help India use its vast coal reserves (burning coal directly is bad).

| Methanol | Ethanol |
|---|---|
| Methyl Alcohol ($CH_3OH$) | Ethyl Alcohol (**drinking alcohol**) ($CH_3-CH_2-OH$) |
| Methanol is toxic, and hence, it is **not suitable for consumption**. | Ethanol is used in alcoholic beverages, as an additive in foods, etc. |
| Methanol is mostly used to create other chemicals, such as **acetic acid** and **formaldehyde**. | It has antiseptic properties and is found in anti-bacterial wipes and hand gels.<br>It is also the base of many paints and perfumes because it is a good solvent. |
| Its odour is distinctive, and it burns as a bright white flame. | It has a strong, burning odour and will burn as a bright blue flame. |
| Most of the methanol is produced from **coal** and **natural gas**. | Most of the ethanol is produced by **fermentation of biowaste and food crops**. |
| • They are both used as solvents. Both are **clean fuels**<br>• **Both can be blended with petrol for automobile fuel**. | |

#### Advantages of methanol as fuel

- ✓ Methanol and ethanol are **relatively cleaner fuels** (low carbon emissions).
- ✓ The unit cost of energy produced from methanol is **cheaper** than that from petrol, diesel, LPG, etc.
- ✓ Methanol is lighter than petrol and diesel. It **burns efficiently** in all internal combustion engines, produces **no PM**, **no soot**, **almost nil $SO_X$ and $NO_X$ emissions**.
- ✓ **Methanol 15 % blend (M15)** in petrol will reduce pollution by 33% and diesel replacement by methanol will reduce by more than 80%.
- ✓ Adopting Methanol as a transport fuel requires **little infrastructure modifications** compared to other alternative fuels such as CNG, LPG, etc.

### Methanol Economy

- **Methanol Economy** is the "Bridge" to the dream of a complete "Hydrogen based fuel system". The Concept of a "Methanol Economy" is being actively pursued by China (10% of fuel in the transport sector).
- NITI Aayog has drawn out a comprehensive plan to **replace 20% of crude imports from Methanol alone**. GOI aims to increase **fuel blending (methanol, ethanol, or biodiesel) to 20% by 2030**.

## Liquefied Petroleum Gas (LPG)

- LPG consists mainly of **propane**, **butane**, **butylene**, **propylene**, etc., in various mixtures. It is produced as a **by-product of natural gas (mostly methane)** processing and petroleum refining.
- As **LPG is heavier than air**, places with poor ventilation tend to trap the gas in case of leakage. LPG is **odourless** in its natural state. **Ethyl Mercaptan** or **Ethanethiol** (reaction of **ethylene** with **hydrogen sulphide**) that has a strong odour is added to LPG to detect leakage.

## Liquefied Natural Gas (LNG)

- Liquefied Natural Gas or LNG is natural gas stored as a **super-cooled liquid (cryogenic)** (-120 to -170°C). It is used in heavy-duty applications in developed countries like the US, Japan, etc. For many developing nations, using LNG is currently not a practical option.

✓ Advantage: takes up less space thereby extending range and reducing refuelling frequency.

➢ Disadvantage: **high cost** of cryogenic storage, transportation and dispensation.

## Compressed Natural Gas (CNG)

- Natural gas is drawn from gas wells or in conjunction with crude oil. When natural gas is compressed and stored in tanks it is called Compressed Natural Gas or CNG.
- Natural gas is mostly **methane** and, to some extent, **ethane** and **propane**. Other gases, such as nitrogen, carbon dioxide, sulphur compounds, etc., are also present. A sulphur-based odorant is added to CNG to facilitate leak detection.

✓ Advantage over LPG is that **CNG is lighter than air and thus will quickly dissipate** in the case of a leak.

- ✓ CNG is a clean burning fuel, i.e., burning it **leaves little or no residue (reduced engine maintenance)**. Although natural gas **produces GHGs**, it is considerably reduced compared to petrol or diesel.
- ✓ CNG is **much safer compared to petrol and diesel**. It has a **high auto-ignition temperature**.
- ✓ CNG is **cheaper** than petrol and diesel.
- ✓ CNG also carries a high calorific value (50,000 kJ/kg) as compared to petrol (45000 kJ/kg).
- ➢ Disadvantages: **Large fuel tanks**, **less range**, **very few filling stations**, **old vehicles not designed for CNG**.

## Calorific Value of Various Sources of Energy

| Fuel | Calorific Value in Megajoules/kg |
|---|---|
| **Hydrogen** | **141** |
| **Methane ($CH_2$)** | **55** |
| Ethane ($C_2H_6$) | 52 |
| **Natural gas and CNG** | **52** |
| **Liquefied petroleum gas (LPG)** | **50** |
| Propane, butane | 50, 49 |
| **Petrol/gasoline** | **46.4** |
| **Kerosene** | **46.2** |
| **Diesel fuel** | **45.5** |
| **Biodiesel (methyl ester)** | **37** |
| Ethanol ($CH_3-CH_2-OH$) | 29 |
| Methanol ($CH_3OH$) | 23 |
| **Coal anthracite** has the highest – 32; peat has the lowest – 17) | 17-32 |
| Firewood (dry) | 16 |

## Total Installed Power Capacity in India

| Total Installed Power Capacity (31/01/2023) | | |
|---|---|---|
| **Fuel** | **TIC (MW)** | **% of Total** |
| **Coal** | 2,04,435 | 49.7% ↓ |
| **Gas** | 24,824 | 6.1% ↓ |
| **Lignite** | 6,620 | 1.6% ↓ |
| **Diesel** | 589 | 0.1% ↑ |
| **Total Fossil Fuel** | **2,36,469** | **57.4% ↓** |
| **Solar** | 63,894 | 15.1% |
| **Hydro Power (large)** | 46,850 | 11.4% |
| **Wind** | 41,983 | 10.2% |
| **BM Power/Cogen** | 10,210 | 2.5% |

| | | |
|---|---|---|
| **Small Hydro Power** | 4,940 | 1.2% |
| **Waste to Energy** | 523 | 0.1% |
| **RES (OE)** | 1,21,550 | 29.5% |
| **RES (Incl. Hydro)** | **1,68,400** | **40.9%** |
| **Nuclear** | 6,780 | 1.6% |
| **Total Non-Fossil Fuel (RES)** | **175 180** | **42 5%** |
| **Total** | **4,11,649** | **100%** |

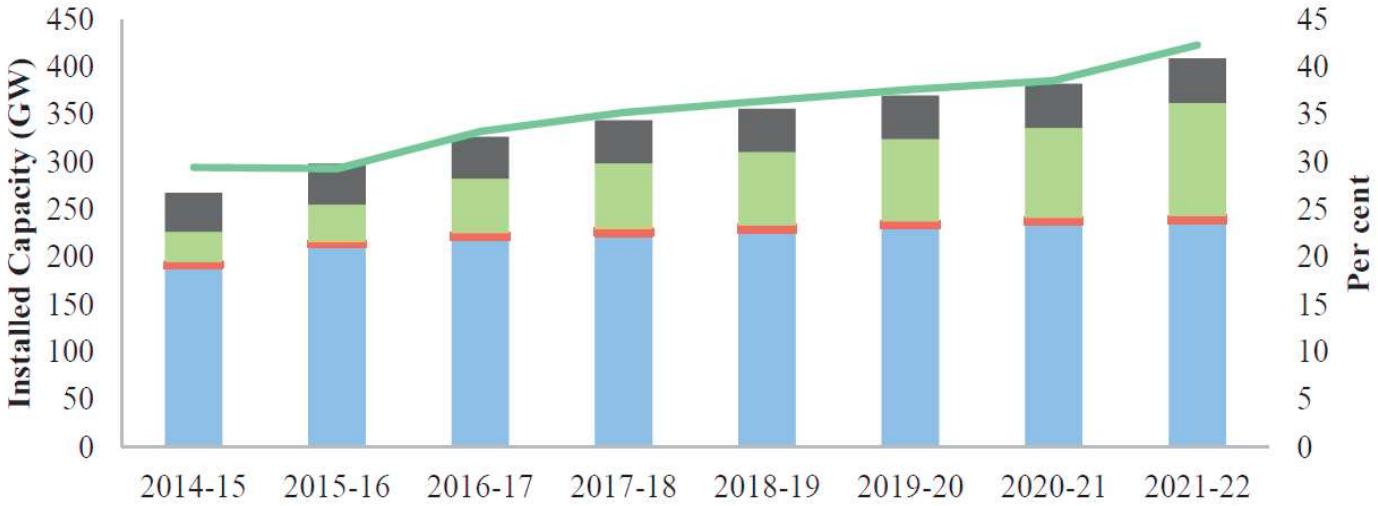
1) **Public Sector (49.6%) (Decreasing over time)**
    1. **State Sector (25.4%)**
    2. **Central Sector (24.2%)**
2) **Private Sector (50.4%) (Increasing over time)**

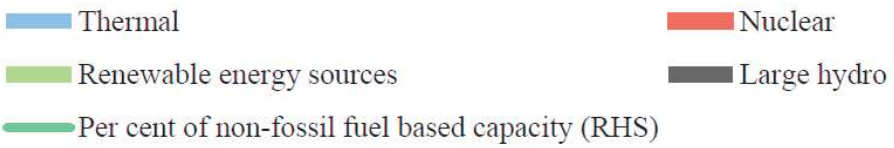
TIC: Total Installed Capacity (in MW) | BM Power/Cogen: Biomass Power, Cogeneration | RES: Installed capacity in respect of Renewable Energy Sources | RES (OE) = RES – Nuclear – Large Hydro | RES (Incl. Hydro) = RES – Nuclear

## Total Installed Renewable Power Capacity

TIC: Total Installed Capacity (in GW) | Target: Target for 2022

| Total Installed Renewable Power Capacity | | | |
|---|---|---|---|
| **Source** | **TIC (May 21)** | **TIC (Feb 23)** | **Target** |
| **Solar power** | **41.06** | **63.3** | **100** |
| **Wind power** | **39.44** | **41.9** | **60** |
| **Biomass power** | **10.17** | **10.2** | **10** |
| **Waste-to-Power** | **0.17** | **0.52** | |
| **Small hydropower** | **4.79** | **4.93** | **5** |
| **Large Hydro** | **46.32** | **46.85** | N/A |
| **TOTAL** | **142** | **168** | **175** |

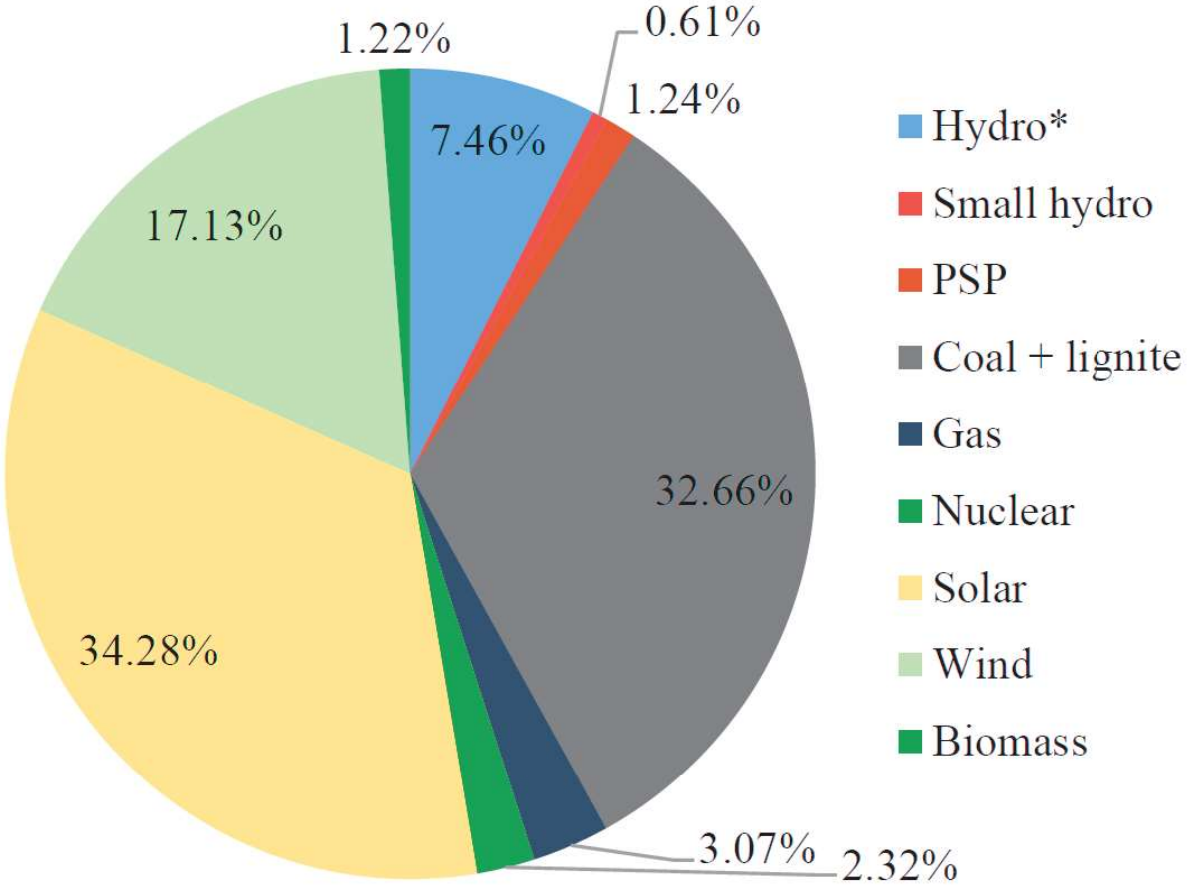





⇨ ***[UPSC 2016] Give an account of the current status and the targets to be achieved pertaining to renewable energy sources in the country. Discuss in brief the importance of National Programme on Light Emitting Diodes (LEDs).***

⇨ ***[UPSC 2018] "Access to affordable, reliable, sustainable and modern energy is the sine qua non to achieve Sustainable Development Goals (SDGs)." Comment on the progress made in India in this regard.***

- India has set a target of **175 GW of renewable energy capacity by 2022**, which includes **100 GW of solar energy**. This target includes **40 GW rooftop** and **60 GW through large and medium grid-connected solar power projects**.
- In line with the Prime Minister's announcement at COP26 (50% of energy from renewables by 2030), the Ministry of New and Renewable Energy is working towards achieving **500 GW of installed electricity capacity from non-fossil sources by 2030**.




***Projected Optimal Mix of Installed Capacity for 2029-30***

- The installed electricity-generating capacity in the country at present is **411 GW**, including **175 GW from non-fossil fuel sources**, which is about **42% of the total**.

- The Ministry of Power has prepared a detailed Transmission Plan for the Integration of over **500 GW RE Capacity by 2030**. The planned additional transmission systems required is an **estimated cost of 2.44 lakh crore**.
- Because renewable-energy generation is only available for a limited time every day, the plan envisages installing battery storage capacity worth 51.5 GW by 2030 to provide "round-the-clock power".

***[UPSC 2022] Do you think India will meet 50% of its energy needs from renewable energy by 2030? Justify your answer. How will the shift of subsidies from fossil fuels to renewables help achieve the above objective? Explain. (250 words)***

## World Energy Outlook and India Energy Outlook Report 2022

- India's energy requirements will peak in the coming decade, as per the World Energy Outlook (WOE) report for 2022, published by the International Energy Agency (IEA).

### Findings of the report

- India will have the highest population by 2025. This, along with urbanisation and industrialisation, will spur a huge rise in energy demand of >3% per year from 2021-2030.
- In India, the **demand for coal will continue to rise**. This **demand will peak anywhere between the late 2020s and early 2030s**. However, the peak will be followed by a **steep decline in coal demand** as the deployment of **cheap**, **clean energy alternatives like renewables**.
- By 2030, renewables will meet more than 60% of the growth in demand for power and account for 35% of the electricity mix, with solar PV alone accounting for more than 15%. Coal will still meet a third of overall energy demand growth by 2030, and oil, mainly for transport, another quarter.
- There remained a **huge gap** between the climate pledges made previously (previous NDCs) and their ability **to limit global warming to 1.5°C by 2100**. However, additional pledges made in 2021 (**revised NDCs**), "notably by **India**", will show a faster decline in emissions by 2050.
- Currently, low-emissions sources account for around 40% of electricity generation, with 30% coming from renewables and another 10% from nuclear.
- Within ten years, if countries are taking the necessary action to deliver on their climate pledges, the world will be deploying around **210 gigawatts (GW) of wind capacity** each year and **370 GW of solar**.

### How Feasible Is India's 'Net-Zero by 2070' Pledge?

- **WOE's 'Announced Pledges Scenario' (APS – ideal case scenario)** assumes that all aspirational targets announced by governments are met, including their long-term net zero to limit global warming to 1.5°C. As per the APS, more rapid progress in deploying low-emissions alternatives means that **India could be within reach of its goal to achieve net zero emissions by 2070 (only if all the pledged targets are met in time and in full)**.

### Towards 'Net-Zero by 2070'

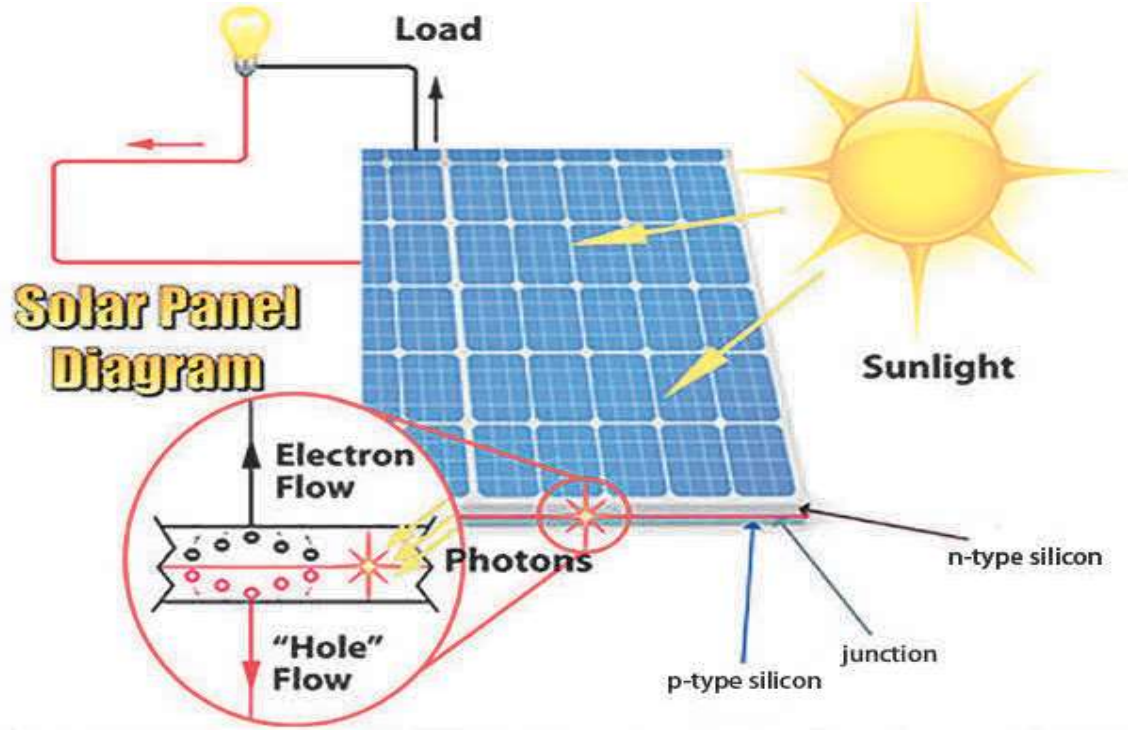
- India promised to **reduce the emissions intensity of its GDP by 45% from 2005 levels by the year 2030** and achieve about **50% cumulative non-fossil fuel electric power by 2030** as part of its updated NDC.
- India's steps towards establishing a **carbon market** and **boosting the energy efficiency of buildings** and **appliances** will also help.
- Government programmes such as the **Gati Shakti National Master Plan** (a Rs 100 lakh-crore project for developing 'holistic infrastructure' in India by bringing various ministries and stakeholders together) and the **Atmanirbhar Bharat Abhiyaan (self-reliant India)** could promote a "robust growth" in renewables and electric mobility, notably for two/three-wheelers.

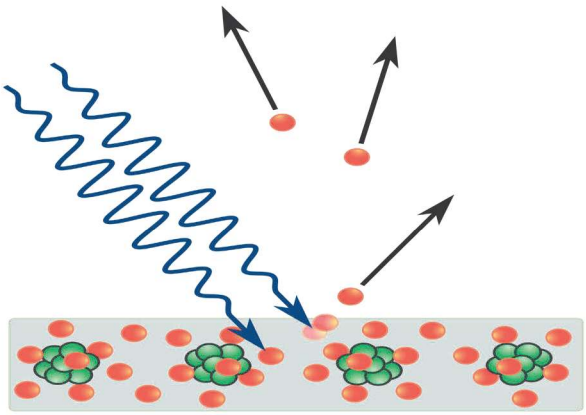
### International Energy Agency (IEA)

- The IEA, an **autonomous intergovernmental organisation**, **analyses data on energy use and requirements** and **provides policy recommendations** and **solutions** to countries for **sustainable energy growth**.
- The **IEA's World Energy Outlook report**, published **annually**, captures the world's energy trends and transitions and predicts future trajectories.

## 26.2. Solar Energy

- Solar energy can be converted directly into **electrical energy (direct current or DC) by photovoltaic (PV) cells**, commonly called solar cells. Photovoltaic cells are made of **silicon** and other **semiconductor materials**. When **sunlight (photons)** strikes the silicon atoms, it causes electrons to flow, creating an electrical current. This principle is called as the **photoelectric effect**.





**[UPSC 2014] With reference to technologies for solar power production, consider the following statements:**

1. 'Photovoltaics' is a technology that generates electricity by direct conversion of light into electricity, while 'Solar Thermal' is a technology that utilises the Sun's rays to generate heat which is further used in electricity generation process.
2. Photovoltaics generates Alternating Current (AC), while Solar Thermal generates Direct Current (DC).
3. India has manufacturing base for Solar Thermal technology, but not for Photovoltaics.

***Which of the statements given above is/are correct?***

a) 1 only
b) 2 and 3 only
c) 1, 2 and 3
d) None

**Explanation**

- **Photoelectric effect** ➔ When light strikes on a suitable semiconductor material, **electrons are dislodged (photons dislodge electrons)**
- **Photovoltaic** ➔ The dislodged electrons, if channelled through a conductor, will create electric current (voltage or potential difference) — electric current is nothing but the movement of electrons from high potential to low potential area (more electrons to fewer electrons region))
- **Rotating → AC**, **Stationary → DC**. **Electric generators** and **wind turbines generate AC** while **solar panels generate DC**.
- Solar thermal ➔ converting light into heat. E.g., **solar cooker** and **solar water heater**. Electricity can be generated by using hot water steam to rotate the turbine ➔ AC current.

***Answer: a) 1 only***

## International Solar Alliance (ISA)

- **ISA**, or the **International Agency for Solar Policy and Application (IASPA)**, is a **treaty-based inter-governmental organisation**. Its objective is to work for efficient consumption of solar energy to reduce dependence on fossil fuels.
- ISA was proposed by PM Modi at the **India Africa Summit** ahead of the Paris Summit, and was launched by **India** and **France** at the 2015 UNFCCC **(COP21**, **Paris)** through **Paris Declaration**. It is headquartered in **Gurugram**, **India**.
- ISA was established as an alliance of 123 countries, most of them being **sunshine countries**, which **lie either completely or partly between the Tropic of Cancer and the Tropic of Capricorn**. **Countries that do not fall within the Tropics can join** the alliance, however, **with the exception of voting rights**. As of Feb 2023, 92 countries (members) have signed and ratified the **ISA Framework Agreement**.
- ISA will **not duplicate or replicate the efforts** that others are currently engaged in but will establish networks, **develop synergies with them**, **and supplement their efforts** in a sustainable manner.
- To deploy cost-effective solutions, especially in the Least Developed Countries (LDCs) and the Small Island Developing States (SIDS), ISA is partnering with multilateral development banks (MDBs), development financial institutions (DFIs), and other international institutions such as:
  - ✓ International Renewable Energy Agency (IRENA),
  - ✓ Renewable Energy and Energy Efficiency Partnership (REEEP),
  - ✓ International Energy Agency (IEA),
  - ✓ Renewable Energy Policy Network for the 21st Century (REN21),
  - ✓ United Nations bodies, bilateral organisations etc.

## Objectives of the ISA

- ✓ To mobilise investments of more than **USD 1000 billion** **(1 trillion USD) by 2030**.
- ✓ To take coordinated action for promoting solar finance, solar technologies, R&D, capacity building etc.
- ✓ **Reduce the cost of finance** to increase investments in solar energy in member countries.
- ✓ Scale-up applications of solar technologies in member countries.
- ✓ Facilitate collaborative R&D activities in solar energy technologies among member countries.
- ✓ Promote a common cyber platform for cooperation and exchange of ideas among member countries.

⇨ *ISA aims to create a **World Solar Bank** with an authorised capital of **$15 billion** to fund projects.*

## ISA Targets

- The ISA has set a target of **1000 GW of solar energy by 2030**.

## Delhi Solar Agenda

- The Delhi Solar Agenda was **adopted in the Founding Conference** of the ISA. It states that the ISA member States inter-alia have agreed to pursue an increased share of solar energy in the final energy consumption in the respective national energy mix.

## Solar Facility by International Solar Alliance (ISA)

- ISA, in its 5th General Assembly meeting, approved the **Solar Facility**. **Solar Facility** is a **payment guarantee mechanism** that is expected to **stimulate investments into solar projects** through two financial components – a **Solar Payment Guarantee Fund** and **Solar Insurance Fund**.
- Its objective is to **attract private capital to flow into "underserved markets" in Africa**. The ISA would aim to crowdsource investments from various **donors** across the globe, and proposed projects in **Africa** would be able to purchase payment guarantees or partial insurance premiums from these funds.

### [UPSC 2016] Consider the following statements:

1) The International Solar Alliance was launched at the United Nations Climate Change Conference in 2015.
2) The Alliance includes all the member countries of the United Nations.

***Which of the statements given above is/are correct?***

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

***Answer: a) 1 only***

## One Sun One World One Grid (OSOWOG)

- **OSOWOG** is **India's initiative** to build a **global ecosystem** of **interconnected renewable energy resources**. The blueprint for the OSOWOG will be developed under the **World Bank's** technical assistance programme that is implemented to accelerate the deployment of **grid-connected rooftop solar installations**.
- The concept of OSOWOG intends to tap the global solar energy potential for the benefit of all nations and requires an **international electricity grid to allow inter-country free flow of power**. To achieve this, the OSOWOG will require certain changes in the regulatory framework, especially in two areas:
  1. Grid security for the Indian grid.
  2. Development of appropriate energy exchange.
- The grid has to be a **"smart grid"** in order to obtain the highest efficiencies given the constraints of transmission of solar power, **i.e.**, **transmission losses**.
- OSOWOG is planned to be completed in **three phases**.
  1. The first phase will entail interconnectivity within the Asian continent;
  2. The second phase will add Africa and
  3. The third phase will globalise the whole project.
- OSOWOG is seen as **India's counter to China's Belt and Road initiative (BRI)**

## Steps taken by India to increase the share of Solar Energy

- Globally, **India ranks 4th in terms of installed renewable power**, **wind power (4th)** and **solar power (4th) capacity**. The National Institute of Solar Energy has assessed the Country's solar potential of about **748 GW**, assuming **3% of the waste land area** to be covered by Solar PV modules.
- The Indian government has implemented a scheme named **KUSUM** that aims to **replace the use of diesel in our farm sector with solar energy**. Under this scheme, India has targeted the solarisation of 2.8 million irrigation pumps. India has also set up a **Project Preparation Facility** to develop **bankable Solar Energy projects** in ISA member countries with the help of **EXIM Bank of India**.
- Solar energy has taken a central place in India's National Action Plan on Climate Change with National Solar Mission as one of the key Missions. The Mission's objective is to establish India as a global leader in solar energy. The Mission targeted installing 100 GW grid-connected solar power plants by 2022.

***[UPSC 2020] Describe the benefits of deriving electric energy from sunlight in contrast to the conventional energy generation. What are the initiatives offered by our Government for this purpose? (250 words).***

### PM-KUSUM Scheme

- PM-KUSUM (**Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan**) was launched in 2019 by the **Ministry of New and Renewable Energy (MNRE)** to support the installation of **off-grid solar pumps in rural areas** and **reduce dependence on the grid**, **in grid-connected areas**. It consists of three components:
  1. **10 GW of Decentralized Ground Mounted Grid Connected Renewable Power Plants**.
  2. **Installation of 17.50 lakh standalone (off-grid) Solar Powered Agriculture Pumps**.
  3. **Solarisation of 10 Lakh Grid-connected Solar Powered Agriculture Pumps**.
- All three components combined, PM-Kusum aimed to add a solar capacity of **25.75 GW by 2022**. The total central financial support provided under the scheme would be Rs. 34,422 crores.
- Besides reducing emissions, the scheme aims to address challenges of irrigation supply, subsidy burden on discoms (~Rs 50,000 crores) and farmer income (sale of surplus).

#### Union Budget 2020 sets new targets

- The scheme is now extended to
  1. **Set up 20 lakh standalone solar pumps (earlier, it was 17.5 lakhs)**.
  2. **Solarisation of 15 Lakh Grid-connected Solar Pumps (earlier it was 10 lakh)**.
- The scheme will also allow farmers to set up grid-connected solar power generation on barren land.

#### Expected benefits of the PM-KUSUM Scheme

✓ It reduces farmers' dependence on diesel and kerosene.

✓ It enables the farmers to set up solar power generation capacity and sell it to the grid.

- ✓ It enables farmers would be able to earn a livelihood through their baron land also.
- ✓ Besides reducing emissions, the scheme also reduces the subsidy burden on discoms (~Rs 50,000 crores).

### Criticism of the PM-KUSUM Scheme

- ➢ The scheme results in over-exploitation of groundwater.
- ➢ PM-KUSUM may not help reduce discoms' subsidy burden because the installation of pumps is not mandatorily tied to a decrease in subsidised agricultural power supply.
- ➢ The proposed scheme of installing solar plants on farmland might benefit only wealthy farmers, as it requires large investment or the ability to lease land for 25 years.

## Rooftop Solar (RTS) Programme

- The MNRE had, in 2015, approved a programme called the '**grid connected rooftop and small solar power plants programme**', which aimed to install **4.2 GW** rooftop solar plants by the year 2019-20. But, in the first phase **only 2.1 GW** of rooftop solar (RTS) systems could be installed.
- **The Ministry of New and Renewable Energy** issued guidelines to implement the second phase of the grid-connected rooftop solar photovoltaic programme. Under the second phase, **22 GW** of rooftop solar PV projects must be set up.
- **Karnataka** ranked the best for setting up a rooftop solar (RTS) project, according to the state rooftop solar attractiveness index (SARAL) released by the Centre. **Telangana**, **Gujarat** and **Andhra Pradesh** scored a rating of A++, while J&K was placed at the bottom.
- In the second phase, the electricity distribution companies (discoms) will play a key role in the expansion of RTS. This is to ease the consumer's challenge of approaching multiple agencies to get an RTS plant installed.

## National Programme on Solar PV Modules

- The cabinet approved a **production linked incentive (PLI) scheme** with an outlay of Rs 4,500 crore **to add 10 GW capacity of integrated solar PV modules manufacturing plants**. Solar capacity addition presently depends largely upon **imported solar PV cells** and modules.

### Expected Benefits

- ✓ **Additional 10 GW** capacity of integrated solar PV manufacturing plants.
- ✓ **Direct investment** of around Rs.17, 200 crore in solar PV manufacturing projects.
- ✓ **Increased Demand** of Rs.17, 500 crore over 5 years for 'Balance of Materials'.
- ✓ **Direct employment** of about 30,000 and indirect employment of about 1,20,000 persons.
- ✓ Import substitution of around Rs.17, 500 crore every year **(Reduce imports in sectors like fuel)**.
- ✓ **Impetus to Research** and **Development** to achieve higher efficiency in solar PV modules.
- ✓ It will support the Atmanirbhar Bharat initiative.

## National Wind-Solar Hybrid Policy

- **MNRE** released a **solar-wind hybrid policy in 2018**. The Policy seeks to promote new hybrid projects as well as **hybridisation of existing wind/solar projects**.
- The Policy provides for:
  - ✓ Integration of wind and solar at AC as well as DC level.
  - ✓ Flexibility in the share of wind and solar components.
  - ✓ Procurement of power from a hybrid project on a tariff-based transparent bidding process.
- For a project to be recognised as a hybrid project, the rated power capacity of one resource should be at least 25% of the rated power capacity of another resource.
- The objective of the policy is to provide a framework for the promotion of a large grid-connected wind-solar hybrid system for **efficient utilisation of transmission infrastructure and land**. It also aims at **reducing the variability in renewable power generation** and achieving better grid stability.

### MoEF relaxed the lease norms for wind power projects

- Currently, to establish a wind power project over forest land, the existing procedure requires payment of **mandatory charges for compensatory afforestation and Net Present value (NPV)**. In addition to these charges, the companies had to pay an additional lease rent of Rs. 30,000 per MW.
- **MoEF has now relaxed the mandatory charging** of lease rent of Rs. 30,000/- per MW for wind power projects. It is expected that this step will **boost the investment in wind power projects** and make it cheaper.

## Issues with Solar Power (in India)

- India is not a major manufacturer of solar panels, and most of them are **imported** and assembled in India, which makes solar power in India **relatively expensive**.
- Though most of India gets abundant sunshine, high levels of **atmospheric pollution** and **aerosols** reduce solar power generation efficiency by absorbing and scattering the sun's rays and by **soiling solar panels**. This **increases maintenance costs** and **water requirements** for cleaning.
- Solar parks need 7,000-20,000 litres of water per megawatt (MW) per wash. Many solar installations in India are located in **arid and semi-arid areas** bringing significant risk to the local ecosystem and communities.
- Large-scale solar parks are set up by clearing a large expanse of land of vegetation. This can lead to the loss of wildlife habitats and soil erosion. Unlike wind facilities, there is less opportunity for solar projects to share land with agricultural/forestry uses.

### Pollution

- Solar panel manufacturers use **hazardous chemicals** and materials to clean the semiconductors. Some of these chemicals include hydrofluoric acid, sulfuric acid, hydrogen fluoride, and so on.

- Solar photovoltaic panel is essentially made up of **glass**, **aluminium**, **metals**, **silicon** and **polymer fractions**. While glass and aluminium (together constituting ~80% of the total weight) are non-hazardous, a few other materials used in the panel, like **polymers**, **antimony-containing glasses** (used to improve stability the glass upon exposure to ultraviolet radiation), **lead**, **mercury**, **zinc** and **cadmium compounds** (carcinogens), are **hazardous**.
- PV module recycling is still not commercially viable. The polymer component used in solar modules is difficult to recycle and can only be incinerated (air pollution).
- A lot of waste is generated during the installation of solar panels. And panels that are damaged are disposed of in an unscientific manner. When buried in the ground, they can contaminate soil (**leaching of heavy metals**), waterbodies, and if burnt, they contaminate the air.

## Not tapping into the commercial potential of recycling

- India has so far failed to put in a mechanism to address the problem of end-of-life solar waste, including environmentally hazardous materials, from solar photovoltaic panels.
- There are clear environmental and commercial benefits of recycling. High-value materials like silver and solar-grade silicon can be recovered viably. But the problem is that in India we don't have the requisite recycling facilities that can recover these materials.

## Karnataka's Pavagada

- **Pavagada Solar Park** (Tumakuru district, Karnataka) is billed as the world's largest solar park spread over 13,000 acres of land.
- The arid region with fallow land was not irrigated, and a drought-like situation prevailed continuously. ISA said that Pavagada can be an example for states like Rajasthan with abundant wasteland.
- A committee constituted in 2015 to deal with lease rent finalised a rate of Rs 21,000/acre/annum with a 5% escalation every two years. The lease is for 28 years.

### Issues

- The solar park helped only big farmers who have more than 25 acres of land.
- The temperature of the villages near the park is higher due to the reflection and adsorption of light by the solar panels.
- Pavagada is close to the **Jayamangali Blackbuck Reserve**, which is a habitat for the Blackbuck as well as the **Great Indian Bustard**.
- Large mammals like bears and leopards, which were once seen frequently, are no longer around. There is a decline in the populations of birds, and **pollinators** like bees and butterflies.

***[UPSC 2020] India has immense potential of solar energy though there are regional variations in its development. Elaborate. (250words)***

## 26.3. Wind Energy

- India currently has an installed capacity of **41 GW (Feb 2023)**, the **fourth highest** in the world. However, this is just 29% of its target, which is to install **140 GW by 2030**. **TN** accounts for 25% of this installed capacity, followed by **Gujarat** at 24%.

### Major Wind Farms

| Location | Capacity |
|---|---|
| Jiuquan Wind Base (Gansu Wind Farm), China | 20 GW |
| Alta Wind Energy Centre, US | 1.54 GW |
| **Muppandal Wind Farm**, **Kanyakumari district** | **1.5 GW** |
| **Jaisalmer Wind Park**, **Rajasthan** | **1.06 GW** |

#### Muppandal Wind Farm, India

- The area of Muppandal features vast barren land, which is not fit for cultivation but boasts of **high-pressure winds (due to the funnelling effect)**, making it an ideal location for the development of wind farms. Muppandal receives strong winds for nine months a year from the west, due to the presence of the Western Ghats mountain range.

### Wind vs Solar

#### Solar is the winner

- India's aspiration to become a global solar energy power has affected the wind power sector. Tariffs for wind power are currently similar to those for solar power. However, wind's long-term competitiveness vis-à-vis solar may weaken if **costs in the solar sector drop faster** as the **best wind sites are taken up**.
- Development of wind parks (similar to solar parks), where the **government takes care** of the **land** and **integration of power to the grid** (two difficult challenges), is entirely **missing for the wind sector**. Moreover, large wind projects are viable only in a few states like TN, Gujarat and Rajasthan.
- Due to the capricious nature of wind, **power generation is highly variable and seasonal**. Due to high variability, wind projects face a higher risk of curtailment putting them at a disadvantageous place with respect to solar projects.

#### Wind is the winner

- Wind energy brings distinct value to the overall energy mix as it is **available during peak-demand time** in the evening (7 pm-10 pm), unlike solar.
- Wind energy generation is the **highest** from June to October in **TN** and August to September in **Gujarat** when **solar demand tends to slow down due to monsoons**.

- Unlike other sectors (such as **solar power**), which are **heavily dependent on China** (for the import of components, **strategic and rare earth minerals**, etc.), the wind energy sector empowers **local manufacturing of components**.

## Offshore Wind Energy

- Globally, the offshore wind market has grown from 29.2 GW in 2019 to **35.3 GW in 2020**, according to the Global Wind Report 2021 of the Global Wind Energy Council (GWEC).
- Leading in total offshore wind installations was the UK (10 GW), followed by China (9.99 GW), Germany (7.7 GW), Netherlands (2.6 GW) and Belgium (2.2 GW), as of 2020. (They are all located in the **westerly wind belt — more predictable high-speed winds**)
- Global offshore capacity would exceed **2,000 GW by 2050**, with **India accounting for 140 GW**, according to a report by the EU. India's plans are to achieve **5 GW of offshore wind by 2022** and **30 GW by 2030**.

### Potential in India

- According to the MNRE, the 7,600 km-long Indian coastline has an **offshore wind energy potential of 140 GW by 2050**. **36 GW** of offshore wind energy potential exists off the coast of **Gujarat**, and nearly **35 GW** exists off the **TN** coast, according to an assessment by the National Institute of Wind Energy (NIWE).

### Policy

- The **National Offshore Wind Energy Policy** was notified in 2015 to provide a legal framework for the development of the offshore wind sector in India.
- Policy authorises the MNRE to work in close coordination with other government entities for the development of offshore wind energy within the entire, exclusive economic zone (EEZ) of the country.
- **NIWE** has been designated as the nodal agency to carry out or facilitate necessary resource assessment activity for offshore wind development.

## Onshore vs Offshore

### Offshore wins

- The onshore wind energy potential estimated by the **National Institute of Wind Energy (NIWE)** stands at **300 GW at 100 m hub height**. However, many onshore wind energy projects are adversely affected due to **land acquisition issues**. Offshore wind energy does not have that constraint.
- The tariff discovered through e-auction started moving upwards on account of the **exhaustion of best wind sites**. Hence, offshore wind can be seen as a viable future option.

- **Onshore wind is more intermittent than offshore**. At sea, winds are free from any obstruction and thus flow more smoothly, with higher speed. With onshore wind, utilisation is at best 35%, but with offshore, it could be up to 50-55% due to stronger winds at sea.

### Onshore wins

- According to the MNRE, the exact cost of the offshore turbine and tariff cannot be ascertained at this stage. It could be **more expensive than onshore wind** (by 2-3 times) and **solar power**.
- Offshore wind turbines require longer blades, and transporting them over long distances is not viable. Ports in TN and Gujarat would have to be developed such that blades can be manufactured near the closest port from the offshore site.
- Offshore plants have significant challenges, including subsea cabling, turbine foundation, installation of turbines including logistics, grid interconnection and operation, development of transmission infrastructure and coastal security during the construction and operation period.

## Wind Power: Issues and Challenges

- The stagnation in wind power is due to a lack of financial incentives and difficulties in finding land for the projects. Another major issue is that most of the good wind sites have already been taken over in India.
- Onshore wind power is becoming financially uncompetitive, and off-shore wind power is **considered financially unviable**. One of the reasons is the shift to a **bidding route that seeks the lowest per-unit price during an auction**. (This makes wind energy highly **uncompetitive** against cheaper options like solar).

### Envirnmental and Health Issues

- As with all energy supply options, wind energy can have adverse environmental impacts, including the potential to **reduce**, **fragment**, **or degrade habitat** for wildlife, fish, and plants. Furthermore, spinning turbine blades can **pose a threat to flying wildlife like birds and bats**.
- **Wind turbine syndrome** and **wind farm syndrome** are terms for the alleged adverse human health effects related to the proximity of wind turbines — some might experience symptoms that include decreased quality of life, annoyance, stress, sleep disturbance, headache, anxiety, depression, and cognitive dysfunction.

### Repowering

- The Muppandal Wind Farm in Kanyakumari is the largest onshore farm in India. But the wind turbines here are also among the oldest, some of them over 25 years old.
- Simply put, repowering means replacing older turbines with newer, higher-capacity ones or retrofitting them with more efficient components. Turbines can also be repowered by **increasing their height**, where wind speeds are stronger.

- In 2016, India came up with a **repowering policy** that allowed repowering for turbines under 1MW power. Still, it has had very few takers as there is no financial incentive to go for repowering. There are no benefits, and the costs are as high as setting up a new wind turbine ➔ **High maintenance and upgradation costs in the long run**.

***[UPSC 2022] Examine the potential of wind energy in India and explain the reasons for their limited spatial spread. (150 words)***

## 26.4. Biofuel

- **Any hydrocarbon fuel**, i.e., solid, liquid or gas, that is **produced from an organic matter**, which may be living or once living material, **in a short period of time** is considered a biofuel. Examples of biofuels include:
  - ✓ Solid: Wood, manure
  - ✓ Liquid: **Bioethanol** and **Biodiesel**
  - ✓ Gaseous: **Biogas**
- As **biofuels emit less carbon dioxide ($CO_2$) than conventional fuels** they can be **blended with existing fuels** as an effective way of reducing $CO_2$ emissions in the **transport sector**. Biofuels represent around 3% of road transport fuels in use around the world.

### Generations of Biofuel

#### First Generation Biofuels

- The First Generation biofuels are **produced directly from food crops** by abstracting the oils for use in **biodiesel** or **producing bioethanol** through conventional methods like **fermentation**. Crops such as **wheat** and **sugar** are the most widely used feedstock for **bioethanol**, while **rapeseed oil** has proved highly effective for use in **biodiesel**.
- First-generation biofuels have a number of problems:
  - ➢ These biofuels can produce **Negative Net energy gains**, **releasing more carbon** in their production than their feedstock captures in their growth.
  - ➢ The most contentious issue is '**fuel vs food**'.
  - ➢ **Biofuels from food grains** have been blamed for the **increase in food prices** over the last couple of years.

#### Second Generation Biofuels

- The 2G biofuels are produced from **non-food crops** such as **wood**, **organic waste**, **food crop waste &specific biomass crops**, therefore eliminating the main problem with first-generation biofuels. They are also aimed at being **more cost-competitive** in relation to existing fossil fuels.

- Life cycle assessments of second-generation biofuels have also indicated that they will increase **Positive net energy gains**, overcoming another of the main limitations of first-generation biofuels.

### Third Generation Biofuels

- The Third Generation of biofuels takes advantage of **specially engineered energy crops such as algae**. The algae are cultured to act as a **low-cost**, **high-energy**, **and entirely renewable feedstock**. It is predicted that algae will have the potential to produce **more energy per acre than conventional crops**.
- Algae can also be grown using land and water unsuitable for food production. A further benefit of algae-based biofuels is that the fuel can be manufactured into a **wide range of fuels**, **such as diesel**, **petrol**, **and jet fuel**. **It is potentially carbon neutral (the same amount of carbon is absorbed and emitted)**.

### Fourth Generation Biofuel

- The Fourth Generation of biofuels is aimed at not only producing sustainable energy but also a way of **capturing and storing $CO_2$**. Biomass materials, which have absorbed $CO_2$ while growing, are converted into fuel using the **same processes as second-generation biofuels**. This process differs from second and third-generation production as at all stages of production, the **carbon dioxide is captured using processes such as oxy-fuel combustion**.
- The carbon dioxide can then be **geo-sequestered** by storing it in old oil and gas fields or saline aquifers. This carbon capture makes 4$^{th}$ generation biofuel production **carbon-negative** rather than simply carbon neutral, as it locks away more carbon than it produces. This system not only captures and stores carbon dioxide from the atmosphere, but it also **reduces $CO_2$ emissions by replacing fossil fuels**.

## Advantages of Biofuels

### Increases the life of Vehicle Engine

- ✓ Biofuels are adaptable to current engine designs and perform very well in most conditions.
- ✓ They have **higher cetane** and **better lubricating properties**. This keeps the engine running for longer, requires less maintenance and brings down overall pollution.

### Less Carbon Emissions

- ✓ Biofuel is made from renewable resources and is relatively less flammable compared to fossil diesel.
- ✓ Biofuel causes less harmful carbon emissions compared to standard diesel.
- ✓ Studies suggest that biofuels **reduce greenhouse gases by up to 65 per cent**.

### Easy to Source

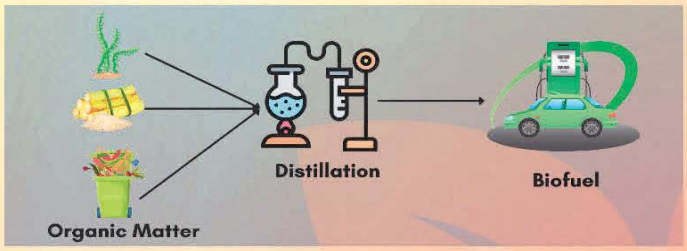
- ✓ Biofuels are made from many different renewable sources such as **manure**, **waste from crops**, **corn**, **switchgrass**, **soybeans**, **algae** and plants grown specifically for the fuel.

# BIOFUEL

## What is Biofuel?

Any hydrocarbon fuel i.e. Solid, Liquid or Gas, that is produced from an organic matter which may be living or once living material, in a short period of time is considered a biofuel.

Biofuels emit less carbon dioxide ($CO_2$) than conventional fuels they can be blended with existing fuels as an effective way of reducing $CO_2$ emissions in the transport sector.




### Examples

Solid: Wood, Manure

Liquid: Bioethanol and Biodiesel

Gaseous: Biogas

## Generations of Biofuel

### 1st Generation Biofuel

- Produced directly from food crops
- It has High Carbon Content.
- Made from Edible Items. Eg- Sugar, Corn. Starch etc.
- These biofuels can produce Negative Net energy gains.

### 2nd Generation Biofuel

- Produced from non-food crops.
- Eg- Rice Husk, Wood Chips etc.
- Greenhouse Gas content less than 1st Generation Biofuel.

### 3rd Generation Biofuel

- Produced from specially engineered energy crops such as algae.
- It is Carbon Neutral ($CO_2$ Emitted = $CO_2$ Sequestrated)

### 4th Generation Biofuel

- Made from 'Genetically Engineered Crops'.
- They are Carbon Negative.
- They are aimed at not only producing sustainable energy but also a way of capturing and storing $CO_2$.
- It also reduces $CO_2$ emissions by replacing fossil fuels.

# National Biofuel Policy 2018

MNRE has set an indicative target of

- 20% blending of ethanol in petrol
- 5% blending of biodiesel in diesel

to be achieved by 2030.



The Policy categorises biofuels as: -

1. Basic Biofuels – First Generation (1G) bioethanol & biodiesel and
2. Advanced Biofuels – 2G ethanol, Municipal Solid Waste to drop-in fuels,
3. Third Generation (3G) biofuels, bio-CNG etc.

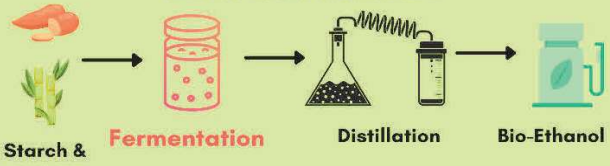
The Ministry also plans on creating a 'National Biomass Repository' through a nation-wide appraisal program

The Policy allows use of surplus food grains for production of ethanol for blending with petrol with the approval of National Biofuel Coordination Committee.



# Some Important Biofuels

## Bioethanol

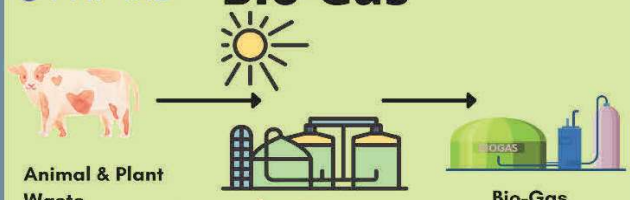



It is commonly blended with petrol

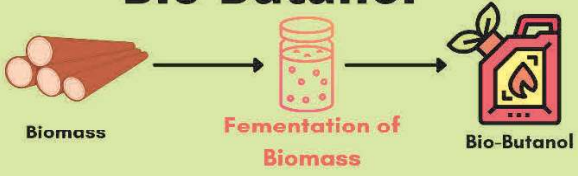
## Bio-Diesel


## Bio-Gas






## Bio-Butanol




Its primary use is as a fuel in internal combustion engines.

***[UPSC 2023] Discuss several ways in which microorganisms can help in meeting the current fuel short-age. (Answer in 150 words)***

### Economic Security

- ✓ If more people start shifting towards biofuels, a country can reduce its dependence on fossil fuels.
- ✓ Fuelling homes, businesses and vehicles with biofuels are less expensive than fossil fuels.
- ✓ More jobs will be created with a growing biofuel industry, which will keep our economy secure.

### Lower Levels of Pollution

- ✓ Biofuels are **biodegradable** and reduce the possibility of soil contamination and contamination of underground water during transportation, storage or use.

### Cost-Benefit

- ✓ As of now, biofuels cost the same in the market as gasoline does. However, the overall cost-benefit of using them is much higher. They are cleaner fuels, which means they produce fewer emissions when burnt. With the increased demand, they have the potential to become cheaper in the future as well.

## Disadvantages of Biofuels

### High Cost of Production and Future Price

- ➢ **High Cost of Production:** Biofuels are quite expensive to produce in the current market. The interest and capital investment being put into biofuel production is fairly low.
- ➢ Constantly rising prices may make the use of biofuels as harsh on the economy as the rising gas prices are doing.

### Industrial Pollution

- ➢ The carbon footprint of biofuels is less than the traditional forms of fuel when burnt.
- ➢ However, the process by which they are produced makes up for that.
- ➢ Large-scale industries meant for churning out biofuel are known to emit large amounts of emissions and cause small-scale water pollution as well.
- ➢ Unless more efficient means of production are put into place, the overall carbon emission does not get a very big dent in it. It also causes an increase in **$NO_x$**.

### Changes in Land Use and Pollution

- **Biofuel production can encourage monoculture**. If the land is used to grow a biofuel feedstock, it has to be cleared of native vegetation, which then leads to ecological damage done in three ways.
- ➢ **First**, the damage is caused by destroying local habitant and reduces the overall health of natural resources of the region. The native forest is almost always better at removing $CO_2$ from the atmosphere

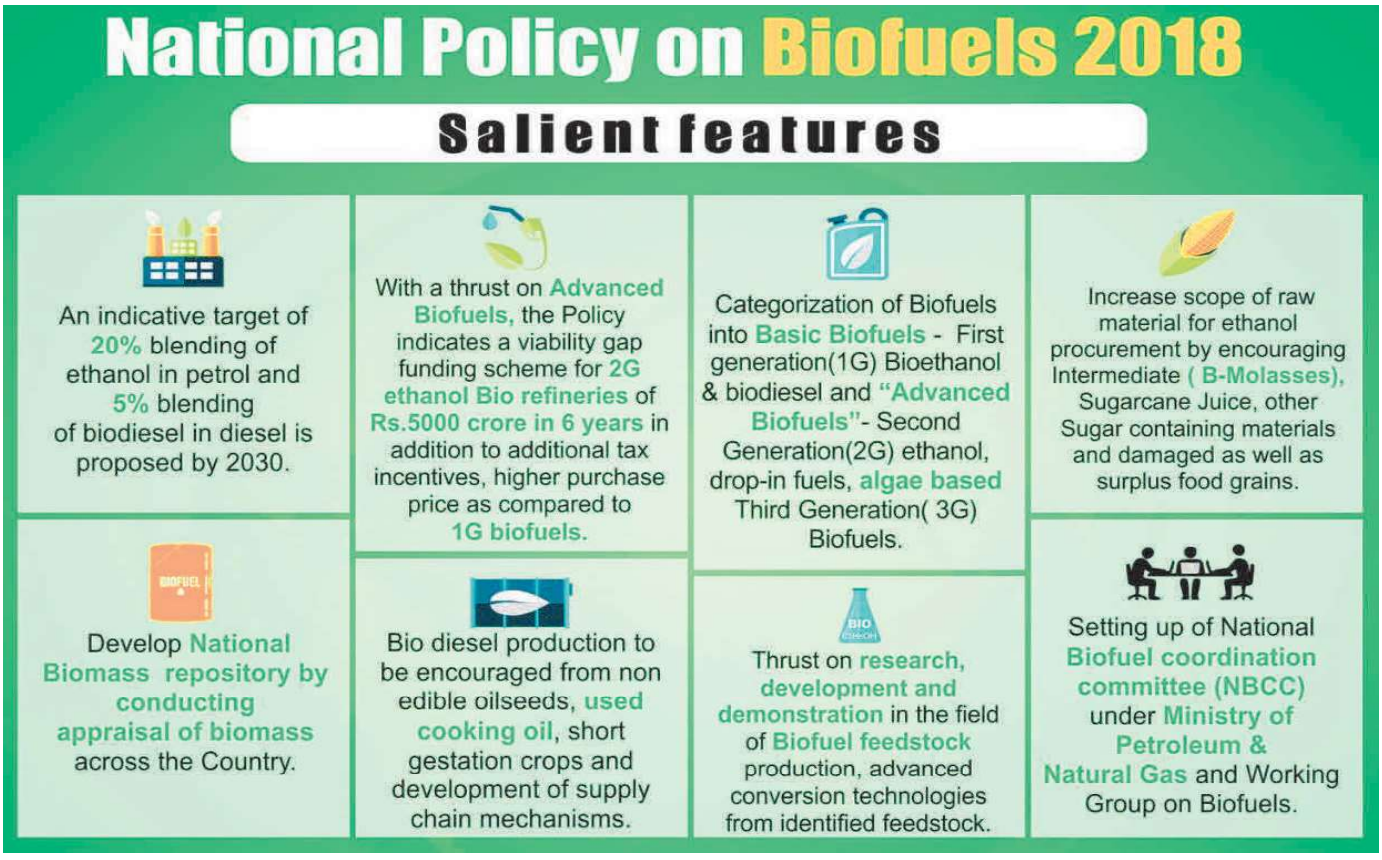
than a biofuel feedstock partly because the CO2 remains trapped and is never released by burning as with fuel stock.

- **Secondly**, the damage is done by the **carbon debt** created. Estimates have shown that deforesting native land can produce a carbon debt that can take 500 years to repay.
- **Finally**, changing land to an agricultural status almost always means fertilisers are going to be used to get the most yields per area. The problem is runoff and other agricultural pollution. Thus, creating more farmland is likely to damage waterways and energy used in treatment plants, and other mitigation strategies lead to an even larger carbon debt.

### Biofuel is less suitable for use in low temperatures

- It is more likely to attract moisture than fossil diesel, which creates problems in cold weather.
- It also increases microbial growth in the engine that clogs the engine filters.

## National Policy on Biofuels 2018




### Evolution of Indian Biofuels

| | |
|---|---|
| **1975** | India begins examining the feasibility of blending ethanol with petrol. |
| **2002** | The government **mandates the blending of 5% ethanol in some states**. |
| **2004** | Problems related to the supply of molasses as a feedstock forced the Indian government to suspend the mandatory blending of ethanol in petrol. |

| | |
|---|---|
| **2005** | The resurgence in sugar and molasses production results in renewed interest in the ethanol programme.<br>The government fixes the purchase price of ethanol by oil companies at Rs 18.25 per litre. |
| **2006** | The government announces a Biodiesel Purchase Policy, fixing the purchase price for oil companies at Rs 25 per litre. Initially, **5% biodiesel is blended with diesel**, with plans to **extend the blending to 20%**. |
| **2007** | A Biofuels Mission focusing specifically on **pongamia** and **jatropha** has also been launched. |
| **2009** | National Biofuel Policy 2009 launched. |
| **2018** | National Biofuel Policy 2018 Launched. |

- National Policy on Biofuel 2018 is a revised version of the National Policy on Biofuels made by the **Ministry of New and Renewable Energy** during the year 2009.

## The Highlights of the Policy are

1. MNRE has set a target of **20% blending of ethanol in petrol** and **5% blending of biodiesel in diesel to be achieved by 2030**. (The percentage of the same currently stands at around **2% for petrol and less than 0.1% for diesel**).
2. The Policy categorises biofuels as: -
    1. **Basic Biofuels – First Generation (1G) bioethanol** and **biodiesel**
    2. **Advanced Biofuels – Second Generation (2G) ethanol**, **Municipal Solid Waste to drop-in fuels**,
    3. **Third Generation (3G) biofuels**, **bio-CNG etc**.

- The Policy expands the scope of raw material for ethanol production by allowing the use of-
    - ✓ **Sugarcane juice**, **sugar-containing materials (like sugar beet**, **sweet sorghum) and starch-containing materials like Corn**, **Cassava**, **etc**.
    - ✓ **Damaged food grains** like wheat, broken rice, and rotten potatoes are unfit for human consumption.
    - ✓ **Surplus food grains** with the approval of the National Biofuel Coordination Committee.

**[UPSC 2020] According to India's National Policy on Biofuels, which of the following can be used as raw materials for the production of biofuels?**

1) Cassava
2) Damaged wheat grains
3) Groundnut seeds
4) Horse gram
5) Rotten potatoes
6) Sugar beet

***Select the correct answer using the code given below:***

a) 1, 2, 5 and 6 only
b) 1, 3, 4 and 6 only
c) 2, 3, 4 and 5 only
d) 1, 2, 3, 4, 5 and 6

***Answer: a) 1, 2, 5 and 6 only***

- The use of damaged food grains and surplus food grains for the production of ethanol will increase its availability for **Ethanol Blended Petrol (EBP) Programme**.
- **Bioethanol:** Fuels produced from materials that have
  - ✓ **sugar** such as sugar cane, sugar beet, sorghum, etc.;
  - ✓ **starch** such as corn, cassava, potatoes, algae, etc.;
  - ✓ **cellulosic materials** such as bagasse, waste wood, agricultural/forestry residues, etc. or
  - ✓ other renewable industrial waste falls in this category.
- **Biodiesel:** This category includes methyl or ethyl ester of fatty acids derived from **non-edible vegetable oil**, **acid oil**, **used cooking oil**, **animal fat and bio-oil**.
- **Advanced biofuels:** 2G ethanol, drop-in fuels, algae-based 3G biofuels, bio-CNG, **bio-methanol**, **dimethyl ether (DME)**derived from **bio-methanol**, **bio-hydrogen**, drop-in fuels produced from municipal solid waste (MSW), etc. have been included in this category.
- **Drop-in fuels:** These are fuels derived from biomass, Agri-residues, MSW, plastic wastes, etc., that can be used in existing engines without having to modify their fuel distribution system.
- **Bio-CNG:** These fuels are purified form of biogas produced from agricultural residues, dung, food waste, sewage water but their composition and energy potential are comparable to fossil-based natural gas.
- The Policy allows the **use of surplus food grains for the production of ethanol** for blending with petrol with the approval of the **National Biofuel Coordination Committee**.

## Ethanol Blended Petrol (EBP) Programme

- The National Policy on Biofuels-2018, approved by the Government, envisages an indicative target of **20% blending of ethanol in petrol** and **5% blending of biodiesel in diesel by 2030**.
- Under the EBP programme, ethanol blending in petrol is being undertaken by the Oil Marketing Companies.

### Revised E20 Target

- **GOI** has **advanced the target for 20% ethanol blending in petrol (also called E20)** to **2025** from **2030**. E20 will be rolled out from **April 2023** in a phased manner. **E20** fuel is a blend of **20% ethanol with gasoline**. The **current permissible level** of blending is **8.5% of ethanol**.
- An expert committee report on the **Roadmap for Ethanol Blending in India by 2025** proposes a gradual rollout E10 (10% ethanol-blended fuel) by April 2022 and phased rollout of **E20 from April 2023 to**

**April 2025** and production of E10 engine-tuned vehicles from April 2023 and **E20-tuned engine vehicles from April 2025**.

## Some Important Biofuels

### Bioethanol

- Bioethanol (aka **ethanol or ethyl alcohol ($C_2H_5OH$)**) is an **alcohol** produced from **starch and sugar crops**. It is mainly produced by **fermentation** and by **reacting ethylene with steam**.
- **Ethanol** is a **clear**, **colourless liquid**. It is biodegradable, low in toxicity and causes little environmental pollution. It burns to produce carbon dioxide and **water**. It is a high-octane fuel and has replaced lead as an **octane enhancer in petrol**.
- By blending ethanol with gasoline, we can also **oxygenate the fuel mixture so it burns more completely** and reduces polluting emissions.

### Biobutanol

- Biobutanol is a **four-carbon alcohol** produced by the fermentation of biomass. The production of biobutanol can be carried out in ethanol production facilities. Its properties are similar to that of **gasoline**.
- Some gasoline-powered vehicles can even use biobutanol **without being modified**. However, it has a **lower energy content**, **on average 10-20%**, **than that of gasoline**, which is a major disadvantage of biobutanol.
- Biobutanol exhibits the potential to **reduce carbon emissions** by 85% when compared to gasoline, thus making it a viable and suitable alternative to gasoline and gasoline-ethanol blended fuels.

### Biodiesel

- Biodiesel is made from **renewable sources** such as **vegetable/plant/animal oils** for use in diesel engines. Vegetable oils are chemically called triglycerides (fats).
- Biodiesel comprises esters of long-chain fatty acids derived from these oils. To make biodiesel, fats in the vegetable oil (triglycerides) are reacted with **alcohol** — usually **methanol**. In this reaction, glycerine (in triglycerides) is replaced by methanol to produce **methyl ester (biodiesel)**.
- Biofuel development in India centres around the cultivation of **Jatropha plant seeds** — rich in oil (40%).
- In 2008, the Indian Government announced its **'National Biofuel Policy'**. It aims to meet 20% of India's diesel demand with fuel derived from plants.

#### Biodiesel blend

- The biodiesel blend is a mix of biodiesel with fossil fuel, designated as BXX, where XX represents the volume percentage of biodiesel in the blend (**B100 means pure biofuel**). Currently, biodiesel is blended with the fossil fuel in the proportion of 2%, 5%, etc, although technically it can be used as a pure fuel with some minor modifications in existing engine systems.

- The blend ratio is based more on the available quantity of biodiesel rather than technical reasons. Filling stations in the European Union countries and the United States supply everything from B2 to B100. **Except for B100**, these blends can be **used in any existing diesel engine without any modifications**.

### Advantages of Biodiesel

- ✓ Biodiesel has **intrinsic lubricating properties** **(diesel engines are long-lasting compared to petrol engines because of this very property)** due to the presence of long-chain fatty acids.
- ✓ The **Cetane Index (CI)**, a measure of the inflammability of fuel, is more than 56 to 58 for biodiesel compared to 50/52 for fossil fuel. A higher CI value will mean **better ignition and combustion**.
- ✓ The biodiesel molecule contains about 11% oxygen, facilitating improved combustion and **less soot**.
- ✓ The **sulphur content in biodiesel is as low** as 0.001%.
- ✓ As its viscosity is similar to fossil fuel, no changes are required **in the existing fuel injection equipment**.
- ✓ It is **less toxic** and biodegradable.
- ✓ It is much safer to handle due to its **high flash point** — more than 130 °C compared to 51 °C for diesel.
- ✓ Biodiesel requires **less energy to produce** than fossil fuels (for every unit of energy needed to produce biodiesel, 3.24 units of energy are gained) (each litre of biodiesel saves 2.2 kg of greenhouse gases).
- ✓ Biodiesel production does not hurt the production of edible oil (the 'food or fuel' dilemma doesn't exist).

### ✓ Advantages over other alternative fuels

- ✓ Unlike alternative fuels such as CNG, LNG, LPG, and ethanol, biodiesel is both renewable and sustainable.
- ✓ Unlike other alternative fuels, biodiesel doesn't require significant modifications to existing infrastructure.
- ✓ CNG, LNG, LPG, etc. (**low energy content per volume** = frequent refuelling) require bigger storage space.
- ✓ Ethanol manufactured from molasses is renewable, but its calorific value is less than that of biodiesel.
- ✓ Switching to biodiesel would be **far smoother and cheaper**.
- ✓ Abundant availability of fallow land and labour, favourable weather conditions, availability of a wide range of oilseed crops such as soybean, neem, mohwa, jatropha, castor, kusum palash and karanjia.

### Biodiesel from (Used Cooking Oil) UCO

- Used Cooking Oil-based Biodiesel under the '**Randhan se Indhan** **(from cooking to fuelling)' scheme** was flagged off recently.

#### *Harmful effects of UCO*

- ➢ Repeated use and frying leads to the formation of **TPC (Total Polar Compound)**.
- ➢ It increases **trans fats** and gives rise to free radicals.
- ➢ It chokes and clogs municipal sewers and drastically **reduces the efficiency** of the **Wastewater Treatment Plants**.

- It **raises chemical oxygen demand** in the water body and severely harms the aquatic and marine life.
- It **harms the marine fauna** by coating them with oily layers, literally reducing their ability to breathe, thus **choking them to death**.

### Biogas

- Biogas is primarily **methane (50–65%)** and **carbon dioxide (35–50%)**. It is produced through a process of **anaerobic decomposition** (anaerobic digestion) from biomass.
- **Anaerobic digestion** uses the process of **fermentation** to break down organic matter. Biomass sources include agriculture residue, cattle dung, sugarcane press mud, municipal waste, etc. After purification, it is compressed and called **Compressed Bio-Gas (CBG) (pure methane content of over 95%)**. **CBG (calorific value ~52,000 KJ/kg) is similar to CNG** in its composition and energy potential.
- Biogas production is **carbon–neutral; there is no net addition of carbon to the environment** (the carbon in biogas comes from plant matter that fixed this carbon from atmospheric $CO_2$).
- Challenges: Lack of biowaste segregation and collection at the household level.

#### SATAT Scheme

- **Sustainable Alternative Towards Affordable Transportation (SATAT)** was launched in 2018 by the **Ministry of Petroleum** and **Natural Gas** in association with PSU Oil Marketing Companies (OMC) like Indian Oil Corporation Ltd.
- Under the SATAT scheme, entrepreneurs shall set up **CBG plants** and produce and supply CBG to Oil Marketing Companies (OMC) for sale as an **alternative**, **green automotive and industrial fuel**.
- Benefits of the SATAT scheme
  - ✓ Efficient tackling of urban air pollution due to farm **stubble-burning** and carbon emissions.
  - ✓ Enhance farmers' income, rural employment, and entrepreneurship.
  - ✓ Efficient treatment/disposal of **municipal solid waste**.
  - ✓ Promotion of organic farming by using **Fermented Organic Manure (FOM)** produced from CBG plants.
  - ✓ Buffer against crude oil/gas price fluctuations.

## 26.5. Hydrogen Economy

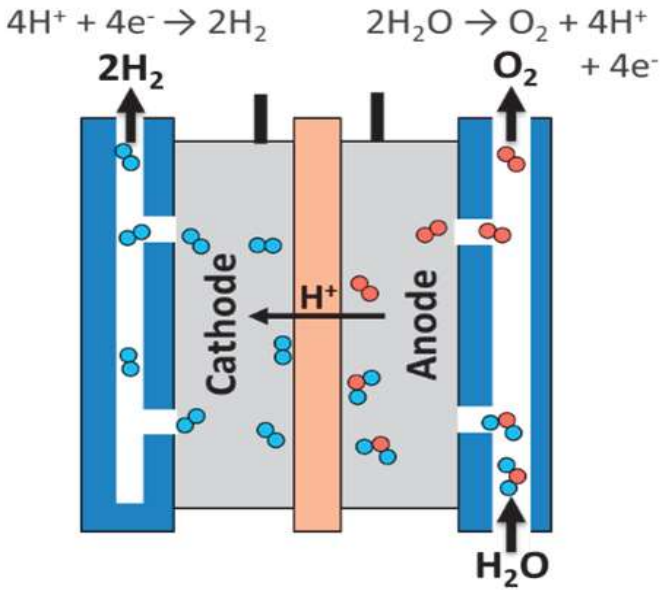
- **Hydrogen** is a **clean source of energy** because it is a **zero-emission fuel** producing only **water vapour** as a **byproduct**.
- **Hydrogen Economy** is the vision of using **hydrogen as a low-carbon energy source** (solid, liquid, or gaseous fuel) to **decarbonise** sectors such as steel, cement, transport (**1/3$^{th}$ of GHG emissions** come from this sector), etc.

### Hydrogen

- Hydrogen is the **most abundant chemical substance** in the universe. At standard temperature and pressure, hydrogen is a **non-toxic**, **odourless**, **tasteless**, **colourless**, and **highly combustible diatomic gas with the molecular formula $H_2$**.
- Being the lightest gas, it is **barely found in pure form in the earth's atmosphere**. It must be produced from other compounds such as **natural gas**, **biomass**, **alcohol**, or **water**. It is used especially in the **processing of fossil fuels** and **ammonia** (a compound of hydrogen and nitrogen).

## Hydrogen as an Energy Carrier

- Hydrogen **never occurs freely**. It has to be **produced from other sources of energy**. Hence, it is an **energy carrier (like electricity)** and **not an energy source**. Energy carriers allow the transport of energy from one place to another.
- To produce hydrogen, the **electrolysis process** is used for splitting the components of water into **hydrogen** and **oxygen**. Electrolysis is the process by which an electric current is passed through a substance to effect a **chemical change**. A chemical change is one in which the substance loses or gains an electron (oxidation or reduction).




## Hydrogen as fuel

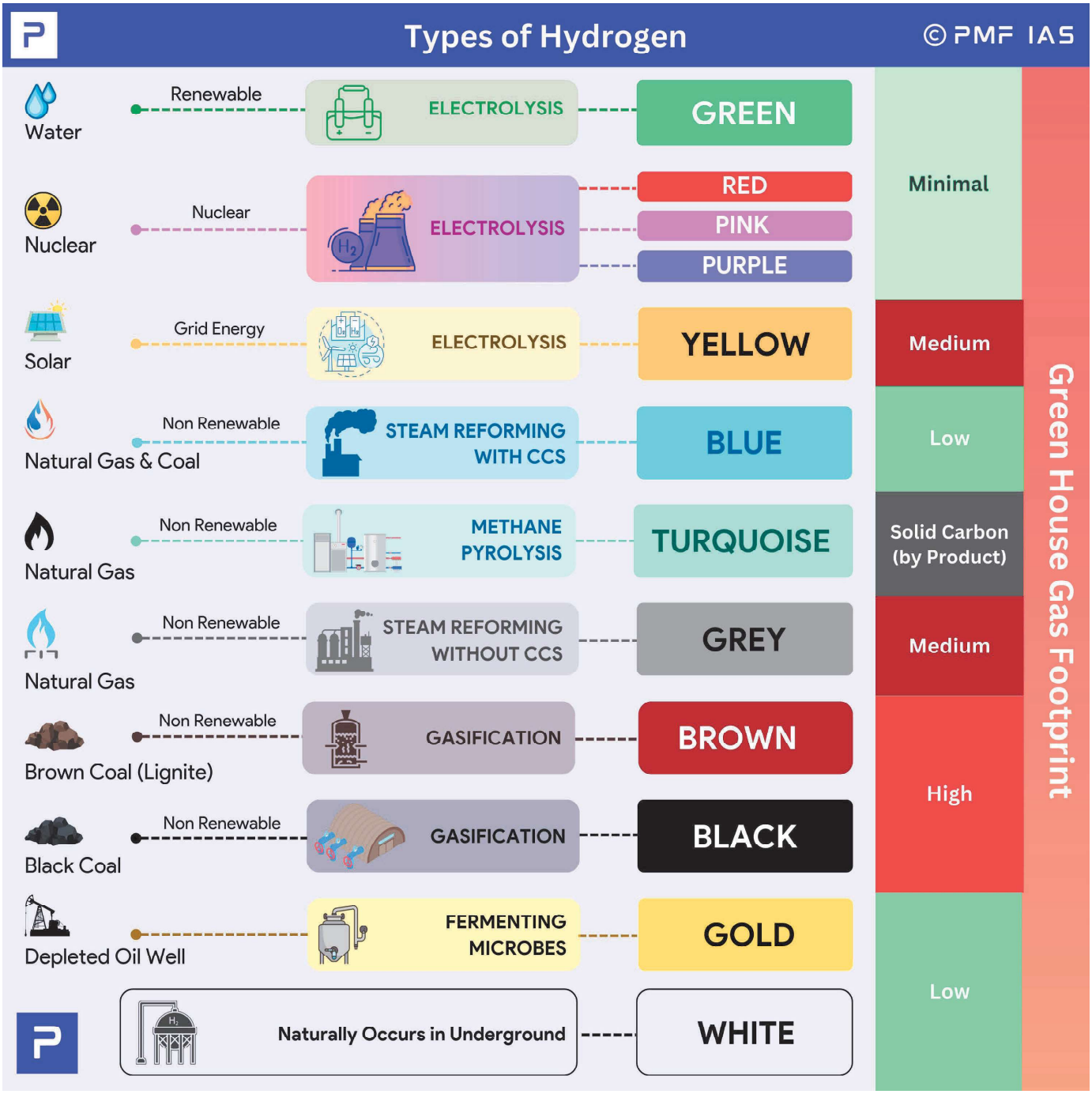
- Hydrogen fuel is abundantly available. It is **renewable** and **non-polluting** (only by-product hydrogen fuel cell leaves is **water)**. Compared to diesel or gas, $H_2$ is **more fuel-efficient** as it can produce more energy per pound of fuel.
- It can be **produced from a wide variety of resources** and can be used in a wide range of applications, such as power generation, as a transport fuel for low-carbon vehicles, etc.

## Challenges

➢ It is challenging to transport and store hydrogen.

- A **relative lack of off-the-shelf engine technology** that can currently run safely on hydrogen.
- Safety concerns due to the **high reactivity of hydrogen fuel with environmental oxygen**.
- Hydrogen has to be produced from either water or organic compounds like **methane** through **electrolysis (energy-intensive ➔ high carbon footprint)**.
- **Lack of efficient photochemical water-splitting tech**.
- Lack of fuelling station infrastructure (hydrogen vehicle economy is not promising).
- **Electric vehicles are overall a lot more efficient than hydrogen-powered vehicles**.

## Types of Hydrogen



- Based on the energy source used in the production of hydrogen, it is classified into different types:
  - **Brown Hydrogen:** Produced using **Coal without carbon sequestration**.
  - **Grey Hydrogen:** Produced using **Natural Gas/fossil fuels without carbon sequestration**.
  - **Blue Hydrogen: Produced using Natural Gas/fossil fuels with carbon sequestration**.
  - **Green Hydrogen: Produced using Renewable Energy (solar, wind, tidal)**. Carbon sequestration is not needed.

## Current Status of Hydrogen Economy in India

- Most Hydrogen in India is produced through reforming **methane ($CH_4$)**, resulting in significant **$CO_2$ emissions**. Hydrogen is used mainly as an **industrial feedstock** in the creation of **ammonia-based fertilisers**.
- The **National Hydrogen Energy Road Map** was adopted by the **National Hydrogen Energy Board** in 2006. The main objective was to identify the pathways that will lead to the **gradual introduction of hydrogen energy** and **facilitate the creation of hydrogen energy infrastructure** in the country.
- The **Union Budget for 2021-22** has announced a **National Hydrogen Energy Mission (NHM)** that will draw up a **road map for using hydrogen as an energy source**.
- The Road and Transport Ministry issued a notification proposing amendments to the Central Motor Vehicles Rules, 1989, to **include safety evaluation standards for hydrogen fuel cell-based vehicles**.
- **Delhi** became the **first city in India** to operate buses with **hydrogen-enriched CNG (HCNG)**.

### Hydrogen-enriched compressed natural gas (HCNG)

- **H-CNG** is a mixture of **compressed natural gas** and **4-9% hydrogen** by energy. Blending increases the H/C ratio of the fuel and gives it a **flame speed up to eight times higher than CNG**.
- The **Ministry of Road Transport** has allowed the use of **H-CNG (18% blending of $H_2$ with CNG)** in CNG engines. Central Motor Vehicles Rules 1989 were amended for the inclusion of H-CNG as an automotive fuel.
- HCNG **reduces hydrocarbon emissions** and **emissions of CO by up to 70%**. Engines can be calibrated to **release lower amounts of NO**.
- It is an ideal fuel for high-load applications and heavy-duty vehicles. It enables up to 5 % savings in fuel. It leads to better performance due to a **higher Octane rating of $H_2$**.

### Hydrogen Blended Natural Gas

- Blending of Hydrogen into Natural Gas is the **addition of Hydrogen** produced from renewable, nuclear, or other resources into natural gas pipelines.
- The government is planning to **blend 15% green hydrogen with piped natural gas (PNG)** for domestic, commercial and industrial consumption. The move is in line with India's ambitious targets for reducing greenhouse gas emissions and becoming **carbon neutral by 2070**.

- This initiative will be part of the government's **National Hydrogen Energy Mission** aimed at generating hydrogen from green power sources.

**[UPSC 2019] In the context of the proposals to the use of hydrogen-enriched CNG (H-CNG) as fuel for buses in public transport, consider the following statements**

1) The main advantage of the use of H-CNG is the elimination of carbon monoxide emissions.
2) H-CNG as fuel reduces carbon dioxide and hydrocarbon emissions.
3) Hydrogen up to one-fifth by volume can be blended with CNG as fuel for buses.
4) H-CNG makes the fuel less expensive than CNG.

***Which of the statements given above is/are correct?***

a) 1 only
b) 2 and 3 only
c) 4 only
d) 1, 2, 3 and 4

**Explanation**

- ***H-CNG reduces CO emissions. It does not eliminate it completely.***

***Answer: b) 2 and 3 only***

**[UPSC 2023] With reference to green hydrogen, consider the following statements:**

1. It can be used directly as a fuel for internal combustion.
2. It can be blended with natural gas and used as fuel for heat or power generation.
3. It can be used in the hydrogen fuel cell to run vehicles.

***How many of the above statements are correct?***

a) Only one
b) Only two
c) All three
d) None

**Explanation**

- Hydrogen being combustible can be directly used in IC engines either independently or by blending.
- Fuel cell electric vehicles produce electricity using a fuel cell powered by hydrogen.

***Answer: c) All***

## Green Hydrogen – Future of Hydrogen Economy

✓ It **releases no carbon by-products** because it is produced using **renewable energy**. **Water** and **water vapour** are the only by-products. So it has a **low carbon footprint**.

✓ It is very difficult to use renewable energy as a steady source of energy supply. So, green hydrogen helps in the utilisation of renewable energy while meeting the energy needs steadily.

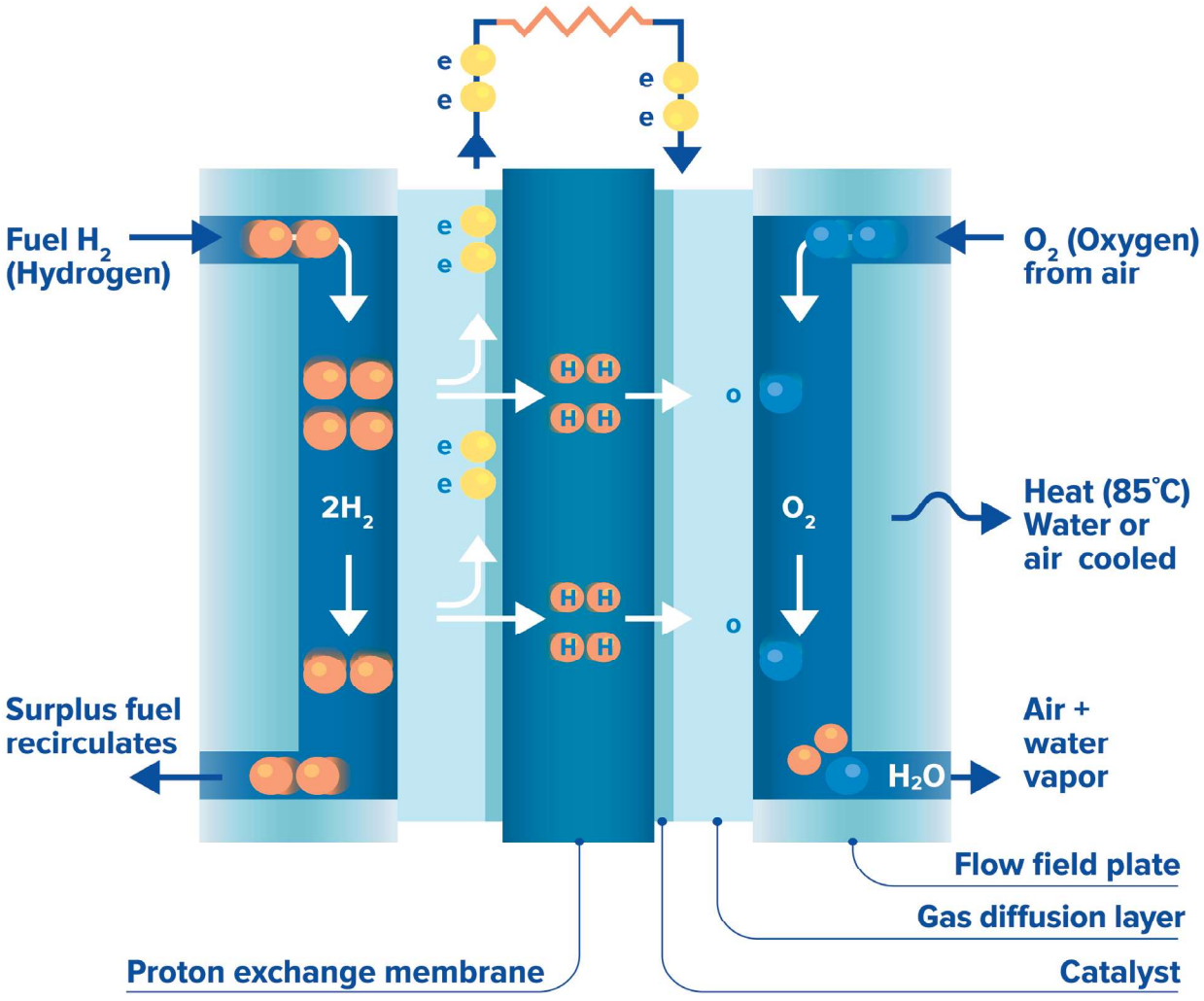
✓ It is light, storable for a long time and **energy-dense** (storing a large amount of energy in relation to its volume). So, it is suitable for long-distance mobilisation.

### Challenges in the use of Green Hydrogen

- High transportation cost of renewable energy required in green hydrogen production.
- High cost of production, lack of infrastructure, and limited technology to use green hydrogen in different sectors.

## Hydrogen Fuel Cell

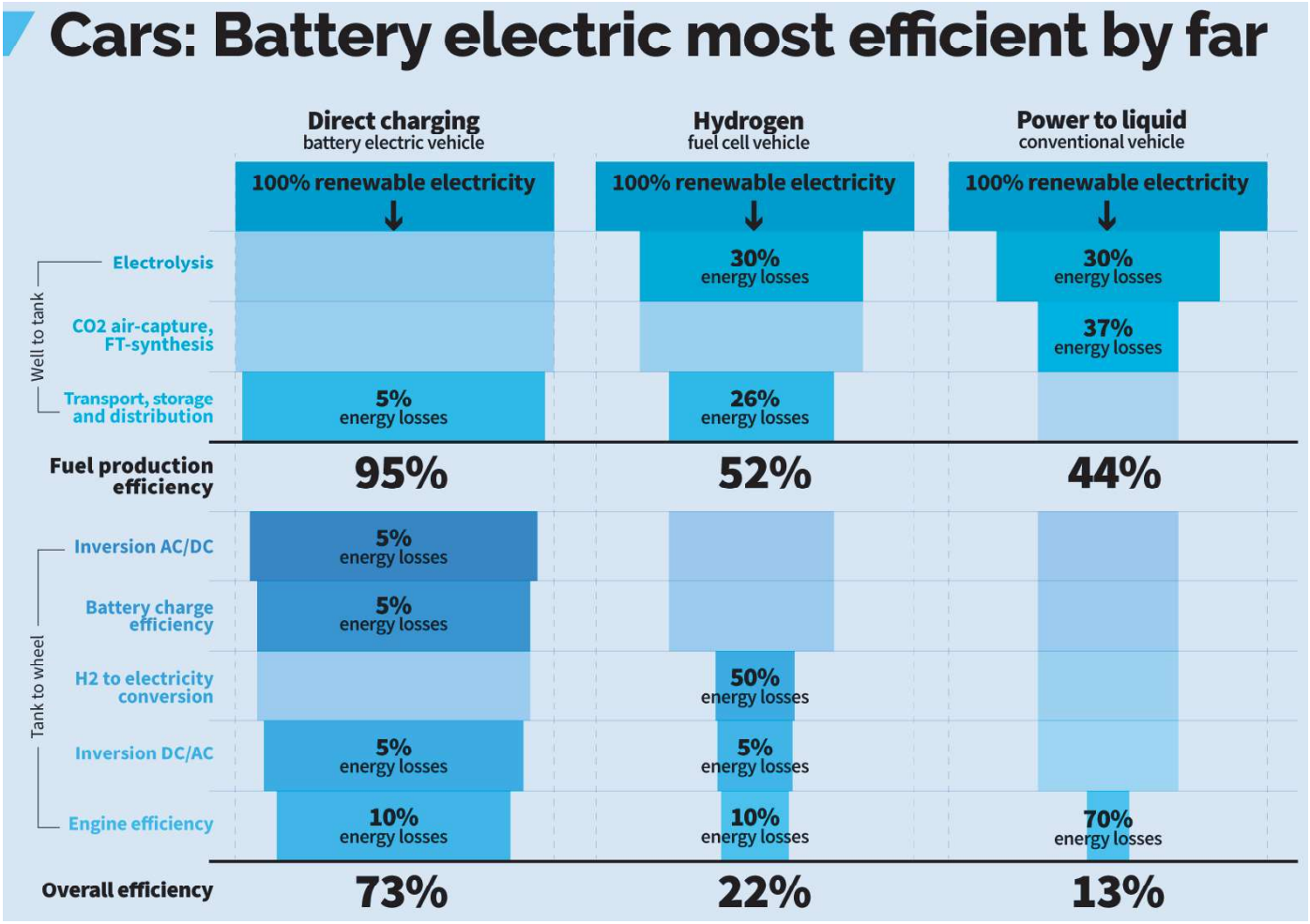
- Hydrogen is transformed into electricity by a device called a **fuel cell stack** to power a car or truck. A hydrogen fuel cell is an **electrochemical device** **(chemical energy → electrical energy)** that produces electrical energy using hydrogen and oxygen through an **oxidation-reduction reaction**.




- A fuel cell, like conventional cells, consists of an **anode** and **cathode** sandwiched around an **electrolyte**. Hydrogen is fed to the anode, and oxygen is fed to the cathode. At the anode, a **catalyst** (it increases the rate of a chemical reaction), usually made from **platinum** or **palladium** or **gold** separates the hy-

drogen molecules (through oxidation) into **protons** (positively charged subatomic particles) and **electrons** (negatively charged subatomic particles) and then both **subatomic particles** (a particle which is smaller than an atom in size) take different paths to the cathode.

- The electrons go through an external circuit, creating a flow of electricity. The protons move to the cathode through the electrolyte, where they unite with oxygen and electrons to produce the by-products (water, air and heat).
- **Hydrogen** and **phosphoric acid** are the most common types of fuel cells, although fuel cells that run on **methanol**, **ethanol**, and **natural gas** are also available.
- **Advantages of fuel cells:** Fuel cells are more efficient than thermal power plants (thermal energy → mechanical energy → electrical energy ➔ less efficient due to loss of energy in the form of heat) as there is a **direct conversion of chemical energy into electrical energy**.
- **Disadvantages of Fuel Cells:** Fuel cells are costly to produce (**platinum** and **palladium catalysts are expensive**).




**In the Decreasing order of overall efficiency: EVs > Hydrogen > Diesel > Petrol vehicles**

## National Hydrogen Mission

- Launched in 2021, the **National Hydrogen Mission** aims to aid the government in meeting its climate targets under the **Paris Agreement (2015)** and making India a **green hydrogen hub**. The mission provides various benefits to **Green Hydrogen** and **Green Ammonia manufacturers**.

## National Green Hydrogen Mission (NGHM)

- With a vision to make India an energy-independent nation and to decarbonise critical sectors, the Government approved the **National Green Hydrogen Mission (NGHM)** in January 2023 with an initial outlay of **INR 19,744 crore**. The Mission will facilitate demand creation, production, utilisation and export of Green Hydrogen and mobilisation of over INR 8 lakh crore of investment by 2030.
- NGHM will be crucial for decarbonising harder-to-abate sectors such as fertilisers, refining, methanol, maritime shipping, iron and steel and long-haul transport. Green hydrogen is also an important element of **India's Long Term Low Emissions Development Strategy (LT-LEDS)**.

## Salient Features of the National Green Hydrogen Mission

### Likely Outcomes by 2030

✓ Green hydrogen production capacity of at least **5 MMT (Million Metric Tonne) per annum**.
✓ Cumulative reduction in fossil fuel imports over INR 1 lakh crore and creation of over 6 lakh jobs.
✓ Renewable energy capacity addition of about **125 GW** and abatement of nearly **50 MMT of annual GHG emissions**.

### Interventions

✓ Financial incentive targeting domestic manufacturing of **electrolysers** and production of Green Hydrogen.
✓ Regions capable of supporting large scale production and/or utilisation of Hydrogen to be developed as **Green Hydrogen Hubs**.

### Policy Framework

❖ Development of an enabling policy framework to support the establishment of a Green Hydrogen ecosystem.
❖ Robust Standards and Regulations framework.
❖ Public-private partnership framework for R&D.

## Opportunities

✓ In India, renewable tariffs have fallen in recent years, and electrolyser costs are expected to fall in the future.
✓ NITI's report estimates that the cumulative value of the green hydrogen market in India will be US$ 8 billion by 2030 and US$ 340 billion by 2050.
✓ The electrolyser market will be approximately US$ 5 billion by 2030 and US$ 31 billion by 2050.

✓ The adoption of green hydrogen will also result in **3.6 Giga tonnes of cumulative $CO_2$ emission reduction by 2050**.

### Challenges

- The cost of electrolysers is crucial for making green hydrogen economically viable. Hence, there is a need for innovation in electrolyser technology and the rapid increase in its scale of production to **drive down the cost of electrolysers** and green hydrogen.
- Access to **critical minerals essential for renewable energy** at a reasonable cost will continue to be an effective constraint in the face of the concentration of these minerals in certain geographies, with a monopoly in access to some countries.

## 26.6. Challenges Faced by Renewable Energy

- Wind and solar power have a **lower plant load factor (PLF) than thermal power**. Therefore, renewable capacity addition needs to be higher than for thermal plants to generate the same amount of electricity.
- Renewable energy **relies on intermittent sources** like sun, wind, tides, etc., and hence, its **output is constrained to specific hours of the day**. This can create **issues in matching peak power demand**.
- For example, solar output is maximum between 11 am and 3 pm, while wind output is highest in the late evening and early morning. However, peak demand for power is reached in the evening hours of 6-9 pm, which cannot be catered to by either wind or solar.
- Its usage leads to **lower utilisation of transmission lines** and, hence, **relatively increased costs of transmission**. The NITI Aayog observed that electricity buyers in poor states are relatively less willing to purchase renewable electricity due to higher costs than conventional sources.
- Distribution companies **(DISCOMS) in India are loss-making** and **unable to build infrastructure to help transition to renewable energy sources**.

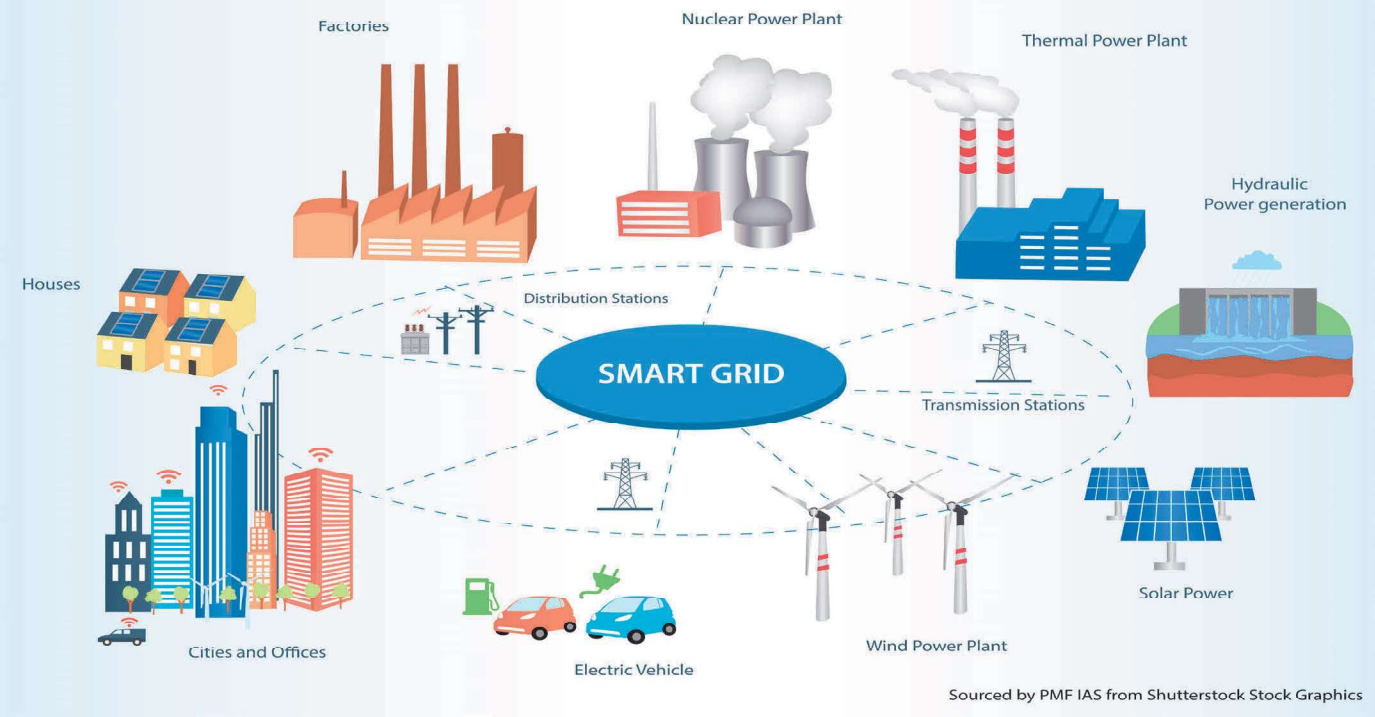
### Smart Grid to Address the Challenges

- Smart grid uses digital technology that allows for two-way communication between the utility and its customers, and the sensing along the transmission lines for **efficient management** of the distribution system.
- Smart Grid will consist of controls, computers, **automation**, and new technologies and equipment working together with the electrical grid to respond digitally to quickly changing electric demand. Smart grids are essential for reliability, availability, and efficiency.
- **National Smart Grid Mission (NSGM):** The Mission was launched in 2015. It seeks to plan and monitor the implementation of policies and programmes related to Smart Grid.

**The benefits associated with the Smart Grid include:**

✓ More efficient transmission of electricity

- ✓ Quicker restoration of electricity after power disturbances
- ✓ Reduced peak demand
- ✓ **Increased integration of large-scale renewable energy systems**




## Hybrid Energy Systems

- To overcome the shortcomings in renewable sources of energy, there is a need to focus on hybrid systems of energy storage and supply to cut down costs and ensure a continuous supply of electricity.

### What do hybrid systems constitute?

- Hybrid systems of energy storage and supply include **flexible energy resources** that can **rapidly ramp up or down power supply as needed**.
- These could include hydro or gas-based power or energy storage solutions (**batteries**).

### How do they work?

- Hybrid systems store excess energy during renewable generation hours and release it into the grid during peak demand hours. In this way, it can provide both baseload and flexible 24x7 clean energy.

### The cost advantages

- ✓ Hybrid systems are becoming increasingly cost-competitive, driven by reducing costs of battery storage.
- ✓ Also, Li-ion battery costs are expected to fall from the current $220-240/kWh to below $100 in the next 3-4 years.
- ✓ Similarly, costs of solar energy have plummeted from ₹4.63/kWh in 2016 to ₹2.50/kWh in the latest auctions.

### Can hybrid systems substitute coal-fired power plants?

- The hybrid systems can potentially be competitive with 30-40% of existing coal-fired stations in India.

## Critical Minerals are the Key to Green Transition

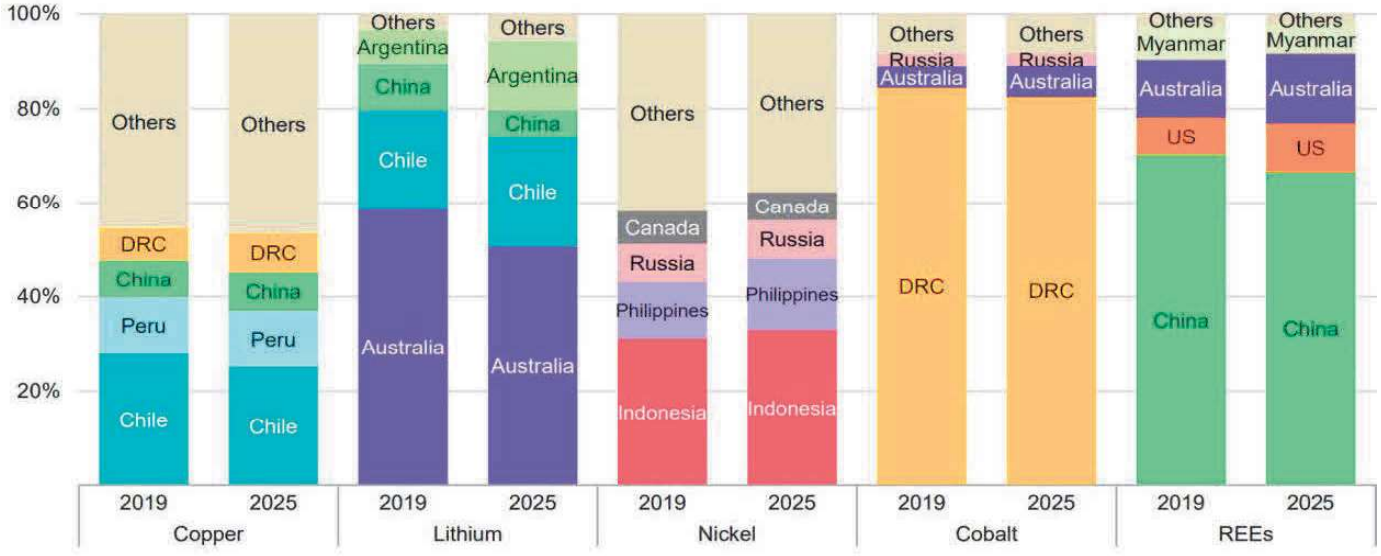
- Solar photovoltaic (PV) plants, wind farms and electric vehicles (EVs) **generally require more minerals than their fossil fuel-based counterparts**. A typical electric car requires six times the mineral inputs of a conventional car, and an onshore wind plant requires nine times more mineral resources than a gas-fired plant.
- **Cobalt**, **copper**, **lithium**, **nickel**, and **rare earth elements (REEs)** are critical for producing **electric vehicles** and **batteries** and **harnessing solar power** and **wind energy**.
  - ✓ **Lithium**, **nickel**, **cobalt**, **manganese** and **graphite** are crucial to **battery performance**, **longevity** and **energy density**.
  - ✓ **REEs** are essential for **permanent magnets** that are vital for **wind turbines** and **EV motors**.
  - ✓ Electricity networks need a huge amount of **copper** and **aluminium**, with copper being a cornerstone for all electricity-related technologies.

### Challenges to India

- While the demand for critical minerals is set to increase because of the global preference and emphasis towards renewable energy, the global supply chain of critical minerals is **highly concentrated** and **unevenly distributed**. The skewed distribution poses a **supply risk** in the face of its enhanced demand.

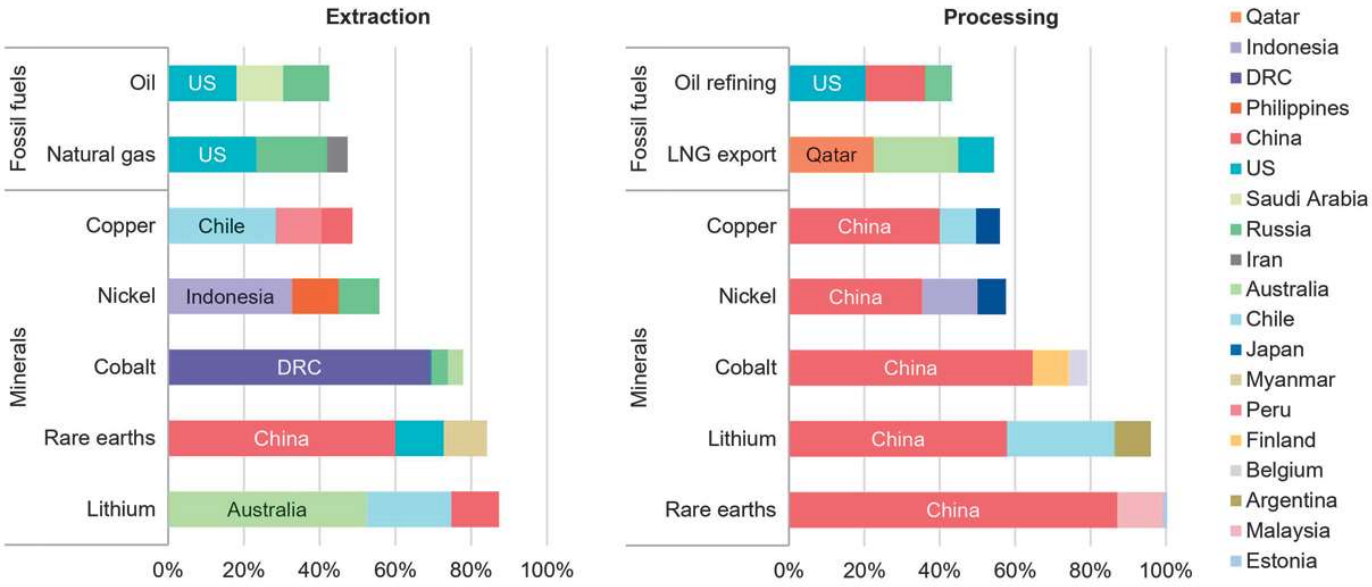
### Measures required

- A well-crafted multidimensional mineral policy would reduce our dependence. India has resources of **nickel**, **cobalt**, **molybdenum**, and **heavy REEs**, but further exploration would be needed to evaluate the reserves.




***Concentration of production of selected minerals in 2019 and 2025***

Share of top three producing countries in production of selected minerals and fossil fuels, 2019




- Recently, the Geological Survey of India (GSI) discovered **5.9 mt of lithium** deposits in the G3 category (quantities associated with a known deposit that can be estimated with a low level of confidence) in the **Salal-Haimana area of the Reasi District of J&K**. This was the first discovery of lithium deposits in the country.
- There is a need to create **strategic mineral reserves** along the lines of strategic petroleum reserves to ensure a continuous supply of minerals.
- Policies should consider investing in internal research, including technological innovation for mineral exploration and processing and the development of Recycling, Reusing, and Repurposing (R3) technologies.

## KABIL to Ensure Supply of Critical Minerals

- In order to ensure the mineral security of the nation and to attain self-reliance in the area of critical and strategic minerals, the **Ministry of Mines** has created a joint venture company, namely **Khanij Bidesh India Ltd**. **(KABIL)**, with the participation of three Central Public Sector Enterprises:
  1. **National Aluminium Company Ltd**. **(NALCO)**,
  2. **Hindustan Copper Ltd**. **(HCL) and**
  3. **Mineral Exploration Company Ltd**. **(MECL)**.
- The equity participation between NALCO, HCL and MECL is in the ratio of 40:30:30.
- The objective of constituting KABIL is to ensure a consistent supply of **critical and strategic minerals** to the Indian domestic market. Among such twelve minerals identified as strategic minerals, which have a meagre resource base, **lithium** and **cobalt** are significant.

## KABIL functions

- The KABIL would carry out identification, exploration, development, mining and processing of strategic minerals **overseas** for commercial use and meeting country's requirement of these minerals.
- The new company will help in building partnerships with other mineral rich countries like Australia and those in Africa and South America.
- **KABIL (Ministry of Mines)** and the Government of Australia signed an MoU for cooperation in the field of mining/processing of critical/strategic minerals like lithium and cobalt.

⇨ ***[UPSC 2017] "In spite of adverse environmental impact, coal mining is still inevitable for development". Discuss.***

⇨ ***[UPSC 2022] Do you think India will meet 50% of its energy needs from renewable energy by 2030? Justify your answer. How will the shift of subsidies from fossil fuels to renewables help achieve the above objective? Explain. (250 words)***

## 26.7. Measures to Boost Renewable Energy

### Indian Renewable Energy Development Agency

- IREDA is a **Mini Ratna (Category – I) Public Limited Government Company**. It is **under** the administrative control of the **Ministry of New** and **Renewable Energy**.
- IREDA is established as a **Non-Banking Financial Institution** in **1987**. It is **engaged in** promoting, developing and extending financial assistance for setting up projects relating to new and renewable sources of energy and energy efficiency/conservation with the motto: **"Energy for Ever"**.

#### Objectives

❖ To **give financial support** to specific projects and schemes for generating electricity/energy through renewable sources and conserving energy through energy efficiency.

❖ To **increase IREDA's share** in the **renewable energy sector** by way of innovative financing.

**[UPSC 2015] With reference to the Indian Renewable Energy Development Agency Limited (IREDA), which of the following statements is/are correct?**

1) It is a Public Limited Government Company.
2) It is a Non – Banking Financial Company.

Select the correct answer using the code given below.

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 or 2

***Answer: c) Both 1 and 2***

### Green Bonds for Funding Renewables

- SEBI has strengthened the framework for **green bonds** by **enhancing the scope of the definition of green debt security** by including new modes of sustainable finance — '**blue**' and '**yellow**' bonds (sub-categories of **green debt securities**) — in relation to pollution prevention and control and eco-efficient products.
- **Blue bonds relate to water management and the marine sector**, while **yellow bonds pertain to solar energy**.
- **Blue bonds** are modes of sustainable finance raised for **sustainable maritime sector including sustainable fishing**, **sustainable water management** etc.
- **Yellow bonds** are modes of **sustainable finance raised for solar energy generation and the associated upstream and downstream industries**.
- These measures have been taken in the backdrop of **increasing interest in sustainable finance** in India as well as around the globe, and with a view to aligning the extant framework for green debt securities with the updated **Green Bond Principles (GBP)**.

## Green Bonds

- The regulatory framework defines **Green Debt Securities** as debt securities issued for **raising funds that are to be utilised for projects or assets falling under certain (environmentally sustainable) categories**.
- Indian companies raised nearly $7 billion through ESG (Environmental, Social and Governance) and green bonds in 2021, compared to $1.4 billion in 2020.
- Most of the green bonds issued by Indian issuers are listed on offshore exchanges as issuers are finding it more attractive to list on bourses falling outside SEBI's framework.

## Need for green bonds

- Over the last few years, **Green Bonds have emerged as an important financial instrument to deal with the threats of climate change and related challenges**.
- According to the **International Finance Corporation (IFC)**, a **World Bank Group's institution**, climate change threatens communities and economies, and it poses risks to agriculture, food, and water supplies. A lot of financing is needed to address these challenges. It's critical to **connect environmental projects** with **capital markets** and **channel capital towards sustainable development** – and Green Bonds are a way to make that connection.

## Sovereign green bonds

- **Sovereign green bonds** are **issued by governments** to raise resources for environmentally sustainable projects. In the Union Budget for 2022-23, the government announced that it will be issuing **sovereign green bonds** as part of its overall market borrowings to mobilise resources for green infrastructure.

- The government plans to invest the funds raised through the issue of green bonds in environmentally sound and sustainable projects that would help in reducing the carbon intensity of the economy.

## 26.8. Energy Conservation Measures

⇨ *The cover decision of COP 27, titled the **Sharm el-Sheikh Implementation Plan**, notes the 'importance of the transition to sustainable lifestyles and sustainable patterns of consumption and production for efforts to address climate change'.*

### Energy Conservation Act 2001

- It is a legal framework that regulates energy consumption and promotes energy efficiency and energy conservation. It applies to **appliances**, **vehicles**, **industrial** and **commercial establishments and buildings**.
- The act provides for the **legal framework** and **regulatory mechanism** at the **Central and State levels** to embark upon an energy efficiency drive in the country.
- **5 major provisions of the EC Act relate to:**
    1) Designated Consumers
    2) **Standard and Labelling of Appliances**
    3) **Energy Conservation Building Codes**
    4) **Creation of the Bureau of Energy Efficiency**
    5) Establishment of **Energy Conservation Fund**
- **ECA Amendment Act 2010:** It empowered the Central Government to issue the **energy savings certificate to the designated consumer** whose energy consumption is less than the prescribed norms.

### Bureau of Energy Efficiency (BEE)

- The Bureau of Energy Efficiency is a **statuary agency** under the **Ministry of Power**. It was created in 2002 under the provisions of the **2001 Energy Conservation Act**.
- BEE's function is to develop programs that will increase the conservation and efficient use of energy. It **mandatory for certain appliances in India to have BEE ratings**.

### Energy Conservation Building Code (ECBC)

- It was launched by the **Ministry of Power** in 2007. It sets minimum energy standards for **commercial buildings** with a connected load of 100kW or contract demand of 120 KVA and above. Implementation of code is **voluntary in nature**.

#### ECO Niwas Samhita 2018

- The **Ministry of Power** has launched the ECO Niwas Samhita 2018. It is also known as **Energy Conservation Building Code for Residential Buildings (ECBCR)**.

- Eco Niwas Samhita aims to benefit the occupants and the environment by **promoting energy efficiency** in the design and construction of homes, apartments and townships.

## Stars and Labelling Programme (BEE Star Label)

- The star rating system is a labelling system under which the manufacturer is required to place a label indicating how much electricity the appliance is likely to consume under pre-set conditions.
- **BEE** initiated the Standards and Labelling programme for equipment and appliances in **2006**. It aims to provide the consumer with an **informed choice about energy saving** and, thereby, the cost-saving potential of the relevant marketed product. The scheme is invoked for 23 equipment/appliances, including 10, **for which it is mandatory**.

### Mandatory Appliances

1. **Room Air Conditioners**
2. **Frost Free Refrigerators**
3. **Tubular Florescent Lamp**
4. **Distribution Transformer**
5. **Room Air Conditioner (Casettes**, **Floor Standing Tower**, **Ceiling**, **Corner AC)**
6. **Direct Cool Refrigerator**
7. **Color TV**
8. **Electric Geysers**
9. **Inverter Air conditioners**
10. **LED Lamps**

### Voluntary Appliances

1. **Induction Motors**
2. **Agricultural Pump Sets**
3. **Ceiling Fans**
4. Domestic Liquefied Petroleum Gas (LPG) Stoves
5. **Washing Machine**
6. Computer (Notebook /Laptops)
7. Ballast (Electronic/Magnetic)
8. Office equipment's (Printer, Copier, Scanner, MFD's).
9. Diesel Engine Driven Monoset Pumps for Agriculture
10. Soli State Inverter
11. **Diesel Generator**
12. Chillers
13. Microwave Ovens

**[UPSC 2016] On which of the following can you find the BEE Star Label?**

a) Ceiling fans
b) Electric geysers
c) Tubular fluorescent lamps

***Select the correct answer using the code given below.***

a) 1 and 2 only
b) 3 only
c) 2 and 3 only
d) 1, 2 and 3

***Answer: d) all***

## Chiller Star Labelling Program

- It was launched by the **Ministry of Power**. It has been formulated by **BEE**. It encourages the deployment of **Energy Efficient Chiller Systems** in the country by providing star rating in terms of its energy performance.
- This initiative will promote advancement technology for central **HVAC (Heating**, **ventilation**, **and air conditioning) systems** and will also facilitate **energy-efficient solutions for** large commercial and industrial applications.

### What are Chillers?

- Chillers are used extensively for space conditioning of buildings and industrial **cooling applications**. Chillers are **energy-intensive systems** that contribute more than 40% of the total energy consumption in commercial buildings.

## UJALA and SLNP

**Unnat Jyoti by Affordable LEDs for All (UJALA)** and **LED Street Lighting National Programme (SLNP)**.

- SLNP is the world's largest streetlight replacement programme. UJALA is the world's largest domestic lighting project. Both have been implemented by **Energy Efficiency Services Limited (EESL)**, a **joint venture of PSUs under the Ministry of Power**.
- Under the SLNP programme, over 1.03 crore smart LED streetlights have been installed to date. This enabled an estimated greenhouse gas (GHG) emission reduction of 4.80 million $tCO_2$ annually.
- Through the UJALA initiative, over 36.13 crore LED bulbs have been distributed across India. This has resulted in an estimated GHG emission reduction of 38 $mtCO_2$ annually.
- Apart from this, the Government of India initiated the **Gram Swaraj Abhiyan (GSA)** in 2018, which was aimed at apprising rural communities of various government welfare schemes and initiatives.

## New Energy Performance Standards for ACs

- The **Bureau of Energy Efficiency (BEE)** has notified new energy standards for Room Air Conditioners. The **24 °C default setting** has been made mandatory from Jan 1, 2020, for all room air conditioners (RACs) covered under the ambit of the BEE star-labelling program.
- Additionally, the **Indian Seasonal Energy Efficiency Ratio (ISEER)** as per the new standards will be applicable from 1st January 2021 onwards.

### Benefits of "24 °C default setting" for ACs

✓ As per BEE, the total connected load in India due to air conditioning will be 200 GW by 2030. Every 1°C increase in the AC temperature setting results in a saving of **6% of electricity consumed**. The 24°C default setting will result in savings of 20 billion units of electricity in one year alone.

✓ Normal human body temperature is approximately 36-37°C, commercial establishments, hotels and offices maintain temperature around 18-21°C. This is not only uncomfortable but is actually unhealthy.

## Indian Seasonal Energy Efficiency Ratio (ISEER)

- Previously, the star rating of ACs in India worked using the **Energy Efficiency Ratio (EER)**. EER is the ratio of **cooling capacity to power input**. Air conditioners with higher EER are preferred, as these are more efficient.
- In many countries, the **Seasonal Energy Efficiency Ratio** is used for calculating the energy efficiency of the air conditioner as there is season-wise variation in temperature. Taking this into consideration, BEE has defined the **Indian Seasonal Energy Efficiency Ratio (ISEER)** for **ACs as a star rating method for India** from January 2018.
- ISEER is the ratio of Cooling Seasonal Total Load (CSTL) to Cooling Seasonal Energy Consumption (CSEC).

## Sustainable Energy for All (SE4All)

- It is a **multi-stakeholder partnership** between governments, the private sector and civil society. It was launched by the **UN Secretary-General in 2011**. It supports progress on **Sustainable Development Goal 7** and the **Paris Agreement** by meeting 3 interlinked objectives to be **achieved by 2030:**
  - ✓ **Double the rate of improvement in energy efficiency**.
  - ✓ **Double the share of renewable energy in the energy mix**.
  - ✓ **Universal access to modern energy services**.

# The Energy Conservation (Amendment) Bill, 2022

- Rajya Sabha passed the **Energy Conservation (Amendment) Bill**, **2022**, which proposes to amend the **Energy Conservation Act 2001**.

## Objectives of the Energy ConservationBill, 2022

- The Bill is enacted to address the following objectives:

✓ To achieve **revised Nationally Determined Contributions (NDCs)** adopted at **COP-26 (Glasgow) goals**

- ✓ To mandate the use of **non-fossil sources** (including **green hydrogen**, **green ammonia**, **biomass**, **ethanol** and feedstock)
- ✓ To establish **carbon markets** in the country

## Provisions of the Energy Conservation Bill, 2022

### Mandatory use of non-fossil sources of energy

- The Bill empowers the **Central government** to specify the designated consumers to meet a minimum share of energy consumption from non-fossil sources. Different consumption thresholds may be specified for different non-fossil sources and consumer categories.

⇨ *Designated consumers: They include - (i) industries such as mining, steel, cement, textile, chemicals, and petrochemicals, (ii) the transport sector, including Railways, and (iii) commercial buildings, as specified in the schedule.*

### Carbon trading

- The Bill empowers the Central Government or any authorised agency to issue **carbon credit certificates** to entities registered under the scheme. The entities will be entitled to purchase or sell the certificate. Any other person may also purchase a credit certificate on a voluntary basis.

⇨ ***Carbon credit:*** *It implies a tradeable permit to produce a specified amount of carbon emissions.*

### Energy conservation code for buildings

- The 2001 Act allowed the Central government to specify an 'energy conservation code for buildings', which is prescribed in terms of **area**.
- ✓ The 2022 Bill amends this to provide for an '**energy conservation and sustainable building code**', which will provide norms for energy efficiency, use of renewable energy, and other requirements for **green buildings**.

### Applicability to residential buildings

- Under the 2001 Act, the 'energy conservation code' applies to **commercial buildings** having a minimum connected load of 100 kilowatts (kW) or contract load of 120 kilo volt-ampere (kVA).
- ✓ Under the 2022 Bill, the new 'energy conservation and sustainable building code' **will also apply to the office and residential buildings** meeting the above criteria. It also **empowers the state govts to lower the load thresholds**.

### Standards for vehicles and vessels

- Under the 2001 Act, the energy consumption standards can be specified for equipment and appliances that consume, generate, transmit, or supply energy.
- ✓ The 2022 Bill **expands the scope to include vehicles** (as defined under the Motor Vehicles Act, 1988), and vessels (ships and boats). Failure to comply with standards will be punishable with a penalty.

**Regulatory powers of SERCs**

- The 2001 Act entrusted the State Electricity Regulatory Commissions (SERCs) to adjudge penalties under the Act.

✓ The Bill empowers SERCs also to make regulations for discharging their functions.

**Composition of the governing council of BEE**

- The 2001 Act provided for the setting up of the **Bureau of Energy Efficiency** (BEE).

✓ The Bill proposes to strengthen the composition of BEE and make it more representative.

**---------- End of Chapter ----------**

# 27. Water Conservation

A hundred cities worldwide, including **30 in India**, face the risk of severe water scarcity by 2050 due to a dramatic increase in their population percentage to 51 % by 2050, from 17 % in 2020, according to a recent report by the World Wide Fund for Nature (WWF). The cities include global hubs such as Beijing, Jakarta, Johannesburg, Istanbul, Hong Kong, Mecca and Rio de Janeiro. **More than half** of the identified cities are from China and India. **Jaipur** topped the list of Indian cities, followed by Indore and Thane. Mumbai, Kolkata, and Delhi are also featured on the list. Difference between Water Scarcity, Water stress and Water risk

| Water Scarcity | Water Stress | Water Risk |
|---|---|---|
| • "Water scarcity" refers to the **lack of adequate availability or supply of water**.<br>• Water scarcity is a physical, objective reality that can be measured consistently across regions and over time.<br>• **"Water scarcity"** is one aspect of many that contribute to **"water stress."**<br>• **An area could be highly water-stressed but not water-scarce** if, for example, it had **water pollution** but plentiful supplies of contaminated water. | • "Water stress" refers to the **ability**, **or lack thereof**, to meet human and ecological demand for water.<br>• It is caused either due to **water scarcity** or the **unusable nature of the available water**.<br>• Compared to scarcity, "water stress" is a more inclusive and broader concept.<br>• It considers several physical aspects related to water resources, including water scarcity, but also **water quality**, **environmental flows**, and the **accessibility of water**. | • "Water risk" refers to the **probability of an entity experiencing a deleterious water-related event**.<br>• Water risk is **felt differently by every sector of society** and the organisations within them and thus is defined and interpreted differently.<br>• For example, areas or sectors with poor water management can be at "water risk" sooner or later. Cities like Bengaluru are at "water risk" due to the rampant encroachment of water bodies. |

- **Water-scarce regions:** Rajasthan, Gujarat, **rain-shadow part of Western Ghats** (Hyderabad-Karnataka, Vidarbha), and other drought-prone regions.
- **Water stress regions (spatial pattern of water stress):** All the **water-scarce regions** plus the regions affected by
  - ✓ **Urban and industrial pollution** (Ganga-Yamuna industrial region, mining hotbeds like Odisha, Jharkhand and metropolitan cities like Mumbai and Bengaluru),
  - ✓ **alkalinity and salinity** (overexploited regions like Punjab-Haryana),
  - ✓ **marine saline ingress** (coastal regions affected by cyclones and storm surges or sea-level rise)

⇨ ***[UPSC] What is water stress? How and why does it differ regionally in India?***

⇨ ***Mains Practise: What is the difference between water scarcity and water stress? Describe the spatial pattern of water stress in India.***

## 27.1. India's Water Situation

- India accounts for 16% of the world's population, living in less than **2.5% of the global area** and has **just 4% of the worldwide water resources**.
- Water scarcity is **prevalent in the basins** of the Indus, Krishna, Cauvery, Subarnarekha, Pennar, Mahi, Sabarmati and east-flowing rivers, and west-flowing rivers of Kutch and Saurashtra, including Luni.
- According to the **Central Water Commission (CWC)**, the estimated water resources potential of the country, which occurs as natural runoff in the rivers, is 1,999 billion cubic metres (BCM). Of this, the estimated utilisable resources are 1,122 BCM per year — **690 BCM per year of surface water** and **432 BCM per year of replenishable groundwater**.

### Per-Capita water situation

- According to the CWC, per capita availability in the country will decrease from 1,434 cubic metres in 2025 to 1,219 cubic metres in 2050. As per CWC benchmarks:
  1) 1700 cubic meters/person/year – 1000 cubic meters/person/year = **Water Stressed Condition**.
  2) Less than 1000 cubic meters/person/year = **Water Scarcity Condition**.
  3) 1000 cubic meters/person/year – 500 cubic meters/person/year = **Chronic Water Scarcity**.
  4) **Less than 500 CM/person/year = Absolute Scarcity**.

⇨ *The absolute minimum water requirement for domestic usage is **50 litres per person per day**.*

⇨ *The ideal requirement is 100-200 litres/person/day.*

### India's groundwater situation

- According to 'Water and Related Statistics 2019' by the CWC, the annual replenishable groundwater resources in India (2017) are **432 BCM**, out of which 393 BCM is the yearly "extractable" groundwater availability.
- The current annual groundwater extraction is **249 BCM**, the **largest user being the irrigation sector**. The **CGWB has classified** the country's assessment units (blocks, taluks, mandals, etc.) into **safe**, **semi-critical and over-exploited** in terms of groundwater resources. Jal Shakti Ministry had said **14% of the country's assessment units are semi-critical**, **5% are critical**, and **17% are over-exploited** as of 2017.

**[UPSC 2020] Consider the following statements:**

1. 36% of India's districts are classified as "overexploited" or "critical" by the Central Ground Water Authority (CGWA).
2. CGWA was formed under the Environment (Protection) Act.
3. India has the largest area under groundwater irrigation in the world.

***Which of the statements given above is/are correct?***

a) 1 only
b) 2 and 3 only
c) 2 only
d) 1 and 3 only

**Explanation**

⇨ **Critical 5% + over-exploited 17% = 22% | Semi-critical 17% + Critical 5% + over-exploited 14% = 36%.**

⇨ India has the largest area under groundwater irrigation, followed by China.

***Answer: b) 2 and 3 only***

**[UPSC 2023} Consider the following statements:**

1. Statement-I: According to the United Nations' 'World Water Development Report, 2022,' India extracts more than a quarter of the world's groundwater withdrawal each year.
2. Statement-II: India needs to extract more than a quarter of the world's groundwater each year to satisfy the drinking water and sanitation needs of almost 18% of the world's population living in its territory.

***Which one of the following is correct in respect of the above statements?***

a) Both Statement-I and Statement-II are correct and Statement-II is the correct explanation for Statement-I
b) Both Statement-I and Statement-II are correct and Statement-II is not the correct explanation for Statement-I
c) Statement-I is correct but Statement-II is incorrect
d) Statement-I is incorrect but Statement-II is correct

Answer(c)

**Explanation**

***Statement 1 is correct***

- According to the UN's World Water Development Report, 2022, the country extracts 251 cubic km or more than a quarter (26%) of the world's groundwater withdrawal each year.

***Statement II is incorrect***

- 89% of India's extracted groundwater is being used for irrigation and not for drinking or sanitation.

***Answer: c) I is correct but II is incorrect***

- India is the **2nd largest producer of wheat in the world**. However, with severe groundwater depletion, the cropping intensity in the winter season may decrease by up to 20% by 2025. (Some of the important **winter crops are wheat**, **barley**, **mustard** and **peas**). 13% of the villages in which farmers plant a winter crop are in critically water-depleted regions.

- A study has now pointed out that India could experience **more flash droughts** by the end of this century. Even if all regions that are currently using depleted groundwater for irrigation will switch to using canal irrigation, cropping intensity may decline by 7% nationally.
- About **85% of the rural water supply** in India is dependent on groundwater. Due to the rampant drawing of subsurface water, the **water table in many regions** of the country has **dropped significantly** in recent years, resulting in a threat to groundwater sustainability. An average drop in groundwater level by 1 m would **increase India's total carbon emissions by over 1%**.
- The **Indo-Gangetic Plain**, **North-western**, **Central** and **Western parts** of India account for the most intensive groundwater-based irrigation. Among these regions, **Western India** and **the Indo-Gangetic Plain** have **more than 90% of the area irrigated using groundwater**.

### Causes for depletion

- **Unsustainable usage** of water:
  - ✓ Frequent pumping of water from the ground.
  - ✓ Usage rate is greater than the Recharge rate.
- **Low-intensity rainfall** during the monsoon. Groundwater depletion is further worsened by the substantial increase in the **concurrent hot** and **dry monsoon** in India.
- Agriculture needs a large amount of groundwater.
- The **Green Revolution** era led to **unsustainable groundwater use for irrigation**. Green Revolution led to a large **increase in rice cultivation in north-western India**, mainly in Punjab and Haryana, which are less suitable for rice cultivation due to **predominantly light soils**.
- There are **limited storage facilities** owing to the **hard rock terrain in central India**.

## 27.2. Measures by the Government

- Water being a **state subject**, steps for conservation are undertaken by the State government, and the Central Government supplements the efforts.
- **National Water Policy (2012)** has been formulated by the Department of Water Resources. It advocates for **rainwater harvesting** and **conservation of water**.
- **Central Ground Water Authority (CGWA)** has issued directions under the **Environment Protection Act**, **1986**, for **mandatory rainwater harvesting** for all target areas in the country, including UTs.
- **Central Ground Water Board (CGWB)** prepared a document entitled "**Master Plan for Artificial Recharge to Ground Water in India"** in 2013. It envisages the construction of **1.11 crore rainwater harvesting** and **artificial recharge structures** in the country by harnessing surplus monsoon runoff to augment groundwater resources.
- The **Ministry of Housing** and **Urban Affairs** has released **Model Building Bye-laws**, **2016**. It recommends Rainwater Harvesting for all types of buildings with a plot size of 100 sq. m or more. **It aims for**

**sustainable management of groundwater resources** with community participation in water-stressed blocks of Gujarat, Haryana, Karnataka, MP, Maharashtra, Rajasthan, and UP.

- Creation of a **new Ministry of Jal Shakti** by merging Ministries of **Water Resources**, **River Development** and **Ganga Rejuvenation** with **Drinking Water** and **Sanitation** for dealing with **all matters relating to water in one place in an integrated manner**.
- The government has **launched various programmes:**
  - ✓ **Atal Bhujal Yojana (Atal Jal)**
  - ✓ **Jal Shakti Abhiyan** for water conservation would focus on 1,592 "water-stressed" blocks in 257 districts.
  - ✓ **Jal Jeevan Mission (JJM)**
  - ✓ **Micro Irrigation Fund under NABARD**
  - ✓ A **National Perspective Plan (NPP)** has been formulated for water resources development to transfer water from surplus to deficit areas.
- Projects related to rainwater harvesting, rejuvenation of water bodies, and recharging of groundwater through:
  - ✓ **Atal Mission for Rejuvenation and Urban Transformation (AMRUT) by MoHUA**
  - ✓ **Mahatma Gandhi National Rural Employment Guarantee Scheme** (**MGNREGS**)
  - ✓ **Pradhan Mantri Krishi Sinchayee Yojana – Watershed Development Component** (**PMKSY-WDC**).

## Central Ground Water Board (CGWB)

- **CGWB** is a **subordinate office** and **the apex organisation** of the **Ministry of Jal Shakti** dealing with **groundwater and related issues**. It is mandated to develop and disseminate technologies and monitor and implement national policies for the scientific and sustainable development and management of India's groundwater resources.
- **Central Ground Water Authority (CGWA) has been constituted by GOI under the Environment (Protection) Act, 1986** to regulate and control the development and management of **groundwater resources** in the country. It works under the **Department of Water Resources**, **Ministry of Jal Shakti**.

### Powers and Functions:

- **CGWA** has been conferred with the following powers:
  1. Exercise of powers under the **Environment (Protection) Act, 1986**
  2. To resort to penal provisions
  3. To regulate and control, management and development of groundwater in the country
  4. Exercise of powers under the Environment (Protection) Act, 1986, for the appointment of officers.

### Regulatory Measures

- CGWA is **regulating the withdrawal of groundwater** by industries/projects in **802 Over-exploited** and **169 Critical Assessment Units**. A list of these critical areas has been circulated to the **SPCBs** and **MoEF**, which refer the new industries/projects to **CGWA for obtaining permission**.
- CGWA has notified 162 critical/overexploited areas for control and regulation of the development of groundwater resources. **Construction of new groundwater structures is prohibited in the notified areas**.

### NGT vs CGWB

- NGT has **struck down the Central Ground Water Authority's (CGWA) 2020 guidelines**, saying they were against the law. NGT ordered commercial entities to follow new rules for getting permission to extract groundwater.

#### NGT Guidelines

- **Environmental Impact Assessments (EIA)** will now form the basis of granting such permissions. There must be **no general permission for groundwater withdrawal**, particularly to any commercial entity, without EIA.
- **Water management plans** need to be prepared for all OCS (overexploited, critical and semi-critical) assessment units in the country based on the mapping data, starting with overexploited blocks.
- Permission to extract groundwater **must be for specified times** and **quantity of water**, not for perpetuity.

#### Why such guidelines?

- **India accounted for 25% of the total annual global water extracted**. There was no claim over groundwater levels improving, nor was there a projection for future improvement in the past 23 years of regulation by the CGWB.
- India was at the bottom of the water quality index, at **120 among 122 countries**. Most states achieved less than half the total score in the augmentation of groundwater resources. Almost none of the states have built the infrastructure required to recharge groundwater in over-exploited and critical areas.

**[UPSC 2022] Which one of the following has been constituted under the Environment (Protection) Act, 1986?**

a) Central Water Commission
b) Central Ground Water Board
c) Central Ground Water Authority
d) National Water Development Agency

## Central Water Commission (CWC)

- CWC was established in **1945**. It is a **technical organisation** that functions as part of the **Ministry of Jal Shakti**. It is entrusted with providing consultation to various state governments on water bodies-related issues and coordinating various governmental schemes for the conservation, control, and utilisation of water resources.
- It has the responsibility of **initiation and coordination of schemes** introduced by the Ministry of Jal Shakti. They include schemes to conserve/control water resource usage in the country and the States. The schemes also help in the fields of **flood management**, **irrigation activities**, **drinking water supply**, **hydroelectricity generation**, etc.

## National Aquifer Mapping and Management Programme (NAMMP)

- Aquifer mapping is a process to characterise the **quantity**, **quality** and **sustainability of groundwater** in aquifers.
- NAMMP, a **central sector scheme** of the **Department of Water Resources**, which is **aimed at delineating aquifer and water availability**, is being implemented by the **Central Ground Water Board (CGWB)** to facilitate sustainable management of groundwater resources. It is a part of the **Ground Water Management and Regulation Scheme** (a central sector scheme)

### Objectives of the Programme

- Delineation and characterization of aquifers in 3D to understand their disposition.
- Identification and quantification of groundwater issues.
- Development of groundwater management plans.

## Atal Bhujal Yojana (ATAL JAL)

- ATAL JAL is a Rs. 6000 crore **World Bank-approved Central Sector Scheme** of the **Ministry of Jal Shakti**. The funding pattern is **50:50 between the Government of India and the World Bank**. The scheme will be implemented over a period of **5 years (2020-21 to 2024-25)**. It aims to improve **groundwater management in priority areas through community participation**.
- The priority areas identified under the scheme fall in the states of **Gujarat**, **Haryana**, **Karnataka**, **MP**, **Maharashtra**, **Rajasthan** and **UP**.
- They also cover two major types of groundwater systems found in India – **alluvial and hard rock aquifers** – and have varying degrees of institutional readiness and experience in groundwater management.

### Features of ATAL JAL Scheme

- ATAL JAL will promote **panchayat-led groundwater management** and behavioural change with a primary focus on demand-side (water consumption) management. It envisages c**ommunity-led Water Security Plans**. Concepts such as '**Water User Associations**' and **Water Budgeting** will be introduced. Better-performing districts and panchayats will get more funds.

## Jal Shakti Abhiyan

- GOI launched the **Jal Shakti Abhiyan (JSA)**, a time-bound **water conservation campaign** to be carried out in two phases across the 255 districts having critical and over-exploited groundwater levels.

### Reasons for the failure of Jal Shakti Abhiyan

- JSA was **not a funding programme** and **did not create any new intervention on its own**. It only aimed to make water conservation a **'people's movement'** through schemes like the **MGNREGA**. These projects primarily involved building tanks and ponds and building recharge wells.

#### Not much scientific planning went into JSA

- Water planning should be based on **hydrological units** like river basins and catchment areas. However, JSA was planned based on administrative boundaries. This resulted in the division of basins/aquifers into multiple units that followed multiple policies.
- There was no data on basin-wise rainfall, and no analysis of runoff and groundwater maps were rarely used. As a result, **water harvesting in a district was sometimes at the cost of water in adjoining districts**.
- The JSA ignored the fact that most of India's water-stressed basins, particularly those in the peninsular regions, are facing closure, with the demand exceeding supply. Hence, **groundwater recharge happens at the cost of surface water and vice versa**.

#### Facile assumptions

- The per capita water allocation was 55 litres for rural &135-150 litres for those living in urban areas. However, JSA **stressed the rural areas and conveniently ignored the urban areas**. Therefore, the JSA's asking villagers to save water appears hypocritical, particularly when district administrations blatantly allow the sewage generated from cities to pollute village water sources.

#### Lack of long-term solutions

- Most of the farm bunds built with soil collapse within one monsoon season. There are issues like lack of proper engineering supervision of these structures, involvement of multiple departments with less or no coordination, and limited funding under MGNREGA and other schemes.
- Finally, there have hardly been any efforts undertaken to dissuade farmers from growing water-intensive crops such as paddy, sugarcane, and banana.

***[UPSC 2020] What are the salient features of the Jal Shakti Abhiyan. launches by the Government of India for water conservation and water security? (250 words).***

## Jal Jeevan Mission (JJM)

- JJM, **launched in 2019**, envisions providing **safe and adequate drinking water through individual household tap connections by 2024** to all households in **rural India**.

- The programme will also implement **source sustainability measures** as mandatory elements, such as **recharge and reuse** through **grey water (used wastewater that has not come into contact with faeces) management**, **water conservation**, **rainwater harvesting**, etc.
- JJM will be based on a **community approach to water (Jan Andolan for water — making water everyone's priority)** and will include extensive information, education, and communication as a key component.
- The **mission will converge** with other **Central and State Government Schemes** to achieve its objectives of sustainable water supply management across the country.
- The **Jal Shakti Ministry** is the nodal ministry for the implementation of the mission. The **fund-sharing pattern between the Centre and states** is **90:10 for Himalayan and North-Eastern States**, **50:50 for other states**, and **100% for Union Territories**.

### Jal Jeevan Mission (URBAN)

- JJM Urban has been announced under the **Housing and Urban Affairs Ministry**. It aims to provide universal coverage of water supply to all households through functional taps in all statutory towns in accordance with **Sustainable Development Goal 6 (clean water and sanitation for all)**. It **complements** the Jal Jeevan Mission (Rural).

#### Objectives

- It proposes to **cover the estimated gap:**
  - ✓ 2.68 crore in urban household tap connections.
  - ✓ 2.64 In sewer connections in 500 AMRUT cities.
- Rejuvenation of water bodies to augment sustainable fresh water supply and **create green spaces**.
- To reduce floods and enhance amenity value through **Urban Aquifer Management plans**.
- To promote the **circular economy of water** by focusing on **recycling/reuse** of treated sewage, rejuvenation of water bodies and water conservation.
- To spread awareness among the masses through the **Information**, **Education** and **Communication campaign**.
- To conduct **Pey Jal Survekshan** in cities to ascertain:
  - ✓ Equitable distribution of water.
  - ✓ Reuse of wastewater.

## Jal, Jeevan, Hariyali Mission (JJHM)

- **JJHM** is an autonomous body (society) registered under the Societies Registration Act 1860, under the Rural Development Department, Govt. of **Bihar**.
- Objectives of the mission are climate sustenance, conservation and rejuvenation of water bodies and groundwater, ensuring adequate water availability, climate resilient agriculture, etc.

- The mission involves the implementation of the following:
  - ✓ Rejuvenation of all public conventional water storage structures
  - ✓ Construction of check dams and other water harvesting structures in small rivers/drains
  - ✓ Creation of new sources and delivery of water from the surplus river area to water deficit areas
  - ✓ Construction of Rain Water Harvesting Structures in the buildings
  - ✓ Creation of nurseries and **dense plantation of trees**
  - ✓ Promoting the usage of Alternative Cropping, Drip Irrigation, and **Organic Farming**
  - ✓ Promotion of the usage of **solar energy** and encouraging conservation of energy

### Har Ghar Gangajal Scheme

- The **Har Ghar Gangajal project** was launched in Rajgir and Gaya. It is part of the **Bihar** government's **Jal**, **Jeevan**, **Hariyali Mission**. The scheme, described as a "lift-store-tame-treat-supply", will harvest the excess water in the **Ganga** during the monsoon season and then treat, store, and pipe it to the parched Rajgir, Gaya and Bodhgaya. The area is rocky and water-deficient, and the indiscriminate use of ground-water has lowered the water table.

⇨ *Rajgir, Gaya and Bodhgaya region is the nucleus of the ancient Magadh kingdom and is associated with the founders of both Buddhism and Jainism.*

## BIS – Drinking Water Standards

- BIS recommends the **acceptable limits of substances to be implemented in drinking water**.

| Substance/Characteristic | Requirement (Acceptable Limit) (mg/l) | Permissible limit (mg/l) |
|---|---|---|
| pH Value | 6.5 – 8.5 | NR |
| Total Dissolved Solid | 500 | 2000 |
| Aluminium | 0.03 | 0.2 |
| Ammonia | 0.5 | NR |
| Calcium | 75 | 200 |
| Chloride | 250 | 1000 |
| Chloramines | 4.0 | NR |
| Cadmium | 0.003 | NR |
| Fluoride | 1.0 | 1.5 |
| Arsenic | 0.01 | 0.05 |
| Lead | 0.01 | NR |
| Iron | 0.3 | NR |
| Magnesium | 30 | 100 |
| Mercury | 0.001 | NR |
| Nickel | 0.02 | NR |
| Selenium | 0.01 | NR |

| | | |
|---|---|---|
| **Sulphide** | **0.05** | **NR** |
| **Nitrate** | **45** | **NR** |
| **Copper** | **0.05** | **1.5** |
| **Total Hardness ($CaCo_3$)** | **200** | **600** |
| **Phenolic compounds** | **0.001** | **0.002** |

NR: No relaxation | All parameters except pH are in mg/l

## BIS' Public Drinking Water Supply Draft

- BIS has prepared a draft **'Drinking water supply quality management system requirements for piped drinking water'** standard for the supply system of piped drinking water. It outlines the process of water supply, from raw water sources to household taps. It has been developed keeping in view the **Centre's Jal Jeevan Mission** for providing **safe** and **adequate drinking water to all rural households by 2024 through tap connections**.
- It sets the **Indian Standard (IS) 10500** for the treated water for drinking. The **IS 10500** outlines the acceptable limit of **heavy metals such as arsenic**, **the pH value of water**, **turbidity**, **the total dissolved solids**, and the **colour** and **odour**.
- The draft suggests the adoption of the concept of a District Metering Area (DMA) where it is possible. DMA is a concept for **controlling leakages in the water network**. It also mentions that water should be sampled at the treatment plant every four hours against quality parameters.

### Bureau of Indian Standards (BIS)

- BIS is the **National Standard Body of India** established under the **BIS Act 2016** for the harmonious development of the activities of **standardisation**, **marking** and **quality certification of goods**.
- BIS is involved in various activities as given below:
  - ✓ Standards Formulation
  - ✓ Product Certification Scheme
  - ✓ Compulsory Registration Scheme
  - ✓ Foreign Manufacturers Certification Scheme
  - ✓ Hall Marking Scheme
  - ✓ Laboratory Services
  - ✓ Laboratory Recognition Scheme
  - ✓ Sale of Indian Standards
  - ✓ Consumer Affairs Activities, etc.

## National Hydrology Project (NHP)

- NHP is a pan India, **World Bank-assisted Central Sector Scheme**, with a **100% grant to the States**. It is to be implemented for **8 years**, from 2016-17 to 2023-24. It intends to provide a system for real-time water resources data acquisition, storage, collation and management.
- NHP data will be stored on a real-time basis and can be accessed by users at the State/District/village level. It will **reduce the vulnerability of many regions to recurring floods** and **droughts**, as the absence of real-time ground information for the entire country creates difficulties in issuing timely alerts.
- The objectives of the project are to
  - ✓ **improve reliability** and **accuracy of Hydrology** and **Ground Water data throughout India**,
  - ✓ establish an effective hydrological database,
  - ✓ design aids to assist in the effective water resources planning and management,
  - ✓ build resilience against flooding and droughts due to uncertainties of climate change.

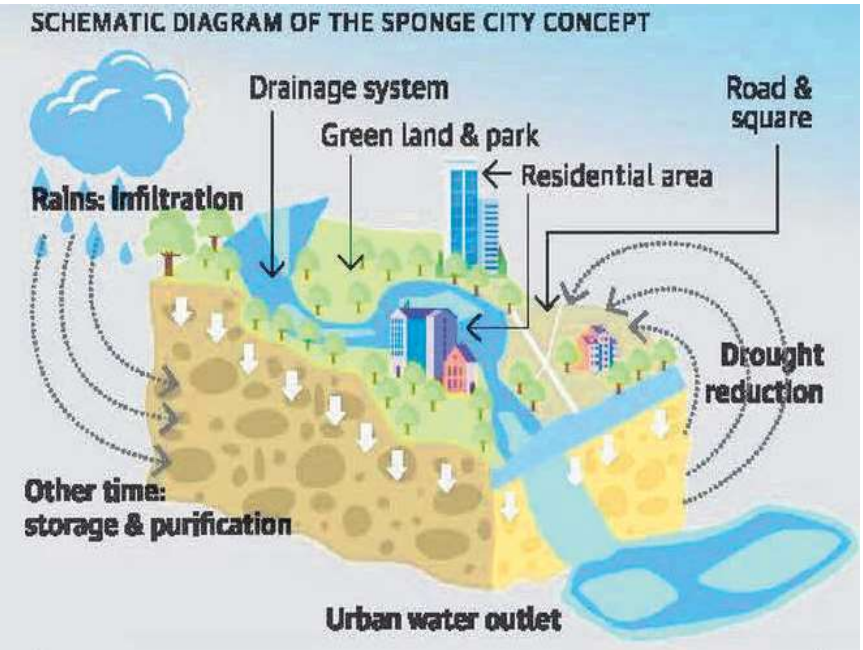
## 27.3. Recommended Conservation Measures

### Clean water sanctuaries

- Over 70% of India's surface water (rivers and lakes) and groundwater is polluted. Indians will soon need **reverse osmosis (RO)** for homes, which will add to the existing burden. The only unpolluted sources of water that remain are the **waters underlying the floodplains of rivers (for bulk water)** and **subterranean natural mineral water underlying forest tracts (for drinking)**. These are two non-invasive sources that can perennially provide unpolluted water.
- **Floodplains** can be secured by planting **organic food forests or fruit forests**, which don't consume much water. Carving out lakes, as has been lately suggested, would require digging out vast quantities of sand. This will affect the wetland ecology of the floodplains. It will also cause a **loss of water due to evaporation**.
- The natural mineral water that underlies forests is of the highest international quality. Unpolluted **rainwater percolates through** the humus or leaf cover on the forest floor while picking up **nutrients** and then through the underlying rock while picking up minerals. It finally settles in underground aquifers. This is the highest quality **natural mineral water for drinking**. All regions in the sweep of the **Western and Eastern Ghats have such forest aquifers**.

### Sponge City Concept

- The Sponge City indicates a particular type of city in which water is **Conserved + Stored + Recharged + Sustainably used**. A sponge city **does not act like an impermeable system**, not allowing any water to filter through the ground. It **acts like a sponge** and **absorbs the rainwater**.
- The absorbed water is naturally filtered by the soil and allowed to **reach into the urban aquifers**. This allows for the extraction of water from the ground through urban or peri-urban wells. This water can be easily treated and used for the city water supply.




## What does a Sponge City need in practice?

- A sponge city **needs to be abundant with spaces that allow water to seep through them**. Instead of only impermeable concrete and asphalt, the city needs more:

✓ Contiguous open green spaces, interconnected waterways, channels and ponds across neighbourhoods.

✓ **Green roofs** that can retain rainwater and naturally filter it before it is recycled or released into the ground.

## Benefits of a Sponge City

✓ Replenished groundwater and thus greater accessibility to water resources for cities.

✓ Cleaner groundwater due to the increased volume of naturally filtered stormwater.

✓ **Reduction in flood risk** as the city offers more permeable spaces for the natural percolation of water.

✓ Lower burdens on drainage systems, water treatment plants, artificial channels and natural streams.

✓ Greener, healthier, more enjoyable urban spaces.

✓ Enriched biodiversity around green open spaces, wetlands, urban gardens and green rooftops.

## Measures Required for Water Conservation

- We need better policies in eastern India **to expand irrigation** and thus increase agriculture productivity. This will also release some pressure from north-western Indian states.
- Water resource management plans need to **incorporate the effects of climate change** in order to predict future supplies accurately.
- **Traditional conservation methods must be revived** like:
  - ✓ Constructing farm ponds, check dams, gully plugging, dug wells, and borewells.
  - ✓ Artificial glaciers in Ladakh and Tamaswada Pattern nallahs treatment in Maharashtra.

- **Need for greater regulation** and **strict penalties:**
  - ✓ Currently, regulations are more of a toothless tiger.
- Encouraging farmers to **adopt micro-irrigation techniques** such as drip irrigation and micro-sprinklers.
  - ✓ The government has initiated schemes like the **DRIP programme**, **more drop per crop**, **Krishi Sinchai Yojana** to ensure economical water use practices in agriculture.
- **Artificial recharge** of tube wells, water reuse, afforestation, and scientific methods of agriculture should also be done.
- It is **recommended to study the aquifer geometry:**
  - ✓ Establish the saline-fresh interfaces within a few km of the coastal area.
  - ✓ To study the effects of glaciers melting on the recharge potential of aquifers in the Ganga basin and its effects on the transboundary aquifer systems, particularly in the arid and semi-arid regions.

## 27.4. Droughts

- **Flash droughts intensify more rapidly than normal**, posing a risk to agriculture, ecosystems and water availability. They develop at an **unusually fast rate** due to **extreme weather conditions** and persist from a few weeks to some months. **Conventional droughts**, on the other hand, take months to years to develop to full intensity.
- Flash droughts can be localised to a specific region or can become widespread. Several factors, including **atmospheric anomalies and anthropogenic GHG emissions**, play an important role. In **1979**, India faced a severe flash drought, affecting about 40% of the country.

### What is Drought?

- As defined by the IMD, drought is a consequence of the **natural reduction in the amount of precipitation for a long period of time**. It is associated with other climatic factors like **high winds** and **temperatures** and **low relative humidity**. These factors can aggravate the severity of the drought event.
- As per the **Manual for Drought Management 2016**, drought is declared considering the following factors:
  1. **The extent of rainfall deviation (depreciation)**
  2. **The consequent dry spell**
- A **drought year** is defined by the Indian Meteorological Department (IMD) as a year in which:
  - ✓ The overall **rainfall deficiency is more than 10% of the Long Period Average value (LPA) value**; and
  - ✓ If more than **20% of its area is affected by drought conditions**, **either moderate or severe or combined moderate** and **severe**.
  - ✓ When the spatial coverage of drought is **more than 40%**, it will be called **All India Severe Drought Year**.

- The 2009 Manual of Drought Management classifies droughts into 3 categories:
  1. **Meteorological drought**
  2. **Hydrological drought**
  3. **Agricultural drought**

## International Efforts for Drought Management

- The **United Nations Development Programme (UNDP)** launched the **Integrated Drylands Development Programme (IDDP)**, which aims to strengthen resilience by working on the **twin vulnerabilities** of **Poverty** and **Unsustainable land management in the drylands**.
- The **United Nations Office for Disaster Risk Reduction (UNISDR)** developed a **Drought Risk Reduction framework** that provides a comprehensive framework for both higher-level and local action.
- In 2013, the **World Meteorological Organization (WMO)** and the **Global Water Partnership (GWP)** launched the **Integrated Drought Management Programme (IDMP)** to address drought issues. The **IDMP** and its partners have adopted 3 pillars of drought management.
  1. **Monitoring** and **Early Warning Systems**: Monitoring and analysing drought indicators such as precipitation, temperature, etc.
  2. **Vulnerability** and **Impact Assessment:** It considers social, economic and environmental factors to determine a community's susceptibility to drought hazards.
  3. **Mitigation** and **Response:** Drought mitigation includes structural (i.e., appropriate crops, dams and engineering projects) and non-structural measures (i.e., policies, public awareness, and legal framework).

## Drought Management in India

- There is **no single**, **legally accepted definition of drought in India**. Some states resort to their own definitions of drought. The **State Government is the final authority** when it comes to declaring a region as drought-affected.
- India has published two important documents in respect of managing a drought.
  1. **Manual for Drought Management**, **2009** by **Ministry of Agriculture** (not Ministry of Earth Sciences).
  2. **Guidelines for Management of Drought**, **2010** by **National Disaster Management Authority**.
- However, these documents **have no binding force** and are mere guidelines to be followed if so advised.
- **Drought would certainly fall within the definition of "disaster"** as defined under Section 2(d) of the Disaster Management (DM) Act, 2005 – SC in Swaraj Abhiyan Vs Union of India in 2016.
  - ✓ **National Disaster Management Authority (NDMA)** to be the **agency responsible for drought management**, particularly with respect to chalking out long-term preventive and mitigation measures.
  - ✓ However, the **state government concerned would be the final authority to declare a drought**.

- ✓ **Droughts can also be declared for a particular village in a district**, **a taluka**, **a tehsil or a block**.

## Way forward

- There is a need for efficient **drought monitoring** and **early warning systems** in India.
- **Drought Vulnerability** and **Impact Assessment** needs to be done at regular intervals.
- **Framework for the Assessment** of **Benefits of Action or Cost of Inaction (BACI)** for Drought Preparedness must be adopted. It suggests a methodological framework for the assessment of **BACI** as a tool to support a shift in drought policy and programs from **crisis management to a risk management approach**.
- **National Drought Management Policy Guidelines** must be included while formulating policies:
  - ✓ It was codified by the **WMO** and the **Global Water Partnership (GWP)**.
  - ✓ It provides a template for action that countries can use in the development of a national drought management policy and drought preparedness/mitigation plans.
- **Preventive Methods:**
  - ✓ Judicious use of surface and groundwater.
  - ✓ **Cloud seeding in drought-prone regions** of India.
  - ✓ Use of modern micro-irrigation methods like drip and sprinkler irrigation.
  - ✓ Afforestation
  - ✓ Use of traditional water conservation techniques.
- **Mitigation measures**
  - ✓ Contingency Crop Planning by providing other options to farmers, like **drought-resistant crops**.
  - ✓ Arrangements must be made for relief employment programmes on the lines of MGNERGA.
  - ✓ **Crop Insurance schemes** like PM Fasal Bima Yojna.

**---------- End of Chapter ----------**

# 28. Major Species and Invasive Species

⇨ ***Turtle**, **Bigcat**, **Crocodile**, **Vulture**, **Rhino**, and **Dolphin** species are described in the chapter on "**Wildlife Conservation**."*

**[UPSC 2012] Which one of the following groups of animals belongs to the category of endangered species?**

a) Great Indian Bustard, Musk Deer, Red Panda and Asiatic Wild Ass
b) Kashmir Stag, Cheetal, Blue Bull and Great Indian Bustard
c) Snow Leopard, Swamp Deer, Rhesus Monkey and Saras (Crane)
d) Lion-tailed Macaque, Blue Bull, Hanuman Langur and Cheetal

***Obsolete question***

**[UPSC 2013] Consider the following fauna of India:**

1. Gharial
2. Leatherback turtle
3. Swamp deer

***Which of the above is/are endangered?***

a) 1 and 2 only
b) 3 only
c) 1, 2 and 3
d) None

***Obsolete question***

**[UPSC 2012] Consider the following:**

1) Black-necked crane
2) Cheetah
3) Flying squirrel
4) Snow leopard

***Which of the above are naturally found in India?***

a) 1, 2 and 3 only
b) 1, 3 and 4 only
c) 2 and 4 only
d) 1, 2, 3 and 4

***Cheetah is extinct in India. The rest are naturally found.***

## 28.1. Mammals

- Habitat loss and fragmentation, plantation agriculture, pollution, invasive species, human encroachment, climate change, depletion of water resources, land degradation, zoonotic diseases, hunting, poaching, etc., are common threats faced by most of the species.

### Mammals – Critically Endangered (CR)

#### Mammal – CR – Andaman White Toothed Shrew

- Andaman white-toothed shrew is a small **mouse-like insectivorous nocturnal** mammal. It was **recently discovered on Narcondam Island**, a volcanic island.
- **Distribution:** It is **endemic to the Andaman Islands**.
- **Habitat:** Tropical moist deciduous and evergreen forests.
- **Threats:** Natural disasters (tsunami, earthquake, flooding, storms, etc. | **IUCN: CR**



#### Mammal – CR – Pygmy Hog

- **Pygmy Hog** is the **world's smallest wild pig**. It is one of the **indicator species of grassland habitats**.

> ⇨ ***Indicator species:*** *An organism whose presence, absence or abundance reflects a specific environmental condition.*

- **Pygmy hog-sucking Louse** is a critically endangered parasite that feeds only on Pygmy Hogs.
- It lives in sociable family groups of up to 20, led by a **matriarch**.
- **Distribution:** It is **found only in Manas WLS (Assam)**. Earlier, it was found across north India.
- **Habitat:** Dense, tall riverine grasslands.
- **Threats:** Habitat loss and hunting. | **IUCN: CR** | **WPA: Sch I**


**[UPSC 2013] Consider the following**

1. Star tortoise
2. Monitor lizard
3. Pygmy hog
4. Spider monkey

***Which of the above are found in India?***

a) 1, 2 and 3 only
b) 2 and 3 only
c) 1 and 4 only
d) 1, 2, 3 and 4

**Explanation**

- **Monitor lizards** are a common species in India. Legend has it that **Chhatrapati Shivaji Maharaj** used an adult monitor lizard to climb the sides of a fort's wall. They are said to have a firm grip and can climb any surface without any support or effort.
- Spider monkeys are New World monkeys. They are found in Mexico, Central America, and South America, while Old World monkeys are found in Africa, central to southern Asia, and Japan.

***Answer: a) 1, 2 and 3 only***

## Mammal – CR – Himalayan Brown Bear

- It is a **species of brown bear**. It is **one of the largest carnivores in the highlands of the Himalayas** and the **largest mammal found in Kashmir**. It **hibernates during winter**.

⇨ *Brown bear: It is a large bear species found across Eurasia and North America.*

- **Distribution:** North India (**J&K**, **HP** and **Uttarakhand**), Pakistan, Nepal, Tibet, China, and Central Asia.
- **Habitat:** Forests at high altitudes and alpine meadows.
- **Threats:** Killing by livestock herders and poaching (for fur and body parts).
- **IUCN: CR | CITES: Appx I | CMS: Appx I | WPA: Sch I**
- **While the brown bear as a species is classified as Least Concern (IUCN)**, this **Himalayan sub-species is highly endangered**, and its population is declining.

## Mammal – CR – Kashmir Stag / Hangul

- Kashmir stag (or Hangul) is the **only Asiatic sub-species of the Elk** (the largest subspecies of Red deer, found in high mountains of Central Asia). It is the **state animal of J&K**.
- **Distribution:** It is **endemic to Kashmir** and is **now restricted to Dachigam NP**. Earlier, it was widely distributed in the mountains of Kashmir and Chamba district of HP.
- **Habitat:** Mountainous areas, where it spends summers in alpine meadows and winters in valleys.
- **Threats:** Over-grazing by domestic livestock and poaching.
- **IUCN: CR | CITES: Appx I | CMS: Appx I | WPA: Sch I**


## Mammal – CR – Large Rock Rat / Elvira rat

- Large rock rat (or Elvira rat) is a medium-sized, **nocturnal** and **fossorial (burrowing) rodent**.
- **Distribution:** It is **endemic to the type locality of Kurumbapatti, Salem, TN (Eastern Ghats)**.
- **Habitat:** Rocky areas of tropical dry deciduous scrub forest.
- **Threats:** Habitat loss (esp. due to mining and quarrying, logging, agriculture) | **IUCN: CR | WPA: Sch I**


## Mammal – CR – Malabar Large-Spotted Civet / Malabar Civet

- The Malabar Large-Spotted Civet (or Malabar Civet) is a medium-sized **cat-like carnivorous mammal**.
- **Distribution: Endemic to the southern Western Ghats**.
- **Habitat:** Lowland forests and swamps of coastal plains.
- **Threats:** Habitat loss due to agriculture and plantations.
- **IUCN: CR | CITES: Appx III | WPA: Sch I**


**[UPSC 2023] Consider the following fauna:**

1. Lion-tailed Macaque
2. Malabar Civet
3. Sambar Deer

***How many of the above are generally nocturnal or most active after sunset?***

a) Only one
b) Only two
c) All three
d) None

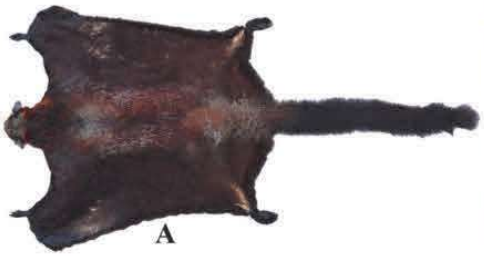
**Explanation**

- The Malabar civet is nocturnal and elusive. Hence, very little is known about its ecology.

***Answer: a) Only one***

## Mammal – CR – Namdapha Flying Squirrel

- The Namdapha flying squirrel is **nocturnal** like all other flying squirrels. It is **restricted to Namdapha NP** (the **largest protected area in the Eastern Himalaya biodiversity hotspot**)
- **Habitat:** Along streams of dry deciduous montane forests.
- **Threats:** Habitat loss and climate change. | **IUCN: CR** | **WPA: Sch I**





# Mammals – Endangered (EN)

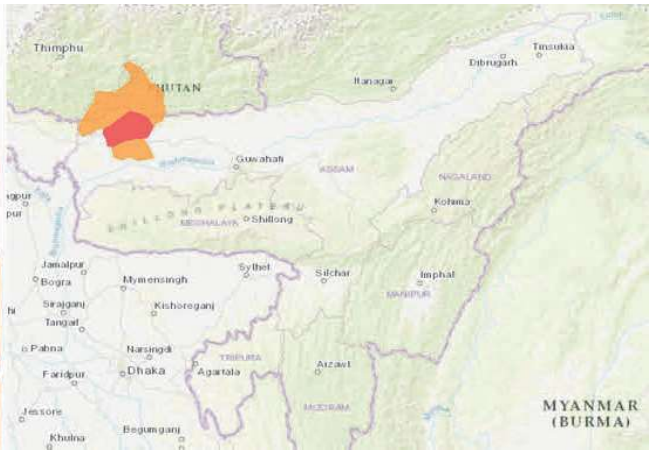
## Mammal – EN – Dhole / Asiatic Wild Dog / Indian Wild Dog

- Dhole is a **dog-like carnivorous mammal**.
- It is a highly social animal that lives in large clans without rigid hierarchical dominance.

- **Distribution:** Central, South, East and SE Asia. In India, it is **not very common in Western India**.
- **Habitat:** Grassland and forested regions (from tropical dry and moist deciduous to boreal forests).
- **IUCN: EN | CITES: Appx II | WPA: Sch I**


## Mammal – EN – Gee's Golden Langur / Golden Langur

- Gee's golden langur is an **Old World monkey (native to Africa and Asia)** with golden fur.
- **Distribution:** It is **endemic to Western Assam and Southern Bhutan**. **Manas NP (India)**, **Royal Manas NP (Bhutan)**, and **Black Mountains (Bhutan)** are famous for their species.
- **Habitat:** Moist evergreen, riverine, moist deciduous forests, temperate, and subalpine forests.
- **Threats: Inbreeding depression**.
- **IUCN: EN | CITES: Appx I | WPA: Sch I**




## Mammal – EN – Himalayan Musk Deer / White-Bellied Musk Deer

- Himalayan musk deer (or White-bellied musk deer) is a musk deer species occurring in the Himalayas. The Musk deer family **differs from true deer** (cervids) in that it **lacks antlers**.
- **Male musk deer secretes a scented substance called musk**, which is used in the **perfume industry**.
- **Distribution:** Himalayas of Bhutan, India, Nepal, and China.
- **Habitat:** High alpine environments.
- **Threats:** Hunting (for musk) and habitat loss.

- **IUCN: EN | CITES: Appx I | WPA: Sch I**


## Mammal – EN – Hispid Hare / Assam Rabbit

- Hispid hare (or Assam rabbit) is **native to South Asia**.
- **Distribution:** Himalayan foothills of the Indian Subcontinent.
- **Habitat:** Tall grasslands, locally termed **"elephant grass"**.
- **IUCN: EN | CITES: Appx I | WPA: Sch I**


## Mammal – EN – Indian Hog Deer

- It is a small deer **native to the Indo-Gangetic Plain**, Nepal, and mainland SE Asia.
- **Habitat:** It prefers wet, tall grasslands, often associated with rivers (esp. floodplain grasslands).
- **IUCN: EN | CITES: Appx III | WPA: Sch I**

## Mammal – EN – Kondana Rat

- The Kondana rat is a nocturnal burrowing rodent that is **found only in Pune**, **Maharashtra**, India.
- **Distribution:** It is known to occur at only four localities in Pune: the **Singharh plateau**, the **Torna plateau**, the **Rajgad plateau**, and **Raireshwar**.
- **Habitat:** Tropical and subtropical dry deciduous forests.
- **Threats:** Tourism and wood harvesting | **IUCN: EN**



## Mammal – EN – Lion-Tailed Macaque

- Lion-tailed macaque is an **Old World monkey** **endemic to the Western Ghats**. Unlike other macaques, this **arboreal** species **avoids humans**.
- **Distribution: Karnataka**, **Kerala**, and **TN**.
- **Habitat:** Prefers tropical evergreen rainforests but is also found in monsoon forests.
- **Threats:** Habitat loss, hunting, and wood harvesting.
- **IUCN: EN** | **CITES: Appx I** | **WPA: Sch I**


**[UPSC 2013] In which of the following States is lion-tailed macaque found in its natural habitat?**

1. TN
2. Kerala

3. Karnataka
4. Andhra Pradesh

***Select the correct answer using the codes given below.***

a) 1, 2 and 3 only
b) 2 only
c) 1, 3 and 4 only
d) 1, 2, 3 and 4

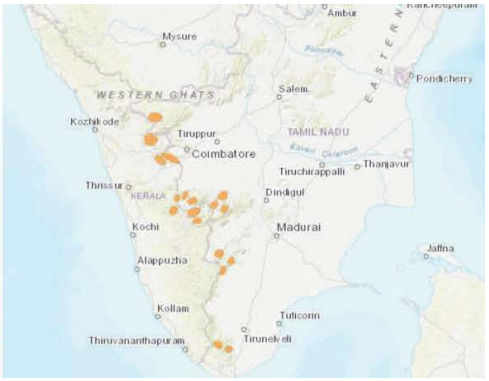
***Lion-tailed macaque is found in the Western Ghats. So, AP is the odd option. Answer: a) 1, 2 and 3 only***

## Mammal – EN – Nilgiri Tahr

- **Nilgiri Tahr**, locally known as **Varaiaadu**, is the **state animal of TN**. It is the **only mountain ungulate in southern India** among the 12 species found in India.

⇨ *Ungulate: herbivorous hoofed mammal. E.g., cow.*

- **Distribution:** It is **endemic to the Nilgiri Hills**. It is **limited to the Western Ghats in Kerala and TN**. The **Eravikulam NP in Anamalai Hills (Kerala)** has the **largest population**.
- **Habitat:** Tropical montane grasslands, **sholas forests** and rocky areas at high elevations.
- **Threats: Acacia** and **eucalyptus plantations**.
- **IUCN: EN | WPA: Sch I**




## Mammal – EN – Red Panda

- Red panda (or **Lesser panda**) is an **arboreal mammal native to the eastern Himalayas and SW China**. It is an **indicator species** and an **umbrella species** for the Himalayan Ecosystem.
- It is **not related to the giant panda**.

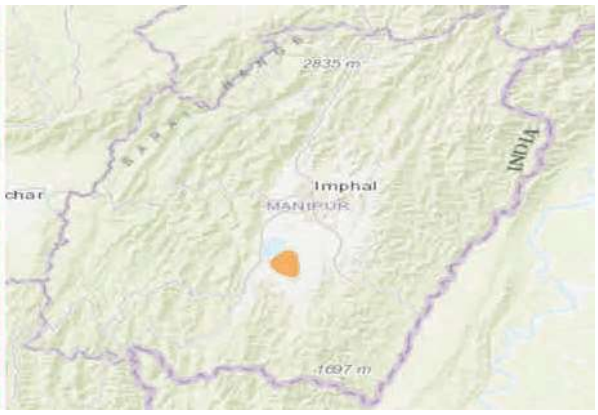
⇨ ***Umbrella species:*** *A species whose conservation confers protection to a large number of co-occurring species.*

- Though red panda is **carnivorous**, **it rarely eats meat**, and **bamboo constitutes its main diet**.

- It is both **nocturnal** and **crepuscular** (active during twilight and dawn).
- **Distribution:** Bhutan, India, Nepal, Myanmar and China. In India, it occurs in the states of **Sikkim**, **WB**, **Arunachal Pradesh**, and **Meghalaya**. It is the **state animal of Sikkim**.
- **Habitat:** Temperate montane forests with dense bamboo-thicket understorey.
- **Threats: Inbreeding depression**.
- **IUCN: EN | CITES: Appx I | WPA: Sch I**


## Mammal – EN – Sangai / Brow-Antlered Deer / Dancing Deer

- Sangai is a **subspecies of Eld's deer** in South and SE Asia.
- It is **endemic to Manipur**. It is the **state animal of Manipur**.
- **Distribution:** It is **found only at Keibul Lamjao NP** over the **floating biomass in the Logtak Lake**, **which is locally called phumdi**.
- **Threats:** Habitat loss and hunting.
- **IUCN: EN | CITES: Appx I | WPA: Sch I**




## Mammal – EN – Western Hoolock Gibbon

- The western hoolock gibbon (or white-browed gibbon) is one of the three species of hoolock gibbon (lesser apes) and is the **only ape found in India**.
- **Distribution:** Bangladesh, India (**NE India**) and Myanmar (west of the Chindwin River).
- **Habitat:** Tropical evergreen rainforests, tropical evergreen and semi-evergreen forests, etc.
- **Threats:** Habitat loss and hunting.

- **IUCN: EN | CITES: Appx II | WPA: Sch I**


### Mammal – EN – Wild Water Buffalo

- Wild water buffalo is a large bovine **native to the Indian subcontinent** and **SE Asia**.
- It is the **state animal of Chhattisgarh**.


- **Distribution:** It is found in **Central and Northeast India**, **predominantly in Assam**. **Kaziranga**, **Manas**, and **Dibru-Saikhowa NPs** are famous for it.
- **Habitat:** Low-lying alluvial grasslands, including beels (ox-bow), river banks, and chaporis (small sandy islands within braided river systems).
- **IUCN: EN | CITES: Appx III | WPA: Sch I**

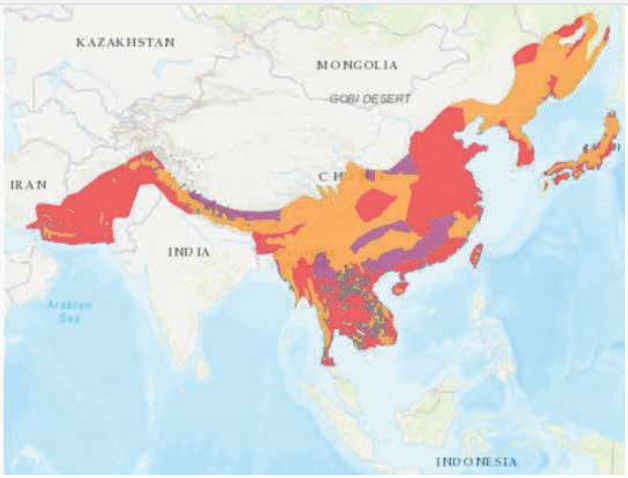
## Mammals – Vulnerable (VU)

### Mammal – VU – Asian Black Bear

- The Asian black bear (also known as the **Moon bear** or **White-chested bear**) is a medium-sized **arboreal**, omnivorous bear species **native to Asia**.
- **Distribution:** Iran, north of the Indian subcontinent, Korean Peninsula, China, Russian Far East, Japan, Taiwan, and SE Asia. It occurs in the **Himalayan** and **NE regions**.

- **Habitat:** Variety of forested habitats.
- **IUCN: VU | CITES: Appx I | WPA: Sch I**

⇨ *The **Himalayan Black Bear** is a **subspecies of the Asian Black Bear**.*




## Mammal – VU – Asian Small-Clawed Otter / Oriental Small-clawed otter

- Asian small-clawed otter (or Oriental small-clawed otter) is the **smallest otter species** in the world.
- Otters are **carnivorous semiaquatic mammals**.
- **Distribution:** It is **native to South** and **SE Asia**. In India, it is found in the **Himalayan region** and **Western** and **Eastern Ghats**.
- **Habitat:** Freshwater swamps, rivers, mangroves, tidal pools, coastal lagoons and estuaries.
- **IUCN: VU | CITES: Appx I | WPA: Sch I**


## Mammal – VU – Barasingha / Swamp Deer

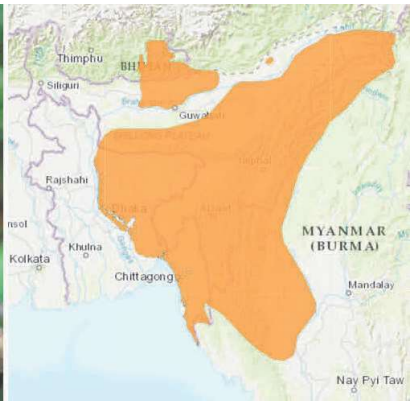
- Barasingha (Swamp deer) is **native to the Indian subcontinent**. It is the **state animal of MP and UP**.
- **Distribution:** Isolated localities in **north** and **central India** and Nepal. **Kanha TR** (MP) is famous for it.
- **Habitat:** Open forests, tall grasslands and mangroves.
- **IUCN: VU | CITES: Appx I | WPA: Sch I**


## Mammal – VU – Bonnet Macaque

- It is a species of macaque **endemic to southern India**.
- **Distribution: South of rivers Godavari and Tapti**.
- **Habitat:** All forest types, plantations and urban areas.
- **IUCN: VU | WPA: Sch I**

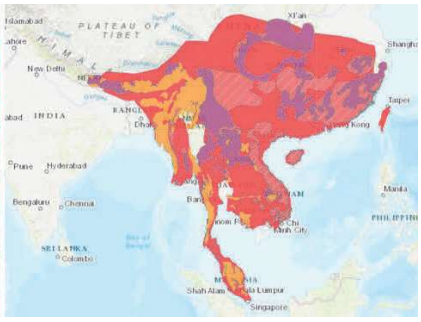

## Mammal – VU – Capped Langur

- Capped Langur is an arboreal **herbivore**.
- **Distribution:** Bangladesh, Bhutan, India (**NE India south of Brahmaputra River**) and Myanmar.
- **Habitat:** Subtropical, evergreen, deciduous, and sub-montane forests.
- **IUCN: VU | CITES: Appx I | WPA: Sch I**



## Mammal – VU – Clouded Leopard / Mainland Clouded Leopard

- Clouded leopard is the **smallest of the big cats**. It is the **state animal of Meghalaya**.
- **Distribution:** Found from the Himalayan foothills in India and Nepal through Mainland Southeast Asia into China. **Dampa TR** (Mizoram) has the **highest population density** of clouded leopards.
- **IUCN: VU | CITES: Appx I | WPA: Sch I**




## Mammal – VU – Dugong / Sea Cow

- Dugong is one of four living **species of Sea cows**. It is the **largest herbivorous marine mammal**.

⇨ ***Sea cows:*** *They are an order of fully aquatic, herbivorous mammals that inhabit swamps, rivers, estuaries, marine wetlands, and coastal marine waters.*

- **Distribution:** East Africa, South Asia, SE Asia, East Asia and Australia. In India, it is found in the **Palk Bay**, **Gulf of Mannar**, **A&N Islands**, and **Gulf of Kutch**.
- **Habitat:** Coastal areas (**shallow to medium deep**) with **warm waters (15-17°C)** and **seagrass beds of sub-tropical and tropical species of seagrass**.
- **Threats: Loss of seagrass beds**, shipping, fishing, recreational activities, pollution and natural disasters.
- **IUCN: VU | CITES: Appx I | CMS: Appx II | WPA: Sch I**

⇨ ***India's first dugong conservation reserve*** *is being set up in* ***Palk Bay*** *in* ***TN***.


### [UPSC 2013] Consider the following animals:

1. Sea cow
2. Sea horse
3. Sea lion

***Which of the above is/are mammal/mammals?***

a) 1 only
b) 1 and 3 only
c) 2 and 3 only
d) 1, 2 and 3

***A sea horse is a Bony Fish (NCERT). Answer: b) 1 and 3 only***

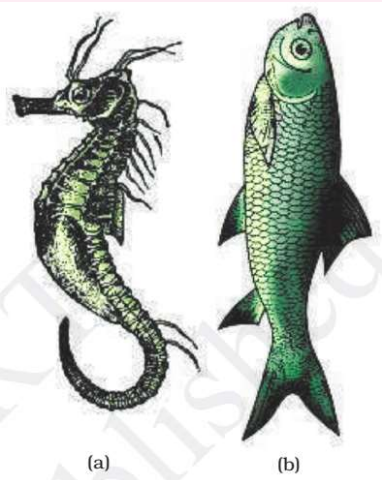


**Figure 4.20** Examples of Bony fishes : (a) *Hippocampus* (b) *Catla*


**[UPSC 2015] With reference to 'dugong', a mammal found in India, which of the following statements is/are correct?**

1) It is a herbivorous marine animal.
2) It is found along the entire coast of India
3) It is given legal protection under Schedule 1 of the Wildlife (Protection) Act, 1972.

***Select the correct answer using the code given below.***

a) 1 and 2
b) 2 only
c) 1 and 3
d) 3 only

***It is found mainly on the west coast. Answer: c) 1 and 3 only***

## Mammal – VU – Eastern Hoolock Gibbon

- It is one of the three species of hoolock gibbon.
- **Distribution: Myanmar (east of the Chindwin River)**.
- **Habitat:** Evergreen, scrub and semi-deciduous forests, mountainous broadleaf and pine forests.
- **IUCN: VU | CITES: Appx II**


## Mammal – VU – Fishing Cat

- This **nocturnal** cat of **South** and **SE Asia** is an **adept swimmer** and prey on fish.
- It is the **state animal of WB** and the **ambassador of Chilika**, **India's oldest Ramsar Site**.
- **Distribution:** In India, it is found in plains of Ganga, Yamuna, Brahmaputra, Sundarbans delta, coastal wetlands along the Bay of Bengal, and Chilika lagoon.
- **Habitat:** Wetlands, mangroves, rivers and streams.
- **Threats: Habitat loss (esp. due to shrimp farming)**, unsustainable fishing practices and poaching.
- **IUCN: VU | CITES: Appx II | WPA: Sch I**

⇨ ***Fishing Cat Project (TFCP)*** *is a research and conservation project functioning in* ***WB*** *and* ***Odisha****.*


## Mammal – VU – Four-Horned Antelope / Chausingha

- Four-horned antelope (Chausingha) is an **antelope with four horns**, **which distinguishes it from most other bovids** (mammals with cloven hoofs and unbranched hollow horns).
- **Distribution:** India and Nepal. In India, it spans **from the Himalayan foothills to the Deccan Plateau**.
- **Habitat:** Open, dry, deciduous mixed forests in undulating or hilly areas and **never far from water**.
- **Threats:** Hunting and **competition with livestock**.
- **IUCN: VU | CITES: Appx III | WPA: Sch I**


## Mammal – VU – Gaur / Indian Bison

- Gaur (Indian bison) is the **largest among the wild cattle and bovids**.
- The **domesticated form** of the gaur is called **Gayal or Mithun**.
- **Distribution:** Native to South Asia, SE Asia and East Asia. In India, it is found in the **Himalayan foothills**, **NE India**, **Eastern Ghats**, and **Western Ghats**. It is an attraction for **NPs of Wayanad**, **Nagarhole**, **Mudumalai** and **Bandipur**. **Trishna WLS** (Tripura) is **India's only natural breeding centre for bison**.
- **Habitat:** Evergreen, semi-evergreen, moist deciduous and dry deciduous forests.
- **IUCN: VU | CITES: Appx I | WPA: Sch I**


## Mammal – VU – Mainland Serow

- Mainland serow is a serow species (medium-sized **goat/ antelope-like mammals**). **Himalayan serow**, a **subspecies of the Mainland serow**, is the **state animal of Mizoram**.
- **Distribution:** It is **native to the Himalayas**, **NE India**, SE Asia, and China.
- **Habitat:** Mountain slopes with rugged, steep hills.
- **Threats:** Over poaching and habitat loss.
- **IUCN: VU | CITES: Appx I**
- Himalayan Serow is protected under **Schedule I** of the **Wildlife Protection Act**, **1972**.


## Mammal – VU – Nilgiri Langur / Nilgiri Leaf Monkey

- Nilgiri langur is **endemic to the Nilgiri Hills**. It is the attraction of **Silent Valley NP** of Kerala.
- **Distribution: Western Ghats (Karnataka, TN, and Kerala)**.
- **Habitat:** Evergreen, semi-evergreen, moist deciduous forests, and montane evergreen forests.
- **IUCN: VU | CITES: Appx II | WPA: Sch I**


## Mammal – VU – Nilgiri Marten

- Nilgiri marten is **endemic to the Western Ghats**.
- **Habitat:** Evergreen forests and montane forest grasslands.
- **Threats:** Habitat loss and **hunting (for its fur)**.
- **IUCN: VU | CITES: Appx III | WPA: Sch I**

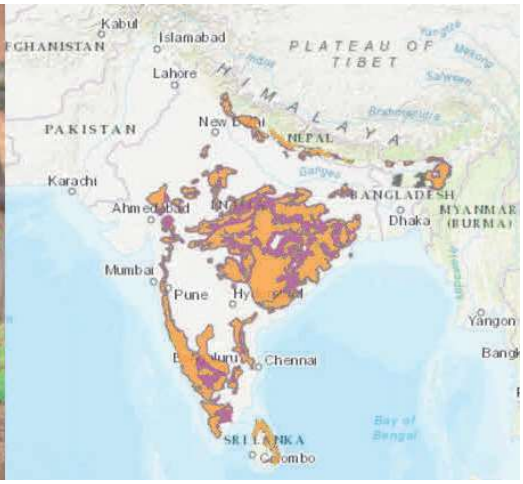
## Mammal – VU – Sambar

- Sambar is a **large deer species** **native to the Indian subcontinent and SE Asia**. This **nocturnal** species is the **state animal of Odisha**.
- **Distribution: India (except hot deserts and high altitude Himalayas)**, Nepal, Bhutan and SE Asia.
- **Habitat:** No Indian ungulate adapts to various forest types like the sambar. However, it is **always found close to a water source**.
- **IUCN: VU** | **WPA: Sch I**



## Mammal – VU – Sloth Bear

- Sloth bear is **native to the Indian subcontinent**.
- **Distribution:** Terai of India, Nepal and Bhutan and Sri Lanka.
- **Habitat:** Wide range of habitats, including moist and dry tropical forests, savannahs and grasslands.
- **IUCN: VU** | **CITES: Appx I** | **WPA: Sch I**


## Mammal – VU – Smooth-Coated Otter

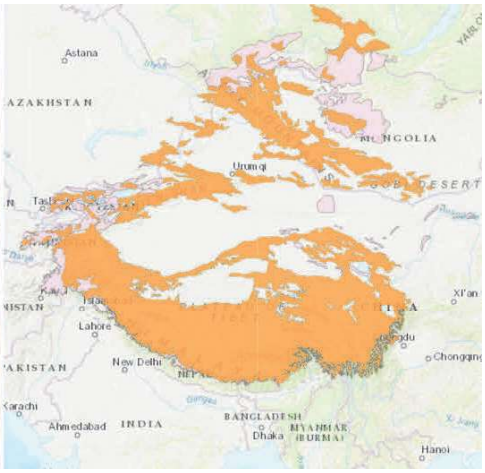
- Smooth-coated otter is **native to the Indian subcontinent** and **SE Asia**. Otters are carnivorous **semia-quatic mammals** with diets based on fish, birds, small mammals, etc.
- **Distribution:** It occurs all over India (except hot deserts, high-altitude Himalayas, and central part of the Deccan Plateau).
- **Habitat:** Freshwater swamps, rivers, mangroves, tidal pools, coastal lagoons and estuaries.
- **IUCN: VU** | **CITES: Appx I** | **WPA: Sch I**


## Mammal – VU – Snow Leopard

- Snow leopard (or **Ghost of the Mountains**) is a **keystone** and **indicator species** of high-altitude habitat. It is a **flagship species for the high-altitude Himalayan ecosystem**.

> ⇨ ***Keystone species:*** *A species whose addition to or loss from an ecosystem leads to significant changes in the occurrence of at least one other species.*
>
> ⇨ ***Flagship species:*** *Species selected to act as an ambassador, icon or symbol for a defined habitat, issue, campaign or environmental cause. They are chosen for their vulnerability, attractiveness or distinctiveness.*

- **Distribution:** Native to mountains of Central and South Asia. It occurs in the **Himalayan region**.
- **Habitat:** Alpine and subalpine zones.
- **Threats:** Habitat loss, poaching, climate change, **tourism**, and **competition with livestock**.
- **IUCN: VU** | **CITES: Appx I** | **WPA: Sch I**

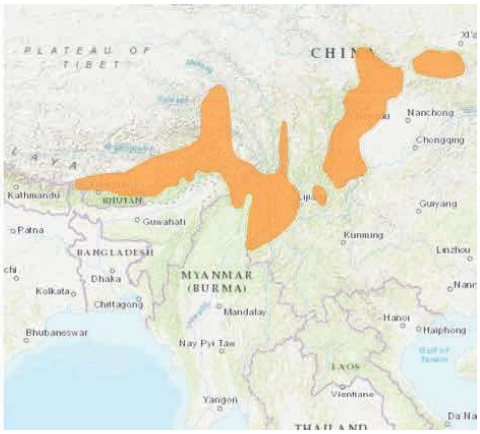



## Mammal – VU – Stump Tailed Macaque / Bear Macaque

- Stump-tailed macaque (or Bear macaque) is a macaque species **native to South Asia and SE Asia**.
- **Distribution:** It is found in **NE India** **(south of the Brahmaputra River)**.
- **Habitat:** Tropical semi-evergreen forest, wet evergreen forest and moist deciduous forest.
- **IUCN: VU** | **CITES: Appx II** | **WPA: Sch I**


## Mammal – VU – Takin

- Takin is a **large ungulate species** (herbivorous hoofed mammal).
- **Distribution:** NE India (**Arunachal Pradesh** and **Sikkim**), Bhutan, China, and Myanmar.
- **Habitat:** Forested valleys to rocky alpine zones.
- **IUCN: VU** | **CITES: Appx II** | **WPA: Sch I**




## Mammal – VU – Indo-Pacific Humpback Dolphin

- **Indo-Pacific humpback dolphin** (or **Chinese white dolphin**) is a species of humpback dolphin.
- It was regarded as a subspecies of the Indian Ocean humpback dolphin (which ranges from East Africa to India), but a study revealed them to be a **separate species**.
- **Distribution:** It is found in the eastern Indian and western Pacific Oceans.
- **Habitat:** It inhabits tropical to warm-temperate coastal waters, mangrove swamps and estuarine areas.
- **Significance:** Indo-Pacific humpback dolphins **can appear grey**, **white**, **or pink**, depending on their location. They are white in China, grey in the Indian Ocean, and pink in Singapore, Thailand, and Hong Kong. This happens **due to thermoregulation** in the blood vessels close to the dolphins' skin.

> ⇨ ***Thermoregulation:*** *A mechanism by which mammals self-regulate their body temperatures independent of external temperatures. It helps to maintain a steady internal body temperature.*

- **Threats:** Fishing, pollution, habitat destruction (by developmental activities), and water transportation
- **IUCN: VU** | **CITES: Appx I** | **CMS: Appx II** | **WPA: Sch I**


## Mammals – Near Threatened (NT)

### Mammal – NT – Argali / Great Tibetan Sheep

- Argali (or Great Tibetan sheep), the **world's largest wild sheep**.
- **Distribution:** It is native to the highlands of Central Asia. Within India, it is **restricted to Ladakh**. **Hemis NP** in Ladakh is famous for it. It is occasionally found in **Spiti (HP)** and **Sikkim**.
- **Habitat:** Mountains, steppe valleys and rocky outcrops.
- **IUCN: NT | CITES: Appx II | CMS: Appx II | WPA: Sch I**


### Mammal – NT – Asiatic Golden Cat

- It is a medium-sized **wild cat** native to the **Indian subcontinent**, **SE Asia and China**.
- **Distribution:** It is **found only in NE India** in the Indian subcontinent. Recently, a melanistic Asian golden cat was sighted in WB's **Buxa TR**.
- **Habitat:** Tropical, subtropical and mixed evergreen forests and dry deciduous forests.
- **IUCN: NT | CITES: Appx I | WPA: Sch I**


## Mammal – NT – Assamese Macaque

- Assamese macaque is an **Old World monkey native to South and SE Asia**. This **diurnal** and **omnivorous** species is both arboreal and terrestrial.
- **Distribution:** In India, it is found in **NE India**, **WB**, and **Uttarakhand**.
- **Habitat:** Tropical and subtropical semi-evergreen forests, dry deciduous and montane forests.
- **Threats:** Hunting, invasive species, diseases and **pet trade**.
- **IUCN: NT** | **CITES: Appx II** | **WPA: Sch I**


## Mammal – NT – Chiru / Tibetan Antelope

- Chiru is a medium-sized **bovid** (mammal with cloven hoof and unbranched hollow horns).
- **Distribution:** It is **native to the Tibetan plateau**. A small number occur in **Ladakh**. **Karakoram (Nubra Shyok) WLS** and **Changthang Cold Desert WLS** of Ladakh are famous for it.
- **Habitat:** High-altitude plains, hills, plateaus, and valleys consisting of alpine, desert steppe, and meadows.
- **Threats: Hunting for its fine wool called shahtoosh**.
- **IUCN: NT** | **CITES: Appx I** | **WPA: Sch I**



**[UPSC 2011-12] Q2. What is the difference between the antelopes Oryx and Chiru?**

a) Oryx is adapted to live in hot and arid areas, whereas Chiru is adapted to live in steppes and semi-desert areas of cold high mountains.
b) Oryx is poached for its antlers whereas Chiru is poached for its musk.
c) Oryx exists in western India only whereas Chiru exists in north-east India only.
d) None of the statements a, b, and c given above is correct.

***Answer: a)***


## Mammal – NT – False Killer Whale

- False killer whale is a species of **oceanic dolphin** that occurs in tropical, subtropical, and warm temperate oceans.
- **IUCN: NT | CITES: Appx II | WPA: Sch I**


## Mammal – NT – Grey Slender Loris

- Grey slender loris is a small **nocturnal primate** that is arboreal and **omnivorous**.
- It acts as a **biological predator of pests** in crops and benefits farmers.
- Its four sub-species are **Malabar slender loris**, **Mysore slender loris**, **Ceylonese slender loris**, and **Highland slender loris**.
- **Distribution:** It is **native to India** **(Andhra Pradesh**, **Karnataka**, **Kerala**, and **TN)** and **Sri Lanka**.

- **Habitat:** Rainforests, dry semi-deciduous forests, scrub, swamp, acacia, bamboo, and montane forests.
- **Threats:** Hunting, road kills, **electrocution**, and **pet trade**.
- **IUCN: NT | CITES: Appx II | WPA: Sch I**

⇨ ***Kadavur Slender Loris Sanctuary*** *in TN is* ***India's first Slender Loris Sanctuary***.



## Mammal – NT – Grizzled Giant Squirrel / Sri Lankan Giant Squirrel

- Grizzled giant squirrel (or Sri Lankan Giant Squirrel) is a large squirrel **endemic to India and Sri Lanka**.
- **Distribution:** In India, it is found in **Kerala** and **TN** in Southern India.
- **Habitat:** Tropical dry deciduous and montane forests.
- **IUCN: NT | CITES: Appx II | WPA: Sch I**



## Mammal – NT – Himalayan Goral / Grey goral

- Himalayan goral (or Grey goral) is a **bovid species**.
- **Distribution:** Himalayan region of Bhutan, Tibet, India, Nepal, and Pakistan.
- **Habitat:** Steep mountainous areas with rocky terrain and sometimes evergreen forests near cliffs.
- **Threats:** Hunting and **competition with livestock**.
- **IUCN: NT | CITES: Appx I | WPA: Sch I**



## Mammal – NT – Himalayan Tahr

- Himalayan tahr is a **large**, **even-toed**, **ungulate** (hoofed mammal) **native to the Himalayas**.
- **Distribution:** Himalayan region of India (**J&K**, **HP**, **Uttarakhand**, and **Sikkim**), Bhutan and Nepal.
- **Habitat:** Steep rocky mountain slopes with rhododendrons.
- **IUCN: NT | WPA: Sch I**


## Mammal – NT – Indian Wild Ass / Khur

- Indian wild ass (or Khur) is a **subspecies of the onager** (Asiatic wild ass) **native to South Asia**.
- **Distribution:** Today, it is **only found in the Indian Wild Ass Sanctuary (Little Rann of Kutch) and its surrounding areas** in Gujarat.
- **Habitat:** Semi-desert and grassland areas.
- **Threats:** Habitat loss (due to agriculture, development, and **salt extraction**), the invasive **Prosopis juliflora shrub**, and **encroachment and grazing by the Maldhari tribe**.
- **IUCN: NT | CITES: Appx I | WPA: Sch I**


**[UPSC 2011] A sandy and saline area is the natural habitat of an Indian animal species. The animal has no predators in that area but its existence is threatened due to the destruction of its habitat. Which one of the following could be that animal?**

a) Indian wild buffalo
b) Indian wild ass
c) Indian wild boar
d) Indian Gazelle

## Mammal – NT – Malayan Giant Squirrel / Black giant squirrel

- Malayan giant squirrel is a large tree squirrel **native to the Indo-Malayan zootope**.
- **Distribution:** Bangladesh, India (**NE India** and **WB**), Nepal, Bhutan, China, and SE Asia.

- **Habitat:** Tropical and subtropical montane evergreen forests and dry deciduous forests.
- **Threats: Jhum agriculture practice** and hunting.
- **IUCN: NT | CITES: Appx II | WPA: Sch I**



## Mammal – NT – Marbled Cat

- It is a wild cat **native to South and SE Asia**.
- **Distribution:** In India, it occurs in **Eastern Himalayan foothills** and **hilly areas of NE India**.
- **Habitat:** Moist deciduous-evergreen forests in hills.
- **IUCN: NT | CITES: Appx I | WPA: Sch I**



## Mammal – NT – Markhor / Screw-Horned Goat

- Markhor is the **world's largest mountain goat**. It is the **national animal of Pakistan**.
- **Distribution:** Native to South and Central Asia. In India, it is found in **Jammu** and **Kashmir**.
- **Habitat:** Mountainous terrain with cliffs.
- **IUCN: NT | CITES: Appx I | WPA: Sch I**



## Mammal – NT – Rusty-Spotted Cat

- Rusty-spotted cat is **one of the smallest cats**.
- **Distribution: India (except WB and NE India)**, Nepal (Terai region) and Sri Lanka.
- **Habitat:** Moist and dry deciduous forests, scrub and grassland, but is **absent in evergreen forests**.
- **IUCN: NT | CITES: Appx I | WPA: Sch I**



### Mammal – NT – Siberian Ibex / Asiatic Ibex

- Siberian Ibex is a species of **wild goat native to Central Asia**.
- Himalayan Ibex is a sub-species of Siberian Ibex.
- **Distribution:** Mountain ranges of **North India (J&K, Ladakh and HP)**, Pakistan, Russia, China and Central Asian countries.
- **IUCN: NT | CITES: Appx III | WPA: Sch I**



## Mammals – Least Concern (LC)

### Mammal – LC – Asian Palm Cat / Common Palm Civet

- The Asian palm civet (also called **Toddy cat** and Musang) is **a cat-like mammal**.
- **Kopi luwak coffee (Civet coffee)**, an expensive coffee, is produced from the seeds of coffee berries that are eaten and defecated by the Asian palm civet.
- **Distribution:** It is native to South and SE Asia.
- **Habitat:** Wide range of habitats, including evergreen and deciduous forests, swamp forests, mangroves, monoculture plantations, village and urban environments.
- **Threats:** Hunting and **captivity for civet coffee production**.
- **IUCN: LC | CITES: Appx III | WPA: Sch I**

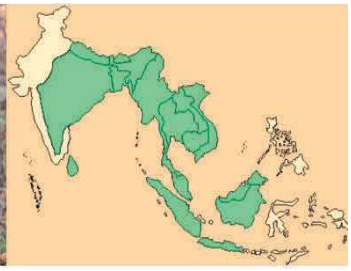

## Mammal – LC – Asiatic Caracal

- Asiatic caracal or **siya gosh** (black ear) is a sub-species of caracal, a medium-sized **felid (cat) species**. It is a primarily **nocturnal**, difficult-to-sight **carnivorous** animal.
- **Distribution:** Africa, Central Asia, and South Asia. In India, it is mainly found in **Kutch (Gujarat)**, **Malwa Plateau (MP)** and **Aravalli hill range**.
- **Habitat:** Arid and semi-arid scrub forests and ravines.
- **IUCN: LC | CITES: Appx I | WPA: Sch I**



## Mammal – LC – Barking Deer / Indian Muntjac / Common Muntjac / Southern Red Muntjac

- Barking deer is an **omnivorous** species that **makes a barking sound when frightened by a predator**. It is **locally called Kaakad**.
- **Distribution:** It is **native to South and SE Asia**.
- **Habitat:** Wide variety of forests and scrubs of plains and mountains, and croplands near woody habitats.
- **IUCN: LC | CITES: Appx I | WPA: Sch I**

## Mammal – LC – Bharal / Blue Sheep

- **Bharal** (Blue sheep) is a caprine (informally **goat-antelope**) **native to the high Himalayas**.
- **Distribution:** Himalayan regions of the Indian Subcontinent, China, and Myanmar. **Nanda Devi NP** (Uttarakhand) and **Khangchendzonga NP** (Sikkim) are famous for it.
- **Habitat:** A variety of habitats across the high Himalayas.
- **IUCN: LC | CITES: Appx III | WPA: Sch I**


## Mammal – LC – Blackbuck / Indian Antelope

- **Blackbuck** is an antelope **native to India** and **Nepal**. It is the **state animal of Andhra Pradesh**.
- **Distribution: It was once found in almost the whole of the Indian subcontinent south of the Himalayas**. At present, it is extinct in Bangladesh and Pakistan.
- **Habitat:** Grasslands, dry thorn scrubs, scrublands, lightly wooded country and agricultural margins.
- **Threats:** Hunting and habitat loss.
- **IUCN: LC | CITES: Appx III | WPA: Sch I**

## Mammal – LC – Chinkara / Indian Gazelle

- **Chinkara** is **native to Iran**, **Afghanistan**, **Pakistan** and **India**. It is the **smallest Asiatic antelope**.
- There are six subspecies of Indian gazelle. Of these, **Deccan chinkara**, **Gujarat chinkara** and **Salt Ranga Chinkara** ( Delhi, Punjab, and Haryana) **are found in India**.
- **Distribution:** The Deccan chinkara ranges from the **Ganges Valley (west of WB) to the Deccan Plateau**. The Gujarat chinkara is found in the **Thar Desert**, **Rann of Kutch**, **Kathiawar**, **and Saurashtra region**. Salt Ranga Chinkara inhabits **Delhi**, **Punjab**, and **Haryana**.
- **Habitat:** Arid deserts, dry scrub, and light forests. It is a **shy species** that avoids human habitation.

- **IUCN: LC | CITES: Appx III | WPA: Sch I**


## Mammal – LC – Chital / Spotted Deer

- Chital is a deer species **native to the Indian subcontinent**. **Antlers are present only in males**.
- **Distribution:** In India, it is not found in high Himalayan regions and arid areas of Northwest India.
- **Habitat:** Variety of habitats, but **avoids extremes** such as dense evergreen forests and deserts.
- **IUCN: LC | WPA: Sch II**

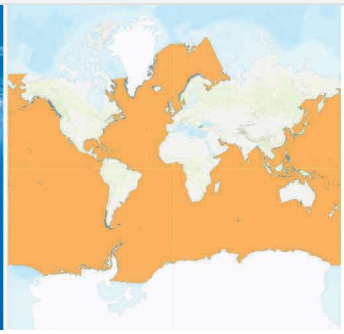

## Mammal – LC – Golden Jackal / Common Jackal

- Golden jackal (or Common jackal) is a **wolf-like canine** that is **omnivorous**.
- **Distribution:** Southeast Europe, Central Asia, Western Asia, South Asia and SE Asia.
- **Habitat:** Semi-arid areas, forests, mangroves, agricultural fields, rural and semi-urban habitats.
- **IUCN: LC | CITES: Appx III | WPA: Sch I**


## Mammal – LC – Humpback Whale

- Humpback whale is a baleen whale known for its **elaborate courtship songs and displays**.
- **Distribution:** It is found in **all oceans and seas** around the world.
- **Habitat:** It breeds in tropical coastal waters and migrates to middle and high latitudes.
- **Threats:** Oil and gas drilling, shipping transportation, fishing and pollution.
- **IUCN: LC | CITES: Appx I | CMS: Appx I | WPA: Sch I**

⇨ ***Arabian Humpback Whales*** *are a small* ***subspecies of humpback whales*** *of the Arabian Sea. They are the* ***most genetically distinct humpback whales*** *and the* ***most isolated whale population on Earth****.*

## Mammal – LC – Indian Flying Fox / Greater Indian Fruit Bat

- The **Indian Flying Fox** is the **largest bat species in India**. It is **nocturnal** and feeds mainly on ripe fruits and nectar. It can **transmit several viruses to humans**, such as the **Nipah virus**.
- **Distribution:** It is **native to the Indian subcontinent**.
- **Habitat:** It lives in **colonies** on large trees in rural and urban areas.
- **Threats:** Habitat loss, electrocution, and hunting.
- **IUCN: LC | CITES: Appx II | WPA: Sch II**



## Mammal – LC – Indian Fox

- Indian fox (Bengal fox) is a small fox **endemic to the Indian subcontinent**.
- **Habitat:** It prefers semi-arid, flat to undulating terrain, scrub and grassland habitats.
- **Threats:** Habitat loss, invasive species and diseases.
- **IUCN: LC | CITES: Appx III | WPA: Sch I**



## Mammal – LC – Indian Giant Flying Squirrel

- The **Indian giant flying squirrel** (also called Large brown flying squirrel or Common giant flying squirrel) is one of the largest flying squirrels. It is **nocturnal** and **arboreal**, like all other flying squirrels.
- **Distribution:** South Asia, mainland SE Asia, and China. It is patchily distributed in India.
- **Habitat:** Deciduous and evergreen forests and plantations.
- **IUCN: LC | WPA: Sch I**


**[UPSC 2023] Consider the following statements regarding the Indian squirrels:**

1. They build nests by making burrows in the ground.
2. They store their food materials like nuts and seeds in the ground.
3. They are omnivorous.

***How many of the above statements are correct?***

a) Only one
b) Only two
c) All three
d) None

**Explanation**

***Statement 1 is incorrect***

- Most of the Indian squirrel species are **arboreal (tree dwelling)**.
- Indian giant squirrel is found in the forests of northeast India.
- Red giant flying squirrel is the most common flying squirrel in Arunachal Pradesh. It is also found in the other regions of eastern Himalayas.
- **Indian palm squirrel** is one of the smaller squirrels in India. It is found south of the Vindhyas.
- Unlike tree squirrels, **marmots (large ground squirrels)** are ground-dwellers that live in open grasslands and nest in burrows underground. They are uncommon in India.
- The **Himalayan marmot** is a marmot species that inhabits alpine grasslands throughout the Himalayas and on the Tibetan Plateau.

**Statement 2 is correct**

- Squirrels are known for storing their food, such as nuts and seeds, in various locations, including underground. This behaviour is called **caching**, and it helps them survive during periods when food

may be scarce. Squirrels have excellent spatial memory and can remember the locations of their food caches.

***Statement 3 is correct***

- Indian squirrels are **omnivores**. They feed mainly on nuts and fruits but will also eat seeds, insects, small mammals and reptiles, eggs, and even sometimes chicks of birds.

***Answer: b) Only two***

## Mammal – LC – Indian Grey Mongoose

- The Indian grey mongoose is the **state animal of Chandigarh**.
- **Distribution:** Native to **Indian subcontinent** and **West Asia**.
- **Habitat:** Open forests, scrublands and cultivated fields.
- **IUCN: LC | CITES: Appx III | WPA: Sch I**


## Mammal – LC – / Mouse Deer

- Indian spotted chevrotain is the **smallest deer in India**.
- **Distribution:** This **nocturnal** and **shy** creature is **endemic to India**.
- **Habitat:** Tropical deciduous, moist evergreen, semi-evergreen, and montane forests and plantations.
- **IUCN: LC | WPA: Sch I**


## Mammal – LC – Nilgai / Blue Bull

- Nilgai (or blue bull) is the **largest antelope in Asia**.

- **Distribution:** Found in **India**, **Nepal**, and **Pakistan**. **Indravati NP** (Chhattisgarh), **Pench TR** (MP), **Ranthambhore** and **Keoladeo NPs** of Rajasthan are famous for it.
- **Habitat:** Arid areas, grassy plains, dry deciduous forests and farmlands. Avoids dense forests and deserts.
- **IUCN: LC | CITES: Appx III | WPA: Sch II**


## Mammal – LC – Red Fox

- Red fox is the **largest of the true foxes** and one of the most widely distributed.
- **Distribution:** Entire Northern Hemisphere. In India, it is **not found in Peninsular India**.
- **Habitat:** It has been recorded in habitats as diverse as tundra, desert, forest, and city centres.
- **IUCN: LC | CITES: Appx III | WPA: Sch I**

## Mammal – LC – Rhesus Monkey / Rhesus Macaque

- **Rhesus monkey** has the **widest geographic range of all non-human primates**. It is **diurnal**, **omnivorous**, and **alternatively arboreal and terrestrial**.
- **Distribution:** South, Central, and SE Asia.
- **Habitat:** A variety of habitats, including human habitations.
- **IUCN: LC | CITES: Appx II**
- Recently, they has been **removed from the schedules of the Wildlife Protection Act** (WPA), a move that **allows humans to treat them akin to stray cats or dogs**.

⇨ ***Hanuman langur (Gray langur)*** *is distributed* ***throughout India except NE India****, while* ***Rhesus macaque*** ***occurs in all habitats of India north of Godavari****. In southern Indian states (south of Godavari), it is replaced by* ***Bonnet macaque****.*


## Mammal – LC – Small Indian Civet

- It's a **cat-like mammal native to South and SE Asia**.
- **Habitat:** Inhabits a wide array of forests, grasslands, shrubs, mangroves, etc., as well as plantations.
- **Threats: Hunting (esp. for civet musk, a scented substance)** and habitat loss.
- **IUCN: LC | CITES: Appx III | WPA: Sch I**


## Mammal – LC – Tibetan Wild Ass

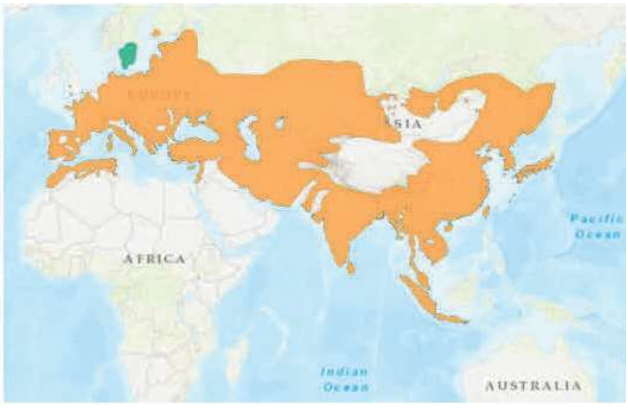
- Tibetan Wild Ass (or **Kiang**) is the **world's largest wild ass native to the Tibetan Plateau**.
- **Distribution:** India, Pakistan, China, and Nepal. In India, two subspecies occur: **Western Kiang in Ladakh**, **Uttarakhand**, and **Southern Kiang in Sikkim**.
- **Habitat:** Montane and alpine grasslands.
- **IUCN: LC | CITES: Appx II | CMS: Appx II | WPA: Sch I**


## Mammal – LC – Travancore Flying Squirrel

- The Travancore flying squirrel is **arboreal** and **nocturnal** like all other flying squirrels.
- **Distribution: South India** and **Sri Lanka**.
- **Habitat:** Evergreen, deciduous and montane forests.
- **IUCN: LC | WPA: Sch I**


### Mammal – LC – Wild Boar

- Wild boar (also known as **wild swine** and **common wild pig**) is one of the widest-ranging mammals.
- **Distribution:** It is **native to Eurasia and North Africa**.
- **Habitat:** Wide variety of temperate and tropical habitats. It often ventures onto agricultural land.
- **IUCN: LC | WPA: Sch II**




## Mammals – Miscellaneous (Misc)

### Mammal – Misc – Asiatic Wildcat / Asian Steppe Wildcat / Indian Desert Cat

- The Asiatic wildcat (or **Indian desert cat**) is **an African wildcat subspecies**.
- It is a **solitary**, **nocturnal** hunter.
- **Distribution:** SW and Central Asia, Pakistan, India, Mongolia, and China. In India, it is found in **Gujarat**, **Haryana**, **Maharashtra**, **MP**, **Rajasthan**, and a few sites in **Andhra Pradesh**, **Karnataka**, and **UP**.
- **Habitat:** Scrub deserts, mountainous areas with sufficient vegetation, and temperate forests.

- **Threats:** Habitat loss, **illegal trade**, and hunting.
- **IUCN: LC | CITES: Appx II | WPA: Sch I**


## Mammal – Misc – Black Panther

- Black Panther is the **melanistic colour variant** **of leopard or jaguar**. It has excess black pigments, but their typical rosettes are also present.
- **Kabini WLS** along the river Kabini is home to a rare species of leopard, the Black Panther (Ghost of Kabini). The Kabani River separates Bandipur NP and Nagarhole NP.
- **Habitat:** Tropical forests.

## Mammal – Misc – Himalayan Wolf

- The Himalayan Wolf is a prominent lupine predator found across the **Himalayas** and **Tibetan Plateau**.
- **Distribution:** In India, it is found in **Ladakh**, **HP**, **Uttarakhand**, **Sikkim**, and **Arunachal Pradesh**.
- **Threats: Climate change** and killing by humans to protect their cattle.
- **IUCN: VU | CITES: Appx I | WPA: Sch I**

## Mammal – Misc – Pangolin

- **Pangolin** (**Scaly Anteater**) is a **nocturnal**, **scaly-skinned insectivorous mammal**.
- This burrow-dwelling animal is the **most trafficked mammal** in the world.
- It is a **terrestrial animal** (but is **capable of climbing trees and swimming**).
- **Threats:** Trafficking and hunting, habitat loss (esp., mining and quarrying, agriculture), etc.
- Out of the eight species of pangolin, **Indian Pangolin** and **Chinese Pangolin** are **found in India**.

| Difference between Chinese Pangolin and Indian Pangolin | |
|---|---|
| **Chinese Pangolin (CR)** | **Indian Pangolin (EN)** |
| **Smaller scales** | Comparatively **larger scales** |
| **The terminal scale is absent** on the lower side of the tail. | **The terminal scale is present** on the lower side of the tail. |
| **Distribution:** The Himalayan regions of the Indian Subcontinent and mainland SE Asia. It is found in **NE India** and the **Himalayan region** of India. | **Distribution:** Indian subcontinent south of the Himalayas. Found **from the Himalayan foothills to the far south**. |
|  |  |
| **Habitat:** Tropical forests, limestone, bamboo, broad-leaf and coniferous forests, grasslands and farmlands. | **Habitat:** Tropical forests, open land, grasslands, arid areas, including in close proximity to villages |
| **IUCN: CR** | **IUCN: EN** |
|  |  |
| **CITES: Appx I \| WPA: Sch I** | |

**[UPSC 2021] Consider the following animals:**

1) Hedgehog
2) Marmot
3) Pangolin

***To reduce the chance of being captured by predators, which of the above organisms rolls up/roll up and protects/ protect its/their vulnerable parts?***

a) 1 and 2
b) 2 only
c) 3 only
**d) 1** and **3**

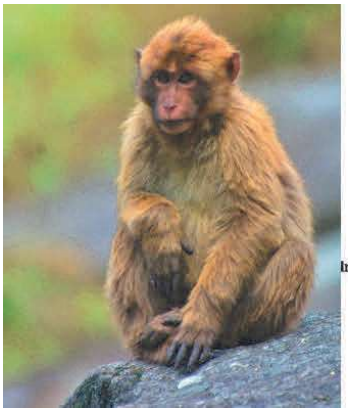
## Mammal – Misc – Pig-Tailed Macaque

| Northern Pig-tailed Macaque (VU) | Southern Pig-tailed Macaque (EN) |
|---|---|
| **Distribution:** Bangladesh, China, **NE India**, and mainland SE Asia. | **Distribution:** Maritime SE Asia (Thailand, Malaysia, and Indonesia). |
| **Habitat:** Tropical forests, coastal forests, swamp forests, and montane forests. | **Habitat: Mostly found in rainforest**, but also occurs in plantations and gardens. |
| **IUCN: VU \| CITES: Appx II \| WPA: Sch I** | **IUCN: EN \| CITES: Appx II** |
| Social grouping of **both Northern and Southern Pig-tailed Macaque** is **matriarchal**. | |
|  |  |
|  |  |

## Mammal – Misc – Porcupine

| Indian Crested Porcupine (LC) | Malayan Porcupine / Himalayan Crestless Porcupine (LC) |
|---|---|
| **Both** the Indian Crested Porcupine and Malayan Porcupine are **rodent species**. | |
| **Distribution: North-west and entire South India**. | **Distribution:** Nepal, **NE India**, Bangladesh, China and SE Asia. |
| **Habitat:** Broad array of natural habitats, including plantations and gardens. | **Habitat:** Various forest habitats, including agricultural areas. |
| **Threats: Considered agricultural pests and trapped**. | **Threats:** Habitat loss, **hunted for food and medicinal use**. |
| **IUCN: LC \| WPA: Sch I** | **IUCN: LC \| WPA: Sch I** |
|  |  |
|  |  |

## Mammal – Misc – Sela Macaque



- **Sela Macaque** is a **new species of Old World monkey recorded from Arunachal Pradesh**. It is named after the **Sela Pass** (located between the Tawang and West Kameng districts of Arunachal Pradesh).
- It is a **major cause of crop loss** in the West Kameng district of Arunachal Pradesh. | **WPA: Sch I**

## 28.2. Birds

### Birds – Critically Endangered (CR)

#### Bird – CR – Nicobar Megapode / Nicobar scrubfowl

- Nicobar megapode or Nicobar scrubfowl is a **megapode endemic to the Nicobar Islands**.

> ⇨ ***Megapode:*** *Birds that build a giant mound nest with soil and vegetation, with the eggs hatched by the heat produced by decomposition.*

- **Habitat:** Coastal forests.
- **IUCN: VU** | **WPA: Sch I**

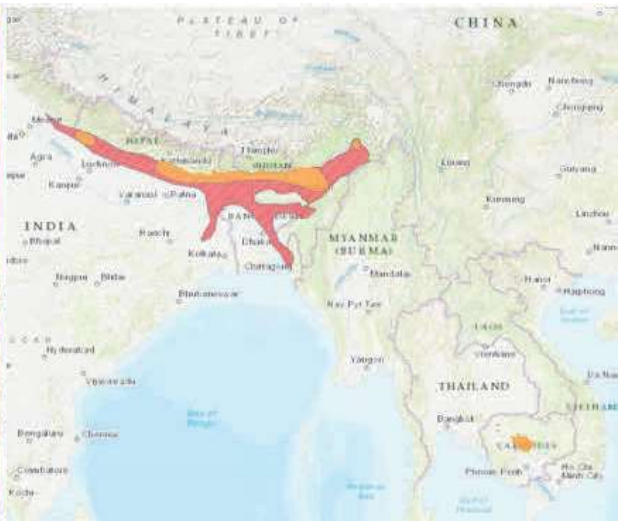
#### Bird – CR – Baer's Pochard

- **Baer's pochard** is a **freshwater diving duck** of Eastern Asia, South Asia& mainland SE Asia.
- **Distribution:** In India, it is found in **NE India**, **WB**, **Odisha** and **terai areas**.
- **Habitat:** It breeds around **freshwater habitats**.
- **IUCN: CR** | **CMS: Appx I** | **WPA: Sch I**


#### Bird – CR – Bengal Florican

- **Bengal Florican** is a **rare bustard species** that is **well known for its mating dance**.

- **Habitat:** Grasslands interspersed with scrublands.
- **Distribution:** Native to the Indian subcontinent, Cambodia, and Vietnam. Mainly found in **UP**, **Assam**, **Arunachal Pradesh** and the terai regions of Nepal.
- **IUCN: CR | CITES: Appx I | WPA: Sch I**




## Bird – CR – Black-Naped Pheasant Pigeon

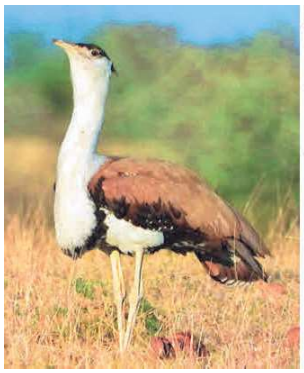
- The **Black-Naped Pheasant Pigeon** is a large, terrestrial pigeon **endemic to Fergusson Island (Papua New Guinea)**. It feeds on seeds and fallen fruits. It was recently sighted after 140 years.
- **Habitat:** Rainforests | **IUCN: CR**

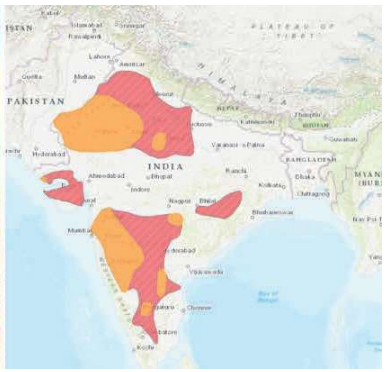

## Bird – CR – Bugun Liocichla

- Bugun liocichla was the **first bird discovered since India's Independence** (discovered in 2006).
- It is named in honour of the **Bugun community** of West Kameng district.
- **Distribution: Endemic to Arunachal Pradesh**. **Eaglenest WLS** (Arunachal Pradesh) is famous for it.
- **Habitat:** Hillsides covered with shrubs and small trees.
- **Threats:** Habitat loss and degradation
- **IUCN: CR | WPA: Sch I**


## Bird – CR – Great Indian Bustard

- The **Great Indian Bustard** (GIB) is **one of the heaviest flying birds**. It is an **omnivorous flagship grassland species** and is the **state bird of Rajasthan**.
- **Distribution:** It is **native to the Indian subcontinent** (a few pockets in India and Pakistan). In India, it is mainly confined to **Rajasthan and Gujarat**. A small population also occurs in **Maharashtra**, **Karnataka**, and **Andhra Pradesh**. Its largest population **(95%)** is found in Rajasthan (**Jaisalmer**).
- It was the mascot for the **13th COP of Conservation of Migratory Species** held in India in 2020.
- **Habitat: Dry grassland** and **steppe region**.
- **Threats:** Habitat loss (mainly due to agricultural expansion), hunting, and **mortality due to collisions with power lines and windmills** (they have **poor frontal vision**).
- **IUCN: CR | CITES: Appx I | CMS: Appx I | WPA: Sch I**






### Project Great Indian Bustard

- It was launched in 2014 jointly by the Rajasthan government, the Wildlife Institute of India and the Compensatory Afforestation Fund Management and Planning Authority (CAMPA).
- Protected Areas dedicated to GIBs: **Desert NP**, **Rajasthan**; Kutch Bastard Sanctuary, Gujarat; Karera WLS, MP; **Great Indian Bustard Sanctuary (Jawaharlal Nehru Bustard Sanctuary)**, **Maharashtra**.

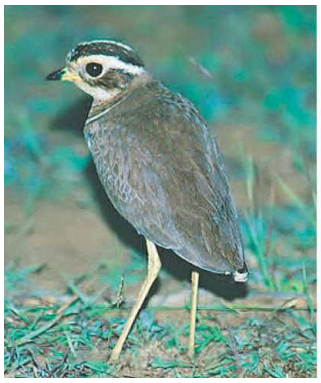
## Bird – CR – Himalayan Quail / Mountain Quail

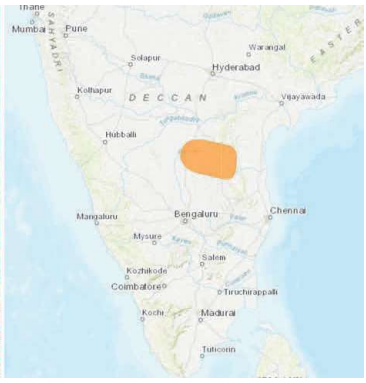
- The **Himalayan quail** is a bird belonging to the **pheasant family**.
- It was last sighted before 1877 and so is **feared to be extinct**. **Hunting during the colonial period** contributed significantly to the decline in its population.

- **Distribution: Found only in the Uttarakhand**.
- **Habitat:** Long grass and scrubs on steep hillsides.
- **IUCN: CR | WPA: Sch I**


## Bird – CR – Jerdon's Courser

- **Jerdon's courser** is a **nocturnal bird** considered to be extinct until its rediscovery in 1986.
- **Distribution:** It is **endemic to Eastern Ghats** (**found only in Andhra Pradesh and Telangana**).
- **Habitat:** Scrub jungles of the **Sri Lankamaleswara WLS**
- **IUCN: CR | WPA: Sch I**






## Bird – CR – Pink Headed Duck

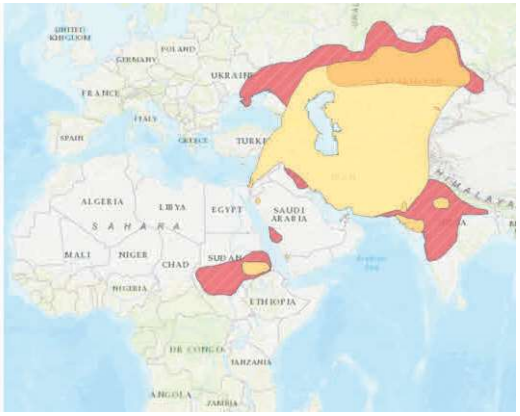
- Pink-headed duck is a **rare species of waterfowl** that was last sighted in 1949 (**feared to be extinct**).
- **Distribution:** It is recorded in **India**, **Bangladesh**, and **Myanmar**.
- **Habitat:** Wetlands surrounded by bushes and high grass.
- **IUCN: CR | CITES: Appx I | WPA: Sch I**

## Bird – CR – Siberian Crane

- **Siberian crane** (Siberian white crane / Snow crane) is the **world's third-rarest crane species**.
- **Distribution:** It is a resident of East and Central Asian Russia and **migrates to India during winter**. **Keoladeo NP**, **Rajasthan** **(formerly Bharatpur Bird Sanctuary)** is famous for this migratory bird.
- **Habitat: Most aquatic crane species** prefer shallow freshwater wetlands with good visibility.
- **Threats: Pesticide pollution**, habitat loss (esp. conversion into agricultural fields) and hunting.
- **IUCN: CR | CITES: Appx I | CMS: Appx I | WPA: Sch I**

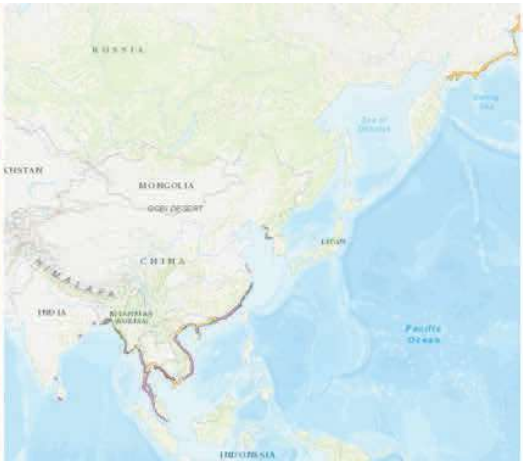

## Bird – CR – Sociable Lapwing

- Sociable lapwing is one of the most threatened of all birds that live on the Eurasian steppes.
- **Distribution:** It is found in Central Asian countries. It **migrates to North India during winter**.
- **Habitat:** Dry grasslands, steppes and temperate deserts.
- **IUCN: CR | CMS: Appx I | WPA: Sch I**




## Bird – CR – Spoon Billed Sandpiper

- It is known for its **spatula-shaped bill**.
- **Distribution:** It breeds in Russia and, in winter, **migrates to South Asia and mainland SE Asia**.
- **Habitat:** Lagoon spits and sandy coastal mudflats.
- **IUCN: CR | CMS: Appx I | WPA: Sch I**


## Bird – CR – White-Bellied Heron

- White-bellied heron (or Imperial heron), a brownish-grey heron, is the **second-largest heron species**.
- **Distribution:** It is found in **India (Arunachal Pradesh, Assam)**, Bangladesh, Bhutan, and Myanmar.
- **Habitat:** Inland swamp forests, forested rivers and submontane grasslands.
- **IUCN: CR | WPA: Sch I**



## Bird – CR – Yellow-Breasted Bunting

- **Yellow-breasted bunting** is a species of passerine bird.
- **Distribution:** It breeds in Finland to the Bering Sea. It **migrates to South Asia and SE Asia during winter**. In South Asia, it is found in **NE India**, Nepal and Bangladesh.
- **Habitat:** Wet meadows with tall vegetation and scattered scrub, cultivated fields and grasslands.
- **Threats:** Hunting and **trapping during migration**.
- **IUCN: CR | WPA: Sch I**


## Birds – Endangered (EN)

### Bird – EN – Black-Bellied Tern

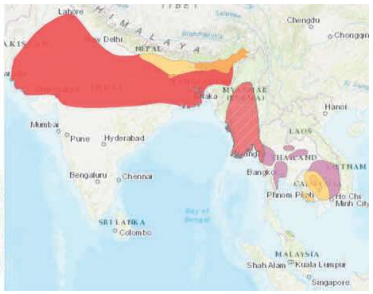
- It is found **near large rivers in the Indian subcontinent**.
- **Distribution:** Found all over India (except the Thar desert and high-altitude Himalayan region).
- **Habitat:** Large rivers and marshes.
- **Threats:** pollution, invasive species, etc.
- **IUCN: EN | WPA: Sch I**


### Bird – EN – Forest Owlet

- **Forest owlet** is **endemic to Central India**.
- **Distribution: MP and Maharashtra**.
- **Habitat:** Dry deciduous forests.
- **IUCN: EN | CITES: Appx I | WPA: Sch I**


### Bird – EN – Greater Adjutant

- **Greater adjutant** (also called **Calcutta adjutant** and **Hargila** in Assamese) is a **stork species**.
- **Distribution:** South Asia and mainland SE Asia. It is **found in two colonies in India**: the **largest colony is in Assam**, and **the smaller one is around Bhagalpur**, **Bihar**.
- **Habitat:** Wetlands, mangroves, intertidal flats and urban areas. It makes its nest in tall trees.
- **Threats:** Habitat loss, hunting, and pollution.
- **IUCN: NT | WPA: Sch I**

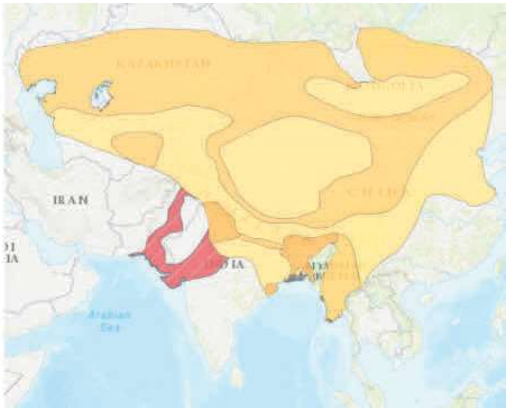

## Bird – EN – Indian Skimmer

- Indian skimmer or **Indian scissors-bill** is one of the three species that belong to the skimmer genus.
- **Distribution:** Found along the **major rivers of the Indian Subcontinent** and Indo-China.
- **Habitat:** Large rivers and lakes, swamps and coastal wetlands such as estuaries.
- **IUCN: EN | WPA: Sch I**



## Bird – EN – Pallas's Fish-Eagle

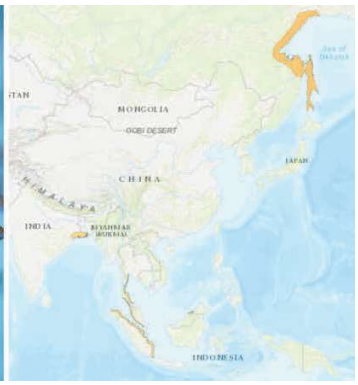
- **Pallas's fish eagle** (also called **Pallas's sea eagle** and Band-tailed fish eagle) is a large **sea eagle**.
- **Distribution:** Central, East, South and SE Asia. It **migrates to the northern Indian subcontinent** during winter. It is found in **North and NE India** (with **strongholds in Assam and Uttarakhand**).
- **Habitat:** Wetlands, large lakes and rivers.
- **IUCN: EN | CITES: Appx II | CMS: Appx I | WPA: Sch I**


## Bird – EN – Spotted Greenshank

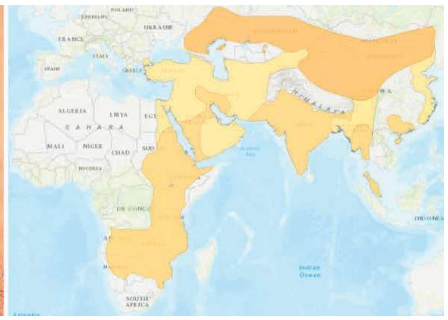
- Spotted greenshank or **Nordmann's greenshank** is a **migratory shorebird** of the sandpiper family.
- **Distribution:** It breeds in Russia and migrates to East, South, and SE Asia.
- **Habitat:** Estuaries, coastal mudflats and meadows, lowland swamps, saltpans and rice fields.

- **IUCN: EN | CITES: Appx I | CMS: Appx I**

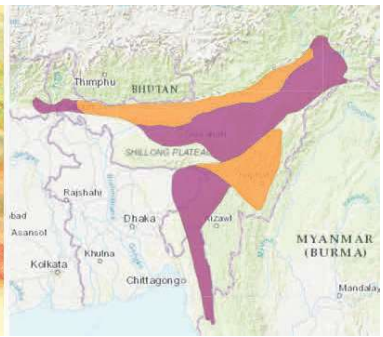

## Bird – EN – Steppe Eagle

- The steppe eagle is a large bird of prey.
- **Distribution:** Central, East, South and SE Asia. It is also seen in Eastern and Southern Africa.
- **Habitat:** Steppe, semi-desert, and mountainous regions.
- **IUCN: EN | CITES: Appx II | CMS: Appx I | WPA: Sch I**


## Bird – EN – Manipur Bush Quail

- **Manipur bush quail** is a small, **ground-dwelling** bird in the pheasant family.
- **Distribution:** It is **endemic to NE India and Bangladesh**. This **shy bird** was last sighted in 1907.
- **Habitat:** It inhabits damp grasslands and scrub.
- **IUCN: EN | WPA: Sch I**


# Birds – Vulnerable (VU)

## Bird – VU – Common Pochard

- Common pochard is a medium-sized **diving duck**.
- **Distribution:** It is **found everywhere in India (except southward of Central Deccan)**.
- **Habitat:** Swamps, marshes, lakes and slow-flowing rivers.
- **Threats:** Hunting, tourism, invasive species, and diseases.
- **IUCN: VU** | **WPA: Sch I**

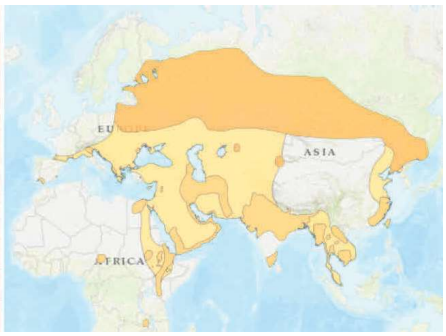
## Bird – VU – Great Indian Hornbill

- **Great Indian Hornbill** (or **Great Pied Hornbill**) is a **largest hornbill in India**. It is the **state bird of Arunachal Pradesh and Kerala**.
- **Distribution:** It is **native to the Indian Subcontinent**, **SE Asia**, **and China**. In India, it is found in the **Himalayan foothills**, **NE India**, and **Western Ghats**.
- **Habitat:** Tropical evergreen forests.
- **IUCN: VU** | **CITES: Appx I** | **WPA: Sch I**

⇨ ***Hornbill Festival*** *is celebrated every year from 1st to 10th December in Kimasa (Heritage Village of* ***Nagaland****) to celebrate the nature and traditions of Naga tribes.*

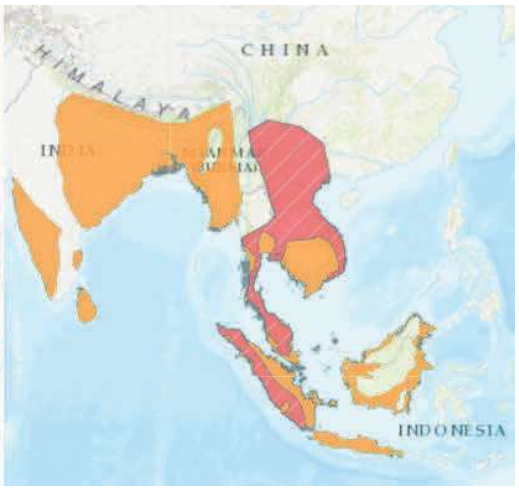

## Bird – VU – Greater Spotted Eagle

- The Greater Spotted Eagle is a large bird of prey.
- **Distribution:** Central and East Europe, East Asia, South Asia, and SE Asia.
- **Habitat:** Lowland forests near wetlands, nesting in different types of (generally tall) trees.
- **IUCN: VU** | **CITES: Appx II** | **CMS: Appx I** | **WPA: Sch I**


## Bird – VU – Lesser Adjutant

- Lesser adjutant is a large bird of the **stork family**.
- **Distribution:** Indian subcontinent and SE Asia. It is found in NE India, in **the foothills of the Himalayas**, **Gangetic plains**, **Eastern Ghats**, and **Western Ghats**.
- **Habitat:** Large rivers, lakes, agricultural wetlands, etc.
- **Threats:** Habitat loss, hunting, and pollution.
- **IUCN: NT | WPA: Sch I**


## Bird – VU – Narcondam Hornbill

- **Narcondam hornbill** is **endemic to the volcanic island of Narcondam** **(Andamans Is.)**.
- **Habitat:** Open mixed forest.
- **IUCN: VU | CITES: Appx II | WPA: Sch I**


## Bird – VU – River Tern

- River tern is **found along inland rivers** in Iran, Afghanistan, Indian Subcontinent, and SE Asia.

- **Habitat:** Rivers and freshwater lakes.
- **Threats:** Hunting, pollution, invasive species.
- **IUCN: VU | WPA: Sch I**



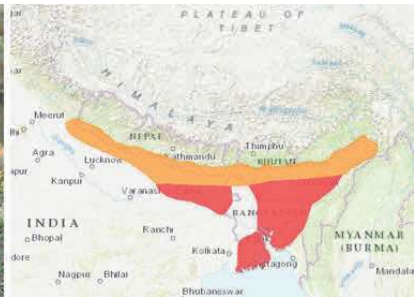
## Bird – VU – Sarus Crane

- **Sarus crane**, a large **nonmigratory crane**, is the **tallest flying bird in the world** (4ft average height).
- **Distribution:** Indian subcontinent, SE Asia, and Australia. In India, it is seen in the **Himalayan foothills**, **Northwest India (except the Thar desert)**, and **Central India**.
- **Habitat:** Open wet and dry grasslands and agricultural fields.
- **IUCN: VU | CITES: Appx II | WPA: Sch I**



## Bird – VU – Swamp Francolin

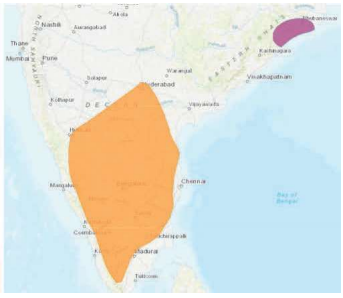
- Swamp francolin (**Swamp partridge**) is a francolin species **native to the Himalayan foothills**.
- **Habitat:** Natural grasslands and wet agricultural areas dominated by sugarcane and paddy.
- **IUCN: VU**


## Bird – VU – Yellow-Throated Bulbul

- Yellow-throated bulbul is a songbird in the bulbul family.
- **Distribution:** It is **endemic to the Deccan Peninsula**.
- **Habitat:** Forests, shrubland, and rocky areas.
- **Threats:** Habitat loss (esp. due to **quarrying** and **mining**).

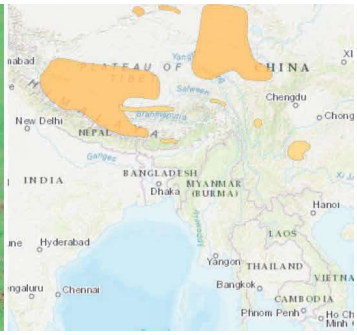
- **IUCN: VU | WPA: Sch IV**

## Birds – Near Threatened (NT)

### Bird – NT – Black Necked Crane

- The **Black-necked crane** is the **state bird of UT of Ladakh** **(it was the state bird of erstwhile J&K)**.
- **Distribution:** It is **native to Ladakh**, **Sichuan (China) and Tibet**. It **migrates to Arunachal Pradesh** and Bhutan during the winter.
- **Habitat:** Inland grassy wetlands at high elevation.
- **IUCN: NT | CITES: Appx I | CMS: Appx I | WPA: Sch I**


### Bird – NT – Mrs Hume's Pheasant

- Mrs Hume's Pheasant (or Hume's Bar-tailed Pheasant) is a long-tailed terrestrial bird. It is the **state bird of Manipur and Mizoram** and a **flagship bird of Manipur** (called **Nongin in Manipuri**).
- **Distribution:** China, **India (NE India)**, Myanmar and Thailand.
- **Habitat:** Tropical and sub-tropical forests and scrublands.
- **IUCN: NT | CITES: Appx I | WPA: Sch I**



### Bird – NT – Oriental Darter

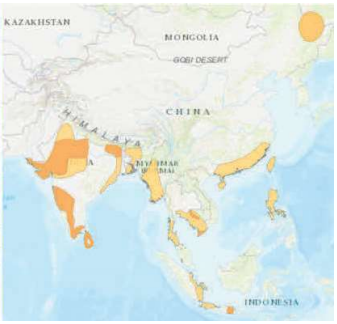
- Oriental darter (**Snakebird**) is a **water bird of tropical South Asia and SE Asia**.

- **Distribution:** Found all over India (except the high-altitude Himalayas). It is more common in Assam.
- **Habitat:** Shallow inland wetlands.
- **IUCN: NT | WPA: Sch II**



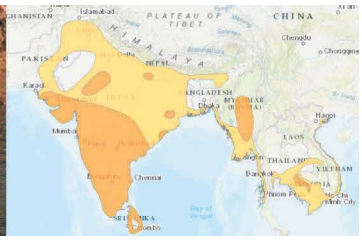
## Bird – NT – Oriental White Ibis / Indian White Ibis

- Oriental white ibis (also called Black-headed ibis and Black-necked ibis) is a **water bird**.
- **Distribution:** Indian subcontinent and SE Asia. In India it is **more common in Western India**.
- **Habitat:** Freshwater marshes, lakes, rivers, flooded grasslands, paddy fields, mangroves, salt marshes.
- **IUCN: NT | WPA: Sch II**


## Bird – NT – Painted Stork

- Painted stork is a **large shorebird endemic to the Indian subcontinent and SE Asia**.
- **Distribution: River plains** of the Indian subcontinent and mainland SE Asia.
- **Habitat:** Freshwater marshes, lakes and reservoirs, flooded fields, river banks, etc.
- **Threats:** Hunting, pollution, invasive species.
- **IUCN: LC | WPA: Sch II**


**[UPSC 2014] If you walk through countryside, you are likely to see some birds stalking alongside the cattle to seize the insects, disturbed by their movement through grasses, Which of the following is/are such bird/birds?**

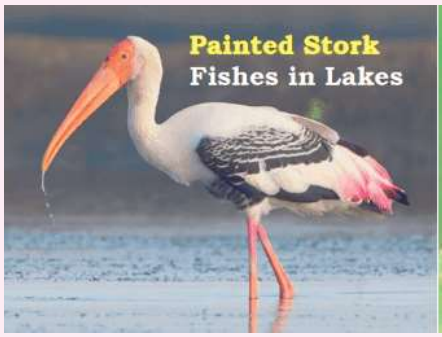
1. Painted Stork
2. Common Myna
3. Black-necked Crane

***Select the correct answer using the code given below.***

a) 1 and 2
b) 2 only
c) 2 and 3
d) 3 only

**Explanation**

- Black-necked crane feeds on meadows at higher altitudes on the Tibetan plateau.

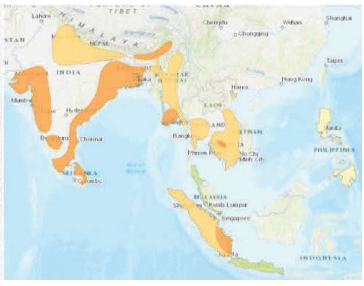




***Answer: b) 2 only***

## Bird – NT – Spot-Billed Pelican

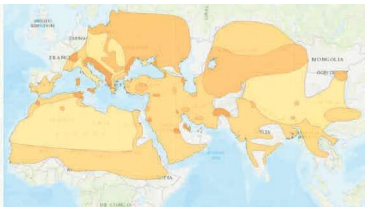
- Spot-billed pelican (or **Grey pelican)** is a member of the pelican family.
- **Distribution:** South and SE Asia. In India, it occurs in **coastal areas of peninsular India**, the **terai region of North India** and the **Himalayan foothills in NE India**.
- **Habitat:** Wetlands (**freshwater and saline**). It breeds colonially in **Acacia bushes**, tall trees or palms.
- **IUCN: NT | WPA: Sch II**



## Bird – NT – White Eyed Pochard

- White-eyed pochard is a medium-sized **diving duck**.
- **Distribution:** Europe, Central Asia, East Asia, South Asia, and SE Asia.
- **Habitat:** Prefers fresh standing water with rich vegetation. Rarely found on flowing streams or rivers.

- **Threats:** Habitat loss, hunting, tourism.
- **IUCN: NT | WPA: Sch II**

### Nicobar Pigeon / Nicobar Dove

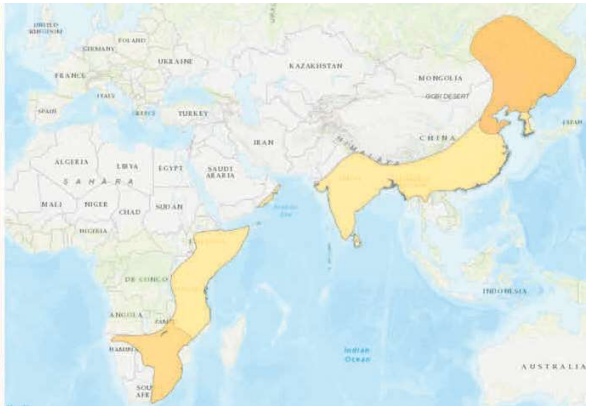
- **Nicobar Pigeon** is found in the **A&N Islands and SE Asia**.
- It is the **dodo's closest extant relative (EX)**.
- **Habitat:** Forests and scrublands.
- **Threats:** Agriculture, aquaculture, hunting, invasive species, diseases. | **IUCN: NT | WPA: Sch I**



## Birds – Least Concern (LC)

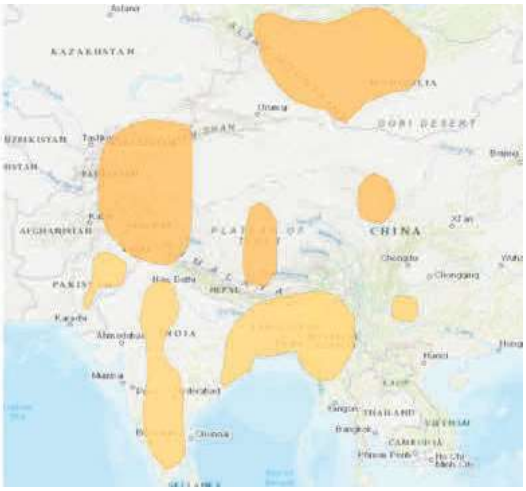
### Bird – LC – Amur Falcon

- The Amur falcon is a raptor and is the **world's longest-distance migrating raptor**. **Nagaland** is known as the **"Falcon Capital of the World"**.
- **Distribution:** East, South and SE Asia, and Eastern and Southern Africa.
- **Habitat:** Open woods and marshes.
- **Threats: Illegal trapping and killing during migration**.
- **IUCN: LC | CITES: Appx II | CMS: Appx II | WPA: Sch II**

## Bird – LC – Bar-Headed Goose

- It is **one of the world's highest-flying birds**.
- **Distribution:** It breeds in Central Asia in colonies and winters in South Asia. In India, it is found in **Central India**, **Peninsular India and NE India**.
- **Habitat:** Summer habitat includes high-altitude lakes and cultivated fields for winter.
- **IUCN: LC | WPA: Sch II**




## Bird – LC – Black-and-Orange Flycatcher

- Black-and-orange flycatcher is a tiny Old World flycatcher.
- **Distribution:** It is **endemic to the Western Ghats** (found mainly in Nilgiris, Palni, and Annamalai hills).
- **Habitat: Shola forests** (stunted tropical montane forest) and moist thickets in ravines.
- **IUCN: LC | WPA: Sch II**


## Bird – LC – Common Hill Myna

- The common hill myna (**Baster hill myna**) is **native to eastern India** and **mainland SE Asia**. It is the **state bird of Chattisgarh**. **Kanger Valley NP** (Chhattisgarh) is famous for the species.
- **Habitat:** Evergreen and wet deciduous forests. It prefers areas with high rainfall and humidity.
- **Threats:** Overexploitation for **pet trade**.
- **IUCN: LC | CITES: Appx II | WPA: Sch I**


## Bird – LC – Edible-Nest Swiftlet

- The **edible-nest swiftlet** (or **white-nest swiftlet**) is a small bird known for its **opaque and whitish nest**, **which is exclusively made of solidified saliva**.
- **Distribution: India (only Andaman Islands)** and SE Asia.
- **Habitat:** It **breeds in colonies** in coastal areas, limestone caves, and rock crevices.
- **IUCN: LC**


## Bird – LC – Greater Flamingo

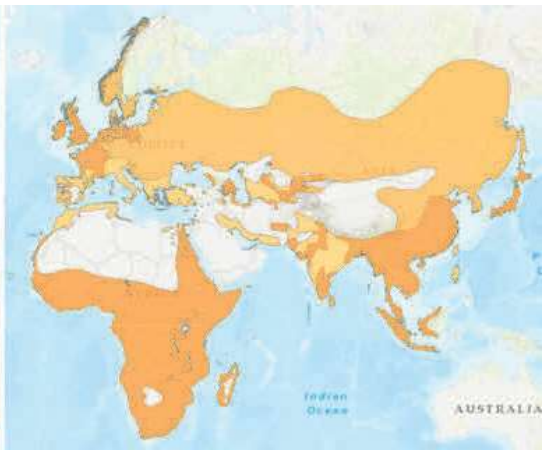
- **Greater flamingo** is the **most widespread** and the **largest flamingo species**.

⇨ ***Flamingos:*** *They are large shore birds with S-like long necks, sticklike legs and pink or reddish feathers.*

- **Distribution:** It is found in Africa, the Indian subcontinent, the Middle East, and southern Europe. It is found almost all over India (except the high-altitude Himalayas, East and NE India).
- It is the **state bird of Gujarat**, where it is observed at the **Nal Sarovar Bird Sanctuary**, **Khijadiya Bird Sanctuary**, **Flamingo City**, and **Thol Bird Sanctuary**.
- **Habitat:** Shallow eutrophic waterbodies such as saline lagoons, saltpans and saline or alkaline lakes.
- **IUCN: LC | CITES: Appx II | WPA: Sch II**

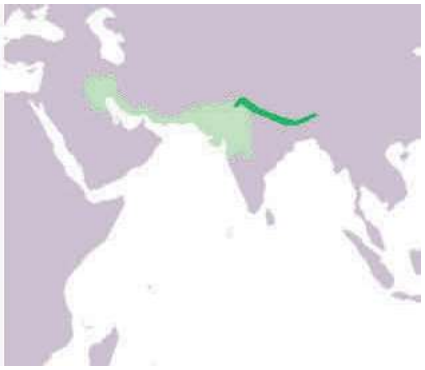

## Bird – LC – Grey Heron

- Grey heron is **native throughout temperate Europe and Asia and also parts of Africa**.
- **Distribution:** Found all over India (except the Thar desert and high-altitude Himalayas).
- **Habitat:** Watery habitat that can supply its food.
- **IUCN: LC | WPA: Sch II**

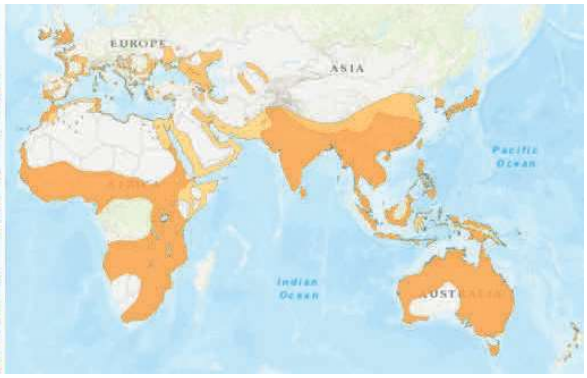
## Bird – LC – Himalayan Bulbul

- Himalayan bulbul (or **White-cheeked Bulbul**) is a songbird.
- **Distribution:** It is **endemic to the Himalayan region of the Indian subcontinent**.
- **Habitat:** Tropical and sub-tropical forests, shrublands, agricultural fields, towns and gardens.
- **IUCN: LC | WPA: Sch II**

## Bird – LC – Little Egret

- The Little Egret is a **migratory aquatic bird**.
- **Distribution:** Southern Europe, Middle East, Africa, South and SE Asia, and Australia.
- **Habitat:** Fresh, brackish or saline wetlands.
- **Threats:** wetland degradation
- **IUCN: LC | WPA: Sch II**




## Bird – LC – Nilgiri Flycatcher

- The Nilgiri flycatcher is an insectivorous Old World flycatcher. The male is indigo-blue, while the female is grey with a bluish tinge.
- **Distribution:** It is **endemic to the Western Ghats**.
- **Habitat:** Evergreen hill forests and **shola forests** (stunted tropical montane forest).
- **IUCN: LC | WPA: Sch II**


## Bird – LC – Snow Partridge

- Snow partridge is a gamebird in the **pheasant family**
- **Distribution: High-altitude Himalayan regions of the Indian Subcontinent and China**.
- **Habitat:** Alpine pastures and open hillside above treeline.
- **Threats:** Habitat loss
- **IUCN: LC | WPA: Sch II**


## Bird – LC – House Sparrows

- House Sparrow is a very **social bird** and is gregarious in all seasons when feeding, often forming flocks with other types of birds. It roosts communally, its nests are usually grouped in clumps, and it engages in several social activities (such as dust and water bathing and social singing).
- It was declared as the **state bird of New Delhi** in 2012.
- **Distribution:** It is **native to Eurasia and North Africa**. **European settlers transported it all over the world**, and it can now be **found on all continents except China**, **Japan**, **and Siberia**.
- **Habitat:** It is found in varied habitats and climates close to human settlements in both rural and urban settings. It avoids extensive woodlands, grasslands, and deserts away from human development.
- **Threats:** Destruction of habitats and food sources, pollution, urbanisation, and global warming.
- **IUCN: LC | WPA: Sch II**

## Bird – LC – White-Bellied Sea Eagle

- White-bellied sea eagle (or **white-breasted sea eagle**) is a large **diurnal** bird of prey.
- In Kasargod, it is locally known as Beeman Aamma and Palappoovan Aamma.
- Recently, it has been declared as the **official bird of Kasargod district**.
- **Distribution:** It is resident of **India**, **Sri Lanka**, **SE Asia**, and **Australia**.
- **Habitat:** It inhabits inshore seas, islands, coasts, mangroves, estuaries and terrestrial wetlands.
- **Threats:** Habitat loss, hunting, pollution, and natural disasters.
- **IUCN: LC | CITES: Appx II | WPA: Sch I**

⇨ *Kasaragod has become the **first district in India** **to officially designate its own bird species**.*


## 28.3. Fish

### Fish – Critically Endangered (CR)

#### Fish – CR – Deolali Minnow

- **Deolali minnow** is a carp (minnow) fish species **endemic to the Western Ghats**, India.
- **Distribution:** It is **found only in the Darna River near Deolali in Nashik** (Maharashtra, India).
- Recently, **Nandur Madhameshwar** (Maharashtra) was declared **a new Ramsar site**, providing sanctuary to the Deolali minnow. It is the **first Ramsar site in Maharashtra**.
- **Habitat:** This **freshwater fish** is recorded from hill streams with rocky gradients.
- **Threats:** Problematic non-native species | **IUCN: CR**

#### Fish – CR – Ganges Shark

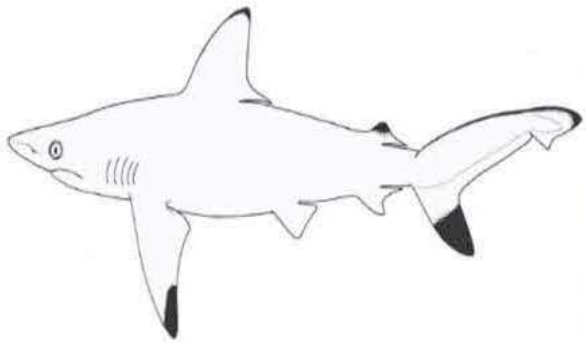
- The Ganges Shark is a **freshwater shark found only in rivers and possibly estuaries**.
- Its small eyes **(like dugong)** suggest it is **adapted to turbid water** (cloudy water with poor visibility).
- **Distribution:** It is **endemic to India and Bangladesh**. Its major population is found in the Ganges and Brahmaputra River Systems (India) and the Padma River (Bangladesh). It is also found in the Mahanadi River, the Indus River System, the Yangon River (Myanmar), Malaysia, and Indonesia.
- **Habitat:** Tropical and sub-tropical rivers and estuaries. It **can survive in muddy waters**.
- **Threats:** Overfishing, habitat degradation, building of dams and pollution
- **IUCN: CR** | **WPA: Sch I**


## Fish – CR – Hump Backed Mahseer

- **Hump-backed mahseer** is a **freshwater fish**. It is the **largest masheer** species. It is known as the **Tiger of Water** or **Tiger of Cauvery** due to the fight it puts up during fishing.
- **Distribution:** It is **endemic to the Cauvery River basin** in the Western Ghats. This **migratory** species is an important **bio-indicator for the health of the Cauvery River**.
- **Habitat:** Inland freshwater and wetlands.
- **Threats:** Construction of dams, destructive fishing methods, reduced water flow rates, pollution, etc
- **IUCN: CR**


## Fish – CR – Pondicherry Shark

- Pondicherry shark (or Long-nosed shark) is a rare shark of the **Indo-Pacific region**.
- **Distribution:** South and SE Asia, Australia, Africa, Arabian Peninsula, North and South America
- **Habitat:** Inshore waters.
- **Threats:** Unregulated fishing | **IUCN: CR** | **WPA: Sch I**



## Fish – Others

### Mammal – EN – Whale Shark

- Whale shark is the **largest shark** and the **largest fish species**.
- **Distribution:** Tropical and warm-temperate oceans and seas.
- **Threats:** Oil and gas drilling, shipping, fishing and recreation.
- **IUCN: EN | CITES: Appx II | CMS: Appx I | WPA: Sch I**
- In 2001, the whale shark became the **first fish to be listed in Schedule I of WPA, 1972**.

### Fish – EN – Golden Mahseer / Himalayan mahseer

- **Golden mahseer** is a large, golden-coloured fish **endemic to the Himalayan region**. It is also known as the **Tiger of Indian Rivers** because it is the toughest freshwater sport fish.
- It is the **national fish of Pakistan**. It is also the **state fish of** the states of **Arunachal Pradesh**, **HP**, **Uttarakhand**, **MP** and the UT of **J&K**.
- **Distribution:** Basins of the Indus, Ganges and Brahmaputra rivers.
- **Habitat: High-energy streams and rivers** in montane and submontane regions. It has adapted to thrive in dams and lakes.
- **Threats:** Habitat degradation, fishing, recreational activities, pollution and natural disasters | **IUCN: EN**


**[UPSC 2022] Which of the following is not a bird?**

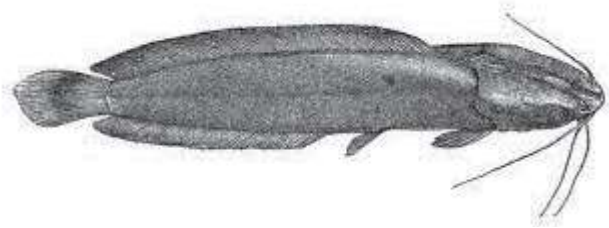
a) Golden Mahseer
b) Indian Nightjar
c) Spoonbill
d) White Ibis

### Fish – EN – Wagur

- Wagur is a **walking catfish species native to Ganga and Brahmaputra river basins** in India, Nepal, Bhutan, and Bangladesh.

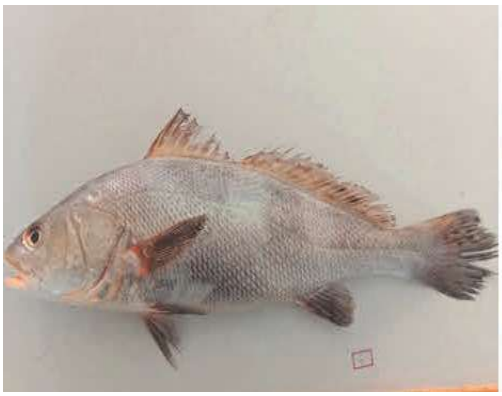
> ⇨ ***Catfish:*** *Fishes with prominent barbels that resemble a cat's whiskers.*
> ⇨ ***Walking catfish:*** *A species of freshwater airbreathing catfish that can "walk" and wiggle across dry land to find food or suitable environments.*

- **Habitat:** Freshwater and brackish water. It can exist in cloudy, low-oxygen waters. During the rainy season, it is found in the flooded rice fields.
- **Threats:** Fishing, problematic (native and non-native) species and pollution | **IUCN: EN**



## Fish – NT – Black Spotted Croaker / Ghol Fish

- **Black Spotted Croaker** (or **Ghol fish**) is an expensive **marine fish**. It was declared the **state fish of Gujarat** during the Global Fisheries Conference India 2023 in Ahmedabad.
- It is one of the largest fish found in India.
- **Distribution:** It is found in the **Indo-Pacific region** from the **Persian Gulf to the Pacific Ocean**.
- **Habitat:** It inhabits marine neritic zones (The neritic or sublittoral zone is the shallow marine area from the shoreline to the continental shelf edge).
- **Significance:** It is used to **make beer and wine**, and its **air bladder is used in pharmaceuticals**.
- **Threats:** Overexploitation. | **IUCN: NT**




## Fish – LC – Blue Finned Mahseer

- Blue-finned mahseer (also called **Black mahseer** and **Deccan mahseer**) is a **large freshwater fish**.
- **Distribution:** It is **found in the Deccan Peninsula and Sri Lanka**.
- **Habitat:** It prefers cool, fast-flowing, rocky streams. But it also occurs in rivers, lakes, and reservoirs.
- **Threats:** Overfishing, dam constructions, invasive species and pollution | **IUCN: LC**


**[UPSC 2019] Consider the following pairs:**

***Wildlife: Naturally found in***

1) Blue finned mahseer: Cauvery river
2) Irrawaddy dolphin: Chambal river
3) Rusty-spotted cats: Eastern ghats

***Which one of the pair given above are correctly matched?***

a) 1 and 2 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

***Irrawaddy dolphins are confined to the east coast of India. Answer: c) 1 and 3 only***

## Fish – VU – Helicopter Catfish

- Helicopter catfish (or wallago catfish) is a **freshwater catfish native to South and SE Asia**.
- Various names in different regions, such as Borali in Assamese, Aaththu vaalai in Tamil, Sareng in Manipuri, Balia in Odiya, and Boal in Bengali know it.
- **Habitat:** Freshwater water bodies and tidal waters.
- **Threats:** Fishing, recreational activities, pollution and natural disasters | **IUCN: VU**

## 28.4. Others

### Amphibians

#### Amphibians – VU – Kalinga Cricket Frog

- **Kalinga Cricket Frog** is **endemic to Eastern Ghats** (Odisha and Andhra Pradesh). It is also in the Western Ghats.
- **Habitat:** Agricultural fields, streams, swamps, wetlands.
- Cricket frogs are **indicators of a healthy ecosystem**.
- Adaptive Mechanism: **Morphological Phenotypic Plasticity**

⇨ ***Morphological Phenotypic Plasticity*** *is the ability of an organism to show drastic morphological (physical) variations in response to natural environmental variations or stimuli.*

#### Amphibians – NT – Purple Frog

- **Purple frogs** (or pignose frogs) have **co-existed with dinosaurs**. They live in tunnels and **come out only during early rains for breeding**.
- **Distribution: Endemic to south Western Ghats (Kerala)**.
- **Habitat:** Montane evergreen forest.
- **Threats:** Habitat loss, tourism, invasive species | **IUCN: NT**


#### Amphibians – Misc. – Micrixalus (Dancing Frogs)

- **Micrixalus (Dancing Frogs)** is a genus of frogs **endemic to the Western Ghats**.
- It is the **most threatened amphibian genus in India**, with 92% of its species threatened.

- It is the fifth most threatened amphibian genus globally.
- These frogs are called **"dancing frogs"** because they **wave their feet to attract females during the breeding season**. This act is called "foot flagging".
- **Habitat:** They are found **near perennial streams** in the **shola forests**, wet evergreen forests, swamps, and secondary forests.
- **Threats:** Habitat loss, pollution, climate change, invasive species (**mosquito fish**), and **chytrid fungus**.

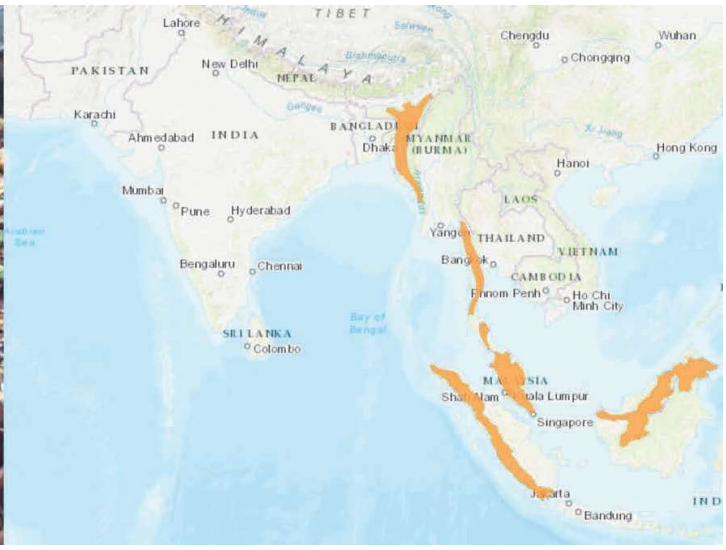
### Amphibians – Misc. – Nyctibatrachidae (Night Frogs)

- Nyctibatrachidae is a genus of frogs **endemic to the Western Ghats**.
- It is the **second most threatened amphibian genus in India**, with 84% of its species threatened.
- These frogs are called **"night frogs"** because of their **nocturnal nature** and **dark colour**.
- **Habitat**: They occur near streams in hilly evergreen forests.
- **Threats:** Habitat loss, pollution, climate change, and **chytrid fungus**.

## Reptiles

### Reptile – CR – Asian Giant Tortoise

- Asian Giant Tortoises are the **largest tortoises in mainland Asia** and are found in Bangladesh, India, Indonesia, and Malaysia, among other places.
- **IUCN Red List: CR | WPA: Sch I**




## Reptile – EN – Black Spotted/Pond Turtle

- The black pond turtle, or the Indian spotted turtle, is a freshwater turtle **endemic to South Asia**.
- **Distribution:** Bangladesh, India, Nepal, Pakistan.
- **Habitat:** Found in **lentic water bodies**, they are mainly **carnivorous** and feed on snails or larvae.
- **IUCN: EN**


## Reptile – EN – Jeypore Ground Gecko

- **Jeypore ground gecko** (also called **Jeypore Indian gecko** and **Patinghe Indian gecko**) is **endemic to the Eastern Ghats**, India. The type locality is probably **Patinghe Hill near Jeypore** in Orissa.
- **Distribution:** Found in a handful of locations in **southern Odisha** and **northern Andhra Pradesh**.
- **Habitat:** It **resides below rock boulders** in semi-evergreen high-altitude forests.
- **Threats: Pet trade**, forest fires, quarrying, mining, etc.
- **IUCN: EN | CITES: Appx II | WPA: Sch I**

⇨ *It is **recently added to the CITES list in the 19th COP to CITES**.*


## Reptile – VU – Star Tortoise

- **Distribution:** NW India (Gujarat, Rajasthan, and MP), East and South India (TN, Andhra Pradesh, Karnataka, and Odisha), SE Pakistan, and Sri Lanka.
- **Threats:** Traded for meat and **pet trade**.
- **IUCN: VU** | **CITES: Appx I** | **WPA: Sch I**


## Reptile – VU – Indian Flapshell Turtle

- Indian flapshell turtles are found in **Bangladesh**, **India**, **Myanmar**, **Nepal**, and **Pakistan**. They are possibly extant in Afghanistan.
- **Habitat:** Found in **freshwater** rivers and swamps.
- **IUCN: VU**


## Reptile – NT – Brown Roofed Turtle

- The species is **endemic to South Asia**. Two subspecies are recognised.
- **Distribution:** Bangladesh, India, Nepal, Pakistan.
- **Habitat:** Found in **freshwater** swamps and rivers, they prefer to bask in the sun twice a day and often prefer muddy areas. | **IUCN: NT**


## Reptile – NT – Sispara Day Gecko

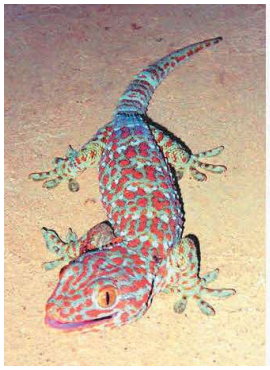
- **Sispara day gecko** is a **diurnal** gecko species **endemic to the Nilgiri Hills** of Western Ghats.
- **Distribution:** It is found in **TN** and **Kerala**.
- **Habitat:** Tropical evergreen to mixed dry deciduous forests
- **Threats:** Habitat loss | **IUCN: NT**


## Reptile – LC – Indian Golden Gecko

- **Indian golden gecko** or **Beddome's golden gecko** is a gecko species **endemic to the Eastern Ghats**.
- **Distribution: Orissa**, **Andhra Pradesh** and **TN**.
- **Habitat:** Along streams, rocky areas, and human habitations.
- **IUCN: LC** | **WPA: Sch I**


## Reptile – LC – Tokay Gecko

- Tokay gecko is a **nocturnal**, **arboreal** gecko **native to Asia and some Pacific Islands**.
- **Distribution:** Bhutan, China, India and SE Asia. In India, it occurs in **NE India**, **WB** and **Bihar**.
- **Habitat:** Rainforests, where it lives on trees and rock cliffs.
- **Threats: Hunting for medicinal uses**.
- **IUCN: LC | CITES: Appx II | WPA: Sch I**




## Reptile – LC – Indian Tent Turtle (*Pangshura tentoria*)

- The species is found in **India**, **Nepal**, and **Bangladesh**.
- **IUCN: LC**


## Reptile – DD – Assam Keelback / Peal's Keelback

- Assam keelback is a **non-venomous** snake species of the **Colubridae family** (the largest snake family). Recently, it was rediscovered after 129 years on the Arunachal Pradesh-Assam border.
- **Distribution:** It is **endemic to NE India**.

- **Habitat:** Lowland evergreen forests and Brahmaputra Valley tropical evergreen forest | **IUCN: DD**


## Spiders

### Spider – CR – Peacock Tarantula

- **Peacock tarantula** (also called **Gooty tarantula** and **Metallic tarantula**) is an Old World tarantula species that is **blue**.
- **Distribution:** It is **endemic to the Nallamala Hills (Eastern Ghats)** of **Andhra Pradesh**.
- **Habitat:** Dry deciduous forests.
- **Threats: Illegal pet trade**.
- **IUCN: CR | CITES: Appx II | WPA: Sch II**


### Spider – CR – Rameshwaram Parachute Spider

- Rameshwaram parachute spider is a **tarantula species endemic to Rameshwaram**, **TN** (India).
- **Habitat:** Coastal savannah, tropical lowland rain forests, plantations and human habitations
- **Threats:** Habitat fragmentation and tourism.
- **IUCN: CR | CITES: Appx II | WPA: Sch II**


## Insects

### Insect – EN – Migratory Monarch Butterfly

- The migratory monarch butterfly is a subspecies of the monarch butterfly. It is famous for its migration from the northern US and Canada to Mexico and California during winter (travels around 4000 km).
- It **breeds in only one plant**, **the Milkweeds** (where the female monarchs lay their eggs).
- **Distribution:** It is native to North America and Oceania. It is also reported in the Indian Subcontinent, China, Central Asia and Europe.
- **Habitat:** Forests, shrublands and grasslands.
- **Significance:** It is an **important pollinator** and provides various ecosystem services such as **maintaining the global food web**.
- **Threats: Removal of milkweeds**, habitat loss, climate change and pollution.
- **IUCN: VU | CMS: Appx II**

### Insect – LC – Golden Birdwing

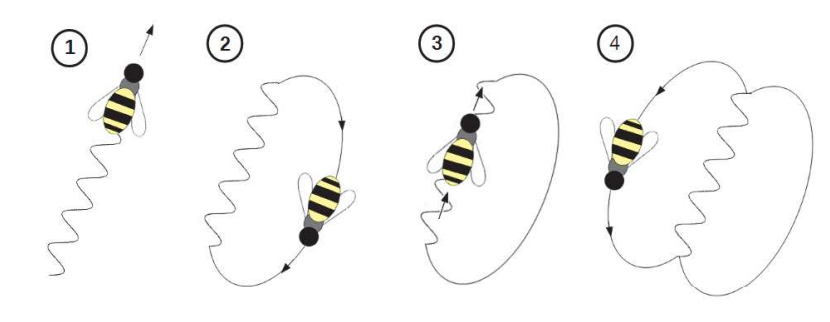
- **Golden birdwing** is a **large tropical butterfly**. This **Himalayan butterfly** is **India's largest butterfly** (it has replaced the Southern Birdwing butterfly as the largest).
- **Distribution:** South and SE Asia. In India, it is found in **NE India** and **some parts of North India**.
- **Habitat:** Forests and scrublands. | **IUCN: LC | CITES: Appx II | WPA: Sch II**

**[UPSC 2023] Which of the following organisms perform waggle dance for others of their km to indicate the direction and the distance to a source of their food?**

a) Butterflies
b) Dragonflies
c) Honey Bees
d) Wasps

**Explanation**

- Waggle dance is a form of communication adopted by the bees. The patterns of the dance indicate the direction to food, hive, etc.




## Plants

### Plant – CR – Eulophia Obtusa

- **Eulophia obtuse** (**Ground orchid**) is a rare orchid.
- **Distribution: Bangladesh**, **North India and Nepal**.
- It was **rediscovered in India in Dudhwa TR** after 118 years.
- **Habitat:** Grows seasonally in grasslands.
- **IUCN: CR | CITES: Appx II**

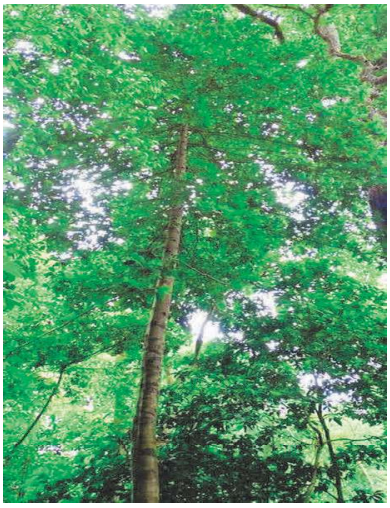
### Plant – CR – Indian Bdellium-Tree

- Indian bdellium-tree is a flowering plant which **produces a fragrant resin called gugal**.
- **Distribution:** It is **native to Western India and adjoining regions of Pakistan**. In India, it is recorded mainly in Gujarat and Rajasthan.
- **Habitat:** Semi-arid climates and is **tolerant to poor soil**.

- **Uses:** Gum of gugal is **anti-inflammatory** and used in medicines. Because of its fragrance, it is also used in the production of incense sticks and perfumes.
- **Threats:** Livestock farming and ranching, logging and wood harvesting, invasive alien species and diseases | **IUCN: CR**

## Plant – CR – Pyrostria Lalji

- Pyrostria lalji is a tall tree species in the **coffee family**. It is distinguished by a long stem and a whitish coating on the trunk.
- **Distribution: Endemic to Madagascar**, it is now discovered in **South Andaman's Wandoor forest**.
- **Habitat:** Tropical wet evergreen forests | **IUCN: CR**



## Plant – CR – Malabar River Lily

- Malabar river lily is **endemic to four streams in Kasaragod and Kannur districts in Kerala**.
- It is an integral part of the river ecosystem, providing shelter for fish and other aquatic life.
- It is locally called **Periya Polathali**.
- Recently, it has been declared as the **official flower of Kasargod district**.
- **Habitat:** It grows in a seasonal running stream.
- **Threats:** Habitat loss, dam construction, sand mining, pollution, and overcollection.

- **IUCN: CR**

⇨ ***Kasaragod*** *has become the* ***first district in India*** ***to officially designate its own flower species***.

## Plant – EN – Globba Andersonii

- Globba andersonii (also known as **Dancing Ladies** and **Swan Flowers Plant**) is a **narrowly endemic plant species because it is restricted to the Teesta River Valley**.
- **Distribution:** Darjeeling and Kalimpong of **WB** and **Sikkim**.
- **Habitat:** Grows in a dense colony as a **lithophyte** (**plant growing on bare rock**) near evergreen forests | **IUCN: EN**


## Plant – NT – Chenkurinji

- **Chenkurinji** (Shenduruni) is **native to the Western Ghats** in India. It is **endemic to Agasthyamalai Biosphere Reserve** and **Shenduruni WLS** (named after the plant itself).
- **Distribution:** Western Ghat areas of **TN** and **Kerala**.
- **Habitat:** Wet evergreen forests.
- **Uses:** It has **medicinal benefits** and is used to lower blood pressure and treat arthritis.
- **Threats:** It is **very susceptible to climate change**, which leads to shifting in flowering season, less effective pollination and inbreeding depression | **IUCN: NT**

## Plant – Misc – Blue Poppy

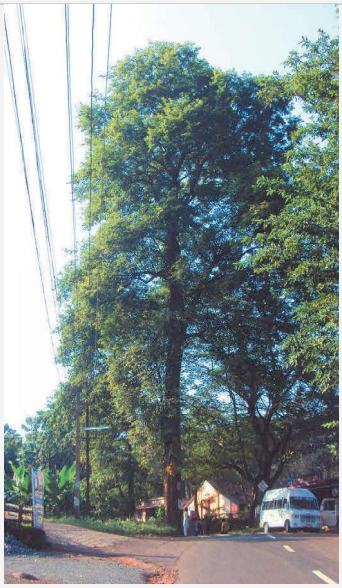
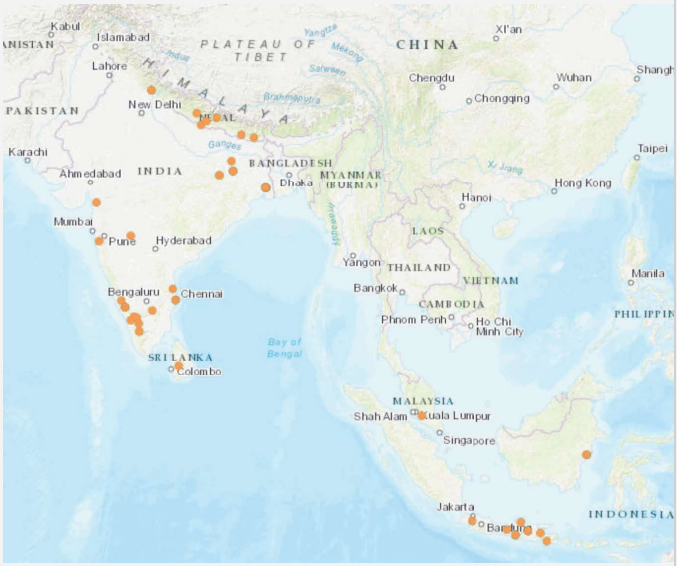
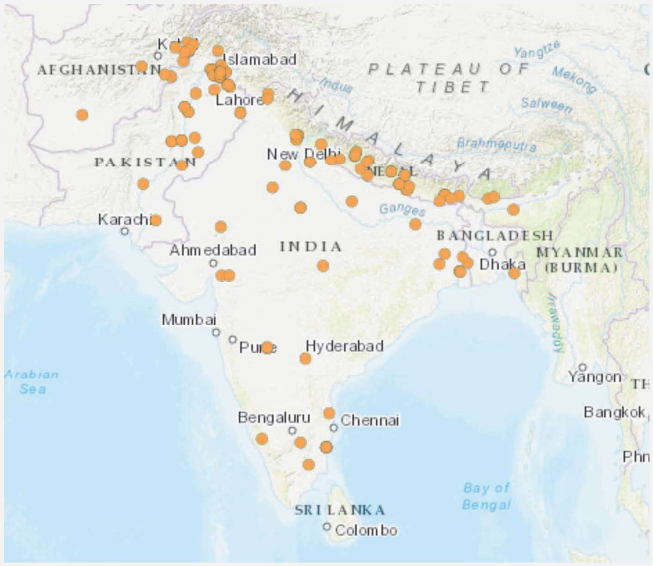
- The blue poppy is called the **Queen of Himalayan Flowers**. Its **roots are poisonous**, and it contains **narcotic** constituents. It is the **national flower of Bhutan**.
- **Distribution:** It is **native to the Himalayas**, **Myanmar**, **Tibet and China**. It is found in abundance at **Hemkund Sahib Lake** and **Valley of Flowers** of Uttarakhand.
- **Habitat:** Rock crevices and hill slopes.

## Plant – Misc – Glycosmis Albicarpa

- Glycosmis albicarpa is a **gin berry species** in the orange family. It bears a large white fruit with **a distinct gin aroma**.
- **Distribution:** It is **endemic to the Western Ghats** of southern India. It was discovered in the **Kanyakumari WLS** in TN.
- **Habitat:** It is an **evergreen small tree** found as undergrowth in semi-evergreen forests.

## Plant – Misc – Indian Rosewood (VU) vs North Indian Rosewood (LC)

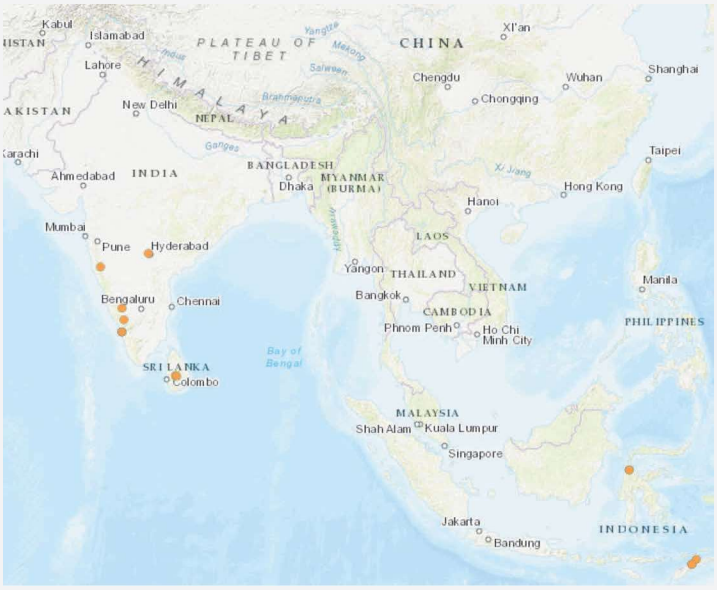
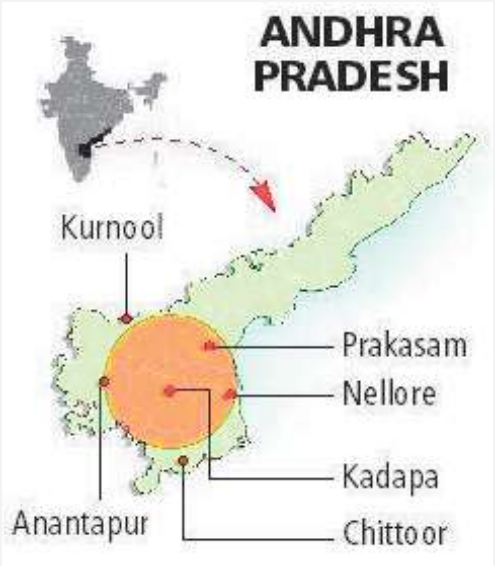
| *Indian Rosewood (Dalbergia latifolia)* | *North Indian Rosewood (Dalbergia sissoo)* |
|---|---|
| A large **evergreen** tree native to low-elevation **monsoon forests of south India**. Its drier subpopulations are deciduous. | Fast-growing, hardy, medium to large **deciduous tree** native to the **foothills of the Himalayas**. |
| It is **native to India** (**TN**, **Karnataka**, **Andhra Pradesh**, **UP** and **Sikkim**). It is the **state tree of Punjab**. | It is **native to the Indian subcontinent and southern Iran**. It is endemic to the **tropical Himalayas**. |

| | |
|---|---|
| **Habitat:** Evergreen or deciduous tropical or sub-tropical forests with deep, well-drained, and moist soils. It **can grow in slightly saline soil**. | **Habitat:** Tropical and subtropical forests with well-drained sandy river banks. |
| It produces a hard, durable, heavy wood that is durable and **resistant to rot and insects**. | Its timber is **less valuable** because of its abundance. |
| **Threats:** Logging and wood harvesting. | **Threats:** Logging and wood harvesting. |
| **IUCN: VU \| CITES: Appx II** | **IUCN: LC \| CITES: Appx II** |
|  |  |
|   |   |

## Plant – Misc – Indian Sandalwood (VU) vs Red Sandalwood (EN) (They belong to different Genera)

- **Sandalwood (Chandan/Srigandha)** is wood from trees in the genus **Santalum**. **Indian Sandalwood (*Santalum album*)** is the **only major native sandalwood species in India**.
- **Red Sandalwood/Lal Chandan (*Pterocarpus santalinus*)**, though it has the word 'sandalwood' in its name, belongs to a different order and genus (**Pterocarpus**).

- **Sandalwood Spike Disease** is a significant problem for the Indian Sandalwood (*Santalum album*) compared to the Red Sandalwood/Lal Chandan (*Pterocarpus santalinus*).

| Indian Sandalwood (White Sandalwood) | Red Sandalwood (Red Sanders) |
|---|---|
| *Scientific name:* ***Santalum album*** | *Scientific name:* ***Pterocarpus santalinus*** |
| They are small to medium-sized **tropical evergreen trees** | They are **medium-sized tropical deciduous trees** |
| **Habitat:** Dry deciduous and evergreen forests | **Habitat:** Tropical dry deciduous forests |
| They can grow up to altitudes around 700 m | The best wood grows at altitudes around 750 m |
| They are **semi-root parasites** (tap the roots of other species for water and nutrients) | They are **autotrophs** |
| They are native to southern India and SE Asia and are mainly found in the forests of **Karnataka** and **TN**<br>  <br>  | They are endemic to the **southern Eastern Ghats**, mainly found in the **Seshachalam forests** and Palakonda hills of **Chittoor**, **YSR (Kadapa)**, **Annamayya** and **Tirupati** districts of AP)<br>  <br>  |
| They **retain aroma for decades** | **Non-aromatic** (still used in incense, perfumes, etc.) |
| They are slow-growing | They are **very slow growing** (reforestation is tough) |

| | |
|---|---|
| They grow well in alkaline soil | Can survive on a variety of soils, including degraded soils |
| Its wood is used as timber (strong and durable). Because of its **aroma** and **therapeutic properties**, sandalwood oil is extensively used in **perfumes**, **incense**, **cosmetics**, **soaps**, etc. | It is valued for its **rich red colour** and its **therapeutic properties**. It is used to make exquisite furniture, woodcrafts, and musical instruments in China and Japan. |
| Its wood is one of the most expensive in the world | Wood is scarce and a lot more expensive |
| **IUCN Red List: VU** | **IUCN: EN \| CITES: Appx II (export is prohibited)** |
| Both species are **angiosperms (flower and fruit-bearing)** | |

### Sandalwood Cultivation in India

- Growing sandalwood (both red and white) by individuals was banned until 2002. **Today**, **many states permit sandalwood cultivation**, but **cutting and harvesting wood**, **using it**, **or selling it in the open market is illegal**. Permission is required from the state forest department, which sends its officials to cut the trees and buy the sandalwood. Because of these restrictions, sandalwood cultivation is rare in India, while other countries grow and export sandalwood freely. This is **not good for India** from both the conservation and economic perspective.

**[UPSC 2016] With reference to 'Red Sanders', sometimes seen in the news, consider the following statements:**

1. It is a tree species found in a part of South India.
2. It is one of the most important trees in the tropical rainforest areas of South India.

***Which of the statements given above is/are correct?***

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

⇨ **Red sanders** are one of the most important trees in the **tropical deciduous areas** of South India. So, the answer is a) 1 only.

### Sandalwood Spike Disease (SSD)

- SSD) is an infectious disease caused by **phytoplasmas** (**bacterial pathogens** affecting the plant tissues of agriculturally important coconut, sugarcane, and sandalwood).
- **Sap-sucking insect vectors** and **seedlings from infected sandalwood trees** transmit phytoplasmas, causing a **reduction in leaf size**, stiffening and reduced internode length. Presently, there is **no cure for the infection**. The **infected tree must be cut down and removed**.

- It is likely to be the **most destructive of known diseases to infect Indian sandalwood**.

### Plant – Misc – Kanjiram

- Kanjiram is a tree species deriving its name from **'kasara'**, meaning **wormwood**.
- It is known for being the natural source of the **highly poisonous compound strychnine**.
- Monkeys and birds, such as the gray langur and hornbill species, eat the toxic fruit
- Recently, it has been declared as the **official tree of Kasargod district**.
- **Distribution:** It is a medium-sized deciduous tree **native to India and SE Asia**.
- **Habitat:** Moist deciduous forests.
- **Uses:** It is used in **traditional medicine** to treat various conditions (like paralysis, epilepsy, etc).
- **Threats:** Habitat loss, overexploitation, **red sand mining**, and climate change.

⇨ *Kasaragod has become the first district in India to officially designate its own tree species.*

## 28.5. Invasive Species

### Invasive Plant Species

#### Acacia / Wattles

- **Acacia** is an **evergreen**, **drought-resistant** plant species **native to Africa and Australasia**. It has a long root system that penetrates deep in search of water and thorny leaves to prevent water loss. It **reproduces rapidly**, **forming a canopy that prevents other species from growing**.
- In the Western Ghats, vast plantations of **acacia** and **eucalyptus** were raised in the past by converting grasslands and **shola forests** for **tannin production**, destroying the original habitat of **Nilgiri Tahr**.

⇨ ***Tannin:*** *Found in the bark, pods, and leaves of acacia, it is an organic substance used to preserve leather.*

#### Billygoat Weed

- **Billygoat-weed** (also called **chickweed** or **goat weed)** is a herb **native to Tropical America**, **especially Brazil**. It has **medicinal properties**. It is also an **insecticide** and **nematicide**.
- It is an invasive weed outside its native range. It is **a moderate weed in rice cultivation in Asia**.

## Carrot Grass / Congress Grass

- **Carrot grass** is a flowering plant **native to the American tropics**. It is a common **invasive species in India**, **Australia**, **and parts of Africa**.
- It produces allelopathic chemicals that **suppress crop and pasture plants**, causing disastrous yield losses, so it is also called **famine weed**.
- It releases allergens that **cause pollen allergy**, **dermatitis**, **and respiratory malfunction** in humans, cattle and domestic animals.

## Eucalyptus

- **Eucalyptus** is a **fast-growing evergreen tree native to Australia**. It has medicinal properties, such as **antimicrobial** and **antibacterial** (used for colds and respiratory problems, pain relief, dental care, fungal infections, and wounds). It also acts as an **insect repellent**.
- It is an **invasive species outside its native range**. It **reproduces rapidly**, **which prevents other native species from growing**. This also leads to fodder scarcity for native fauna.

## Forked Fanwort

- **Forked Fanwort** (or **Mullan Payal**) is a pink flowering submerged **perennial aquatic plant** **native to South America**. It grows in stagnant to slow-flowing freshwater and is **commonly used in aquariums**. It is an invasive species; it spreads rapidly and **displaces native aquatic plants**.

## Lantana

- **Lantana** is a flowering plant **native to the American tropics**. It is an invasive species; once it is introduced into a habitat, it spreads rapidly. It **outcompetes native species**, leading to a reduction in biodiversity. If it infests pastures and farmlands, it **suppresses the pastures (grasses) and crops**. It also affects the livestock by reducing pastures and by its toxicity (**it is poisonous for livestock**).

## Mexican Prickly Poppy

- The **Mexican prickly poppy** is a poppy species **native to Mexico** that has been widely naturalised in many parts of the world. It is an **annual herb** that is **tolerant of drought and poor soil**.
- It tends to grow along roadsides, in fallow and cultivated lands, riverbanks, and floodplains. It competes with and **replaces native species**. It is also a **significant crop weed**. Its seeds resemble those of mustard, so they are **used in adulteration of mustard**, rendering them poisonous.

## Mikania Micrantha

- **Mikania micrantha** is a **tropical perennial creeper native to North**, **Central**, **and South America**. It grows best in areas with high humidity, light, and soil fertility, though it can **adapt to less fertile soils**. The **featherlike seeds** are dispersed by wind.
- It has **medicinal properties** and is used to **stop minor external bleeding**. It is an invasive weed that grows very vigorously and is **widespread in the tropics**.
- It slows the germination and growth of other plant species. **Introduced in India as ground cover in tea plantations** in the 1940s, it is now a serious threat to plantation crops and forest covers.

## Prosopis Juliflora

- **Prosopis juliflora** (or **Ganda babool**) is a small tree **native to Mexico**, **South America and the Caribbean**. It has become established as an **invasive weed in Africa**, **Asia**, **Australia and elsewhere**. It has **long roots and can deplete water resources rapidly**.
- It **grows rapidly and prevents the growth of other native species**. Its rapid growth **hampers the movement of wild animals** in the forests. It **enhances the malaria parasite transmission** capacity of Anopheles mosquitoes and provides them with sugar that is critical to their survival.
- The government introduced Prosopis juliflora in the **Banni grasslands to fight salinity and to stop the advancement of the Rann of the Kutch**. The plant thrived in the non-saline and low-saline soils and **invaded the Banni grasslands**. The plant took away much of the rechargeable water and aggravated droughts in the region. To the **Maldhari herders** of the Kutch region, this has meant a **huge loss of**

**pastures**. But it has also created unexpected income: **Prosopis charcoal**. **Prosopis juliflora wood has high carbon content; charcoal derived from it is in high demand**.

**[UPSC 2018] Why is a plant called Prosopis juliflora often mentioned in news?**

a) Its extract is widely used in cosmetics.
b) It tends to reduce the biodiversity in the area in which it grows.
c) Its extract is used in the synthesis of pesticides.
d) None of the above

## Water Hyacinth

- **Water Hyacinth** is a **free-floating perennial hydrophyte** (a plant that grows either partly or totally submerged in water) **native to South America**. It has been naturalized throughout the world and has a wide range of habitats (tropical, subtropical, temperate, and rainforest zones).
- It is known as the **'Terror of Bengal'**, **'German Weed'** in Bangladesh, **'Florida Devil'** in South Africa and **'Japanese Trouble'** in Sri Lanka.
- It is an **invasive species outside its native range**. It grows and reproduces quickly and covers large portions of ponds and lakes. **Water bodies already affected by human activities are particularly vulnerable** (e.g., artificial reservoirs and eutrophic lakes). It **drains oxygen from the water bodies**, resulting in the devastation of aquatic biodiversity.

## Conocarpus

- Conocarpus is an **evergreen tree species** with dark-green shiny leaves **native to tropical regions**.

- They are an **exotic mangrove species** that grows fast.
- They have become an **invasive species** in some areas, including India.
- They are **not palatable to wild herbivores or domesticated animals**.
- Their plantations are planted for their salt tolerance, wind resistance, fuelwood, ornamentation, etc.
- The **Gujarat government** has prohibited the plantation of Conocarpus trees in forest and non-forest areas due to their negative impact on the environment and human health.
- Before Gujarat, **Telangana** had banned the Conocarpus tree species.

## Invasive Mammal, Fish and Amphibian Species

### Domestic Cats

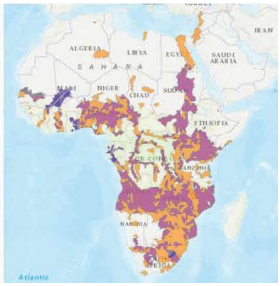
- Domestic cats (*Felis catus*) were **not always this widespread**.
- Wildcats (*Felis silvestris*) were probably first domesticated in West Asia some 10,000 years ago.
- They **spread via sailing ships** much later.
- Today, domestic cats (*Felis catus*) are one of the **world's 100 worst invasive alien species**.

### African Catfish

- It is a species of **nocturnal airbreathing catfish**. It is **native to Africa and the Middle East**.

> ⇨ ***Airbreathing catfish:*** *This is a species of catfish that can wiggle across dry land by breathing air to find food or suitable environments.*

- **Habitat:** Freshwater lakes, rivers, and swamps. It **can survive in turbid and low-oxygen waters**. Hence, it is **illegally raised in polluted ponds and lakes**.
- It is a **voracious carnivorous fish** that **poses a threat to indigenous fish varieties because it preys on them**. Factoring in the health and environmental hazards posed by the African catfish, the Central government issued a ban on catfish farming (breeding, transportation, and **sale)** in 2000.



## Gambusia Fish

- **Gambusia** (or mosquitofish) are **freshwater fish native to North America**.
- It is an **omnivore** that eats tiny organisms, including mosquito larvae, insects, and algae.
- It is used as a **biocontrol to lower mosquito populations** because it is a voracious feeder of mosquito larvae, a self-sustaining control method, and is cost-effective.
- In many places where Gampusia has been introduced, they have become **invasive species**.
- The IUCN has declared Gambusia as one of the **100 worst invasive alien species in the world**.

⇨ *Gambusia has been part of **malaria control in India since 1928**, including the Urban Malaria Scheme.*

⇨ *In the 1990s, the introduction of mosquitofish in **Nainital Lake** to control malaria had adverse effects on the lake's ecosystem health.*

⇨ *Multiple countries, including India, have listed Gambusia as an invasive species.*

⇨ *However, the fish is still a prominent part of India's malaria control programmes and are released into freshwater bodies across the country, like Andhra Pradesh, Chandigarh, and Uttar Pradesh.*

## Indian Bullfrog

- **Indian bullfrog** is a large species of fork-tongued frog found in South and SE Asia.
- It is an **invasive species in Maldives**, **Madagascar**, **and India's Andaman Islands**, where it was introduced. It has become **a threat to native wildlife**, which includes fish, lizards, frogs, etc.

**---------- End of Chapter ----------**