

## Environment for General Studies UPSC Civil Services Exam

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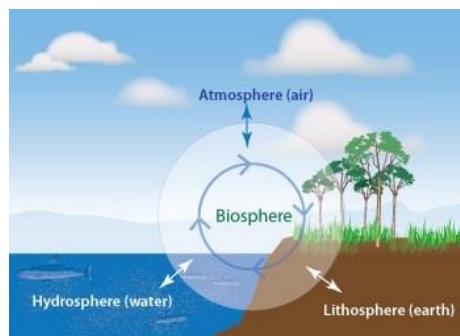
## 1. Environment and Ecology

### 1.1 Environment

- Environment is the natural component in which biotic (living) and abiotic (non-living) factors interact among themselves and with each other.
- These interactions shape the **habitat** and **ecosystem** of an organism.
- In biological sense, environment constitutes the physical (nutrients, water, air) 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 are dependent on the environment to carry out their natural life processes and to meet their physical requirements (food, energy, water, oxygen, shelter etc.).

## Biosphere

- The biosphere is the **biological component (supporting life)** of earth which includes the **lithosphere, hydrosphere and atmosphere**.
- The biosphere includes all living organisms on earth, **together with the dead organic matter** produced by them.

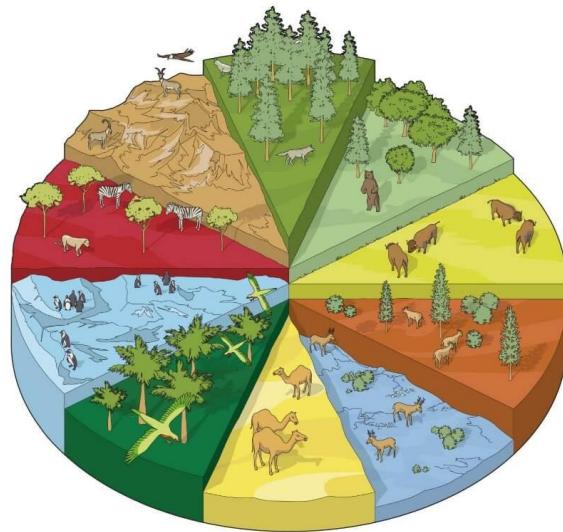


*Biosphere ([Source](#))*

- Biosphere is **absent at extremes** of the North and South poles, the highest mountains and the deepest oceans, since existing hostile conditions there do not support life (**life is the characteristic feature of biosphere**).
- Occasionally spores of fungi and bacteria do occur at great height beyond 8,000 metres, but they are metabolically inactive, and hence represent only dormant life.

## Habitat

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



## Difference between Habitat and Environment

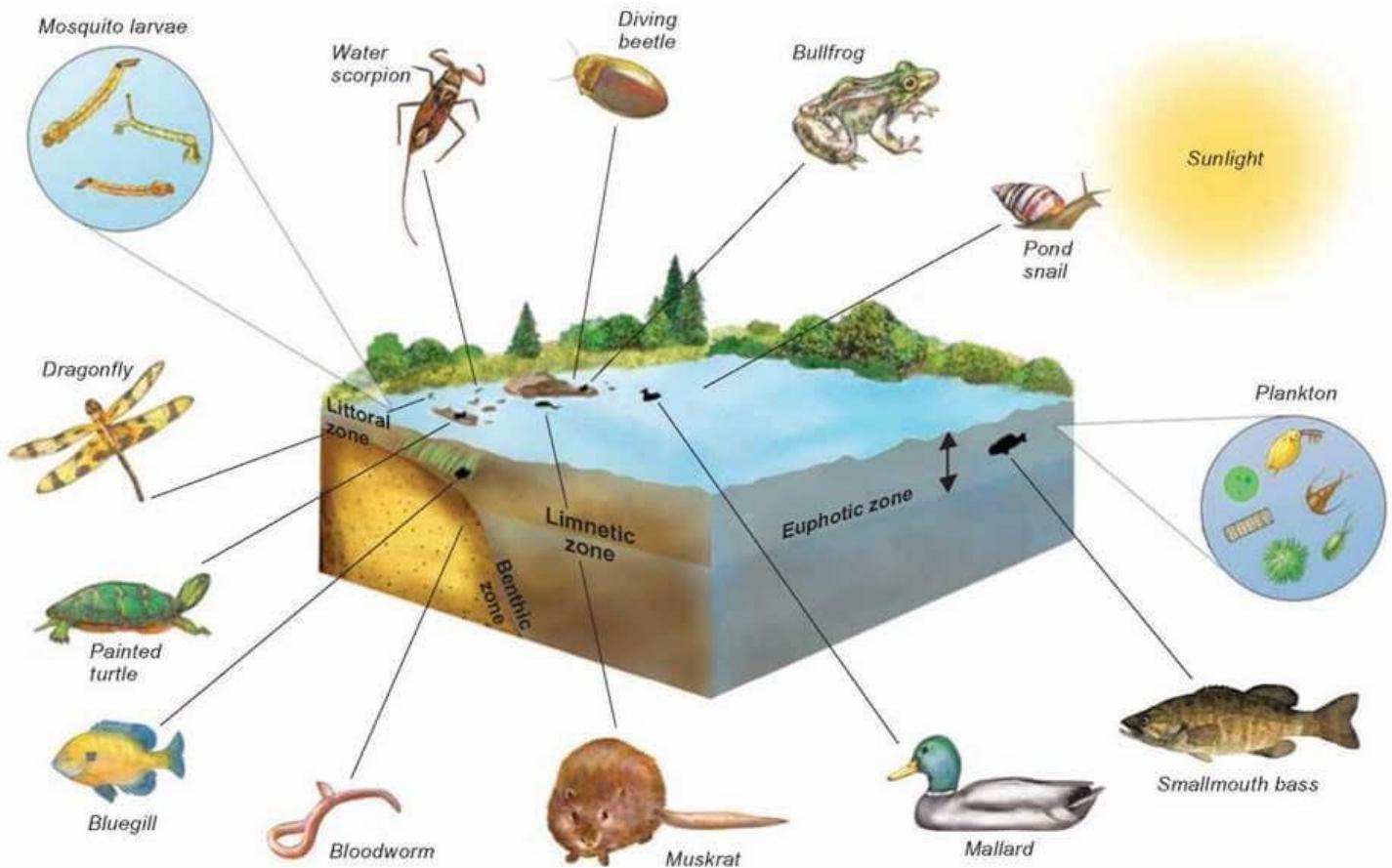
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- A habitat always has **life** in it, whereas the environment does not necessarily have life in it.
- **All habitats are environments, but all environments are not habitats.**
- A habitat is always a **preference of one species**.
- An environment 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

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- An ecosystem can be visualised as a **functional unit of nature**, where living organisms (producers, consumers, and decomposers) interact among themselves and also with the surrounding physical environment.
- An ecosystem can be of any size but usually encompasses **specific and limited species**. E.g. Aquatic Ecosystem. (**This is how ecosystem is different from Environment**)
- In the ecosystem, biotic and abiotic components are linked together through **nutrient cycles** and **energy flows**.
- Everything that lives in an ecosystem is dependent 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 has an impact on everything else.

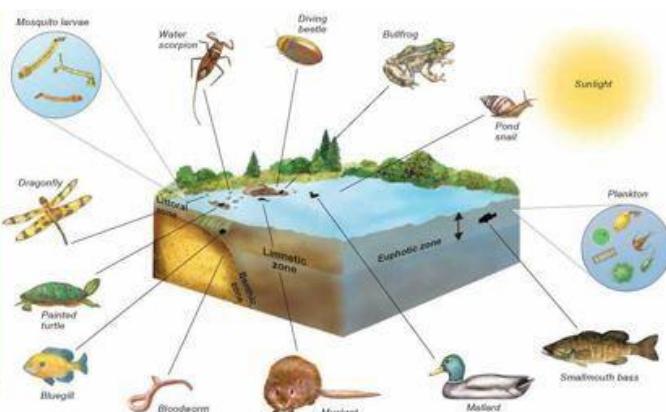


Aquatic Ecosystem ([Source](#))

## Classification of Ecosystems

- Forest, grassland and desert are some examples of **terrestrial ecosystems**; pond, lake, wetland, river and estuary are some examples of **aquatic ecosystems**.
- Crop fields and an aquarium are human-made ecosystems.

## Difference between Ecology, Environment & Ecosystem



Environment (Left) and an Aquatic Ecosystem (Right)

- **Ecology** is the study of interactions between organisms, organisms and the surroundings occurring within an ecosystem or environment.
- An ecosystem is a functional unit of the environment (mostly biosphere).
- An environment is a group of ecosystems.

**Environment → Can be almost everything or a small region.**

**Habitat → Area where an organism lives.**

**Biosphere → The region on earth that supports life.**

**Ecosystem → Producers, Consumers, Decomposers and their relationships (tiny environment). It is the functional unit of the environment.**

**Q. Which one of the following is the best description of the term “ecosystem”?**

- A community of organisms interacting with one another
- That part of the Earth which is inhabited by living organisms
- A community of organisms together with the environment in which they live.
- The flora and fauna of a geographical area.

Explanation:

- A community of organisms interacting with one another – no specific term.
- That part of the Earth which is 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.

**Answer: c)**

## **Components of an Ecosystem**

- The components of the ecosystem are categorized into abiotic or non-living and biotic or living components. Both the components of the ecosystem and environment are the same.

### **Abiotic Components**

- Abiotic components are the inorganic and non-living parts which act as major limiting factors.

#### **Limiting factor**

- A lot of factors determine the survival of an organism. One single factor can limit the range of an organism.

- This single factor is called as a **limiting factor**.
- For example, **seeds don't germinate quickly in evergreen rain forests** in spite of good rains and vegetation as the surface soil is **heavily leached** (nutrients washed away by running water). Here, poor soil is the limiting factor.
- Likewise, **germinated saplings may not survive due to lack of light** because of the dense canopy. Here, the absence of light (shade of the forest) is the limiting factor.

**Q. If a tropical rain forest 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 the trees in a rain forest have poor viability
- c) the rain forest species are slow-growing
- d) exotic species invade the fertile soil of rain forest.

Explanation:

- The soil of rain forest is deficient in nutrients (true): Rainforest  $\Rightarrow$  It rains almost every day  $\Rightarrow$  The topsoil is continuously washed away  $\Rightarrow$  nutrients are also washed away (leaching of nutrients)  $\Rightarrow$  very little fertility remains in topsoil  $\Rightarrow$  most of the seeds don't germinate for years  $\Rightarrow$  regeneration is very slow (it takes decades). But the layer below topsoil (sub-soil) is very fertile. Thus, plants grow very quickly 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  $\Rightarrow$  detachable structure that can give rise to a new plant, e.g. a bud, sucker, or spore (sexual reproduction in plants). Seed-bearing plants are more significant than propagules in a rainforest.
- The rain forest species are slow-growing (false): The plant species in rainforests compete for sunlight. Hence, they grow as rapidly as they can.
- Exotic species (non-native) invade the fertile soil of rain forest: this statement is wrong as the rainforest soil is heavily leached. Hence, they are not fertile. But exotic invasive species are a threat to the rainforests, especially when the forests are cleared.

Answer: a)

## Light

- The spectral quality of solar radiation is important for life.
- The UV component of the spectrum is harmful to many organisms.

## Rainfall

- Majority of biochemical reactions take place in an aqueous medium.

### Temperature

- A few organisms can tolerate and thrive in a wide range of temperatures (they are called **euthermal**).
- A vast majority of them are restricted to a narrow range of temperatures (**stenoethermal**).

### Atmosphere

- 21% oxygen helps in the survival of many organisms; **78% nitrogen prevents spontaneous combustion** and 0.038% carbon dioxide helps primary producers in the **synthesis of carbohydrates**.

### Organic compounds

- Proteins, carbohydrates, lipids etc. are essential for energy transfer in the living world.

### Inorganic compound

- Carbon, carbon dioxide, water, sulphur, nitrates, phosphates, and ions of various metals are essential for organisms to survive.

### Altitude

- **Vertical zonation of vegetation** is caused due to altitude.
- Change in temperature with altitude is a limiting factor.

### 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 earth.
- The neutral pH is conducive for the survival and sustenance of living organisms.

### Salinity

- Some organisms are tolerant of a wide range of salinities (**euthaline**).
- Others are restricted to a narrow range of salinities (**stenothaline**).

## **Effect of Abiotic Components on Terrestrial Primary Producers (Plants)**

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### Light

- Extremely **high intensity favours root growth than shoot growth** which results in **increased transpiration**, short stem, **smaller thicker leaves**.
- On the other hand, **low intensity of light retards growth, flowering and fruiting**.

- When the Intensity of light is less than the minimum, the plants cease to grow due to the **accumulation of CO<sub>2</sub>** and finally die.
- 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 elongation of cells (etiolated plants)**.
- **Plants grown in ultraviolet and violet light are dwarf**.

### Frost

- Frost results in **freezing the soil moisture**.
- The plants are **killed due to increased transpiration when their roots are unable to supply moisture**.
- Water in the intercellular spaces of the plant gets frozen into ice. This results in **increasing concentration of salts and dehydration of cells**.
- Also, frost leads to the formation of canker (various plant diseases with similar symptoms caused by a wide range of fungi, bacteria, and viruses).

### Snow

- Snow 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.
- Snow shortens the period of vegetative growth.

### Temperature

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

### 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 together, but the shoots die.
- E.g. sal, red sanders, silk cotton tree etc.

## Biotic Components

### **Primary producers or Autotrophs (self-nourishing)**

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

### **Consumers or Heterotrophs or Phagotrophs (other nourishing)**

- Consumers 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** which feed mainly on plants. E.g. sheep, rabbit, etc.
- **Secondary consumers** feed on primary consumers. E.g. wolves, dogs, snake, etc.
- Carnivores which feed on both primary and secondary consumers are called **tertiary consumers**. E.g. lion (can eat wolves), snakes etc.
- **Omnivores** are organisms which consume both plants and animals. E.g. man, bear, **pig**, etc.

#### **Micro consumers or Saprotophys (decomposers or osmotrophs)**

- They are **bacteria and fungi** which obtain energy and nutrients from dead organic substances (**detritus**).
- **Earthworm** and certain soil organisms (such as **nematodes**, and **arthropods**) are detritus feeders and help in the decomposition of organic matter and are called **detritivores**.

## **1.2 Ecology – Principles and Organizations**

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- 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 to their physical surroundings (environment).

## **Levels of Organizations in Ecology**

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- Ecology encompasses the study of **individual, organisms, population, community, ecosystem, biome and biosphere** which form the various levels of ecological organisation.

# Levels of Organization

Ecologist study organisms ranging from the various levels of organization:

- Species
- Population
- Community
- Ecosystem
- Biome
- Biosphere



## Individual and Species

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

## Population

- 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 and/or immigration or negative due to death and/or emigration.
- In the case of 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.
  - Study of pug marks can provide the following information reliably:
    - ✓ Presence of different species in the area of study.
    - ✓ Identification of individual animals.
    - ✓ Population of large cats (tigers, lions etc.).
    - ✓ **Sex ratio and age** (young or adult) of large cats. ([sex of tigers can be determined from pugmarks](#))

## Community

- Communities in most instances 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 are dependent 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.

## Ecosystem

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- An ecosystem is a community of organisms interacting with each other and with their environment such that energy is exchanged and system-level processes, such as the cycling of elements, emerge.

## Biome

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- A biome is a **large naturally occurring community of flora and fauna occupying a major habitat**. E.g. Rainforest biome or tundra biome.
- Plants and animals in a biome have common characteristics due to similar climates and can be found over a range of continents.
- Biomes are distinct from habitats because **any biome can comprise a variety of habitats**.

## Biosphere

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- The biosphere includes all living organisms on earth, together with the dead organic matter produced by them.

## Principles of Ecology

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### Adaptation

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- An adaptation is, "the appearance or behaviour or structure or mode of life of an organism that allows it to survive in a particular environment".

Adaptation may be:

- Morphological – when trees grew higher, the giraffe's neck got longer;
- Physiological – in the absence of an external source of water, the kangaroo rat in North American deserts is capable of meeting all its water requirements through its **internal fat oxidation** (in which water is a by-product). It also has the ability to concentrate its urine so that minimal volume of water is used to remove excretory products;

- Behavioural – animals migrating temporarily to a less stressful habitat.

### Examples of Adaptation

- Many desert plants have a **thick cuticle** on their leaf surfaces and have their **stomata arranged in deep pits** to minimise water loss through transpiration.
- Some desert plants like Opuntia, **have no leaves – they are reduced to spines**, 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 huge ears?
- We need to breathe faster when we are on high mountains. After some days, our body adjusts to the changed conditions on the high mountain.
- Such 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, are called **acclimatisation**.
- The body compensates low oxygen availability **by increasing red blood cell production, decreasing the binding capacity of haemoglobin** and by increasing breathing rate.
- A **hyperthermophile** is an organism that thrives in extremely hot environments — from 60 °C. E.g. Archaeabacteria flourish in hot springs and deep-sea hydrothermal vents.
- 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 starts increasing.
- Some species are capable of burrowing into the soil to hide and escape from the above-ground heat.

### Variation

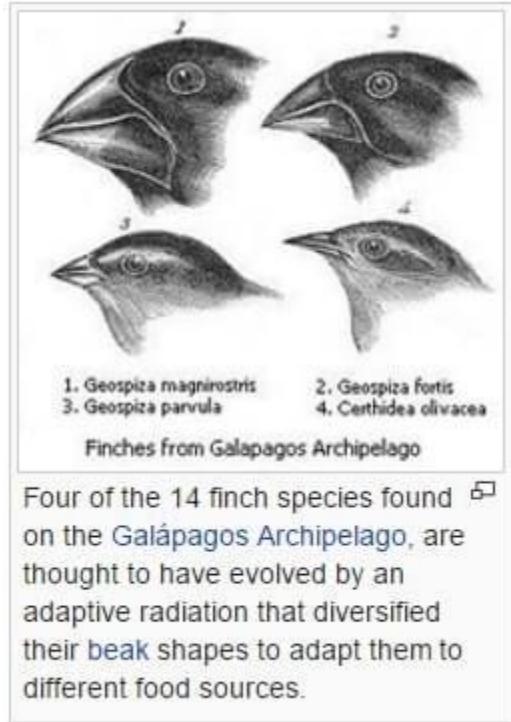
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- Variations are **induced by changes in genetic makeup** due to **addition or deletion of certain genes**.
- **Mutations, change in climate, geographical barriers** etc. induce variations over a period of time.
- The difference in the colour of skin, type of hair; curly or straight, eye colour, blood type among different ethnic groups represents variation within human species.

### Adaptive radiation

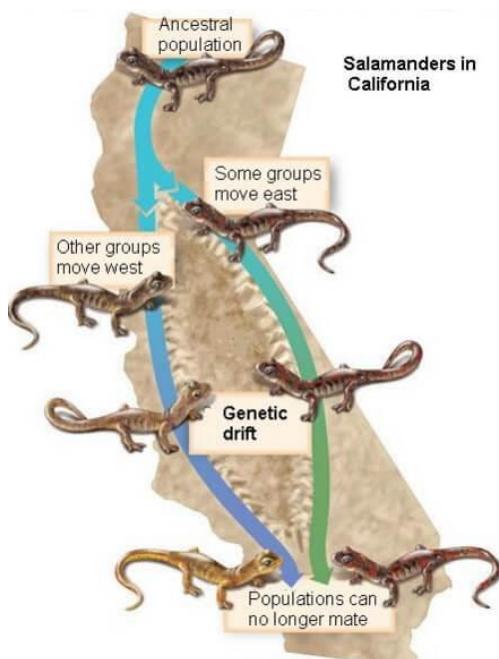
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- Adaptive radiation is a process in which organisms diversify from an ancestral species into a multitude of new forms when the environment creates new challenges or opens new environmental niches.



## Speciation

- Speciation is the process by which **new species are formed**, and **evolution is the mechanism by which speciation is brought about**.
- A species comprises of many populations. Often different populations of a species remain isolated due to some geographic barrier such as mountain, ocean, river, etc.
- Geographic isolation leads to speciation (**allopatric speciation or geographic speciation**).



- After a long period of time, the sub-populations become very different (**genetic drift**) and get isolated, reproductively, i.e. they no longer interbreed.
- Later even when the barrier is removed, the sub-populations are unable to interbreed, and thus subsequently the sub-populations become two different species.

## Mutation

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- Mutation (a change in genetic material that results from an **error in replication of DNA**) 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

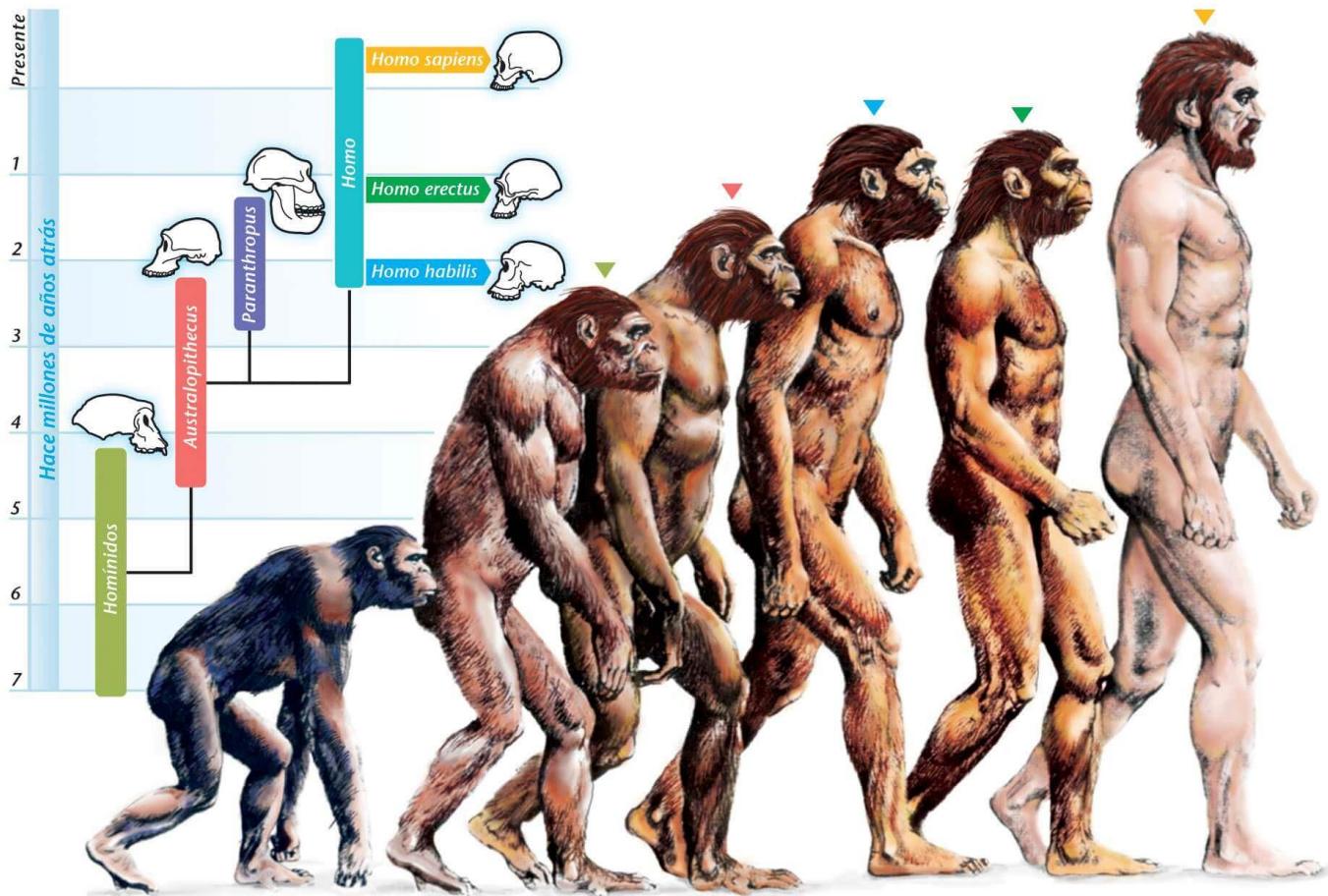
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- Natural Selection is the mechanism proposed by **Darwin and Wallace**.
- Natural selection is the process by which species adapt to their environment.
- It is an evolutionary force that selects **among variations, i.e. genes that help the organism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

## Evolution

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- Evolution is the **change which gives rise to new species**.
- It happens in order to make the organism better suitable to the present environment.



- Evolution involves the processes of natural selection, adaptation, variation etc.
- A valid theory of evolution was propounded by Charles Darwin and Alfred Wallace in 1859.
- This theory has been extended in the light of progress in genetics and is known as **Neo-Darwinism**.

## Extinction

- The primary reason behind extinctions is environmental change or biological competition.
- Extinction occurs when species cannot evolve fast enough to cope with the changing environment.
- At present, the 6<sup>th</sup> Mass Extinction (Anthropogenic Extinction – human induced) is in progress.

**Q. 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 promoting 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.

Answer: d)

**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 or certain habits, which enable a plant or an animal to live in its surroundings, is called adaptation and not evolution. E.g. **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 small problems due to changes in the surroundings, is called **acclimatization** (True). E.g. Soldiers undergo rigorous acclimatization training before they can serve in harsh climatic regions like Siachen Glacier.
- Gradual changes in an organism to survive in an environment is call evolution and not Adaptation. E.g. The evolution of 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:

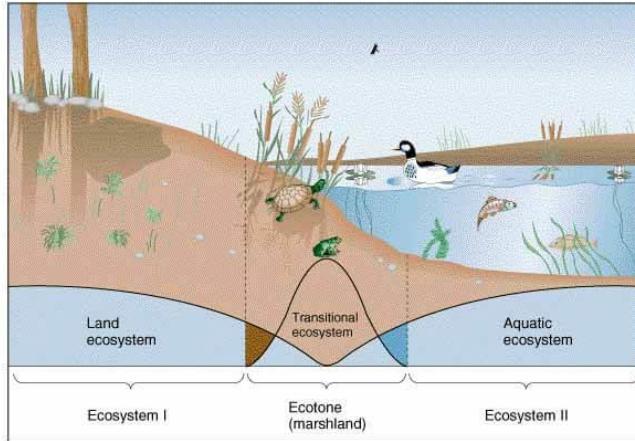
- Sloping branches (prevent accumulation of snow) and needle-like leaves (reduce transpiration) – Taiga vegetation.
- Deep roots – Desert vegetation
- Waxy stem, thick leaves or no leaves – Desert vegetation
- Canopy – the characteristic feature of tropical forests – rainforests, deciduous forests etc.

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

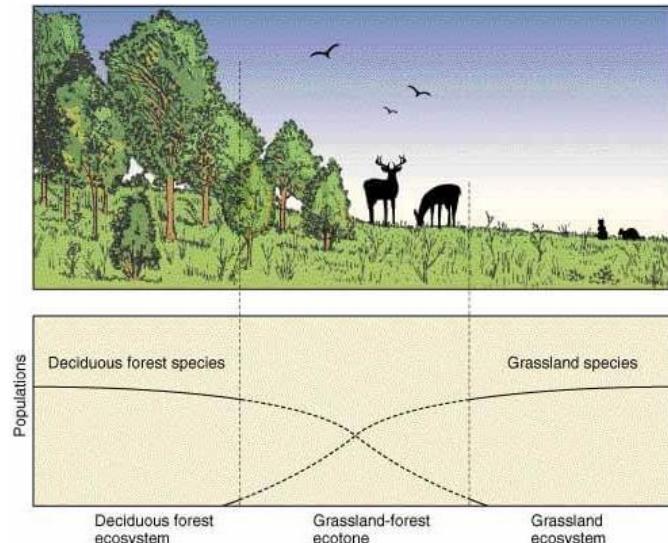
### 1.3 Ecotone

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



[Picture Credits](#)



[Picture Credits](#)

## Characteristics of Ecotone

- It 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 decreases 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.

## 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.

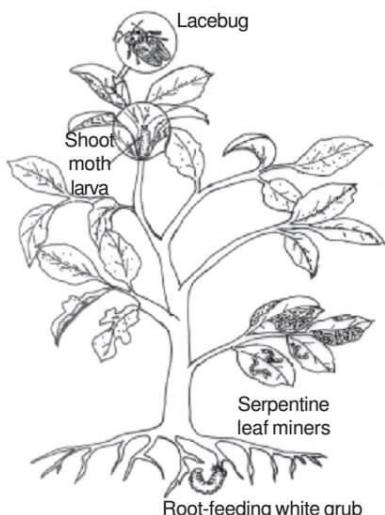
- Ecozone occurs across the environmental gradient (gradual change in abiotic factors such as altitude, temperature (thermocline), salinity (halocline), depth, etc.).

## Edge Effect – Edge Species

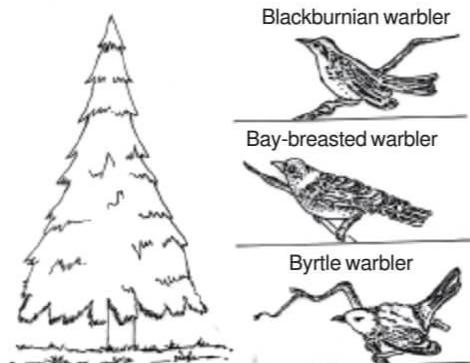
- Edge effect refers to the **changes in population or community** structures that **occur at the boundary of two habitats (ecotone)**.
- Sometimes the number of species and the population density of some of the species in the ecotone is much greater than either community. This is called **edge effect**.
- The organisms which occur primarily or most abundantly in this zone are known as **edge species**.
- In the terrestrial ecosystems edge effect is especially applicable to **birds**.
- For example, the **density of birds is greater in the ecotone** between the forest and the desert.

## Ecological Niche

- Niche refers to the **unique functional role and position of a species in its habitat or ecosystem**.
- The functional characteristics of a species in its habitat is referred to as "niche" in that common habitat.
- In nature, many species occupy the same habitat, but they perform different functions:
  - habitat niche – where it lives, food niche – what is eats or decomposes & what species it competes with,
  - reproductive niche – how and when it reproduces,
  - physical & chemical niche – temperature, land shape, land slope, humidity & another requirement.
- Niche plays an important role in the **conservation of organisms**. If we have to conserve species in its native habitat, we should have knowledge about the **niche requirements of the species**.



Different species of insects feeding on different parts of the same plant



The three species of warbler birds search for insects as food in the forest at different levels in the tree and so occupy different niches

## Difference between niche and habitat

- The habitat of a species is like its 'address' (i.e. where it lives) whereas niche can be thought of as its "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, a large number of 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.

**Q. 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 in which an animal lives and moves on a daily or periodic basis (a little bigger than habitat – home → office → home).

Answer: b) Niche

## 2. Functions of Ecosystem

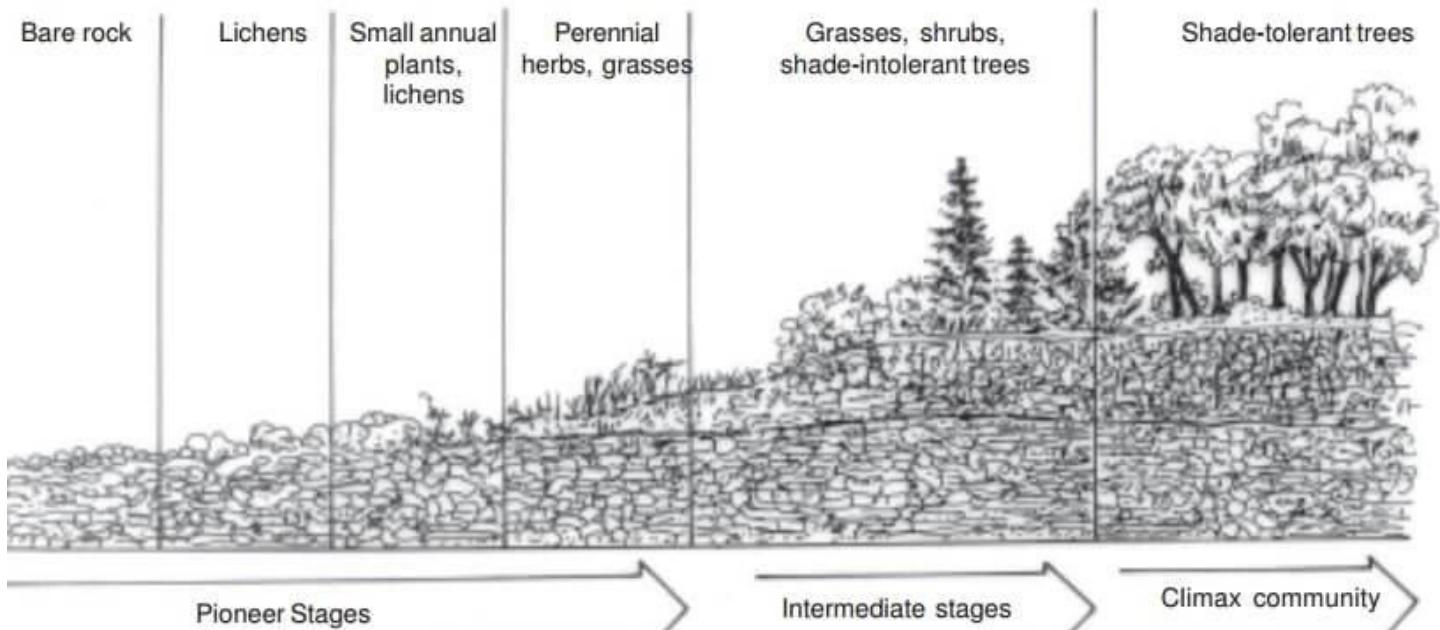
- The function of an ecosystem includes:
  1. **Ecological succession or ecosystem development**
  2. **Homeostasis (or cybernetic) or feedback control mechanisms**
  3. **Energy flow through the food chain**
  4. **Nutrient cycling (biogeochemical cycles)**

### 2.1 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**.

- Succession is a universal process of **directional change in vegetation**, on an ecological time scale.
- Succession occurs due to large scale changes or destruction (natural or manmade).
- The process involves a progressive series of changes with one community replacing another until a **stable, mature, climax community** develops.

## Stages



Primary Succession (Picture Credits: NIOS Environment)

- The first plant to colonize an area is called the **pioneer community**.
- The final stage of succession is called the **climax community**.
- **A climax community is stable, mature, more complex and long-lasting.**
- The stage leading to the climax community is called **successional stages or seres**.
- Each transitional community that is formed and replaced during succession is called a **stage in succession or a seral community**.
- Succession is characterized by the following: **increased productivity, the shift of nutrients from the reservoirs, increased diversity of organisms, and a gradual increase in the complexity of food webs.**
- **Succession would occur faster in area existing in the middle of the large continent.** This is because here seeds of plants belonging to the different **seres** would reach much faster.

## Primary Succession

- Primary succession takes place an over **where no community has existed previously**.

- Such areas include rock outcrops, newly formed deltas and sand dunes, emerging volcano islands and lava flows, glacial moraines (muddy area exposed by a retreating glacier), etc.
- 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 conditions by their growth and development.

**Q. 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 (usually green) or cyanobacteria and fungi**.
- Fungi provide shelter, water and minerals to the algae and, in return, the alga provides food.

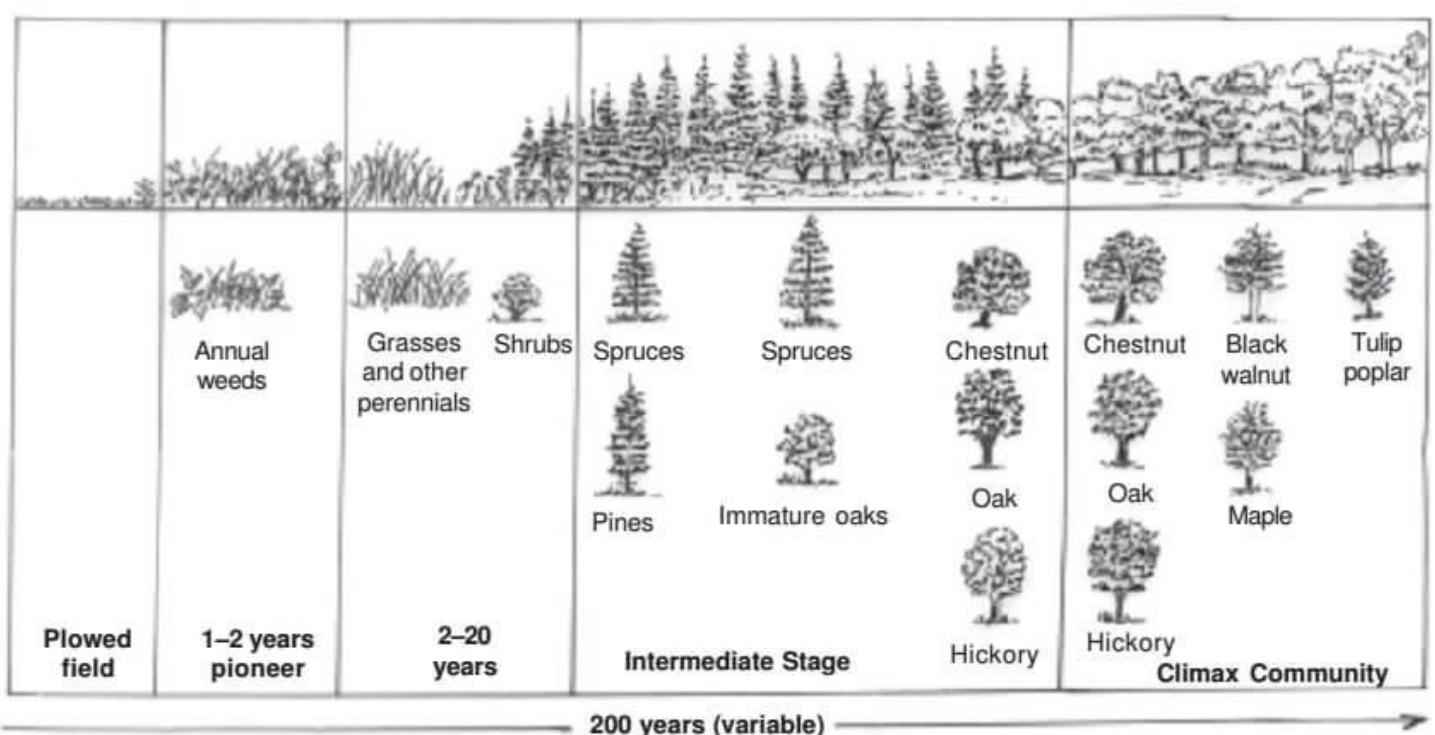
Answer: b) Algae and Fungi

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

## **Secondary Succession**

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



Secondary Succession (Picture Credits: NIOS Environment)

- 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.
  - This abandoned land is first invaded by hardy species of grasses that can survive in bare, sun-baked soil.
  - These grasses may be soon joined by tall grasses and herbaceous plants. These dominate the ecosystem for some years along with mice, rabbits, insects and seed-eating birds.
  - Eventually, some trees come up in this area, seeds of which may be brought by wind or animals.
  - And over the years, a forest community develops. Thus, an abandoned land over a period becomes dominated by trees and is transformed into a forest.

## Difference Between Primary and Secondary Succession

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

## **Autoenic and Allogenic Succession**

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

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

**Q. 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.
- Also, grasslands develop in regions with scanty rainfall where plant growth cannot be achieved.
- Though forests form the climax community in most of the 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) water limits and fire

### **Autotrophic and Heterotrophic succession**

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- 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.

### **Succession in Plants**

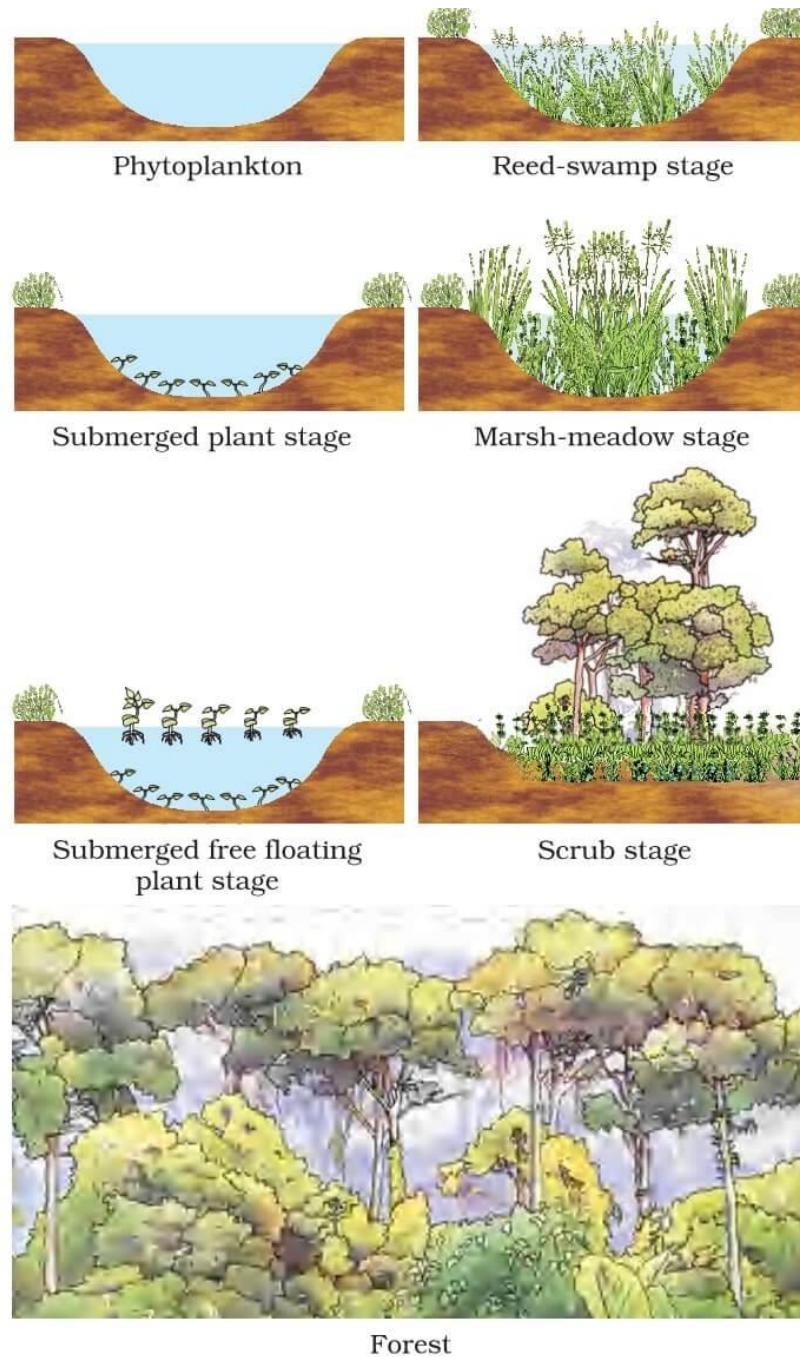
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- Succession that occurs on land (dry areas) where moisture content is low for e.g. on a bare rock is known as **xerarch**.
- Succession that takes place in a water body, like ponds or lake is called **hydrarch**.
- Both hydrarch and xerarch successions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

### **Succession in Water**

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- In primary succession in water, the pioneers are the small phytoplankton, and they are replaced with time by free-floating angiosperms, then by rooted hydrophytes, sedges, grasses and finally the trees.
- The climax again would be a forest. With time the water body is converted into land.
- Another important fact is to understand that **all succession whether taking place in water or on land, proceeds to a similar climax community – the mesic.**



**Figure 14.5** Diagrammatic representation of primary succession

## 2.2 Homeostasis in Ecosystem

## Homeostasis

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

## Regulate

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

## 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.

### Why these conformers had not evolved to become regulators?

- Thermoregulation is energetically expensive for many organisms. This is particularly true for small animals like shrews and hummingbirds.
- Heat loss or heat gain is a function of surface area. 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; then they have to expend much energy to generate body heat [a lot of food goes into heat generation] through metabolism.
- This is the main reason why **very small animals are rarely found in polar regions.**

## Migrate

- The organism can move away temporarily from the stressful habitat to a more hospitable area and return when a stressful period is over

- Every winter the famous **Keoladeo National Park (Bhartpur) in Rajasthan** hosts thousands of migratory birds coming from Siberia and other extremely cold northern regions.

### Suspend

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- In bacteria, fungi and lower plants, various kinds of thick-walled **spores** are formed which help them to survive unfavourable conditions – these germinate on the availability of suitable environment.
- In higher plants, seeds and some other vegetative reproductive structures serve as means to tide over periods of stress besides helping in dispersal.
- In animals, the organism, if unable to migrate, might avoid the stress by escaping in time. The familiar case of bears going into **hibernation** during winter is an example of an escape in time.
- Some snails and fish go into **aestivation** to avoid summer-related problems – heat and desiccation.
- Under unfavourable conditions, many zooplankton species in lakes and ponds are known to enter dia-pause, a stage of suspended development.

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

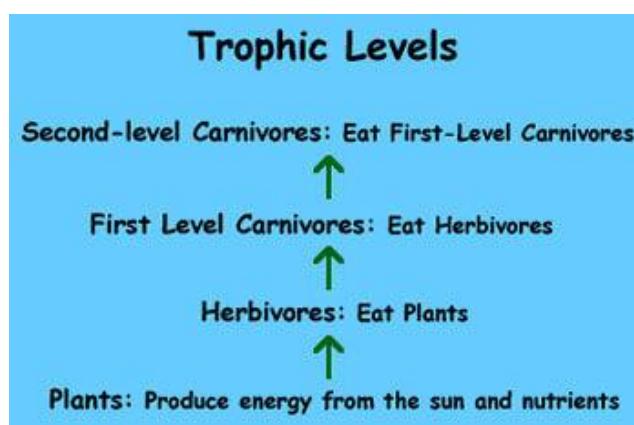
## 2.3 Energy Flow Through an Ecosystem – Trophic Levels

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(Trophe = Nourishment)

- A trophic level is the **representation of energy flow in an ecosystem**.
- The trophic level of an organism is the position it occupies in a food chain.

- Trophic level interaction deals with how the members of an ecosystem are connected based on nutritional needs.



[Pic Credits](#)

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

- Energy flows through the trophic levels from producers to subsequent trophic levels is **unidirectional**.
- Energy level **decreases** from the first trophic level upwards due to loss of energy in the form of heat at each trophic level.
- This energy loss at each trophic level is quite significant. Hence there are usually not more than four-five trophic levels (beyond this the energy available is negligible to support an organism).
- The trophic level interaction involves three concepts namely
  - 1) Food Chain
  - 2) Food Web
  - 3) Ecological Pyramids

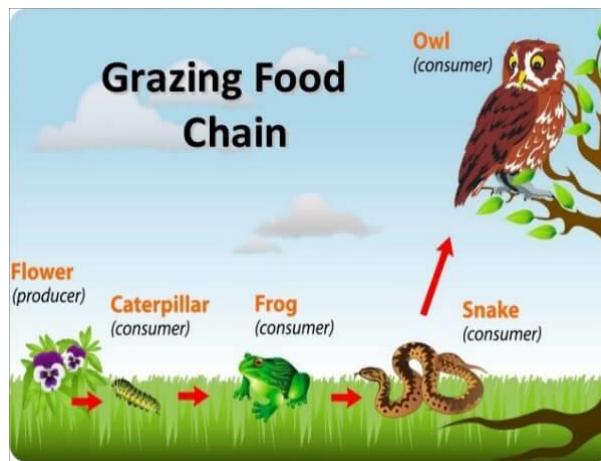
## Food Chain

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

- The trophic level of an organism is the position it occupies in a food chain.
- Types of Food Chains: **1) Grazing food chain and 2) Detritus food chain**

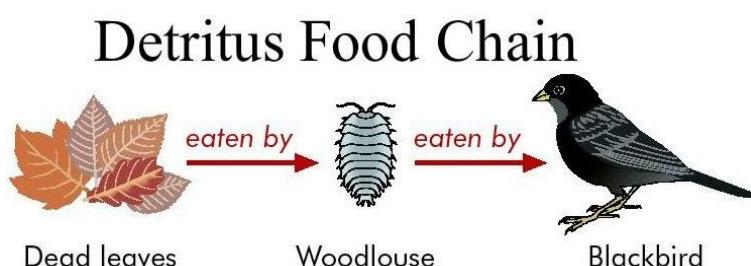
### Grazing food chain

- The consumers which start the food chain, utilising the **plant or plant part as their food**, constitute the grazing food chain.
- For example, in a terrestrial ecosystem, the grass is eaten by a caterpillar, which is eaten by lizard and lizard is eaten by a snake.
- In Aquatic ecosystem **phytoplankton** (primary producers) are eaten by zooplanktons which are eaten by fishes and fishes are eaten by pelicans.



### Detritus food chain

- This type of food chain **starts from organic matter** of dead and decaying animals and plant bodies from the grazing food chain.
- Dead organic matter or detritus feeding organisms are called **detrivores or decomposers**.
- The detritivores are eaten by predators.
- In an **aquatic ecosystem, the grazing food chain is the major conduit for energy flow**.
- As against this, **in a terrestrial ecosystem, a much larger fraction of energy flows through the detritus food chain than through the grazing food chain**.



- Bacterial and fungal enzymes degrade detritus into simpler inorganic substances. This process is called **catabolism**.
- **Humification** and **mineralisation** occur during decomposition in the soil.
- Humification leads to accumulation of a dark-coloured amorphous (formless) substance called **humus** that is highly resistant to microbial action and undergoes decomposition at an extremely **slow rate**.
- Being **colloidal** in nature, humus serves as a **reservoir of nutrients**.
- The humus is further degraded by some microbes and release of inorganic nutrients occur by the process known as **mineralisation**.
- Warm and moist environment favour decomposition whereas low temperature and anaerobiosis inhibit decomposition resulting in a buildup of organic materials (**soils become acidic like in taiga**).

**Q. With reference to the food chains in ecosystems, which of the following kinds of organism is/are known as decomposer organism/organisms?**

- 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 breakdown organic matter into simple inorganic substances.
- Virus represents dormant life. They are metabolically inactive as long as 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, such as paramecium and euglena. They're not decomposers either.

Answer: b) 2 and 3 only

**Q. 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

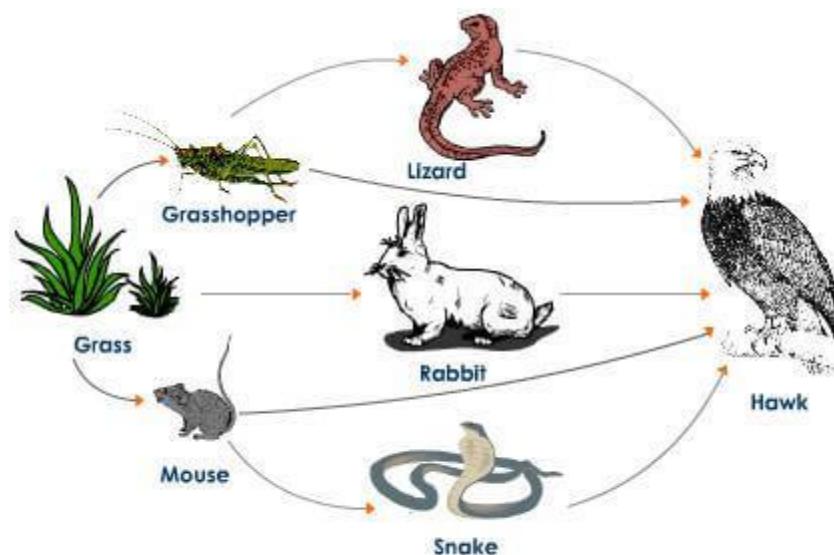
Explanation:

- The food chain starts with a producer and ends with a top consumer.
- **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.**
  - ✓ **Dinoflagellates (flagellated protists).**
- **Crustaceans form a very large group of arthropods which includes crabs, lobsters, crayfish, shrimp, krill and barnacles (Biology NCERT).**
- Herrings are a fish, and they eat crustaceans.

Answer: (a) Diatoms-Crustaceans-Herrings. Tough question.

## Food Web

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



A Food Web In a Grassland Ecosystem With Five Possible Food Chains

Picture Credits**Q. 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:

- A food chain illustrates the order in which a chain of organisms feed upon each other. (True)
- Food chains are found within the populations of a species. (Man won't eat man – so, false)
- A food chain illustrates the numbers of each organism which are eaten by others (food web illustrates the number, not the food chain).

Answer: a) 1 only

**Types of Biotic Interactions in a Food Web**

'0' is no effect; '−' is detrimental; '+' is beneficial.

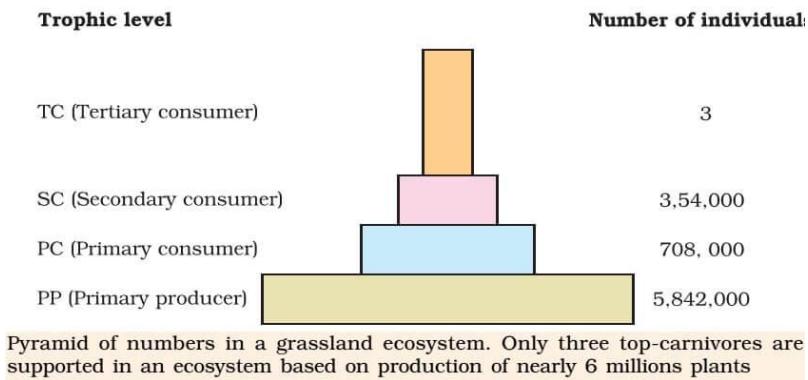
Type of interaction	Species		Effect	Comments
	1	2		
<b>Negative Interactions</b>				
Amensalism	−	0	One species is inhibited while the other species is unaffected.	<ul style="list-style-type: none"><li>• The bread mould fungi Penicillium produce penicillin an antibiotic substance which inhibits the growth of a variety of bacteria.</li><li>• A large tree shades a small plant, retarding the growth of the small plant. The small plant has no effect on the large tree.</li></ul>
Predation	+	−	One species (predator) benefits while the second species	<ul style="list-style-type: none"><li>• Predators like leopards, tigers and cheetahs use speed, teeth and claws to hunt and kill their prey.</li></ul>

			(prey) is harmed and inhibited.	<ul style="list-style-type: none"> <li>Predators help in maintaining species diversity in a community, by reducing the intensity of competition among competing prey species.</li> </ul>
Parasitism	+	-	Beneficial to one species (parasite) and harmful to the other species (host).	<ul style="list-style-type: none"> <li>Parasitism involves parasite living in or on another living species called the host.</li> <li>The parasite gets its nourishment and often shelter from its host.</li> <li>Tap worm, roundworm, malarial parasite, many bacteria, fungi, and viruses are common parasites of humans.</li> <li>The <b>female mosquito is not considered a parasite</b>, although it needs our blood for reproduction. Why? Because it <b>doesn't live on the host</b>.</li> </ul>
Competition	-	-	Adversely affects both species.	<ul style="list-style-type: none"> <li>Competition occurs when two populations or species, both need a vital resource that is in short supply.</li> </ul>
<b>Positive Associations</b>				
Commensalism	+	0	One species (the commensal) benefits, while the other species (the host) is neither harmed nor inhibited	<ul style="list-style-type: none"> <li><b>Suckerfish often attaches to a shark</b>. This helps the suckerfish get protection, a free ride as well as a meal from the leftover of the shark's meal. The shark does not, however, get any benefit nor is it adversely affected by this association.</li> <li>Another example of commensalisms is the <b>relationship between trees and epiphytic plants</b>.</li> </ul>
Mutualism	+	+	Interaction is favourable to both species	<ul style="list-style-type: none"> <li><b>Sea anemone gets attached to the shell of hermit crabs</b> for the benefit of transport and obtaining new food while the anemone provides camouflage and protection utilizing its stinging cells to the hermit crab.</li> <li>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.</li> <li>Such close associations are called <b>symbiosis</b> (symbiosis is intense mutualism – E.g. <b>coral and zooxanthellae</b>).</li> </ul>
<b>Neutral Interactions</b>				
Neutralism	0	0	Neither species affects the other	<ul style="list-style-type: none"> <li>True neutralism is extremely unlikely.</li> </ul>

## Ecological Pyramids

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

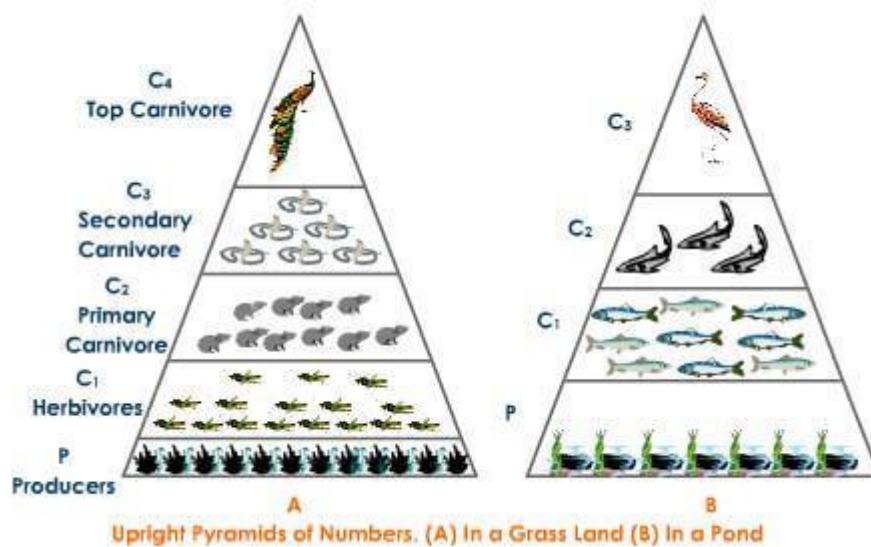
## Pyramid of Numbers



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

## Pyramid of numbers – upright

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

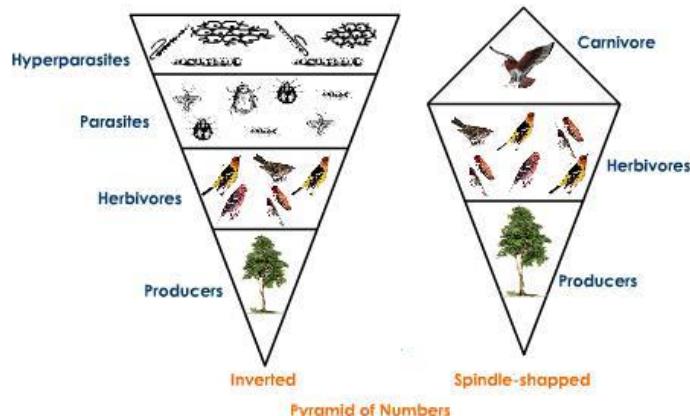


### Credits

- This type of pyramid can be seen in the **grassland ecosystem** and **pond ecosystem**.
- The grasses occupy the lowest trophic level (base) because of their abundance.
- The next higher trophic level is primary consumer – herbivores like a grasshopper.
- The individual number of grasshoppers is less than that of grass.
- The next energy level is a primary carnivore like rats.
- The number of rats is less than grasshoppers, because, they feed on grasshoppers.
- The next higher trophic level is secondary carnivore like snakes. They feed on rats.
- The next higher trophic level is the top carnivore like Hawk.
- With each higher trophic level, the number of individual decreases.

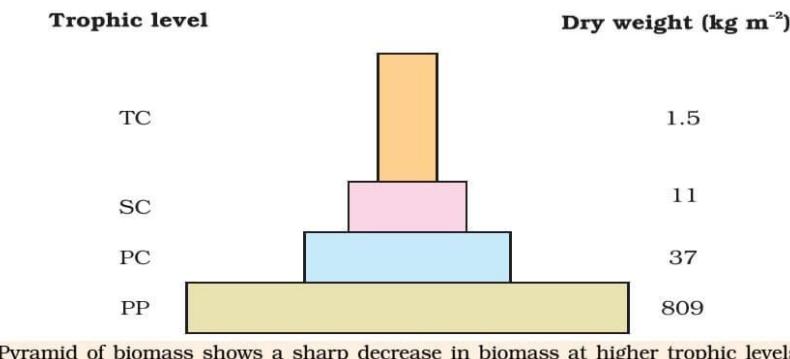
### **Pyramid of numbers – inverted**

- In this pyramid, the number of individuals is increased from lower level to higher trophic level. E.g. **Tree ecosystem**.



### Credits

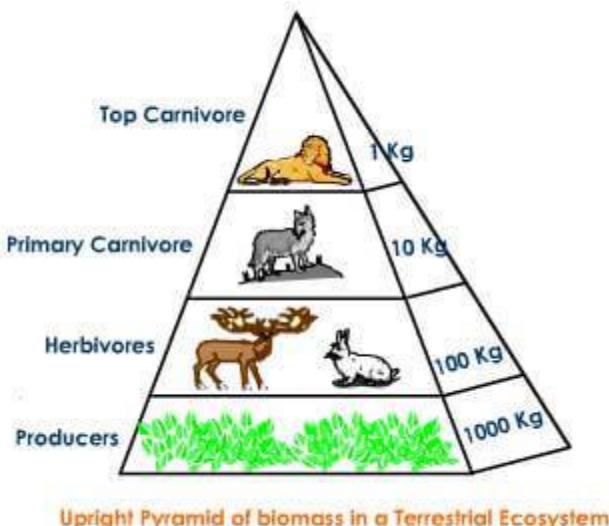
## Pyramid of Biomass



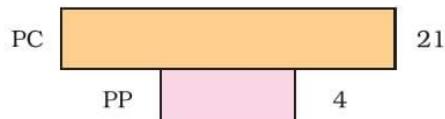
- Pyramid of biomass is usually determined by collecting all organisms occupying each trophic level separately and measuring their dry weight.
- This overcomes the size difference problem because all kinds of organisms at a trophic level are weighed.
- Each trophic level has a certain mass of living 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 ecosystems on land**, the pyramid of biomass has a large base of primary producers with a smaller trophic level perched on top.
- The biomass of producers (autotrophs) is at the maximum. The biomass of next trophic level i.e. primary consumers is less than the producers. The biomass of next higher trophic level i.e. secondary consumers is less than the primary consumers. The top, high trophic level has very less amount of biomass.

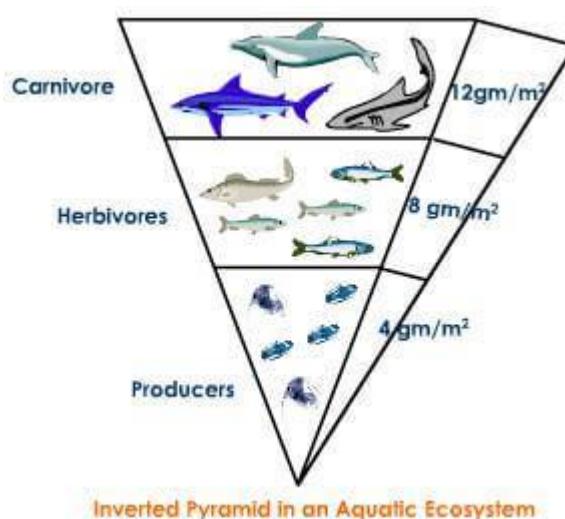


## Pyramid of Biomass – Inverted



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

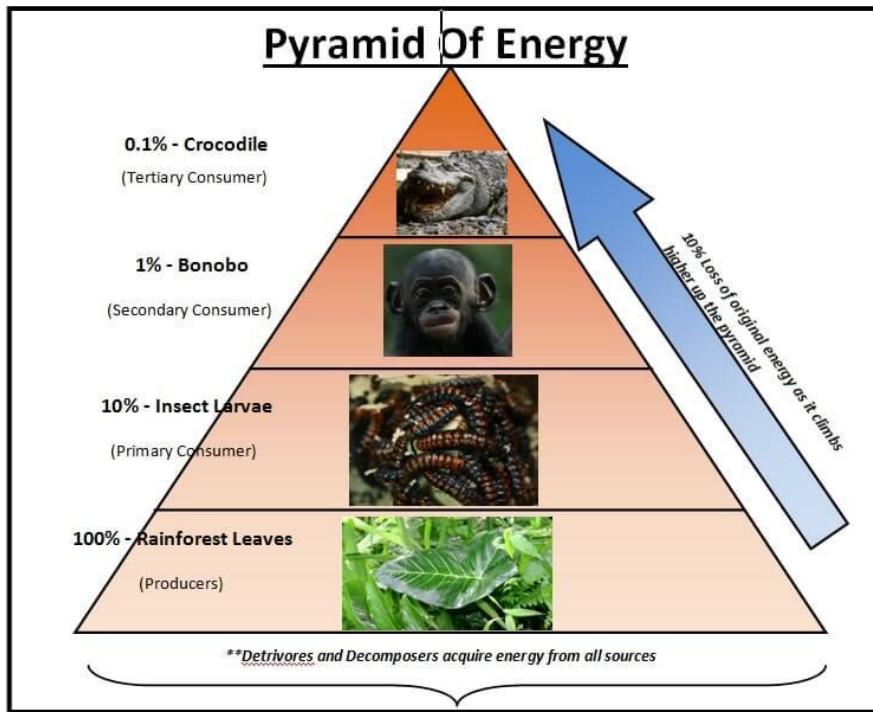
- In contrast, in many **aquatic ecosystems**, the pyramid of biomass may assume an inverted form. (**In contrast, a pyramid of numbers for the aquatic ecosystem is upright**)
- This is because the producers are tiny phytoplankton that grows and reproduces rapidly.
- Here, the pyramid of biomass has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



*Pic credits*

## Pyramid of Energy

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



[Pic Credits](#)

- Suppose an ecosystem receives 1000 calories of light energy in a given day. Most of the energy is not absorbed; some is reflected to space; of the energy absorbed only a small portion is utilized by green plants, out of which the plant uses up some for respiration and of the 1000 calories; therefore only 100 calories are stored as energy-rich materials.
- Now suppose an animal, say a deer, eats the plant containing 100 calories of food energy. The deer use some of it for its metabolism and stores only 10 calories as food energy. A lion that eats the deer gets an even smaller amount of energy. Thus, usable energy decreases from sunlight to producer to herbivore to carnivore. Therefore, the energy pyramid will always be upright.
- Energy pyramid concept helps to explain the phenomenon of **biological magnification** – the tendency for toxic substances to increase in concentration progressively with higher trophic levels.

## Ecological Efficiency

- Ecological efficiency describes the efficiency with which energy is transferred from one trophic level to the next.
- The number of trophic levels in the grazing food chain is restricted as the transfer of energy follows 10 per cent law – only 10 per cent of the energy is transferred to each trophic level from the lower trophic level.
- The decreases at each subsequent trophic level is due to two reasons:
  - At each trophic, a part of the available energy is lost in respiration or used up in **metabolism**.
  - A part of the energy is lost at each transformation.

## Limitations of Ecological Pyramids

- It does not consider the same species belonging to two or more trophic levels.
- It assumes a simple food chain, something that seldom exists in nature; **it does not accommodate a food web.**
- Moreover, **saprophytes** (plant, fungus, or microorganism that lives on decaying matter) are not given any place in ecological pyramids even though they play a vital role in the ecosystem.

## Pollutants and Trophic Level – Biomagnification

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

### **Chlorinated Hydrocarbons (CHC)**

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

### **Applications of Chlorinated Hydrocarbons (CHC)**

- CHCs are used in the production of polyvinyl chloride (a synthetic plastic polymer used to make PVC pipes).
- **Chloroform, dichloromethane, dichloroethane, and trichloroethane** are useful solvents.
- These solvents are immiscible with water (not forming a homogeneous mixture when mixed with water) and effective in cleaning applications such as degreasing and dry cleaning.
- **DDT, heptachlor and endosulfan** are widely used as pesticides.

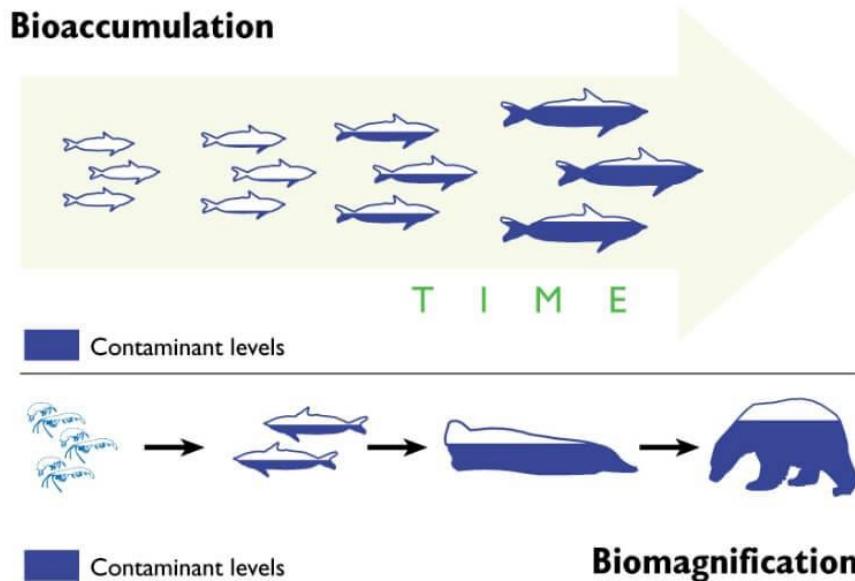
### **Effects of CHC**

- **Dioxins** (toxic by-products produced when organic matter is burned in the presence of chlorine in industrial or natural processes such as volcanic eruptions and forest fires), and some insecticides, such as DDT, are **persistent organic pollutants**.
- DDT was widely used a few decades ago as an effective pesticide and insecticide.
- It was later identified as a **persistent organic pollutant**, and its usage was phased out in almost all developed countries.

- It accumulated in food chains and caused eggshell thinning in certain bird species.
- In India, it is still being used by civic administrations as a **mosquito repellent** (disease vector control).
- In India, traces of DDT spray used three decades ago can still be found on the walls of homes.
- Crops that are grown in fields that were sprayed with DDT in the last decades show substantial traces of the insecticide.
- DDT residues continue to be found in mammals all across the planet.
- In Arctic areas, particularly high levels are found in marine mammals.
- The traces of **persistent organic pollutant** are found in human breast milk.
- In some species of milk-producing marine mammals, males typically have far higher levels, as females reduce their concentration by transfer to their offspring through lactation.
- Endosulfan, one of the most widely used pesticide, is an **endocrine disruptor** (enhances the effect of estrogens causing reproductive and developmental damage in both animals and humans).
- Because of its threats to human health and the environment, a global ban on the manufacture and use of endosulfan was negotiated under the **Stockholm Convention in 2011**.

Movement of these pollutants involves two main processes:

- 1) **Bioaccumulation**
- 2) **Biomagnification**

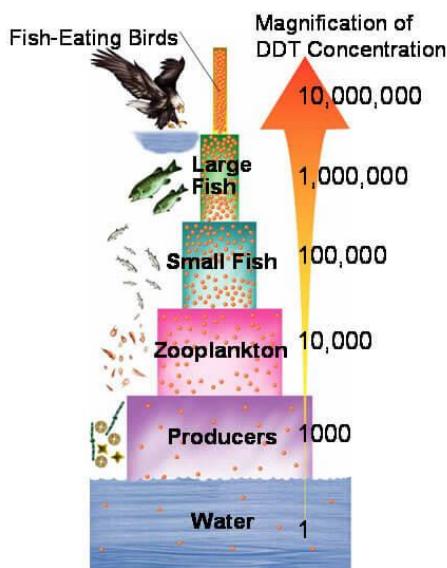


## Bioaccumulation

*Credits*

- Bioaccumulation is the **gradual accumulation of pollutants, chemicals (chronic poisoning) or other substances in an organism.**
- Bioaccumulation occurs when the rate of loss of the substance from the body of the organism through catabolism (breakdown of complex molecules in living organisms), or excretion is lower than the rate of accumulation of the substance.
- As persistent organic pollutants like DDT are long-lasting, the risk of bioaccumulation is high even if the environmental levels of the pollutant are not high.

## Biomagnification



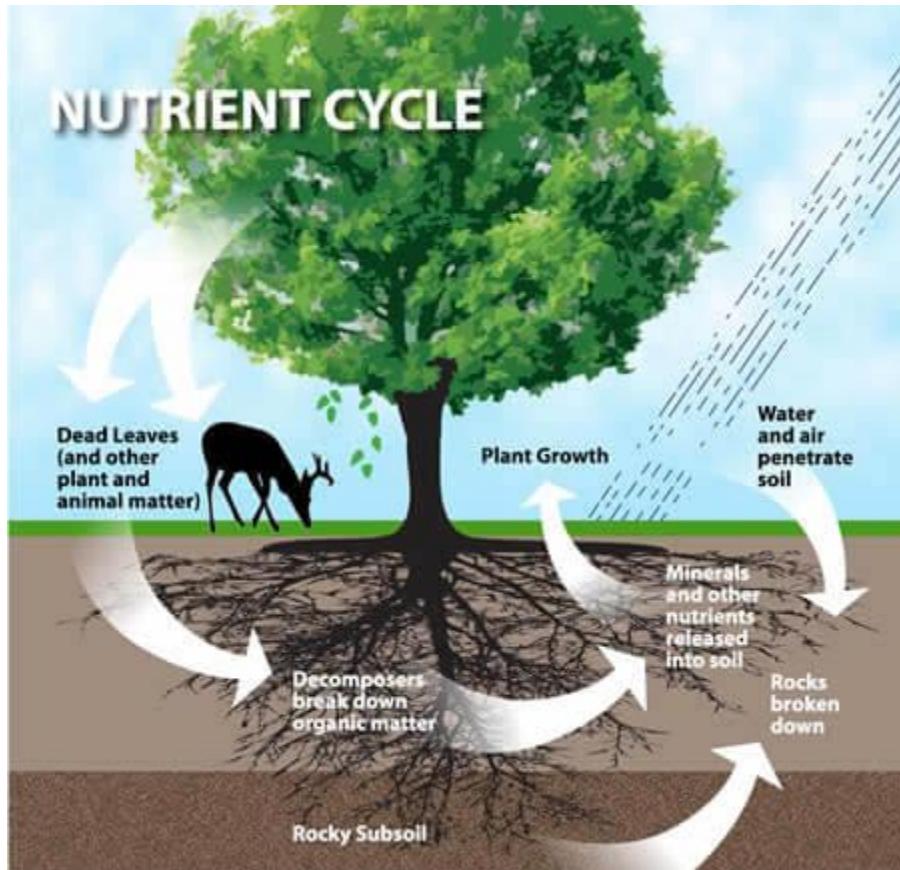
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- Biomagnification refers to **progressive bioaccumulation (increase in concentration) at each trophic level with the passage of time.**
- In order for biomagnification to occur, the pollutant must have a long biological half-life (long-lived), must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

## 2.4 Biogeo Chemical Cycling or Nutrient Cycling

- Energy flow and nutrient circulation are the major functions of the ecosystem.

- Energy is lost as heat forever in terms of the usefulness of the system. On the other hand, nutrients of food matter never get used up. They can be **recycled** again and again indefinitely.
- **Carbon, hydrogen, oxygen, nitrogen and phosphorus** as elements and compounds makeup 97% of the mass of our bodies and are 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 and good health of plants and animals.
- These elements or mineral nutrients are always in circulation moving from non-living to living and then back to the non-living components of the ecosystem in a more or less circular fashion.
- This circular fashion is known as **biogeochemical cycling** (bio for living; geo for atmosphere).
- Among the most important nutrient cycles are the **carbon nutrient cycle** and the **nitrogen nutrient cycle**.
- There are many other nutrient cycles that are important in ecology, including a large number of trace mineral nutrient cycles.



[Pic Credits](#)

## Types of Nutrient Cycles

Based on the replacement period, a nutrient cycle is referred to as Perfect or Imperfect cycle.

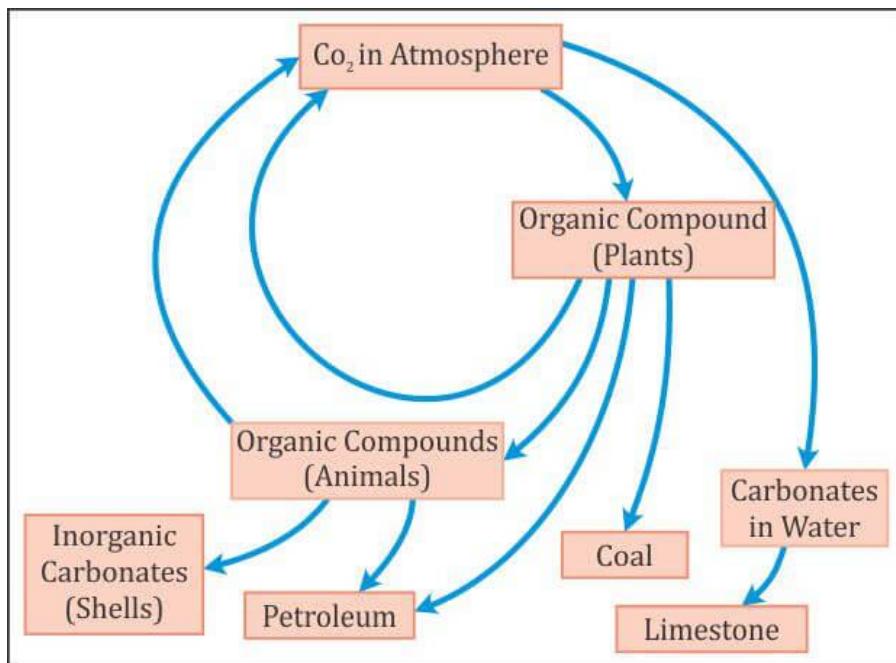
- A perfect nutrient cycle is one in which **nutrients are replaced as fast as they are utilized**.

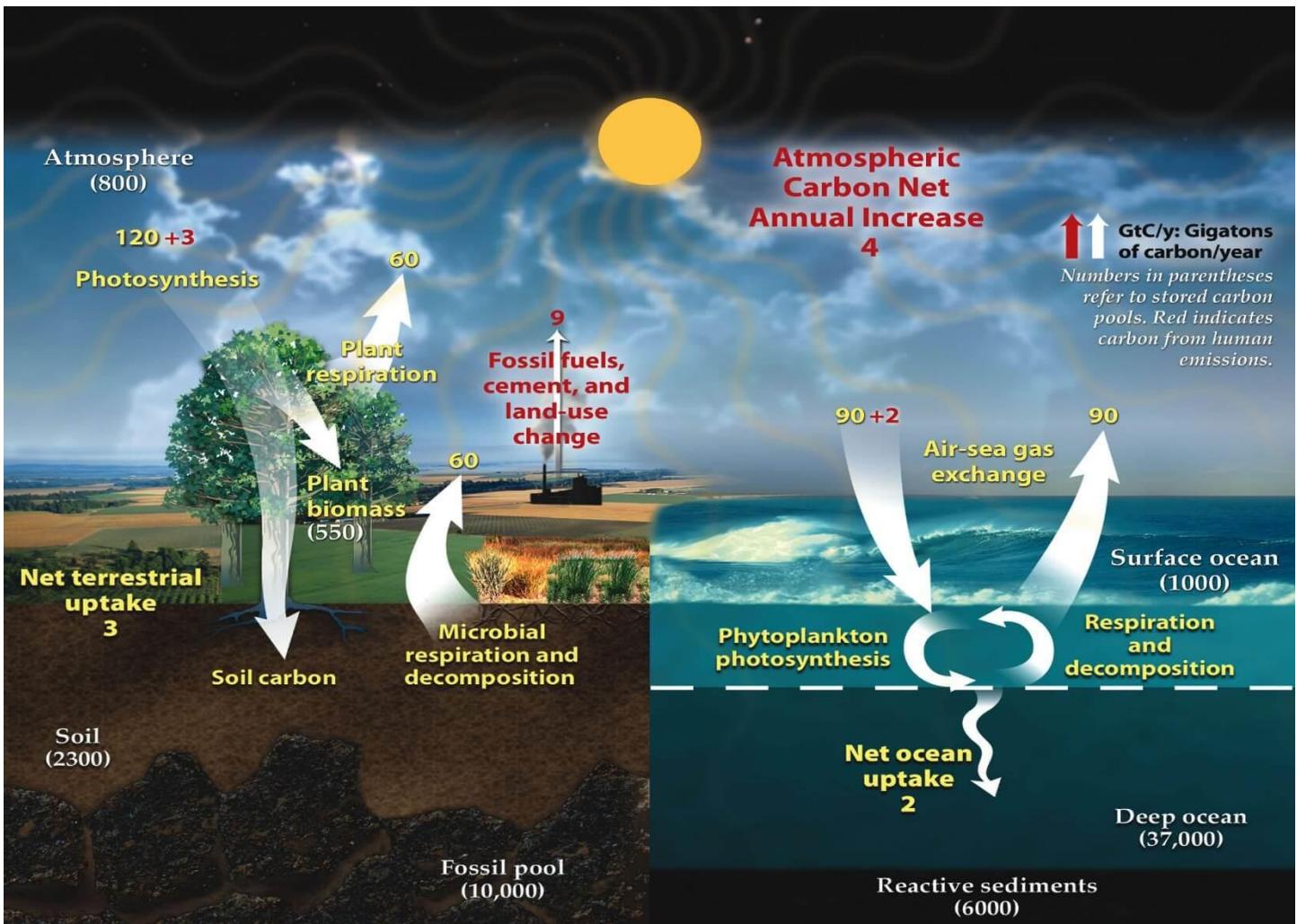
- **Most gaseous cycles** are generally considered as perfect cycles.
- In contrast **sedimentary cycles** are considered relatively imperfect, as **some nutrients are lost from the cycle and get locked into sediments** and so become unavailable for immediate cycling.

Based on the nature of the reservoir, a nutrient cycle is referred to as Gaseous or Sedimentary cycle

- Gaseous Cycle: the reservoir is the **atmosphere or the hydrosphere** — **water cycle, carbon cycle, nitrogen cycle**, etc. and
- Sedimentary Cycle: the **reservoir is the earth's crust** (soluble elements mostly found in earth's crust) — **phosphorous cycle, sulphur cycle, calcium cycle, magnesium cycle** etc.

## Carbon Cycle (Gaseous Cycle)





### Credits

- Carbon is a minor constituent of the atmosphere as compared to oxygen and nitrogen.
- However, without carbon dioxide life could not exist because it is vital for the production of carbohydrates through photosynthesis by plants.
- It is the element that anchors all organic substances from coal and oil to DNA (deoxyribonucleic acid: the compound that carries genetic information).
- Carbon is present in the atmosphere, mainly in the form of carbon dioxide ( $\text{CO}_2$ ).
- Carbon cycle involves a continuous exchange of carbon between the atmosphere and organisms.
- Carbon from the atmosphere moves to green plants by the process of **photosynthesis**, and then to animals.
- By process of respiration and decomposition of dead organic matter, it returns to the atmosphere. It is usually a short term cycle.
- Some carbon also enters a long term cycle. It accumulates as **un-decomposed organic matter in the peaty layers of marshy soil** or as insoluble carbonates in bottom sediments of aquatic systems which take a long time to be released.

- In deep oceans, such carbon can remain buried for millions of years till geological movement may lift these rocks above sea level.
- These rocks may be exposed to erosion, releasing their carbon dioxide, carbonates and bicarbonates into streams and rivers.
- Fossil fuels such as coals, oil and natural gas etc. are organic compounds that were buried before they could be decomposed and were subsequently transformed by time and geological processes into fossil fuels. When they are burned the carbon stored in them is released back into the atmosphere as carbon dioxide.

**Q. Consider the following:**

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

Which of the above **add** 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
- Photosynthesis takes out CO<sub>2</sub> from the carbon cycle. Rest all add CO<sub>2</sub>.

Answer: c) 2,3 and 4 only

**Q. Which one of the following is the process involved in photosynthesis?**

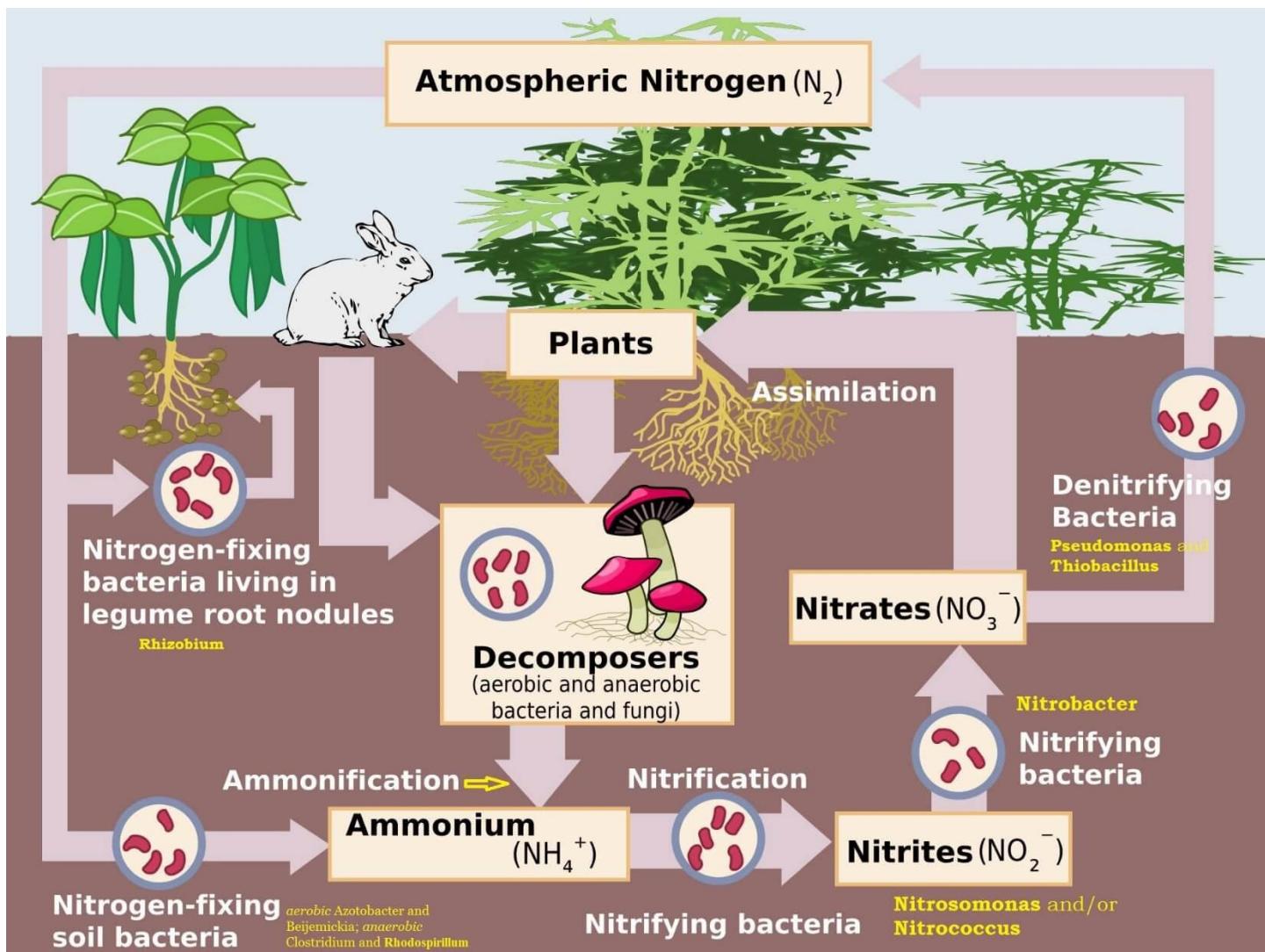
- a) Potential energy is released to form free energy
  - b) Free energy is converted into potential energy and stored
  - c) Food is oxidized to release carbon dioxide and water
  - d) Oxygen is taken, and carbon dioxide and water vapour are given out
- Potential energy is released to form free energy (false – sun's free energy is converted into potential energy in photosynthesis)
  - Food is oxidized to release carbon dioxide and water (false – oxygen is released and not carbon dioxide)
  - Oxygen is taken, and carbon dioxide and water vapour are given out (false – CO<sub>2</sub> is taken, and oxygen is given out)

- Answer: b) Sunlight (free energy) is converted into carbohydrates (potential energy) using water and carbon dioxide. Oxygen is released in the process.

## Nitrogen Cycle (Gaseous Cycle)

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- Apart from **carbon, hydrogen and oxygen**, nitrogen is the most prevalent element in living organisms.
- Nitrogen is a constituent of **amino acids, proteins, hormones, chlorophylls** and many of the vitamins (explained in Biology NCERT).
- Plants compete with microbes for the limited nitrogen that is available in the soil. Thus, nitrogen is a **limiting nutrient** for both natural and agricultural ecosystems.
- Nitrogen exists as two nitrogen atoms ( $N_2$ ) joined by a very strong triple covalent bond ( $N \equiv N$ ).
- In nature, **lightning and ultraviolet radiation** provide enough energy to convert nitrogen **to nitrogen oxides (NO, NO<sub>2</sub>, N<sub>2</sub>O)**.
- **Industrial combustions, forest fires, automobile exhausts and power-generating stations** are also sources of atmospheric nitrogen oxides.



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

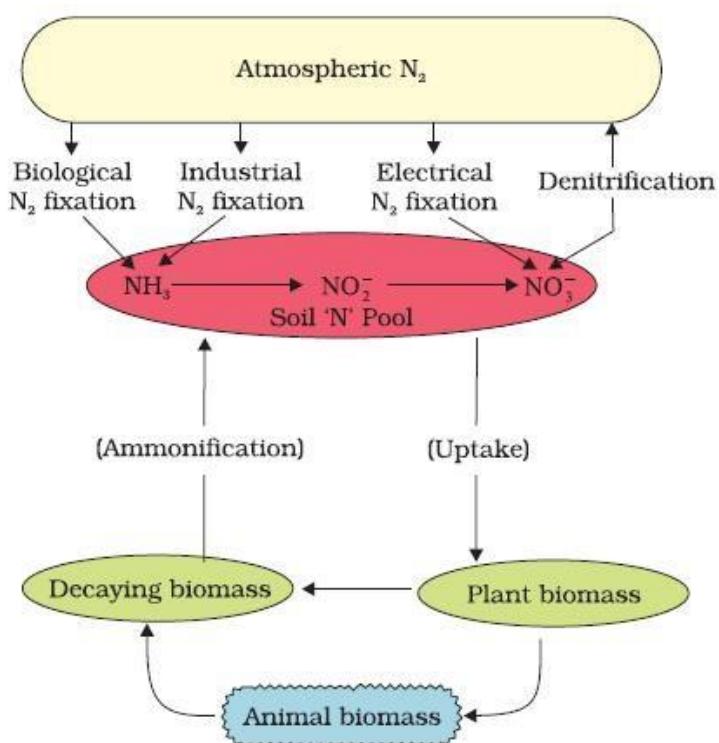
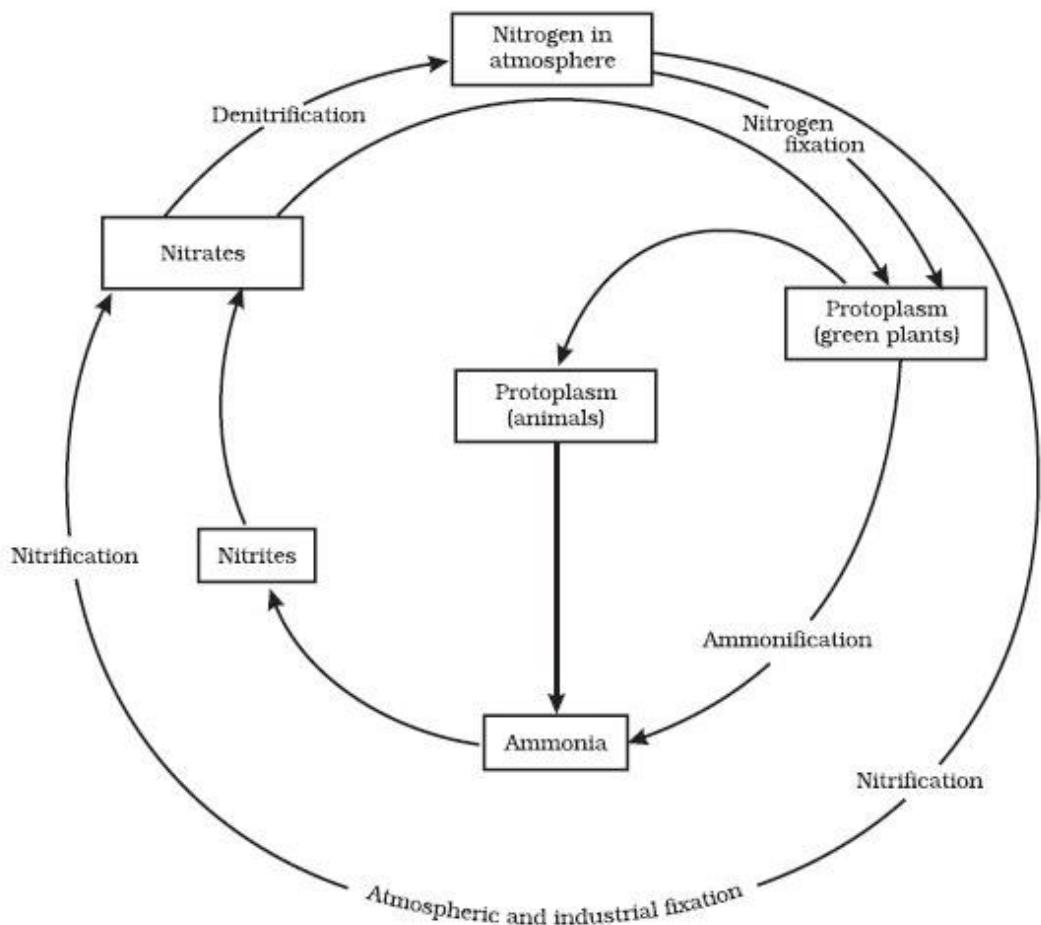
- There is an inexhaustible supply of nitrogen in the atmosphere, but the elemental form cannot be used directly by most of the living organisms.
- Nitrogen needs to be 'fixed', that is, **converted to ammonia, nitrites or nitrates**, before it can be taken up by plants.
- Nitrogen fixation on earth is accomplished in three different ways:
  - By microorganisms (bacteria and blue-green algae),**
  - By man using industrial processes (fertiliser factories) and**
  - To a limited extent by atmospheric phenomena such as thunder and lightning.**
- Certain microorganisms are capable of fixing atmospheric nitrogen into **ammonia ( $NH_3$ )** and **ammonium ions ( $NH_4^+$ )**.
- Ammonia ( $NH_3$ ) is a molecule consisting of nitrogen and hydrogen, while ammonium ( $NH_4^+$ ) is an ion of ammonia that is formed by accepting a hydrogen ion.

- The enzyme, **nitrogenase** which is capable of nitrogen reduction is present exclusively in **prokaryotes**. Such microbes are called N<sub>2</sub>-fixers. These include:
  - ✓ **free-living nitrogen fixing bacteria (non-symbiotic nitrogen-fixing bacteria or nitrogen-fixing soil bacteria)** (e.g. **aerobic Azotobacter and Beijemickia; anaerobic Clostridium and Rhodospirillum**),
  - ✓ **symbiotic nitrogen-fixing bacteria** (e.g. **Rhizobium**) living in association with **leguminous plants** and **non-leguminous root nodule plants** and
  - ✓ **some cyanobacteria** (a major source of nitrogen fixation in oceans) (blue-green algae. E.g. **Nostoc, Anabaena, Spirulina** etc.).
- Leguminous: denoting plants of the pea family (Leguminosae), typically having seeds in pods, distinctive flowers, and root nodules containing nitrogen-fixing bacteria.

## Nitrification – Ammonia to Nitrates

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- Ammonium ions can be directly taken up as a source of nitrogen by some plants.
- Others absorb **nitrates which are obtained by oxidising ammonia and ammonium ions**.
- Ammonia and ammonium ions are oxidised to nitrites or nitrates by two groups of specialized bacteria.
- Ammonium ions are first oxidised to **nitrite** by the bacteria **Nitrosomonas and/or Nitrococcus**.
- The nitrite is further oxidized to **nitrate** with the help of the bacterium **Nitrobacter**.
- These steps are called **nitrification**. These **nitrifying bacteria** are **chemoautotrophs (they use inorganic chemical energy sources to synthesise organic compounds from carbon dioxide)**.
- The nitrate thus formed is absorbed by plants and is transported to the leaves.
- In leaves, it is reduced to form ammonia** that finally forms the amine group of **amino acids**, which are the building blocks of proteins. These then go through higher trophic levels of the ecosystem.
- Nitrification is important in agricultural systems**, where fertiliser is often applied as ammonia.
- Conversion of this ammonia to nitrate increases nitrogen **leaching** because **nitrate is more water-soluble than ammonia**.
- Nitrification also plays an important role in the **removal of nitrogen from municipal wastewater**.
- The conventional removal is nitrification, followed by **denitrification**.



### Ammonification – Urea, Uric Acid to Ammonia

- 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**.
- Some of this ammonia volatilizes and re-enters the atmosphere, but most of it is converted into nitrate by soil bacteria.

## Denitrification – Nitrate to Nitrogen

- Nitrate present in the soil is reduced to nitrogen by the process of **denitrification**.
- In the soil as well as oceans there are special denitrifying bacteria (**Pseudomonas and Thiobacillus**), which convert the **nitrates/nitrites to elemental nitrogen**.
- This nitrogen escapes into the atmosphere, thus completing the cycle.

**Step 1: N<sub>2</sub> Fixing → Nitrogen → Ammonia or Ammonium Ions**

**Step 2: Nitrification → Ammonia or Ammonium Ions → Nitrite → Nitrate**

**Step 3: Ammonification → Dead Matter + Animal Waste (Urea, Uric Acid) → Ammonia or Ammonium Ions**

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

**Step 4: Denitrification → Nitrate → Nitrogen**

- The amount of nitrogen fixed by man through the industrial process has far exceeded the amount fixed by the Natural Cycle.
- As a result, nitrogen fixed by man has become a pollutant which can disrupt the balance of nitrogen. It may lead to **Acid rain, Eutrophication and Harmful Algal Blooms**.

### Q. 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 three adds to the nitrogen cycle.
- Burning coal releases CO, CO<sub>2</sub>, sulphur dioxide and oxides of nitrogen – air pollutants.
- Oxides of nitrogen fall on earth as acid rain. Acidic rain is a complex mixture of nitrous, nitric, sulphurous and sulfuric acids which all combine to lower the pH.
- But, the question asks, "Which of the following adds/add nitrogen to the soil?"
- **Animal waste like urea, uric acid and death of vegetation add nitrogen in the form of nitrates directly into the soil.**
- Coal combustion adds nitrogen to the atmosphere and from there it falls back to earth in the form of acid rain and acid rain adds nitrogen to the soil.
- "The release of nitric oxides into the air in large quantities causes smog and acid rain. The increase in nitrogen and nitrous oxide is caused by automobiles, power plants and a wide variety of industries."
- And also <http://chemistry.elmhurst.edu/vchembook/307nitrogen.html> says:
- "Nitrogen will only react with oxygen in the presence of high temperatures and pressures found near lightning bolts and in combustion reactions in power plants or internal combustion engines. Nitric oxide, NO, and nitrogen dioxide, NO<sub>2</sub>, are formed under these conditions. Eventually, **nitrogen dioxide** may react with water in the rain to form nitric acid, HNO<sub>3</sub>. The nitrates thus formed may be utilised by plants as a nutrient (so, soil gets nitrogen from acid rain)."
- From the above explanation, it is clear that burning of coal by man adds nitrogen to soil but indirectly through acid rain.

Answer: Official UPSC Key says the answer is c) 1 and 3 only.

### Q. 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

- Burning coal releases CO, CO<sub>2</sub>, sulphur dioxide and oxides of nitrogen.

Answer: d) 1, 2 and 3.

**Q. What can be the impact of excessive/inappropriate 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 ground-water 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

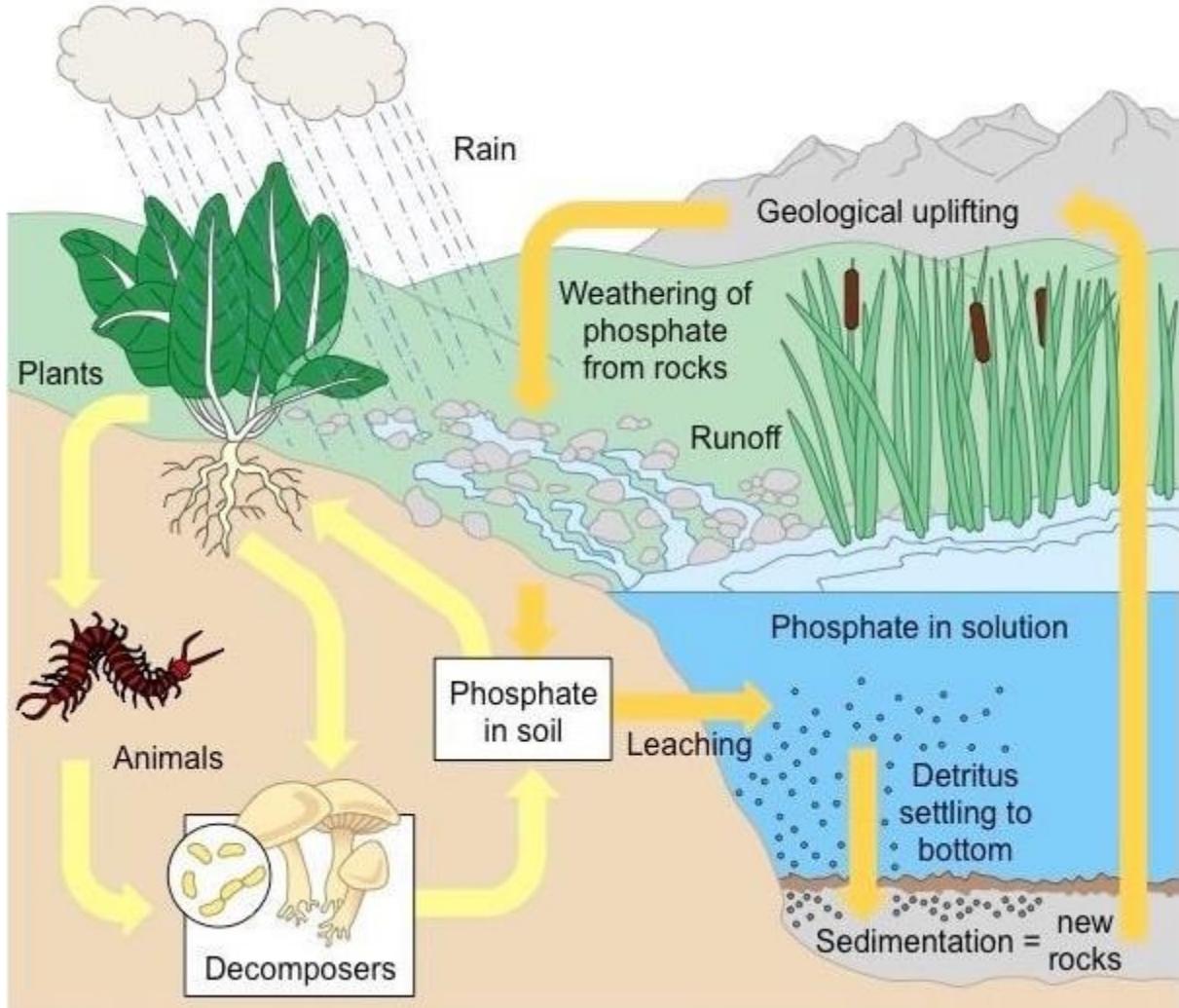
Explanation:

- Nitrification is important in agricultural systems, where fertiliser is often applied as ammonia. Conversion of this **ammonia to nitrate increases nitrogen leaching** because nitrate is more water-soluble.
- Agricultural fertilisation and the use of nitrogen-fixing plants also contribute to atmospheric NO<sub>x</sub>, by promoting nitrogen fixation by microorganisms. Excess NO<sub>x</sub> leads to acid rain. Acid rain lowers pH of the soil (increase in acidity of soil)
- The legume-rhizobium symbiosis is a classic example of mutualism — rhizobia supply ammonia or amino acids to the plant and in return receive organic acids as a carbon and energy source.
- So, **excessive/inappropriate use of nitrogenous fertilisers can make the plants independent of both symbiotic and free-living nitrogen fixers**. Fixers don't get the food from the plants due to a broken relationship and other factors. So, their population decreases.

Answer: c) 2 and 3 only

**Phosphorus Cycle (Sedimentary cycle)**

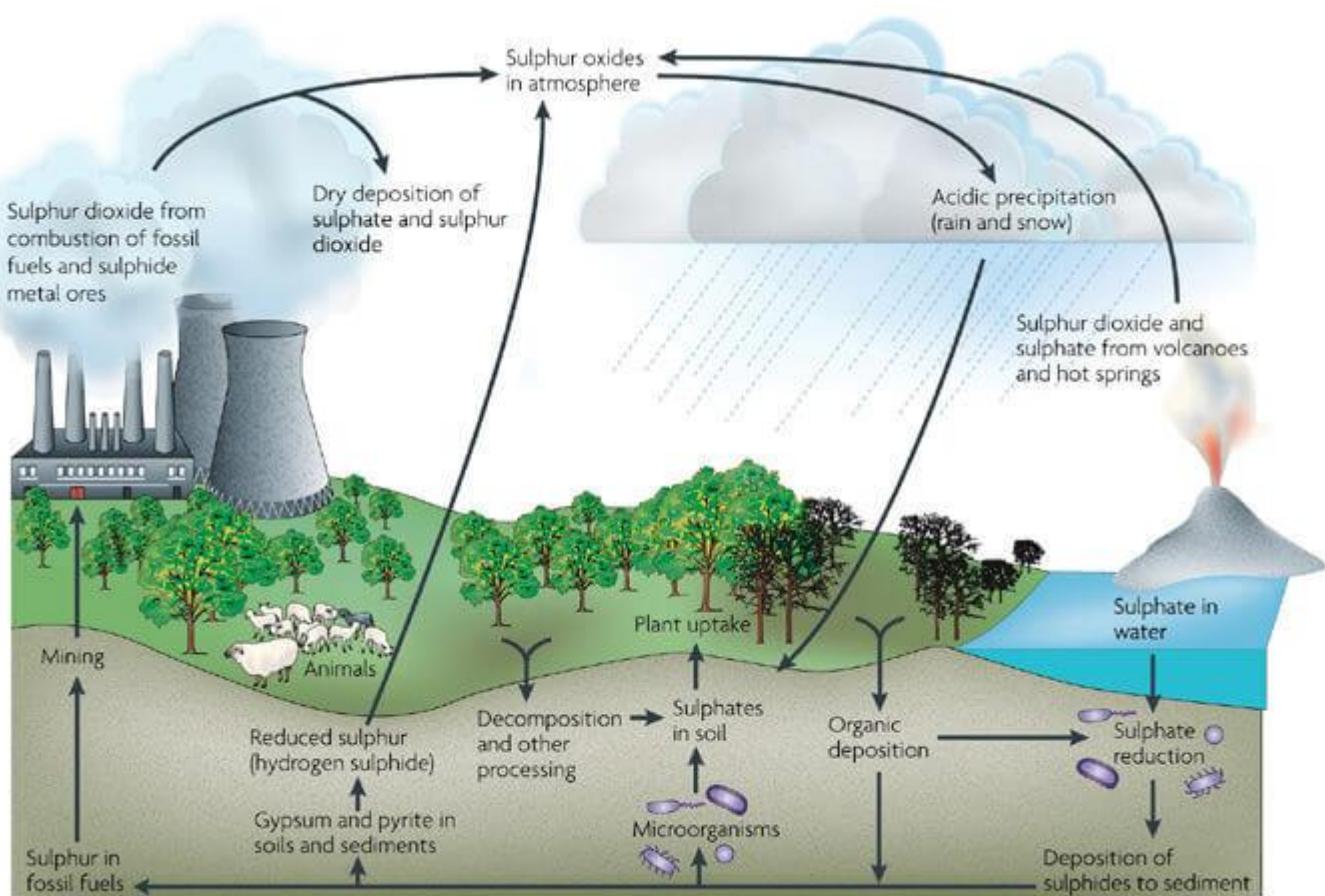
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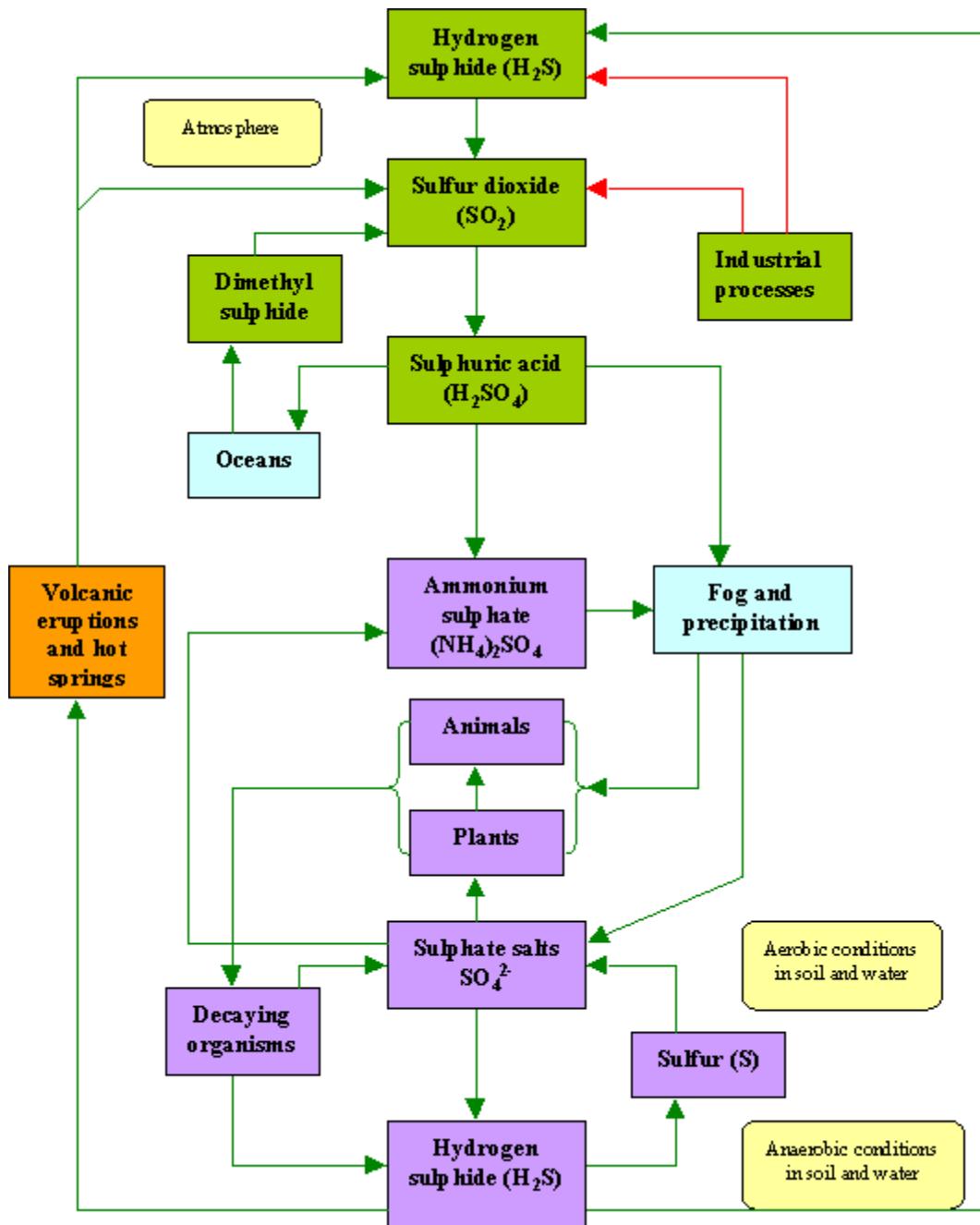
- Phosphorus plays a central role in **aquatic ecosystems** and water quality.
- Unlike carbon and nitrogen, which come primarily from the atmosphere, phosphorus occurs in large amounts as a **mineral in phosphate rocks** and enters the cycle from **erosion and mining activities**.
- This is the nutrient considered to be the **main cause of excessive growth of rooted and free-floating microscopic plants (phytoplankton) in lakes (leads to eutrophication)**.
- The main storage for phosphorus is in the **earth's crust**.
- On land, phosphorus is usually found in the form of **phosphates**.
- By the process of weathering and erosion, phosphates enter rivers, streams and finally oceans.
- In the ocean, phosphorus accumulates on continental shelves in the form of insoluble deposits.
- After millions of years, the crustal plates rise from the seafloor and expose the phosphates on land.
- After more time, weathering will release them from rock, and the cycle's geochemical phase begins again.

## **Sulphur Cycle (Sedimentary cycle)**



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- The sulphur reservoir is in the **soil and sediments** where it is locked in organic (**coal, oil and peat**) and inorganic deposits (**pyrite rock and sulphur rock**) in the form of **sulphates, sulphides and organic sulphur**.
- It is released by weathering of rocks, erosional runoff and decomposition of organic matter and is carried to terrestrial and aquatic ecosystems in salt solution.
- The sulphur cycle is mostly sedimentary except two of its compounds, **hydrogen sulphide ( $H_2S$ )** and **sulphur dioxide ( $SO_2$ )**, which add a gaseous component.
- Sulphur enters the atmosphere from several sources like **volcanic eruptions, combustion of fossil fuels (coal, diesel etc.), from the surface of the ocean and gases released by decomposition**.
- Atmospheric hydrogen sulphide also gets oxidised into sulphur dioxide.

- Atmospheric **sulphur dioxide** is carried back to the earth after being dissolved in rainwater 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 acid** which is incorporated in the proteins of autotroph tissues. It then passes through the grazing food chain.
- Sulphur bound in a living organism is carried back to the soil, to the bottom of ponds and lakes and seas **through excretion and decomposition of dead organic material**.

**Q. 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
- A high content of organic matter (humus) in soil increases its water holding capacity.

Answer: b) 3 only

### **3. Natural Ecosystem**

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

#### **3.1 Biomes or Terrestrial Ecosystems**

- The terrestrial part of the biosphere is divisible into enormous regions called **biomes**.
- **No two biomes are alike.** They are characterized, by distinct climate (precipitation and temperature mainly), vegetation, animal life and general soil type.
- The climate determines the boundaries of a biome and abundance of plants and animals found in each one of them.

## 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

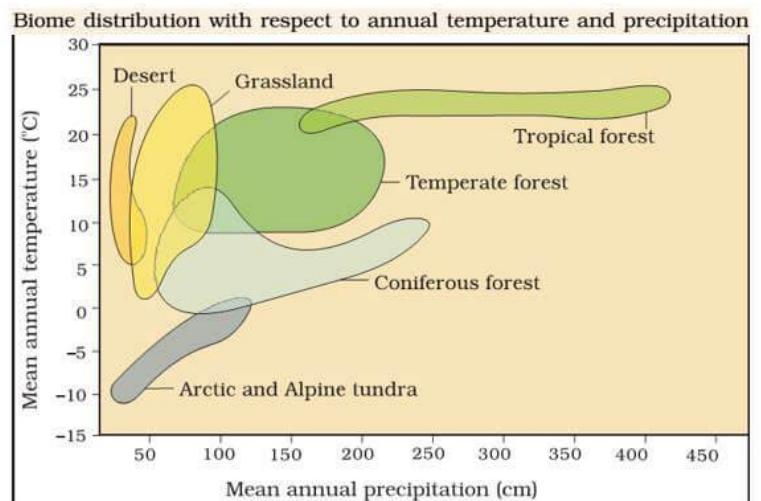
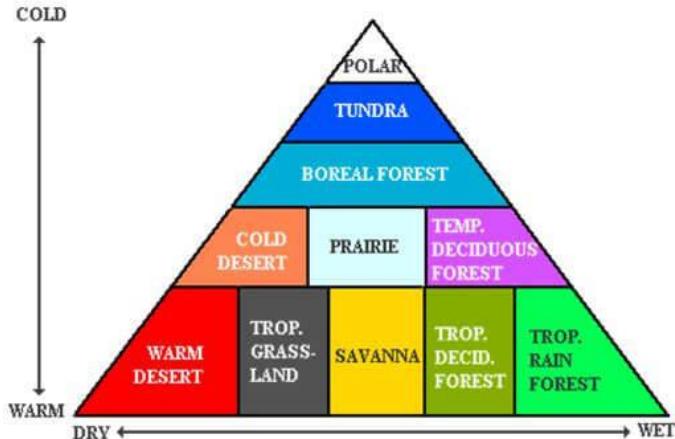
## Grassland

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

## Desert

- Tropical and Mid Latitude Desert Biome

For detailed explanation ad maps, you must go though **Geography > Climatology > Climatic Regions**.



## 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**).
- The lowest form of vegetation like **mosses, lichens** are sparsely found on bare rocks.
- Coastal lowlands **reindeer moss** which provides the only pasturage for reindeers.
- In the summer, birds migrate north to prey on the numerous insects which 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, musk-ox, polar bear, lemming, arctic hare, arctic willow live in tundra region.
- **Reptiles and amphibians are almost absent.**
- Most of the animals have **long life**, e.g. arctic willow has a life span of 150 to 300 years.
- They are protected from chillness by the presence of **thick cuticle and epidermal hair or fur**.
- Mammals **have a large body size and small tail and ear** to avoid the loss of heat from the surface.

## Taiga or Boreal Biome

- Boreal forest soils are characterized by thin **podzols** and are rather poor. This is because:
  - ✓ **The weathering of rocks proceeds slowly** in cold environments
  - ✓ **the litter derived from conifer needle (leaf) is decomposed very slowly** and is not rich in nutrients (humus content is low).
  - ✓ **conifers do not shed their leaves frequently.**

### 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 sandy or loamy subsurface which has **no organic matter (lost due to leaching of nutrients)** to the bottom layers).



- The soils are characterized by low levels of moisture (excessively drained) and nutrients and are loamy or sandy. Others have shallow rooting zones and poor drainage due to subsoil cementation.
  - A low pH further compounds issue. **The low pH (acidic)** is due to **excessive leaching of alkaline** matter which if present would neutralise the organic acids of the accumulating litter.
  - Hence, most Podzols are **poor soils for agriculture**. They are mostly used for grazing.
- 
- The predominant vegetation is an evergreen coniferous forest with species such as spruce, fir and pine.
  - **The conifers require little moisture are best suited to this type of sub-Arctic climate.**
  - **The productivity of boreal forest is lower than those of any other forest ecosystem.**
  - Animals found in this region include Siberian tiger, wolverine, lynx, wolf, bear, red fox, squirrel, and amphibians like Hyla, Rana, etc.

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

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

## **Temperate Rainforest Biome**

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- This is a small biome in terms of area covered. The main stretch of this habitat is along the northwestern 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 around the world.
- **Big coniferous trees** dominate this 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**.
- Grizzly bears are the common mammals found in Alaska.

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

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- 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

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

## Temperate Deciduous Biome (Mediterranean Climate)

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

## Tropical Deciduous Biome (Monsoon Climate)

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- Tropical Monsoon Forests are also known as a drought-deciduous forest; dry forest; dry-deciduous forest; tropical deciduous forest.
- **Teak, neem, bamboos, sal, shisham, sandalwood, khair, mulberry** are some of the important species.

## Savanna or Tropical Wet and Dry Biome

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- 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 excessive loss of water through transpiration, e.g. acacias.
- Trees usually have **broad trunks**, with water-storing devices to survive through the prolonged drought.
- Many trees are umbrella shaped, exposing only a narrow edge to the strong winds.
- Savanna biome is **rich in mammal, bird and reptile diversity**.

## Tropical Rain Forest Biome

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- High temperature and abundant rainfall support a luxuriant tropical rain forest.
- The equatorial vegetation comprises a multitude of evergreen trees, e.g. mahogany, ebony, dyewoods etc.
- In the coastal areas and brackish swamps, mangrove forests thrive.

- All plants struggle upwards (most epiphytes) 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.

#### **Q. 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: d) All

### **Desert Biome**

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- 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.
- 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 the loss of water through transpiration**.
- The seeds of many species of grasses and herbs have **thick, tough skins** to protect them while they lie dormant.

### **3.2 Aquatic Ecosystems**

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- Aquatic ecosystems refer to plant and animal communities occurring in water bodies.
- Aquatic ecosystems are classified into two subgroups: 1) Freshwater ecosystems, such as rivers, lakes and ponds; 2) Marine ecosystems, such as oceans, estuary and mangroves.
- Aquatic ecosystems are classified on the basis of salinity into the following types:

- **Freshwater ecosystems:** water on land which is continuously cycling and has low salt content (**always less than 5 ppt**) is known as fresh water.
- There are two types of freshwater ecosystems: 1) Static or still water (Lentic) ecosystems, e.g. pond, lake, bogs and swamps. 2) Running water (Lotic) ecosystems, e.g. springs, mountain brooks, streams and rivers.
- **Marine ecosystems:** the water bodies containing salt concentration equal to or above that of seawater (i.e., **35 ppt or above**). E.g. shallow seas and open ocean.
- **Brackish water ecosystems:** these water bodies have salt content in between **5 to 35 ppt**. e.g. **estuaries, salt marshes, mangrove swamps and forests**.

## Aquatic Organisms

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

## Factors Limiting the Productivity of Aquatic Habitats

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

### Sunlight

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

### Photic zone

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

### Aphotic zone

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

### Dissolved oxygen

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- In freshwater the average concentration of dissolved oxygen is 10 parts per million by weight.
- This is 150 times lower than the concentration of oxygen in an equivalent volume of air.
- Oxygen enters the aquatic ecosystem through the air-water interface and by the photosynthetic activities of aquatic plants.
- Dissolved oxygen escapes the water body through the air-water interface and respiration of organisms (fish, decomposers, zooplankton, etc.).
- The amount of dissolved oxygen retained in water is also influenced by temperature.
- **Oxygen is less soluble in warm water.** Warm water also **enhances decomposer activity.** Therefore, increasing the temperature of a water body increases the rate at which oxygen is depleted from the water.
- When the dissolved oxygen level falls below 3-5 ppm, many aquatic organisms are likely to die.

### Winterkill

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

### Temperature

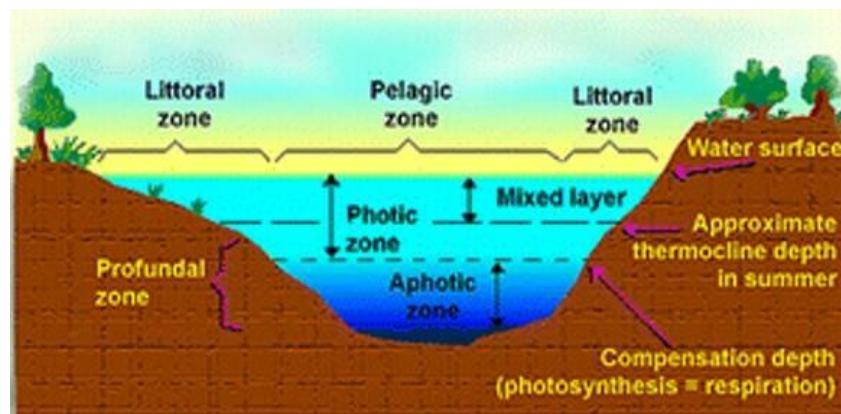
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- Since water temperatures are less subject to change, the aquatic organisms have **narrow temperature tolerance limit.**
- As a result, even small changes in water temperature are a great threat to the survival of aquatic organisms when compared to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

### Wetland Ecosystem

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- Wetlands are areas of marsh or peatland with water that is static or flowing, fresh, brackish or saline, including areas of marine water the depth of which at low tide does not exceed 6 m.
- Wetlands are **transition zones (ecotone)** between terrestrial and aquatic ecosystems.
- E.g. Mangroves, lake littorals (marginal areas between highest and lowest water level of the lakes), floodplains (areas lying adjacent to the river channels beyond the natural levees and periodically flooded during high discharge in the river) and other marshy or swampy areas.



- These habitats experience periodic flooding from adjacent deepwater habitats and therefore supports plants and animals specifically adapted to such shallow flooding or waterlogging.
- Waterlogged soil adapted plant life (**hydrophytes**), and **hydric soils (not enough O<sub>2</sub>)** are the chief characteristics of wetlands.
- India has over 27,000 wetlands, of which 23,000+ are inland wetlands, and around 4000 are coastal wetlands.
- Wetlands occupy 18.4% of the country's area of which 70% are under **paddy cultivation**.
- Natural wetlands in India range from high altitude wetlands in the Himalayas; flood plains of the major river systems; saline and temporary wetlands of the arid and semi-arid regions; coastal wetlands such as lagoons, backwaters, estuaries, mangroves, swamps and coral reefs, and so on.

## Distinction from Lakes

- Lakes are generally **less important** when compared to wetland from the viewpoint of ecosystem and biodiversity conservation.
- There is no clear distinction between lakes and wetlands. Wetlands are shallow water bodies whereas lakes can be deep or shallow.
- National Lake Conservation Programme (NLCP) considers lakes as standing water bodies which 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**.

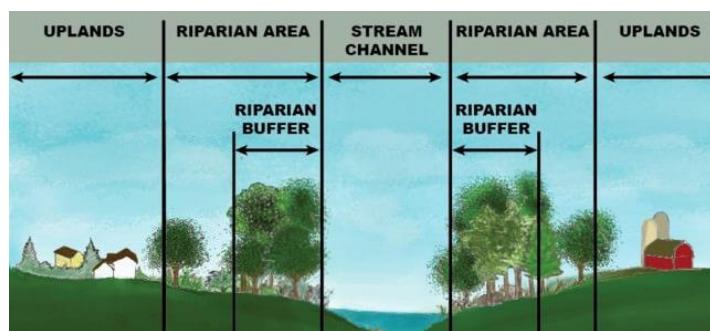
- Wetlands (generally less than 3 m deep over most of their area) are usually **rich in nutrients** (derived from surroundings and their sediments) and have **abundant growth of aquatic macrophytes** (an aquatic plant large enough to be seen by the naked eye).
- They **support high densities and diverse 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 interfere with the utilisation of the water body.
- However, marginal aquatic vegetation is desirable as it checks erosion, serves habitat for wildlife and helps improve water quality.

<b>Characteristic</b>	<b>Lake</b>	<b>Wetland (shallow lake)</b>
<b>Origin</b>	<ul style="list-style-type: none"> <li>• Largest is due to tectonic forces: Fluvial, Geomorphic, increase in the water table, etc.</li> </ul>	<ul style="list-style-type: none"> <li>• Mostly Fluvial, Residual lakes</li> </ul>
<b>Water turnover</b>	<ul style="list-style-type: none"> <li>• Permanent</li> </ul>	<ul style="list-style-type: none"> <li>• Permanent or Temporary</li> </ul>
<b>Water level changes</b>	<ul style="list-style-type: none"> <li>• Relatively small</li> </ul>	<ul style="list-style-type: none"> <li>• Relatively Large</li> </ul>
<b>Thermal stratification</b>	<ul style="list-style-type: none"> <li>• Yes</li> </ul>	<ul style="list-style-type: none"> <li>• No</li> </ul>
<b>Vertical mixing</b>	<ul style="list-style-type: none"> <li>• Thermally regulated</li> </ul>	<ul style="list-style-type: none"> <li>• Wind regulated</li> </ul>
<b>Dominant Producer</b>	<ul style="list-style-type: none"> <li>• <b>Phytoplankton</b></li> </ul>	<ul style="list-style-type: none"> <li>• <b>Macrophytes</b></li> </ul>
<b>Food chain</b>	<ul style="list-style-type: none"> <li>• <b>Grazing Pathway</b></li> </ul>	<ul style="list-style-type: none"> <li>• <b>Detritus Pathway</b></li> </ul>
<b>Productivity</b>	<ul style="list-style-type: none"> <li>• <b>Low</b></li> </ul>	<ul style="list-style-type: none"> <li>• <b>High</b></li> </ul>
<b>Trophic status</b>	<ul style="list-style-type: none"> <li>• Oligotrophic</li> </ul>	<ul style="list-style-type: none"> <li>• Mostly Eutrophic</li> </ul>
<b>Functions-Flood control</b>	<ul style="list-style-type: none"> <li>• Less Significant</li> </ul>	<ul style="list-style-type: none"> <li>• Significant</li> </ul>
<b>Waste treatment</b>	<ul style="list-style-type: none"> <li>• No</li> </ul>	<ul style="list-style-type: none"> <li>• Yes</li> </ul>

## **Importance of Wetlands**

- Wetlands are indispensable for the countless benefits or “ecosystem services” that they provide humanity, ranging from freshwater supply, food and building materials, and biodiversity, to flood control, groundwater recharge, and climate change mitigation.
- Wetlands are habitat to aquatic flora and fauna, numerous species of native and **migratory birds**.
- Wetlands are an important resource for sustainable tourism.
- They carry out water purification, filtration of sediments and nutrients from surface water.
- They help in nutrients recycling, groundwater recharging and stabilisation of local climate.

- Play an important role in flood mitigation by controlling the rate of runoff.
- Buffer (act as a riparian buffer) shorelines against erosion and pollutants.
- They act as a genetic reservoir for various species of plants (especially rice).



## Reasons for depletion

- Excessive pollutants (Industrial effluents, domestic waste, agricultural runoff etc.) are dumped into wetlands beyond the recycling capacity.
- Habitat destruction and deforestation create ecological imbalance by altering the population of wetland species.
- Conversion of wetlands for agriculture and encroachment by public and mafia.
- 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

- Demarcation of wetlands using the latest technology, proper enforcement of laws and stringent punishments for violators.
- Preventing unsustainable aquaculture and cultivation of shellfish.
- Treating industrial effluents and water from farmlands before discharging into wetlands.
- Utilizing wetlands on a sustainable basis by giving enough time for natural regeneration.
- Artificial regeneration for a quick recovery.
- Afforestation, weed control, preventing invasive species is the key to wetland conservation.
- Preventive measures to stop the introduction of exotic invasive species like **water hyacinth**.
- Soil conservation measures & afforestation.
- Preventing grazing in peripherals of wetlands.
- Wildlife conservation, sustainable tourism, eco-tourism and sensitizing local populace.
- **Eutrophication** abatement by processing nutrient rich discharge into the water body.

- Involving the local population in the conservation of wetlands.

## **Measures to Protect Wetlands**

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- **Ramsar Convention on Wetlands**
- **Ramsar Sites in India**
- **Wetlands International**
- **National Wetlands Conservation Programme (NWCP)**

### **Wetlands International**

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- Wetlands International is a global organisation (**NGO**) that works to sustain and restore wetlands and their resources for people and biodiversity.
- Wetlands International's work ranges from research, advocacy and engagement with governments, corporate and international policy fora and conventions.

**Q. With reference to a conservation organisation called 'Wetlands International', which of the following statements is/are correct?**

- 1) It is an intergovernmental organization formed by the countries which are signatories to Ramsar Convention.
- 2) It works at the field level to develop and mobilize knowledge and use the 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

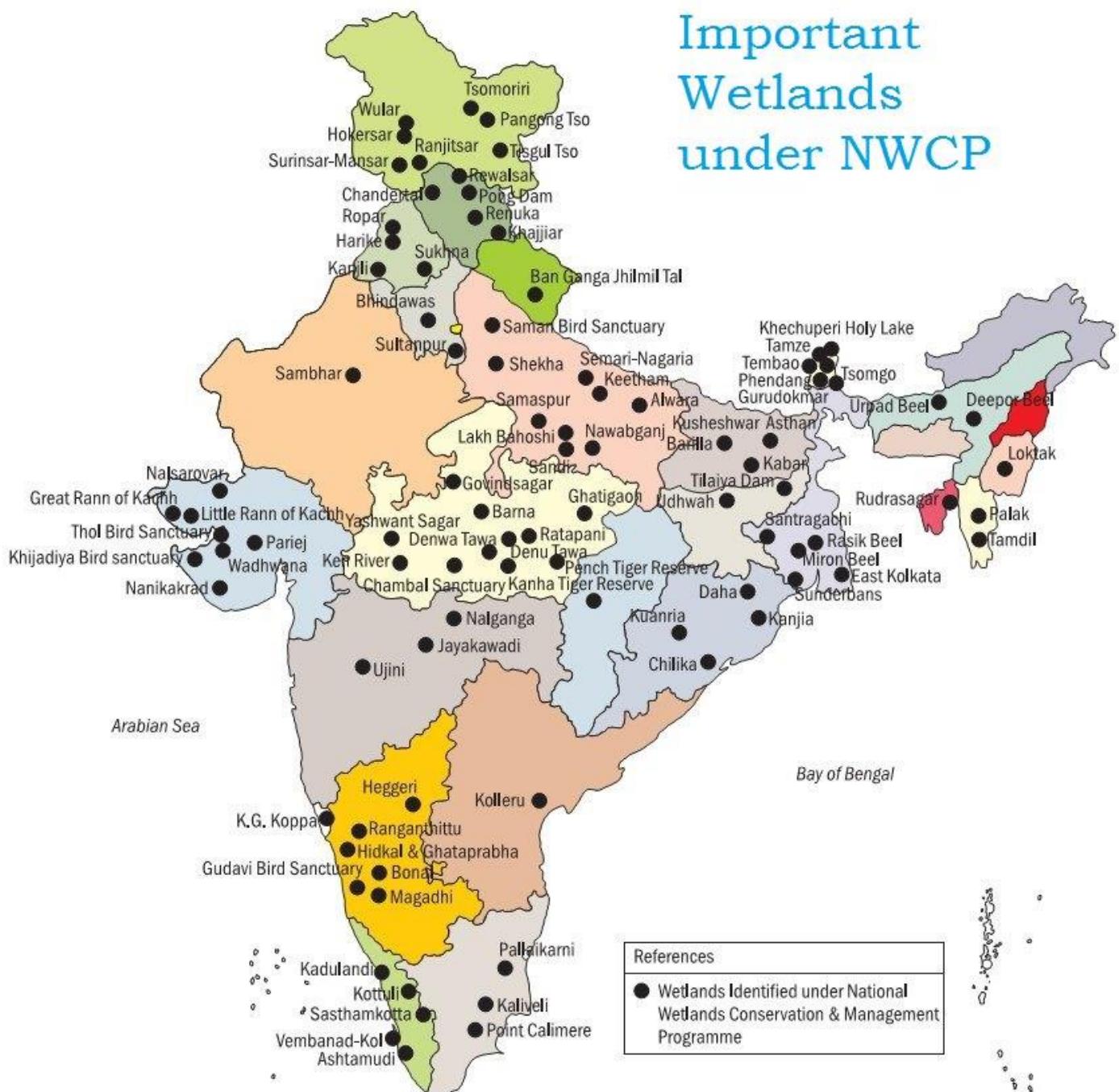
Answer: b) 2 only. Wetlands International is an NGO

### **National Wetlands Conservation Programme (NWCP)**

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- NWCP was implemented in the year 1985-86.
- Under the programme, 115 wetlands have been identified by the MoEF which require urgent conservation and management interventions.

- Criteria for identification of wetlands of national importance under NWCP are the same as those prescribed under the **Ramsar Convention on Wetlands**.
- The **Central Government** is responsible for the overall coordination of wetland conservation programmes.
- It also provides guidelines, financial & technical assistance to state govt.
- Since the land resources belong to them, the State Governments/UT Administration are responsible for the **management of wetlands**.



- Aim: Conservation of wetlands to prevent their further degradation and to ensure their wise use for the benefit of local communities and overall conservation of biodiversity.

## Objectives

- to lay down policy guidelines for conservation and management of wetlands.
- to provide financial assistance for undertaking intensive conservation measures.
- to monitor the implementation of the programme.
- to prepare an inventory of Indian wetlands.

## Ramsar Convention on Wetlands

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- **International treaty** for “**the conservation and sustainable use of wetlands**”.
- It is also known as the **Convention on Wetlands**.
- It is named after the city of **Ramsar in Iran**.
- The Convention was signed on 2<sup>nd</sup> of February 1971.
- The **2<sup>nd</sup> of February** each year is **World Wetlands Day**.
- Number of parties to the convention (COP) is 170.
- At the centre of the Ramsar philosophy is the “**wise use**” of wetlands.
- Wise use: maintenance of ecological character within the context of sustainable development.

## Need for Such Convention

- Wetlands are indispensable for the countless benefits or “ecosystem services” that they provide ranging from freshwater supply, food and building materials, and biodiversity, flood control, groundwater recharge, and climate change mitigation.
- 64% of the world’s wetlands have disappeared in the last century.

## What is wetland

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

## COP

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- COP is the policy-making organ of the Convention which adopts decisions (Resolutions and Recommendations) to administer the work of the Convention.

- Every three years, representatives of the Contracting Parties meet as the Conference of the Contracting Parties (COP)
- COP12 was held in **Punta del Este, Uruguay in 2015. COP13 took place in Dubai, United Arab Emirates, in 2018.**

### **Under the Convention, the Contracting Parties commit to:**

- Work towards the wise use of all their wetlands;
- **Designate suitable wetlands for the List of Wetlands of International Importance** (the "Ramsar List") and ensure their effective management;
- Cooperate internationally on **trans boundary wetlands**, shared wetland systems and shared species.

### **Ramsar Site**

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

### **Transboundary Ramsar Sites**

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



*Global Distribution of Ramsar Sites ([Source](#))*

### **The Montreux Record**

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

**Q. 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 as a result 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)

### **International Organization Partners**

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- The Ramsar Convention works closely with six organisations known as International Organization Partners (IOPs). These are:
  1. **Birdlife International**
  2. **International Union for Conservation of Nature (IUCN)**
  3. **International Water Management Institute (IWMI)**
  4. **Wetlands International**
  5. **WWF**
  6. **International Wildfowl & Wetlands Trust (WWT)**

### Other Partners

- Convention on Biological Diversity (CBD)
- Convention to Combat Desertification (UNCCD),
- Convention on the Conservation of Migratory Species of Wild Animals
- Convention on Migratory Species (CMS),
- World Heritage Convention (WHC) and
- Convention on International Trade in Endangered Species (CITES).

- Project funding is done by various groups like multilateral development banks, bilateral donors, **UN agencies such as UNEP, UNDP, Non-governmental organisations etc.**

## Criteria for Identification of Wetlands under Ramsar Convention

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If a wetland

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

## Ramsar Sites in India

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- As of February 2019, there are **27 Ramsar Sites in India**.
- **Jammu and Kashmir, Himachal Pradesh, Kerala and Punjab have three wetlands each.**
- **West Bengal, Orissa and Rajasthan have two wetlands each.**
- Gujarat, Uttar Pradesh, Tripura, Andhra Pradesh, Tamil Nadu, Assam, Madhya Pradesh, Manipur Jammu & Kashmir have one wetland each.

Sl. No.	Name of Site	State	Area (in Sq. km.)
1	<b>Asthamudi Wetland</b>	Kerala	614
2	<b>Bhitarkanika Mangroves</b>	Orissa	650
3	<b>Bhoj Wetlands</b>	Madhya Pradesh	32.01
4	<b>Chandertal Wetland (Chandra Taal)</b>	Himachal Pradesh	0.49
5	<b>Chilka Lake</b>	Orissa	1165
6	<b>Deepor Beel</b>	Assam	40
7	<b>East Calcutta Wetlands</b>	West Bengal	125
8	<b>Harike Lake</b>	Punjab	41

9	<b>Hokera Wetland</b>	Jammu and Kashmir	13.75
10	<b>Kanjli Lake</b>	Punjab	1.83
11	<b>Keoladeo Ghana NP</b>	Rajasthan	28.73
12	<b>Kolleru Lake</b>	Andhra Pradesh	901
13	<b>Loktak Lake</b>	Manipur	266
14	<b>Nalsarovar Bird Sanctuary</b>	Gujarat	120
15	<b>Point Calimere</b>	Tamil Nadu	385
16	<b>Pong Dam Lake</b>	Himachal Pradesh	156.62
17	<b>Renuka Wetland</b>	Himachal Pradesh	0.2
18	<b>Ropar Lake</b>	Punjab	13.65
19	<b>Rudrasagar Lake</b>	Tripura	2.4
20	<b>Sambhar Lake</b>	Rajasthan	240
21	<b>Sasthamkotta Lake</b>	Kerala	3.73
22	<b>Sunderbans Wetland</b>	West Bengal	4230
23	<b>Surinsar-Mansar Lakes</b>	Jammu and Kashmir	3.5
24	<b>Tsomoriri Lake</b>	Jammu and Kashmir	120
25	<b>Upper Ganga River (Brijghat to Narora Stretch)</b>	Uttar Pradesh	265.9
26	<b>Vembanad Kol Wetland</b>	Kerala	1512.5
27	<b>Wular Lake</b>	Jammu & Kashmir	189
			<b>11,121.31</b>

(Source: [Ministry of Environment & Forests, Government of India](#))

## Notable Ramsar Sites in India

Ramsar Site	Comments
<b>Asthamudi Wetland</b>	<ul style="list-style-type: none"> <li>A natural backwater in Kollam district.</li> <li>It forms an estuary with Sea at <b>Neendakara</b> (famous fishing harbour in Kerala).</li> </ul>
<b>Bhitarkanika Mangroves</b>	<ul style="list-style-type: none"> <li>The core area of Bhitarkanika Wildlife Sanctuary was declared Bhitarkanika National Park.</li> <li>Bhitarkanika Wildlife Sanctuary includes <b>Gahirmatha Marine Wildlife Sanctuary</b>.</li> <li>Bhitarkanika Mangroves, a part of Bhitarkanika Wildlife Sanctuary was designated a Ramsar Wetland of International Importance in 2002.</li> <li>It is famous for its <b>saltwater crocodiles</b> and <b>Olive ridley sea turtle</b>.</li> </ul>
<b>Bhoj Wetlands</b>	<ul style="list-style-type: none"> <li>Consists of two lakes located in the city of Bhopal.</li> <li>The two lakes are the Bhojtal and the Lower Lake.</li> <li>It is a humanmade reservoir.</li> </ul>

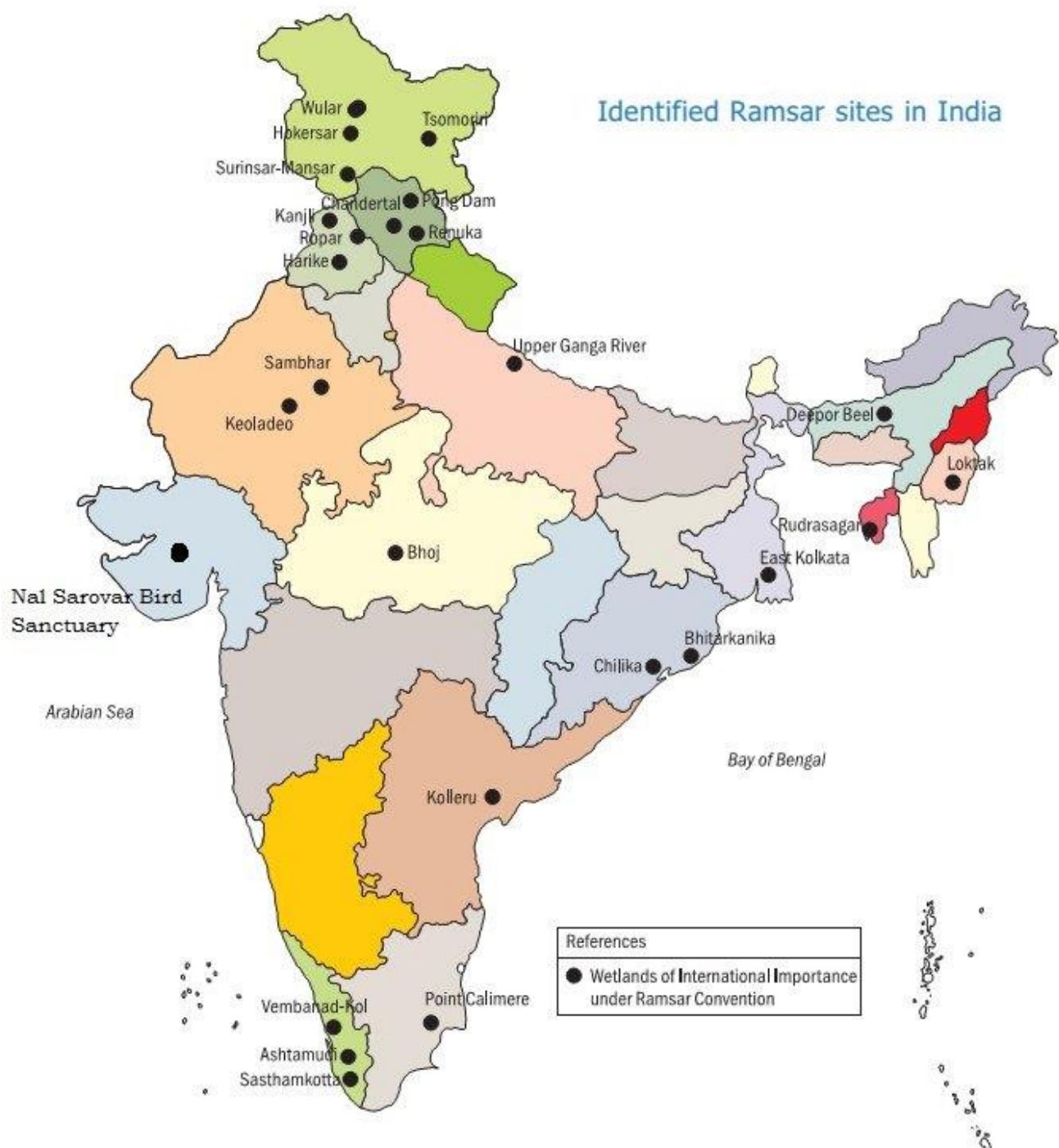
	<ul style="list-style-type: none"><li>The largest bird of India, the <b>sarus crane</b> (<i>Grus antigone</i>) is found here.</li></ul>
<b>Chilka Lake</b>	<ul style="list-style-type: none"><li>Chilka Lake is a <b>brackish water lagoon</b> at the mouth of the <b>Daya River</b>.</li><li>It is the <b>largest coastal lagoon in India</b>.</li><li>Birds from as far as the Caspian Sea, Lake Baikal, the Aral Sea and other remote parts of Russia, Kirghiz steppes of Mongolia, Central and Southeast Asia, Ladakh and Himalayas come here.</li><li>In 1981, Chilika Lake was designated the <b>first Indian wetland of international importance under the Ramsar Convention</b>.</li><li><b>Nalbana Island</b> (bird sanctuary) is the core area of the Ramsar designated wetlands of Chilika Lake.</li><li>The <b>Irrawaddy dolphin (Vulnerable)</b> is the flagship species of Chilika lake.</li><li>Chilka is home to the only known population of Irrawaddy dolphins in India.</li><li>It is classified as critically endangered in five of the six other places it is known to live.</li></ul>
<b>Deepor Beel</b>	<ul style="list-style-type: none"><li>It is a permanent freshwater lake, in a former channel of the Brahmaputra River.</li></ul>
<b>East Calcutta Wetlands</b>	<ul style="list-style-type: none"><li>The wetland forms an urban facility for treating the city's wastewater.</li></ul>
<b>Keoladeo Ghana NP</b>	<ul style="list-style-type: none"><li>A complex of ten artificial, seasonal lagoons, varying in size, situated in a densely populated region.</li><li>Placed on the Montreux Record in 1990 due to "water shortage and an unbalanced grazing regime".</li><li>Additionally, the invasive growth of the grass <i>Paspalum distichum</i> has changed the ecological character of large areas of the site, reducing its suitability for certain waterbird species, notably the <b>Siberian crane</b>.</li></ul>
<b>Kolleru Lake</b>	<ul style="list-style-type: none"><li><b>Bird sanctuary and wildlife sanctuary.</b> I was previously a lagoon, but now it is several kilometres inland due to the coastline of emergence and delta formation.</li></ul>
<b>Loktak Lake</b>	<ul style="list-style-type: none"><li>Loktak Lake is the largest freshwater lake in the north-eastern region.</li><li>Keibul Lamjao the only floating national park in the world floats over it.</li></ul>
<b>Nalsarovar Bird Sanctuary</b>	<ul style="list-style-type: none"><li><b>A natural freshwater lake (a relict sea) that is the largest natural wetland in the Thar Desert Biogeographic Province.</b></li><li>Besides a few mammalian species including the wild ass and the black buck, its migratory bird population includes rosy pelicans, flamingoes, white storks, brahminy ducks and herons.</li><li>Thousands of migratory waterfowl flock to this sanctuary just after the Indian monsoon season.</li></ul>
<b>Point Calimere</b>	<ul style="list-style-type: none"><li>One of the last remnants of Dry Evergreen Forests.</li><li>Habitat: Dry Evergreen Forests, Mangrove &amp; Wetlands.</li></ul>

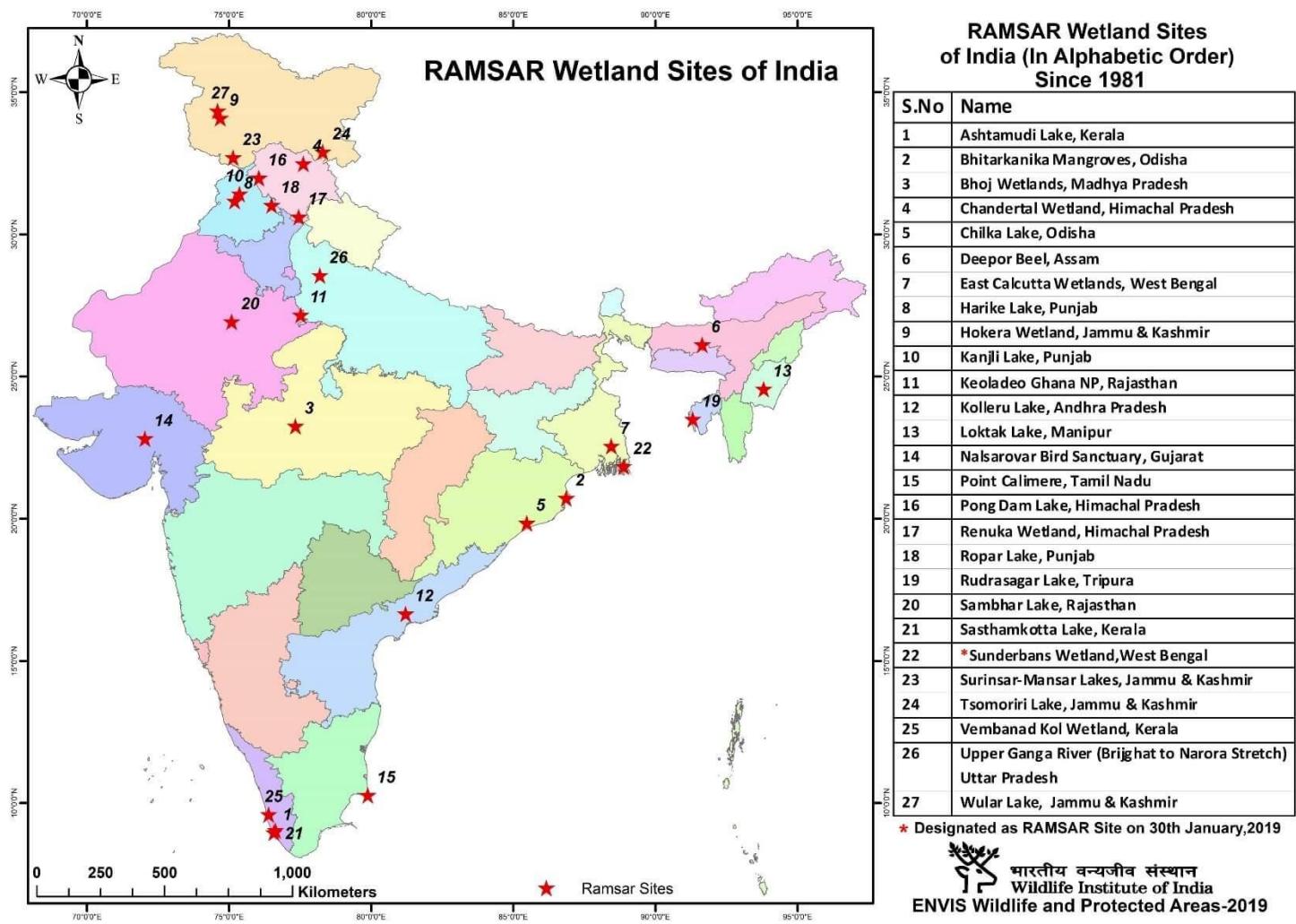
	<ul style="list-style-type: none"> <li>Winter Migrants: Spoon Billed Sandpiper, Greater Flamingos.</li> </ul>
<b>Sambhar Lake</b>	<ul style="list-style-type: none"> <li>The Sambhar Salt Lake, <b>India's largest inland salt Lake</b>.</li> <li>A key wintering area for tens of thousands of <b>flamingos</b> and other birds that migrate from northern Asia.</li> </ul>
<b>Tsomoriri Lake</b>	<ul style="list-style-type: none"> <li>A freshwater to brackish lake lying at 4,595m above sea level.</li> <li>The site is said to represent the only breeding ground outside of China for one of the most endangered cranes, the <b>Black-necked crane</b>, and the only breeding ground for <b>Bar-headed geese</b> in India.</li> <li>The <b>Great Tibetan Sheep or Argali</b> and <b>Tibetan Wild Ass</b> (<i>Equus kiang</i>) are endemic to the Tibetan plateau, of which the Changthang is the westernmost part.</li> </ul>
<b>Upper Ganga River (Brijghat to Narora Stretch)</b>	<ul style="list-style-type: none"> <li>The river provides habitat for IUCN Red-listed <b>Ganges River Dolphin</b> and <b>Gharials</b>.</li> </ul>
<b>Vembanad Kol Wetland</b>	<ul style="list-style-type: none"> <li><b>Longest lake of India</b>.</li> <li>Largest lake of Kerala.</li> <li><b>Second largest Ramsar Site in India after Sundarbans</b>.</li> <li>It is below sea level and is famous for exotic fish varieties and Paddy fields that are below sea level.</li> </ul>
<b>Wular Lake</b>	<ul style="list-style-type: none"> <li>The <b>largest freshwater lake in India</b>.</li> </ul>

### Largest and Smallest, Newest and Oldest Ramsar Sites in India

Largest Ramsar Sites in India (Area in Sq. km)		
<b>1. Sunderbans Wetland</b>	<b>West Bengal</b>	<b>4230</b>
<b>2. Vembanad Kol Wetland</b>	<b>Kerala</b>	<b>1512.5</b>
<b>3. Chilka Lake</b>	<b>Orissa</b>	<b>1165</b>
<b>4. Kolleru Lake</b>	<b>Andhra Pradesh</b>	<b>901</b>
<b>5. Bhitarkanika Mangroves</b>	<b>Orissa</b>	<b>650</b>
<b>6. Asthamudi Wetland</b>	<b>Kerala</b>	<b>614</b>
Smallest Ramsar Sites in India (Area in Sq. km)		
<b>1. Renuka Wetland</b>	<b>Himachal Pradesh</b>	<b>0.2</b>
<b>2. Chandertal Wetland</b>	<b>Himachal Pradesh</b>	<b>0.49</b>
3. Kanjli Lake	Punjab	1.83
Newest Ramsar Sites in India (Year)		
<b>1. Sunderbans Wetland</b>	<b>West Bengal</b>	<b>2019</b>
2. Nalsarovar Bird Sanctuary	Gujarat	2012

Oldest Ramsar Sites in India (Year)		
<b>1. Chilka Lake</b>	<b>Orissa</b>	<b>1981</b>
<b>2. Keoladeo Ghana NP</b>	<b>Rajasthan</b>	<b>1981</b>





भारतीय वन्यजीव संस्थान  
Wildlife Institute of India  
ENVIS Wildlife and Protected Areas-2019

### Source and Credits

## Estuarine Ecosystem

- An estuary is a place where a river or a stream opens into the sea (mouth of the river).
- It is a partially enclosed coastal area of **brackish water** (salinity varies between 0-35 ppt) with one or more rivers or streams flowing into it, and with a free connection to the open sea.
- At the estuaries, freshwater carrying fertile silt and runoff from the land mixes with the salty sea water.
- Estuaries form a **transition zone (ecotone)** between river environments and maritime environments.
- Examples of estuaries are river mouths, coastal bays, tidal marshes, lagoons and deltas.



- Estuaries are formed due to rise in sea level, movement of sand and sandbars, glacial processes and tectonic processes.
- All the plants and animals in the estuaries are subjected to variations in salinity to which they are adapted (**osmoregulation**).
- Estuaries are greatly influenced by tidal action. They are periodically washed by sea water once or twice a day based on the number of tides.
- In some narrow estuaries, tidal bores are significant. Tidal bores cause great damage to the estuarine ecology.

## Importance of Estuaries

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- They are the most productive (**more productive than wetlands**) water bodies in the world because of the mixing of freshwater and saline water zone where marine organisms of both the ecosystems meet.
- **Ecotone regions (transitional zones)** like mangroves, wetlands, estuaries, grasslands etc. have far greater productivity compared to 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.
- Also, an estuary has **very little wave action**, so it provides a calm refuge from the open sea and hence becomes ideal for the survival of numerous aquatic species.
- Estuaries are most **heavily populated** areas throughout the world, with about 60% of the world's population living along estuaries and the coast.
- 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.
- Mangroves act as a filter trapping suspended mud and sand carried by rivers which leads to delta formations around estuaries.
- **Precipitation of clay and alluvium particles in the estuarine region is high** because of the exposure to saline water (saline water precipitates fine alluvium).

- Estuaries store and recycle nutrients, traps sediment and forms a buffer between coastal catchments and the marine environment.
- They also absorb, trap and detoxify pollutants, **acting as a natural water filter**.
- Estuaries with their wetlands, creeks, lagoons, mangroves and sea-grass beds are rich in natural resources including fisheries.
- **They are deep and well protected from marine transgressions, and hence they are ideal locations for the construction of ports and harbours.**
- The banks of estuarine channels form a favoured location for human settlements, which use the estuaries for fishing and commerce but nowadays also for dumping civic and industrial waste.

## Differences between Lagoon and Estuary

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- A lagoon is a stretch of salt water separated from the sea by a **low sandbank or coral reef**.
- Backwaters in Kerala are **mostly lagoons** where seawater flows inwards through a small inlet that is open towards the sea.
- **In estuaries, the water flows fast and strong, while in lagoons the water is shallower and flows sluggishly.**
- Estuaries are usually deeper than lagoons. Also, **lagoons mostly don't have any fresh water source** while the estuaries have at least one. Lagoons are more saline than estuaries.
- **Lagoons are formed due to falling in sea levels** (coastline of emergence. E.g. Kerala Coast) whereas **estuaries are mostly formed due to rise in sea levels** (coastline of submergence. E.g. Konkan coast)

## Estuarine Vegetation

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- Only certain types of plants and animals adapted to the "brackish" estuarine waters flourish in the estuaries.
- **Factors** influencing the distribution of organism in an estuary are **its salinity and the amount of flooding**.
- Estuaries support diverse habitats, such as mangroves, salt marshes, sea-grass, mudflats etc.
- Estuaries are very dynamic and productive ecosystems since the river flow, tidal range and sediment distribution is continuously changing in them.
- In general, the **phytoplankton of estuaries are diatoms, dinoflagellates, green algae, blue-green algae**.
- Towards the sea coast of the estuaries, there are large algae and seagrasses. Near the mouth of the rivers and deltas, there are mangrove forests.
- Estuaries are homes to all kind of 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-worts, eelgrass, salt grasses, cordgrasses, seagrass, sedge, bulrush etc.

## India Estuarine Ecosystem

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- The Country has 14 major, 44 medium and 162 minor rivers drains into the sea through various estuaries.
- **Major estuaries occur in the Bay of Bengal.** Many estuaries are locations of some of the **major seaports**.
- 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 considered as subsections of estuaries**).
- Two typical examples of estuaries on the west coast are the **Mandovi** and **Zuari estuaries**.

## Issues of Indian Estuarine Ecosystem

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- Modifications of the estuarine catchments result in changes in water flow in various estuaries, either far in excess or much lower than required (E.g. Hooghly, Godavari, Pulicat etc.)
- Pollution through industries and combined city sewage discharge.
- Recreational boating and fishing.
- Navigation, dredging and shipping (e.g. Hooghly).
- Expansion of urban and rural settlements, mining & industries, agriculture and dumping of solid wastes.
- Overexploitation of target fish stock due to increased demand.
- Reclaiming the fringed areas for intensive aquaculture in pens.
- Obstructing the migratory routes of fish and prawn recruitment (e.g., Chilka, Pulicat).
- Polluting the environment through feeding of stocked fish and prawn in pens (Chilka).
- Destruction of biodiversity through prawn seed collection and operation of small-meshed nets (e.g., Hooghly, Chilka, Pulicat).
- Submergence of catchment areas due to rising in water level.

## Mangroves

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- Mangroves represent a characteristic littoral (near the seashore) forest ecosystem.
- These are mostly evergreen forests that grow in sheltered low lying coasts, estuaries, mudflats, tidal creeks backwaters (coastal waters held back on land), marshes and lagoons of tropical and subtropical regions.
- **Mangroves grow below the high water level of spring tides.**
- The best locations are where abundant silt is brought down by rivers or on the backshore of accreting sandy beaches.
- Mangroves are **highly productive ecosystems**, and the **trees may vary in height from 8 to 20 m**. They protect the shoreline from the effect of cyclones and tsunamis.
- They are breeding and spawning ground for many commercially important fishes.

- Since mangroves are located between the land and sea, they represent the best example of **ecotone**.
- Mangroves are shrubs or small trees that grow in coastal saline or brackish water.
- Mangroves are salt tolerant trees, also called **halophytes**, and are adapted harsh coastal conditions.
- Mangrove vegetation **facilitates more water loss**. Leaves are thick and contain salt-secreting glands. Some block absorption of salt at their roots itself.
- They contain a complex salt filtration system and complex root system to cope with salt water immersion and wave action.
- They are adapted to the **low oxygen (anoxic)** conditions of waterlogged mud.
- They produce **pneumatophores (blind roots)** to overcome the respiration problem in the **anaerobic soil** conditions.
- Mangroves occur worldwide in the **tropics and subtropics**, mainly between latitudes 25° N and 25° S.
- They require **high solar radiation** to filter saline water through their roots. This explains why mangroves are confined to only tropical and sub-tropical coastal waters.
- Mangroves occur in a variety of configurations. Some species (e.g. **Rhizophora**) send arching prop roots down into the water.
- While other (e.g. **Avicennia**) send vertical "Pneumatophores" or air roots up from the mud.
- Adventitious roots which emerged from the main trunk of a tree above ground level are called stilt roots.



*Prop roots and pneumatophores*



*Stilt roots*

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

## Mangroves in India

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- The mangroves of **Sundarbans** are the largest single block of tidal halophytic mangroves of the world.
- This mangrove forest is famous for the Royal Bengal Tiger and crocodiles.
- Mangrove areas here are being cleared for agricultural use.
- The mangroves of **Bhitarkanika (Orissa)**, which is the second largest in the Indian sub-continent, harbour high concentration of typical mangrove species and high genetic diversity.
- Mangrove swamps occur in profusion in the intertidal mudflats on both side of the creeks in the Godavari-Krishna deltaic regions of Andhra Pradesh.
- Mangroves of **Pichavaram and Vedaranyam** are degraded mainly due to the construction of aquaculture ponds and salt pans.

- On the west coast of India, mangroves, mostly scrubby 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 Avicennia marine, Avicennia officinalis and Rhizophora mucronata are found mainly in **Gulf of Kutch and the Kori creek**.
- Mangroves are of scrubby type with stunted growth, forming narrow, discontinuous patches on soft clayey mud.
- The condition of the mangroves is improving especially in the Kori creek region, which is a paleodelta of the Indus river (once upon a time it was part of Indus delta).
- In size, mangroves range from bushy stands of dwarf mangroves found in Gulf of Kutch, to taller stands found in the Sunderbans.
- On the Andaman & Nicobar Islands, the small tidal estuaries and the lagoons support a dense and diverse undisturbed mangrove flora.

## **Importance of Mangroves**

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

## **Threats**

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

**Q. Which one of the following is the correct sequence of ecosystems in the order of decreasing productivity?**

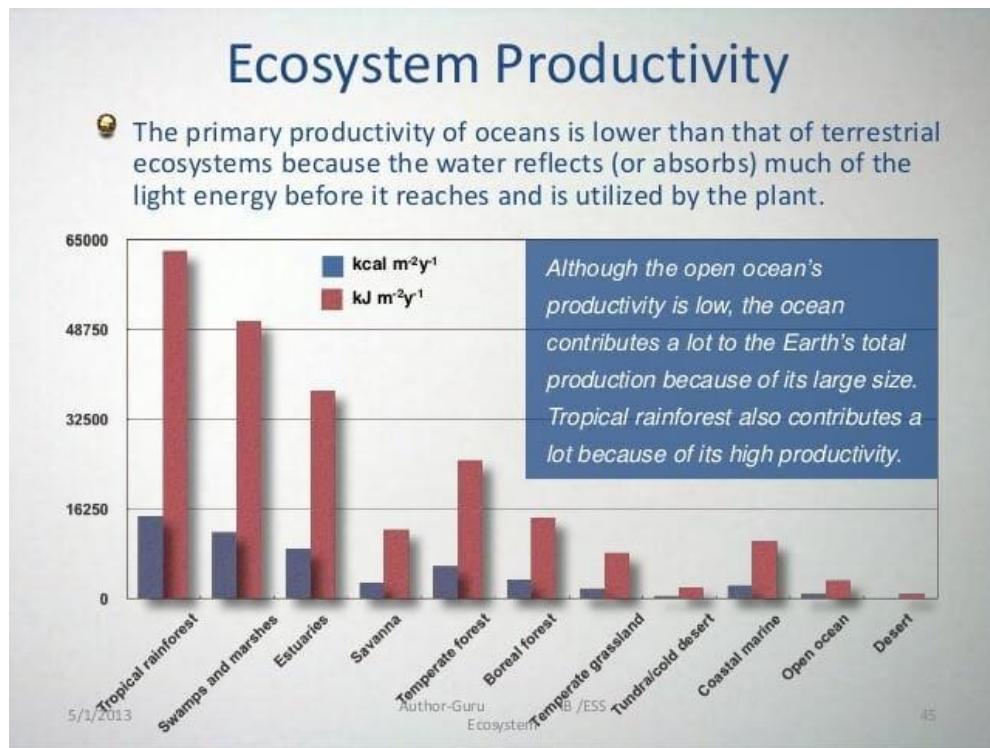
- a) Oceans, lakes, grasslands, mangroves
- b) Mangroves, oceans, grasslands, lakes
- c) Mangroves, grasslands, lakes, oceans
- d) Oceans, mangroves, lakes, grasslands

Explanation:

- Productivity = production/unit area/unit time.
- Production/unit area depends on the number and diversity of producers.
- Ecotones have greater productivity compared to the surrounding ecosystems. Mangroves and grasslands are ecotones. (Tropical Rainforests is an exception as it has productivity comparable to wetlands because of its rich diversity of primary producers).
- Note: Grasslands are not transitional all the time. E.g. Steppe. Non-transitional grasslands have very low productivity because of very limited diversity of primary producers. (Grasslands become transitional only when they are narrow).
- So, the order of decreasing productivity will be like
- Mangroves ,..... , ..... , .....
- Oceans = very deep and hence productivity is limited to the surface only (Below in the aphotic zone productivity is negligible. Aphotic zone in oceans is few kilometres).
- Also, surface water in oceans is very poor in nutrients. Nutrient-rich cold water flows as a sub-surface flow lying in the aphotic zone. Sunlight and nutrients are far apart, and hence primary productivity is very low except in regions where there is an upwelling of nutrient-rich cold water (Cold and Warm current mixing zones).
- So open ocean ecosystem has the least productivity. (Desert ecosystem also has very low productivity, lesser than oceans).
- So, the answer will look like Mangroves, ...., ...., Oceans.
- The only such option is c)

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

- Lakes just like oceans have low productivity. But due to some plants in the photic zone, **lakes have productivity slightly greater than that of oceans.**



## 4. Global Environmental Issues and Environmental Degradation

The important global environmental issues are:

- ✓ **Biodiversity Loss**
- ✓ **Desertification**
- ✓ **Depletion of Ozone Layer (explained in Geography > Climatology > Polar Vortex > Ozone Depletion)**
- ✓ **Acid Rain**
- ✓ **Oil Spills**
- ✓ **Dumping of Hazardous Wastes**
- ✓ **Climate change due to greenhouse effect and global warming.**
- Environmental degradation is making 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 industrialization in turn has led to overexploitation of natural resources.
- The consequences of such exploitation are evident in the form of soil erosion, desertification, loss of biodiversity, pollution of land, air and water bodies.

## 4.1 Major Causes of Environmental Degradation

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### Air pollution

- Pollution: Gaseous pollutants: Oxides of carbon, nitrogen and sulphur.
- Particulate matter: Fine metal dust, fly ash, soot, cotton dust and radioactive substances.
- Burning of plastics: Emits polychlorinated biphenyls (PCBs).
- Industrial catastrophes: Accidental release of some poisonous gases like **phosgene ( $\text{COCl}_2$ )** and **methyl isocyanate** (as it happened in Bhopal in 1985) were fatal.
- Secondary air pollutants formed from complex reactions between primary pollutants, such as **smog and acid rain**.
- **Global warming:** Increasing use of fossil fuels is a leading cause of increasing levels of  $\text{CO}_2$  and other greenhouse gases in the atmosphere.

### Water pollution

- Industrial and domestic effluents: Pathogens, heavy metals in water bodies and soil.
- Hazardous waste/Toxic substances: Use of a various type of chemicals today have serious health implications. The incidence of cancer, genetic mutations and damage to nervous, immune and hormonal systems.

### Soil degradation

- Deforestation, overgrazing, intensive cultivation, over irrigation etc. results in the loss of topsoil and fertility of the land. Prolonged degradation of land leads to desertification.

### Damage to ecology and biodiversity

- Habitat fragmentation and destruction: Industrialization and associated infrastructure development have led to the destruction of habitats of many species.
- Invasive populations: Introduction of new alien species or non-native species reduces the populations' growth of native species.
- Overexploitation and introduction of a new or genetically modified species reduce the productivity of natural ecosystems.

## 4.2 Consequences of Environmental Degradation

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- **Increased sensitivity to diseases:** Cultivated species of plants, fishes and other domesticated animals have become increasingly sensitive to pest and diseases.

- **Genetic resistance:** An increased use of insecticides, pesticides and antibiotics has speeded up **directional natural selection** and caused **genetic resistance in pathogens**.
- **Effect on nutrient recycling:** Use of fertilisers in agricultural fields interferes with the natural biogeochemical cycles.
- **Loss of biodiversity:** Habitat destruction and habitat fragmentation are threatening the survival of many endangered species.
- **Climate change/global warming:** Air pollution is making the planet inhospitable due to events like global warming, acid rain, ocean acidification etc.
- **Melting of ice caps and glaciers/Sea level change:** Global warming is posing a serious threat to Himalayan and polar ecosystems by melting snow at a faster rate. Rise in sea level in future is a serious threat to coastal landforms.
- **Change in weather patterns:** The incidence of extreme weather events and change in weather patterns have become common due to environmental degradation.
- **Depletion of water resources:** Water pollution has created a tremendous scarcity of quality water resources.
- **Desertification:** Lot of arable lands is converted to wasteland due to erosion, salinity and loss of fertility.

### 4.3 Air Pollution

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#### Pollution

- Pollution may be defined as the addition of undesirable material into the environment as a result of human activities. The agents which cause environmental pollution are called pollutants.
- A pollutant may be defined as a physical, chemical or biological substance released into the environment which is 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 and Radiation pollution.**
- In order to control environmental pollution, the Government of India has passed the **Environment (Protection) Act, 1986** (Bhopal disaster) to protect and improve the quality of our air, water and soil.
- Air pollution may be defined as the presence of any solid, liquid or gaseous substance **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**.
- An ever-increasing use of fossil fuels in power plants, industries, transportation, mining, construction of buildings, stone quarries had led to air pollution.

- Fossil fuels contain small amounts of **nitrogen** and **sulphur**.
- Burning of fossil fuels like coal (thermal power plants) and petroleum release different **oxides of nitrogen 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 Taj Mahal. This phenomenon is called as **Marble cancer**.
- Other kinds of pollutants are **chlorofluorocarbons (CFCs)** which are used in **refrigerators, 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.
- 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 a visible indication of air pollution.

## Classification of Pollutants

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According to the form in which they persist after release into the environment.

- **Primary pollutants:** These are persistent in the form in which they are added to the environment, e.g. **DDT, plastic, CO, CO<sub>2</sub>, oxides of nitrogen and sulphur, etc.**
- Secondary Pollutants: These are formed by interaction among the primary pollutants. For example, **peroxy-acetyl nitrate (PAN)** is formed by the interaction of **nitrogen oxides** and **hydrocarbons**.

According to their existence in nature

- **Quantitative Pollutants:** These occur in nature and become pollutant when their concentration reaches beyond a threshold level. E.g. carbon dioxide, nitrogen oxide.
- **Qualitative Pollutants:** These do not occur in nature and are human-made. E.g. fungicides, herbicides, DDT etc.

## Particulate pollutants

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- Particulate pollutants are matter suspended in air such as dust and soot.
- Major source of SPM (suspended particulate matter) are industries, vehicles, power plants, construction activities, oil refinery, railway yard, market place, industries, etc.
- Their size ranges from **0.001 to 500 micrometres** ( $\mu\text{m}$ ) in diameter.
  - ✓ Particles less than 10  $\mu\text{m}$  float and move freely with the air current.

- ✓ Particles which are more than 10  $\mu\text{m}$  in diameter settle down.
- ✓ Particles less than 0.02  $\mu\text{m}$  form **persistent aerosols**.
- According to the Central Pollution Control Board (CPCB), particulate size **2.5  $\mu\text{m}$  or less in diameter (PM 2.5)** are responsible for causing the **greatest harm to human health**.
- These fine particulates can be inhaled deep into the lungs and can cause breathing and respiratory symptoms, irritation, inflammations and **pneumoconiosis** (disease of the lungs caused due to inhalation of dust. It is characterised by inflammation, coughing, and fibrosis – excess deposition of fibrous tissue).

## Fly ash

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

## Composition

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- Fly ash particles are **oxide rich and consist of silica, alumina, oxides of iron, calcium, and magnesium and toxic heavy metals like lead, arsenic, cobalt, and copper**.
- Major oxides are present are **aluminium silicate** (in large amounts), **silicon dioxide** ( $\text{SiO}_2$ ) and **calcium oxide** ( $\text{CaO}$ ).

## Uses

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- Cement can be replaced by fly ash up to 35%, thus reducing the cost of construction, making roads, etc.
- Fly ash bricks are light in weight and offer high strength and durability.
- Fly ash is a better fill material for road embankments and in concrete roads.
- Fly ash 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. But if it gets deposited on the leaf, it will reduce photosynthesis.
- It also enhances the water holding capacity of the land.

## Policy measures of MoEF

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- The Ministry of Environment and Forests has made it **mandatory to use Fly Ash-based products** in all construction projects, road embankment works, and low lying landfilling works within 100 km radius of Thermal Power Station and mine filling activities within 50 km radius of Thermal Power Station.

**Q. With reference to 'fly ash' produced by the power plants using the 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 does not contain any 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
- Fly ash does contain heavy toxic elements like arsenic, cobalt, lead etc.

Answer: a) 1 and 2

## **Lead**

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

## **Metallic Oxides**

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- Oxides of iron, aluminium, manganese, magnesium, zinc and other metals have an adverse effect due to deposition of dust on plants during mining operations and metallurgical processes.
- They create physiological, biochemical and developmental disorders in plants and also contribute towards reproductive failure in plants.

## **Nanoparticles (NPs)**

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- Nanoparticles are particles with dimensions comparable to 1/10<sup>9</sup> of a meter (1 divided by 100 crores).

- Major natural processes that release NPs in the atmosphere are **forest fires, volcanic eruptions, weathering, dust storms from desert** etc.
- Naturally occurring NPs are quite heterogeneous in size and can be transported over thousands of kilometres and remain suspended in the air for several days.
- Nanotechnology has a global socioeconomic value, with applications ranging from electronics to biomedical uses (delivering drugs to target sites).
- Man-made NPs are unknowingly or purposely released in the environment during various industrial and mechanical processes.

### **Effects of Nanoparticles on the environment**

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- After releasing in the environment, NPs will accumulate in various environmental matrices such as air, water, soil and sediments including wastewater sludge.
- NPs in the environment influences **dust cloud formation, environmental hydroxyl radical concentration, ozone depletion, or stratospheric temperature change**.

#### **Effect of NPs on dust cloud formation**

- NPs in environment coagulate and form dust cloud.
- Dust cloud formation decreases sunlight intensity.

#### **Asian brown clouds impact on Himalayan glaciers**

- Asian brown clouds carry large amounts of soot and **black carbon (NPs)** and deposit them on the Himalayan glaciers.
- This could lead to higher absorption of the sun's heat (**reduced albedo**) and potentially contributing to the increased melting of glaciers.

#### **NPs and ozone depletion**

- NPs can result in increased production of **reactive oxygen species (ROS), including free radicals like Cl<sup>-</sup>**.
- Radicals like Cl<sup>-</sup> destroy ozone. (Explained in Geography > Climatology > Polar Vortex > Ozone Depletion)

*In chemistry, a radical (a free radical) is an atom, molecule, or ion that has unpaired valence electrons.*

#### **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 the **abundance of water vapour in the stratosphere**.
- This will cause stratospheric cooling due to the formation of **Stratospheric clouds** (mostly ice crystals).
- Stratospheric clouds destroy ozone. (Geography > Climatology > Polar Vortex > Ozone Depletion)

**Q. 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

## **Major Gaseous Air Pollutants, Their Sources & Effects**

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### **Carbon monoxide (CO)**

- Carbon monoxide (CO) is a colourless, odourless, tasteless and highly toxic gas that is **slightly less dense than air**. It is **short-lived** (stay only a few months) in the atmosphere.
- Carbon monoxide is produced from the exhaust of **internal combustion engines** and **incomplete combustion** of various other fuels. **Iron smelting** also produces carbon monoxide as a by-product.
- It forms when there is not enough oxygen to produce carbon dioxide ( $\text{CO}_2$ ).
- 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.

### **Health Effects**

- Carbon monoxide poisoning is the most common type of fatal air poisoning (poor ventilation and heat management in laptops and other electronics can cause the release of CO).
- It is toxic to **haemoglobin animals (including humans)** when encountered in concentrations above about 35 ppm.
- **It combines with haemoglobin to produce carboxyhaemoglobin, which usurps the space in haemoglobin that normally carries oxygen.**

## Environmental Effects

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- 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 the formation **of ground-level ozone (tropospheric ozone)** and **can elevate concentrations of methane (a strong GHG).**

- ✓ **Carbon monoxide reacts with hydroxyl radical (-OH) to produce peroxy radical.**
- ✓ **Peroxy radical reacts with nitrogen oxide (NO) to form nitrogen dioxide (NO<sub>2</sub>) and hydroxyl radical.**
- ✓ **NO<sub>2</sub> gives O<sub>3</sub> via photolysis (separation of molecules by the action of light).**

## Carbon dioxide (CO<sub>2</sub>)

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- 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.
- Because carbon dioxide is **soluble in water**, it occurs naturally in groundwater, rivers and lakes, in ice caps and glaciers and also in seawater.

## Effects on Health

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- CO<sub>2</sub> 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 in the presence of sufficient oxygen, manifesting as dizziness, headache, and unconsciousness.

## Effects on Environment

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- Carbon dioxide is an important **greenhouse gas**.
- 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**.

## **Chlorofluorocarbons (CFCs)**

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- Chlorofluorocarbons (CFCs) are used in **refrigerators, air conditioners and aerosol sprays**.
- Since the late 1970s, the use of CFCs has been heavily regulated because of their destructive effects on the **ozone layer**. (Explained in Geography > Climatology > Polar Vortex > Ozone Depletion)
- 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 substances including CFCs which are responsible for ozone depletion.

## **Ozone ( $O_3$ )**

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- It occurs naturally in the stratosphere and absorbs harmful ultraviolet rays of the sun.
- However, at the ground level, it is a pollutant (**Greenhouse gas**) with highly toxic effects.
- Vehicles and industries are the major sources of ground-level ozone emissions.
- **Carbon monoxide, Nitrogen dioxide** play a major role in converting  $O_2$  to  $O_3$ .
- Ozone makes our eyes itchy, and watery. It lowers our resistance to cold and pneumonia.

## **Nitrogen oxide ( $NO_x$ )**

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- $NO_x$  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**.

*Oxygen and nitrogen do not react at ambient temperatures. But at high temperatures, they produce various oxides of nitrogen. Such temperatures arise inside an internal combustion engine or a power station boiler.*

- **Agricultural fertilisation** and the **use of nitrogen-fixing plants** also contribute to atmospheric  $NO_x$ , by promoting nitrogen fixation by microorganisms.
- **NO and  $NO_2$  (contribute to global cooling)** should not be confused with **nitrous oxide ( $N_2O$  – GHG)**, which is a **greenhouse gas** and has many uses as an **oxidiser**.

## **Effects on Health and Environment**

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- They are believed to aggravate **asthmatic conditions** and create many respiratory health issues.

- The reduction of NO<sub>x</sub> emissions is one of the most important technical challenges facing **biodiesel**.
- NO<sub>x</sub> gases react to form **smog** and **acid rain** as well as being central to the formation of **tropospheric ozone**. (Explained in Geography > Climatology > Forms of Condensation > Smog)
- When **NO<sub>x</sub> and volatile organic compounds (VOCs)** react in the presence of sunlight, they form **photochemical smog**.
- Mono-nitrogen oxides eventually form nitric acid when dissolved in atmospheric moisture, forming a component of acid rain.
- **NO and NO<sub>2</sub> emissions** cause **global cooling** through the formation of -OH radicals that **destroy methane molecules**, countering the effect of greenhouse gases.

## Sulphur dioxide (SO<sub>2</sub>)

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- It is a toxic gas with a pungent, irritating smell. It contributes to **acid rain**.
- It is released naturally by **volcanic activity**. It is abundantly available in the atmosphere of **Venus**.
- Sulphur dioxide is primarily produced for sulfuric acid manufacture.
- Inhaling sulphur dioxide is associated with increased respiratory symptoms and premature death.
- It also weakens the functioning of certain nerves.
- It is also produced by
  - ✓ **burning coal in thermal power plants** and **diesel fuels**.
  - ✓ some industrial processes, such as the production of paper and smelting of metals.
  - ✓ reactions involving **Hydrogen Sulphide (H<sub>2</sub>S) and oxygen**.
  - ✓ The **roasting of sulphide ores such as pyrite, sphalerite, and cinnabar (mercury sulphide)**.

## Volatile organic compounds (VOCs)

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- Volatile Organic Compounds (VOCs) are a large group of **carbon-based** chemicals that easily **evaporate** at room temperature.
- For example, **formaldehyde**, which evaporates from paint, has a boiling point of only –19 °C.
- Formaldehyde causes irritation to the eyes and nose and allergies.
- The main indoor sources are **perfumes, hair sprays, furniture polish, glues, air fresheners, moth repellents, wood preservatives**, and other products.
- Health effects: irritation of the eye, nose and throat, headaches, nausea and loss of coordination.
- Long term health effects: suspected to damage the liver and other parts of the body.

## Benzene

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- Benzene is a natural constituent of **crude oil** and is one of the elementary petrochemicals.
- Because benzene has a **high octane number**, it is an important component of **gasoline (petrol)**.
- Benzene increases the **risk of cancer** and other illnesses.
- Benzene is a notorious cause of **bone marrow failure**.

## Ethylene

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- Ethylene is widely used in the chemical industry.
- Much of this production goes toward **polyethylene**, a widely used plastic containing polymer chains of ethylene units in various chain lengths.
- Ethylene 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 cause adverse health effects like headache, drowsiness, dizziness and unconsciousness.
- Ethylene is not but **ethylene oxide is a carcinogen (cancer-causing agent)**.

## Biological pollutants

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

## Asbestos

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- Asbestos refers to a set of six naturally occurring silicate **fibrous minerals** — chrysotile, crocidolite, amosite, anthophyllite, tremolite, and actinolite.
- It is now known that prolonged inhalation of asbestos fibres can cause serious and fatal illnesses including **lung cancer, mesothelioma, and asbestosis** (a type of pneumoconiosis).

## Radon

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- 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.

## Occupational Health Hazards

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### Black lung disease

- In coal mining areas coal dust is the main air pollutant. The deposits of coal dust make miners lungs look black instead of a healthy pink and hence the name black lung disease.
- Black lung disease is the common name for **pneumoconiosis (CWP) or anthracosis**, a lung disease of older workers in the coal industry, caused by inhalation over many years, of small amounts of coal dust.
- The particles of fine coal dust accumulate in the lungs. Eventually, this build-up causes thickening and scarring making the lungs less efficient in supplying oxygen to the blood.

## **Chemicals and Biological Agents**

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- Substances such as **benzene, chromium, nitrosamines** and **asbestos** may cause cancers of lung, bladder, skin, mesothelium, liver, etc.
- Occupational asthma is caused due to exposure to organic dust, microorganisms, bacteria, fungi and moulds and several chemicals.
- **Silicosis** first reported from Kolar gold mines in 1947 is a common disease among miners, pottery and ceramic industry workers.
- **Pneumoconiosis** and **byssinosis** are common among mica and textile industry workers respectively.

## **Prevention and Control of Air Pollution**

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### **Indoor Air Pollution**

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- Paints, carpets, furniture, etc. in rooms may give out volatile organic compounds (VOCs).
- Use of disinfectants, fumigants, etc. may release hazardous gases.
- In hospitals, pathogens present in waste remain in the air in the form of spores.
- In congested areas, slums and rural areas burning of firewood and biomass results in lot of smoke.
- Children and ladies exposed to smoke may suffer from acute respiratory problems.

### **Prevention and control of indoor air pollution**

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- Use of wood and dung cakes should be replaced by cleaner fuels such as biogas, LPG or electricity. The use of solar cookers must be encouraged.
- Those species of trees such as baval (Acacia nilotica) which are least smoky should be used.
- Charcoal is a comparatively cleaner fuel.
- Indoor pollution due to the decay of exposed kitchen waste can be reduced by covering the waste properly.
- Segregation of waste, pre-treatment at the source, sterilisation of rooms will help.

## Control of Industrial Pollution

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- Industrial pollution can be greatly reduced by:
  - ✓ use of cleaner fuels such as liquefied natural gas (LNG) in power plants, fertiliser plants etc. which is cheaper in addition to being environmentally friendly.
  - ✓ employing environment-friendly industrial processes so that emission of pollutants and hazardous waste is minimized.
  - ✓ installing devices which reduce the release of pollutants.
- Devices like filters, **electrostatic precipitators, inertial collectors, scrubbers, gravel bed filters or dry scrubbers** are described below:

### Filters

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- Filters remove particulate matter from the gas stream.
- Baghouse filtration system is the most common one and is made of cotton or synthetic fibres (for low temperatures) or glass cloth fabrics (for higher temperature up to 290<sup>0</sup>C).

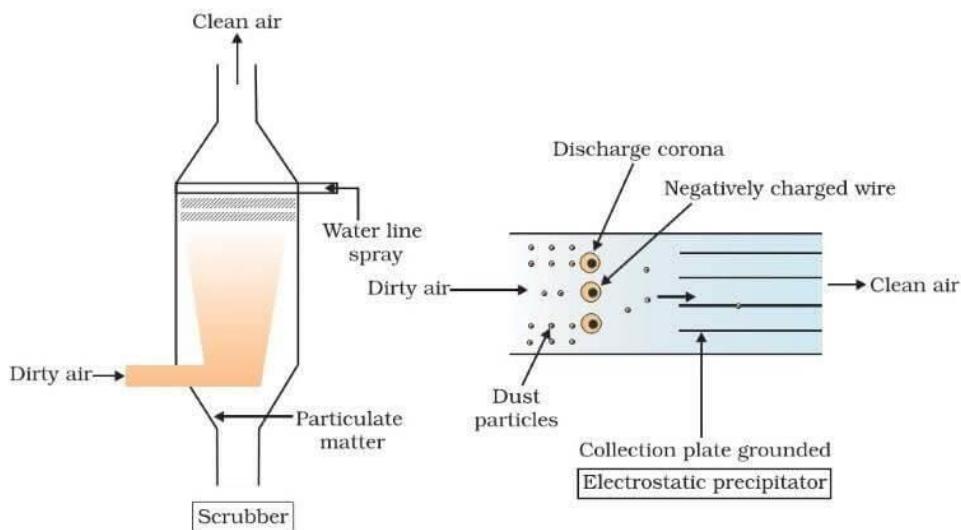
### Electrostatic precipitators (ESP)

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- Electrostatic precipitation can remove over 99 per cent particulate matter present in the exhaust.
- The **emanating dust is charged with ions**, and the **ionised particulate matter is collected on 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 velocity of air 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 by rapping the surface.
- ESPs are used in boilers, furnaces, and many other units of **thermal power plants, cement factories, steel plants**, etc.



## Inertial collectors

- It works on the principle that inertia of SPM (suspended particulate matter) in gas is higher than its **solvent** and as inertia is a function of the mass of the particulate matter, this 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 followed by their removal or else the particles are wetted by a scrubbing liquid.
- The particles get trapped as they travel from supporting gaseous medium across the interface to the liquid scrubbing medium. (this is just like mucus in trachea trapping dust)
- A scrubber can remove gases like **sulphur dioxide**.

## Catalytic converter

- Catalytic converters, having expensive metals namely **platinum-palladium** and **rhodium** as the catalysts, are fitted into automobiles for reducing the emission of poisonous gases.
- 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.
- Motor vehicles equipped with catalytic converter should use **unleaded petrol** because the lead in the petrol inactivates the catalyst.

Apart from the use of the above mentioned devices, other control measures are:

- increasing the height of chimneys.
- closing industries which pollute the environment.
- shifting of polluting industries away from cities and heavily populated areas.
- development and maintenance of a green belt of adequate width.

## Steps Taken to Control Vehicular Pollution

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- The emission standards for automobiles have been set which if followed will reduce the pollution.
- Standards have been set for the durability of catalytic converters which reduce vehicular emission.
- 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 price of diesel is much lower than petrol which promotes the use of diesel. To reduce the emission of **sulphur dioxide, sulphur content in diesel has been reduced to 0.05%**.
- Earlier lead in the form of **tetraethyl lead** was added in the petrol to **raise octane level** for the **smooth running** of engines. 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 were converted to run on CNG by the end of 2002.

- CNG burns most efficiently, unlike petrol or diesel, in the automobiles and very little of it is left unburnt.
- Moreover, **CNG is cheaper than petrol or diesel**, cannot be siphoned off by thieves **and 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.

- Simultaneously parallel steps taken in Delhi for reducing vehicular pollution include phasing out of old vehicles, **use of unleaded petrol, use of low-sulphur petrol and diesel**, use of catalytic converters in vehicles, application of stringent pollution-level norms for vehicles, etc.
- The Government of India through a new auto fuel policy has laid out a roadmap to cut down vehicular pollution in Indian cities.
- More stringent norms for fuels means **steadily reducing the sulphur and aromatics content** in petrol and diesel fuels.
- The goal, according to the roadmap, is to **reduce sulphur to 50 ppm in petrol and diesel and bring down the level of aromatic hydrocarbons to 35 per cent**.

## BS VI from 2020

- From April **2017**, BS IV norms are applicable nationwide.
- October 2018: Supreme Court 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 manufacturers.

### Bharat Stage (BS) norms

- The BS norms are instituted by the government to regulate the emission of air pollutants from motor vehicles.
- The norms were introduced in 2000.
- 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**.
- The norms are meant to be adopted by using appropriate fuel and technology.
- As the stage goes up, the control of emissions become stricter.
- 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 (Intended Nationally Determined Contributions)

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

### Differences between BS IV and BS VI

- The **extent of sulphur** is the major difference between Bharat Stage IV and Bharat Stage VI norms.
- **BS-IV fuels contain 50 parts per million (ppm) sulphur**; the **BS-VI grade fuel only has 10 ppm sulphur**.
- BS VI can bring
  - ✓ **PM in diesel cars down by 80 per cent.**
  - ✓ **nitrogen oxides from diesel cars by 70 per cent and in petrol cars by 25 per cent.**
- BS VI also makes **onboard diagnostics (OBD) 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 that 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**

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- Compliance requires a higher investment in technology to make new vehicles.
- Upgrading vehicles in stock is an additional burden for the manufacturers.
- BS VI-compliant vehicles will be expensive.
- BS VI-compliant fuel too will be more expensive.

## **National Air Quality Monitoring Programme**

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- Central Pollution Control Board (CPCB) has been executing a nationwide programme of ambient air quality monitoring known as **National Air Quality Monitoring Programme (NAMP)**.

The National Air Quality Monitoring Programme (NAMP) is undertaken

- to determine the status and trends of ambient air quality;
- to ascertain the compliance of NAAQS;
- to identify non-attainment cities;
- to understand the natural process of cleaning in the atmosphere; and
- to undertake preventive and corrective measures.

## **National Ambient Air Quality Standards (NAAQS)**

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The NAAQS have been revisited and revised in November 2009 for 12 pollutants, which include

- **sulphur dioxide (SO<sub>2</sub>)**,
- **nitrogen dioxide (NO<sub>2</sub>)**,
- **particulate matter having micron (PM10)**,
- **particulate matter having a size less than 2.5 microns (PM2.5)**,
- **ozone**,
- **lead**,
- **carbon monoxide (CO)**,
- **arsenic**,
- **nickel**,
- **benzene**,

- **ammonia, and**
- **benzopyrene.**

## National Air Quality Index (AQI)

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- Launched by the Environment Ministry in April 2015.
- Initiative under '**Swachh Bharat**'.

### AQI

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- It helps the common man to judge the air quality within his vicinity.
- Index constituted as a part of the Government's mission to improve the culture of cleanliness.

### Old vs new

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- While the earlier measuring index was limited to three indicators, the current measurement index had been made quite comprehensive by the addition of more parameters.

### Previously who measured Air pollution

- Central Pollution Control Board along with State Pollution Control Boards have been operating the **National Air Monitoring Program (NAMP)**.

### Why is AQI necessary?

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- Quality of data from some cities remains weak, and the standards set for pollutants fall short of World Health Organization recommendations.
- The pollution related analysis using a vast number of complex parameters was complicated for the common man to understand.

### Categories of air pollution under AQI

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- There are six AQI categories, namely Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe.

### Pollutants considered

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- The AQI will consider eight pollutants (**PM10, PM2.5, NO<sub>2</sub>, SO<sub>2</sub>, CO, O<sub>3</sub>, NH<sub>3</sub>, and Pb**).

**Q. In the cities of our country, 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

### Alternatives

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- Government is disincentivising use of private vehicles through **congestion charging**.
- The National Green Tribunal has ordered that diesel vehicles over 10 years old not ply on Delhi roads.

***Smog is already explained in detail in Geography > Climatology > Forms of Condensation > Smog***

***Ozone Depletion is already explained in detail in Geography > Climatology > Polar Vortex > Ozone Depletion.***

### Effects of Air Pollution: Acid Rain – Acidification

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- Acid rain refers to any precipitation (rain, fog, mist, snow) that is more acidic than normal (**pH of less than 5.6**. pH below 7 is acidic).
- Acid rain is caused by atmospheric pollution from acidic gases such as **sulphur dioxide** and **oxides of nitrogen** emitted from the burning of fossil fuels.
- It is also recognized that acidic smog, fog, mist, move out of the atmosphere and settle on dust particles which in turn accumulate on vegetation as acid depositions.
- When rain falls, the acid from these depositions leak and form acid dews.

### The pH scales

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- The pH scale is a measure of 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.
- It is based on **hydrogen ion concentration** in an aqueous solution.
- pH values decrease as hydrogen ion levels increase.
- A solution with pH 4 is ten times more acidic than pH 5, and a hundred times more acidic than pH 6.
- Whilst the pH range is usually given as 0 to 14, lower and higher values are theoretically possible.

## Gases that cause acid rain

Acidic gases	Source
<b>SO<sub>x</sub> (Sulphur oxides)</b>	<ul style="list-style-type: none"><li>• Fossil fuel burning, 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.</li></ul>
<b>NO<sub>x</sub> (Nitrogen oxides – NO, NO<sub>2</sub> and N<sub>2</sub>O)</b>	<ul style="list-style-type: none"><li>• Fossil fuel burning, lightning, biomass burning, forest fires, oceans, power plants.</li><li>• (NO and N<sub>2</sub>O are mentioned in NIOS Environment)</li></ul>

### Q. 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<sub>2</sub> react with rainwater to form **weak carbonic acid**. Hence, rainwater is **naturally slightly acidic**. But this is not enough to call it acid rain (acid rain must have **pH of less than 5.6**).
- Even increased concentration of CO and CO<sub>2</sub> 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<sub>2</sub>O (nitrous oxide).

More details:

- **N<sub>2</sub>O and NO are neutral in nature.**
- [N<sub>2</sub>O<sub>3</sub>, NO<sub>2</sub> and N<sub>2</sub>O<sub>5</sub> are acidic in nature.](#)
- These **acidic oxides react with water** and produce acids like **HNO<sub>3</sub> (nitric acid)** and **HNO<sub>2</sub> (nitrous acid)** which causes acid rain.

- The neutral oxides are comparatively less, and they combine with oxygen and produce nitrogen dioxide.
- Thus, **N<sub>2</sub>O and NO** are indirectly involved ( $2\text{NO} + \text{O}_2 \rightarrow 2\text{NO}_2$ ) in causing acid rain.

**Answer: d) nitrous oxide (laughing gas) and sulphur dioxide**

## Types of Acid Deposition

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- "Acid rain" is a broad term referring to a mixture of wet and dry deposition (a form of deposition material) from the atmosphere.

### Wet Deposition

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

### Dry Deposition

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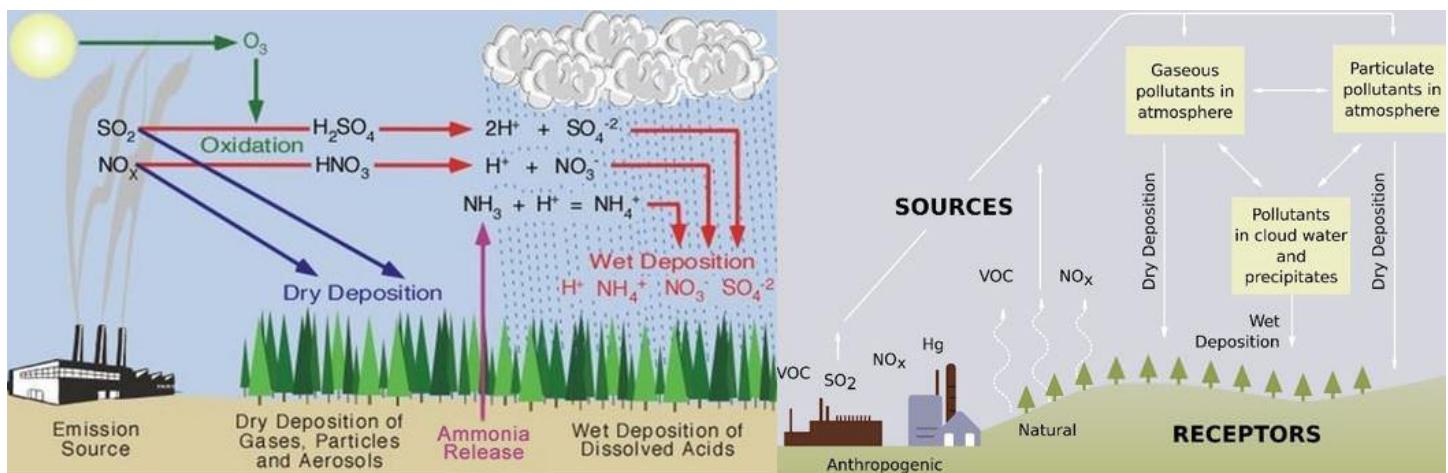
- In areas where the weather is dry, the acid chemicals may become incorporated into dust or smoke and fall to the ground through dry deposition, **sticking to the ground, buildings, vegetation, cars, etc.**
- Dry deposited gases and particles can be washed from these surfaces by rainstorms, through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

## Chemistry of Acid Rain

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

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



## Harmful effects of acid rain

- Acid precipitation affects both aquatic and terrestrial organisms.
- It also damages buildings and monuments.

### Effects on humans

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

### Effects on soil

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

### Effects on aquatic life

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

### Effect on terrestrial life

- Acid rain damage **cuticle** of plant leaves and reduces photosynthesis.
- Acidic medium promotes **leaching** of heavy metals like **aluminium, lead** and **mercury**. Such metals when percolate into ground water affect soil micro flora/fauna.
- Other indirect effects of acid rain on wildlife are loss or alteration of food and habitat resources.

### **Effects on microorganisms**

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

### **Effect on buildings, monuments and materials**

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

### **Acid Rain Areas**

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- They are concentrated in the industrialised belt of the northern hemisphere.
- Scandinavia, Canada, the Northeast United States and North-western Europe.

### **In India**

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- In India, the first report of acid rain came from Bombay in 1974.
- Instances of acid rain are being reported from metropolitan cities.
- Lowering of soil pH is reported from north-eastern India, coastal Karnataka and Kerala, parts of Orissa, West Bengal and Bihar.

### **Acid Rain Control**

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- Use of low sulphur fuel or natural gas or washed coal (chemical washing of pulverised coal) in thermal plants can reduce incidences of acid rain.

- Buffering: the practice of adding a neutralising agent to the acidified water to increase the pH. Usually, lime in the form of **calcium oxide and calcium carbonate** is used.

## Ocean Acidification

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- Ocean acidification has been called the "**evil twin of global warming**" and "**the other CO<sub>2</sub> problem**".
- Ocean acidification is the ongoing decrease in the pH of the Earth's oceans, caused by the uptake of **carbon dioxide (CO<sub>2</sub>)** from the atmosphere.
- An estimated 30–40% of the carbon dioxide from human activity released into the atmosphere dissolves into oceans, rivers and lakes.
- To achieve chemical equilibrium, some of it reacts with the water to form **carbonic acid**.
- Some of these extra carbonic acid molecules react with a water molecule to give a **bicarbonate ion** and a **hydronium ion**, thus **increasing ocean acidity (H<sup>+</sup> ion concentration)**.
- Checking CO and CO<sub>2</sub> emissions and controlling pollution are the only means to reduce ocean acidification.

## Other contributors

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- Eutrophication leads to large plankton blooms, and when these blooms collapse and sink to the sea bed the subsequent respiration of bacteria decomposing the algae leads to a decrease in seawater oxygen and an increase in CO<sub>2</sub> (a decline in pH).

## Effects of Ocean Acidification

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- **Oceans are an important reservoir for CO<sub>2</sub>**, absorbing a significant quantity of it (one-third) produced by anthropogenic activities and effectively buffering climate change.
- The uptake of atmospheric carbon dioxide is occurring at a rate exceeding the natural buffering capacity of the oceans.
- Increasing acidity depresses metabolic rates and immune responses in some organisms.
- Seawater absorbs CO<sub>2</sub> to produce carbonic acid, bicarbonate and carbonate ions.
- However, the increase in atmospheric CO<sub>2</sub> levels lead to a decrease in pH level, an increase in the concentration of carbonic acid and bicarbonate ions, causing a decrease in the concentration of carbonate ions.
- The decrease in the amount of carbonate ions available makes it **more difficult for marine calcifying organisms, such as coral** (calcareous corals) and some plankton (calcareous plankton), to form biogenic calcium carbonate.

- Commercial fisheries are threatened because acidification harms calcifying organisms which form the base of the Arctic food webs.
- Increasing acidity accentuates coral bleaching as corals are very sensitive to changes in water composition.

## Impact of Ocean Acidification on Cloud Formation

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

### Artificial Cloud seeding

- Cloud seeding is the process of spreading either dry ice or more commonly, **silver iodide aerosols**, into the upper part of clouds to try to stimulate the precipitation process and form rain.
- 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

## Q. 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 statements 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:

We have already learnt that ocean acidification decreases the calcifying ability of corals, calcareous plankton, crustaceans etc. It also adversely affects cloud formation and cloud seeding. So, Options 1, 2 and 4 are correct.  
Answer: d) 1, 2, 3 and 4

## 4.4 Water Pollution

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

### Point and non-point sources of pollution

- When pollutants are discharged from a specific location such as a drain pipe carrying industrial effluents discharged directly into a water body it represents point source pollution.
- In contrast, non-point sources include discharge of pollutants from diffused sources or from a larger area such as runoff from agricultural fields, grazing lands, construction sites, abandoned mines and pits, etc.

## Causes of Water Pollution

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### Sewage Water

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

### Dissolved Oxygen (DO)

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- Presence of organic and inorganic wastes in water decreases the dissolved oxygen content of the water.
- Water having DO content below 8.0 mg/L may be considered as contaminated.
- Water having DO content below 4.0 mg/L is considered to be highly polluted.
- DO content of water is important for the survival of aquatic organisms.
- A number of factors like surface turbulence, photosynthetic activity, O<sub>2</sub> consumption by organisms and decomposition of organic matter are the factors which determine the amount of DO present in water.
- The **higher amounts of waste increase the rates of decomposition and O<sub>2</sub> consumption** thereby **decreases the DO content of water**.

## **Biological Oxygen Demand (BOD)**

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- Water pollution by organic wastes is measured in terms of Biochemical Oxygen Demand (BOD).
- BOD is the **amount of dissolved oxygen needed by bacteria in decomposing the organic wastes** present in water. It is expressed in milligrams of oxygen per litre of water.
- The **higher value of BOD indicates low DO content of water.**
- Since BOD is **limited to biodegradable materials**, it is not a reliable method of measuring water pollution.

### **Q. Biological Oxygen Demand (BOD) is a standard criterion for (2017)**

- a) Measuring oxygen levels in blood
- b) Computing oxygen levels in forest ecosystems
- c) Pollution assay in aquatic ecosystems
- d) Assessing oxygen levels in high altitude regions

## **Chemical oxygen demand (COD)**

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- Chemical oxygen demand (COD) is a slightly better mode used to measure pollution load in the water.
- COD measures the **amount of oxygen in parts per million required to oxidise organic (biodegradable and non-biodegradable) and oxidizable inorganic compounds** in the water sample.

## **Industrial Wastes**

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- 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<sup>3</sup>)** such as **mercury, cadmium, copper, lead, arsenic** and a variety of organic compounds.

## **Agricultural sources**

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

- Wastes from poultry farms, piggeries and slaughterhouses etc. reach the water through runoff.

## **Thermal and Radiation Pollution**

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- Power plants – thermal and nuclear, chemical and other industries use a lot of water for cooling purposes, and the used hot water is discharged into rivers, streams or oceans.
- Discharge of hot water may increase the temperature of the receiving water by 10 to 15 °C above the ambient water temperature. This is **thermal pollution**.
- Increase in water temperature **decreases dissolved oxygen** in the water.
- Unlike terrestrial organisms, aquatic organisms are adapted to a uniform steady temperature of the environment. A sudden rise in temperature kills fishes and other aquatic animals.
- One of the best methods of reducing thermal pollution is to store the hot water in cooling ponds, allow the water to cool before releasing into any receiving water body
- Nuclear accidents near water bodies or during natural calamities like tsunami and earthquakes pose the risk of radiation leakage (radiation exposure) into water bodies. E.g. **Fukushima Daiichi nuclear disaster**.
- Radiation exposure causes mutations in the DNA of marine organisms. If those mutations are not repaired, the cell may turn cancerous.
- **Radioactive iodine** tends to be absorbed by the thyroid gland and can cause thyroid cancer.

## **Marine pollution**

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- Oceans are the ultimate sink of all natural and manmade pollutants.
- The sewerage and garbage of coastal cities are also dumped into the sea.
- The other sources of oceanic pollution are navigational discharge of oil, grease, detergents, sewage, garbage and radioactive wastes, offshore oil mining, oil spills.

## **Oil Spills**

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- The most common cause of oil spill is leakage during marine transport and leakage from underground storage tanks.
- An oil spill could occur during offshore oil production as well.

## **Impact of oil spill on marine life**

- Oil being **lighter** than water covers the water surface as a thin film **cutting off oxygen** to floating plants and other producers.

- Within hours of an oil spill, the fishes, shellfish, plankton die due to suffocation and metabolic disorders.
- Birds and sea mammals that consume dead fishes and plankton die due to poisoning.

## Invasive species

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- Plants of **water hyacinth** are the world's most problematic aquatic weed, also called '**Terror of Bengal**'.



- They grow abundantly in **eutrophic water bodies** and lead to an imbalance in the ecosystem.
- They cause havoc by their excessive growth leading to stagnation of polluted water.

## Underground water pollution

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- In India at many places, the groundwater is threatened with contamination due to seepage from industrial and municipal wastes and effluents, sewage channels and agricultural runoff.
- Pollutants like **fluorides, uranium, heavy metals and nutrients like nitrates and phosphates** are common in many parts of India.

## Nitrates

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- Dissolved nitrates commonly contaminate groundwater.
- 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**.

**Methaemoglobin is a form of the oxygen-carrying metalloprotein haemoglobin. Methaemoglobin cannot bind oxygen, unlike oxyhaemoglobin.**

- High level of nitrates may form carcinogens and can accelerate eutrophication in surface waters.

## Trace metals

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- Include **lead, mercury, cadmium, copper, chromium** and **.**

- These metals can be toxic and carcinogenic.

## Arsenic

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- Seepage of industrial and mine discharges, fly ash ponds of thermal power plants can lead to arsenic in groundwater.
- In India and Bangladesh (Ganges Delta), millions of people are exposed to groundwater contaminated with high levels of arsenic, a highly toxic and dangerous pollutant.
- Chronic exposure to arsenic causes **black foot disease**. It also causes diarrhoea and also lung and skin cancer.

## Fluoride

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- Excess fluoride in drinking water causes **neuromuscular disorders, gastrointestinal problems, teeth deformity, hardening of bones and stiff and painful joints (skeletal fluorosis)**.
- Pain in bones and joint and outward bending of legs from the knees is called **Knock-Knee syndrome**.
- Fluorosis is a common problem in several states of the country due to the intake of high fluoride content water.

**Q. 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 easiest option is 3) Fluoride. So, (b) can be eliminated.
- The next easiest option is Arsenic (Heavy metal). Damn!

- Next easiest option is Uranium. Many columns are written on uranium mining and its ill-effects. So, (a) also can be elevated. (a) and (b) eliminated. (c) and (d) remains.
- The knowledge of either "Sorbitol" or "Formaldehyde" will tell us the answer.
- Formaldehyde is more known than sorbitol. Googling didn't give me any authentic source that called formaldehyde a water pollutant. It is used as a preservative to preserve human organs. It finds some application in textile, resins and wood industry.
- Sorbitol (glucitol) is a sugar alcohol with a sweet taste which the human body metabolises slowly.

Answer: c) 1, 3 and 5 only

## Effects of Water Pollution

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### Effects of Water Pollution on Human Health

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- Domestic and hospital sewage contain many undesirable pathogenic microorganisms, and its disposal into water without proper treatment may cause an outbreak of serious diseases, such as typhoid, cholera, etc.
- Metals like **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 extremely toxic **methyl mercury**, which can cause numbness of limbs, lips and tongue, deafness, blurring of vision and mental derangement.
- Pollution of water bodies by **mercury causes Minamata** (neurological syndrome) disease in humans.
- Lead causes **lead poisoning** (Lead interferes with a variety of body processes and is toxic to many organs and tissues).
- The compounds of lead cause anaemia, headache, loss of muscle power and bluish line around the gum.
- Water contaminated with **cadmium** can cause **itai itai** disease also called **ouch-ouch disease** (a painful disease of bones and joints) and cancer of lungs and liver.

### Effects of Water Pollution on the Environment

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- Micro-organisms involved in biodegradation of organic matter in sewage waste consume a lot of oxygen and make water oxygen deficient killing fish and other aquatic creatures.
- Presence of large amounts of nutrients in water results in **algal bloom** (excessive growth of planktonic algae). This leads to **ageing of lakes**.

- A few toxic substances, often present in industrial wastewaters, can undergo biological magnification (Bio-magnification) in the aquatic food chain. This phenomenon is well-known for mercury and DDT.
- High concentrations of DDT disturb calcium metabolism in birds, which causes thinning of eggshell and their premature breaking, eventually causing a decline in bird populations.

## Effects of Water Pollution on Aquatic Ecosystem

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

## Water Pollution Control Measures

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- Realising the importance of maintaining the cleanliness of the water bodies, the Government of India has passed the **Water (Prevention and Control of Pollution) Act, 1974** to safeguard our water resources.
- An ambitious plan to save the river called the **Ganga Action Plan** was launched in 1985.
- In India, the **Central Pollution Control Board (CPCB)**, an apex body in the field of water quality management, has developed a concept of "designated best use".
- Accordingly, the water body is designated as A, B, C, D, E on the basis of
  - ✓ **pH**,
  - ✓ **dissolved oxygen, mg/l**
  - ✓ **BOD, (200C) mg/l**
  - ✓ **total coliform (MPN/100ml)**
  - ✓ **free ammonia mg/l,**
  - ✓ **electrical conductivity etc.**
- The CPCB, in collaboration with the concerned State Pollution Control Boards, has classified all the water bodies including coastal waters in the country according to their "designated best uses".
- This classification helps the water quality managers and planners to set water quality targets and identify needs and priority for water quality restoration programmes for various water bodies in the country.

- The famous **Ganga Action Plan** and subsequently the **National River Action Plan** are results of such exercise.
- **Riparian buffers:** A riparian buffer is a vegetated area (a "buffer strip") near a stream, usually forested, which helps shade and partially protect a stream from the impact of adjacent land uses.
- Treatment of sewage water and the industrial effluents before releasing it into water bodies. Hot water should be cooled before release from the power plants.
- Excessive use of fertilisers and pesticides should be avoided. Organic farming and efficient use of animal residues as fertilisers can replace chemical fertilizers.
- **Water hyacinth** (an **aquatic weed, invasive species**) can purify water by taking some toxic materials and a number of heavy metals from water.
- Oil spills in water can be cleaned with the help of **bregoli** — a by-product of paper industry resembling sawdust, oil zapper, microorganisms.
- It has been suggested that we should plant **eucalyptus** trees all along sewage ponds. These trees absorb all surplus wastewater rapidly and release pure water vapour into the atmosphere.

## **Bioremediation**

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

### **In situ bioremediation**

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

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

**Q. 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 high 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 the latest developments.

### **Ex situ bioremediation**

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

### **Advantages of bioremediation**

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

### **Disadvantages of bioremediation**

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

### **Q. 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

## Phytoremediation

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

## Sewage Water Treatment for Domestic Use

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- Substances that are removed during the process of drinking water treatment include suspended solids, bacteria, algae, viruses, fungi, and minerals such as iron and manganese.
- The processes involved in removing the contaminants include physical processes such as settling and filtration, chemical processes such as disinfection and coagulation and biological processes such as slow sand filtration.

## Coagulation / Flocculation

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- **Aluminium sulphate (alum)** is the most common coagulant used for water purification.
- Other chemicals, such as ferric sulphate or sodium aluminate, may also be used.
- During coagulation, **liquid aluminium sulfate (alum)** is added to untreated water.
- This causes the tiny particles of dirt in the water to stick together or coagulate.
- Next, groups of dirt particles stick together to form larger particles called flocs.
- Flocs are easier to remove by settling or filtration.

## Sedimentation

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- 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.
- Floc which collects on the bottom of the basin is called sludge and is piped to drying lagoons.
- In Direct Filtration, the sedimentation step is not included, and the floc is removed by filtration only.

## Filtration

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- Water flows through a filter designed to remove particles in the water. The filters are made of layers of sand and gravel, and in some cases, crushed anthracite.
- Filtration collects the suspended impurities in water and enhances the effectiveness of disinfection. The filters are routinely cleaned by backwashing.

## Disinfection

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- Water is disinfected before it enters the distribution system to ensure that any disease-causing bacteria, viruses, and parasites are destroyed.
- **Chlorine** is used because it is a very effective disinfectant, and residual concentrations can be maintained to guard against possible biological contamination in the water distribution system.
- The addition of chlorine or chlorine compounds to drinking water is called **chlorination**.
- Chlorine can combine with certain naturally occurring organic compounds in water to produce **chloroform** and other potentially harmful by-products.
- The risk of this is very small, however, when chlorine is applied after coagulation, sedimentation, and filtration.
- **Ozone gas** may also be used for disinfection of drinking water. However, since ozone is unstable, it cannot be stored and must be produced on-site, making the process more expensive than chlorination.
- Ozone has the advantage of **not causing taste or odour problems**. It also 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.

## Sludge Drying

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- Solids that are collected and settled out of the water by sedimentation and filtration are removed to drying lagoons.

## Fluoridation

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- Water fluoridation is the **treatment of community water supplies** for the purpose of adjusting the concentration of the free **fluoride ion** to the optimum level sufficient **to reduce dental caries**.
- Fluoride is generally present in all natural water. Its concentration up to a certain level is not harmful. Beyond that level, the bones start disintegrating. This disease is called **fluorosis**.
- We have fluoride problem in many parts of our country. Bureau of Indian Standards prescribes 1.0 mg/l as desirable and 1.5 mg/l as a maximum permissible limit for drinking water.
- Defluoridation at 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.

### pH Correction

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- Lime is added to the filtered water to adjust the pH and stabilise the naturally soft water in order to minimise corrosion in the distribution system and within customers' plumbing.

**Titbit: National Environmental Engineering Research Institute (NEERI) is at Nagpur.**

### Removal of iron

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- In many parts of our country, we have a problem of excess iron in drinking water, especially in **North-East regions**.
- Iron causes bad taste and odour to the drinking water.
- Bureau of Indian Standards prescribes desirable limit for iron as 0.3 mg/l.
- A major part of iron is oxidised. Then the water is made to react with **oxidising media (limestone)**.
- 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

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- Arsenic is found in groundwater in some parts of West Bengal. Arsenic is highly toxic.
- Bureau of Indian Standards prescribes desirable limit for arsenic as 0.05 mg/l.
- **Bleaching powder and alum** are used for the removal of arsenic.

**Q. Which one among the following industries is the maximum consumer of water in India?**

- a. Engineering
- b. Paper and pulp

- c. Textiles
- d. **Thermal power**

### Water consumption by various industries

1. Thermal power
2. Textile industry
3. Paper and Pulp
4. Iron and Steel industry
5. Fertilizer Industry

### EcoSan toilets

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- 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 resource (as natural fertiliser), which reduces the need for chemical fertilisers.

### Bio-Toilets

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- Designed by **Railways** along with **DRDO**.

### Why Bio Toilets in Rail?

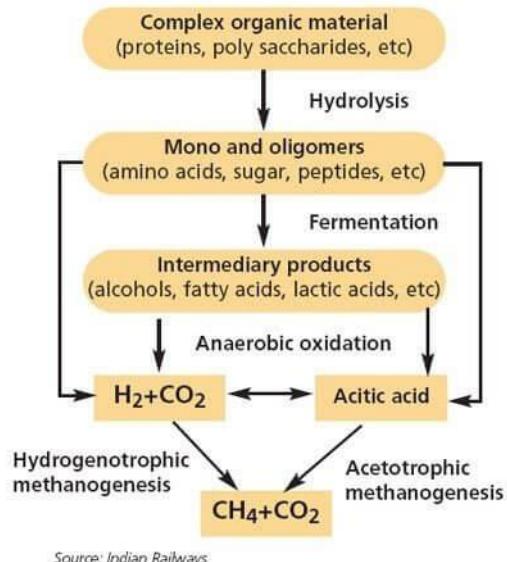
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- Direct discharge of human waste from the existing toilet system in trains causes corrosion of the tracks, costing crores to replace the rail tracks.
- The bio-toilets are fitted underneath the lavatories and the human waste discharged into them is acted upon by a particular kind of **bacteria** that converts it into non-corrosive **neutral water**.

## HOW BIO-TOILETS WORK

Bio-toilets have a colony of anaerobic bacteria that converts human waste into water and small amounts of gases. The gases are released into the atmosphere and the water is discharged after chlorination on the tracks

### Reaction



Source: Indian Railways

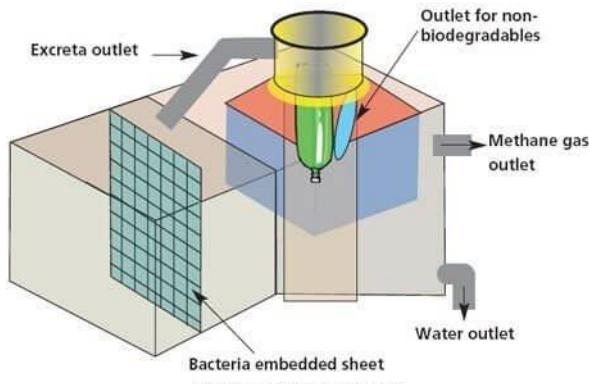


Illustration: Chaitanya Chandan

### Terms associated with Bio-Toilets

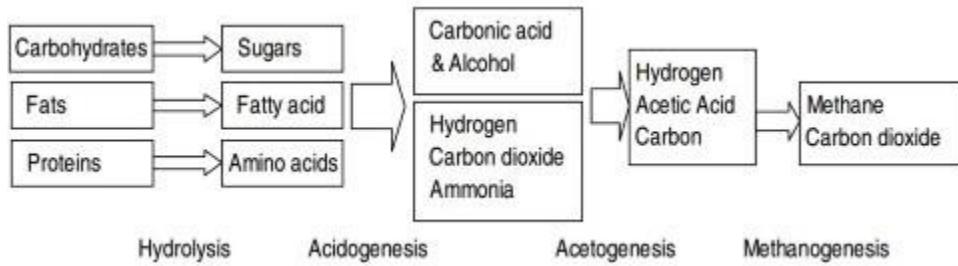
- Bio-digesters:** The term biodigester is used for the shells made up of steel for the **anaerobic** digestion of human waste.
- Bio tank:** The term bio tank is used for the tanks made up of concrete for the anaerobic digestion of human waste.
- Aerobic Bacteria:** Aerobic bacteria are those which flourish in the presence of free dissolved oxygen in the wastewater and consume organic matter for their food, and thereby oxidising it to stable end products.
- Anaerobic Bacteria:** Anaerobic bacteria flourish in the absence of free dissolved oxygen, and survive by utilizing the bounded molecular oxygen in compounds like **nitrates (NO<sub>3</sub>) and sulphates (SO<sub>4</sub>)** etc. thereby

reducing them to stable end products along with evolution of foul-smelling gases like **H<sub>2</sub>S (hydrogen sulphide)**, **CH<sub>4</sub> (methane)**.

- **Facultative Bacteria:** Facultative bacteria can operate either as aerobically or as anaerobically.
- **Anaerobic Microbial inoculums:** a mixture of different types of bacteria responsible for the breakdown of complex polymers into simple sugars which are further broken down into low chain fatty acids and finally into **biogas**.

### **Anaerobic 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** and **Carbon Dioxide**.

### **Aerobic biodegradation**

- Forced aeration is essential which is energy intensive.
- Incomplete aeration (partial aerobic condition) leads to a foul smell.
- Cannot tolerate detergents
- Generate a large amount of sludge.
- Repeated addition of bacteria/enzyme is required for the process.
- Maintenance & recurring cost is high.

### **Anaerobic biodegradation**

- No aeration is required.
- Complete anaerobic conditions.
- More than 99% pathogen inactivation.
- Anaerobes can even degrade detergents/phenyl.
- Sludge generation is very less.
- One time bacterial inoculation is enough.

- Minimal maintenance and no recurring cost.

**Q. 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
- Decomposition of human waste in bio-toilets is carried out by anaerobic bacteria.
  - The final waste is **CO<sub>2</sub> and CH<sub>4</sub>**.

Answer: d) Neither 1 nor 2

## **Eutrophication – Ageing of Lakes**

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- Lakes receive their water from surface runoff and along with its various chemical substances and minerals.
- Over periods spanning millennia, ageing occurs as the lakes accumulate mineral and organic matter and gradually, get filled up.
- The nutrient-enrichment of the lakes promotes the growth of algae, aquatic plants and various fauna. This process is known as natural **eutrophication**.
- Similar nutrient enrichment of lakes at an accelerated rate is caused by human activities and the consequent ageing phenomenon is known as **cultural eutrophication**.
- On the basis of their nutrient content, lakes are categorized as **Oligotrophic (very low nutrients)**, **Mesotrophic (moderate nutrients)** and **Eutrophic (highly nutrient rich)**.
- A vast majority of lakes in India are either **eutrophic or mesotrophic** because of the nutrients derived from their surroundings or organic wastes entering them.

## **Eutrophication and Algal Bloom**

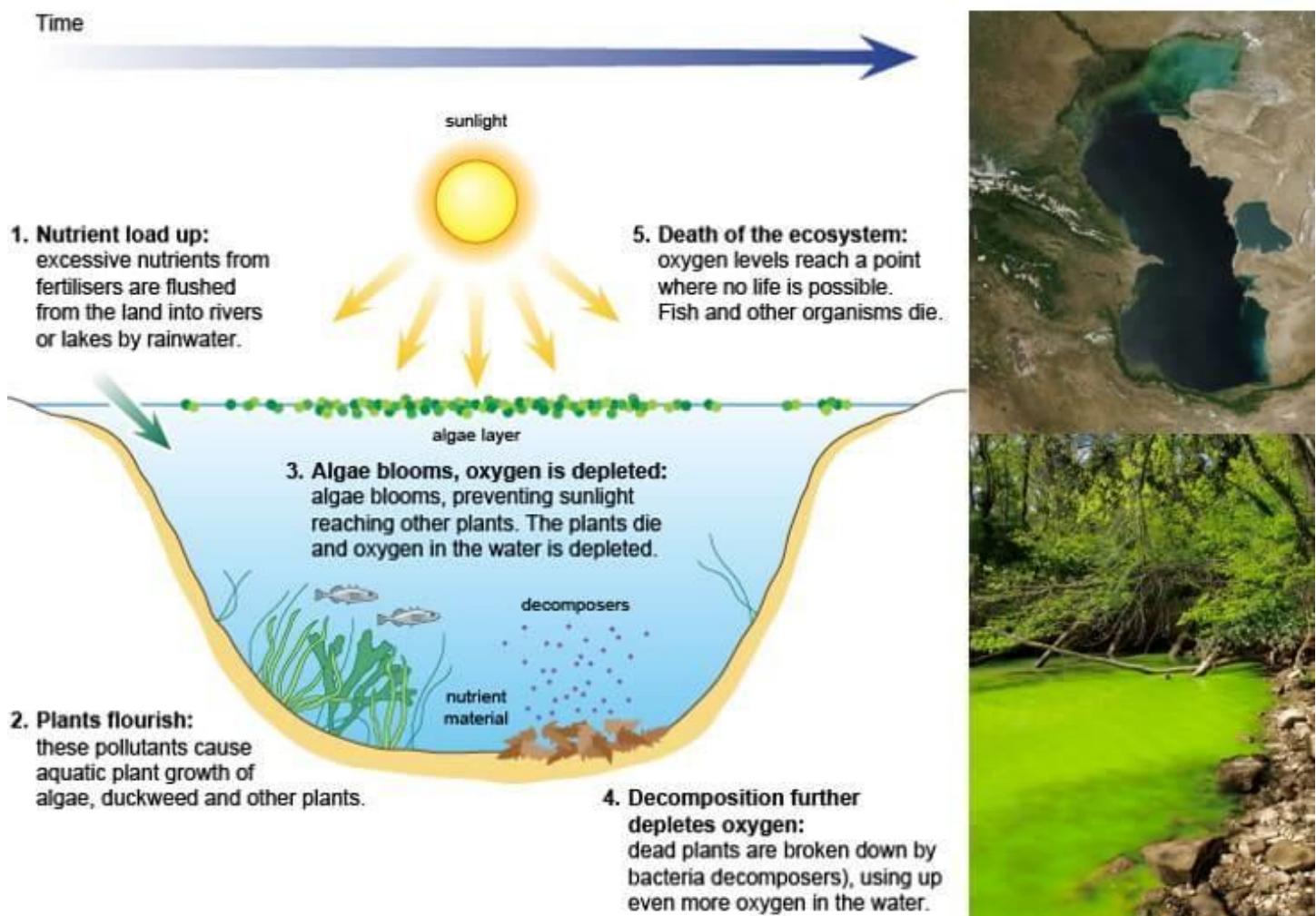
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- Eutrophic water body: it is a body of water rich in nutrients and so supporting a dense plant population, the decomposition of which kills animal life by **depriving it of oxygen**.
- Eutrophication is the response to the addition of nutrients such as **nitrates** and **phosphates** naturally or artificially, fertilising the aquatic ecosystem.
- Phytoplankton (algae and blue-green bacteria) thrive on the excess nutrients and their population explosion covers almost entire surface layer. This condition is known as **algal bloom**.

## Mechanism

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- Phytoplankton are **photosynthetic during day time** adding oxygen to the aquatic ecosystem.
- But **during nights, they consume far more oxygen** as they respire aggressively.
- i.e. Algal blooms accentuate the rate of oxygen depletion as the population of phytoplankton is very high.
- The primary consumers like small fish are killed due to oxygen deprivation caused by algal blooms.
- Death of primary consumers adversely affects 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) created to promote the growth of bacteria such as **Clostridium botulinum** which produces **toxins** deadly to aquatic organisms, birds and mammals.



- Water temperature has also been related to the occurrence of algal blooms, with unusually **warm water being conducive to blooms**.
- Algal blooms can be any colours, but the most common ones are red or brown. These blooms are commonly referred to as **red or brown tides**.

## Effects of Eutrophication

- **Loss of freshwater lakes:** Eutrophication eventually creates **detritus layer** in lakes and produces successively **shallower** depth of surface water.
- Eventually, the water body is reduced into marsh whose plant community is **transformed** from an aquatic environment to a recognizable **terrestrial** environment.
- Algal Blooms restrict the penetration of sunlight resulting in the **death of aquatic plants** and hence restricts the replenishment of oxygen.
- **New species invasion:** Eutrophication may cause the ecosystem competitive by transforming the normal limiting nutrient to abundant level. This cause shifting in species composition of the ecosystem.
- **Loss of coral reefs:** Occurs due to decrease in water transparency (increased turbidity).

- Affects navigation due to increased turbidity; creates colour (yellow, green, red), smell and water treatment problems; increases biomass of inedible toxic phytoplankton, benthic and epiphytic algae and bloom of gelatinous zooplankton.

### **Harmful Algal Blooms**

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- Most algal blooms are not harmful, but some produce toxins. These are known as Harmful Algal Blooms (HABs).
- **Toxicity:** Some algal blooms when died or eaten, release **neuro & hepatotoxins** which can kill aquatic organism & pose a threat to humans. E.g. **Shellfish poisoning**.
- HAB events adversely affect commercial and recreational fishing, tourism, and valued habitats, creating a significant impact on local economies and the livelihood of coastal residents.

### **Mitigation of Eutrophication**

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- Treating Industrial effluents domestic sewage to remove nutrient-rich sludge through wastewater processing.
- **Riparian buffer:** Interfaces between a flowing body of water and land created near the waterways, farms, roads, etc. in an attempt to filter pollution.
- Sediments and nutrients are deposited in the buffer zones instead of deposition in water (**Wetlands, estuaries are natural riparian buffers**).
- Increase in efficiency of nitrogen & phosphorous fertilisers and using them inadequate levels.
- Nitrogen testing & modelling: N-Testing is a technique to find the optimum amount of fertiliser required for crop plants. It will reduce the amount of nitrogen lost to the surrounding area.
- Encouraging organic farming.
- Reduction in nitrogen emission from vehicles and power plants.

### **Harmful Algal Blooms**

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- Algae or phytoplankton are microscopic organisms that can be found naturally in coastal waters.
- They are major producers of oxygen and food for many of the animals that live in these waters.
- When environmental conditions are favourable for their development, these cells may multiply rapidly and form high numbers of cells, and this is called an algal bloom.

## **4.5 Radioactive Pollution**

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

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

1. Accidental leakage, as occurred in the **Three Mile Island, Chernobyl and Fukushima incidents** and
  2. Safe disposal of radioactive wastes.
- At high doses, nuclear radiation is lethal, but at lower doses, it creates various disorders, the most frequent of all being cancer.
  - Continued small dose exposure to nuclear radiation can cause **childhood leukaemia, miscarriage, under-weight babies, infant deaths, increased susceptibility to AIDS and other immune disorders.**

### **Artificial Sources of Radioactive pollution**

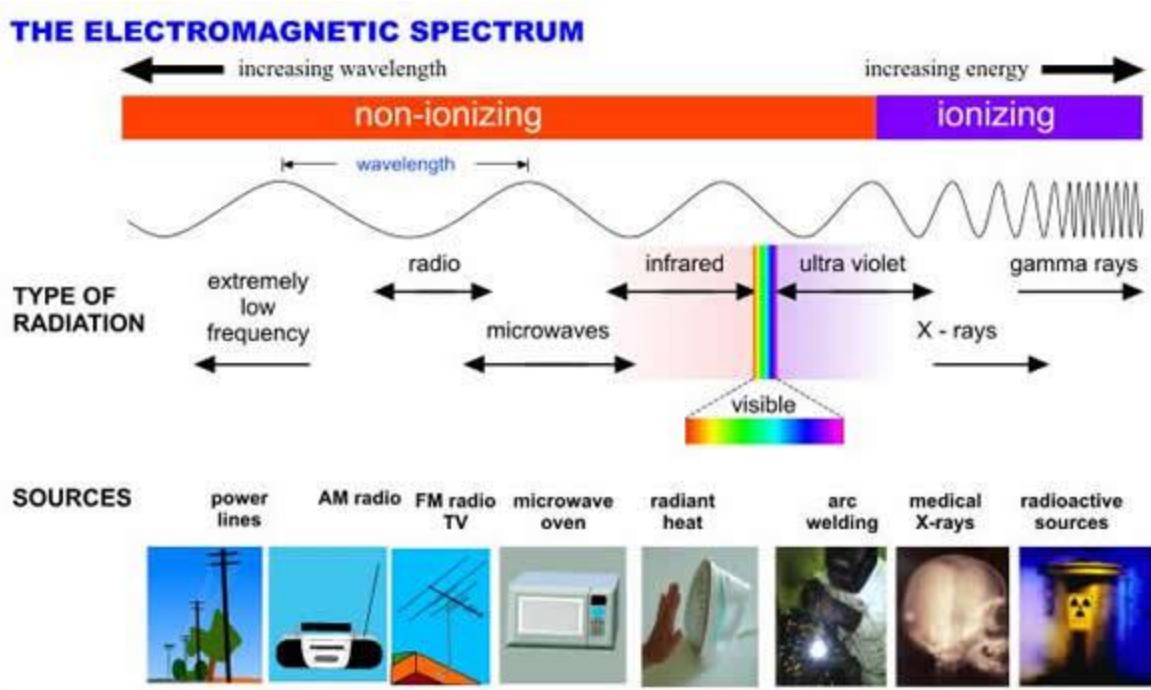
- Accidents in nuclear power plants and nuclear waste.
- Nuclear weapon testing and explosion (Nuclear fallout). The fall Out contains radioactive substances such as **strontium-90, caesium-137, iodine-131**, etc.
- Uranium mining and mining of other radioactive material like **thorium (monazite is the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

### **Natural Sources**

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

### **Ionizing and Non-Ionizing Radiation**

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

### Non-ionizing radiations

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

*In a microwave oven, the radiation causes water molecules in the cooking medium to vibrate faster and thus raising its temperature.*

### Ionising radiations

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

*Ionisation is the process by which an atom or a molecule acquires a negative or positive charge by gaining or losing electrons to form ions, often in conjunction with other chemical changes.*

- Electromagnetic radiations such as **short wavelength ultraviolet radiations (UV)**, **X-rays** and **gamma rays** and energetic particles produced in nuclear processes, electrically charged particles like **alpha and beta particles** produced in radioactive decay and **neutrons** produced in nuclear fission, are highly damaging to living organisms.
- Electrically charged particles produced in the nuclear processes can have sufficient energy to knock electrons out of the atoms or molecules of the medium, thereby producing ions.
- The ions produced in water molecules, for example, can induce reactions that can **break bonds** in proteins and other important molecules.
- An example of this would be when a gamma ray passes through a cell, the water molecules near the DNA might be ionised and the ions might react with the DNA causing it to break.
- They can also cause chemical changes by breaking the chemical bonds, which can damage living tissues.
- Short range effects include burns, impaired metabolism, dead tissues and death of the organisms.
- Long range effects are **mutations** increased the incidence of **tumours and cancer**, shortening of life-span and developmental changes.

- ⇒ Non-ionizing radiations affect only those components which absorb them and have low penetrability.
- ⇒ Ionising radiations have high penetration power and cause breakage of macromolecules.

## Biological Damage Due to Ionizing Radiations

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

## Radiation dose

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- A traditional unit of human-equivalent dose is the **rem**, which stands for radiation equivalent in man.
- At low doses, such as what we receive every day from background radiation (<1 m rem), the cells repair the damage rapidly.
- At higher doses (up to 100 rem), the cells might not be able to repair the damage, and the cells may either be changed permanently or die. E.g. **radiation sickness**.
- Cells changed permanently may go on to produce abnormal cells when they divide and may become cancerous.

## The damage potential of radiation particles

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

## Half-Life – Period of Radioactivity

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

## Accidents at nuclear power plants

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

- In the first two cases, a series of mishaps and errors resulted in overheating of the reactor core and a lot of radiation was released into the environment.
- The leakage from the Three Mile Island reactor was low, and no one was injured immediately.
- However, in the case of Chernobyl, the leakage was very heavy causing the death of some workers and radiation spread over large areas scattered all over Europe.
- The latest one – Fukushima Daiichi nuclear accident was triggered by an earthquake.

## **Safe Disposal of Nuclear Wastes**

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

Some proposed methods of disposing nuclear waste are:

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

## **Impact of Radiation from Mobile Phone Towers**

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

## **Health Impacts**

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

### **Impact on birds**

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

## **4.6 Soil Pollution**

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

### **Causes and Sources of Soil Pollution**

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#### **Plastic bags**

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- They accumulate in soil and prevents germination of seeds. They stay in the soil for centuries without decomposing (non-biodegradable).
- Burning of plastic in garbage dumps release highly toxic and poisonous gases like **carbon monoxide, carbon dioxide, phosgene, dioxins** and other poisonous **chlorinated compounds**.
- Toxic solid residue left after burning remains in the soil. The harmful gases enter soils through chemical cycles.

## Industrial sources

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

## Pesticides and fertilisers

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

## Other pollutants

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

## Effects of soil pollution

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

## 4.7 Noise Pollution

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- Noise by definition is “sound without value” or “any noise that is unwanted by the recipient”.
- Noise level is measured in terms of decibels (dB). An increase of about 10 dB is approximately double the increase in loudness.
- H.O. (World Health Organization) has prescribed optimum noise level as 45 dB by day and 35 dB by night. Anything above 80 dB is hazardous.
- Noise pollution leads to irritation, increased blood pressure, loss of temper, mental depression and annoyance, a decrease in work efficiency, loss of hearing which may be first temporary but can become permanent if the noise stress continues.
- A **green belt of trees** is an efficient noise absorber.

### Ambient Noise Level Monitoring

- Noise Pollution (Control and Regulation) Rules, 2000 define ambient noise levels for various areas.
- The Government of India on Mar 2011 launched a Real-time Ambient Noise Monitoring Network.
- **Silence Zone** is an area comprising not less than 100 metres around hospitals, educational institutions, courts, religious places or any other area declared as such by a competent authority.

## 4.8 Solid Wastes

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

### Effects of Plastic Waste

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- Conventional plastics, right from their manufacture to their disposal are a major problem to the environment.
- The land gets littered by plastic bag garbage and becomes ugly and unhygienic.

- Conventional plastics have been associated with **reproductive problems** in both humans and wildlife.
- **Dioxin** (highly carcinogenic and toxic) by-product of the manufacturing process is one of the chemicals believed to be passed on through **breast milk** to the nursing infant.
- Burning of plastics, especially **PVC** releases **dioxin** and also **furan** into the atmosphere.

⇒ Dioxins are environmental pollutants. They 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)**.

- Plastic bags can also contaminate foodstuffs due to leaching of toxic dyes and transfer of pathogens.
- Careless disposal of plastic bags chokes drains, blocks the porosity of the soil and causes problems for groundwater recharge.
- Plastic disturbs the soil microbe activity. The terrestrial and aquatic animals misunderstand plastic garbage as food items, swallow them and die.
- Plastic bags deteriorate soil fertility as it forms part of manure and remains in the soil for years.

## Industrial solid waste

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

## Plastic waste in road construction

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

## Issues with treatment and disposal of solid waste

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### Open dumps

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

## Landfills

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- It is a pit that is dug in the ground. The garbage is dumped, and the pit is covered with soil every day thus preventing the breeding of flies and rats.
- After the landfill is full, the area is covered with a thick layer of mud, and the site can thereafter be developed as a parking lot or a park.
- All types of waste are dumped in landfills, and when water seeps through them it gets contaminated and in turn, pollutes the surrounding area.
- This contamination of groundwater and soil through landfills is known as leaching.

## Sanitary landfills

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- Sanitary landfill is more hygienic and built methodically to solve the problem of leaching.
- These are lined with materials that are impermeable such as plastics and clay and are also built over impermeable soil.
- Constructing a sanitary landfill is very costly.

## Incineration plants

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

## Pyrolysis

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- It is a process of combustion in the **absence of oxygen** or the material burnt under a **controlled atmosphere of oxygen**. It is an alternative to incineration.
- The gas and liquid thus obtained can be used as fuels.

- Pyrolysis of carbonaceous wastes like firewood, coconut, palm waste, corn combs, cashew shell, rice husk paddy straw and sawdust, yields **charcoal** along with products like **tar, methyl alcohol, acetic acid, acetone** and **fuel gas**.

## **Composting**

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

## **Vermiculture**

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

## **Waste Minimization Circles (WMC)**

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

## **4.9 Hazardous Waste**

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- Any substance that is present in the environment or released into the environment causing substantial damage to public health and welfare of the environment is called hazardous substance.

- Any hazardous substance could exhibit any one or more of the following characteristics: **toxicity, ignitability, corrosivity or reactivity** (explosive).
- Thus, any waste that contains hazardous or very hazardous substance is called hazardous waste.
- Hazardous wastes can originate from various sources such as household, local areas, urban, industry, agriculture, construction activity, hospitals and laboratories, power plants and other sources.

## Stockholm Convention on Persistent Organic Pollutants

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- **Stockholm Convention on Persistent Organic Pollutants** is an international environmental treaty.
- Came into effective in 2004.
- Aims to **eliminate or restrict the production and use of 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".

## Important Listed substances

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- **Aldrin:** Used as an insecticide
- **Heptachlor:** Used as a termiticide (including in the structure of houses and underground), for organic treatment and in underground cable boxes
- **Hexachlorobenzene:** Used 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

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- **Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal.**
- An international treaty that was designed to reduce the movements of hazardous waste between nations.
- Main goal is to prevent the transfer of hazardous waste from developed to less developed countries (LDCs).
- It **does not** address the movement of **radioactive waste**.

## Rotterdam Convention

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

## 4.10 Electronic waste | E-WASTE

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

### Source and health effects

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Particulars	Source	Health Effects
<b>Lead</b>	<ul style="list-style-type: none"><li>• Used in glass panels and gaskets in computer monitors</li><li>• Solder in printed circuit boards and other Components</li></ul>	<ul style="list-style-type: none"><li>• Lead tends to accumulate in the environment and has high acute and chronic effects on plants, animals and microorganisms.</li></ul>
<b>Cadmium</b>	<ul style="list-style-type: none"><li>• Occurs in SMD chip resistors, infra-red detectors, and semiconductor chips</li><li>• Some older cathode ray tubes contain cadmium</li></ul>	<ul style="list-style-type: none"><li>• Toxic cadmium compounds accumulate in the human body, especially the kidneys.</li></ul>
<b>Mercury</b>	<ul style="list-style-type: none"><li>• It is estimated that 22 % of the yearly world consumption of mercury is used in electrical and electronic equipment</li><li>• Mercury is used in thermostats, sensors, relays, switches, medical equipment, lamps, mobile phones and in batteries</li><li>• Mercury, used in flat panel displays, will likely increase as their use replaces cathode ray tubes</li></ul>	<ul style="list-style-type: none"><li>• Mercury can cause damage to organs including the brain and kidneys, as well as the foetus.</li><li>• The developing foetus is highly vulnerable to mercury exposure.</li><li>• When inorganic mercury spreads out in the water, it is transformed to methylated mercury which bio-accumulates</li></ul>

		in living organisms and concentrates through the food chain, particularly via fish.
<b>Hexavalent Chromium/ Chromium VI 29</b>	<ul style="list-style-type: none"><li>Chromium VI is used as corrosion protector of untreated and galvanized steel plates and as a decorative or hardener for steel housings</li><li>Plastics (including PVC): Dioxin is released when PVC is burned.</li><li>The largest volume of plastics (26%) used in electronics has been PVC. PVC elements are found in cabling and computer housings.</li><li>Many computer mouldings are now made with the somewhat more benign ABS plastics</li></ul>	<ul style="list-style-type: none"><li>Chromium VI can cause damage to DNA and is extremely toxic in the environment.</li></ul>
<b>Barium</b>	<ul style="list-style-type: none"><li>Barium is used in computers in the front panel of a CRT, to protect users from radiation</li></ul>	<ul style="list-style-type: none"><li>Studies have shown that short-term exposure to barium causes brain swelling.</li></ul>
<b>Beryllium</b>	<ul style="list-style-type: none"><li>Beryllium is commonly found on motherboards and finger clips</li><li>It is used as a copper-beryllium alloy to strengthen connectors and tiny plugs while maintaining electrical conductivity</li></ul>	<ul style="list-style-type: none"><li>Exposure to beryllium can cause lung cancer.</li><li>Beryllium also causes a skin disease that is characterised by poor wound healing and wart-like bumps.</li></ul>
<b>Toners</b>	<ul style="list-style-type: none"><li>Found in the plastic printer cartridge containing black and colour toners.</li></ul>	<ul style="list-style-type: none"><li>Inhalation is the primary exposure pathway, and acute exposure may lead to respiratory tract irritation. Carbon black has been classified as a class 2B carcinogen, possibly carcinogenic to humans.</li></ul>
<b>Phosphor and additives</b>	<ul style="list-style-type: none"><li>Phosphor is an inorganic chemical compound that is applied as a coat on the interior of the CRT faceplate.</li></ul>	<ul style="list-style-type: none"><li>The phosphor coating on cathode ray tubes contain heavy metals, such as cadmium, and other rare earth metals, for example, zinc, vanadium as</li></ul>

		additives. These metals and their compounds are very toxic.
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**Q. Due to improper/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).

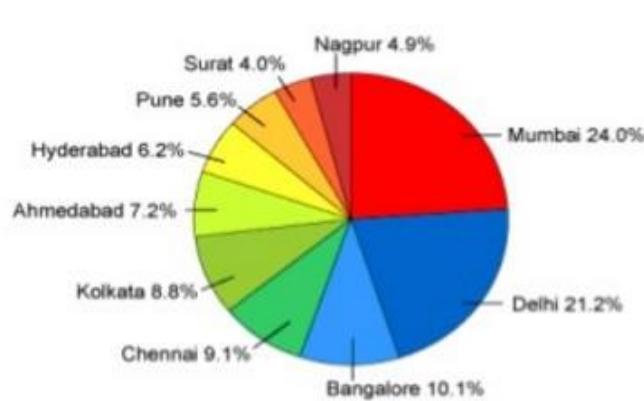
Answer: b) 1, 2, 3, 5 and 6 only

## **E-Waste in India**

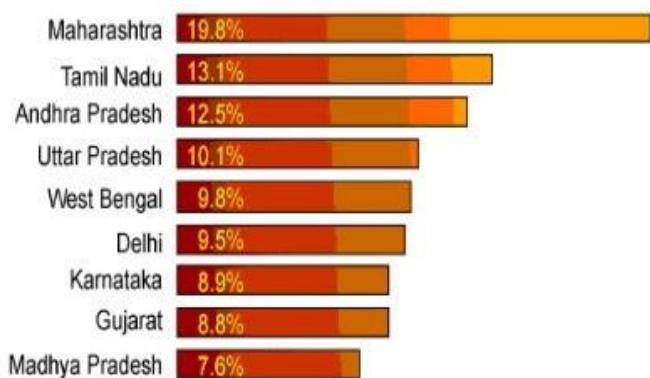
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- India generates about 18.5 lakh metric tonnes (MT) of electronic waste every year, with Mumbai and Delhi-NCR accounting for the biggest chunk. The figure is likely to reach up to 30 lakh MT per year by 2018.
- Bangalore, Chennai, Kolkata, Ahmadabad, Hyderabad, Pune, Surat and Nagpur are other important cities generating a substantial amount of e-waste.

- Among the eight largest e-waste generating states, **Maharashtra** ranks first followed by **Tamil Nadu** (2nd), **Andhra Pradesh** (3rd), Uttar Pradesh (4th), Delhi (5th), Gujarat (6th), Karnataka (7th) and West Bengal (8th).



City-wise E-waste Generation in India (Tonnes/year)



State-wise E-waste Generation in India (Tonnes/year)

- Over half of the e-waste generated in the developed world are exported to developing countries, mainly to China, India and Pakistan, where metals like copper, iron, silicon, nickel and gold are recovered during the recycling process.
- Unlike developed countries, which have specifically built facilities for recycling of e-waste, recycling in developing countries often involves manual participation thus exposing workers to toxic substances present in e-waste.

## **Heavy Metal Toxicity and Methods of Their Prevention**

- Toxic metals are dispersed in the environment through metal smelting industrial emissions, burning of organic wastes, automobiles and coal-based power generation.
- 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 to water bodies.
- Heavy metals cannot be destroyed by biological degradation.
- The heavy metals often encountered in the environment include **lead, mercury, arsenic, chromium**. These are known to cause toxic effects in living organisms.

### **Lead**

- Lead enters the atmosphere from automobile exhaust.
- Tetraethyl lead (TEL)** was added to petrol as an **anti-knock agent** for a smooth running of engines.

- Lead in petrol is being phased out by the introduction of lead-free petrol.
- Many industrial processes use lead, and it is often released as a pollutant.
- Battery scrap also contains lead. It can get mixed up with water and food and create cumulative poisoning.
- Lead can cause irreversible behavioural disturbances, neurological damage and other developmental problems in young children and babies. It is a carcinogen of the lungs and kidneys.

## Mercury

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- In Japan, mass mercury poisoning (**Minamata disease**) was observed in the 1960s, caused by eating fish from Minamata Bay which was contaminated with **methyl mercury**.
- Mercury kills cells in the body and damages organs and thus impairs their functioning.
- Inhalation of mercury vapours is more dangerous than its ingestion.
- Chronic exposure causes lesions in the mouth and skin and neurological problems.
- Mercury thermometers used earlier are getting replaced by mercury-free thermometer.

## Arsenic

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- Arsenic is associated with **copper, iron and silver ores**.
- Arsenic is also emitted from **fossil fuel burning**.
- Liquid effluents from **fertilizer plants** also contain arsenic.
- Groundwater contamination with arsenic is very common in areas where it is present.
- Chronic arsenic poisoning causes melanosis and keratosis (dark spots on the upper chest, back and arms are known as melanosis. The next stage is keratosis in which palms become hard) and leads to loss of appetite, weight, diarrhoea, gastrointestinal disturbances and skin cancer.
- Surface waters are generally free from arsenic pollution and should be preferred for drinking and cooking.

## Cadmium

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- Mining, especially of zinc and metallurgical operations, electroplating industries, etc., release cadmium in the environment.
- It may enter the human body by inhalation or from aquatic sources including fish, etc.
- It may cause hypertension, liver cirrhosis, brittle bones, kidney damage and lung cancer.
- **Itai-itai disease** first reported from Japan in 1965 was attributed to cadmium contamination in water and rice caused by the discharge of effluents from a zinc smelter into a river.

## Other Heavy Metals

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- Metals such as **zinc, chromium, antimony** and **tin** enter food from cheap cooking utensils.
- Preserved foods stored in tin cans also cause contamination by tin.
- Zinc is a skin irritant and affects the pulmonary system.

## 4.11 Marine Pollution

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- 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.
- 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:
  1. **Convention on the Dumping of Wastes at Sea, to be replaced by the 1996 Protocol) and**
  2. **United Nations Convention on Law of the Sea or UNCLOS.**

### Convention on Dumping of Wastes at Sea

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- An inter-governmental conference on the Convention on the Dumping of Wastes at Sea met in London in November 1972 to adopt this instrument, the **London Convention**.
- The Convention has a global character and is aimed at international control and putting an end to marine pollution.
- The definition of dumping under the Convention relates to 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 mineral resources.
- The 1978 amendment dealt with the incineration of wastes at sea.
- Another set of amendments adopted at the same time related to introduction of new procedures for dispute settlement.
- The 1993 amendments banned dumping of low-level radioactive wastes into the seas.
- They phased out the dumping of industrial wastes by 1995 and called for an end to incineration of industrial wastes at sea.
- It is to be noted that dumping of low-level radioactive wastes and industrial wastes as well as incineration of wastes were earlier permitted by the Convention.

- The changing approach, keeping in view the need of the times, led to the adoption of the 1996 Protocol on November 7, 1996.

## 1996 Protocol

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- The Protocol, which became effective in 2006, replaces the 1972 Convention.
- The 1996 Protocol is much more restrictive as compared to the 1972 Convention that allowed dumping provided certain conditions were satisfied.
- 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 cause relation between inputs and their effects."
- The Protocol states that "the polluter should, in principle, bear the cost of pollution".
- The Contracting 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 with the exception of those listed in Annex 1".
- Annex 1 includes dredged material; sewage sludge; fish waste from industrial fish processing operations etc. for which the concern is mainly physical impact.
- The Protocol prohibits incineration of wastes at sea (permitted by the 1972 convention but prohibited under the 1993 amendments).
- The Protocol states that "Contracting Parties shall not allow the export of wastes or other matter to other countries for dumping or incineration at sea".
- The **International Maritime Organization (IMO)** is responsible for Secretariat duties with respect to the Protocol.

## 2006 Amendments to the Protocol

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- Adopted in 2006, the amendments were enforced in 2007.
- The amendments have created a basis in international environment law to **regulate carbon capture and storage in subsealed geological formation**.
- It is part of the measures being considered to address climate change and ocean acidification like developing low carbon energy forms especially for sources of enormous CO<sub>2</sub> emissions.
- The amendments **allow storage of carbon dioxide (CO<sub>2</sub>)** under the seabed but **regulate the sequestration of CO<sub>2</sub> streams from CO<sub>2</sub> capture processes in sub-seabed geological formations**.

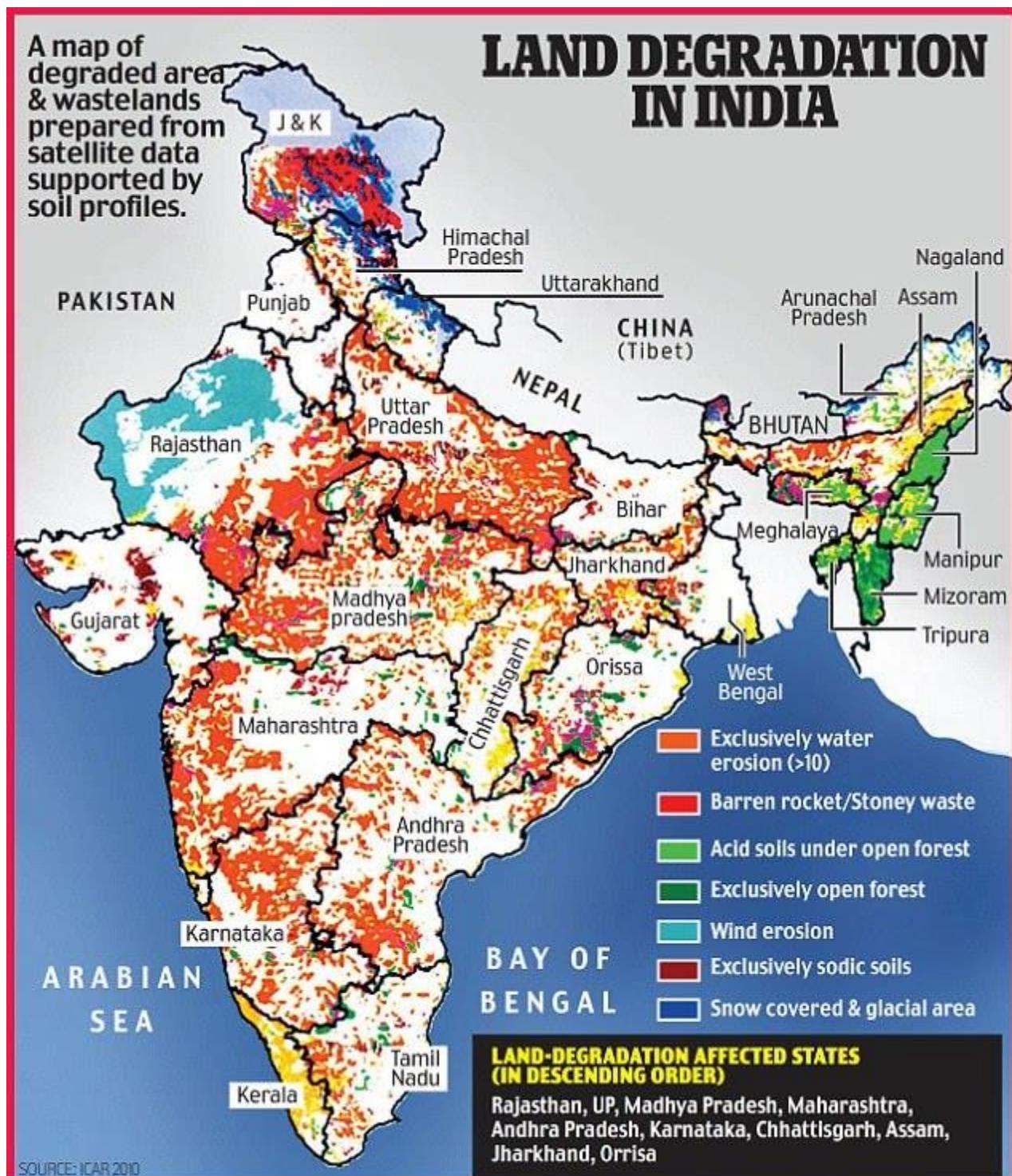
## The United Nations Convention on Law of the Sea

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- UNCLOS establishes general obligations for safeguarding the marine environment and protecting freedom of scientific research on the high seas.
- It also creates an innovative legal regime for controlling mineral resource exploitation in deep seabed areas beyond national jurisdiction, through an **International Seabed Authority**.
- UNCLOS can hold states liable for damage caused by violation of their international obligations to combat pollution of the seas.

## 4.12 Land Degradation

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- Soil degradation is the decline in soil quality caused by its improper use, usually for agricultural, pastoral, industrial or urban purposes.
- Soil degradation is a serious global environmental problem and may be exacerbated by climate change.
- It encompasses physical (soil erosion), chemical (salinity and alkalinity, pollution) and biological deterioration (pollution and deterioration of vegetal cover).

## Deforestation

- The population explosion has created pressure on forest land and resources, and this causes deforestation.
- Deforestation accentuates soil erosion (soil degradation).
- Roots of trees and plants bind the soil particles and regulate the flow of water, thus saving soil from erosion. Deforestation makes soil vulnerable to wind and water erosion.
- The large scale damage to the soil in Shiwalik range, the **Chos of Punjab**, the ravines of Chambal valley are due to deforestation.

## **Major Causes of Deforestation**

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### **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 the yield is modest.
- Then this area 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 rapid increase in population pressure in the forested areas.

### **Development project and Mining**

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- Opencast mining has resulted in deforestation all over the world.

### **Plantation Boom**

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- Increase in demand for cocoa, coffee, tea, sugar, palm oil, rubber etc. have resulted in deforestation in the tropical rainforests.

### **Raw Materials**

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- 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, bees wax.

### **Other Causes**

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- Deforestation also results from overgrazing, agriculture, mining, urbanisation, flood, fire, pest, diseases, defence and communication activities.

## Effects of Deforestation

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- Closed forests (based on canopy level) have diminished due to deforestation leading to an increase in degraded forests.
- Forests recycle moisture (natural motors) from soil into their immediate atmosphere by transpiration where it again precipitates as rain.
- Deforestation results in an immediate lowering of groundwater level (low percolation due to the quick surface runoff on barren lands) and in long-term reduction of precipitation.
- Due to deforestation, this natural reuse cycle is broken, and water is lost through rapid runoff.
- Deforestation affects the biota and neighbouring ecosystems, soil erosion, land degradation, alteration of groundwater channels, pollution and scarce.

## Overgrazing

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- During the rainy season, there is plenty of vegetation and animals get enough fodder.
- But during the dry period, there is a shortage of fodder, and the grass is grazed to the ground and torn out by the roots by animals.
- This leads to lose structure of the soil and the soil is easily washed away by rains.
- Moreover, the soil is pulverised (reduce to fine particles) by the hoofs of animals and thus proves detrimental to topsoil when heavy showers fall on it.
- Soil erosion due to overgrazing is a common site in the hilly areas.

## Faulty Methods of Agriculture

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- 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 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 shifting cultivation leads to the exposure of the soil to rains and sun which results in heavy loss of topsoil, especially on the hill slopes.

## Soil Salinity and Soil Alkalinity

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- In Saline and Alkaline Soils, the topsoil is **impregnated** (soak or saturate with a substance) with saline and alkaline efflorescences (become covered with salt particles).
- Undecomposed rock fragments, on weathering, give rise to **sodium, magnesium and calcium salts and sulphurous acid.**
- Some of the salts are transported in solution by the rivers.
- In regions with 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 the high sub-soil water table, injurious salts are transferred from below by the capillary action as a result of evaporation in the dry season.
- In canal irrigated areas plenty of the 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 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.
- Although Indira Gandhi canal in Rajasthan has turned the sandy desert into a granary, it has given birth to serious problems of salinity and alkalinity.

**Q. Which of the following is/are the possible consequence/s of heavy sand mining in riverbeds? (2018)**

- 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
- Water accumulates in the (pores) space between soil particles and can stay in these spaces' due to capillary action (capillary action explained in Indian Geography > Soils > Saline – Alkaline Soils).
  - Capillary action occurs because water is sticky and helps the water in pores overcome gravity.

- It is because of the capillary action that water (water table) is available just a few feet below the top soil.
- When the soil is removed the capillary action is lost and the water table falls.
- In places of high water table (near marshlands, wetlands, river beds) when the top soil 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 ground water more easily.

Answer: b) 2 and 3 only

## **Effects of salinity and alkalinity**

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- 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.
- Choice of crops is limited to salinity-tolerant crops like cotton, barley etc.
- Quality of fodder and food produced is of poor quality.
- Salinity and alkalinity create difficulties in building and road construction.
- These cause floods due to reduced percolation of water.

## **Steps to treat salinity and alkalinity**

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- Providing outlets for lands to drain out excess water and lower 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 can be removed by adding sulphuric acid or acid forming substances like sulphur 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**

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- 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 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**

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- Drifting of sand and its accumulation on fertile agricultural land.
- Excessive soil erosion by wind and to some extent by water.
- Deposition of sand in rivers, lakes decrease their water containing capacity.
- Lowering of water table leading to acute water shortage.
- Increase in area under wastelands.
- Decrease in agricultural production.
- Increase in frequency and intensity of droughts.

### **Measures of Controlling Desertification**

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- 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**

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- 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 (a) surface drainage and (b) vertical drainage.
  - (a) Surface Drainage. Surface drainage involves the disposal of excess water over ground surface through an open drainage system with an adequate outlet.
  - (b) Vertical Drainage. Any bore or well from which the underlying water is extracted is defined as vertical drainage. It works well in Indo-Gangetic plain where the pumped water is used for irrigating the neighbouring regions.

## Characteristics of Indian Soils

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- Most soils are old and mature.
- Soils of the peninsular plateau are much older than the soils of the great northern plain.
- Indian soils are largely **deficient in nitrogen, mineral salts, humus and other organic materials.**
- Plains and valleys have thick layers of soils while hilly and plateau areas depict thin soil cover.
- Some soils like alluvial and black soils are fertile while some other soils such as laterite, desert and alkaline soils lack infertility and do not yield a good harvest.
- Indian soils have been used for cultivation for hundreds of years and have **lost much of their fertility.**

## Soil Erosion

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- Soil erosion is the loosening and displacement of topsoil particles from the land.
- Soil erosion in nature may be
  - a) a slow process (or geological erosion) or
  - b) a fast process promoted by deforestation, floods, tornadoes or other human activities.
- These two processes are explained below:

## Water Erosion

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- 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.
- Soil erosion by water is termed differently according to the intensity and nature of erosion.
- Raindrop erosion (ii) Sheet erosion (iii) Rill erosion (iv) Steam banks erosion (v) Erosion due to landslides (vi) Coastal erosion.

## Raindrop erosion

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- Raindrops behave like tiny bombs when falling on exposed soil, displace soil particles and destroy soil structure.
- Average size of a raindrop is approximately 5 mm in diameter falling through the air hits the soil at a velocity of 32 km/hr.
- 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**

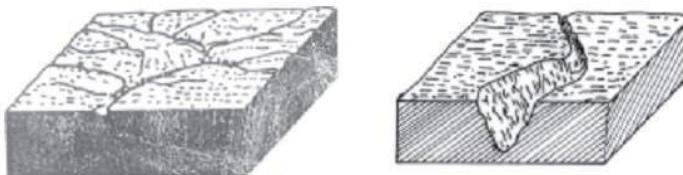
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- The detachment and transportation of soil particles by flowing rainwater is called sheet or wash off erosion.
- This is a very slow process and often remain unnoticed.

### **Rill erosion**

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- In rill erosion finger like rills appear on the cultivated land after it has undergone sheet erosion.
- These rills are usually smoothed out every year while forming.
- Each year the rills slowly increase in number become wider and deeper.
- When rills increase in size, they are called gullies. Ravines are deep gullies.



### **Streambank erosion**

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- The erosion of soil from the banks (shores) of the streams or rivers due to the flowing water is called bank erosion.



### **Landslide**

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- A 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.

## Coastal erosion

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- Coastal erosion of soil occurs along seashores. It is caused by the wave action of the sea and the inward movement of the sea into the land.

## Consequences of water erosion

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- Erosion removes the most fertile part of the soil. The less fertile subsoil is left.
- The fine particles of the topsoil which contain the bulk of nutrients and organic matter needed by the plants are lost from soil erosion.
- Erosion may result in removal of seeds or seedlings so that the soil becomes bare. Bare soil is more vulnerable to erosion both by wind and water.
- Removal of seeds and seedlings reduces the ability of soil to store water.
- Sheet, rill, gully and stream bank erosion also cause siltation of rivers, streams and fields.
- Deposition of silt results in damage of crops and pastures, and sedimentation of water bodies like streams, dams, reservoirs etc.
- Sedimentation of water bodies deteriorate water quality and damage aquatic habitats and organisms.
- Coastal erosion causes the adjoining land to become covered by sand.

## Wind erosion

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- Soil erosion by wind is more common in areas where the natural vegetation has been destroyed. Such conditions occur mainly in arid and dry areas along the sandy shores of oceans, lakes and rivers.
- The loose soil particles are blown and transported from wind by following three ways: (i) Siltation: blown by the wind in a series of short bounces. (ii) Suspension: transported over long distances in the form of suspended particles. (iii) Surface creep: transported at ground level by high-velocity winds.

## Consequences of wind erosion

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- Wind erosion removes the finer soil material including organic matter, clay and silt, in a suspension (colloidal) form and leaving behind coarser, less fertile material.
- The productive capacity of the soil is lost as most of the plant nutrients which remain attached smaller colloidal soil fraction are lost.
- Wind erosion also damages roads and fertile agricultural fields by depositing large quantities of air blown soil particles.

## Soil Conservation

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- Soil conservation is the prevention of soil from erosion or reduced fertility caused by overuse, acidification, salinisation or other chemical soil contamination.
- Soil erosion is the greatest single evil to Indian agriculture and animal husbandry.
- Notable Quotable from Khullar's Indian Geography: "With soil conservation people rise and with its destruction, they fall. Neglect of soil is like killing the hen that lays the golden egg."

## Crop Rotation

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- 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 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.

## Strip Cropping

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- **Crops may be cultivated in alternate strips, parallel to one another.** Some strips may be allowed to lie fallow while in other different crops may be sown.
- Various crops are harvested at different intervals. This ensures that at no time of the year the entire area is left bare or exposed.
- 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.

## Use of Early Maturing Varieties

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- Early maturing varieties of crops take less time to mature and thus put lesser pressure on the soil. In this way, it can help in reducing the soil erosion.

## Contour Ploughing

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- 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 reduce run-off so that plants receive more water.

## **Checking Shifting Cultivation**

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- Checking and reducing shifting cultivation by persuading the tribal people to switch over to settled agriculture is a very effective method of soil conservation.
- This can be done by planning for their resettlement which involves the provision of residential accommodation, agricultural implements, seeds, manures, cattle and reclaimed land.

## **Ploughing the Land in Right Direction**

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- Ploughing the land in a direction perpendicular to wind direction also reduces wind velocity and protects the topsoil from erosion.

## **Mulching**

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- The **bare ground (topsoil) between plants is covered with a protective layer of organic matter** like grass clippings, straw, etc.

## **Benefits**

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- Protects the soil from erosion.
- It helps to retain soil moisture.
- Reduces compaction from the impact of heavy rains.
- Conserves moisture, reducing the need for 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**

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- Stones, grass, 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**

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- Rocks are piled up across a channel to slow down the flow of water. This prevents gullies and further soil loss.

## **Terrace farming**

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- In terracing, a number of terraces are cut along the hill slope.
- These are made on the steep slopes so that flat surfaces are available to grow crops. They can reduce surface run-off and soil erosion.



*Fig 2.5: Terrace Farming*



*Fig 2.6: Contour Ploughing*

## **Contour Bunding**

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- **Contour bunding involves the construction of banks along the contours.**
- **Terracing and contour bunding** which 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.

## **Intercropping**

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- Different crops are grown in alternate rows and are sown at different times to protect the soil from rain wash.

## **Contour ploughing**

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- Ploughing parallel to the contours of a hill slope to form a natural barrier for water to flow down the slope

## **Shelterbelts or Windbreaks**

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- In the coastal and dry regions, rows of trees are planted to check the wind movement to protect soil cover.



## Sand fences

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- Sand fences are barriers made of small, evenly spaced wooden slats or fabric. They are erected to reduce wind velocity and to 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

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- It includes the prevention of forest destruction along with growing new forests or increase area under forests.
- A minimum area 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

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- 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 (reduce to fine particles) by the hoofs of animals. All this leads to the 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

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- 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.
- But indiscriminate dam construction can worsen the condition by creating floods and landslides like it happens in the Himalayan region.

## 4.13 Human Modified Ecosystems and Environmental Degradation

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- Some examples of human-modified ecosystems are agro-ecosystems, plantation forests, rural and urban ecosystems, aquaculture etc.

### Characteristics of human-modified ecosystems

- Highly unstable, unsustainable and have a devastating effect on the environment.
- Highly simplified with very low species diversity and poor nutrient cycling.
- Food chains are simple, small and undergo frequent changes.
- Depend on human (anthropogenic) support for survival.
- Species are highly susceptible to epidemic diseases.
- Highly subject to soil erosion and soil degradation.
- Regeneration and recovery of the environment are very slow.
- Some adverse effects are irreversible for a very long time.

### Agroecosystems

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- Agroecosystems are large areas where commercial crops are cultivated.
- Crops are mostly cultivated as a **monoculture (growing only one type of crop)** on the entire field.

### Characteristics of agro-ecosystems

- Attract weeds and susceptible to plant diseases.
- Soil are poor, deficient in nutrients, require supplement of chemical or fertilizers.
- Need artificial irrigation and water management.

### Disadvantages of agro-ecosystem

- Large scale monoculture of crops results in **severe loss of native biodiversity** including **genetic diversity of crop plants**.

- High yielding varieties of crop plants are **more susceptible to disease**. E.g. smut of sugarcane, maize and sorghum and rust of wheat and bajra.
- Protecting crops from pests and diseases requires large scale use of pesticides and chemicals which pollute the environment.
- Deplete groundwater in many areas due to well irrigation.
- Runoff water from agricultural field laden with fertilisers and pesticides pollute river, lakes and ponds (**Eu-trophication**).

## Plantation Forest

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- It is a humanmade ecosystem consisting of **individuals of a particular tree species**.
- The aim is to grow fast growing trees which are commercially valuable. E.g. **Palm, rubber, eucalyptus** etc.
- Plantation forest is trees planted as a **part of wasteland management** or **commercial plantations**.

### Characteristics of plantation forests

- Plantation forests are generally monoculture, like oil palm plantation, rubber plantation, coffee plantation, **Jatropha curcas (biodiesel)**.
- Plantation forests have trees of approximately the same age.
- Plantation forests are highly susceptible to pathogens.

### Economic importance

- Tree plantation are raised for fruits, oil, rubber, coffee, timber, firewood, pulpwood for making rayon and paper industries.
- Trees are also planted to serve as **windbreaks or shelterbelts**.
- Tree plantations are also raised for controlling soil erosion and for increasing soil fertility.

## Aquaculture

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- Aquaculture is the artificial cultivation of aquatic plants or animals.
- It is primarily carried out for cultivating certain commercially important edible species of fresh and marine water fishes, molluscs, crustaceans and aquatic plants.
- Fisheries include the extraction of food from the sea and the fresh water whereas aquaculture is rearing of the aquatic organisms in artificially made water bodies, e.g. the culture of fish like carps, tilapia (also known as aquatic chicken).

There are two types of aquaculture

- Fish farming is the cultivation of fish in a controlled environment often a coastal or inland pond, lake, reservoir or rice field (paddy) and harvesting when they reach the desired size.
- Fish ranching is a practice of keeping fishes in captivity for the first few years in floating cages in coastal lagoons and releasing them from captivity into water bodies.
- Adults are harvested when they return for spawning to the lagoons. E.g. Salmon and Hilsa which migrate to rivers to spawn are cultivated by fish ranching method.

### **Merits of aquaculture**

- Ecological efficiency is high. 2 kg. of grains are required to add 1 kg live weight.
- High yield in a small volume of water.
- Improved qualities of fish obtained by selection and breeding and genetic engineering.
- Aquaculture reduces over-harvesting of fisheries.
- High profit.

### **Demerits of aquaculture**

- Large inputs of feed, water and land are required.
- Loss of native aquatic biodiversity as it is replaced by a monoculture of a commercially important fish species.
- Produces large amounts of fish wastes that pollute water bodies.
- Aquaculture fishes are very sensitive to pesticide runoff from croplands.
- In aquaculture ponds, high population density is maintained that makes them highly vulnerable to diseases leading to total collapse of the crop.
- Aquaculture tanks or reservoirs are often get contaminated after a few years.

## **Dams, Reservoirs and Diversions**

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- A dam is a structure built in order to store river or tidal water.
- Dams, reservoirs and diversions capture and store runoff water and release it as needed.

They are used for:

- controlling or moderating floods,
- producing hydroelectric power, and
- supply water for irrigation, industry and other uses to rural, suburban and urban areas.

- Support recreational activities such as swimming and boating.

### **Advantages of dams**

- Water released from dams is used to generate electricity.
- Hydroelectricity reduces dependence on coal and hence reduces CO<sub>2</sub> emission.
- Reduces downstream flooding.
- Reduces river silting below the dam.
- Supply irrigation water for croplands.

### **Disadvantages of dams**

- Permanently submerge large areas of forests and croplands.
- Displace a large number of native people.
- Increase water pollution on account of reduced water flow.
- Reduce nutrients replenishment of downstream flood plains.
- Disrupt spawning and migration of some fish species.
- High costs and a long gestation period.
- Large reservoirs increase the risk of earthquakes.

## **Environmental Issues in the Himalayas**

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### **Importance of Himalayan Region**

- With wide-ranging natural vegetation, it acts as a **giant 'carbon sink'**.
- It is one of the most important regions of rich biodiversity, especially the eastern Himalayan region which is a global biodiversity hotspot. It is a storehouse of endemic species.

### **Degradation of Himalayan Environment**

- The Himalayan region, with its young and unstable topography, is one of the most fragile ecosystems on earth.
- It has recently gained notice for its 'vulnerability' due to various unsustainable economic and developmental activities such as unchecked tourism and mountaineering, hydroelectric power projects, indiscriminate urbanisation etc.

### **Biotic pressure**

- Population explosion has resulted in **high biotic pressure** by putting a strain on natural resources.
- Many species are now threatened due to habitat destruction and habitat fragmentation caused by anthropogenic activities.
- Man-animal conflict: snow Leopards are hunted to save livestock.

### **Pollution and solid waste**

- Air pollution due to the increase in vehicle density; water pollution and soil pollution due to domestic sewage are making the region more vulnerable.
- Indiscriminate solid waste dumping as a result of urbanisation and tourism development have resulted in the accumulation of debris along the water courses which cause flash floods in the wet season.

### **Hydroelectric power projects**

- Their construction has weakened the structural stability of the steep slopes causing landslides.
- Tunnel drilling has created new unnatural watercourses that cause more soil erosion and makes the stratum highly unstable increasing the risk of landslides.
- Change of river courses causes accumulation of debris in new sites which increase the chances of flash floods in the wet season.

### **Urbanisation to meet tourism demands**

- The thriving tourist industry has created a great demand for lodging facilities. Buildings are constructed indiscriminately by flouting rules. General non-compliance with prescribed norms and guidelines has become very common.
- The natural sites for these illegal constructions are river banks, dried and old river courses and moderately sloped regions.
- During wet seasons, landslides become common along sloped regions that are affected by construction.
- The debris from the construction sites block the river courses causing flash floods. All these cause great damage to the fragile ecology.

### **Infrastructure development**

- Growing population, thriving tourism, military (security) needs have led to the rapid construction of roads, and railways on the Himalayan slopes.

- Instability caused by infrastructure development is evident in numerous landslides that occur in along the slopes in the region.

### **Cultural/Pilgrimage Tourism**

- Unfortunately, most of the pilgrimage places lack adequate facilities for transport, accommodation, waste disposal and other amenities for the ever-growing number of pilgrims that visit them every year.
- Also, there is a gross lack of a regulatory mechanism for infrastructure creation, management, and for controlling the tourist inflow in such sites.
- As a result, the sensitive ecosystems and cultural values of these areas are facing pressures far beyond their carrying capacities.

### **Deforestation**

- Deforestation is rampant all over India. In spite of their fragile ecosystem, Himalayas are no exception.
- Trees are felled for their timber which finds many domestic and industrial applications.
- Deforestation leads to soil erosion and slope instability. Landslides become common.

### **Climate change/global warming**

- Climate change has evolved as the single biggest threat to the Himalayan ecosystem.
- Melting of glaciers, ice caps and bursting of lakes create havoc downstream.
- The receding snowline has threatened the local biodiversity.
- Many species acclimatised to the cold environment are moving further up the slopes. They lose their normal prey and hence struggle to survive.

## **Initiatives to save Himalayan Environment**

### **Ban on Plastic in HP**

- State government enacted the Himachal Pradesh Non-Biodegradable Garbage (Control) Act, 1995 in order to prevent throwing or depositing non-biodegradable garbage in public drains, roads.
- It was then increased the minimum thickness of plastic carry bags to 70 microns of virgin material, which exceeded the 20-micron thickness recommended by Central Rules.
- Further, the State Government has taken a Cabinet decision to ban plastics altogether in the entire state since 2009.

## **Participatory Conservation of Lakes in the Region**

- The Nainital Lake is the sole source of drinking water for Nainital town, an important tourist destination in Uttarakhand state.
- An increasing inflow of tourists, urban waste making its way into the lake is adversely affecting water quality.
- To conserve the water body, the residents have switched on to a scientific garbage disposal system - under the project name 'Mission Butterfly' by Nainital Lake Conservation Project.
- The sweepers, on a small monthly charge, collect waste from each household and directly transfer it to the compost pits.
- Apart from the residents, schools and hotel owners have extended full cooperation to the authorities, to save its precious eco-system.
- In addition, they are able to generate income and employment by converting it to manure.

## **Assam Hill Land and Ecological Sites Act, 2006**

- The Assam Hill Land and Ecological Sites (Protection and Management) Act, 2006 to prevent indiscriminate cutting of trees and filling up of water bodies in urban areas.
- Under the Act, the state government can bring any hill under its purview for protection.

## **Sikkim's Ecotourism Policy**

- "Sikkim - the Ultimate Tourist Destination" is the policy motto of the state.
- The state is employing a system of environmental fees and permits for entries, and stay time restrictions in some environmentally sensitive high altitude/pristine areas.
- Operationalization of tourism in various modes, such as village tourism, nature tourism, wildlife tourism, trekking/adventure tourism, and cultural tourism in the state and institutionalization of tourism management at the community level.
- Promotion and use of local art & craft, cuisines, etc., along with organizing tourism fairs and festivals.
- Imparting training in tourism-related service industries.
- The efforts made by Sikkim can be a basis of responsible tourism in other Himalayan states.

## **Measures That Can Be Taken to Protect the Himalayan Ecosystem**

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### **Harnessing Religious Sentiments for Conservation**

- Encouraging devotees and tribals to undertake participatory plantation for the rehabilitation of degraded areas.
- Promoting the concept of **eco-cultural landscapes**. Both landscapes are highly evolved with a high level of economic and ecological efficiencies.
- Involving them in maintenance and strengthening of sacred groves/landscape (e.g., Sacred Groves of Meghalaya: The tribal communities - Khasis, Garos, and Jaintias, have a tradition of environmental conservation based on religious beliefs and customary law and are protected from any product extraction.)
- Himalayan Homestays: The Himalayan Homestays programme fosters conservation-based community managed tourism development in remote settlements, by gradually building local capacity and ownership.

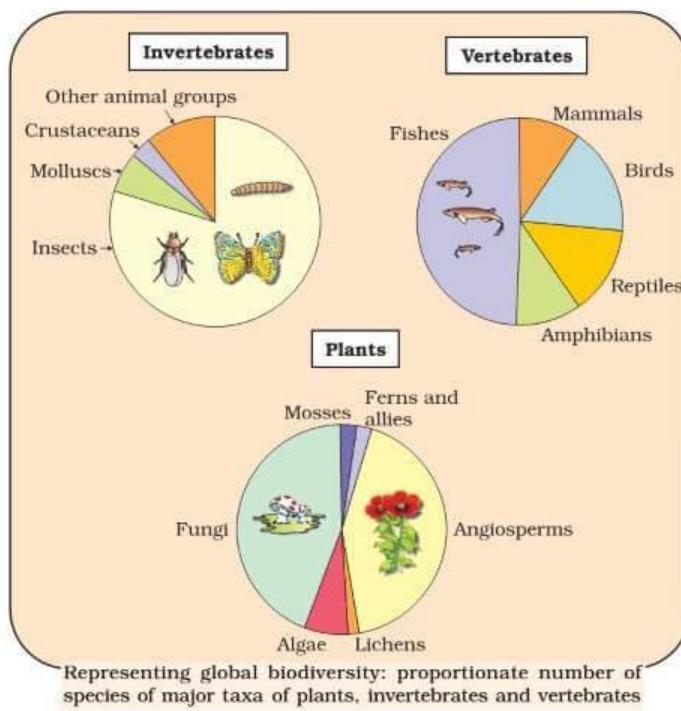
### **Promoting Ecotourism and Regulation of Commercial Tourism**

- Eco-tourism villages, parks, sanctuaries and other areas should be identified to establish a primary base for ecotourism.
- Village communities, especially youths, and rural women should be involved in Ecotourism.
- Restrictions on the entry of vehicles and visitors per day/ per group should be imposed on sensitive ecological sites.
- Local art, crafts, cuisines, and dishes should be promoted and made an integral part of tourist experience in order to ensure economic benefits to the locals and their cultural integrity/ entity is not lost.
- Best practices on commercial trekking should be imposed on a mandatory basis
- Creation of log/bamboo huts should be promoted in busy mountain areas.

## **5. Biodiversity**

- According to IUCN (2004), the total number of plant and animal species described so far is slightly more than 1.5 million.
- Estimates place the global species diversity at several million.
- A large proportion of the species waiting to be discovered are in the tropics.
- 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.
- The number of fungi species in the world is more than the combined total of the species of fishes, amphibians, reptiles and mammals.

- The largely tropical Amazonian rain forest in South America has the greatest biodiversity on earth.



## 5.1 Definitions

### Biodiversity

- Biodiversity is the variety of plant and animal life in the world or in a particular habitat.
- Biodiversity is measured by two major components: **species richness**, and **species evenness**.

### Species richness

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

### Species evenness

- Species evenness is a measure of the relative abundance of the different species making up the richness of an area.
- Example: The sample forest A has 4 tigers, 5 deer and 6 rabbits and sample forest B has 1 tiger, 6 deer and 8 rabbits. Both samples have the same richness (3 species – species richness) and the same total number of individuals (15). However, the sample forest A has more evenness than the sample forest B.
- Low evenness indicates that a few species dominate the site.

### Alpha diversity

- It refers to the diversity within a particular area or ecosystem and is usually expressed by the number of species (i.e., species richness) in that ecosystem.

### Beta diversity

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

### Gamma diversity

- It is a measure of the overall diversity for 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 American, African etc.).
- India has more than 50,000 genetically different strains of rice and 1,000 varieties of mango.
- Genetic diversity allows species to **adapt to changing environments**. This diversity aims to ensure that some species **survive drastic changes** and thus **carry on desirable genes**.
- Species that differ from one another in their genetic makeup do not interbreed in nature.
- Closely-related species have in common much of their hereditary characteristics. For instance, about 98.4 per cent of the genes of humans and chimpanzees are the same.

### Species diversity

- It is the ratio of one species population over total number of organisms across all species in the given biome.  
**'Zero' would be infinite diversity, and 'one' represents only one species present.**
- Species diversity is a measure of the diversity within an ecological community that incorporates both species richness (the number of species in a community) and the evenness of species.
- In general, species diversity decreases as we move away from the equator towards the poles.
- With very few exceptions, tropics (latitudinal range of 23.5° N to 23.5° S) harbour more species than temperate or polar areas.
- **Bioprospecting:** nations endowed with rich biodiversity explore molecular, genetic and species-level diversity to derive products of economic importance.

### Stable community

- A stable community means that there is **not much variation in productivity from year to year**; it is either resistant or **resilient to occasional disturbances** (natural or human-made) and is **resistant to invasions by alien species**.

## Ecological diversity

- Ecological diversity refers to **different types of habitats**. A habitat is the cumulative factor of the climate, vegetation and geography of a region.
- It includes various biological zones, like a lake, desert, coast, estuaries, wetlands, mangroves, coral reefs etc.
- At the ecosystem level, 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

- There are more than 200000 species in India of which several are confined to India (endemic).
- Endemism is the **ecological state of a species being unique to a defined geographic location**, such as an island, nation, country or other defined zone, or habitat type; organisms that are indigenous to a place are not endemic to it 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 extreme opposite of endemism is **cosmopolitan distribution**.

## Keystone species

- **Keystone species** is a species whose addition to or loss from an ecosystem leads to major changes in the occurrence of at least one other species.
- Certain species in an ecosystem is considered more important in determining the presence of many other species in that ecosystem.
- **All top predators (Tiger, Lion, Crocodile, Elephant)** are considered as keystone species because they regulate all other animal population indirectly.
- Hence top predators are given much consideration in conservation.
- If keystone species is lost, it will result in the degradation of the whole ecosystem.
- For example, certain plant species (ebony tree, Indian-laurel) exclusively depends upon **bats for its pollination**. If the bat population is reduced, then regeneration of particular plants becomes more difficult.

## Foundation species

- Foundation species is a **dominant primary producer** in an ecosystem both in terms of abundance and influence. Example: kelp in kelp forests and **corals** in coral reefs.

### Flagship species

- A flagship species 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.
- Example: **Indian tiger, African elephant, giant panda of China**, the leatherback sea turtle, etc.

## 5.2 Biodiversity of India

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- India is recognized as one of the **mega-diverse countries**, rich in biodiversity and associated traditional knowledge.
- India has 23.39% of its geographical area under forest and tree cover.
- With just 2.4% of the land area, India accounts for nearly **7%** of the recorded species even while supporting almost 18% of the human population.
- In terms of species richness, India ranks **seventh** in mammals, **ninth** in birds and **fifth** in reptiles.
- In terms of endemism of vertebrate groups, India's position is **tenth in birds** with 69 species, **fifth in reptiles** with 156 species and **seventh in amphibians** with 110 species.
- India's share of crops is 44% as compared to the world average of 11%.

### India Represents

- Two 'Realms'
- Five Biomes
- Ten Bio-geographic Zones
- Twenty-five Bio-geographic provinces

### Realms

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- Biogeographic realms are **large spatial regions within which ecosystems share a broadly similar biota**.
- A realm is a continent or sub-continent sized area with unifying features of geography and fauna & flora.
- The Indian region is composed of two realms. They are:
  - 1) the Himalayan region represented by Palearctic Realm and

- 2) the rest of the sub-continent represented by Malayan Realm
- In world, Eight terrestrial biogeographic realms are typically recognised. They are
  - 1) Nearctic Realm
  - 2) Palaearctic Realm
  - 3) Africotropical Realm
  - 4) Indomalayan Realm
  - 5) Ocenaia Realm
  - 6) Australian Realm
  - 7) Antarctic Realm
  - 8) Neotropical Realm

## **Biomes of India**

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- The term biome means the **main groups of plants and animals living in areas of certain climate patterns.**
- It includes the way in which animals, vegetation and soil interact together. The plants and animals of that area have adapted to that environment.

The five biomes of India are:

- 1) Tropical Humid Forests**
- 2) Tropical Dry or Deciduous Forests (including Monsoon Forests)**
- 3) Warm deserts and semi-deserts**
- 4) Coniferous forests and**
- 5) Alpine meadows.**

## **Bio-geographic Zones**

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- Biogeography deals with the **geographical distribution of plants and animals.**
- Biogeographic zones were used as a **basis for planning wildlife protected areas in India.**
- There are 10 biogeographic zones which are distinguished clearly in India. They are as follows:
  - 1) Trans-Himalayas**
  - 2) Himalayas**
  - 3) Desert**
  - 4) Semi-arid**
  - 5) Western Ghats**

- 6) Deccan Peninsula
- 7) Gangetic plain
- 8) North-east India
- 9) Islands
- 10) Coasts

## Bio-geographic provinces

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- Bio-geographic Province is an ecosystematic or **biotic subdivision of realms**.
- India is divided into 25 bio geographic zones.

Biogeographic Zones (10)	Biogeographic Provinces (25)
1) Trans Himalaya	1) 1A: Himalaya – Ladakh Mountains 2) 1B: Himalaya – Tibetan Plateau 3) 1C: Trans – Himalaya Sikkim
2) The Himalaya	4) 2A: Himalaya – North West Himalaya 5) 2B: Himalaya – West Himalaya 6) 2C: Himalaya – Central Himalaya 7) 2D: Himalaya – East Himalaya
3) The Indian Desert	8) 3A: Desert – Thar 9) 3B: Desert – Kutch
4) The Semi-Arid	10) 4A: Semi-Arid – Punjab Plains 11) 4B: Semi-Arid – Gujarat Rajputana
5) The Western Ghats	12) 5A: Western Ghats – Malabar Plains 13) 5B: Western Ghats – Western Ghats Mountains
6) The Deccan Peninsula	14) 6A: Deccan Peninsular – Central Highlands 15) 6B: Deccan Peninsular – Chotta Nagpur 16) 6C: Deccan Peninsular – Eastern Highlands 17) 6D: Deccan Peninsular – Central Plateau 18) 6E: Deccan Peninsular – Deccan South
7) The Gangetic Plains	19) 7A: Gangetic Plain – Upper Gangetic Plains 20) 7B: Gangetic Plain – Lower Gangetic Plains
8) The Coasts	21) 8A: Coasts – West Coast

	<b>22) 8B: Coasts – East Coast</b> <b>23) 8C: Coasts – Lakshadweep</b>
<b>9) Northeast India</b>	<b>24) 9A: North-East – Brahmaputra Valley</b> <b>25) 9B: North-East – North East Hills</b>
<b>10) Islands</b>	<b>26) 10A: Islands – Andaman</b> <b>27) 10B: Islands – Nicobars</b>

## Wildlife Diversity of India

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### Himalayan mountain system

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- The west Himalayas have low rainfall, heavy snowfall (temperate conditions).
- In the east Himalayas, there is heavy rainfall, snowfall only at very high altitudes.
- Lower altitudes conditions are similar to the tropical rain forests.

### Himalayan foothills

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

### Western Himalayas (High altitude region)

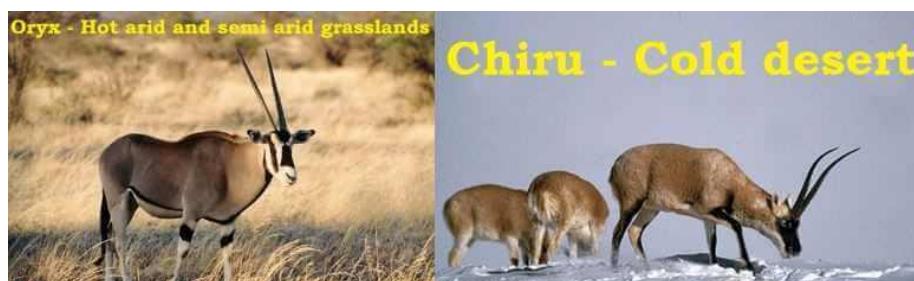
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- Flora: Natural monsoon evergreen and semi-evergreen forests; rhododendrons; **dwarf hill bamboo and birch forests mixed with alpine pastures.**
- Fauna: **Tibetan wild ass (kiang) (Don't confuse this with Asiatic wild ass which is found in Kutch region), wild goats (thar, ibex) and blue sheep; antelopes (Chiru and Tibetan gazelle), deers (hangul of Kashmir stag and shou or Sikkim stag, musk deer); golden eagle, snow cocks, snow partridges; snow leopard, black and brown bears; birds like Griffon vultures.**

### Q. 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.
- They are both antelopes.



Answer: a)

### **Eastern Himalayas**

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- Flora: Oaks, **magnolias, laurels and birches** covered with moss and ferns; coniferous forests of pine, fir, yew and junipers with an undergrowth of scrubby **rhododendrons** and dwarf bamboos; lichens, mosses, orchids, and other epiphytes dominant (due to high humidity and high rainfall).
- Fauna: **Red panda, hog badgers, forest badgers, crestless porcupines, takins etc.**

### **Peninsular - Indian sub-region**

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- It has two zones.
  - a) peninsular India and its extension into the drainage basin of the Ganges river system, and
  - b) desert region of Rajasthan-the Thar of Indian desert region.

### **Peninsular India**

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- It is home to tropical moist deciduous to tropical dry deciduous and scrub vegetation depending upon the variation in rainfall and humidity.
- Flora: **Sal** in north and east extensions (higher rainfall) and **teak** in southern plateau are dominant trees.
- West Ghats have evergreen vegetation (flora and fauna similar to evergreen rainforests of northeastern of India. In dry areas of Rajasthan and Aravalli hills, trees are scattered, and thorny scrub species predominate. The forests give way to more open savannah habit.
- Fauna: **Elephant, wild boar, deers (cheetal or axis deer), hog deer swamp deer or barasingha, sambar, muntjak or barking deer, antelopes (four-horned antelope, Nilgiri, blackbuck, chinkara gazelle), wild dog or dhole, tiger, leopard, cheetah, lion, wild pig, monkey, striped hyena, jackal, gaur.**

## Indian desert

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- Thar desert of Rajasthan has unique flora and fauna.
- Flora: Thorny trees with reduced leaves; cacti, other succulents are the main plants.
- Fauna: Animals are mostly burrowing ones. Among mammals' rodents are the largest group.
- The Indian desert gerbils are mouse-like, rodents, other animals are, **Asiatic wild ass, black buck, desert cat, caracal, red fox; reptiles** (snakes, lizards and tortoise) well represented.
- Desert lizards include agamids and geckos. Among birds, the most discussed is **Great Indian Bustard**.

## Tropical rain forest region

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- Distributed in areas of Western Ghats and northeast India.
- Flora: Extensive grasslands interspersed with densely forested gorges of evergreen vegetation known as sholas occur in the Nilgiris (an offshoot of Western Ghats). **Sholas** also occur in Anamalai and Palani hills.
- The rain forests of the Western Ghats have dense and lofty trees with much species diversity. Mosses, ferns, epiphytes, orchids, lianas and vines, herbs, shrubs make diverse habitat. **Ebony** trees predominate in these forests.
- Fauna: It is very rich with all kinds of animals. There are wild **elephants, gaur and other larger animals**.
- **Most species are tree dwellers. The most prominent are hoolock gibbon (only ape found in India), golden langur, capped langur or leaf monkey, Assam macaque and the pig-tailed macaque, lion-tailed macaque, Nilgiri langur slender loris, bats, giant squirrel, civets, flying squirrels, Nilgiri mongoose, spiny mouse.**

## Andaman and Nicobar Islands

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- Flora: These are home for tropical rain forests. Mangroves are distributed in the coastal areas.
- Fauna: Among mammals, bats and rats; **Andaman pig, crab-eating macaque, palm civet and deers** (spotted deer, barking deer, hog deer, sambar).
- Among marine mammals, there are **dugong, false killer whale, dolphin**.
- Among birds are rare one is **Narcondum hornbill, white-bellied sea-eagle**.
- **Salt-water crocodile**, a number of marine turtles, coconut crab, lizards (the largest being water monitor), 40 species of snakes including cobra, viper, voral and sea snake, python, etc. are present.

## Mangrove swamps of Sundarbans

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- Sunderbans are the delta of the Ganges where both the Brahmaputra and the Ganges join and drain into the Bay of Bengal.
- Flora: Various species of mangroves.
- Fauna. In the higher regions of mangroves, there are spotted deer, pigs, monitor lizard, monkeys. The most interesting animal of Sunderbans is the **Royal Bengal Tiger**.

### 5.3 Loss of Biodiversity

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- The IUCN Red List (2004) documents the extinction of 784 species in the last 500 years.
- Some examples of recent extinctions include the three subspecies (**Bali, Javan, Caspian**) of tiger.
- 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.
- Sixth Extinction (anthropogenic) presently is in progress with current species extinction rates estimated to be 100 to 1,000 times faster than in the 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.
- In general, loss of biodiversity in a region may lead to
  - ✓ decline in plant production,
  - ✓ lowered resistance to environmental perturbations such as drought and
  - ✓ increased variability in certain ecosystem processes such as plant productivity, water use, and pest and disease cycles.

### Cause for the loss of biodiversity

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- There are four major causes – **The Evil Quartet – Habitat loss, Overexploitation, Alien species and Secondary extinction.**

### Habitat loss and fragmentation

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- This is the most important cause of driving animals and plants to extinction.
- Due to the growing human population, 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.
- The most dramatic examples of habitat loss come from tropical rain forests.

- Once covering more than 14 per cent of the earth's land surface, these rain forests now cover no more than 6 per cent. They are being destroyed fast.
- The Amazon rain forest (it is so huge that it is called the 'lungs of the planet') harbouring probably millions of species is being cut and cleared for cultivating soya beans or for conversion to grasslands for raising beef cattle.

## **Man-Animal Conflict**

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- It 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 population growth and encroachment into forest lands.
- Land use transformation – industrialization, infrastructure development, commercial farming etc.
- Species habitat loss, degradation and fragmentation due to above-mentioned reasons.
- Increasing livestock populations and competitive exclusion of wild herbivores.
- 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.
- Climatic factors – climate change-induced habitat destruction.
- Stochastic events (e.g. fire, floods etc.)

## **Impacts**

- Crop damage and damage to property – elephants damage crops and villages.
- Livestock depredation – Himalayan snow leopard preys on goats in the Himalayan region. Farmers trap and kill snow leopards to save their livestock.
- Injuries and deaths – Man eater tigers, are reported to have injured and killed villagers living 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 and biological) – very expensive.
- 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 of animals – Conservation or Biodiversity loss?**

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#### **Natural culling**

- Culling means 'Selection'.
- In the wild, it is the process of weeding out the weak.
- A population boom makes individuals compete for food and safety, and the weaker ones lose out, leaving a smaller population of more able individuals.
- Culling naturally occurs by starvation, disease and predation. It is **nature's way of controlling 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?**

- Man-Animal conflict – too many wild animals compete with humans for resources.
- Threat to life and livelihood (crop, property damage) makes culling necessary.
- Loss of forestland to mines, industry, agriculture, etc. is the primary reason behind the man-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 man-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.

#### **Animal welfare activists vs Pro culling lobby**

- Culling lobby: Affected farmers and government administration.

Arguments by animal welfare activists against culling	Arguments by Culling lobby
<ul style="list-style-type: none"> <li>Ethical grounds: we do not have the right to cull other species.</li> </ul>	<ul style="list-style-type: none"> <li>They support a practical and realistic approach.</li> </ul>
<ul style="list-style-type: none"> <li>Animal welfare activists believe that every individual animal is ethically indispensable, even at the cost of putting entire species at risk.</li> </ul>	<ul style="list-style-type: none"> <li>Conservationists are concerned about the integrity of the ecosystem and the future of entire species.</li> </ul>
<ul style="list-style-type: none"> <li>Culling is against animal conservation.</li> </ul>	<ul style="list-style-type: none"> <li>Culling is for conservation</li> <li>By law, wildlife is protected because they are too few and require protection.</li> <li>But when certain pockets see a population boom in herbivores, farmers cannot wait for predators to reoccupy such areas.</li> <li>The absence of lawful intervention often triggers retaliation by illegal means.</li> <li>In anger, farmers may indiscriminately target wildlife, including those that may not be causing any problem.</li> </ul>
<ul style="list-style-type: none"> <li>Culling drives are often not well monitored frequently leads to free-for-all shooting sprees.</li> </ul>	<ul style="list-style-type: none"> <li>Can be monitored easily using strict guidelines and law enforcement.</li> </ul>
<ul style="list-style-type: none"> <li>Culling can increase people's apathy (lack of interest or enthusiasm) for the conservation of other forms of life.</li> </ul>	<ul style="list-style-type: none"> <li>No concrete evidence to prove that culling increases insensitivity among people.</li> <li>(But practically it does. A lot of people enjoy hunting animals and others might take inspiration from culling)</li> </ul>
 <p>(Some people recruited to cull animals post their pictures along with their prey on social media. This is totally unprofessional as it glorifies killing an animal.)</p>	
<ul style="list-style-type: none"> <li>Culling creates a conducive atmosphere for the poaching mafia to move in.</li> </ul>	<ul style="list-style-type: none"> <li>It is specious (misleading) to claim that time-bound, limited permissions to cull create an atmosphere for poaching.</li> </ul>

	<ul style="list-style-type: none"><li>• This is because most of the cropland areas may not host commercially lucrative wildlife species.</li></ul>
<ul style="list-style-type: none"><li>• They argue that man-animal conflict can be controlled through non-invasive means, including<ul style="list-style-type: none"><li>a) fencing crop fields,</li><li>b) planting chilli around cropland,</li><li>c) creating buffer areas between croplands and the forest's edge,</li><li>d) selecting non-edible crops,</li><li>e) providing adequate and regular compensation for crop loss, etc.</li></ul></li></ul>	<ul style="list-style-type: none"><li>• Fencing merely shifts conflict to the next accessible cropland.</li><li>• Fencing is expensive and its maintenance is not effective.</li><li>• 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.</li><li>• Other measures are mostly long-term and can keep a check on conflict only in situations where crop damage is still reasonable.</li><li>• But in pockets where the situation is already out of hand, the only option is often to reduce the number of habitual crop-raiders.</li></ul>

## **Over-exploitation**

- Humans have always depended on nature for food and shelter, but when 'need' turns to 'greed', it leads to over-exploitation of natural resources.
- In the last 500 years, many species extinctions (Steller's sea cow, passenger pigeon) were due to overexploitation by humans.
- Presently many marine fish populations around the world 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, collection of firewood, hunting of wild animals for skin (for example tigers from reserve forests of India), ivory etc. all result in gradual loss of species.

## **Poaching**

- Large mammals such as the tiger, rhinoceros and the elephant once faced the distinct possibility of complete extinction due to rampant hunting and poaching.

- Global warming (Climate change), natural calamities are other reasons for loss of biodiversity.

## **Alien species invasions**

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- When alien species are introduced unintentionally or deliberately for whatever purpose, some of them turn invasive and cause decline or extinction of indigenous species.
- The **Nile perch** introduced into Lake Victoria in East Africa led eventually to the extinction of an ecologically unique assemblage of more than 200 species of cichlid fish in the lake.
- You must be familiar with the environmental damage caused and threat posed to our native species by invasive weed species like **carrot grass (Parthenium)**, **Argemone**, **Lantana** and **water hyacinth (Eichornia)**.
- The recent illegal introduction of the **African catfish** Clarias gariepinus for aquaculture purposes is posing a threat to the indigenous catfishes in our rivers.
- The colonization of tropical Pacific Islands by humans is said to have led to the extinction of more than 2,000 species of native birds.

## **Some Invasive fauna in India are**

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- **Eucalyptus in Southern India.**
- **Gold Fish**
- **House Gecko**

## **Species Extinction**

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- Extinction is caused through various processes:
  - 1) Deterministic processes that have a cause and effect. E.g. glaciations, human interference such as deforestation.
  - 2) Stochastic processes (chance and random events) that affect the survival and reproduction of individuals. E.g. unexpected changes in weather patterns decreased food supply, disease, increase of competitors, predators or 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 have been identified. These are:
  - ✓ rarity or low abundance
  - ✓ poor dispersal ability

- ✓ high trophic status – as animals occupying a higher trophic level (i.e. the position of a species in a food chain) usually have smaller populations than those at lower levels (e.g. carnivores are fewer in number than herbivores)
- ✓ low adult survival rates

### Co-extinctions

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- When a species becomes extinct, the plant and animal species associated with it in an obligatory way also become extinct.
- 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 extinction of one invariably leads to the extinction of the other.

## 5.4 Biodiversity Conservation

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- 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 there are situations where 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.

### Benefits of Biodiversity conservation

- Conservation of biological diversity leads to conservation of essential ecological diversity to preserve the continuity of food chains.
- The genetic diversity of plants and animals is preserved.
- It ensures the sustainable utilisation of life support systems on earth.
- It provides a vast knowledge of potential use to the community.
- A reservoir of wild animals and plants is preserved, thus enabling them to be introduced, if need be, in the surrounding areas.
- Biodiversity conservation assures sustainable utilization of potential resources.

### In situ conservation

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- 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 protected as **biosphere reserves, national parks, sanctuaries, reserved forests, protected forests** and **nature reserves**.
- India now has **18 biosphere reserves, 104 national parks** and **500 wildlife sanctuaries**.
- **Plantation, cultivation, grazing, felling trees, hunting and poaching are prohibited in biosphere reserves, national parks and sanctuaries.**

### Protected Area Network in India

- **National Board for Wildlife (NBWL)**, chaired by the **Prime Minister of India** provides for policy framework for wildlife conservation in the country.
- The **National Wildlife Action Plan** (2002-2016) was adopted in 2002, emphasizing the people's participation and their support for wildlife conservation.

### Reserved & Protected Forests

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

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

### Wildlife Sanctuaries or wildlife refuges

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- Wildlife Sanctuaries or wildlife refuges are **home to various endangered species**.
- **They are safe from hunting, predation or competition.**
- They are safeguarded from extinction in their natural habitat.
- Certain rights of people living inside the Sanctuary could be permitted.
- Grazing, firewood collection by tribals is allowed but strictly regulated.
- **Settlements not allowed** (few exceptions: tribal settlements do exist constant; efforts are made to relocate them).

- A Sanctuary can be promoted to a National Park.
- There are more than 500 wildlife sanctuaries in India.

## National Park

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- National parks are areas **reserved for wildlife** where they can freely use the habitats and natural resources.
- The difference between a Sanctuary and a National Park mainly 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 allowed.**
- **No grazing** of any livestock shall also be permitted inside a National Park while in a Sanctuary, the Chief Wildlife Warden may regulate, control or prohibit it.

## Eco-Sensitive Zones

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- The **National Wildlife Action Plan (2002–2016)** of MoEFCC 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 purpose of the ESZ was to provide more protection to the parks by acting as a shock absorber or transition zone.
- Eco-Sensitive Zones would minimise forest depletion and man-animal conflict.
- The protected 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 legal status of being a national park and could be a reserved forest, wildlife sanctuary or tiger reserve**.

**Q. 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

- Answer: d) Neither

## Biosphere Reserve

- Large areas of protected land for **conservation of wildlife, plant and animal resources** and **traditional life of the tribals** living in the area.
- May have one or more national parks or wildlife sanctuaries in it.

### Core area

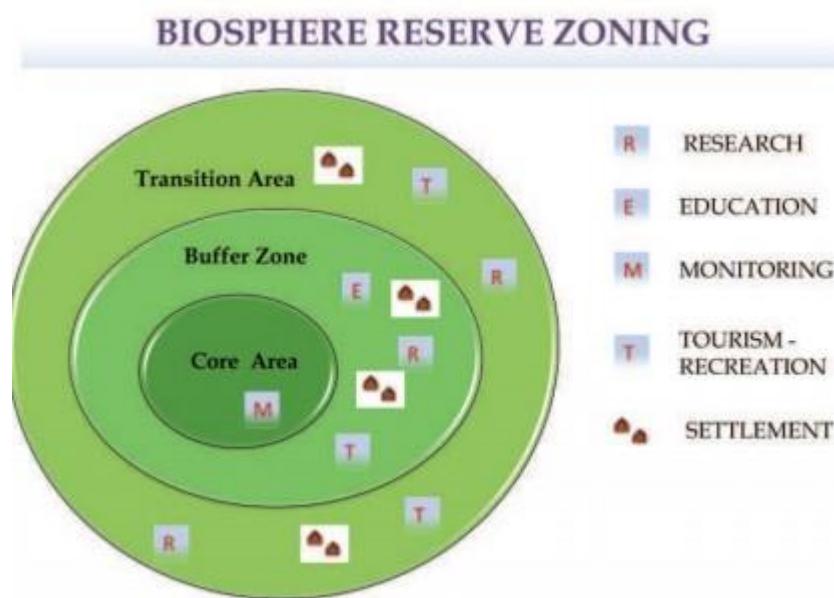
- Comprises a strictly protected ecosystem for conserving ecosystems, species and genetic variation.
- In core or natural zone **human activity is not allowed**.

### Buffer zone

- Used for scientific **research, monitoring, training and education**.

### Transition area

- **Ecologically sustainable human settlements and economic activities (tourism) are permitted.**
- With the cooperation of reserve management and local people, several human activities like settlements, cropping, recreation, and forestry are carried out without disturbing the environment.



## Biosphere Reserves in India

Name	State	Type	Key fauna
1. Nilgiri Biosphere Reserve	Tamil Nadu, Kerala and Karnataka	Western Ghats	<b>Nilgiri tahr, lion-tailed macaque</b>
2. Nanda Devi National Park & Biosphere Reserve	Uttarakhand	Western Himalayas	<b>Snow Leopard, Himalayan Black Bear</b>
3. Gulf of Mannar	Tamil Nadu	Coasts	<b>Dugong or sea cow</b>
4. Nokrek	Meghalaya (Part of Garo Hills)	East Himalayas	<b>Red panda</b>
5. Sundarbans	West Bengal	Gangetic Delta	<b>Royal Bengal tiger</b>
6. Manas	Assam (Terai region)	East Himalayas	<b>Golden langur, red panda</b>
7. Simlipal	Odisha	Deccan Peninsula	<b>Gaur, royal Bengal tiger, elephant</b>
8. Dihang-Dibang	Arunachal Pradesh	Eastern Himalaya	
9. Pachmarhi Biosphere Reserve	Madhya Pradesh	Semi-Arid	<b>Giant squirrel, flying squirrel</b>
10. Achanakmar-Amarkantak Biosphere Reserve	Madhya Pradesh, Chhattisgarh	Maikala Hills	<b>Four-horned antelope, Indian wild dog, Sarus crane, White-rumped vulture</b>
11. Great Rann of Kutch	Gujarat	Desert	<b>Indian wild ass</b>
12. Cold Desert	Himachal Pradesh	Western Himalayas	<b>Snow leopard</b>
13. Khangchendzonga	Sikkim	East Himalayas	<b>Snow leopard, red panda</b>
14. Agasthyamalai Biosphere Reserve	Kerala, Tamil Nadu	Western Ghats	<b>Nilgiri Tahr, elephants</b>
15. Great Nicobar Biosphere Reserve	Andaman and Nicobar Islands	Islands	<b>Saltwater crocodile</b>
16. Dibrugarh-Saikhowa	Assam	East Himalayas	<b>Golden langur</b>
17. Seshachalam Hills	Andhra Pradesh	Eastern Ghats	
18. Panna	Madhya Pradesh	Catchment Area of the Ken River	<b>Tiger, chital, chinkara, sambar and sloth bear</b>

**Q. 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

Answer: a)

## **Tiger Reserves**

- **Same as sanctuaries.** But they are monitored by NTCA under Project Tiger.
- The various tiger reserves were created in the country based on 'core-buffer' strategy.

### Core area

- **The core areas are freed of all human activities.**
- **It has the legal status of a national park or wildlife sanctuary.**
- Collection of minor forest produce, grazing, and other human disturbances are not allowed.

### Buffer areas

- Twin objectives:
  - ✓ providing habitat supplement to spill overpopulation of wild animals from core area.
  - ✓ provide site-specific co-developmental inputs to surrounding villages for relieving their impact on core area.
- Collection of minor forest produce and **grazing by tribals is allowed on a sustainable basis.**
- The Forest Rights Act passed by the Indian government in 2006 recognises the **rights of some forest dwelling communities** in forest areas.

### Conservation Reserves

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- Conservation Reserves can be declared by the **State Governments** in any area owned by the Government, particularly the areas adjacent to National Parks and Sanctuaries and those areas which link one Protected Area with another.
- Such a declaration should be made after having consultations with the local communities.
- The rights of people living inside a Conservation Reserve are **not affected.**

### Community Reserves

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

### Sacred Groves

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- India has a history of religious/cultural traditions that emphasised the protection of nature.
- In many cultures, tracts of forest were set aside, and all the trees and wildlife within were venerated and given total protection.

- Such sacred groves are found in **Khasi and Jaintia Hills in Meghalaya, Aravalli Hills of Rajasthan, Western Ghats regions of Karnataka and Maharashtra and the Sarguja, Chanda and Bastar areas of Madhya Pradesh.**
- In Meghalaya, the sacred groves are the last refuges for a large number of rare and threatened plants.

## Ex Situ Conservation

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- In this approach, threatened animals and plants are taken out from their natural habitat and placed in special setting where they can be protected and given special care.
- **Zoological parks, botanical gardens, wildlife safari parks** and **seed banks** serve this purpose.
- There are many animals that have become extinct in the wild but continue to be maintained in zoological parks.
- In recent years ex-situ conservation has advanced beyond keeping threatened species.
- Now **gametes** of threatened species can be preserved in viable and fertile condition for long periods using cryopreservation techniques.
- Eggs can be fertilized in vitro, and plants can be propagated using tissue culture methods.
- Seeds of different genetic strains of commercially important plants can be kept for long periods in **seed banks**.
- The national gene bank at **National Bureau of Plant Genetic Resources (NBPGR), Delhi** is primarily responsible for conservation of unique accessions on long-term basis, as base collections for posterity, predominantly in the form of seeds.

## Botanical garden

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

### Purpose of botanical gardens

- To study the taxonomy as well as growth of plants.
- To study the introduction and acclimatization process of exotic plants.
- It augments conserving rare and threatened species.

## Zoo

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- Zoo is an establishment, whether stationary or mobile, where captive animals are kept for exhibition to the public and includes a circus and rescue centres but does not include an establishment of a licensed dealer in captive animals.
- The initial purpose of zoos was entertainment, over the decades, zoos have got transformed into centres for wildlife conservation and environmental education.
- Apart from saving individual animals, zoos have a role to play in species conservation too (through captive breeding).
- Zoos provide an opportunity to open up a whole new world, and this could be used in sensitizing visitors regarding the value and need for conservation of wildlife.

**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
- 
- Botanical Garden: Plants are bred in a protected environment far from their natural home, especially for research purposes. So, its ex-situ conservation.
  - Rest all along with protected forests and reserved forests are in-situ conservation methods.

Answer: b) Botanical Garden

## **5.5 Historic Citizen Movements to Conserve Biodiversity**

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### **Chipko Movement**

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- It is a social-ecological movement that practiced the **Gandhian methods of satyagraha** and nonviolent resistance, through the **act of hugging trees to protect them from falling**.
- The modern Chipko movement started in the early 1970s in the **Garhwal Himalayas** of Uttarakhand, with growing awareness towards rapid deforestation.
- The landmark event in this struggle took place on March 26, **1974**, when a group of peasant women in Reni village, Hemwalghati, in Chamoli district, Uttarakhand, India, acted to prevent the cutting of trees and **reclaim their traditional forest rights** that were threatened by the contractor system of the state Forest Department.
- Their actions inspired hundreds of such actions at the grassroots level throughout the region.

- By the 1980s the movement had spread throughout India and led to formulation of people-sensitive forest policies, which put a stop to the open felling of trees in regions as far reaching as Vindhya and the Western Ghats.
- The first recorded event of Chipko however, took place in village Khejarli, Jodhpur district, in 1730 AD, when 363 Bishnois, led by Amrita Devi sacrificed their lives while protecting green Khejri trees, considered sacred by the community, by hugging them.

## Appiko Movement

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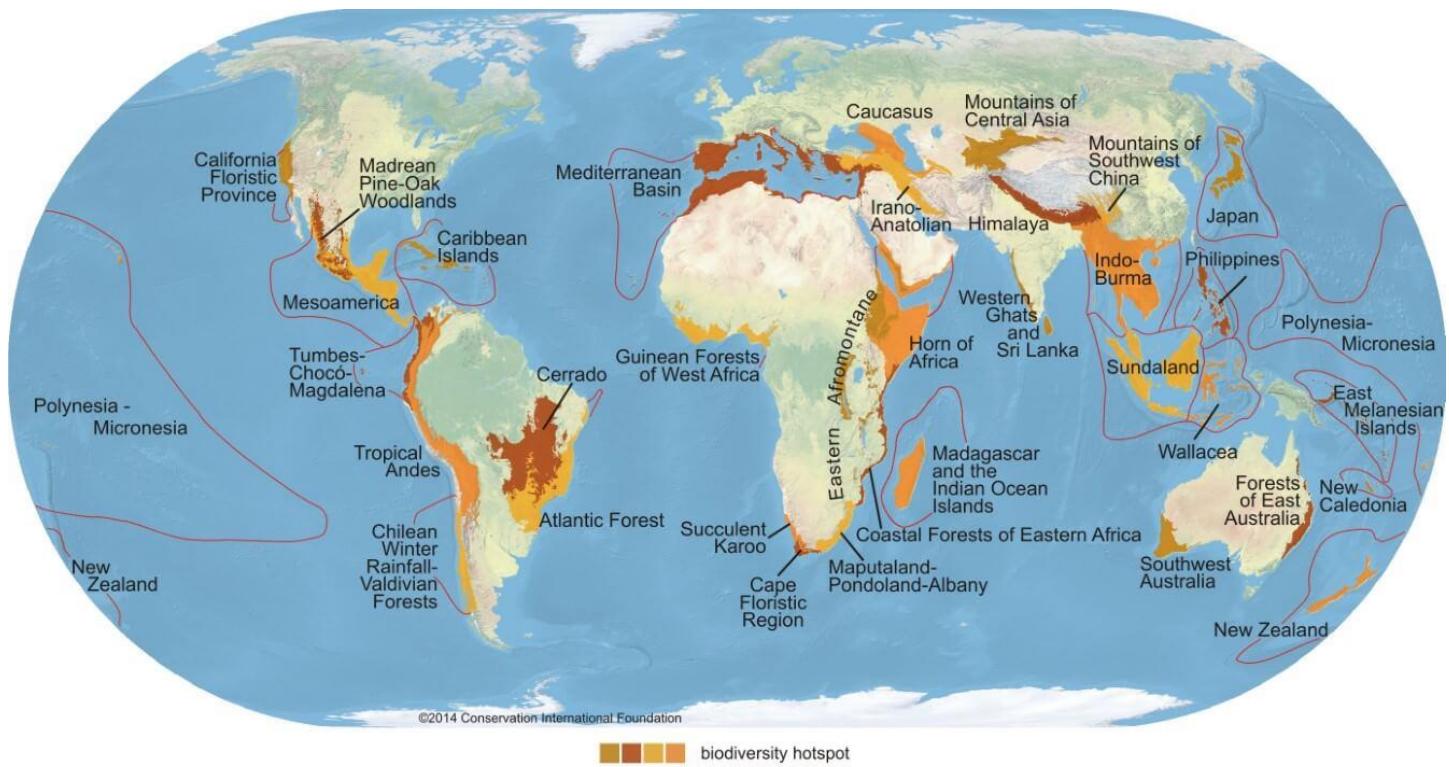
- Appiko movement was a revolutionary movement based on environmental conservation in India.
- The Chipko movement in Uttarakhand in the Himalayas inspired the villagers of the district of Karnataka province in southern India to launch a similar movement to save their forests.
- In September 1983, men, women and children of Salkani 'hugged the trees' in Kalase forest. (The local term for 'hugging' in Kannada is appiko.)
- Appiko movement gave birth to a new awareness all over southern India.

## 5.6 Biodiversity Hot Spots

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- **Biodiversity hotspots** are regions with **high species richness** and a **high degree of endemism**.
- The British biologist **Norman Myers** coined the term "biodiversity hotspot" in 1988 as a biogeographic region characterized both by **exceptional levels of plant endemism** and by **serious levels of habitat loss**.
- **Conservation International (CI)** adopted Myers' hotspots and in 1996, the organization made the decision to undertake a reassessment of the hotspots concept.
- According to CI, to qualify as a hotspot a region must meet two strict criteria:
  - 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, it must have a high percentage of plant life found nowhere else on the planet. A hotspot, in other words, is irreplaceable.**
  - 2) **It has to 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 in the book "Hotspots: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions".
- In 2005 CI published an updated titled "Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions".

- The **35 biodiversity hotspots** cover 2.3% of the Earth's land surface, yet more than 50% of the world's plant species and 42% of all terrestrial vertebrate species are endemic to these areas.
- In 2011, the [Forests of East Australia](#) region was identified as the 35th biodiversity hotspot.



Conservation International (conservation.org) defines 35 biodiversity hotspots — extraordinary places that harbor vast numbers of plant and animal species found nowhere else. All are heavily threatened by habitat loss and degradation, making their conservation crucial to protecting nature for the benefit of all life on Earth.

## Biodiversity hotspots in India

- Himalaya:** Includes the [entire Indian Himalayan region](#) (and that falling in Pakistan, Tibet, Nepal, Bhutan, China and Myanmar).
- Indo-Burma:** Includes entire [North-eastern India, except Assam and Andaman group of Islands](#) (and Myanmar, Thailand, Vietnam, Laos, Cambodia and southern China).
- Sundalands:** [Includes Nicobar group of Islands](#) (and Indonesia, Malaysia, Singapore, Brunei, Philippines).



4) **Western Ghats and Sri Lanka:** Includes entire Western Ghats (and Sri Lanka).

- [Eastern Himalayas](#), which 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](#).

**List of Biodiversity hotspots in India given in Geography notes must be ignored. The info given here is the most accurate.**

[Source](#)

**Q. Consider the following statements: [2010]**

- 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 Nicobar Islands.

**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: d) neither

- The Himalaya Hotspot is home to important populations of numerous large birds and mammals, including 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.

- The spectacular flora and fauna of the Sundaland Hotspot are succumbing to the explosive growth of **industrial forestry** in these islands and to the international animal trade that claims tigers, monkeys, etc.
- 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 also houses important populations of **Asian Elephants, Indian Tigers, the Lion-tailed Macaque, Nilgiri tahr, Indian Giant squirrel**, etc.

## 5.7 World Heritage Sites

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- 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 under the **Convention concerning the Protection of the World Cultural and Natural Heritage**.
- This Convention, which was adopted by the UNESCO in 1972 (and enforced in 1975) provides a framework for international cooperation in preserving and protecting **cultural treasures and natural areas** throughout the world. The first list of World Heritage state was published in 1978.
- The convention defines the kind of sites which can be considered for inscription of the World heritage list (ancient monuments, museums, biodiversity and geological heritage,), and sets out the duties of the State Parties in identifying potential sites and their role in protecting them.

**"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

or

- 1) furnish habitats or rare endangered animals or plants or are sites of exceptional biodiversity".
- 2) There are ten criteria for cultural heritage and natural heritage.
- 3) Nominated sites must be of "outstanding universal value" and meet at least one of the criteria below.

### International Year of Biodiversity

- The United Nations declared 2010 to be the International Year of Biodiversity.
- It is a celebration of life on earth and of the value of biodiversity for our lives.

### Slogan

"Biodiversity is variety of life on earth

Biodiversity is life.

Biodiversity is our life".

## **Man and Biosphere Programme (MAB programme)**

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- It was first started by UNESCO in 1971.
- Later introduced in India in 1986.

### Aim

- Studying the effects of human interference and pollution on the biotic and abiotic components of ecosystems.
- Conservation the ecosystems for the present as well as future.

### The main objects of MAB programme are to:

- Conserve representative samples of ecosystem.
- Provide long term in situ conservation of genetic diversity.
- Provide opportunities for education and training.
- Provide appropriate sustainable managements of the living resources.
- Promote international co-operation.

## **6. International Union for Conservation of Nature**

- (IUCN) is an international organization (**NGO**) working in the field of **nature conservation** and **sustainable use of natural resources**.
- It is involved in data gathering and analysis, 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.
- Its headquarters are in **Gland, Switzerland**.

### **6.1 BirdLife International**

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- BirdLife International is the **world's largest nature conservation partnership**.
- Together they are 120 BirdLife Partners worldwide.

- BirdLife International 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 International Union for Conservation of Nature.
- It identifies the sites known/referred to as '**Important Bird and Biodiversity Areas**'.

**With reference to an organization known as '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
- BirdLife International has nothing to do with the concept "biodiversity hotspots".

Answer: c) 1 and 3 only

## 6.2 CITES

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- CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is also known as the **Washington Convention**)
- It is a **multilateral treaty** drafted as a result of a resolution adopted in 1963 at a meeting of members of the **International Union for Conservation of Nature (IUCN)**.
- CITES entered into force in 1975.
- Convention has 183 parties
- Its aim is to ensure that **international trade in specimens of wild animals and plants does not threaten the survival of the species in the wild**, and it accords varying degrees of protection to more than 35,000 species of animals and plants.
- Although **CITES is legally binding on the Parties** – in other words the member states have to implement the Convention – it does not take the place of national laws.

- Rather it provides a framework to be respected by each Party, which has to adopt its own domestic legislation to ensure that CITES is implemented at the national level.

**Q. With reference to the International Union for Conservation of Nature and Natural Resources (IUCN) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (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
- IUCN is an NGO. CITES is an international agreement between governments (multilateral treaty).
  - Answer: b) 2 and 3 only

Similar treaty: Monitoring the Illegal Killing of Elephants – MIKE

### **6.3 TRAFFIC**

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- TRAFFIC: The Wildlife Trade Monitoring Network (TRAFFIC).
- TRAFFIC is a **NGO** working globally on trade in wild animals and plants in the context of both biodiversity conservation and sustainable development.
- TRAFFIC is a **joint programme of World Wide Fund for Nature (WWF) and IUCN**.
- Traffic is complimentary to CITES.
- The programme was founded in 1976, with headquarters now located in Cambridge, United Kingdom.
- TRAFFIC's mission is to ensure that trade in wild plants and animals is not a threat to the conservation of nature.
- It **investigates and analyses** wildlife trade trends, patterns, impacts and drivers to provide the leading **knowledge base on trade in wild animals and plants**.

**Q. Consider the following statements in respect of Trade Related Analysis of Fauna and Flora in Commerce (TRAFFIC): (2017)**

- 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?

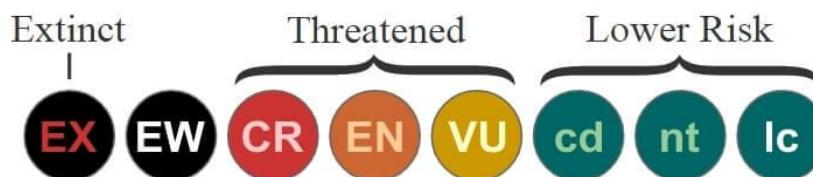
- a) 1 only
- b) 2 only
- c) Both 1 and 2
- d) Neither 1 nor 2

### World Wide Fund for Nature (World Wildlife Fund)

- It is an international **non-governmental organization** founded in 1961.
- It works in the field of the wilderness preservation, and the reduction of human impact on the 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."
- The **Living Planet Report** is published every two years by WWF since 1998.
- WWF has launched several notable worldwide campaigns including **Earth Hour** and **Debt-for-Nature Swap**.

### 6.4 IUCN Red List or Red Data List or Red Book

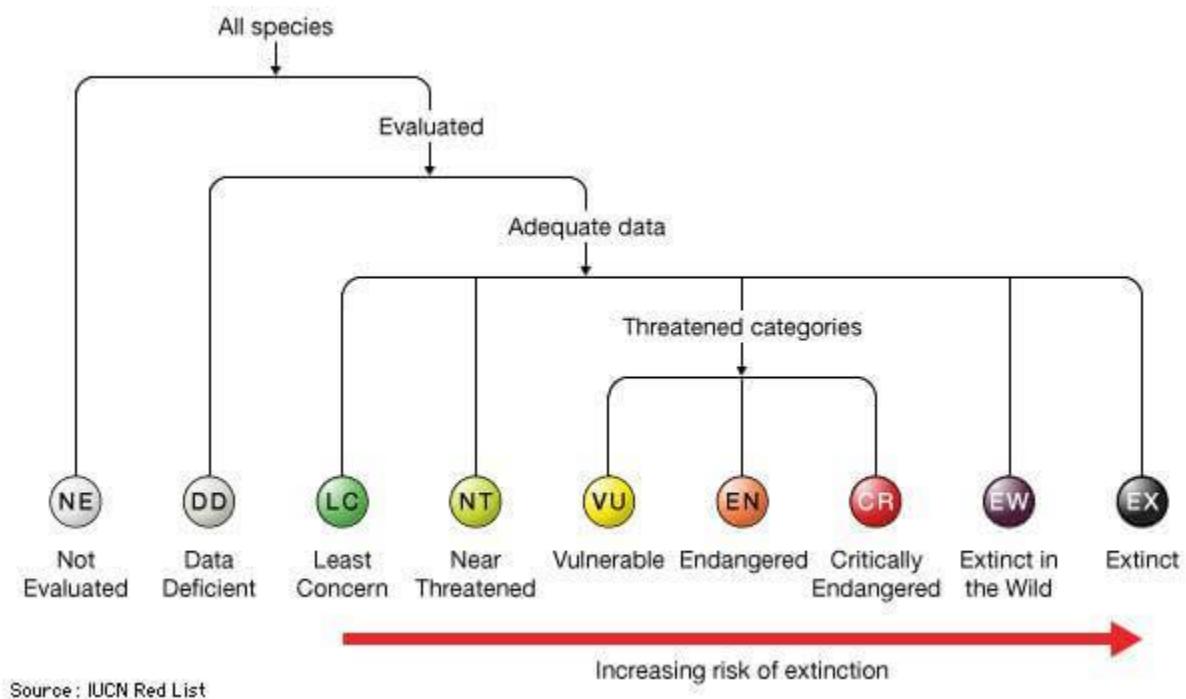
- The IUCN Red List of Threatened Species, founded in 1964, is the world's most comprehensive inventory of the global conservation status of biological species.
- When discussing the IUCN Red List, the official term "**threatened**" is a grouping of three categories: **Critically Endangered, Endangered, and Vulnerable**.



- The **pink pages** in this publication include the **critically endangered species**.
- As the status of the species changes, new pages are sent to the subscribers.

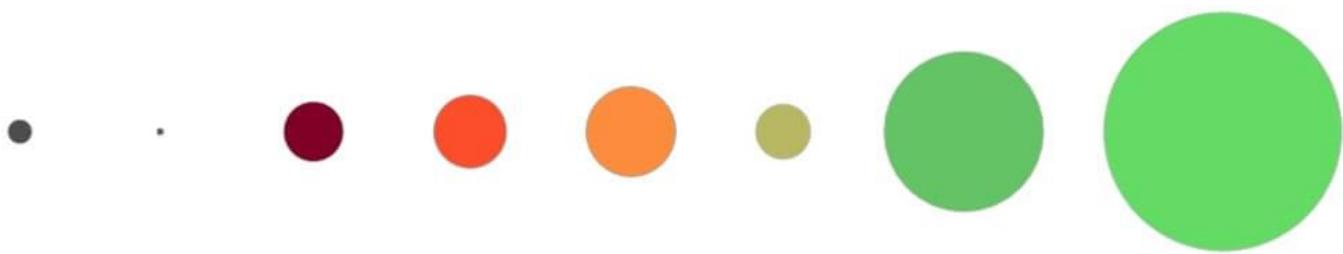
- **Green pages** are used for those species that were **formerly endangered but have now recovered to a point where they are no longer threatened**.
- With passing time, the number of pink pages continue to increase.

Species are classified by the IUCN Red List into nine groups



### Nine Groups in IUCN Red List ([Source](#))

Extinct	Extinct in Wild	Critically Endangered	Endangered	Vulnerable	Near Threatened	Least Concern	All Species
868	78	5176	7705	11654	4406	36952	82065



### Nine Groups in IUCN Red List ([Source](#))

- **Extinct (EX)** → No known individuals remaining.
- **Extinct in the wild (EW)** → Known only to survive in captivity, or as a naturalized population outside its historic range.
- **Critically endangered (CR)** → Extremely high risk of extinction in the wild.
  - ✓ reduction in population (greater than 90% over the last 10 years),
  - ✓ population size (number less than 50 mature individuals),

- ✓ quantitative analysis showing the probability of extinction in wild in at least 50% in their 10 years, and
- ✓ it is therefore considered to be facing an extremely high risk of extinction in the wild.
- **Endangered (EN)** → High risk of extinction in the wild.
- **Vulnerable (VU)** → High risk of endangerment in the wild.
- **Near threatened (NT)** → Likely to become endangered in the near future.
- **Least concern (LC)** → Lowest risk. Does not qualify for a more at-risk category. Widespread and abundant taxa are included in this category.
- **Data deficient (DD)** → Not enough data to assess its risk of extinction.
- **Not evaluated (NE)** → Has not yet been evaluated against the criteria.

**Q. 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 & natural resources in various countries.

Which of the statement given above is/are correct?

- a) 1 & 3
  - b) 2 only
  - c) 2 & 3
  - d) 3 only
- 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

## **6.5 IUCN Red List India (As of March 2019)**

- The list contains critically endangered, endangered and vulnerable species.
- The list is updated by Zoological Survey of India (ZSI) from time to time as per the International Union for Conservation of Nature (IUCN), 1996.

### **'Critically Endangered' Mammals**

#### **Himalayan Brown/Red Bear (*Ursus arctos isabellinus*)**



- Distribution: Nepal, Tibet, north India, and north Pakistan.
- Threats: loss of suitable habitat and persecution by humans.

### **Pygmy Hog (*Porcula salvania*)**

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- Is the world's smallest wild pig. This species constructs a nest throughout the year.
- It is one of the most useful indicators of the management status of grassland habitats.
- The grasslands where the pygmy hog resides are crucial for the survival of other threatened species such as Indian Rhinoceros, Swamp Deer, Wild Buffalo, Hispid Hare, Bengal Florican and Swamp Francolin.
- Habitat: Relatively undisturbed, tall **terai grasslands**.
- Distribution: Previously spread across India, Nepal, and Bhutan. Now only found in Assam (Manas Wildlife Sanctuary and its buffer reserves).
- Pygmy hog-sucking Louse (*Haematopinus oliveri*), a parasite that feeds only on Pygmy Hogs will also fall in the same risk category of critically endangered as its survival is linked to that of the host species.
- Threats: The main threats are **loss and degradation of grasslands**, dry-season burning, livestock grazing and afforestation of grasslands. Hunting is also a threat.

### **Andaman White-toothed Shrew (*Crocidura andamanensis*)**

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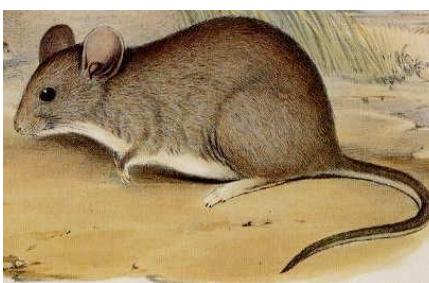
- Distribution: It is endemic to the South Andaman Island of India.
- They are usually active by twilight or in the night.
- Threats: Habitat loss due to selective logging, natural disasters such as tsunami and drastic weather change are thought to contribute to current population declines.

### **Kondana Rat (*Millardia kondana*)**



- Distribution: Known only from the small Sinhagarh Plateau (about one km<sup>2</sup>), near Pune in Maharashtra.
- It is a nocturnal burrowing rodent that is found only in India.
- Habitat: Tropical and subtropical dry deciduous forests and tropical scrub.
- Threats: Major threats are habitat loss, overgrazing of vegetation and disturbance from tourism and recreational activities.

### **Large Rock Rat or Elvira Rat (*Cremnomys elvira*)**



- It is a medium sized, nocturnal and burrowing rodent endemic to India.
- Habitat: Tropical dry deciduous shrub land forest, seen in rocky areas.
- Habitat/distribution: Known only from **Eastern Ghats of Tamil Nadu**. Recorded from an elevation of about 600 m above mean sea level.
- Threats: Major threats are habitat loss, conversion of forests and fuel wood collection.

### **Namdapha Flying Squirrel (*Biswamoyopterus biswasi*)**



- It is a unique (the only one in its genus) flying squirrel that is restricted to a single valley in the **Namdapha N.P. (or) W.L.S. in Arunachal Pradesh.**
- Habitat: Tropical forest.
- Habitat/distribution: Found only in Namdapha Tiger Reserve in Arunachal Pradesh.
- Threats: Hunted for food.

### **Malabar Civet (*Viverra civettina*)**



- It is endemic to India and was first reported from Travancore, Kerala.
- It is nocturnal in nature and found exclusively in the Western Ghats.
- Habitat: Wooded plains and hill slopes of evergreen rainforests.
- Habitat/distribution: Western Ghats.
- Threats: Deforestation and commercial plantations are major threats.

### **Sumatran Rhinoceros (*Dicerorhinus sumatrensis*)**



- It is the smallest and most endangered of the five rhinoceros' species.
- It is now thought to be regionally extinct in India, though it once occurred in the **foothills of the Himalayas** and north-east India.
- The Javan Rhinoceros (*Rhinoceros sondaicus*) is also believed to be extinct in India and only a small number survive in Java and Vietnam.
- Threat: Poaching, loss of habitat.

### **Kashmir stag/hangul (*Cervus elaphus hanglu*)**

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- It is a subspecies of Red Deer which is native to India.
- Habitat: Dense riverine forests, high valleys, and mountains of the Kashmir valley and northern Chamba in Himachal Pradesh.
- **State animal of Jammu and Kashmir.**
- Threat: habitat destruction, over-grazing by domestic livestock, and poaching.

## **'Endangered' Mammals**

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### **Tigers (including Bengal Tiger)**

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- 2015: International Union for Conversation of Nature (IUCN), said that tiger numbers have grown to 3,890—a marked increase from estimates in 2010 that put the number at "as few as 3,200."
- The general observation is that the population of tigers in India has increased while that of the rest of the world has decreased.

## **Asiatic Lion (Included Gir Lions)**

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- Habitat: Gir forests in Gujarat
- Threats: Habitat destruction, Diseases spreading from domestic animals.

## **Red Panda**

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- Red panda is endemic to the **temperate forests of the Himalayas**.
- Habitat: Sikkim and Assam, northern Arunachal Pradesh.
- Threats: habitat loss and fragmentation, poaching, and inbreeding depression.

## **Dhole/Asiatic wild dog or Indian wild dog (*Cuon alpinus*)**

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- Distribution: They occur in most of India south of the Ganges, particularly in the Central Indian Highlands and the Western and Eastern Ghats of the southern states.
- In north-east India, they inhabit Arunachal Pradesh, Assam, Meghalaya, and West Bengal.
- Threats: Habitat loss, depletion of its prey base, competition from other predators, persecution and possibly diseases from domestic and feral dogs.

## **Eld's deer/thamin or brow-antlered deer (*Panolia eldii*)**

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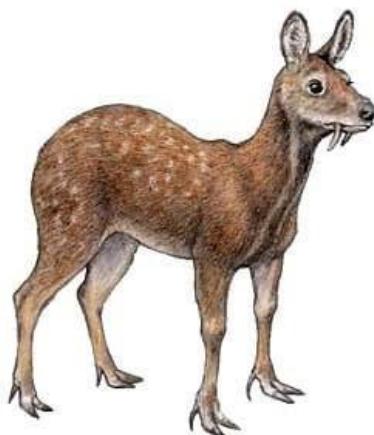
- Distribution: Keibul Lamjao National Park (KLN), Manipur.
- Threats: Overgrazing, loss of grassland habitat.

### **Golden langur (*Trachypithecus geei*)**



- Primate, is an Old World monkey
- Distribution: small region of western Assam and in the neighbouring foothills of the Black Mountains of Bhutan.
- Threats: Deforestation, human encroachments.

### **Himalayan / White-bellied Musk Deer**



- Habitat: Kashmir, Kumaon and Sikkim.
- Threat: poaching & illegal trade for its musk. Only males produce the musk.

### **Hispid hare/ Assam rabbit (*Caprolagus hispidus*)**

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- Habitat: Southern foothills of the central Himalayas.
- Threats: The habitat of hispid hares is highly fragmented due to increasing agriculture, flood control, and human development.

### **Hog deer**

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- Habitat: Terai region and grasslands in northern India.
- Threats: Hunting, habitat loss, habitat fragmentation, human encroachments.

### **Lion-tailed macaque/ wanderoo (*Macaca silenus*)**

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- Endemic to the Western Ghats.
- Avoids human presence and they do not live, feed or travel through plantations.
- Habitat: Evergreen forests in the Western Ghats range.
- Threat: Habitat fragmentation due to spread of agriculture and tea, coffee, teak and cinchona, construction of water reservoirs and human settlements to support such activities.

**Q. In which of the following States is lion-tailed macaque found in its natural habitat?**

- 1) Tamil Nadu
- 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 Western Ghats. So, AP is the odd option.

Answer: a) 1, 2 and 3 only

**Nilgiri tahr**



- The Nilgiri tahr is the largest of the three tahr species, inhabit montane grasslands of Western Ghats. It is the state animal of Tamil Nadu.
- Threats: Habitat loss, overgrazing, illegal hunting.

### **What is/are unique about 'Kharai camel', a breed found in India?**

- 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

Answer: a) 1 and 2 only

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

- Since 2015, Kharai camels are getting protection similar to [endangered species](#).
- During monsoons, they swim to the mangrove islands in hordes.



- For eight months in a year, the Kharai camels are completely dependent on the mangrove islands

- Kharai camels are a main source of livelihood of Jat and Rabari communities (Kutch region).

#### **Q. 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.

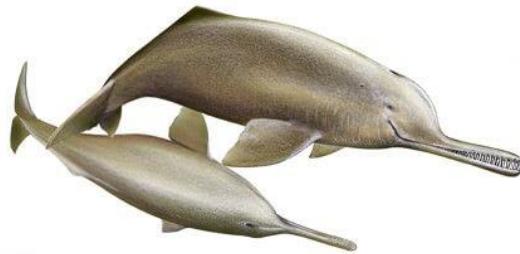
Select the correct answer using the code given below.

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

Answer: a) 1 and 2 only

## **'Endangered' Marine Mammals**

### **Freshwater (river) dolphin / South Asian River Dolphin**



- Because of the sound it produces when breathing, the animal is popularly referred to as the '**Susu**'.
- Susu can only live in freshwater and is **essentially blind**. Hence, susu are also known as **blind dolphin**.
- They hunt by emitting ultrasonic sounds.
- Distribution: India, Bangladesh, Nepal and Pakistan which is split into two subspecies, the Ganges river dolphin and Indus river dolphin.
- 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.

#### **Ganges river dolphin (Susu)**

- Habitat: Ganges and Brahmaputra Rivers and their tributaries in Bangladesh, India and Nepal.
- The Ganges river dolphin has been recognized by the government of India as its **National Aquatic Animal**.

### **Indus river dolphin**

- Habitat: Indus River in Pakistan and its Beas and Sutlej tributaries.

#### **Q. 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
- 'Susu' [shares its habitat with crocodiles](#), freshwater turtles and wetland birds, many of which are fish eaters and are potential competitors with dolphins.

Answer: c) 1, 3 and 4 only

#### **Q. Which one of the following is the national aquatic animal of India?**

- a) Saltwater crocodile
- b) Olive ridley turtle
- c) Gangetic dolphin
- d) Gharial

Answer: c) Susu

### **'Vulnerable' Mammals**

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#### **Lion**

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- Placed in Vulnerable category.
- Threats: Trade in bones is the major reason for their dwindling numbers.

### **Nilgiri langur/ Nilgiri leaf monkey (*Trachypithecus johnii*)**

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- **Moved from Endangered to Vulnerable.**
- Habitat: Hilly areas of Western Ghats in Tamil Nadu and Kerala.
- Threats: Habitat degradation, development activities, introduction of exotic tree species.

### **Great Indian one horn Rhinoceros**

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- Habitat: Found only in the tall grasslands and forests in the foothills of the Himalayas (Terai region).
- National Parks: Kaziranga National Park, Pabitora wildlife sanctuary, Manas National Park, Assam.
- Status in the Wild: Moved from Endangered to Vulnerable.
- Threat: Poached for its horn (in SE Asian countries it is a belief that its horn has medicinal properties), habitat loss, habitat fragmentation.

### **Gaur/Indian Bison**

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- The gaur (*Bos gaurus*), also called Indian bison, is a large bovine native to South Asia and Southeast Asia.
- Gaur are largely confined to evergreen forests or semi-evergreen and moist deciduous forests, but also occur in deciduous forest areas at the periphery of their range.

- The domesticated form of the gaur is called gayal or mithun.
- Threats: Habitat loss, habitat fragmentation.

### **Four-horned antelope, Chousingha**

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- The four-horned antelope must drink water regularly in order to survive.
- Distribution: Presently it is confined to the Indian subcontinent. Scattered between the foothills of the Himalayas in the north to the Deccan Plateau in the south. Gir National Park has 1000 of these animals.
- Threats: Loss of its natural habitat due to agricultural expansion. Four-horned skull and horns have made it a popular target for hunters.

### **Takin**

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- Distribution: Mountainous regions in the Himalayan Mountains and western China.
- Threats: Largely due to overhunting and the destruction of their natural habitat, takin are considered Endangered in China and Vulnerable as per the IUCN.

### **Nilgiri marten**

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- Endemic to the Western Ghats. Inhabits areas that are far from human disturbance.
- Threat: habitat loss and fragmentation, hunting for its fur.
- Only species of marten found in southern India.

### **Barasingha or swamp deer (*Rucervus duvaucelii*)**



- Habitat: Isolated localities in northern and central India, and southwestern Nepal.
- Threats: Hunting for horns, habitat fragmentation and habitat loss.

### **Oriental small-clawed otter/ Asian small-clawed otter (*Aonyx cinerea*)**



- Semiaquatic mammals which feed on fish, amphibians, birds and small mammals.
- It is a smallest otter species in the world.
- Habitat: It lives in **mangrove swamps** and **freshwater wetlands**.
- Threat: habitat loss, pollution and hunting.

### **Clouded leopard (*Neofelis nebulosa*)**



- Habitat: Himalayan foothills through mainland Southeast Asia into China. They occur in northern West Bengal, Sikkim, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Tripura.
- Threat: deforestation and poaching.

### **Asian black bear/ moon bear or white-chested bear (*Ursus thibetanus*)**



- Habitat: Seen across much of the Himalayas, Korea, north-eastern China, the Russian far east and the Honshu and Shikoku islands of Japan.
- Threats: deforestation and active hunting for its body parts.

### **'Vulnerable' Herbivorous Marine Mammals**

#### **Dugong/Sea Cow**



- Threat: hunting (meat and oil), habitat degradation, and fishing-related fatalities.

## Manatees Species

- Dugong belongs to manatees species.
- Habitat: Indian seas (near shore waters of Gulf of Mannar, Gulf of Kachchh and Andaman and Nicobar Islands), Caribbean Sea, Gulf of Mexico, the Amazon Basin, and West Africa
- Threat: Coastal development, red tide, hunting.

**Q. With reference to 'dugong', a mammal found in India, which of the following statements is/are correct?**

- 1) It is an 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

Explanation:

- Dugong is an herbivorous animal. It eats sea grass and aquatic plants found in shallow oceans (at depths sea grass and aquatic plants don't grow due to absence of sunlight).

## 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

## 'Near Threatened' Mammals

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### Wild ass/ khur (Equus hemionus khur)

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- Showed an increase in population. **Moved from Endangered (2015) to Near Threatened (2019).**
- Distribution: Mostly occurs in Rann of Kutch region.
- Population steadily increasing.
- Today, its last refuge lies in the Indian Wild Ass Sanctuary, Little Rann of Kutch.
- Threats: Diseases, habitat degradation due to salt activities, Invasive species **Prosopis juliflora** shrub, and encroachment and grazing by the **Maldhari**.

#### **Q. Why is a plant called *Prosopis juliflora* often mentioned in news? (2018)**

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- 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
- **Prosopis juliflora** is an invasive species.

Answer: b) it reduces biodiversity

#### **Q. 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
- Sandy saline area → Kutch region.
  - Indian wild buffalo → Terai region.
  - Indian wild boar → can survive in different types of habitat: grasslands, taiga, tropical rainforests, but they prefer life in deciduous forests.
  - Chinkara (Indian gazelle) → Thar desert.

Answer: b) Indian wild ass

### **Chiru/ Tibetan Antelope**

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- 2016: Tibetan antelope has been **moved from Endangered to Near Threatened**.
- Habitat: Tibet cold desert.
- Threat: The chiru is threatened by hunting for its fine wool which is used to make the shahtoosh scarves, meat, magnificent horns.

### **Marbled cat (*Pardofelis marmorata*)**

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- Habitat: northern India and Nepal, through south-eastern Asia to Borneo and Sumatra. In India - Sikkim, Darjeeling, moist tropical forest.
- Threats: hunting, habitat destruction for marbled cat and its prey.

### **Himalayan tahr**

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- Habitat: Himalayas.
- Threats: The major threats in China are uncontrolled hunting and deforestation. In India, Himalayan tahr is sometimes hunted for meat, and there is apparently significant competition with livestock for summer grazing in some areas.

### **Markhor (*Capra falconeri*)**



- The markhor is the national animal of Pakistan.
- Habitat: Mountains of central Asia. In India - some parts of Jammu and Kashmir .
- Status: Moved from endangered to Near Threatened in 2015
- Threats: Hunting (both for meat and for its twisted horns), armed conflict and habitat loss.

### **Least concern**

### **Blackbuck (Salman Khan)**



- **Moved from Near Threatened to Least Concern.**
- Distribution: In the Indian subcontinent, the blackbuck can also be found in deserts (in the north western region), coastal areas, mountains (in the northern-north-eastern region) Habitat: Grass land.
- Threat: excessive hunting for meat and sporting trophies, as well as habitat loss.

## 'Not Evaluated' Mammals

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### Himalayan wolf

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- Conservation Status is 'Not Evaluated'. Several biologists feel that it needs be in the 'Critically Endangered List'.
- Distribution: Trans-Himalayan region of Himachal Pradesh, Jammu and Kashmir.
- Threats – Climate Change, Prey by humans to protect their cattle.

## Crocodile species in India

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- **Gharials (Critically Endangered)** once thrived in all the major river systems of the Indian Subcontinent.
- Today, they are extinct in the Indus River, in the Brahmaputra of Bhutan and Bangladesh, and in the Irrawaddy River.
- Their distribution is now limited to only 2% of their former range.
- The **mugger (or marsh) crocodile (Vulnerable)** is a freshwater species found sparsely in various lakes, rivers and marshes in the Indian subcontinent.

- Apart from the eastern coast of India, the **saltwater crocodile (Least Concern)** is extremely rare on the Indian subcontinent.
- A huge population is present within the **Bhitarkanika Wildlife Sanctuary of Odisha** and they are known to be present in smaller numbers throughout the Indian and Bangladeshi portions of the Sundarbans.

## 'Critically Endangered' Birds

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### The Jerdon's Courser (*Rhinoptilus bitorquatus*)

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- It is a nocturnal bird found only in the northern part of the state of Andhra Pradesh in peninsular India (**Sri Lankamaleswara Wildlife Sanctuary**).
- Habitat: Undisturbed scrub jungle with open areas.
- Distribution: Jerdon's Courser is endemic to Andhra Pradesh.
- Threats: Clearing of scrub jungle, creation of new pastures, growing of dry land crops, Illegal trapping of birds, plantations of exotic trees, quarrying and the construction of the River Canals.

### White-bellied Heron (*Ardea insignis*)

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- Distribution: Extremely rare bird found in five or six sites in Assam and Arunachal Pradesh, one or two sites in Bhutan, and a few in Myanmar.

- Habitat: Rivers with sand or gravel bars or inland lakes.
- Threats: Loss and degradation of lowland forests and wetlands through direct exploitation and disturbance by humans.

### **Bengal Florican (*Houbaropsis bengalensis*)**



- A rare bustard species that is very well known for its **mating dance**.
- Habitat: Grasslands occasionally interspersed with scrublands.
- Distribution: Native to only 3 countries in the world - Cambodia, India and Nepal. In India, it occurs in 3 states, namely Uttar Pradesh, Assam and Arunachal Pradesh.
- Threats: Ongoing conversion of the bird's grassland habitat for various purposes including agriculture is mainly responsible for its population decline.

### **Himalayan Quail (*Ophrysia superciliosa*)**



- Habitat: Tall grass and scrub on steep hillsides.
- Distribution: Western Himalayas.
- Threats: Indiscriminate hunting during the colonial period along with habitat modification.

### **Pink-headed Duck (*Rhodonessa caryophyllacea*)**



- Males have a deep pink head and neck from which the bird derives its name.
- Habitat: Overgrown still-water pools, marshes and swamps in lowland forests and tall grasslands.
- Distribution: Recorded in India, Bangladesh and Myanmar. Maximum records are from north-east India.
- Threats: Wetland degradation and loss of habitat, along with hunting are the main causes of its decline.

### **Sociable Lapwing (*Vanellus gregarius*)**



- It is a **winter migrant** to India.
- Habitat: Fallow fields and scrub desert.
- Distribution: central Asia, Asia Minor, Russia, Egypt, India, Pakistan. In India, habitat is restricted to the north and north-west of the country.
- Threats: Conversion of habitat to arable land, illegal hunting and proximity to human settlements.

### **Spoon Billed Sandpiper (*Eurynorhynchus pygmeus*)**



- India is home to some of the last existing wintering grounds of this species.
- Habitat: Coastal areas with sparse vegetation.
- Distribution: Has been recorded along the coastlines of West Bengal, Orissa, Kerala and Tamil Nadu.
- Threats: Habitat degradation and land reclamation. Human disturbance also leads to high incidence of nest desertion.

### **Siberian Crane (*Grus leucogeranus*)**



- It is a large, strikingly majestic migratory bird that breeds and winters in wetlands.
- They are known to arrive in **winter at Keoladeo National Park, Rajasthan**.
- Habitat: Wetland areas.
- Located distribution: Keoladeo National Park in Rajasthan.
- Threats: Pesticide pollution, wetland drainage, development of prime habitat into agricultural fields, and to some extent, hunting.

### **Endangered Birds**

#### **Forest Owlet (*Heteroglaux blewitti*)**



- **Moved from Critically Endangered to Endangered.**
- Habitat: Dry deciduous forest.
- Habitat: South Madhya Pradesh, in north-west Maharashtra and north-central Maharashtra.
- Threats: Logging operations, burning and cutting of trees damage roosting and nesting trees of the Forest Owl.

## 'Vulnerable' Birds

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### Great Indian Hornbill

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- Habitat: Rainforest regions of India (Western Ghats and North eastern region of India), Southeast Asia.
- Threats: Habitat loss and hunting.

**Q. In which of the following regions of India are you most likely to come across the 'Great Indian Hornbill' in its natural habitat? (2016)**

- a) Sand deserts of northwest India
- b) Higher Himalayas of Jammu and Kashmir
- c) Salt marshes of western Gujarat

- d) Western Ghats

### **Black-Necked Crane (*Grus nigricollis*)**

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- The threat to the future of a vulnerable bird species has halted the Rs. 6,400-crore hydro power project in Tawang, Arunachal Pradesh.
- The species breeds on the Tibetan plateau and migrates to Tawang for the winter.
- The bird, most commonly found in China, is legally protected in Bhutan and India and is considered sacred to certain Buddhist traditions.

### **Q. 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. As of 2019, the status of many of these animals has changed.

### **'Critically Endangered' Reptiles**

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#### **Gharial (*Gavialis gangeticus*)**

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- It is the most uniquely evolved crocodilian in the world, a specialized, river-dwelling, fish-eater.
- Habitat: Clean rivers with sand banks.

- Distribution: Only viable population in the **National Chambal Sanctuary**, spread across three states of Uttar Pradesh, Rajasthan and Madhya Pradesh in India.
- Small non-breeding populations exist in Son, Gandak, Hoogly and Ghagra rivers. Now extinct in Myanmar, Pakistan, Bhutan and Bangladesh.
- Threats: The combined effects of dams, barrages, artificial embankments, change in river course, pollution, sand-mining, riparian agriculture and ingress of domestic and feral livestock.

**Q. If you want to see gharials in their natural habitat, which one of the following is the best place to visit? (2017)**

- a) Bhitarkanika Mangroves
- b) Chambal River
- c) Pulicat Lake
- d) Deepor Beel

### **Hawksbill Turtle (*Eretmochelys imbricata*)**



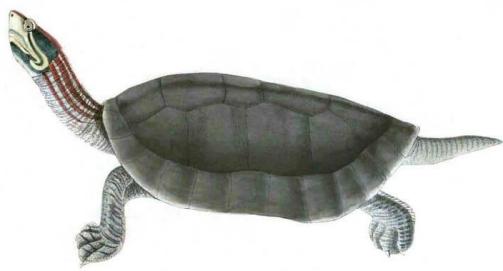
- The species is migratory in nature and nesting occurs in about 70 countries across the world.
- Maturation is slow and is estimated between 25 — 40 years.
- Habitat: Nesting occurs on insular, sandy beaches.
- Distribution: In India they are found in the Andaman and Nicobar Islands, the coast of Tamil Nadu and Orissa.
- Threats: Turtle shell trade, egg collection, slaughter for meat, oil pollution and destruction of nesting and foraging habitats.

### **Four-toed River Terrapin or River Terrapin (*Batagur baska*)**



- Habitat: Freshwater rivers and lakes.
- Distribution: Bangladesh, Cambodia, India, Indonesia and Malaysia.
- Threats: Use of flesh for medicinal purposes, demand for eggs, which are considered a delicacy

### **Red-crowned Roofed Turtle or the Bengal Roof Turtle (Batagur kachuga)**



- Habitat: Deep, flowing rivers but with terrestrial nest sites.
- Distribution: Found in India, Bangladesh and Nepal. In India it resides basically in the watershed of the Ganga.
- Threats: Water development projects, water pollution, human disturbance and poaching for the illegal wildlife market.

### **'Vulnerable' Reptiles**

#### **Leatherback Turtle (Dermochelys coriacea)**



- **Moved from Critically Endangered to Vulnerable.**
- It is the largest of the living sea turtles, weighing as much as 900 kg.

- Jellyfish is their primary food.
- Habitat: Tropical and subtropical oceans.
- Distribution: Found in tropical and temperate waters of the Atlantic, Pacific, and into Indian Oceans.
- Threats: High sea fishing operations, harvesting of eggs, destruction of nests by wild predators and domesticated species such as cats, dogs and pigs.
- Artificial lighting disorients hatchlings and adults and causes them to migrate inland rather than towards the sea.
- Threats to habitat include construction, mining and plantation of exotics.

**Q. 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
- Gharial are 'Critically Endangered'. Swamp deer (barasingha) and Leatherback turtle are 'Vulnerable'.

Answer: d) none

**Olive ridley sea turtle**

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- Also known as the Pacific ridley sea turtle.
- Distribution: found in warm and tropical waters, primarily in the Pacific and Indian Oceans.
- Olive ridley turtles are best known for their behaviour of synchronized nesting in mass numbers.
- In the Indian Ocean, the majority of olive ridleys nest near **Gahirmatha** in Odisha.

- The coast of Odisha in India is the largest mass nesting site for the olive ridleys.
- 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.
- Coastal development, natural disasters, climate change, and other sources of beach erosion have also been cited as potential threats to nesting grounds.

### What's the difference between turtles and tortoises?

Turtle	Tortoise
• Lives in water	• Lives on land
• Come to land to lay eggs	• Everything happens on land
• Good swimmers	• Bad swimmers
• Carnivores (flesh eating)	• Herbivores (plant eating)

Terrapins are almost a combination of turtles and tortoises. They live in water, mostly small dams or ponds; however they can also live on land.

### 'Near Threatened' Reptiles

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#### Sispara day gecko (*Cnemaspis sisparensis*)

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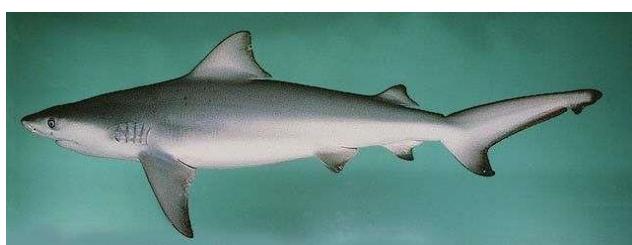
- Distribution: Endemic to Western Ghats, and found in Sispara, Nilgiris, Kavalai near Cochin.
- Threats: Habitat conversion and modification.

### 'Critically Endangered' Fish

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#### The Pondicherry Shark (*Carcharhinus hemiodon*)

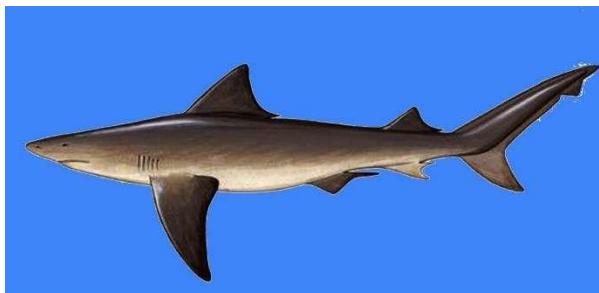
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- Distribution: Indian Ocean – from Gulf of Oman to Pakistan, India and Sri Lanka.
- In scattered localities spanning India to New Guinea. Also been recorded at the mouth of the Hooghly river.
- Threats: Large, expanding, and unregulated commercial fisheries in inshore localities and habitats.

### **The Ganges Shark (*Glyptis gangeticus*)**

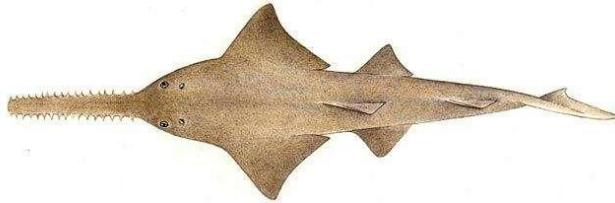
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- It occurs in the turbid waters of the **Ganga river and the Bay of Bengal**.
- The small eyes suggest that it is adapted to living in turbid water (just like dugong), while the slender teeth of the species suggest that it is primarily a fish-eater.
- Distribution: It occurs in India and possibly in Pakistan. The Ganga river system and Hooghly river mouth are its known habitats.
- Threats: Major fisheries targeting sharks. Other probable threats include overfishing, pollution, increasing river use and construction of dams and barrages.

### **Large-tooth Sawfish (*Pristis microdon*)**

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- Distribution: Western part of the Indo-Pacific (East Africa to New Guinea, Philippines and Vietnam to Australia).
- In India, it is known to enter the **Mahanadi river**, up to 64 km inland, and also is very common in the estuaries of the Ganga and Brahmaputra.
- Threats: The principal threat to all sawfish are fisheries. Their long tooth-studded saw makes them extraordinarily vulnerable to entanglement in any sort of net gear.
- When sawfish are caught in by catch, they often end up being traded because of the very high value of their products (meat is high quality and fins and saws extremely valuable in international trade).

- Major habitat changes include construction of dams over rivers, siltation, pollution from industries and mining operations.

### **Long-comb Sawfish or Narrow-snout Sawfish (*Pristis zijsron*)**

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- This species was reported as frequently found in shallow water. It inhabits muddy bottoms and also enters estuaries.
- Distribution: Indo-Pacific region including Australia, Cambodia, China, India, Indonesia and Malaysia.
- Threats: This species has been damaged intensively, both as a target species and as incidental by catch in commercial, sport or shark-control net fisheries, as well as for aquarium display. As a result, it has become severely depleted in recent decades, and now appears to have been extirpated from many parts of its range.

### **'Endangered' Fishes**

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#### **Knife-tooth Sawfish (*Anoxypristes cuspidata*)**

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- Distribution: Widespread in western part of the Indo-Pacific region, including Red Sea.
- Threats: Similar to Long-comb Sawfish.

### **'Critically Endangered' Spiders**

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#### **Rameshwaram Ornamental or Rameshwaram Parachute Spider (*Poecilotheria hanumavilasumica*)**

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- It was recently described in 2004 and is only found in India.
- The species is semi-social, which means they live partly in groups.
- Habitat: Arboreal (living in trees) and tend to live in hiding.
- Distribution: Endemic to India. Spread along the coastal savannah, tropical lowland rain forests and montane forests up to an altitude of 2000 m above mean sea level.
- Threats: Major threats causing the disappearance of this species is habitat alteration and degradation.

### **Gooty Tarantula, Metallic Tarantula or Peacock Tarantula (*Poecilotheria metallica*)**



- It was first found in Gooty (Ooty/Udagamandalam).
- Habitat: Wooded mountain area.
- Distribution: Endemic to South India.
- Threats: They are one of the most expensive spiders in the illegal pet trade.

### **'Critically Endangered' Corals**

#### **Fire corals (*Millepora boschmai*)**



- They are more closely related to jellyfish than corals.
- Distribution: Indonesia, Gulf of Chiriquí, Panama Pacific Province. Possibly extinct from Australia, India, Indonesia, Malaysia, Panama, Singapore and Thailand.
- Threats: Collected for decoration and jewellery trade. This group is also sensitive to temperature rise and is thought to have completely disappeared from the majority of marine areas possibly because of growing global warming related bleaching effects.

## Others

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### Flying squirrel



- Flying squirrels are mammals too, but they don't really fly.
- They jump from high in trees and glide through the air like a kite.
- Flying squirrels are a tribe of 44 species of squirrels.
- Their conservation status varies from Near Threatened to Endangered.
- Indian giant flying squirrel is included under 'Least Concerned'.

### **Q. 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
- Black-necked crane is commonly found in Tibetan and trans-Himalayan region. In winters they migrate to less colder regions of Indian Himalayas.
  - Cheetah is an **extinct species**. They have gone extinct during pre-independence era. Reason: They were hunted down by various Indian kings and British officers.
  - Flying Squirrels are found in many Indian forests.
  - Snow leopard is an 'endangered' specie found in the Himalayan ranges.

Answer: b) 1, 3 and 4 only

## **Steps Taken by the Government for Wildlife Protection**

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- All the states, **excluding Jammu and Kashmir** (it has its own Act), adopted **Wildlife (Protection) Act in 1972** which **prohibits any type of trade for endangered and rare species**.
- The Central Government provides financial assistance to the State Governments for the conservation and protection of the endangered species.
- **National ban was imposed on tiger hunting in 1970** and Wildlife Protection Act became effective in 1972.
- Innumerable numbers of National Parks, Wildlife Sanctuaries, Parks etc. have been established by the government.
- In 1992, Central Zoo Authority (CZA) was initiated for the supervision of the management of zoological parks in the country.
- In 1996, the Wildlife Advisory Committee and Wildlife Institute were established for seeking advice on different features of Wildlife conservation and matters related to it.

India is part of five main International Conventions which are associated to wildlife conservation:

- 1) Convention on International Trade in Endangered Species (CITES),**
- 2) Coalition Against Wildlife Trafficking (CAWT),**
- 3) International Whaling Commission (IWC),**
- 4) United Nations Educational, Scientific and Cultural Organization – World Heritage Committee (UNESCO – WHC) and**
- 5) Convention on Migratory Species (CMS).**

## 6.6 Misc. Topics

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### Migratory Birds

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- Migration refers to the cyclical seasonal movement of birds from one place to other.
- The distance of migration ranged from short distance to thousands of kilometres.
- But at the end of period, birds will eventually return to the original place.

### Reasons for migration

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- To avoid adverse factors (extreme climatic condition)
- To manage food shortage
- To manage shortage of water
- To have a better breeding conditions
- Less competition for safe nesting places

### Migratory birds of India

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Winter birds	Summer birds
<ul style="list-style-type: none"><li>• Siberian Cranes, Greater Flamingo, Common Teal, Yellow Wagtail, White Wagtail, Northern Shoveler, Rosy Pelican, Wood Sandpiper, Spotted Sandpiper, Eurasian Pigeon, Black Tailed Godwit, Spotted Redshank Starling Bluethroat, Long Billed Pipit.</li></ul>	<ul style="list-style-type: none"><li>• Asian Koel, Black Crowned Night Heron, Eurasian Golden Oriole, Comb Duck, Blue Cheeked Bee Eater, Blue Tailed Bee-Eater, Cuckoos.</li></ul>

### Egg Laying Mammals

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- The unique feature of **monotremes**, a sub division of mammal, is that monotremes lay eggs rather than giving birth to their young.
- There are only five living Monotreme/egg laying Mammals species: they are – the duck-billed **platypus** and four species of spiny anteaters (also known as **echidna**).
- All of them are found only in **Australia and New Guinea**.
- In echidnas, the egg is carried in a pouch on the female's belly until the young hatches, at which point the barely-developed young must find a mammary gland and latch onto it for nourishment.



## Marsupials

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- Marsupials are the group of mammals commonly thought of as **pouched mammals** (like the wallaby and kangaroo).
- Marsupial mammals have placenta, but it is very short-lived and does not make as much of a contribution to foetal nourishment.
- They give birth very early and the young animal, essentially a helpless embryo, climbs from the mother's birth canal to the nipples.
- There it grabs on with its mouth and continues to develop, often for weeks or months depending on the species.

### List of common Marsupials

- Kola
- Kangaroo
- Wallaby
- Tasmanian devils



## Insectivorous Plants

- These plants are specialized in trapping insects and are popularly known as insectivorous plants.
- They are very different from normal plants in their mode of nutrition. They, however, never prey upon humans or large animals.
- Insectivorous plants can broadly be divided into active and passive types based on their method of trapping their prey.
- The active ones can close their leaf traps the moment insects land on them.
- The passive plants have a 'pitfall' mechanism, having some kind of jar or pitcher-like structure into which the insect slips and falls, to eventually be digested.
- The insectivorous plants often have several attractions such as brilliant colors, sweet secretions and other curios to lure their innocent victims.

### Why do they hunt despite having normal roots and photosynthetic leaves?

- These plants are usually associated with rain-washed, nutrient-poor soils, or wet and acidic areas that are ill-drained.
- Such wetlands are **acidic due to anaerobic conditions, which cause partial decomposition of organic matter** releasing acidic compounds into the surroundings.
- As a result, most microorganisms necessary for complete decomposition of organic matter cannot survive in such poorly oxygenated conditions.

- Normal plants find it difficult to survive in such nutrient poor habitats.
- The hunter plants are successful in such places because they supplement their photosynthetic food production by trapping insects and digesting their nitrogen rich bodies.

## Insectivorous plants of India

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- Insectivorous plants of India belong mainly to three families:
- Droseraceae (3 species),
- Nepenthaceae (1 species) and
- Lentibulariaceae (36 species).

## Drosera and Aldrovanda

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- Drosera and Aldrovanda belong to family Droseraceae.
- Drosera or Sundew inhabit wet infertile soils or marshy places.
- Aldrovanda is a free-floating, rootless aquatic plant, the only species found in India, occurs in the salt marshes of Sunderbans, south of Calcutta. It also grows in fresh water bodies like ponds, tanks and lakes.

## Insect trapping mechanism of Drosera



- The tentacles on the leaves secrete a sticky fluid that shines in the sun like dew-drops. Therefore, the Drosera are commonly known as **sundews**.
- When an insect lured by these glistening drops alights on the leaf surface it gets stuck in this fluid and are absorbed and digested.

## Insect trapping mechanism of Aldrovanda



- On the leaf midrib are found some sensitive trigger hairs. The two halves of the leaf blade of Aldrovanda close along the midrib the moment an insect comes into contact with the leaf, trapping the victim inside.

### Pitcher Plants Family: Nepenthaceae

- Pitcher plants belong to family nepenthaceae. The members of the family are commonly known as 'pitcher plants' because their leaves bear jar-like structures.
- Distribution: Confined to the **high rainfall hills and plateaus of north-eastern region**, at altitudes ranging from 100-1500 m, particularly in **Garo, Khasi and Jaintia hills of Meghalaya**.

### Insect trapping mechanism of pitcher plant



- Nepenthes conforms to the pitfall type of trap. A honey like substance is secreted from glands at the entrance of the pitcher. Once the insect enters into the pitcher, it falls down because of the slipperiness.
- The inner wall, towards its lower half, bears numerous glands, which secrete a proteolytic enzyme. This enzyme digests the body of the trapped insects and nutrients are absorbed.

### Utricularia and Pinguicula

- Utricularia and Pinguicula belong to family Lentibulariaceae.

### Insect trapping mechanism of Utricularia or Bladderworts



- The Bladderworts generally inhabit freshwater wetlands and waterlogged areas.
- Some species are associated with moist moss covered rock surfaces, and damp soils during rains.
- Utricularia in its bladders mouth, has sensitive bristles or hairs. When an insect happens to contact these hairs the door opens, carrying the insect into the bladder along with a little current of water.
- The door is shut when water fills the bladder, the enzymes produced by the inner wall of the bladder digest the insect.

### Insect trapping mechanism of Pinguicula or Butterwort



- It grows in the alpine heights of Himalayas, from Kashmir to Sikkim, along stream-sides in cool boggy places.
- In Pinguicula, an entire leaf works as trap. When an insect lands on the leaf surface, it gets stuck in the sticky exudate. the leaf margins roll up thus trapping the victim.

### Medicinal Properties of Insectivorous Plants

- Drosera are capable of curdling milk, its bruised leaves are applied on blisters and used for dyeing silk.
- Nepenthes in local medicine to treat cholera patients, the liquid inside the pitcher is useful for urinary troubles, it is also used as eye drops.
- Utricularia is useful against cough, for dressing of wounds, as a remedy for urinary disease.

### Threats

- Gardening trading for medicinal properties is one of the main causes for their decline.

- Habitat destruction is also rampant, the wetlands harbouring such plants being the main casualties during the expansion of urban and rural habitation.
- Pollution caused by effluents containing detergents, fertilizers, pesticides, sewage etc. into the wetlands is yet another major cause for their decline (Since insectivorous plants do not tolerate high nutrient levels).
- Moreover, polluted water bodies are dominated by prolific water weeds which cause elimination of the delicate insectivorous plants.

## Indian Vulture Crisis

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- India is most favourable region for Vultures: Hindus do not eat cows, which they consider sacred, and when a cow dies, it is left to be fed on by vultures.
- India has a high species diversity and hence vultures get lot of food.
- Nine species of vulture can be found living in India. But today, most are in danger of extinction due to a veterinary drug called **diclofenac** (vultures do not have a particular enzyme to break down diclofenac).

## Diclofenac

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- Diclofenac is a common **anti-inflammatory drug administered to livestock** and is used to treat the symptoms of inflammation, fevers and/or pain associated with disease or wounds.
- Diclofenac 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 (*Gyps bengalensis*) fell 99.7% between 1993 and 2002.
- The populations of the Indian vulture (*Gyps indicus*) and the slender-billed vulture (*Gyps tenuirostris*) fell 97.4%.
- The percentages differ slightly because the white-rumped vulture is more sensitive to diclofenac than the other two species, but all three were in danger of extinction.
- Two other species of Gyps, the Himalayan vulture (*Gyps himalayensis*) and the Eurasian griffon (*Gyps fulvus*) 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

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- Vultures previously played an important role in public sanitation in India and their disappearance has resulted in an explosion of rats and wild dogs and the spread of diseases resulting in an estimated cost of up to ₹1700 billion (US\$25 billion) (as of 2015).

- The carcasses formerly eaten by vultures' rot in village fields leading to contaminated drinking water.
- These 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.
- The mammals also carry diseases from rotting carcasses such as rabies, anthrax, plague etc. and are indirectly responsible for thousands of human deaths.

## Diclofenac Alternative

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- The drug was banned for veterinary use in India in March 2006.
- A replacement drug was quickly developed and proposed after tests on vultures in captivity: **meloxicam**.
- Meloxicam affects cattle the same way as diclofenac but is harmless for vultures.
- Diclofenac for human use was still being diverted into veterinary uses through black markets in certain parts of India.

## Conservation Status of India Vultures (As of March 2019)

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### Critically Endangered

- White-Rumped Vulture (*Gyps bengalensis*)
- White-Backed Vulture (*Gyps africanus*)
- Ruppell's Vulture (*Gyps rueppellii*)
- Indian Vulture (*Gyps indicus*)
- Slender-Billed Vulture (*Gyps tenuirostris*)

### Endangered

- Cape Vulture (*Gyps coprotheres*)

### Near Threatened

- Himalayan Vulture (*Gyps himalayensis*)

### Least Concern

- Griffon Vulture (*Gyps fulvus*)

## Critically Endangered

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### White-Rumped Vulture (*Gyps bengalensis*)



- The white-rumped vulture was very common especially in the Gangetic plains of India, and often seen nesting on the avenue trees within large cities in the region.

### **White-Backed Vulture (*Gyps africanus*)**



### **Ruppell's Vulture (*Gyps rueppellii*)**



### **Indian Vulture (*Gyps indicus*)**



- The Indian vulture is found only to the south of the Ganges and breeds on cliffs.

### **Slender-Billed Vulture (*Gyps tenuirostris*)**



- The slender-billed vulture is found along the Sub-Himalayan regions and into Southeast Asia.

### **Endangered**

### **Cape Vulture (*Gyps coprotheres*)**



## Near Threatened

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### Himalayan Vulture (*Gyps himalayensis*)



- Found along the Himalayas and the adjoining Tibetan Plateau

## Least Concern

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### Griffon Vulture (*Gyps fulvus*)



## Vulture Safety Zones

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- 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 VSZ on the Indian borders.

VSZ's provide

- A safe source of food that is free of contamination from veterinary drugs, poisons and other agricultural chemicals.
- A place where vultures can feed free from human disturbances.
- Extra food close to breeding colonies, this helps to increase their breeding success by improving the survival chances of the young vultures.

### Vulture Restaurants

- At this restaurant, tables are reserved only for the unique and rare vultures by Maharashtra and Punjab forest departments.

## 7. Climate Change

- Climate change means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (100 years).
- Climate change is usually measured in major shifts in temperature, rainfall, snow, and wind patterns lasting decades or more.
- Humans are creating climate change by burning large amounts of fossil fuels (coal, oil, natural gas), **deforestation (when forests are cut down or burned, they can no longer store carbon, and the carbon is released to the atmosphere)**.

### 7.1 Greenhouse effect and Global Warming

- 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 and 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 the **infrared 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

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- The green-house effect is a natural phenomenon and has been occurring 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 percent of total greenhouse warming.
- Average global temperatures are maintained at about 15°C due to natural greenhouse effect.
- Without this phenomenon, average global temperatures might have been around –17°C and at such low temperature life would not be able to exist.

## Greenhouse Gases (GHGs)

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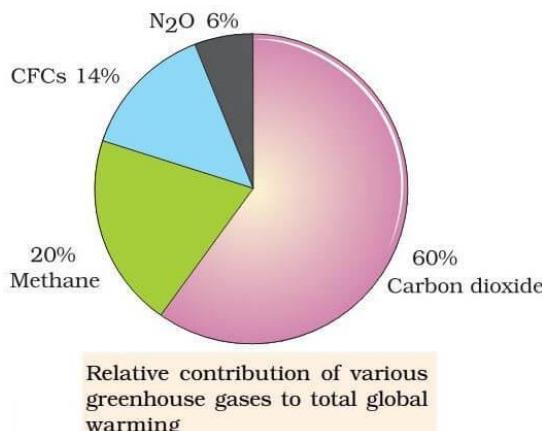
- Atmospheric gases like **carbon dioxide, methane, nitrous oxide ( $N_2O$ ), water vapour, and chlorofluorocarbons** are capable of **trapping the out-going infrared radiation** from the earth's surface thereby causing **greenhouse effect**.
- Hence these gases are known as **greenhouse gases** and the heating effect is known as **greenhouse effect**.

**Oxides of Nitrogen with general formula  $NO_x$  –  $NO$ ,  $NO_2$  – Nitrogen oxide, Nitrogen dioxide etc. are global cooling gasses while Nitrous oxide ( $N_2O$ ) is a greenhouse gas.**

- If greenhouse gases are not checked, by the turn of the century the temperature may rise by 5°C.
- Scientists believe that this rise in temperature will lead to deleterious changes in the environment and resulting in odd climatic changes (e.g. increased incidence of El Nino), thus leading to increased melting of polar ice caps as well as of other places like the Himalayan snow caps.

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

- Over many years, this will result in a rise in sea level that can submerge many coastal areas and lead to loss of coastal areas and ecosystems like swamps and marshes (most important ecosystems from the point of ecological services), etc.



Gas	Sources and Causes
Carbon dioxide (CO <sub>2</sub> )	Burning of fossil fuels, deforestation
Chlorofluorocarbons (CFCs)	Refrigeration, solvents, insulation foams, aero propellants, industrial and commercial uses
Methane (CH <sub>4</sub> )	Growing paddy, excreta of cattle and other livestock, termites, burning of fossil fuel, wood, landfills, wetlands, fertilizer factories.
Nitrogen oxides (N <sub>2</sub> O)	Burning of fossil fuels, fertilizers; burning of wood and crop residue.
Carbon Monoxide (CO)	Iron ore smelting, burning of fossil fuels, burning e-waste.

## Carbon dioxide

- Carbon dioxide is meteorologically a very important gas as it is **transparent to the incoming solar radiation but opaque to the outgoing terrestrial radiation**.
- It absorbs a part of terrestrial radiation and reflects back some part of it towards the earth's surface. It is **largely responsible for the greenhouse effect**.
- Its **concentration is greater close to the earth's surface as it is denser than air**.

## 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 the harmful UV radiation**.
- At ground level, pollutants like **NO<sub>2</sub> react with volatile organic compounds** in the **presence of sunlight** to **produce ozone (tropospheric ozone)**.

## Water vapour

- Water vapour is also a variable gas in the atmosphere, which decreases with altitude.
- Water vapour also decreases from the equator towards the poles.

- In the warm and wet tropics, it may account for **four per cent** of the air by volume, while in the dry and cold areas of desert and polar regions, it may be less than one per cent of the air.
- One unique feature about this greenhouse gas is that it **absorbs both incoming (a part of incoming) and outgoing solar radiation.**

## Methane

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- Methane is the **most important greenhouse gas after carbon dioxide.**
- It is produced from **decomposition of animal wastes and biological matter.**
- The emission of this gas can be restricted by using animal wastes and biological matter to produce **gobar gas (methane).**

## Nitrous Oxide (N<sub>2</sub>O)

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- **N<sub>2</sub>O or Nitrous Oxide is a greenhouse gas.**
- **NO and NO<sub>2</sub>** (nitric oxide or nitrogen oxide and nitrogen dioxide) emissions cause **global cooling** through the formation of (OH) radicals that **destroy methane molecules**, countering the effect of GHGs.

## Carbon Monoxide

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- Carbon monoxide is a **short-lived greenhouse gas (it is less dense than air).**
- It has an **indirect** radiative forcing effect by **elevating concentrations of methane** and **tropospheric ozone** through chemical reactions with other atmospheric constituents (e.g., the hydroxyl radical, OH.) that would otherwise destroy them.
- Through natural processes in the atmosphere, it is eventually **oxidized to carbon dioxide.**

## Fluorinated gases

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### Chlorofluorocarbons (CFCs)

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- **CFCs were phased out via the Montreal Protocol** due to their part in **ozone depletion (explained in Geography > Climatology > Polar Vortex).**
- This anthropogenic compound is also a greenhouse gas, with a much **higher potential to enhance the greenhouse effect** than CO<sub>2</sub>.

### Hydrofluorocarbons

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- Hydrofluorocarbons are used as **refrigerants, aerosol propellants, solvents, and fire retardants.**
- These chemicals were developed as a **replacement for chlorofluorocarbons (CFCs).**

- Unfortunately, HFCs are potent greenhouse gases with **long atmospheric lifetimes**.

## Perfluorocarbons

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- Perfluorocarbons are compounds produced as a **by-product in aluminium production** and the **manufacturing of semiconductors**.
- Like HFCs, PFCs generally have **long atmospheric lifetimes** and **high global warming potential**.

## Sulphur hexafluoride

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- Sulphur hexafluoride is also a greenhouse gas.
- Sulphur hexafluoride is used in **magnesium processing and semiconductor manufacturing**, as well as a **tracer gas for leak detection**.
- Sulphur hexafluoride is used in electrical transmission equipment, including circuit breakers.

## Black Carbon or Soot

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- Black carbon (BC) is a solid particle or aerosol (though not a gas) that contributes to warming of the atmosphere. Black carbon, commonly known as soot.
- Soot is a form of **particulate air pollutant**, produced from **incomplete combustion**.
- Black carbon warms the earth by absorbing heat in the atmosphere and by **reducing albedo** (the ability to reflect sunlight) when deposited on snow and ice.
- BC is the **strongest absorber of sunlight and heats the air directly**.
- In addition, it darkens snow packs and glaciers through deposition and leads to melting of ice and snow.
- Regionally, **BC disrupts cloudiness and monsoon rainfall**.
- Black carbon stays in the atmosphere for **only several days to weeks**.
- Thus, the effects of BC on the atmospheric warming and glacier retreat disappear within months of reducing emissions.

## Brown Carbon

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- Brown carbon is a ubiquitous and unidentified component of organic aerosol.
- Biomass burning (possibly domestic wood burning) is shown to be a major source of brown carbon
- Brown carbon is generally referred for greenhouse gases and black carbon for particles resulting from impure combustion, such as soot and dust.

**Q. 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

Among GHGs, **only water vapor has the ability to absorb both incoming (UV) and outgoing (infrared) radiation.**

**Answer: d) the infrared part of the solar radiation (outgoing radiation).**

### **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.

### **Q4. What is 'Greenhouse Gas Protocol'? (2016)**

- a) It is an international accounting tool for government and business leaders to understand, quantify and manage greenhouse gas emissions
- b) It is an initiative of the United Nations to offer financial incentives to developing countries to reduce green-house gas emissions and to adopt eco-friendly technologies
- c) It is an inter-governmental agreement ratified by all the member countries of the United Nations to reduce greenhouse gas emissions to specified levels by the year 2022
- d) It is one of the multilateral REDD+ initiatives hosted by the World Bank

**Answer: a)**

### **Global Warming Potential (GWP) & Lifetime of Green House Gases**

Gas	GWP (100-year)	Lifetime (years)
Carbon di oxide	1	50-200
Methane	21	12

<b>Nitrous oxide</b>	<b>310</b>	<b>120</b>
<b>Hydrofluorocarbons (HFCs)</b>	<b>140 -11,700</b>	<b>1-270</b>
<b>Perfluorocarbons (PFCs)</b>	<b>6,500-9,200</b>	<b>800-50,000</b>
<b>Sulphur hexafluoride (SF<sub>6</sub>)</b>	<b>23,900</b>	<b>3,200</b>

## Global Warming – Impacts

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### Melting of the ice caps

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- Melting of the ice caps and glaciers will lead to rise in sea level.
- **Thermal expansion** also contributes to sea level rise.
- Fertile agricultural lands on the coast will be submerged and saline water intrusions will degrade the neighbouring land. Ground water in such regions will become useless.
- Populous cities lying on the coasts will be submerged under the sea.
- Flooding in Himalayas and Ganga plains in wet season and drought in dry season will severely affect the country.
- As a result of thawing of snow, the **amount of arable land in high-latitude region is likely to increase** by reduction of the amount of frozen lands.
- At the same time **arable land along the coast lines are bound to be reduced** as a result of rising sea level and saline water inundations.

### Extreme Climatic Events

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- Increased likelihood of extreme events such as heat wave, flooding, hurricanes, etc. will offset all the economic advancements made.
- Changes in rainfall patterns (E.g. 2015 Chennai floods, 2018 Kerala floods) will severely impact agriculture.

### Environmental Degradation

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- Reduced hydroelectric power generation due to abnormal behaviour of glaciers will further increase dependence on fossil fuels.
- Widespread vanishing of animal populations due to habitat loss will add more species to the 'threatened' and 'extinct' list.

### Rising Health Related Issues

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- Spread of diseases (like malaria, etc.) in tropics will put more pressure on the health care sector.

- It is anticipated that there will be an increase in the number of deaths due to greater frequency and severity of heat waves and other extreme weather events.
- Lack of freshwater during droughts and contamination of freshwater supplies during floods compromise hygiene, thus increasing rates of diseases like cholera, diarrhoea etc.

## Biodiversity Loss

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- **Loss of Plankton** due to warming of seas will adversely affect marine food chain.
- **Bleaching of Coral Reefs** (rain forests of the ocean) will cause great loss of marine biodiversity.
- Rising temperature would increase fertilizer requirement for the same production targets and result in **higher GHG emissions, ammonia volatilization** and cost of crop production.
- Rising temperatures will further affect the physical, chemical and biological properties of fresh water lakes and rivers, with adverse impacts on many individual fresh water species.

## No Food Security

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- 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.
- Moderate warming (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.
- In coastal areas, sea level rise will exacerbate water resource constraints due to increased salinization of groundwater supplies.

## Deterioration of Carbon sinks

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

## Sea Level Change

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- Sea level change means the fluctuations in the mean sea level over a considerably long period of time.

## Processes that cause Change in Sea Level

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1. **Eustatic changes** occur when the volume of sea water changes due to factors such as
  - ✓ global warming and melting of ice sheets (rise in sea level) or ice ages (fall in sea level) and
  - ✓ changes in the volume of mid-oceanic ridges.
2. **Tectonic changes** occur due to a change in the level of land.
  - ✓ Isostatic changes take place due to 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 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.

## Importance of understanding Sea Level Changes

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- It provides key evidences regarding climate change in the past.
- It helps in estimating the rates of tectonic upliftment in the past geological periods.
- To assess the suitability of coastal locations for industrial and agricultural development.
- To protect 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 only if we know the likely areas to be affected by future sea level rise.
- By identifying the areas of possible submergence in the near future it becomes possible to set up tidal power generation plants in suitable locations.

## Changes in Global Sea Level

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### Short-Term

- Short-term changes occur during a year.
- Commonly, seasonal variations of 5-6 cm in sea level are observed in a year.

Short-term sea level change may be due to a complex interaction of the following factors:

- **Marine water density:** Temperature and salinity control the density of sea water. Low temperature and high salinity produce high density of sea water and lower sea level.
- **Atmospheric pressure:** Low pressure results in higher local sea level 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 between the two sides of a fast-flowing current.
- **Ice formation and fall in sea level:** During winter the ocean water trapped in the icecaps of the northern and the southern hemispheres leads to a fall in sea level.
- **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.

The twentieth century has observed short-term global sea level rise due to the following factors.

- **Global warming** in the last century due to anthropogenic activities has resulted in **thermal expansion** of ocean water. So, the sea level has risen by about 10 to 15 cm in the past 100 years.
- Melting of ice-sheets in the Antarctica by about 3 per cent of its total volume of ice has, to some extent, contributed to global sea level rise.
- In the last century, about 15 per cent of the total volume of the Greenland ice cap melted.
- Besides these areas of ice-melt, other glaciers are also estimated to have contributed about 48 per cent of the global sea level rise.

### **Long-Term**

- 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.

### **Impact of Sea Level Fall**

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- A drop in sea level causes the **death of coral reefs** as the continental shelves on which they are formed are left dry. So, fresh coral reefs emerge along the fringe of dead corals.
- In places of shallow continental shelves, the fall in sea level leads to greater aridity in the continental hinterland due to reduced surface runoff.
- A fall in sea level in temperate and high latitude regions causes extension of ice caps and glacial tongues onto the continental shelves.

### **Impact of Possible Rise in Sea Level**

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- Ice melt in the Antarctica may prove to be dangerous in the near future if the temperature of the atmosphere continues to increase.

- A vast segment of the populated land, viz., the low-lying densely populated coastal areas, will be submerged. Even the small islands will be wiped out.
- An estimated global population of about one billion will be affected by rise in sea levels.
- Immense damage may be caused to the coastal structures like ports, industrial establishments, etc.
- As a result of the rise in sea level, almost 33 per cent of the world's crop lands could be submerged (coastal plains and deltas are made up of very fertile soils).
- Accelerated coastal erosion may cause damage to and destruction of beaches, coastal dunes and bars.
- As a consequence, a vast section of the coastal land will remain unprotected against the direct attack of sea waves.
- Groundwater resources of the coastal regions will be severely affected by salinization due to marine water intrusion.
- The ecosystem will suffer heavy damages as the deltas, coral atolls and reefs will be destroyed. New coral reefs on the outer fringe of the dead corals will be formed.
- As a result of rise in sea level, the mouths of drainage basins will undergo submergence. This will lead to a readjustment of the long-profiles of the rivers, which are likely to show a rise.
- Islands are the worst affected by the recent rise of sea level. Some of the affected islands are the Carteret Islands, located on the north-east of Papua New Guinea in the Pacific Ocean, and Tuvalu Islands, about 1000 km north of Fiji in the South Pacific.

To check the phenomenon of sea level rise that 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 maximum risk of submergence.

## **7.2 Reducing Carbon in the Atmosphere to fight Climate Change**

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- Clean coal technology, Carbon capture and storage Carbon Sink and Carbon Sequestration.

### **Clean coal technology to reduce CO<sub>2</sub> in atmosphere**

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- Half of the world's electricity is generated by burning coal.
- Coal will remain a dominant energy source for years to come.
- **CO<sub>2</sub> and CO (carbon monoxide)** are the major greenhouse gas which are released during burning of coal.
- Along with the above gases, **nitrogen oxides (destroys ozone)** and **sulphur oxides (acid rains)** are also released.

- Clean coal technology seeks to reduce harsh environmental effects by using multiple technologies to **clean coal and contain its emissions.**
- Some clean coal technologies **purify the coal before it burns.**
- One type of coal preparation, coal washing, **removes unwanted minerals** by mixing crushed coal with a liquid and allowing the impurities to separate and settle.
- Other systems **control the coal burn to minimize emissions of sulphur dioxide, nitrogen oxides and particulates.**
- **Electrostatic precipitators** remove particulates by charging particles with an electrical field and then capturing them on collection plates.
- **Gasification avoids burning coal altogether.** With gasification, steam and hot pressurized air or oxygen combine with coal in a reaction that forces carbon molecules apart.
- The resulting **syngas, a mixture of carbon monoxide and hydrogen**, is then cleaned and burned in a gas turbine to make electricity.
- **Wet scrubbers, or flue gas desulfurization systems, remove sulphur dioxide**, a major cause of acid rain, by spraying flue gas with limestone and water.
- Low-NO<sub>x</sub> (nitrogen oxides) burners reduce the creation of nitrogen oxides, **a cause of ground-level ozone**, by restricting oxygen and manipulating the combustion process.

## India's coal

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- Coal mined in India is a poor quality coal (India's coal is not Carboniferous Coal. It is Gondwana coal) with less carbon, high ash (hard to dispose) 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).
- Should employ clean coal technology.

## Carbon capture and storage

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- 'Carbon capture and storage' catches and **sequesters (hide) carbon dioxide (CO<sub>2</sub>)** from stationary sources like power plants.
- Capture: Flue-gas separation removes CO<sub>2</sub> and condenses it into a concentrated CO<sub>2</sub> stream.
- After capture, secure containers sequester the collected CO<sub>2</sub> to prevent or stall its re-entry into the atmosphere.
- The two storage options are **geologic and oceanic** (must hide the CO<sub>2</sub> until peak emissions subside hundreds of years from now).

## **Geologic storage involves injecting CO<sub>2</sub> into the earth.**

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- **Depleted oil or gas fields** and **deep saline aquifers safely** store CO<sub>2</sub> while **coal seams** absorb it.
- **Ocean storage**, a technology still in its early stages, involves injecting liquid CO<sub>2</sub> into waters 500 to 3,000 meters deep, where it dissolves under pressure.
- However, this method would slightly decrease pH and potentially harm marine habitats.

**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
- From figure (below) it is clear that abandoned coal seems, depleted oil and gas reservoirs can be used for carbon sequestration.

Answer: d) all

## **Carbon Sink and Carbon Sequestration**

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- A carbon sink is a **natural or artificial reservoir** that **accumulates and stores some carbon-containing chemical compound for an indefinite period**.
- The process by which carbon sinks remove carbon dioxide (CO<sub>2</sub>) from the atmosphere is known as **carbon sequestration**.

## **Carbon Sink vs Carbon Source**

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- A carbon sink is anything that absorbs more carbon than that it releases, whilst a carbon source is anything that releases more carbon than is absorbed.
- **Forests, soils, oceans** and the **atmosphere** all store carbon and this carbon moves between them in a continuous cycle.

- This constant movement of carbon means that forests act as sources or sinks at different times.

### **Carbon Dioxide Fertilization**

- Earth's vegetated lands have shown significant **greening** largely due to rising levels of atmospheric CO<sub>2</sub>.
- Greening means an **increase in leaves on plants and trees**.
- Increased concentrations of CO<sub>2</sub> **increases photosynthesis**, spurring plant growth.
- **Carbon dioxide** fertilization contributes to 70 percent of the greening effect.
- The second most important driver is **nitrogen**, at 9 percent.
- The rest occurs due to land cover changes, climate change, precipitation and sunlight changes.
- Plants acclimatize to rising CO<sub>2</sub> concentration and the **fertilization effect diminishes over time**.
- That is, raising CO<sub>2</sub> concentrations may be beneficial for plants in the short run, but in the long run it is harmful due to climate change.

### **Carbon Dioxide Fertilization is increasing carbon sink on land**

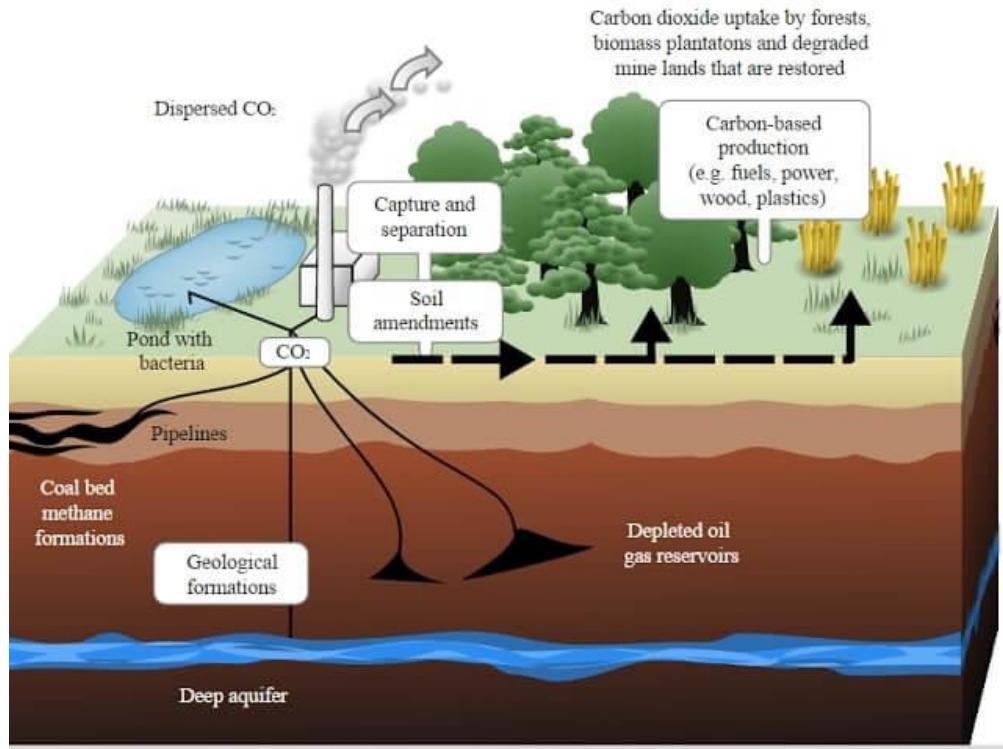
- Every year, about half of the 10 billion tons of carbon emitted into the atmosphere from human activities remains temporarily stored, in about **equal parts**, in the **oceans and plants**.
- Studies have reported an **increasing carbon sink on land** since the 1980s, which is entirely consistent with the idea of a greening Earth.

### **Q. Which of the following statements best describes "carbon fertilization"? (2018)**

- 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

### **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 greenhouse gases.
- Carbon dioxide is naturally captured from the atmosphere through biological, chemical, or physical processes.



## Forests as carbon Sinks

- Forests are carbon stores, and they are carbon dioxide sinks when they are increasing in density or area.
- **Trees absorb CO<sub>2</sub> during photosynthesis thereby converting atmospheric CO<sub>2</sub> 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 and when the biomass is used as fuel (coal and petroleum) it releases CO<sub>2</sub> back into the atmosphere (carbon source).**
- **Ocean is also a very important carbon sink. Most of the carbon is trapped in the ocean and if a small fraction of this carbon is released the consequences will be disastrous.**
- In Canada's boreal forests as much as **80% of the total carbon is stored in the soils as dead organic matter.**
- Tropical forests absorb about 18% of all carbon dioxide added by fossil fuels.
- In the context of climate change, the most important carbon stores are the natural fossil fuel deposits.
- But **when humans burn** coal, oil and natural gas, they turn fossil carbon stores into atmospheric carbon.
- This release of carbon from fossil fuel has caused greenhouse gas (GHG) concentrations in the atmosphere to soar to levels more than 30 per cent higher than at the beginning of the industrial revolution.

- Because of this increase in atmospheric carbon, 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.**
- Indeed, the **Kyoto Protocol**, the international communities' main instrument for halting global warming 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.**

**Q. 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 important carbon sink. Global warming by 3 °C will turn these forests into carbon source.**
- Corals are very sensitive to temperature changes. 3 °C rise in global temperature will lead to widespread coral mortality.
- 3° C rise in global temperature will lead to submergence of many low lying coastal wetlands due to rise in sea levels. Inland wetlands like **Keoladeo Ghana National Park** will not be affected.
- It has been estimated that a sea-level rise of approximately 2.3 metres (7.5 ft) for each degree Celsius of temperature ca occur within the next 2,000 years. (<http://goo.gl/LH3RMI>)
- Cultivation of cereals in tropics will take a hit. But in temperate regions their production increases in the short run.

Answer: b) 1 and 2 only

## 7.3 Ozone Depleting Substances

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**Ozone Depletion is already explained in Geography > Climatology > Polar Vortex**

- Ozone depleting substances are man-made gases that destroy ozone once the gases reach the ozone layer.

**Ozone depleting substances include:**

1. **chlorofluorocarbons (CFCs)**
2. **hydrochlorofluorocarbons (HCFCs)**
3. **hydrobromofluorocarbons (HBFCs)**
4. **halons** (were used in fire extinguishers)
5. **methyl bromide** (was used as fumigant. Fumigation is a method of pest control by suffocating pests with poison)
6. **carbon tetrachloride** (formerly widely used in fire extinguishers, refrigerant and as a cleaning agent)
7. **methyl chloroform** (solvent for organic compounds; used for cleaning metal parts and circuit boards).

**They have been used as:**

- refrigerants in commercial, home and vehicle air conditioners and refrigerators
- foam blowing agents
- a component in electrical equipment
- industrial solvents
- solvents for cleaning (including dry cleaning)
- aerosol spray propellants
- fumigants.

### **Chlorofluorocarbons**

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- Chlorofluorocarbons (CFCs) were widely used as refrigerants until the 1980s.
- They are also considered greenhouse gases that cause climate change.
- There are still CFCs left in older industrial air conditioning and refrigeration systems.

### **Hydrochlorofluorocarbons**

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- Hydrochlorofluorocarbons (HCFCs) have been used as a **substitute for CFCs**.
- They do less damage to the ozone layer than CFCs.

### **Halons**

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- Halons are halocarbon gases that were originally developed for use in fire extinguishers.
- Production and consumption of halons ended in 1994 in developed countries

## Vienna Convention for the Protection of the Ozone Layer

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- 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 Substances that Deplete the Ozone Layer

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- The Montreal Protocol under the Vienna Convention (the protocol) was agreed in **1987**.
- It facilitates **global cooperation in reversing the rapid decline in atmospheric concentrations of ozone**.
- Under the protocol countries agreed to **phase out the production and consumption of certain chemicals that deplete ozone**.
- 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**.
- Climate projections indicate that the ozone layer will return to 1980 levels between 2050 and 2070.

## Kigali amendment to Montreal Protocol 2016

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- Kigali is the capital city of Rwanda.
- In the 28th meeting of the Parties (2016) to the Montreal Protocol, negotiators from 197 nations have signed an agreement to amend the Montreal Protocol in Kigali.
- The parties are expected to **reduce the manufacture and use of Hydrofluorocarbons (HFCs) by roughly 80-85% from their respective baselines, till 2045**.
- This phase down is expected to arrest the global average temperature rise up to **0.5 °C by 2100**.
- It is a **legally binding** agreement between the signatory parties with non-compliance measures.
- It came into effect from 1st January 2019.

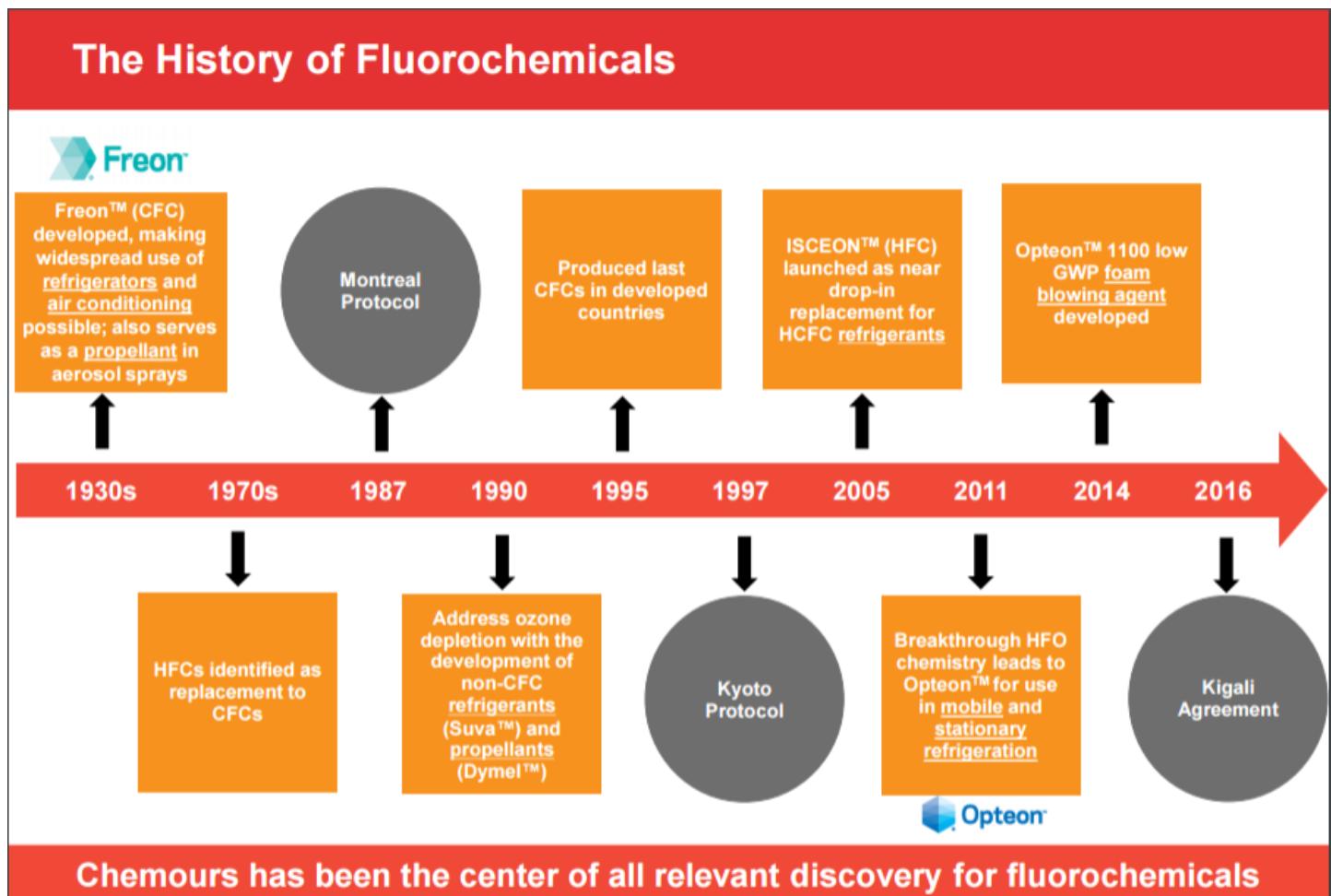
## India's position

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- India has agreed on a lenient schedule as it consumes only **3%** of HFCs as compared to the other nations like the **USA (37%)** and **China (25%)**.

## Hydrofluorocarbons (HFCs)

- **Hydrofluorocarbons (HFCs)** are used since as an alternative to CFCs and HCFCs.
- HFCs **do not contribute to ozone depletion**.
- However, they are potent greenhouse gases with **high global warming potential**.



## 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.

## Advantages of HFCs

Fluorochemical	Ozone Depleting Potential	Global Warming Potential
CFS	High	High
HCFCs	Low	High

HFCs	Zero	High
HFOs	Zero	Very Low

[Source](#)

## The Ozone Depleting Substances Rules

- The rules are framed under the jurisdiction of **Environment (Protection) Act**.
- These Rules set the deadlines for phasing out of various ODSs, besides regulating production, trade import and export of ODSs and the product containing ODS.
- These Rules prohibit the use of CFCs in manufacturing various products beyond 1st January 2003 except in metered dose inhaler and for other medical purposes.
- Similarly, use of halons is prohibited after 1st January 2001 except for essential use.
- Other ODSs such as **carbon tetrachloride** and **methylchloroform** and CFC for metered dose inhalers can be used upto 1st January 2010.
- Further, the use of **methyl bromide** has been allowed upto 1st January 2015.
- Since **HCFCs are used as interim substitute to replace CFC, these are allowed up to 1st January 2040**.

**Q. 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 pressurizing 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

Answer: c) CFCs were used as refrigerants, pressurizing agents (foam and aerosol cans) and for cleaning electronic equipment.

**Q. 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
- 
- Bretton Woods Conference established the International Bank for Reconstruction and Development (IBRD) and the International Monetary Fund (IMF).
  - Montreal Protocol is an international treaty to protect the ozone layer by phasing out the production of ozone depleting substances. It is legally binding.
  - Kyoto Protocol implemented the objective of the UNFCCC to fight global warming by reducing greenhouse gas 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 a supplementary agreement to the 1992 Convention on Biological Diversity (CBD) on "Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization".

Answer: b)

## 8. International Conventions, NGOs, Laws

### **Nature conservation**

- United Nations Conference on Environment and Development (UNCED)
- Convention on Biological Diversity (CBD)
- Ramsar Convention on Wetlands (explained in "Wetland Ecosystem")
- Convention on International Trade in Endangered Species of Fauna and Flora (CITES) (explained in "IUCN Red List")
- The Wildlife Trade Monitoring Network (TRAFFIC) (explained in "IUCN Red List")
- Convention on the Conservation of Migratory Species (CMS)
- Global Tiger Forum (GTF)
- Hazardous material (explained in "Solid Waste")
- Stockholm Convention (mentioned under "Hazardous Waste")
- Basel Convention (mentioned under "Hazardous Waste")
- Rotterdam Convention (mentioned under "Hazardous Waste")

**Land**

- United Nations Convention to Combat Desertification (UNCCD)

**Marine environment**

- International Whaling Commission (IWC)

**Atmosphere**

- Vienna convention and Montreal Protocol (explained in "Ozone Depleting Substances")
- United Nations Framework Convention on Climate Change (UNFCCC)
- Kyoto Protocol

## 8.2 United Nations Conference on the Human Environment (1972)

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- The United Nations Conference on the Human Environment was first held in **Stockholm**, Sweden, in 1972.
- It marked the emergence of international environmental law.

**Stockholm Declaration**

- It is also known as **The Declaration on the Human Environment**.
- It set out the principles for various international environmental issues, natural resource management, pollution prevention and the relationship between the environment and development.

### United Nations Environment Programme (UNEP) or UN Environment

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- UNEP is an **agency of the United Nations**.
- It **coordinates the UN's environmental activities**.
- It assists developing countries in implementing environmentally sound policies and practices.
- It was founded as a result of the United Nations Conference on the Human Environment 1972.
- It has overall responsibility for environmental problems among United Nations agencies.
- Addressing climate change or combating desertification, are overseen by other **UN organizations**, like the UNFCCC and the United Nations Convention to Combat Desertification.
- UNEP's activities cover a wide range of issues regarding the atmosphere, marine and terrestrial ecosystems, environmental governance and green economy.
- The **World Meteorological Organization** and **UN Environment** established the **Intergovernmental Panel on Climate Change (IPCC)** in 1988.

- UN Environment is also one of several **Implementing Agencies for the Global Environment Facility (GEF)** and the **Multilateral Fund for the Implementation of the Montreal Protocol**.
- It is also a member of the **United Nations Development Group**.
- UNEP has registered several successes, such as the **1987 Montreal Protocol**, and the **2012 Minamata Convention, a treaty to limit toxic mercury**.
- UNEP has sponsored the development of solar loan programmes.
- The solar loan programme sponsored by UN Environment helped finance solar power systems in India.

## **Intergovernmental Panel on Climate Change (IPCC)**

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- IPCC is a **scientific intergovernmental body** under the auspices of the **United Nations**.
- It was first established in 1988 by two United Nations organizations, the **World Meteorological Organization (WMO)** and the **United Nations Environment Programme (UNEP)**.
- Membership of the IPCC is open to all members of the WMO and UNEP.
- 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.
- The IPCC **does not carry out its own original research**.
- Thousands of scientists and other experts contribute on a **voluntary basis**.
- The 2007 Nobel Peace Prize was shared, in two equal parts, between the IPCC and an American Environmentalist.

**The aims of the IPCC are to assess scientific information relevant to:**

- Human-induced climate change,
- The impacts of human-induced climate change,
- Options for adaptation and mitigation.

## **IPCC Assessment Reports (AR)**

- In accordance with its mandate, the IPCC prepares at regular intervals comprehensive Assessment Reports of scientific, technical and socio-economic information relevant for the understanding of human induced climate change, potential impacts of climate change and options for mitigation and adaptation.

## **Special Reports**

- Special Reports have been prepared on topics such as aviation, regional impacts of climate change, technology transfer, emissions scenarios, land use, land use change and forestry, carbon dioxide capture and storage and on the relationship between safeguarding the ozone layer and the global climate system.

## **Conservation of Migratory Species**

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- Full name: The Convention on the Conservation of Migratory Species of Wild Animals.
- **Convention on Migratory Species** or the **Bonn Convention** or **Global Wildlife conference**.
- It is an international treaty, concluded under the aegis of the **United Nations Environment Programme**.
- The Convention was signed in 1979 in Bonn, Germany and entered into force in 1983.
- The CMS is the only global and **UN-based intergovernmental organization** established exclusively for the conservation and management of terrestrial, aquatic and avian **migratory species** throughout their range.

## **Global Environment Facility**

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- The Global Environment Facility (GEF) unites 183 countries in partnership with international institutions, civil society organizations (CSOs), and the private sector to address global environmental issues while supporting national sustainable development initiatives.
- An **independently operating financial organization**, the GEF provides grants for projects related to biodiversity, climate change, international waters, land degradation, the ozone layer, and persistent organic pollutants.

### **The GEF also serves as financial mechanism for the following conventions:**

- **Convention on Biological Diversity (CBD)**
- **United Nations Framework Convention on Climate Change (UNFCCC)**
- **UN Convention to Combat Desertification (UNCCD)**
- **Stockholm Convention on Persistent Organic Pollutants (POPs)**
- **Minamata Convention on Mercury**
- The GEF, although not linked formally to the Montreal Protocol on Substances that Deplete the Ozone Layer (MP), supports implementation of the Protocol in countries with economies in transition.

### **The GEF works with 18 agencies. Notable ones among them are:**

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- 1) **United Nations Development Programme**
- 2) **United Nations Environment**
- 3) **World Bank**

- 4) Food and Agriculture Organization
- 5) Asian Development Bank
- 6) International Fund for Agricultural Development
- 7) World Wildlife Fund - US
- 8) Conservation International
- 9) International Union for Conservation of Nature (IUCN)

#### **Areas of work**

- Biodiversity, Climate change, International waters, Land degradation, Sustainable forest management / REDD+ and Ozone depletion

#### **Q. With reference to 'Global Environment Facility', 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 organization.
- It may fund scientific research, but it is not directly involved in scientific research.
- IPCC takes care of most of the research work.

Answer: a)

### **8.3 UNCED or Earth Summit 1992, Rio De Janeiro Brazil**

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- **Earth Summit 1992** is also known as **The United Nations Conference on Environment and Development (UNCED)**.
- **Earth Summit 1992** succeeded in raising public awareness of the **need to integrate environment and development**.
- 190 countries pledged their commitment to achieve by 2010, a significant reduction in the current rate of biodiversity loss at global, regional and local levels.

- As a follow-up, 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** was also held in Rio and is also commonly called **Rio+20 or Rio Earth Summit 2012**.

**The issues touched included:**

- checking production of toxic components, such as **lead in gasoline**, or poisonous waste including radioactive chemicals,
- alternative sources of energy to replace the use of fossil fuels,
- new reliance on public transportation systems in order to reduce vehicle emissions, congestion in cities,
- the health problems caused by polluted air and smoke, and
- the growing usage and limited supply of water.

**Q. What is Rio+20 Conference, often mentioned in the news?**

- a) It is the United nations Conference on Sustainable Development
- b) It is a Ministerial Meeting of the World Trade Organization
- c) It is a Conference of the Inter-governmental Panel on Climate Change
- d) It is a Conference of the Member Countries of the Convention on Biological Diversity

Answer: a) United nations Conference on Sustainable Development

**The Earth Summit resulted in the following documents:**

1. **Rio Declaration:** principles intended to guide countries in future sustainable development.
2. **Agenda 21:** non-binding action plan of the United Nations with regard to sustainable development.
3. **Forest Principles:** Non-legally binding document on Conservation and Sustainable Development of All Types of Forests.

**Landmark Agreements**

- An important achievement of the summit was an agreement on the Climate Change Convention which in turn led to the **Kyoto Protocol** and the **Paris Agreement**.
- Important **legally binding agreements (Rio Convention)** were opened for signature:
  - a) **Convention on Biological Diversity.**
  - b) **United Nations Convention to Combat Desertification.**

## 8.4 Agenda 21

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- Agenda 21 is a **non-binding** action plan of the **United Nations (UN)** related to **sustainable development**.
- It was an outcome of the **Earth Summit 1992**.
- The number 21 refers to an agenda for the 21st century.
- Its aim is achieving **global sustainable development**.
- Since 2015, **Sustainable Development Goals** are included in the Agenda 2030.

**Q. With reference to 'Agenda 21', sometimes seen in the news, consider the following statements: (2016)**

- 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

Answer: a) 1 only

### **United Nations Convention to Combat Desertification (UNCCD)**

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- The Convention stemmed from a direct recommendation of the **Rio Conference's Agenda 21 in 1994**.
- UNCCD is a Convention to **combat desertification** and mitigate the effects of drought through national action programs (NAP).
- National action programs (NAP) incorporate long-term strategies supported by international cooperation.
- It is the only **internationally legally binding framework set up to address desertification**.
- It was adopted in Paris, France in 1994 and entered into force in 1996.
- It has 196 parties, making it truly global in reach.
- **2006 was declared "International Year of Deserts and Desertification"**.
- The UN Convention to Combat Desertification has established a Committee on Science and Technology (CST).
- CST is composed of government representatives competent in the fields of expertise relevant to combating desertification and mitigating the effects of drought.
- UNCCD collaborates closely with Convention on Biological Diversity (CBD).

**Q. What is/are the importance(s) of the 'United Nations Convention to Combat Desertification'?**

- 1) It aims to promote effective action through innovative national programs and supportive inter-national partnerships.
- 2) It has a special/particular focus on South Asia and North Africa regions, and its Secretariat facilitates the allocation of major portion of financial resources to these regions.
- 3) It is committed to bottom-up approach, encouraging the participation of local people in combating the desertification.

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: c) 1 and 3 only

### **Rio+5 (1997)**

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

### **Rio+10 (2002) or Earth Summit 2002**

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- **Rio+10 (2002) or Earth Summit 2002 or World Summit on Sustainable Development.**
- Took place in Johannesburg, South Africa in 2002.
- Rio+10 affirmed UN commitment to Agenda 21, alongside the Millennium Development Goals.
- **Johannesburg Declaration:** committing the nations of the world to sustainable development.

### **Rio+20 (2012)**

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- **Rio+20 (2012) or United Nations Conference on Sustainable Development.**
- Rio+20 was a 20-year follow-up to the Earth Summit 1992 and 10-year follow-up to the Earth Summit 2002.
- It is also known as Rio 2012 or Earth Summit 2012.
- Hosted by Brazil in Rio de Janeiro in 2012.
- It reaffirmed the commitment to **Agenda 21**.
- It was the third international conference on **sustainable development**.

- ⇒ **Earth Summit 1992 (Rio de Janeiro) = UN Conference on Environment and Development (UNCED)**
- ⇒ **Earth Summit 2002 (Johannesburg) = World Summit on Sustainable Development (WSSD)**
- ⇒ **Earth Summit 2012 (Rio de Janeiro) = UN Conference on Sustainable Development (UNCSD)**

## **Partnership for Action on Green Economy (PAGE)**

- PAGE, launched in 2013, is a direct response to the **Rio+20 Declaration**, The Future We Want.
- Rio+20 Declaration called upon the UN system and the international community to aid interested countries in developing, adopting and implementing **green economy policies** and strategies.
- PAGE supports nations in reframing economic policies and practices around sustainability.
- PAGE seeks to assist countries in achieving **SDG (2030 Agenda)**, especially SDG 8: "**Promote sustained, inclusive and sustainable economic growth, full and productive employment.**"
- PAGE brings together the expertise of **five UN agencies – UNEP, ILO, UNIDO, UNDP and UNITAR**.

ILO: International Labour Organization

UNIDO: UN Industrial Development Organization

UNITAR: UN Institute for Training and Research.

## **Q. The Partnership for Action on Green Economy (PAGE), a UN mechanism to assist countries 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

## **2030 Agenda – Sustainable Development Goals (SDGs)**

- The UN 2030 Agenda for **Sustainable Development** was launched in **2015**.
- The UN 2030 Agenda's Sustainable Development Goals (SDG) aim at **eradicating poverty in all forms** and "**seek to realize the human rights of all and achieve gender equality**".
- The Sustainable Development Goals (SDGs) are a collection of 17 global goals, and their 169 targets, set by the United Nations General Assembly in **2015** for the year **2030** (UNGA resolution "2030 Agenda").



#### Q8. Consider the following statements: (2016)

- 1) The Sustainable Development Goals were first proposed in 1972 by a global think tank called the 'Club of Rome'.
- 2) The Sustainable Development Goals have to be achieved by 2030.

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

#### Goal 2: Zero hunger

"End hunger, achieve food security and improved nutrition, and promote sustainable agriculture".

- This would be accomplished by
  - ✓ **doubling agricultural productivity and incomes** of small-scale food producers (women and indigenous peoples), by
  - ✓ ensuring **sustainable food production systems**, and by
  - ✓ progressively improving **land and soil quality**.

- Other targets deal with maintaining genetic diversity of seeds, increasing access to land, preventing trade restriction and distortions in world agricultural markets, eliminating wastage and ending malnutrition.

## **Goal 6: Clean water and sanitation**

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**"Ensure availability and sustainable management of water and sanitation for all."**

- Safe drinking water and hygienic toilets.
- Toilets in schools and work places.
- **Equitable sanitation** for addressing the specific needs of women and girls, disabled, aged persons.

## **Goal 7: Affordable and clean energy**

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**"Ensure access to affordable, reliable, sustainable and modern energy for all."**

- 2030 target: access to affordable and reliable energy while increasing the share of renewable energy.

## **Goal 11: Sustainable cities and communities**

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**"Make cities and human settlements inclusive, safe, resilient, and sustainable."**

- 2030 target is to ensure access to safe and affordable housing.

## **Goal 12: Responsible consumption and production**

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**"Ensure sustainable consumption and production patterns."**

- The targets of Goal 12 include:
  - ✓ using eco-friendly production methods
  - ✓ reducing the amount of waste.
  - ✓ Increase national recycling rates.

## **Goal 13: Climate action**

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**"Take urgent action to combat climate change and its impacts by regulating emissions and promoting developments in renewable energy."**

## **Goal 14: Life below water**

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**"Conserve and sustainably use the oceans, seas and marine resources for sustainable development."**

- The targets include
  - ✓ preventing and reducing marine pollution and acidification,

- ✓ protecting marine and coastal ecosystems and regulating fishing.
- Microplastics come from a variety of sources, including from larger plastic debris.
- **Microbeads**, a type of microplastic (tiny pieces of **Polyethylene**), are very tiny pieces of plastic that are added to **health and beauty products, such as some cleansers and toothpastes**.

## 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."**

- Goal 15 calls for more attention to **preventing invasion of introduced species** and **more protection of endangered species**.

## Millennium Development Goals

- The **Sustainable Development Goals (SDGs) replaced the MDGs in 2016**.
- The Millennium Development Goals (MDGs) were eight international development goals for the year 2015.
- MDGs had been established following the Millennium Summit of the United Nations in 2000.
- United Nations Millennium Declaration was adopted.

## Millennium Development Goals by 2015

1. To eradicate extreme poverty and hunger
2. To achieve universal primary education
3. To promote gender equality and empower women
4. To reduce child mortality
5. To improve maternal health
6. To combat HIV/AIDS, malaria, and other diseases
7. To ensure environmental sustainability
8. To develop a global partnership for development



### Transition to green economy

- Three priorities in transition of economy to green economy are
  - a) Decarbonizing the economy;
  - b) Commit the environmental community to justice and equity; and
  - c) Conserve the biosphere.

### Measures to adapt green economy

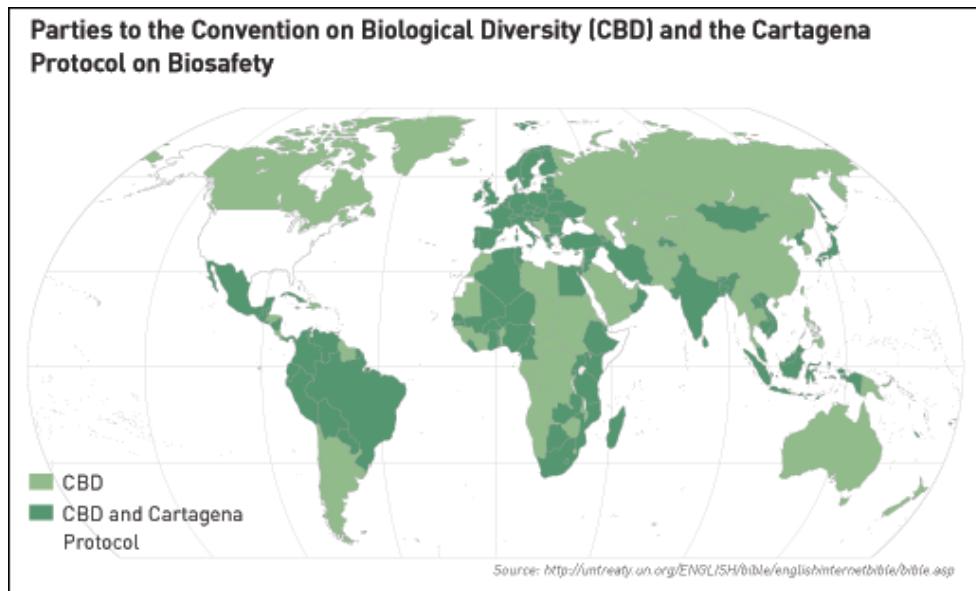
- Energy audit can reduce your building's climate footprint.
- Sustainable fishing practices.
- Sustainably managed forests.
- Usage electronic files to reduce your demand for paper products.
- Support certified sustainable forest products.
- Car-pooling or taking public transport.
- Walking or riding a bike for short trips.
- Wise water use.
- Development of clean, renewable energy by using solar, wind, tidal, etc will contribute to green economy.
- Recycling appropriate materials and composting food waste.

Moving towards a green economy has the potential to achieve sustainable development.

## 8.5 Convention on Biological Diversity

- Biodiversity conservation is a collective responsibility of all nations.
- Convention on Biological Diversity (CBD) is a step towards conserving biological diversity or biodiversity with **the involvement of the entire world.**

- The Convention on Biological Diversity (a multilateral treaty) was opened for signature at the **Earth Summit in Rio de Janeiro in 1992** and entered into effect in 1993.
- The convention called upon all nations to take appropriate measures for conservation of biodiversity and **sustainable utilisation** of its benefits.
- The Convention has three main goals:
  - 1) **conservation of biological diversity (or biodiversity);**
  - 2) **sustainable use of its components; and**
  - 3) **fair and equitable sharing of benefits arising from genetic resources.**
- It is often seen as the key document regarding **sustainable development**.
- The Convention is **legally binding**; countries that join it ('Parties') are obliged to implement its provisions.
- 195 UN states and the European Union are parties to the convention.
- All UN member states, with the exception of the **United States**, have ratified the treaty.



- At the 2010 10th Conference of Parties (COP) to the Convention on Biological Diversity in October in Nagoya, Japan, the **Nagoya Protocol** was adopted.

## Cartagena Protocol

- CBD covers the rapidly expanding field of **biotechnology** through its **Cartagena Protocol on Biosafety**.
- It addresses technology development and transfer, benefit-sharing and biosafety issues.
- The **Biosafety Protocol seeks to protect biological diversity** from the potential risks posed by living modified organisms resulting from modern biotechnology.

## Nagoya Protocol

- It is the **second Protocol to the CBD**; the first is the 2000 Cartagena Protocol on Biosafety.
- It is a 2010 supplementary agreement to the 1992 Convention on Biological Diversity (CBD).
- The 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.

**Q. Consider the following pairs (2016):**

Terms sometimes seen 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**

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

- Popularly known as the **International Seed Treaty**.
- International agreement in harmony with the **Convention on Biological Diversity**.
- Aims at guaranteeing food security through the conservation, exchange and **sustainable use of the world's plant genetic resources for food and agriculture** (PGRFA), as well as the **fair and equitable benefit sharing arising from its use**.

**Q. 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
- World Heritage Convention explained in "Biodiversity", rest two in this section.

**Answer: d) all**

## **The Economics of Ecosystems and Biodiversity (TEEB)**

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

**Q. 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 recognize, demonstrate and capture the value of eco-systems and biodiversity.

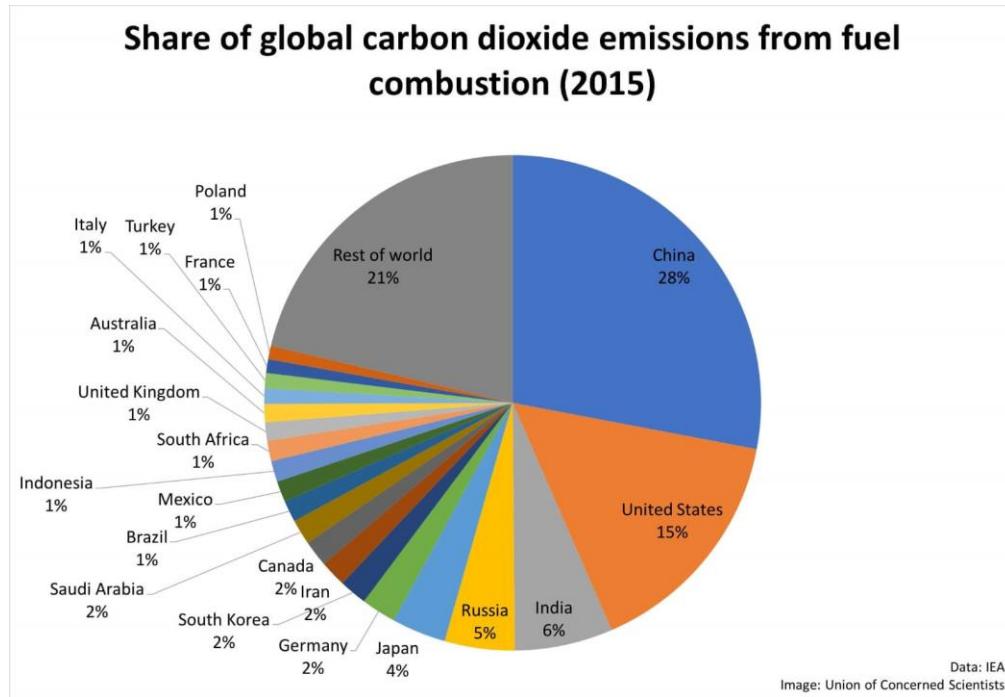
Select the correct answer using the code given below.

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

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

## 8.6 UNFCCC: United Nations Framework Convention on Climate Change

- International environmental treaty that came into existence under the aegis of UN.
- UNFCCC is negotiated at the **Earth Summit 1992**.
- Signed in **1992, New York** City.
- As of March 2019, UNFCCC has **197 parties**.
- Role: UNFCCC provides a framework for negotiating specific international treaties (called "protocols") that **aim to set binding limits on greenhouse gases**.
- Objective of UNFCCC: **Stabilize greenhouse gas concentrations** in the atmosphere at a level that would prevent dangerous consequences.
- Legal Effect: Treaty is considered **legally non-binding**.
- The treaty itself **sets no binding limits on greenhouse gas emissions for individual countries**.



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### Conferences of the Parties (COP) – UNFCCC

- The COP is the **decision-making body** of UNFCCC.
- All States that are Parties to the Convention are represented at the COP.
- They review the implementation of any legal instruments that the COP adopts.
- They promote the effective implementation of the Convention.
- The first COP meeting was held in **Berlin, Germany in March 1995**.

- The parties to the convention have met **annually** since 1995.
- In 1997, the **Kyoto Protocol (3rd COP)** was concluded and established **legally binding obligations for developed countries to reduce their greenhouse gas emissions.**
- **COP 21 (2015) was held in Paris in 2015.**
- COP 22 (2016) was held at Marrakesh, Morocco.
- COP 23 (2017) was held at Bonn, Germany.
- **COP 24 (2018) was held at Katowice, Poland.**
- **COP 25 (2019) will be held at Santiago, Chile during Nov-Dec 2019.**

## List of UNFCCC Summits

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- **1995: COP 1, The Berlin Mandate**
- 1996: COP 2, Geneva, Switzerland
- **1997: COP 3, The Kyoto Protocol on Climate Change**
- 1998: COP 4. Buenos Aires, Argentina
- 1999: COP 5, Bonn, Germany
- 2000: COP 6. The Hague. Netherlands
- 2001: COP 6, Bonn. Germany
- 2001: COP 7. Marrakech, Morocco
- **2002: COP 8, New Delhi, India**
- 2003: COP 9, Milan, Italy
- 2004: COP 10. Buenos Aires. Argentina
- **2005: COP 11/CMP 1. Montreal, Canada Montreal, (Kyoto Protocol was ratified in 2005)**
- 2006: COP 12/CMP 2, Nairobi. Kenya
- 2007: COP 13/CMP 3, Bali, Indonesia
- 2008: COP 14/CMP 4, Poznan. Poland
- 2009: COP 15/CMP 5, Copenhagen, Denmark
- 2010: COP 16/CMP 6, Canciin, Mexico
- 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**
- 2016: COP 22/CMP 12, Marrakech, Morocco

- 2017: COP 23/CMP 13, Bonn, Germany.
- 2018: COP 24/CMP 14, Katowice, Poland.

## Criticisms of the UNFCCC

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- Nothing except Kyoto Protocol made any binding limits on GHG emissions.
- Never achieved its stated goals of reducing the emission of carbon dioxide.
- Negotiations are governed by consensus and small group of countries often block the negotiations.
- It is easy for the developed countries to escape from their responsibility: **United States**, one of the biggest polluters **never ratified Kyoto Protocol**.
- **Canada pulled out of Kyoto Protocol** citing wealth transfers out the country due to binding limits.
- Treaty doesn't cover developing countries who now include the largest CO<sub>2</sub> emitters (India and China).
- **Japan, Russia didn't sign second Kyoto** term because it would impose restrictions on it not faced by its main economic competitors, China, India and Indonesia.

## Kyoto Protocol (COP 3; UNFCCC Summit 1997)

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

## What is Common but Differentiated Responsibilities – Kyoto Protocol?

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- It puts the obligation to reduce current emissions on **developed countries** on the basis that they are historically responsible for the current levels of greenhouse gases in the atmosphere.

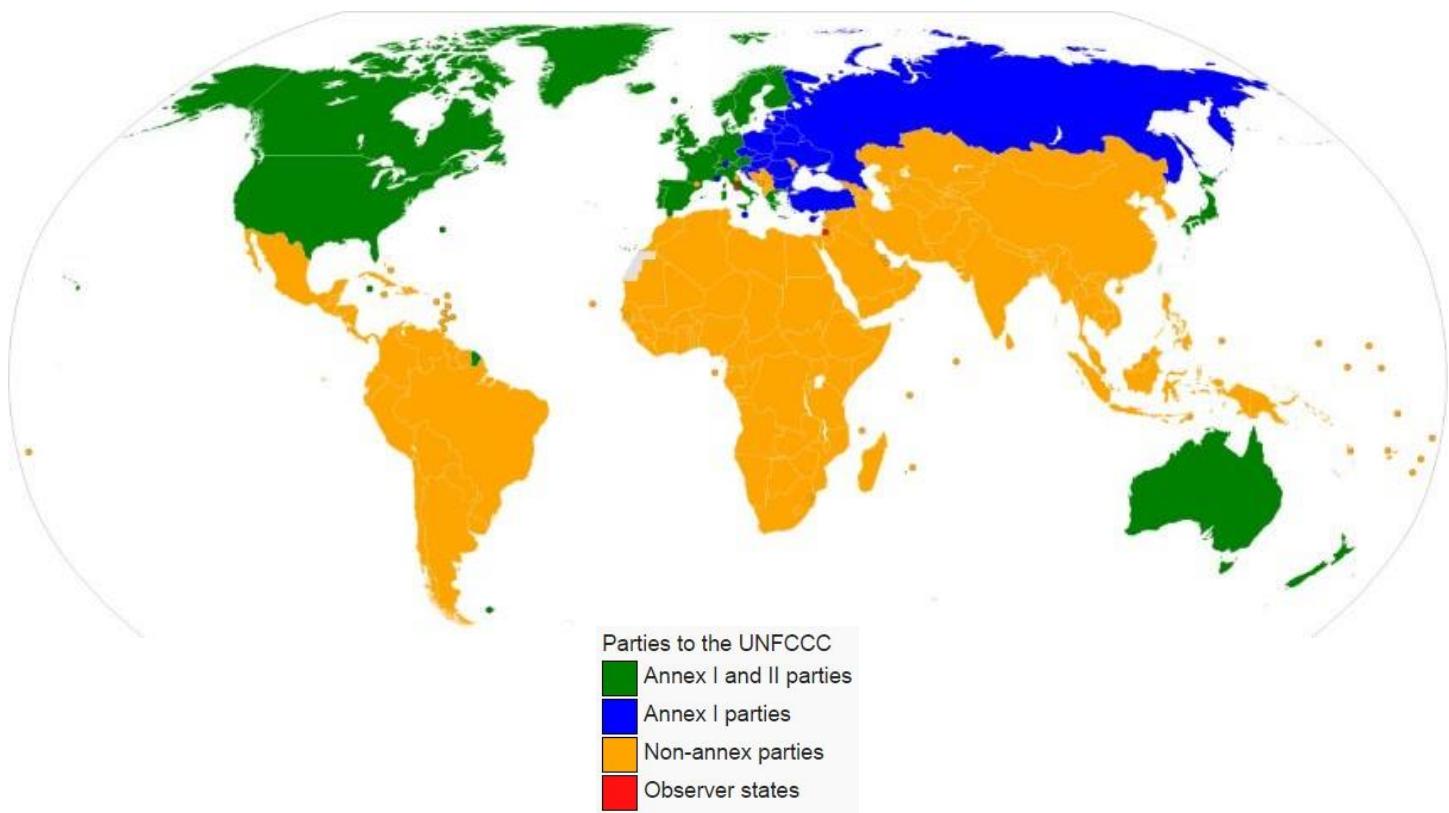
**CBDR divides countries into two categories.**

1. Historically biggest polluting developed countries like US, UK, France, Japan, Russia etc. (they are polluting the earth since Industrial Revolution).
  2. Recently polluting developing countries like **China, India, Brazil**, etc. (polluting since 1950s).
- “Common” → Every country (both developing and developed) must take part in the fight against climate change.
  - “But differentiated responsibilities” → Historically biggest polluters should do more compared to the recent polluters, i.e., responsibilities proportional to pollution caused.
  - Thus, under CBD, developed countries like US, UK, Russia etc. must contribute more to reduce GHGs.
  - **They must accept to certain binding limits on GHG emissions.**
  - They must contribute funds towards reducing GHG emissions in developing and least developed countries.
  - On the other hand, developing and least developed countries should do everything possible to cut down their GHG emissions. But **nothing is binding on them, and every initiative is voluntary.**

### Classification of Parties and their commitments – Kyoto Protocol

<b>Annex I</b>	<ul style="list-style-type: none"><li>• <b>Developed countries [US, UK, Russia etc.] + Economies in transition (EIT)</b> [Ukraine, Turkey, some eastern European countries etc.]</li></ul>
<b>Annex II</b>	<ul style="list-style-type: none"><li>• <b>Developed countries</b> (Annex II is a subset of Annex I).</li><li>• Required to provide <b>financial and technical support</b> to the EITs and developing countries to assist them in reducing their greenhouse gas emissions.</li></ul>
<b>Annex B</b>	<ul style="list-style-type: none"><li>• Annex I Parties with first or second-round Kyoto greenhouse gas emissions targets.</li><li>• The first-round targets apply over the years <b>2008–2012</b> and the second-round Kyoto targets, which apply from <b>2013–2020</b>.</li><li>• <b>Compulsory binding targets</b> to reduce GHG emissions.</li></ul>
<b>Non-Annex I</b>	<ul style="list-style-type: none"><li>• Parties to the UNFCCC not listed in Annex I of the Convention (mostly low-income developing countries).</li><li>• <b>No binding targets</b> to reduce GHG emissions.</li></ul>
<b>LDCs</b>	<ul style="list-style-type: none"><li>• Least-developed countries</li><li>• <b>No binding targets</b> to reduce GHG emissions.</li></ul>

- Developing countries may volunteer to become Annex I countries when they are sufficiently developed.



## What is commitment period – Kyoto Protocol?

- Under Kyoto Protocol, there are two commitment periods:
  1. **2008 – 2012 and**
  2. **2013 – 2020.**
- The second commitment period was agreed on in 2012, known as the **Doha Amendment to the protocol**.
- Each commitment period has its own binding targets set for developed countries to reduce their GHG emissions.
- Nations that miss their Kyoto target in 2012 **will incur a penalty of an additional third** added to whatever cut they agree under a new treaty in Copenhagen.
- During first commitment period (2008-12), more than 35 countries had binding targets.
- **Canada withdrew in 2012 after the first commitment period.**
- **Japan, New Zealand and Russia** have participated in Kyoto's first-round but have not taken on new targets in the second commitment period.
- As of January 2019, 124 states have accepted the Doha Amendment, while entry into force requires the acceptances of 144 states.
- Thus, the **second commitment period is a failure**.
- Negotiations were held in Lima in 2014 to agree on a post-Kyoto legal framework that would obligate all major polluters to pay for CO<sub>2</sub> emissions.

- **China, India, and the United States (three big villains)** have all signalled that they will not ratify any treaty that will commit them legally to reduce CO<sub>2</sub> emissions.

### **The Kyoto Protocol emission target gases include**

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- **Carbon dioxide (CO<sub>2</sub>),**
- **Methane (CH<sub>4</sub>),**
- **Nitrous oxide (N<sub>2</sub>O),**
- **Sulphur hexafluoride (SF<sub>6</sub>),**
- **groups of hydro fluorocarbons (HCFs) and**
- **groups of Per fluorocarbons (PFCs).**

### **Flexible Market Mechanisms – Kyoto Protocol**

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- 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**”.

#### **The Kyoto Flexible Market Protocol mechanisms include:**

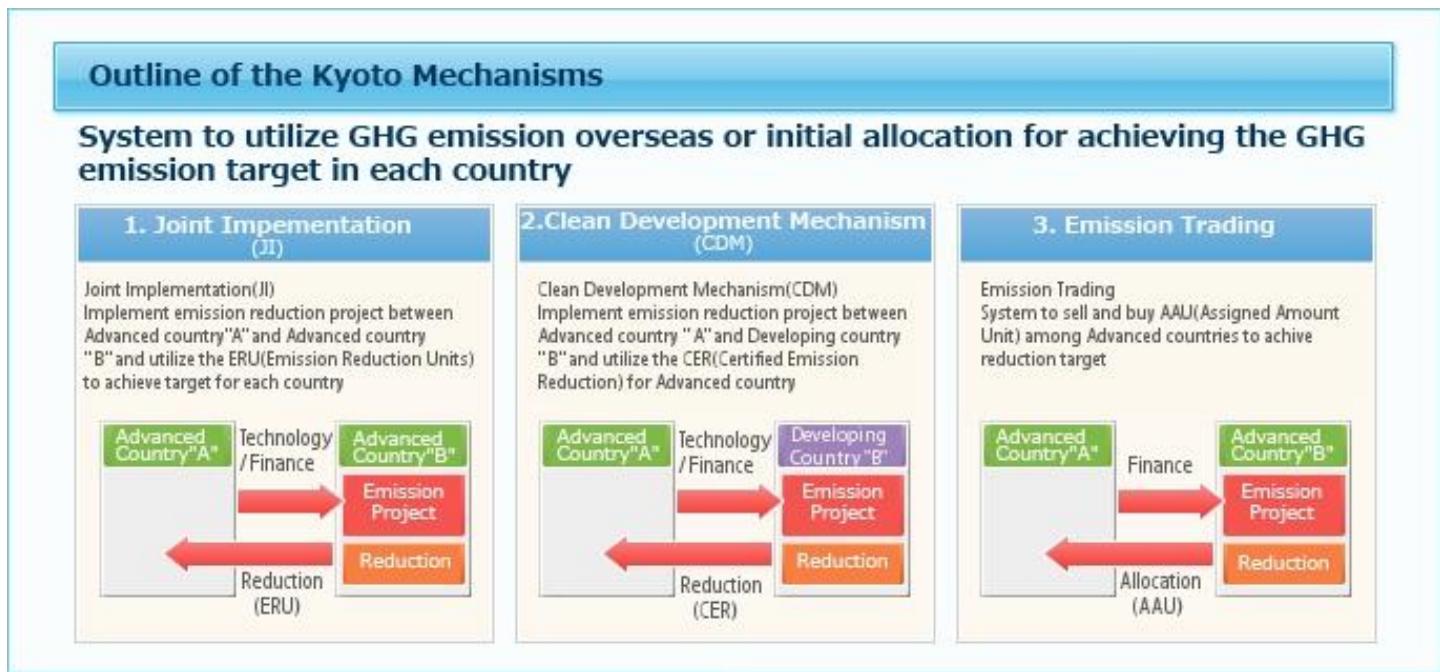
1. **Clean Development Mechanism (CDM)**
2. **Emission Trading**
3. **Joint Implementation (JI)**

### **Clean Development Mechanism (CDM) – Kyoto Protocol**

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- CDM allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to **implement an emission-reduction project in developing countries**.
- Hypothetical E.g. of CDM: Australia takes up or finances some environment benefitting project in India (solar power projects, wind power projects, afforestation etc.) and earns some **carbon credits (certified emission reduction credits)**. Now it shows these earned carbon credits to the world and tells them how it is working towards meeting its Kyoto targets.
- Such projects can earn saleable **certified emission reduction (CER) credits**, each equivalent to **one tonne of CO<sub>2</sub>**, 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 and least developed countries to create clean energy (solar, wind energy etc.) and gain some carbon credits thereby meeting their Kyoto Quota (Kyoto units) of emissions without violations.

- Suppose a developed country has a Kyoto Quota of 100 Carbon Credits, it can emit 100 tonnes of CO<sub>2</sub>.
- Due to negligence it emits 110 tonnes of CO<sub>2</sub>, i.e. 10 carbon credits are lost (Kyoto Quota violation).
- Now the country has to make up for its lost carbon credits to avoid penalty.
- So, it invests some money (equal to 10 carbon credits) in developing 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 penalty.



[Pic Credits](#)

## Carbon Credits Trading [Carbon Trading] – Kyoto Protocol

### Carbon credit – Kyoto Protocol

- A carbon credit (often called a **carbon offset**) is a **tradable certificate or permit**.
- One carbon credit is equal to **one tonne of carbon dioxide**.
- Carbon credits are a part of attempts to mitigate the growth in concentrations of GHGs.
- Carbon credits or carbon offsets can be acquired through afforestation, renewable energy, **CO<sub>2</sub> sequestration, methane capture, buying from an exchange (carbon credits trading)** etc..
- Carbon trading is the name given to the **exchange of emission permits**.
- This exchange may take place within the economy or may take the form of international transaction.
- Under 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 right to emit **one tonne of CO<sub>2</sub>**.

- A developing nation such as India, turns out to be a seller of such credits, which eventually provides them with monetary gains.
- Carbon credits are traded at various exchanges across the world.
- **Multi-Commodity Exchange of India** (MCX) launched futures trading in carbon credits in 2009.

### Types of Carbon trading

- Emission trading and
- Offset trading.

#### **Emission trading/'cap-and-trade'**

- Emissions trading allows countries to sell unused emission units to countries that have exceeded their targets.
- Carbon is tracked and traded like any other commodity in a "carbon market."

Other trading units in the carbon market:

- A removal unit (RMU) by reforestation.
- An emission reduction unit (ERU) generated by a joint implementation project.
- A certified emission reduction (CER) generated from a clean development mechanism project activity.

#### **Offset Trading/Carbon Project/'baseline-and credit' trading**

- Another variant of carbon credit is to be earned by a country by investing some amount of money in such projects, known as **carbon projects**, which will emit lesser amount of greenhouse gas in the atmosphere.
- For example, suppose a thermal plant of 800 megawatt capacity emit 400 carbon-equivalent in the atmosphere. Now a country builds up an 800 megawatt wind energy plant which does not generate any amount of emission as an alternative of the thermal plant. Then by investing in this project the country will earn 400 carbon-equivalent.
- Offset Trading is a variant of Emission Trading or Carbon Trading.

#### **Carbon tax (not related to Kyoto Protocol)**

- It is a **tax on all fossil fuels in proportion to carbon dioxide emissions**.
- Proposed in may developed and developing countries.
- The proposal faced political resistance (politician – corporate nexus, people feared more burden).
- India has a carbon tax of sorts. Budget of 2010-11 introduced a **cess of Rs. 50 per tonne of 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** in 2017.
- 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**.

## **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 goes above its emissions cap and does not try to make up the difference through any of the mechanisms available, then said country must make up the difference plus an **additional thirty percent during the next period**.
- The country could also be banned from participating in the 'cap and trade' program.

## **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<sub>2</sub>, which can be counted towards meeting its Kyoto target.
- 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.

### **Q. 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 greenhouse gases 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.
- Answer d) Carbon credit prices are traded on an exchange. So, their prices are never fixed.

## **Benefits of Flexible Market Mechanisms**

- Stimulating green investment in developing countries.
- Including the private sector in this endeavour to cut and hold steady GHG emissions at a safe level.

- It also makes "leap-frogging" — possibility to skip older, dirtier technology for newer, cleaner infrastructure and systems, with obvious longer-term benefits.
- Strengthen the Protocol's environmental integrity, support the carbon market's credibility and ensures transparency of accounting by Parties.

## Criticism of Kyoto Protocol

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- Under Kyoto Protocol, Annex 1 countries can meet their targets by cutting emissions or buying unused allowances (carbon credits, carbon trading) from other countries. This kind of approach ignores long term social and economic costs. It is like committing only half of what one needs to commit.
- 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 like China and India, which have since become the world's largest and fourth largest polluters.

## Important UNFCCC Summits Post Kyoto

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- After the Kyoto Protocol, parties to the Convention have agreed to further commitments.
- CMP: Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol.
- COP11 / CMP 1 was held in **Montreal, Canada in 2005 (Kyoto Protocol was ratified in 2005)**.

## Bali (Indonesia) Climate Change Conference 2007 (COP 13; CMP 3)

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COP 13: It is the 13th session of the Conference of the Parties to the UNFCCC

CMP 3: It is the 3rd session of the COP serving as the Meeting of the Parties to the Kyoto Protocol.

- Governments adopted the Bali Road Map.

### Bali Road Map included:

- Reaching an agreed outcome and adopting a decision at COP15 in Copenhagen.
- The review of the **financial mechanism, going beyond the existing Global Environmental Facility**.

## Poznan (Poland) Climate Change Conference 2008 (COP 14; CMP 4)

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- It launched the **Adaptation Fund** under the Kyoto Protocol.
- The Fund is financed in part by 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) Climate Change Conference 2009 (COP 15; CMP 5)**

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- The Copenhagen Accord included the goal of **limiting the maximum global average temperature increase to no more than 2 degrees Celsius above pre-industrial levels**, subject to a review in 2015.
- Developed countries promised to provide US\$30 billion for the period 2010-2012, and to mobilize long-term finance of a further **US\$100 billion a year by 2020** from a variety of sources.

## **Cancún (Mexico) Climate Change Conference 2010 (COP 16; CMP 6)**

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- Parties **agreed to commit to a maximum temperature, rise of 2 degrees Celsius above pre-industrial levels**, and **to consider lowering that maximum to 1.5 degrees in the near future**.
- Parties agreed to establish a **Green Climate Fund** to provide financing to projects, programmes, policies and other activities in developing countries via thematic funding windows.
- Governments also agreed to include carbon capture and storage (CCS) in the projects under the Clean Development Mechanism (CDM), subject to technical and safety standards.

## **Durban (Denmark) Climate Change Conference 2011 (COP 17; CMP 7)**

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- The outcomes included a decision by Parties to adopt a universal legal agreement on climate change as soon as possible, and no later than 2015.
- **Second phase of Kyoto Protocol was secured.**
- **Approved the Governing Instrument for the GCF.**

### **Green Climate Fund**

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- **COP 16 → Decision Made to Establish GCF.**
- **COP 17 → Parties approved the Governing Instrument for the GCF → Legal Approval**
- **COP 18 → Songdo, Incheon, Republic of Korea will host GCF.**
- The Fund will start operating from 2013.
- 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 by 2020.

### **Q. 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 climate change.
- 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

Answer: a) 1 only

### **Doha (Qatar) Climate Change Conference 2012 (COP 18; CMP 8)**

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- The conference 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 – 2020**).
- The extension of the Kyoto Protocol until 2020 limited in scope to only 15% of the global CO<sub>2</sub> emissions.
- This was due to the lack of participation of **Canada, Japan, Russia, Belarus, Ukraine, New Zealand** and the **United States**. (they all refused to join the second commitment period under the Kyoto Protocol)
- Also, **developing countries like China, India and Brazil are not subject to any emissions reductions** under the Kyoto Protocol.
- The conference made little progress towards the funding of the Green Climate Fund.

### **Warsaw (Poland) Climate Change Conference 2013 (COP 19; CMP 9)**

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- The conference led to an agreement that all states would start cutting emissions as soon as possible, but preferably by the first quarter of 2015.
- The term **Intended Nationally Determined Contributions** was coined in Warsaw.
- Further the **Warsaw Mechanism** was proposed, which would provide expertise, and possibly aid, to developing nations to cope with loss and damage from such natural extremities as heatwaves, droughts and floods and threats such as rising sea levels and desertification.

### **Lima (Peru) Climate Change Conference 2014 (COP 20; CMP 10)**

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- The overarching goal of the conference is to reduce greenhouse gas emissions (GHGs) to **limit the global temperature increase by 2030 to 2 degrees Celsius above 1850 baseline or Pre Industrial era**.
- The agreement urged parties to take national pledges by finalizing their **Intended Nationally Determined Contributions (INDC) by November 2015** (before Paris Summit).
- No agreement was reached due to lack of consensus between developed and developing countries.

## Developed vs. Developing

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- Wealthy nations like the U.S, EU argued that emissions from developing countries are consistently rising and they need to commit to more serious emission cuts.
- But India accused them of watering down the CDR principle envisaged in earlier.
- India stuck to its conventional position that the developed countries should shoulder a bigger burden as they are responsible for the problem in the first place.
- India confirmed that poverty alleviation would continue to be its primary concern and hence it will not compromise with its share of carbon credits.

## India's position

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- **China agreed a deal in 2014 under which its emissions would peak by 2030** (after 2030, it will start reducing its carbon footprint).
- India, the **world's third largest carbon emitter**, is under pressure to make commitments like China.
- India says carbon emissions will grow as it strives to beat poverty.
- India wants to use its carbon credits to alleviate poverty and is not ready to accept anything other than 'common but differentiated responsibilities'.

## What India must do other than blaming developed nations

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- India must demonstrate concerns about climate change issues (2015 Chennai floods, 2013 Uttarakhand floods, 2018 Kerala floods are all the effects of climate change).
- Emissions in India are rising dangerously, and the environmental costs will offset all its economic progress.
- India had to make a pragmatically determined national pledge before Paris Summit (**India announced its INDC in October 2015**).

TARGETS FOR PARIS AGREEMENT			
			
<b>INDIA</b> Emission intensity of GDP <b>33-35%</b> below 2005 levels by 2030, Power capacity to be 40% non fossil fuel based	<b>CHINA</b> Emission intensity of GDP <b>60-65%</b> below 2005 levels by 2030. Peak emissions around 2030. Non-fossil fuel to be 20% of primary energy consumption by 2030	<b>USA</b> Absolute emissions <b>26-28%</b> below 2005 levels by 2025	<b>EU (28)</b> Absolute emissions <b>40%</b> below 1990 levels by 2030

Source: uefccc.int

## Paris Climate Change Conference 2015 (COP 21; CMP 11)

- No agreement was reached in Lima.
- All agreements and decisions were reserved for Paris Summit 2015.
- Paris Summit is one of the most important environmental conference because of the **INDC commitments** made by major polluters.
- The conference objective is to achieve a **legally binding and universal agreement on climate to be signed in 2015 and implemented by 2020**.
- Prior to the conference, 146 national climate panels publicly presented draft national climate contributions (so-called Intended Nationally Determined Contributions, INDCs).
- However, no detailed timetable or country-specific goals for emissions were incorporated into the Paris Agreement – as opposed to the previous Kyoto Protocol.
- There will be neither a mechanism to force a country to set a target by a specific date nor enforcement measures if a set target is not met.

## Paris Agreement

- The conference negotiated the Paris Agreement, a global agreement on the reduction of climate change.
- It entered into force in November **2016** after (ratification by 55 countries that account for at least 55% of global emissions) had been met.
- Signatories: [195 as of 2019](#); 180+ countries have ratified; **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 expected key result was an agreement **to set a goal of limiting global warming to "well below 2 °C Celsius compared to pre-industrial levels.**
- The agreement calls for **zero net anthropogenic greenhouse gas emissions to be reached during the second half of the 21st century.**
- In the adopted version of the Paris Agreement, the parties will also "pursue efforts to **limit the temperature increase to 1.5 °C.**"
- The 1.5 °C goal will require zero emissions sometime between 2030 and 2050, according to some scientists.
- The developed countries reaffirmed the commitment to mobilize **\$100 billion a year** in climate finance by 2020 and agreed to continue mobilizing finance at the level of \$100 billion a year until 2025.
- In 2017, **United States** announced that the U.S. would cease all participation in the 2015 Paris Agreement on climate change mitigation.
- In accordance with Article 28 of the Paris Agreement, the earliest possible effective withdrawal date by the United States cannot be before November **2020**. Thus, The U.S. will remain a signatory till November 2020.

### **Climate Neutral Now**

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- The UNFCCC secretariat launched its Climate Neutral Now initiative in 2015.
- The following year, the secretariat launched a new pillar under its Momentum for Change initiative focused on Climate Neutral Now.
- Climate Neutral Now is aiming at encouraging and supporting all levels of society to take climate action to achieve a **climate neutral world by 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.**

**Q. With reference to the Agreement at the UNFCCC Meeting in Paris in 2015, which of the following statements is/are correct? (2016)**

- 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
- It entered into force in November **2016**.

Answer: b) 2 only

#### **Q. Momentum for Change: Climate Neutral Now" is an initiative launched by (2018)**

- a) The Intergovernmental Panel on Climate Change
- b) The UNEP Secretariat
- c) The UNFCCC Secretariat
- d) The World Meteorological Organisation

#### **China-U.S. deal on emission cuts**

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- Prior to the summit, China and the United States have agreed on a timetable to limit emission of GHGs.
- **US agreed to reduce by 2025 its emission of greenhouse gases by 26 per cent to 28 per cent below its 2005 level.**
- **China stated its intent to peak emissions of carbon dioxide in 2030**, if not earlier (from 2030 it will start reducing its emissions).
- It also agreed to raise the share of non-fossil fuels to 20 per cent in the next 16 years.
- India's per capita emissions are estimated at one-tenth of the United States and one-fourth of China.
- China – US deal imposed a fresh pressure on India to make a voluntary commitment.
- India announced its INDCs in the end of 2015.



## What is an INDC?

- During **Warsaw Summit 2013 (COP 19)**, countries agreed to publicly outline **what actions they intend to take under a global agreement well before the Paris Summit 2015**.
- These country commitments are known as Intended Nationally Determined Contributions (INDCs).

## The main points of contention on INDCs

### Inclusion of Adaptation, finance and transfer of technology

- Developed countries are of the view that only actions that help in reducing greenhouse gas emissions should be counted as 'contributions' in INDCs.
- Almost every developing country, including India, however, wants adaptation measures also to be counted.
- Developing countries also want efforts by developed ones on providing money or transferring technology to poorer nations to be included in INDCs.
- This will help in holding the rich countries (biggest culprits that contributed to the increase of GHG emissions since Industrial Revolution) accountable to their promises on ensuring financial and technology flows.

### Commitment Period

- India, European Union, China etc. are in favour of a 10-year commitment period.

- The United States, however, wants five-year commitment period so that countries can make quicker reviews.

### Ex-post Review

- Since the INDCs are '**nationally-determined' and voluntary**', the level of ambition in making 'contributions' is likely to be low.
- Some countries want an assessment of each country's INDC to see whether these are in line with the global 2 degree target.
- India and the United States strongly resent any such provision, saying such an exercise will negate the 'nationally-determined' nature of the 'contributions'.

### Q. The term '**Intended Nationally Determined Contributions**' is sometimes seen in the news in the context of

- pledges made by the European countries to rehabilitate refugees from the war-affected Middle East
- plan of action outlined by the countries of the world to combat climate change
- capital contributed by the member countries in the establishment of Asian Infrastructure Investment Bank
- plan of action outlined by the countries of the world regarding Sustainable Development Goals

Answer: b)

### India's INDC objectives

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- Announced in October 2015 (Lima summit urged every country to announce its INDCs by Nov 2015)
- **Reduce emission intensity by 33 to 35 per cent by 2030 compared to 2005 levels.**

How?

- Introduce new, more efficient and cleaner technologies in thermal power generation.
- Reducing emissions from transportation sector.
- Promote energy efficiency, mainly in industry, transportation, buildings and appliances
- Develop climate resilient infrastructure.
- **Pursue Zero Effect, Zero Defect policy** under Make in India programme.
- **Produce 40 per cent of electricity from non-fossil fuel based energy resources by 2030**, if international community helps with technology transfer and low cost finance.

How?

- Install **175 GW of solar, wind and biomass electricity by 2022**, and scale up further in following years.

- Aggressively pursue development of hydropower.
- Achieve the target of **63 GW of installed nuclear power capacity by 2032**.
- Create an additional **carbon sink of 2.5 to 3 billion tonnes of carbon dioxide equivalent by 2030** through additional forest and tree cover.

How?

- Full implementation of **Green India Mission** and other programmes of afforestation.
- Develop 1,40,000 km long tree line on both sides of national highways.
- Sustainable development.
- Develop robust adaptation strategies for agriculture, water and health sectors.

How?

- Redesign National Water Mission and National Mission on Sustainable Agriculture.
- Active implementation of ongoing programmes like National Initiative on Climate Resilient Agriculture, setting up of 100 mobile soil-testing laboratories, distribution of soil health cards to farmers.
- Additional impetus on watershed development through Neeranchal scheme.
- Effective implementation of National Mission on Clean Ganga.
- Early formulation and implementation of National Health Mission.
- Complete Integrated Coastal Zone Management plan. Mapping and demarcation of coastal hazard lines.

### **Money required to meet India's INDC**

- At least USD 2.5 trillion required between 2015 and 2030 to implement all planned actions.
- **Cess on coal** is being used for funding clean energy projects through **National Adaptation Fund**.
- Tax free infrastructure bonds were introduced for funding 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 within a country.
- They are issued by governments or government authorized Infrastructure companies or Non-Banking Financial Companies.

- Investments up to Rs. 20000 are eligible for income tax deduction under Section 80 CCF of the Income Tax Act.

### National Adaptation Fund on Climate Change (NAFCC)

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- Budget 2015 introduced "**National Adaptation Fund**" for climate change.
- As an initial sum, an amount of Rs 100 crore will be transferred to the Fund.
- Budget provision for the year 2015-16 and 2016-17 is Rs.350 crores.
- **Money obtained from coal cess goes into NAFCC.**
- Objective: Assist States and Union Territories 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**) has been appointed as National Implementing Entity (NIE) responsible for implementation of adaptation projects under the (NAFCC).

## Post Paris Summit

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### Marrakech (Morocco) Climate Change Conference 2016 (COP22; CMP12; CMA1)

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- CMA1 → the first meeting of the parties for the Paris Agreement.
- The purpose of the conference was to discuss and implement plans about combatting climate change and to "[demonstrate] to the world that the implementation of the Paris Agreement is underway".
- COP22 was called as "Action COP" or "**Agriculture COP**".
- **Adaptation of African Agriculture (AAA)** was [launched at COP 22](#).
- AAA is promoted by **FAO** along with various governments, especially African countries.

### International Solar Alliance

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- The **International Solar Alliance (ISA)** is an alliance was initiated by **India**.
- It was initiated at the India Africa Summit, and a meeting of member countries ahead of the Paris Summit.
- The framework agreement opened for signatures in Marrakech in 2016, and 122 countries have joined.
- Most of the 122 countries are **sunshine countries**, which lie either completely or partly between the **Tropic of Cancer and the Tropic of Capricorn**.
- ISA is now extended to all members of UN and is now a treaty-based inter-governmental organization.
- Countries that do not fall within the Tropics can join the alliance with the **exception of voting rights**.
- The primary objective of the alliance is to work for **efficient exploitation of solar energy to reduce dependence on fossil fuels**.
- Headquarters: **Gurugram, Haryana, India**.

**Q. Consider the following statements: (2016)**

- 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

**Bonn (Germany) Climate Change Conference 2017 (COP 23; CMP 13; CMA 1-2)**

- At COP 23 nations of the world met to advance the aims and ambitions of the Paris Agreement and achieve progress on its implementation guidelines.
- Parties will need to finalise the Implementation Guidelines at COP24.

**Katowice (Poland) Climate Change Conference 2018 (COP 24; CMP 14; CMA 1-3)**

- The conference agreed on rules to implement the **Paris Agreement**, which will come into force in **2020**, that is to say the rulebook on how governments will measure, and report on their emissions-cutting efforts.

**UN-REDD and REDD+**

UN-REDD	REDD+
<ul style="list-style-type: none"><li>• The United Nations Programme on <b>Reducing Emissions from Deforestation and Forest Degradation</b>.</li><li>• Headquarters: Geneva, Switzerland.</li><li>• Membership: 64 Partner Countries.</li></ul>	<ul style="list-style-type: none"><li>• <b>Reducing emissions from deforestation and forest degradation</b> and the role of conservation, sustainable management of forests and <b>enhancement of forest carbon stocks</b> in developing countries (REDD+)</li></ul>
<ul style="list-style-type: none"><li>• It is a multilateral <b>collaborative programme</b> of the<ul style="list-style-type: none"><li>✓ <b>Food and Agriculture Organization of the United Nations (FAO)</b>,</li><li>✓ <b>United Nations Development Programme (UNDP)</b> and</li><li>✓ <b>United Nations Environment Programme (UNEP)</b>.</li></ul></li></ul>	<ul style="list-style-type: none"><li>• Voluntary climate change mitigation approach that has been developed by Parties to the UNFCCC.</li></ul>

<ul style="list-style-type: none"><li>It was created in 2008 in response to the UNFCCC decisions on the Bali Action Plan and REDD at COP-13.</li><li>It partners with <b>developing countries</b> to support them in establishing the technical capacities needed to implement <b>REDD+</b> and meet UNFCCC requirements for REDD+ results-based payments.</li></ul>	<ul style="list-style-type: none"><li>REDD+ goes beyond simply deforestation and forest degradation.</li><li>It aims to incentivize developing countries to reduce emissions from deforestation and forest degradation, <b>conserve forest carbon stocks</b>, sustainably manage forests and enhance forest carbon stocks.</li></ul>
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- 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.

### **Q3. Which of the following statements is/are correct?**

Proper design and effective implementation of UN-REDD+ Programme 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.
- <http://www.fao.org/redd/en/> also says the same "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

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- It is a global partnership of governments, businesses, civil society, and Indigenous Peoples focused on reducing emissions from deforestation and forest degradation, forest carbon stock conservation, the sustainable management of forests, and the enhancement of forest carbon stocks in developing countries (activities commonly referred to as REDD+).
- The **World Bank** assumes the functions of trustee and secretariat.
- The World Bank, the Inter-American Development Bank and United Nations Development Programme are Delivery Partners under the Readiness Fund and 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+ activities.
- To test ways to sustain or enhance livelihoods of local communities and to conserve biodiversity.
- To disseminate broadly the knowledge gained in Emission Reductions Programs (ERPs).

**Q. 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
- 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

## 8.7 Others

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## Climate and Clean Air Coalition (CCAC)

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- 2012: a few nations, along with the **United Nations Environment Programme (UNEP)**, came together to form the Climate & Clean Air Coalition.
- It is a partnership of governments, public and private sector, scientific institutions, civil society organizations, etc. committed to protecting the climate through actions to **reduce short-lived climate pollutants**.

## Short-lived climate pollutants (SLCPs)

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- 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<sub>2</sub>.
- SLCPs are responsible for up to **45% of current global warming**, only next to CO<sub>2</sub>.
- SLCPs include black **carbon, methane, tropospheric ozone, and hydrofluorocarbons**.

### Black carbon

- It is a major component of soot and is produced by incomplete combustion of fossil fuel and biomass.
- It is emitted from diesel cars and trucks, ships, residential stoves, forest fires, agricultural open burning, etc.
- Its Global Warming Potential is 460-1500 times stronger than CO<sub>2</sub>.
- Its lifetime varies from a few days to a few weeks.
- When deposited on ice and snow, black carbon causes an **increase of melting rate**.
- It also influences **cloud formation** and impacts regional circulation and rainfall patterns and also has **negative effect on the photosynthesis**.

### Methane (CH<sub>4</sub>)

- Methane is a greenhouse gas that is over **21 times** more potent than CO<sub>2</sub>.
- It has an atmospheric lifetime of about **12 years**.
- It is produced through the **decomposition** of plant and animal waste.
- It is also emitted from coal mines, natural gas and oil systems, and landfills.
- Methane is a precursor of **tropospheric ozone**.

### Tropospheric or ground-level ozone (O<sub>3</sub>)

- Tropospheric ozone is present in the lowest portion of the atmosphere (10–15 km above the ground).
- It has a lifetime of a few days to a few weeks.
- It is not directly emitted but formed by sunlight-driven oxidation of **methane, carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs) and nitrogen oxides (NO<sub>x</sub>)**.

- Tropospheric ozone is responsible for **reductions in crop yields**.

### Hydrofluorocarbons

- Though HFCs represent a small fraction of current greenhouse gas emissions, their potential to warm the atmosphere is **hundreds to thousands of times greater** than that of the same given mass of carbon dioxide.

### Benefits of Reducing SLCPs

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- Reducing methane and black carbon could prevent major crop losses.
- Reducing SLCPs could slow down the warming expected by 2050 by about **0.5 °C**.
- SLCPs play an important role in achieving the **2° C target set by the Paris Agreement**.

### BioCarbon Fund Initiative

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- The **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 greenhouse gas emissions from the land sector, from deforestation and forest degradation in developing countries (REDD+), and from sustainable agriculture, as well as smarter land-use planning, policies and practices.

#### Q. 'BioCarbon Fund Initiative for Sustainable Forest Landscapes' is managed by the

- a) Asian Development Bank
  - b) International Monetary Fund
  - c) United Nations Environment Programme
  - d) World Bank
- Answer: d) World Bank

### Global Climate Change Alliance + (GCCA+)

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- (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** on Climate Change (COP21).

#### Q. With reference to 'Global Climate Change 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:

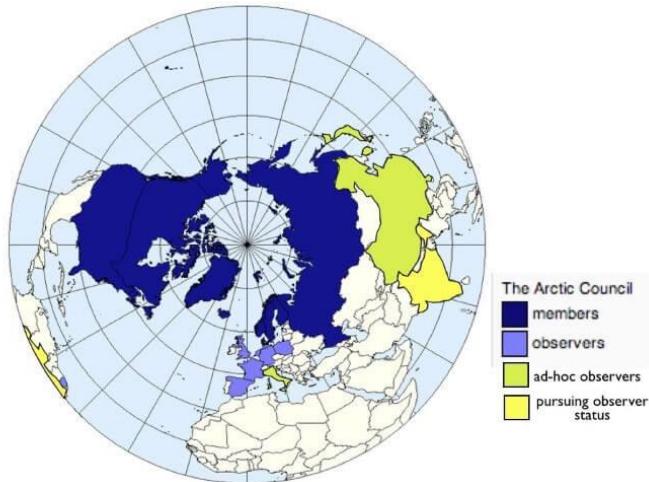
- a) 1 and 2 only
- b) 3 only
- c) 2 and 3 only
- d) 1, 2 and 3

Answer: a) 1 and 2 only

## Arctic Council

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- 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.



### Q. 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)

## 9. National Environmental Legislation

- Our constitution, originally, did not contain any direct provision regarding the protection of natural environment.
- However, after the **United Nations Conference on Human Environment, held in Stockholm in 1972**, Indian constitution was amended to include **protection of the environment as a constitutional mandate**.
- Environment related legislation came very late in **1972 with Wild Life Protection Act 1971**.
- The **forty second amendment (Fundamental Duties)** Clause (g) to Article 51A of the Indian constitution made it a **fundamental duty** to protect and improve the natural environment.
- **Clause (g) to Article 51A** 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 wild life and have compassion for living creatures."
- There is a directive, given to the State as one of the **Directive Principles of State Policy** regarding the protection and improvement of the environment.
- **Article 48A** 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**.
- The **Department of Environment was established in India in 1980** to ensure a healthy environment for the country. This later became the **Ministry of Environment and Forests (MoEF) in 1985**.
- **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 legislations.

## 9.1 Pollution Related Laws

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### The Water (Prevention and Control of Pollution) Act of 1974 and Amendment, 1988

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Some important provisions of this Act are given below:

- The Act vests regulatory authority in **State Pollution Control Boards** to establish and enforce effluent standards for factories.
- A **Central Pollution Control Board** performs the same functions for Union Territories and formulate policies and coordinates activities of different State Boards.
- The Act grants power to SPCB and CPCB to test equipment and to take the sample for the purpose of analysis.
- Prior to its amendment in 1988, enforcement under the Act was achieved through criminal prosecutions initiated by the Boards.
- The **1988 amendment act empowered SPCB and CPCB to close a defaulting industrial plant.**

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

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- The Water Cess Act was passed to generate financial resources to meet expenses of the Central and State Pollution Boards.
- The Act creates economic incentives for pollution control and requires local authorities and certain designated industries to pay a cess (tax) for water effluent discharge.
- The Central Government, after deducting the expenses of collection, pays the central and state boards such sums, as it seems necessary.
- 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 amendment, 1987

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- To implement the decisions taken at the United Nations Conference on the Human Environment held at Stockholm in June 1972, Parliament enacted the nationwide Air Act.
- The main objectives of this Act are to improve the quality of air and to prevent, control and abate air pollution in the country.

Important provisions of this Act are given below:

- The Air Act's framework is **similar to that of the Water Act of 1974.**

- The Air Act **expanded the authority of the central and state boards established under the Water Act, to include air pollution control.**
- States not having water pollution boards were required to set up air pollution boards.
- Under the Air Act, all industries operating within designated air pollution control areas must obtain a “**consent**” (**permit**) **from the State Boards.**
- The **states** are required to prescribe emission standards for industry and automobiles after consulting the central board and noting its ambient air quality standards.
- The Act grants power to **SPCB** and to test equipment and to take the sample for the purpose of analysis from any chimney, fly ash or dust or any other.
- Prior to its amendment in 1988, enforcement under the Act was achieved through criminal prosecutions initiated by the Boards.
- The 1988 amendment act empowered SPCB and CPCB to close a defaulting industrial plant.
- Notably, the 1987 amendment introduced a citizen’s suit provision into the Air Act and extended the Act to include **noise pollution**.

## 9.2 Environment (Protection) Act of 1986

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- In the wake of the **Bhopal tragedy**, the government of India enacted the Environment Act of 1986.
- The purpose of the Act is to implement the decisions of the **United Nations Conference on the Human Environment of 1972**.
- The decisions relate to the protection and improvement of the human environment and the prevention of hazards to human beings, other living creatures, plants and property.
- The Act is an “**umbrella**” for legislations designed to provide a framework for **Central Government**, coordination of the activities of various central and state authorities established under previous Acts, such as the **Water Act** and the **Air Act**.
- In this Act, main emphasis is given to “Environment”, defined to include water, air and land and the inter-relationships which exist among water, air and land and human beings and other living creatures, plants, micro-organisms and property.
- “**Environmental pollution**” is the presence of 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, which may cause harm to human beings, other living creatures, plants, microorganisms, property or the environment.
- Through this Act **Central Government gets full power** for the purpose of protecting and improving the quality of the environment.

### The main provisions of this Act are given below

- The Act empowers the centre to "take all such measures as it deems necessary".
- By virtue of this Act, Central Government has armed itself with considerable powers which include,
  - ✓ coordination of action by state,
  - ✓ planning and execution of nationwide programmes,
  - ✓ laying down environmental quality standards, especially those governing emission or discharge of environmental pollutants,
  - ✓ placing restriction on the location of industries and so on.
  - ✓ authority to issue direct orders, included orders to close, prohibit or regulate any industry.
  - ✓ power of entry for examination, testing of equipment and other purposes and power to analyse the sample of air, water, soil or any other substance from any place.
- The Act explicitly prohibits discharges of environmental pollutants in excess of prescribed regulatory standards.
- There is also a specific prohibition against **handling hazardous substances** except those in compliance with regulatory procedures and standards.
- The Act provides provision for penalties. For each failure or contravention, the punishment included a prison term up to five years or fine up to Rs. 1 lakh, or both.
- The Act imposed an additional fine of up to Rs. 5,000 for every day of continuing violation.
- If a failure or contravention occurs for more than one year, offender may be punished with imprisonment which may be extended to seven years.
- Section 19 provides that **any person**, in addition to authorized government officials, may file a complaint with a court alleging an offence under the Act.
- This "**Citizens' Suit**" provision requires that the person has to give notice of not less than 60 days of the alleged offence of pollution to the Central Government.

### Hazardous Microorganisms/Genetically Engineered Organisms or Cells 1989

- Biosafety concerns have led to the development of regulatory regime in India.
- Aim of 'Rules 1989' is to protect environment, nature and health in connection with application of gene technology and micro-organisms.
- These rules cover areas of research as well as large scale applications of GMOs and their products including experimental field trials and seed production.
- The Rules 1989 also define the competent authorities and composition of such authorities for handling of various aspects of the Rules.

Presently there are six committees:

1. **Recombinant DNA Advisory Committee (RDAC):** The functions are of an advisory nature. It recommends safety regulations for India in recombinant research, use and applications.
2. **Review Committee on Genetic Manipulation (RCGM)** established under the Department of Biotechnology, Ministry of Science and Technology, to monitor the safety related aspects in respect of on-going research projects.
3. **Genetic Engineering Appraisal Committee (GEAC):** it is the apex body constituted in the MoEF under 'Rules 1989', under the **Environment Protection Act, 1986**.
4. **State Biotechnology Coordination Committee (SBCC's)** have a major role in monitoring. It also has powers to inspect, investigate and take punitive action in case of violations of statutory provisions.
5. **District Level Committees (DLCs)** have a major role in monitoring the safety regulations in installations engaged in the use of genetically modified organisms/hazardous microorganisms and its applications in the environment.
6. **Institutional Biosafety Committee (IBSC)** is established under the institution engaged in GMO research to oversee such research and to interface with the RCGM in regulating it.

#### **Q. 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

#### **The Ozone Depleting Substances Rules**

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- The rules are framed under the jurisdiction of **Environment (Protection) Act**.
- These Rules set the deadlines for phasing out of various ODSs, besides regulating production, trade import and export of ODSs and the product containing ODS.

#### **National Ganga River Basin Authority (NGRBA)**

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- National Ganga River Basin Authority (NGRBA) is a financing, planning, implementing, monitoring and co-ordinating authority for the Ganges River, functioning under the **Ministry of Water Resources**.
- The mission of the organization is to safeguard the drainage basin which feeds water into the Ganges by protecting it from pollution or overuse.

- In 2014, the NGRBA has been transferred from the Ministry of Environment and Forests to the **Ministry of Water Resources, River Development & Ganga Rejuvenation.**
- It was established by the Central Government of India, in 2009 under Section 3(3) of the **Environment Protection Act, 1986**, which also declared Ganges as the '**National River' of India.**

## Composition of NGRBA

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- The **Prime Minister** chairs the authority.

Members belonging to the government sector are as follows:

- Prime Minister of India
- Minister of Environment and Forests (Union Minister)
- Minister of Finance
- Minister of Urban Development
- Minister of Water Resources
- Minister of Power
- Minister of Sciences and Technology
- Chief Ministers of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal
- Ministry of Environment and Forests (state minister)
- Ministry of Environment and Forests, secretary.

### Q. Which of the following are the key features of 'National Ganga River Basin Authority (NGRBA)'? (2016)

- 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

Answer: a) 1 and 2 only

## Environmental Impact Assessment (EIA)

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

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

- Individual projects that need require clearance from central government,
- Nuclear power and related projects,
- River valley projects including hydel power, major irrigation and flood control,
- Ports, harbours, airports (except minor ports and harbours),
- Petroleum refineries including crude and product pipelines,
- Chemical fertilizers and pesticides,
- Petrochemical complexes and petrochemical intermediates and production of basic plastics,
- Bulk drugs and pharmaceuticals,
- Exploration for oil and gas and their production, transportation and storage,
- Synthetic rubber,
- Asbestos and asbestos products,
- Hydrocyanic acid and its derivatives,

- Primary metallurgical industries (such as production of iron and steel, aluminium, copper, zinc, lead, and ferro-alloys),
- Chlor-alkali industry,
- Integrated paint complex including manufacture of resins and basic raw materials required in the manufacture of paints,
- Viscose staple fibre (biodegradable fibre similar to cotton) and filament yarn,
- Storage batteries integrated with manufacture of oxides of lead and lead antimony alloy,
- All tourism projects between 200m-500 metres of High Water Line and at locations with an elevation of more than 1000 metres with investment of more than Rs. 5 crores,
- Thermal power plants,
- Mining projects (with lease more than 5 hectares),
- Highway projects except projects relating to improvement work provided it does not pass through ecologically sensitive areas such as National Parks, Sanctuaries, Tiger Reserves, Reserve Forests,
- Tarred roads in the Himalayas and forest areas,
- Distilleries,
- Raw skins and hide,
- Pulp, paper and newsprint, dyes,
- Cement,
- Electroplating,
- Meta aminophenol, etc.

### **The important aspects of EIA are**

- **risk assessment,**
- **environmental management and**
- **post product monitoring.**

### **EIA is to**

- serve as a primary environmental tool with clear provisions.
- apply consistently to all proposals with potential environmental impacts.
- use scientific practice and suggest strategies for mitigation.
- address all possible factors such as short term, long term, small scale and large scale effects.
- consider sustainable aspects such as capacity for assimilation, carrying capacity, biodiversity protection.
- lay down a flexible approach for public involvement.

- have in built mechanism of follow up and feedback.
- include mechanisms for monitoring, auditing and evaluation.

## Benefits of EIA

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- EIA **links environment with development** for **environmentally safe and sustainable development**.
- EIA provides a cost effective method to eliminate or minimize the adverse impact of developmental projects.
- EIA enables the decision makers to analyse the effect of developmental activities on the environment well before the developmental project is implemented.
- EIA encourages the adaptation of mitigation strategies in the developmental plan.
- EIA makes sure that the developmental plan is environmentally sound and within limits of the capacity of assimilation and regeneration of the ecosystem.

## Environmental Components Of EIA

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

### Air environment

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

### Noise

- Levels of noise present and predicted
- Strategies for reducing noise pollution.

### Water environment

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

### Biological environment

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

## Land environment

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

## EIA Process and Procedures

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### Steps in EIA process

- EIA involves the steps mentioned below. However, EIA process is cyclical with interaction between the various steps.
- **Screening:** The project plan is screened for scale of investment, location and type of development and if the project needs statutory clearance.
- **Scoping:** The project's potential impacts, zone of impacts, mitigation possibilities and need for monitoring.
- **Collection of baseline data:** Baseline data is the environmental status of study area.
- **Impact prediction:** Positive and negative, reversible and irreversible and temporary and permanent impacts need to be predicted which presupposes a good understanding of the project by the assessment agency.
- **Mitigation measures and EIA report:** The EIA report should include the actions and steps for preventing, minimizing or bypassing the impacts or else the level of compensation for probable environmental damage or loss.
- **Public hearing:** On completion of the EIA report, public and environmental groups living close to project site may be informed and consulted.
- **Decision making:** Impact Assessment Authority along with the experts consult the project-in-charge along with consultant to take the final decision, keeping in mind EIA and EMP (Environment Management Plan).
- **Monitoring and implementation of environmental management plan:** The various phases of implementation of the project are monitored.
- **Assessment of Alternatives, Delineation of Mitigation Measures and Environmental Impact Assessment Report:** For every project, possible alternatives should be identified, and environmental attributes compared. Alternatives should cover both project location and process technologies.
- Once alternatives have been reviewed, a mitigation plan should be drawn up for the selected option and is supplemented with an Environmental Management Plan (EMP) to guide the proponent towards environmental improvements.
- **Risk assessment:** Inventory analysis and hazard probability and index also form part of EIA procedures.

### Steps in Preparation of EIA report

- Collection of baseline data from primary and secondary sources;

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

### **Environment Management Plan**

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

### **Environmental Appraisal**

- An **Appraisal Committee** constituted by the **Ministry of Environment and Forests** will first scrutinized a project based on the data presented by the project authorities.
- If necessary, the MoEF may also hold consultations with the investors and experts on specific issues as and when necessary.
- After considering all the facets of a projects, environmental clearance is accorded subject to implementation of the stipulated environmental safeguards.
- In case of projects where the project proponents have submitted complete information, a decision is taken **within 90 days**.
- The six regional offices of the Ministry functioning at Shillong, Bhubaneshwar, Chandigarh, Bangalore, Lucknow and Bhopal undertake monitoring of cleared projects.

### **EIA of Coasts**

- Coastal Zone Management Plans (CZMPs) are prepared by coastal states or Union Territories as per rules set by CRZ notification 1991.
- CZMPs are prepared based on identification and categorization of coastal areas for different activities and then submitted to the MoEF for approval.
- The ministry then forms a task force for examining their plans.

### **Single window clearance**

- Environmental clearance + Forestry clearance.
- When a project requires **both environmental clearance** as well as approval under the **Forest (Conservation) Act, 1980**, proposals for both are required to be given simultaneously to the concerned divisions of the Ministry.
- The processing is done simultaneously for clearance or rejection.

- If the project does not involve diversion of forestland, the case is processed only for environmental clearance.

### The Main Participants Of EIA

- EIA applies to public and private sections. The six main players are:
  - 1) Those who propose the project
  - 2) The environmental consultant who prepare EIA on behalf of project proponent.
  - 3) Pollution Control Board (State or National).
  - 4) Public has the right to express their opinion.
  - 5) The Impact Assessment Agency.
  - 6) Regional centre of the Ministry of Environment and Forest.

### Composition of the expert committees for EIA

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The Committees will consist of experts in the following disciplines:

- Eco-system management
- Air/water pollution control
- Water resource management
- Flora/fauna conservation and management
- Land use planning
- Social Sciences/Rehabilitation
- Project appraisal
- Ecology
- Environmental Health
- Subject Area Specialists
- Representatives of NGOs/persons concerned with environmental issues
- The Chairman will be an outstanding and **experienced ecologist or environmentalist or technical professional** with wide managerial experience in the relevant development.
- The representative of Impact Assessment Agency will act as a Member-Secretary.
- Chairman and members will serve in their individual capacities except those specifically nominated as representatives.
- The membership of a committee **shall not exceed 15 members.**

### Salient Features of 2006 Amendment to EIA Notification

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- Environment Impact Assessment Notification of 2006 has decentralized the environmental clearance projects by categorizing the developmental projects in two categories, i.e., **Category A (national level appraisal)** and **Category B (state level appraisal)**.
- 'Category A' projects are appraised at national level by Impact Assessment Agency (IAA) and the Expert Appraisal Committee (EAC) and Category B projects are appraised at state level.
- State Level Environment Impact Assessment Authority (SEIAA) and State Level Expert Appraisal Committee (SEAC) are constituted to provide clearance to Category B process.

### **After 2006 Amendment the EIA cycle comprises of four stages**

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

### **Shortcomings of Environmental Impact Assessment**

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#### **Applicability**

- There are several projects with significant environmental impacts that are exempted from the notification either because they are not listed in schedule I, or their investments are less than what is provided for in the notification.

#### **Composition of expert committees and standards**

- It is being found that the team formed for conducting EIA studies is lacking the expertise in various fields such as environmentalists, wild life experts, Anthropologists and Social Scientists (to study the social impact of the project).

#### **Public hearing**

- Public comments are not considered at the early stage, which often leads to conflict at the later stage of project clearance.
- A number of projects with significant environmental and social impacts have been excluded from the mandatory public hearing process.
- The documents which the public are entitled to are seldom available on time.
- The data collectors do not pay respect to the indigenous knowledge of local people.

### **Quality of EIA**

- One of the biggest concerns with the environmental clearance process is related to the quality of EIA report that are being carried out.
- The reports are generally incomplete and provided with false data.
- Many EIA reports are based on single season data.
- The EIA document in itself is so bulky and technical, which makes it very difficult to decipher so as to aid in the decision making process.

### **Lack of Credibility**

- It is the responsibility of the project proponent to commission the preparation of the EIA for its project.
- The EIA is actually funded by an agency or individual whose primary interest is to procure clearance for the project proposed.
- There is little chance that the final assessment presented is un biased, even if the consultant may provide an unbiased assessment that is critical of the proposed project.
- There are so many cases of fraudulent EIA studies where erroneous data has been used, same facts used for two totally different places etc.
- There is no accreditation of EIA consultants, therefore any such consultant with a track record of fraudulent cases cannot be held liable for discrepancies.
- It is hard to imagine any consultant after being paid lakh of rupees, preparing a report for the project proponents, indicating that the project is not viable.

### **Case Study**

- The MoEF constituted the **Western Ghats Experts Ecology Panel (WGEEP)** in 2010 under the Chairmanship of **Prof. Madhav Gadgil**.
- The Panel submitted its report in 2011 but it was not made public immediately due to its stringent assessment of the condition of Western Ghats.

- The report suggested many radical changes that needs to be brought to conserve Western Ghats.
- The recommendation if implemented would adversely affect mining mafia, sand mafia and local encroachers.
- Under pressure from various stakeholders, MoEF set up the **High Level Working Group (HLWG)** under the Chairmanship of **Dr. K. Kasturirangan** to study recommendations of WGEEP.
- The HLWG had diluted many recommendations of WGEEP to satisfy the interests of various mafia.

### **Monitoring, compliance and institutional arrangements**

- Often, and more so for strategic industries such as nuclear energy projected, the EMPS are kept confidential for political and administrative reasons.
- Details regarding the effectiveness and implementation of mitigation measures are often not provided.
- Emergency preparedness plans are not discussed in sufficient details and the information not disseminated to the communities.

**Q. 'Gadgil Committee Report' and 'Kasturirangan Committee Report', sometimes seen in the news, are related to (2016)**

- 1) constitutional reforms
- 2) Ganga Action Plan
- 3) linking of rivers
- 4) protection of Western Ghats

### **Recommendations to improve EIA process**

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#### **Independent EIA Authority.**

- Sector wide EIAs needed.
- Creation of a centralized baseline data bank.
- Dissemination of all information related to projects from notification to clearance to local communities and general public.

#### **Applicability**

- All those projects where there is likely to be a significant alteration of ecosystems need to go through the process of environmental clearance, without exception.
- No industrial developmental activity should be permitted in ecologically sensitive areas.

#### **Public hearing**

- Public hearings should be applicable to all hitherto exempt categories of projects which have environmental impacts.

## **Quality**

- The focus of EIA needs to shift from utilization and exploitation of natural resources to conservation of natural resources.
- At present EIA reports are extremely weak when it comes to assessment of biological diversity of a project area and the consequent impacts on it. This gap needs to be plugged.
- All EIA reports should clearly state what are the adverse impacts that a proposed project will have. This should be a separate chapter and not hidden within technical details.
- It is critical that the preparation of an EIA is completely independent of the project proponent.

## **Grant of clearance**

- The notification needs to make it clear that the provision for site clearance does not imply any commitment on the part of the impact Assessment agency to grant full environmental clearance.

## **Composition of expert committees**

- The present executive committees should be replaced by expert's people from various stakeholder groups, who are reputed in environmental and other relevant fields.

## **Monitoring, compliance and institutional arrangements**

- The EIA notification needs to build within it an automatic withdrawal of clearance if the conditions of clearance are being violated and introduce more stringent punishment for noncompliance. At present the EIA notification limits itself to the stage when environmental clearance is granted.

## **Redressal**

- The composition of the NGT needs to be changed to include more judicials from the field of environment.
- Citizen should be able to access the authority for redressal of all violation of the EIA notification as well as issues relating to non-compliance.

## **Capacity building**

- NGOs, civil society groups and local communities need to build their capacities to use the EIA notification towards better decision making on projects.

## 9.3 Biodiversity Related Laws

### **Wild Life (Protection) Act of 1972 and Amendment, 1982**

- In 1972, Parliament enacted the Wild Life Act (Protection) Act.
- The Wild Life Act provides for
  - ✓ state wildlife advisory boards,
  - ✓ regulations for hunting wild animals and birds,
  - ✓ establishment of sanctuaries and national parks,
  - ✓ regulations for trade in wild animals, animal products and trophies, and
  - ✓ judicially imposed penalties for violating the Act.
- **Harming endangered species listed in Schedule I 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.**
- **Wildlife wardens** and their staff administer the act.
- An amendment to the Act in 1982, introduced a provision **permitting the capture and transportation of wild animals for the scientific management of animal population.**

**Q. In India, if a species of tortoise is declared protected under Schedule I of the Wildlife (Protection) Act, 1972, what does it imply? (2017)**

- a) It enjoys the same level of protection as the tiger.
  - b) It no longer exists in the wild, a few individuals are under captive protection; and now it is impossible to prevent its extinction.
  - c) It is endemic to a particular region of India.
  - d) Both (b) and (c) stated above are correct in this context.
- Bengal Tiger's IUCN status is 'Endangered'. Gir Lions are also 'Endangered'. Hence they fall under Schedule I of Wildlife (Protection) Act, 1972.

Answer: a) It enjoys the same level of protection as the tiger (Bengal Tiger's IUCN status is 'Endangered').

**Q. According to the Wildlife (Protection) Act, 1972, which of the following animals cannot be hunted by any person except under some provisions provided by law? (2017)**

- 1) Gharial
- 2) Indian wild ass

3) Wild buffalo

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
- From the question, it is clear that the animal should falls under Schedule II or later.
  - Gharial is 'Critically Endangered' and Water buffalo is 'Endangered'. Hence, they fall under Schedule I. (**Almost** every animal listed in Chapter 6 IUCN Red List are in [Schedule I](#)).
  - Indian wild ass is moved from Endangered ([2015](#)) to Near Threatened ([2016](#)). It is listed under [Schedule I](#).

Answer: d) all

## **Forest (Conservation) Act of 1980**

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- First Forest Act was enacted in 1927.
- Alarmed at India's rapid deforestation and resulting environmental degradation, Centre Government enacted the Forest (Conservation) Act in 1980.
- It was enacted to consolidate the law related to forest, the transit of forest produces and the duty liveable on timber and other forest produce.
- **Forest officers** and their staff administer the Forest Act.
- Under the provisions of this Act, **prior approval of the Central Government** is required for diversion of forestlands for non-forest purposes.
- An Advisory Committee constituted under the Act advises the Centre on these approvals.
- The Act deals with the four categories of the forests, namely reserved forests, village forests, protected forests and private forests.

### **Reserved forest**

- A state may declare forestlands or waste lands as reserved forest and may sell the produce from these forests.
- Any unauthorized felling of trees quarrying, grazing and hunting in reserved forests is punishable with a fine or imprisonment, or both

### **Village forests**

- Reserved forests assigned to a village community are called village forests.

## Protected forests

- The **state governments** are empowered to designate protected forests and may prohibit the felling of trees, quarrying and the removal of forest produce from these forests.
- The preservation of protected forests is enforced through rules, licenses and criminal prosecutions.

## Biodiversity Act 2000

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- India's richness in biological resources and indigenous knowledge relating to them is well recognized.
- The legislation aims at regulating access to biological resources so as to ensure **equitable sharing** of benefits arising from their use.
- The Biological Diversity Bill was introduced in the Parliament in 2000 and was passed in 2002.

### Salient features of the biodiversity legislation

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- The main intent of this legislation is to **protect India's rich biodiversity and associated knowledge against their use by foreign individuals and organizations** without sharing the benefits arising out of such use, and to check **biopiracy**.
- This bill seeks to check biopiracy, protect biological diversity and local growers through a three-tier structure of central and state boards and local committees.
- The Act provides for setting up of a **National Biodiversity Authority (NBA), State Biodiversity Boards (SBBs) and Biodiversity Management Committees (BMCs)** in local bodies.
- The NBA will enjoy the power of a **civil court**.
- BMCs promote conservation, sustainable use and documentation of biodiversity.
- NBA and SBB are required to consult BMCs in decisions relating to use of biological resources.
- All foreign nationals or organizations require prior approval of NBA for obtaining biological resources and associated knowledge for any use.
- Indian individuals/entities require approval of NBA for transferring results of research with respect to any biological resources to foreign nationals/organizations.
- Collaborative research projects and exchange of knowledge and resources are exempted provided they are drawn as per the policy guidelines of the Central Government.
- However, Indian citizens/entities/local people including vaidas and hakims have free access to use biological resources within the country for their own use, medicinal purposes and research purposes.
- While granting approvals, NBA will impose terms and conditions to secure **equitable sharing of benefits**.
- Before applying for any form of **IPRs (Intellectual Property Rights)** in or outside India for an invention based on research on a biological resource obtained from India, **prior approval of NBA will be required**.

- The monetary benefits, fees, royalties as a result of approvals by NBA will be deposited in **National Biodiversity Fund**.
- NBF will be used for conservation and development of areas from where resource has been accessed, in consultation with the local self-government concerned.
- There is provision for notifying **National Heritage Sites** important from standpoint of biodiversity by **State Governments** in consultation with local self-government.
- There also exists provision for notifying items, and areas for exemption provided such exclusion does not violate other provisions. This is to exempt normally traded commodities so as not to adversely affect trade.

#### **Q. 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
- The top biotech regulator in India for Genetically Modified Organisms is **Genetic Engineering Appraisal Committee (GEAC)**.

Answer: c) 1 and 3 only

#### **Forest Rights Act, 2006**

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- The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006.
- Forest Rights Act, 2006 provides for the restitution of deprived forest rights across India.
- The Act is providing scope of **integrating conservation and livelihood rights of the people**.

#### **FRA is tool**

- To empower and strengthen the local self-governance
- To address the livelihood security of the people

- To address the issues of Conservation and management of the Natural Resources and conservation governance of India.

### **For the first time Forest Rights Act recognizes and secures**

- Community Rights in addition to their individual rights
- Right to protect, regenerate or conserve or manage any community forest resource which the communities have been traditionally protecting and conserving for sustainable use.
- Right to intellectual property and traditional knowledge related to biodiversity and cultural diversity
- Rights of displaced communities & Rights over developmental activities

### **Salient Features**

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- Nodal Agency for the implementation is **Ministry of Tribal Affairs (MoTA)**.
- This Act is applicable for Tribal and Other Traditional Forest Dwelling Communities.
- The Act provides for recognition of forest rights of other traditional forest dwellers provided they have for at least three generations prior to 13.12.2005 primarily resided in and have depended on the forests for bona-fide livelihood needs.
- The maximum limit of the recognizing rights on forest land is **4 ha**.
- **National Parks and Sanctuaries have been included along with Reserve Forest, Protected Forests for the recognition of Rights.**
- The Act recognizes the right of ownership access to collect, use, and dispose of minor forest produce by tribals.
- Minor forest produce includes all non-timber forest produce of plant origin.
- The rights conferred under the Act shall be heritable but not alienable or transferable.
- 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.

### **Critical Wildlife Habitats (CWH)**

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- The Critical Wildlife Habitats (CWH) have been envisaged in **Forest Rights Act, 2006**.
- CWH are defined under the act as the "areas of national parks and sanctuaries where it has been specifically and clearly established, case by case, on the basis of scientific and objective criteria, that such areas are **required to be kept as inviolate for the purposes of wildlife conservation**"
- 'Inviolate' is a general term used to indicate **no human settlement and usage**.
- **MoTA is the nodal authority for FRA**.

- But the FRA identifies **MoEF&CC** as the agency to notify the guidelines.

## 2011 Guidelines by MoEF&CC

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- A gram sabha's free informed consent must be given before any relocation 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, Forest Department's officers) will take the main responsibility for determining the habitats.
- In order to notify a CWH, the Act requires state governments to establish that the presence of right-holders is causing irreversible damage to wildlife and their habitats.
- After more than a decade of FRA's existence, not a single CWH had been notified.

## August 2018 Guidelines by MoEF

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- In March 2017, the National Tiger Conservation Authority (NTCA) issued an order to deny forest rights in critical tiger habitats (core areas of tiger reserves) in the absence of CWH guidelines.
- MoEF&CC finally issued CWH guidelines in January 2018 and NTCA order was superseded.
- However, unlike 2011, it sent the guidelines to states 'for action' without soliciting public comments.
- Forest rights activists see the guidelines as a dilution of FRA.

## Key features of guidelines

- The Chief Wildlife Warden of a state will notify a seven-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 a national park or sanctuary**.
- The Expert Committee will identify areas within national parks and sanctuaries, 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 of 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 decision on the proposal will be taken by the Standing Committee of the **National Board for Wildlife**.
- A MoTA representative would be invited during the deliberation of the proposal by the standing committee.
- Following the committee's recommendation, the notification of CWH will be published in the official gazette.

## How do the guidelines dilute FRA?

- The guidelines have replaced prior consent of the gram sabha with a public hearing of all stakeholders
- The guidelines require the constitution of an expert committee, of which a MoTA representative would be a member, to carry out extensive and open consultation with all the stakeholders.
- There is no mechanism in the guidelines to address the objections raised during consultations.
- It is also not clear whether there would be single or multiple consultation for an entire Protected Area.
- In the existing guidelines, CWH notification does not stand any public scrutiny once 'open consultations' have been carried out (in contrast the draft notification of every **Eco-sensitive Zones (ESZ)** is put up in public domain for at least **60 days** before its finalisation).
- The guidelines are silent on the issue of settlement of rights before notifying CWHs.

## Q. Consider the following statements: (2018)

- 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) Union Ministry of Environment, Forest and Climate Change 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
- 2016: **Baiga tribe** (living sal forests of Maikal Hills) in Madhya Pradesh is the [first to get habitat rights in India](#).
  - This is for the first time habitat rights have been given 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: 1 and 2 only.

## National Green Tribunal Act, 2010

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- Act of the Parliament of India which enables creation of NGT to handle the **expeditious disposal of the cases pertaining to environmental issues.**
- It was enacted under India's constitutional provision of **Article 21**, which assures the citizens of India the **right to a healthy environment.**
- The specialized architecture of the NGT will facilitate fast track resolution of environmental cases and provide a boost to the implementation of many sustainable development measures.
- NGT is mandated to dispose the cases **within six months** of their respective appeals.

### Origin

- During the Earth Summit 1992, India vowed the participating states to provide judicial and administrative remedies for the victims of the pollutants and other environmental damage.

### Members

- The sanctioned strength of the tribunal is currently 10 expert members and 10 judicial members although the act allows for up to 20 of each.
- The Chairman of the tribunal who is the administrative head of the tribunal also serves as a judicial member.
- Every bench of tribunal must consist of at least one expert member and one judicial member.
- The Chairman of the tribunal is required to be **a serving or retired Chief Justice of a High Court or a judge of the Supreme Court of India.**

### Jurisdiction

- The Tribunal has Original Jurisdiction on matters of "substantial question relating to environment" (i.e. a community at large is affected, damage to public health at broader level) & "damage to environment due to specific activity" (such as pollution).
- The term "substantial" is not clearly defined in the act.

**Q. 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)

#### **Q. How is the National Green Tribunal (NGT) different from the Central Pollution Control Board (CPCB) (2018)**

- 1) The NGT has been established by an Act whereas the CPCB has been created by an executive order of the Government.
- 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
- CPCB is a statutory organisation under the MoEFC.
  - It was established under the Water (Prevention and Control of Pollution) Act, 1974.

Answer: b) 2 only

### **9.4 Acts for Protecting Coastal Environment and Wetlands**

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#### **Coastal Regulation Zone (CRZ)**

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- The coastal stretches of seas, bays, estuaries, creeks, rivers and back waters which are **influenced by tidal action** are declared "Coastal Regulation Zone" (CRZ) in 1991.
- India has created institutional mechanisms such as National Coastal Zone Management Authority (NCZMA) and State Coastal Zone Management Authority (SCZMA) for enforcement and monitoring of the CRZ Notification.

- These authorities have been delegated powers under **Section 5 of the Environmental (Protection) Act, 1986** to take various measures for protecting and improving the quality of the coastal environment and preventing, abating and controlling environmental pollution in coastal areas.

## **Classification Criteria and Regulatory Norms**

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- The coastal regulation zone has been classified for the purpose of regulation of the permitted activities.

### **CRZ-I:**

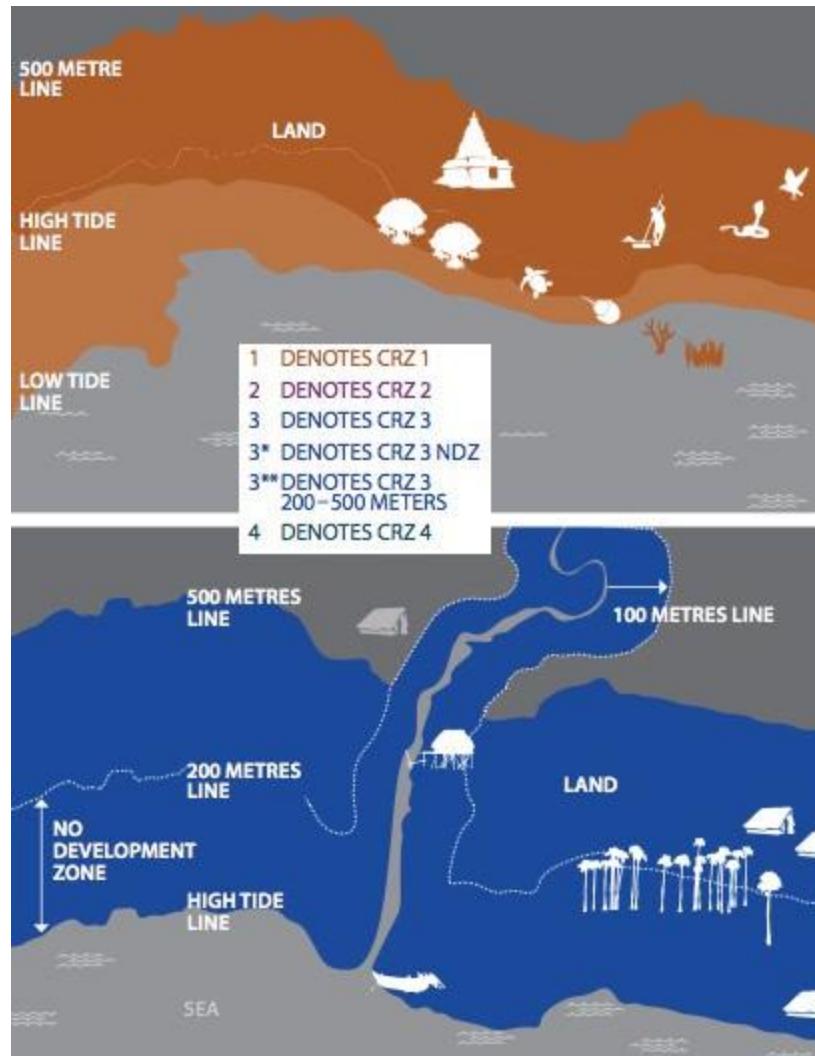
- **Ecological sensitive area and the area between High Tide Line (HTL) and Low Tide Line (LTL).**
- **No new construction is permitted** except for a few specified most essential activities like support activities for Atomic Energy Plants and Defense requirements, facilities required for disposal of treated effluents and other port related water front activities.

### **CRZ-II:**

- The area that have been developed up to or close to the shore line which includes the designated urban areas that are substantially built up.
- Buildings permitted only on the landward side of the existing authorized structures as defined in the notification.

### **CRZ-III:**

- The areas that are relatively undisturbed and those which do not belong to either CRZ-I or CRZ-II which includes mainly the rural area and those not substantially built up within designated urban areas.
- The area up **to 200 meters from HTL is earmarked as "No Development Zone".**
- **No construction is permitted within this zone** except for repairs to the existing authorized structures.
- **Development of vacant plots between 200 and 500 meters of HTL is permitted in CRZ III** for the purpose of construction of dwelling units and hotels/beach resorts subject to certain conditions.



#### CRZ-IV

- The activities impugning on the sea and tidal influenced water bodies will be regulated except for traditional fishing and related activities undertaken by local communities.
- No untreated sewage, effluents, pollution from oil drilling shall be let off or dumped.

#### **Wetlands (Conservation and Management) Rules 2010**

- MoEF has notified the rules in order to ensure that there is no further degradation of wetlands.
- The rules specify activities which are harmful to wetlands such as industrialization, construction, dumping of untreated waste and reclamation and prohibit these activities in the wetlands.
- Other activities such as harvesting, and dredging may be carried out in the wetlands but only with prior permission from the concerned authorities.
- Under the Rules, wetlands have been classified for better management and easier identification.
- **Central Wetland Regulatory Authority** has been set up to ensure proper implementation of the Rules.

## 9.5 Animals Related Laws

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### Animal Welfare Board of India

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- **Statutory advisory body** advising the Government of India on animal welfare laws and promotes animal welfare in the country of India.
- It works to ensure that animal welfare laws in the country are followed; provides grants to Animal Welfare Organizations; and considers itself "the face of the animal welfare movement in the country."
- It was established in 1960 under Section 4 of **The Prevention of Cruelty to Animals Act, 1960**.
- Well-known humanitarian **Rukmini Devi Arundale** was instrumental in setting up the board.
- The subject of Prevention of Cruelty to Animals is under **MoEF**.

### Functions

- The board is highly concerned about "abuse of animals in research" and "cruelty involved when animals were used in entertainment".
- The Board oversees Animal Welfare Organizations (AWOs) by granting recognition to them if they meet its guidelines.
- The Board provides financial assistance to recognized Animal Welfare Organizations (AWOs)
- The Board suggests changes to laws and rules about animal welfare issues.
- The Board issues publications to raise awareness of various animal welfare issues.

### Q. 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
- Animal Welfare Board of India is established under Prevention of Cruelty to Animals Act.
  - Answer: b) 2 and 3 only

## Project Tiger – Tiger Conservation

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- 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, Project Tiger was launched in the **Palamau Tiger Reserve**, and various tiger reserves were created in the country based on a '**core-buffer**' strategy.
- India has more than 80 national parks and 441 Sanctuaries of which some have been declared as Tiger reserves.
- Tiger reserves are governed by the **Project Tiger (1973)**.
- It is a **Centrally Sponsored Scheme** of the **Ministry of Environment and Forests**.
- It is administered by the **National Tiger Conservation Authority**.
- Aim: Protect tigers from extinction by ensuring a viable population in their natural habitats.
- Government has set up a **Tiger Protection Force** under PT to combat poachers.
- PT funds relocation of villagers to minimize human-tiger conflicts.

### Core and Buffer zones

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- The Tiger Reserves are constituted on a 'core-buffer strategy'.

#### Core Zone

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- The core area is kept **free of biotic disturbances** and forestry operations, where collection of minor forest produce, grazing, human disturbances are not allowed within.
- These areas are required to be kept for the purposes of tiger conservation, without affecting the rights of the Scheduled Tribes or such other forest dwellers.
- These areas are notified by the **State Government** in consultation with an Expert Committee (constituted for that purpose).

#### Buffer Zone

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- The Act defines buffer zone as 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.

#### Tiger Task Force

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- The implementation of Project Tiger over the years has highlighted the need for a statutory authority with 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.

**National Board for Wild Life ==> Tiger Task Force ==> National Tiger Conservation Authority**

### **National Tiger Conservation Authority (NTCA)**

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- The National Tiger Conservation Authority was established in December 2005 following a recommendation of the Tiger Task Force.
- National Tiger Conservation Authority administers Project Tiger.
- Administration of the tiger reserves will be in accordance with guidelines of NTCA.
- Tiger reserves in India are administered by field directors as mandated by 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 the approval of the National Board for Wild Life.

### **The Wild Life (Protection) Amendment Act, 2006**

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- The Act provides for creating
  1. **National Tiger Conservation Authority and**
  2. **Tiger and Other Endangered Species Crime Control Bureau (Wildlife Crime Control Bureau).**

### **NTCA members**

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- The Wildlife Protection Amendment Act, 2006 provides for the constitution of the National Tiger Conservation Authority.
- 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

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- The Authority lays down standards, guidelines for tiger conservation in the Tiger Reserves, National Parks and Sanctuaries.
- The Tiger Conservation Authority would be required to prepare an Annual Report, which would be laid in the Parliament along with the Audit Report.
- 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**.
- Provision will be made for the States to establish a **Tiger Conservation Foundation**, based on the good practices emanating from some tiger reserves.

## Problems involved with Project Tiger

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- 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 implications of such recognition for tiger conservation
- The project overlooks the role of abuse of power by authorities in the tiger crisis.

## Steps Taken by the Government

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### Legal Steps

- Amendment of the Wild Life (Protection) Act, 1972 to Wild Life (Protection) Act, 2006 for providing enabling provisions towards constituting the National Tiger Conservation Authority and the Tiger and Other Endangered Species Crime Control Bureau.
- Enhancement of punishment in cases of offence relating to a tiger reserve or its core area.

### Administrative Steps

- Strengthening of anti 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) [Budget 2008]

### Financial Steps

- Financial and technical help is provided to the States under various Centrally Sponsored Schemes, viz. Project Tiger and **Integrated Development of Wildlife Habitats.**

### **International Cooperation**

- India has a bilateral understanding with Nepal on controlling trans-boundary illegal trade in wildlife
- India has signed a protocol on tiger conservation with China.
- India has signed a with Bangladesh for conservation of the Royal Bengal Tiger.
- A sub-group on tiger/leopard conservation has been constituted for cooperation with the Russian Federation.
- 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'.

## Map showing Tiger Reserves



**Titbit:** 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.

## Reasons for falling number of tigers

- **Pressure on habitat, Habitat fragmentation and Habitat destruction:** Caused due to large-scale development projects such as dams, industry, mines, railway lines etc.
- **Incessant poaching:** Tigers are killed so their body parts can be used for Traditional Chinese Medicine.
- **Invasive species:** Destroy the local producers. This has a cascading effect on the food chain. Tigers are the worst hit as they are at the end of the food chain. [Tigers represent an "**Umbrella Species**" that indicate the health of the ecosystem.]

### **Reasons for slightly increased tiger population recently**

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- Wireless communication systems and outstation patrol camps have been developed within the tiger reserves, due to which poaching has declined considerably.
- Fire protection is effectively done by suitable preventive and control measures.
- Voluntary Village relocation has been done in many reserves.
- Livestock grazing has been controlled to a great extent in the tiger reserves.
- Various compensatory developmental works have improved the water regime and the ground and field level vegetation.
- Stringent punishments for violators.
- GIS based digitized database development to evaluate tiger population.

### **Estimation of Tiger Populations**

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- The process of estimating the number of tigers in a given area is called 'Tiger census'.
- It is conducted at regular intervals to know the current tiger populations and population trends.
- Besides estimating the number of tigers the method also helps to gather information on the density of the tiger populations and associated prey.
- The most commonly used technique 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 identification of individuals.
- 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 on the basis of the stripes on the body.
- In the latest technique of DNA fingerprinting, tigers can be identified from their scats.

### **Project Elephant**

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- Tiger faces threat of extinction, whereas the elephant faces threat of attrition.
- The elephant numbers have not increased or decreased drastically but there is an increasing pressure on the elephant habitats.
- Project Elephant was launched in 1992.
- It is a centrally sponsored scheme.

Objectives:

- a) to assist states having populations of wild elephants and to ensure long term survival of identified viable populations of elephants in their natural habitats
- b) addressing man-animal conflict.
- c) Developing scientific and planned management measures for conservation of elephants.
- d) Protecting the elephants from poachers, preventing illegal ivory trade and other unnatural causes of death

## **Elephant Corridor**

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- An elephant corridor is defined as a stretch/narrow strips of forested (or otherwise) land that connects larger habitats with elephant populations and forms a conduit for animal movement between the habitats.
- This movement helps enhance species survival and birth rate.
- There are 88 identified elephant corridors in India.
- Out of total 88 corridors, 20 are in south India, 12 in north-western India, 20 in central India, 14 in northern West Bengal and 22 in north-eastern India.

## **Threats to Elephant Corridors**

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- Habitat loss leading to fragmentation and destruction caused by developmental activities like construction of buildings, roads, railways, holiday resorts and the fixing solar energized electric fencing, etc.
- Coal mining and iron ore mining is the two "single biggest threats" to elephant corridors in central India.
- Orissa, Jharkhand and Chhattisgarh, are mineral-rich states, but also have the highest number of elephant corridors in the country, which makes them known for elephant-man conflicts.
- There is also a serious poaching problem, as elephant ivory from the tusks is extremely valuable.
- 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 conflicts with humans, due to elephants raiding or destroying crops.

## **Mitigation**

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- Fusion of the corridors with nearby protected areas wherever feasible; in other cases, declaration as Ecologically Sensitive Areas or conservation reserves to grant protection.
- During the process of securing a corridor, monitoring for animal movement have to be carried out; depending on the need, habitat restoration work shall also be done.
- Securing the corridors involves sensitizing local communities to the option of voluntarily relocation outside the conflict zones to safer areas.
- Preventing further fragmentation of the continuous forest habitat by encroachment from urban areas.

### **Monitoring of Illegal Killing of Elephants (MIKE) Programme**

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- Mandated by COP resolution of CITES, **MIKE program started in South Asia** in the year 2003 with following purpose:
- To provide information needed for elephant range States to make appropriate management and enforcement decisions, and to build institutional capacity within the range States for the long-term management of their elephant populations

### **Haathi Mere Saathi**

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- **Haathi Mere Saathi** is a campaign launched by the Ministry of environment and forest (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, Srilanka, Tanzania, and Thailand.
- This public initiative was aimed at increasing awareness among people and developing friendship, companionship between people and elephants.

### **Indian (One Horn) Rhino Vision 2020**

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- One horned rhino are poached for their horns.
- Indian rhino vision 2020 implemented by the department of environment and forests, Assam.
- The programme will be supported by **WWF** — India, the international rhino foundation (IRF), and a number of local NGOs.
- **Translocations** are the backbone of the IRV 2020 program.
- The goal set was to populate the potential rhino habitat areas identified viz. Manas NP, Dibru Saikhowa WLS, Laokhowa-Bura Chapor WLS with a viable population of rhino through translocations from Kaziranga NP and Pobitora WLS.

- **Manas National Park** was selected as the first site for translocation of rhinos.
- Ten rhinos have been released into Manas since 2008. Ten more rhinos will be moved from **Kaziranga National Park** before the end of the year.
- The vision of this program is to increase the total rhino foundation in Assam from about 2000 to 3000 by the year 2020 and to ensure that these rhinos are distributed over at least 7 protected areas (PA) to provide long term viability of the one-horned rhino population.
- Concentrating so many rhinos in a single protected area like Kaziranga exposes the species to risks of calamities (epidemics, floods, massive poaching attempts).

## **Project Snow Leopard**

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- The snow leopard is a globally endangered species.
- Merely 7,500 are estimated to be surviving over two million square kilometres in the Himalaya and Central Asian mountains.
- Most snow leopard occur in China, followed by Mongolia and India.

Threats posed due to

- Human interference,
- competition with livestock – people kill them to save their livestock,
- retreating deeper into mountains due to global warming, and
- poaching.

## **Why to conserve the high altitude ecosystem?**

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- The high altitudes of India (> 3000 m) (including the Himalaya and Trans-Himalaya biogeographic zones) support a unique wildlife assemblage of global conservation importance.
- This includes highly endangered populations of species such as the snow leopard, two species of bears, wolf, red panda, mountain ungulates such as the wild yak, chiru, Tibetan gazelle, Tibetan argali, Ladakh urial, two species of musk deer, the hangul, three species of goral, serow, and takin, etc. High altitude lakes and bogs provide breeding grounds for a variety of avifauna including the black-necked crane, barheaded Geese, brahminy ducks, and brown-headed gulls, etc.
- India has ratified international agreements promoting the conservation of high altitude wildlife species such as the snow leopard.
- In 2003, the **Convention on Migratory Species** included the snow leopard as a Concerted Action Species under its Appendix I.

- Similarly, in 2003, the Convention on International Trade in Endangered Species (CITES) expanded the scope of the CITES Tiger Enforcement Task Force to include all Asian big cat species including the snow leopard.

## Sea Turtle Project

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- A significant proportion of world's Olive Ridley Turtle population migrates every winter to Indian coastal waters for nesting mainly at eastern coast.
- With the objective of conservation of olive ridley turtles and other endangered marine turtles, MoEF initiated the Sea Turtle Conservation Project in collaboration of UNDP in 1999 with **Wildlife Institute of India, Dehradun** as the Implementing Agency.
- The project is being implemented in 10 coastal States of the country with special emphasis in State of Orissa.
- The project has helped in preparation of inventory map of breeding sites of Sea Turtles, identification of nesting and breeding habitats along the shore line, and migratory routes taken by Sea Turtles, development of guidelines to safeguard and minimize turtle mortality.
- 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.

## Indian Crocodile Conservation Project

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- The Indian Crocodile Conservation Project has pulled back the once threatened crocodilians from the brink of extinction and place them on a good path of recovery.

## Objectives

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- 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,

*Captive breeding means that members of a wild species are captured, then bred and raised in a special facility under the care of wildlife biologists and other experts.*

*Bringing an animal into captivity may represent the last chance to preserve a species in the wild.*

- To take-up research to improve management.
- To build up a level of trained personnel for better continuity of the project through training imparted at project-sites and through the (erstwhile) Central Crocodile Breeding and Management Training Institute, Hyderabad.

- To involve the local people in the project intimately

## Project Hangul

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- The Kashmir stag also called Hangul is a subspecies of Central Asian Red Deer native to northern India.
- It is the state animal of Jammu & Kashmir
- In Kashmir, it's found in **Dachigam National Park** at elevations of 3,035 meters.
- These deer once numbered from about 5,000 animals in the beginning of the 20th century.
- Unfortunately, they were threatened, due to habitat destruction, over-grazing by domestic livestock and poaching.
- This dwindled to as low as 150 animals by 1970. However, the state of Jammu & Kashmir, along with the IUCN and the WWF prepared a project for the protection of these animals.
- It became known as Project Hangul. This brought great results and the population increased to over 340 by 1980.

## Ganges Dolphin

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- The Ministry of Environment and Forests notified the Ganges River Dolphin as the **National Aquatic Animal**.
- The River Dolphin inhabits the Ganges-Brahmaputra-Meghna and Karnaphuli-Sangu river systems of **Nepal, India, and Bangladesh**.
- It is estimated that their total population is around 2,000 and they are listed in **Schedule I of the Wildlife Protection Act (1972)**.
- The Ganges Dolphin is among the four "obligate" freshwater dolphins found in the world — the other three are the 'baiji' found in the Yangtze River (China), the 'bhulan' of the Indus (Pakistan) and the 'boto' of the Amazon River (Latin America).
- Although there are several species of marine dolphins whose ranges include some freshwater habitats, these four species live **only in rivers and lakes**.
- The Chinese River Dolphin was declared functionally extinct by a team of international scientists in 2006.
- In India, the Ganges River Dolphin is **threatened** by river water pollution and siltation, accidental entanglement in fishing nets and poaching for their oil.
- In addition, alterations to the rivers in the form of barrages and dams are separating populations.

## 9.6 NGOS

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### Bombay Natural History Society

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- The Bombay Natural History Society, founded in 1883, is one of the largest non-governmental organizations in India engaged in **conservation and biodiversity research**.
- It supports many research efforts through grants and publishes the **Journal of the Bombay Natural History Society**.
- It organizes and conducts nature trails and camps for the general public.
- Many prominent naturalists, including the ornithologists Sálím Ali and S. Dillon Ripley, have been associated with it.

**Q. With reference to Bombay Natural History Society (BNHS), consider the following statements:**

- 1) It is an autonomous organization under the Ministry of Environment and Forests.
- 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

Answer: 2 and 3 only

## **9.7 India's National Action Plan on Climate Change**

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- NAPCC was published in 2008 by the then-Prime Minister's Council on Climate Change.
- The National Action Plan hinges on the development and use of new technologies.
- The implementation of the Plan includes public private partnerships and civil society action.
- The focus will be on **promoting understanding of climate change, adaptation and 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 (started in 2010 to promote the use of solar power)**
- 2) **National Mission for Enhanced Energy Efficiency (approved in 2009)**
- 3) **National Mission on Sustainable Habitat (approved in 2011)**
- 4) **National Water Mission**
- 5) **National Mission for Sustaining the Himalayan Ecosystem (approved in 2014)**
- 6) **National Mission for A Green India (approved in 2014)**
- 7) **National Mission for Sustainable Agriculture (approved in 2010)**
- 8) **National Mission on Strategic Knowledge for Climate Change (NMSKCC)**
- 9) **National Bio-Energy Mission (approved in 2017)**

## **National Solar Mission**

- The National Solar Mission is a major initiative to promote ecologically sustainable growth while addressing India's energy security challenge.
- The program was inaugurated in 2010 with a target of 20GW by 2022.
- It was later increased to **100 GW (100,000 MW) in 2015**.
- MNRE has proposed to achieve 60 GW from large and medium scale solar projects, and 40 GW through rooftop solar projects.

### **Net Metering**

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

#### **Q. 'Net metering' is sometimes seen in the news in the context of promoting the (2016)**

- production and use of solar energy by the households/consumers
- use of piped natural gas in the kitchens of households
- installation of CNG kits in motor-cars
- installation of water meters in urban households

Answer: a)

- Committed to Nationally Determined Contributions (Paris Accord), India made a pledge that by 2030, 40% of installed power generation capacity shall be based on clean sources.
- It was determined that **175 GW** of renewable energy capacity will be installed by 2022.
- This includes **100 GW from solar, 60 GW from wind, 10 GW from bio-power and 5 GW from small hydro power.**

### **Objectives**

- To establish India as a global leader in solar energy, by creating the policy conditions for its diffusion across the country as quickly as possible.
- To create an enabling policy framework for the deployment of 100,000 MW of solar power by 2022.
- To create favourable conditions for solar manufacturing capability, particularly solar thermal for indigenous production and market leadership.

### **October 2018**

- India attains global 4th and 5th positions in wind and solar power installed capacities.
- India is at 5th global position for overall installed renewable energy capacity

Source	Installed Capacity (GW) as of October, 2018	Percentage
Thermal	<b>221.76 GW</b>	<b>(63.84%)</b>
Nuclear	<b>6.78 GW</b>	<b>(1.95%)</b>
Hydro	<b>45.48 GW</b>	<b>(13.09%)</b>

<b>Renewable</b>	<b>73.35 GW</b>	<b>(21.12%)</b>
<b>Total</b>	<b>347.37 GW</b>	<b>(100%)</b>
<b>Sector</b>	<b>Target (GW)</b>	<b>Installed capacity (GW) as on 31.10.2018</b>
<b>Solar Power</b>	<b>100</b>	<b>24.33</b>
<b>Wind power</b>	<b>60</b>	<b>34.98</b>
<b>Bio Energy</b>	<b>10</b>	<b>9.54</b>
<b>Small Hydro</b>	<b>5</b>	<b>4.5</b>
<b>Total</b>	<b>175</b>	<b>73.35</b>

## National Mission for Enhanced Energy Efficiency (NMEEE)

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- Objective: Promote the market for energy efficiency by fostering innovative policies and effective market instruments.
- The mission document, which was approved in 2010, established the immense energy efficiency potential of India, which was about Rs. 74,000 crores.
- A recent World Bank study has estimated the country's energy efficiency market to be at 1.6 lakh crores.

NMEEE includes four specific energy efficiency initiatives under its umbrella:

### 1) Perform Achieve and Trade (PAT)

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**Assigning energy reduction targets to large energy intensive industries and distributing Energy Saving Certificates (ESCs) on achievement of the targets. These ESCs can then be traded.**

- Consumers who are not able to meet their energy savings targets will buy the **ESCs**.

### 2) Market Transformation for Energy Efficiency (MTEE)

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**Promoting 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 more efficient LED lighting for households.
- **Super-Efficient Equipment Program (SEEP):** Under this program, the manufacturers are incentivized by the government to elevate the efficiency standards of the equipment. Bureau of Energy Efficiency (BEE) launched the program in the XII five-year plan with a focus on ceiling fans, considering its wide use and impact on domestic energy consumption.

## Bureau of Energy Efficiency

- The Bureau of Energy Efficiency is a statutory agency under the Ministry of Power.
- It was created in March 2002 under the provisions of the nation's **2001 Energy Conservation Act**.
- BEE's function is to develop programs which will increase the conservation and efficient use of energy.
- It mandatory for certain appliances in India to have BEE ratings.

## Standards & Labelling Program (BEE star label)

- The Objectives of Standards & Labeling Program is to provide the consumer an informed choice about the energy saving.

Mandatory Appliances as of March 2019	Voluntary Appliances as of March 2019
<b>1. Room Air Conditioners</b> <b>2. Frost Free Refrigerators</b> <b>3. Tubular Florescent Lamp</b> <b>4. Distribution Transformer</b> <b>5. Room Air Conditioner (Cassettes, Floor Standing Tower, Ceiling, Corner AC)</b> <b>6. Direct Cool Refrigerator</b> <b>7. Color TV</b> <b>8. Electric Geysers</b> <b>9. Inverter Air conditioners</b> <b>10. LED Lamps</b>	<b>1. Induction Motors</b> <b>2. Agricultural Pump Sets</b> <b>3. Ceiling Fans</b> <b>4. Domestic Liquefied Petroleum Gas(LPG) Stoves</b> <b>5. Washing Machine</b> <b>6. Computer (Notebook /Laptops)</b> <b>7. Ballast (Electronic/Magnetic)</b> <b>8. Office equipment's (Printer, Copier, Scanner, MFD's).</b> <b>9. Diesel Engine Driven Monoset Pumps for Agricultural Purposes</b> <b>10. Soli State Inverter</b> <b>11. Diesel Generator</b> <b>12. Chillers</b> <b>13. Microwave Ovens</b>

**Q. On which of the following can you find the Bureau of Energy Efficiency Star Label? (2016)**

- 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

### **3) Energy Efficiency Financing Platform (EEFP)**

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**Increasing the confidence of financial institutions and investors to support energy efficiency initiatives.**

- The EEFP initiative is intended towards catalysing the finances for energy efficiency sector by addressing the barriers and challenges in market development and project implementation.
- It provides a platform for financial institutions, investors and project developers to increase their confidence in supporting energy conservation and efficiency projects.

### **4) Framework for Energy Efficiency Economic Development (FEEED)**

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**Promoting energy efficiency initiatives by hedging against investment risks.**

- BEE institutionalized 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 due to lack of funds.
1. **Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE):** The fund guarantees a risk cover for banks and investors for up to 50% loan amount or INR 10 crore per project, whichever is less.
  2. **Venture Capital Fund for Energy Efficiency (VCFEE):** This fund is intended towards promoting equity financing (stock, share) in the energy efficiency sector and thus reducing the impact of non-availability of debt financing (bond, loan) to small size companies and projects. The equity support is equivalent to INR 2 crore or 15% of total equity whichever is less.

### **National Mission on Sustainable Habitat**

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- 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 code 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, e.g. recycling of material and urban waste management (like producing power from waste).

- 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 legal and regulatory framework.

The Mission is being implemented through the following programmes of **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

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- Objective is to ensure **integrated water resource management** helping to conserve water, minimize wastage and ensure **more equitable distribution** both across and within states.

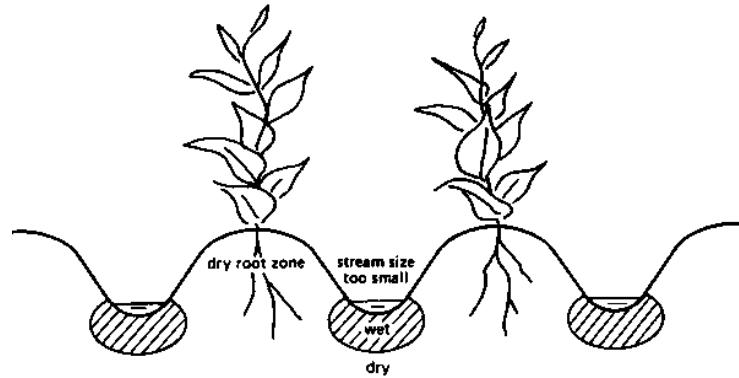
The Mission, in line with National Water Policy, aims to

- 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 rainfall.

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 which rely on sprinklers, drip irrigation and ridge and furrow irrigation.

*Ridge ad furrow irrigation: The crops are grown on the ridges and the furrows are used to irrigate.*



## National Mission for Sustaining the Himalayan Ecosystem (NMSHE)

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- The primary objective of the Mission is to
  - ✓ develop a sustainable model to continuously assess the health status of the Himalayan Ecosystem, and
  - ✓ enable policy bodies in their policy-formulation as also to assist States in the Indian Himalayan Region with implementation of actions selected for sustainable development.

The NMSHE will attempt to address a variety of important issues:

- Himalayan glaciers and associated hydrological consequences.
- Prediction and management of natural hazards.
- Biodiversity conservation and protection.
- Wild life 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 overall decrease in the number of rainy days.
- Increased flood events due to 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 (Green India Mission)

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It aims at

- ✓ protecting; restoring and enhancing India's diminishing forest cover and
- ✓ responding to climate change by a combination of adaptation and mitigation measures.
- ✓ Enhanced annual CO<sub>2</sub> sequestration by 50 to 60 million tons in the year 2020.
- The mission will be implemented on both public as well as private lands.
- The mission will local communities in planning, decision making, implementation and monitoring.

## The intended major outcomes of the project

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- Improved ecosystem services and reversal of land degradation.
- Augmentation of the shared natural resources on which extreme poor communities depend.
- Enhance connectivity between Protected Areas (PA) through biological corridors.

- Inclusive growth by reaching the communities living around remote forest areas.
- Increased wage labour opportunities during the lean agriculture season.

### **Goals of the National Mission for A Green India**

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- Improvement in quality of forest cover 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/peri-urban lands.
- Improvement in tree cover on agricultural lands and other non-forest lands (agroforestry/social forestry).

### **Q11. 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

### **National Mission on Seabuckthorn**

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- The initiative is a part of 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".
- The MoEF and DRDO have launched the initiative for Seabuckthorn cultivation in the cold deserts.
- It has multi-purpose medicinal and nutritional properties.
- It has the ability to fix atmospheric nitrogen.
- It is tolerant to extreme temperatures and has an extensive root system, making it ideal for controlling soil erosion and preventing desertification.

**Q. Government of India encourages the cultivation of 'sea buckthorn'. What is the importance of this plant?**

- 1) It helps in controlling soil erosion and in preventing 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)**

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- NMSA has been formulated for enhancing agricultural productivity especially in rainfed areas.
- 60% of the country's net sown area is rainfed and accounts for 40% of the total food production.
- The 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)**

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- Soil Health Management (SHM) is one of the components under NMSA.

- SHM aims at
  - ✓ promoting Integrated Nutrient Management (INM) through judicious use of chemical fertilizers including secondary and micro nutrients in conjunction with organic manures and bio fertilizers and
  - ✓ fertilizer testing facilities to improve soil test based recommendations to farmers.
- Soil Health Card Scheme is under implementation since 2015 to provide Soil Health Card to all farmers.
- Soil Health Card will provide information to farmers on soil nutrients status of their soil and recommendation on appropriate dosage of nutrients to be applied for improving soil health and its fertility.

## **The National Mission on Strategic Knowledge for Climate Change (NMSKCC)**

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- NMSKCC seeks to build a knowledge system that supports national policy and action for responding effectively to climate change challenges, while **not compromising on the nation's growth goals**.

Mission Objectives:

- Formation of knowledge networks among the existing knowledge institutions engaged in research and development relating to climate science.
- Development of national capacity for modelling the regional impact of climate change on different ecological zones.
- Establishing research networks and encouraging research in the areas of climate change impacts on important socio-economic sectors like agriculture, health, natural ecosystems, biodiversity, coastal zones, etc.

## **National Bio-Energy Mission**

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- The aim of the mission is to push sustainable development of the renewable energy sector.
- The national mission will aim at improving energy efficiency in traditional biomass consuming industries, seek to develop a bio-energy city project and provide logistics support to biomass processing units.
- It will also propose a GIS-based National Biomass Resource Atlas to map potential biomass regions in the country.
- According to estimates, biomass from agro and agro-industrial residue can potentially generate 25,000 MW of power in India.

## **Indian Network on Climate Change Assessment**

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- Launched by MoEF in an effort to promote domestic research on climate change.
- Reports prepared by the INCCA will form a part of India's National Communication (Nat Com) to the United Nations Framework Convention on Climate Change (UNFCCC).

## National Communication (NATCOM)

- In pursuance of the implementation of the provisions of UNFCCC, India's Initial National Communication (NATCOM) has been initiated in 2002 funded by the Global Environment Facility.

## 10. Green Revolution and Modern Agricultural Practises

- Rapid growth in food grain production from using **seeds of high yielding variety** is termed as Green Revolution.

### 10.1 India's first Green Revolution

- The high yielding varieties (HYVs) of wheat and rice have been the key elements in Indian green revolution.
- Though the term "green revolution" refers to wheat and rice, some agricultural scientists include maize, soyabean and sugarcane where spectacular gains in yield have occurred.

Aspects of first Green Revolution:

#### Introduction of High Yielding Varieties (HYV)

- In 1960s, the average national yield of wheat was very low as compared to the wheat yields of agriculturally advanced countries.
- **MS Swaminathan**, former Director General of ICAR (Indian Council of Agricultural Research) 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.
- **Borlaug** recommended the feasibility of using **semi dwarf wheat** of Mexican origin as the agro-climatic condition prevailing in India are similar to Mexico.
- On his recommendation two semi dwarf varieties namely Lerma Rajo and Sonora-64 were chosen and were released for cultivation in irrigated fields.
- These varieties gave very high yield and brought in revolution in wheat production.
- In 1970, **Norman E. Borlaug** was awarded Nobel prize for "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.
- The important high yielding varieties responded favourably to fertilizer and irrigation.

## Use of Chemical Fertilizers and Pesticides

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- **Nitrogenous fertilizers:** Nitrogen containing fertilizers e.g. ammonium sulphate, ammonium nitrate and urea.
- **Phosphate fertilizers:** Phosphate containing fertilizers e.g. ammonium phosphate, calcium dihydrogen phosphate (superphosphate).
- **Potassium fertilizers:** Potassium containing fertilizers e.g. potassium sulphate and potassium nitrate.
- Nitrogenous fertilizers promote plant growth and are essential for food production.
- Pesticides are chemicals which have been developed to kill or control organisms called pests which are unwanted in agriculture.

## Mechanization of Agriculture

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- Increase in productivity on large areas of land brought the idea of farm mechanization.
- To cope up with the shortage of agricultural labour, farm mechanization was the obvious choice for completing agricultural operations.
- The machines which perform various jobs at the farm are water pump, ploughs, combine harvesters, land levellers, cultivators, power operated tractor sprays, reapers, threshers, trolleys and mechanical pickers etc.

## Irrigation

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- High yielding varieties usually **require a lot of water** and hence irrigational facilities were a prerequisite for green revolution.
- **Wells:** There are two types of wells, namely dug wells and tube wells. This kind of irrigation is widely practiced in **plain regions of India**. Overexploitation of wells is well observed in 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 from rivers. Canal irrigation is well suited for regions with clayey soil as clayey soil prevents water percolation. Mostly practiced in south India and Ganga-Yamuna region.
- **River Lift Systems:** In areas where canal flow is insufficient or irregular due to inadequate reservoir release, the lift system is more rational. Water is directly drawn from the rivers for supplementing irrigation in areas close to rivers. Mostly practiced in South India.
- **Tanks:** These are small storage reservoirs, which intercept and store the run-off of smaller catchment areas.

## 10.2 Second Green Revolution for Sustainable Livelihood

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- The first Green Revolution was to ensure food security as there was severe scarcity of food in the country.
- The second Green Revolution aims at creating **sustainable agriculture by leveraging advancements in technology.**

## Need for Second Green Revolution

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- 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.
- Green Revolution, launched in mid-1960s, was mainly confined to well irrigated areas. It was not successful in rain-fed areas, which contribute significantly to the country's 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 ground water is depleted and polluted. The lakes and ponds are becoming life less due to eutrophication – a direct consequence of 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 rise in sea levels. This creates an urgent need to raise agricultural productivity.
- It is necessary to develop a suitable strategy to improve agricultural development in India.

## What we want from Second Green Revolution

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- 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.**

## Bringing Green Revolution in Eastern India (BGREI)

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- Green Revolution that turned India from 'begging bowl' to leading producer of food-grains.

- BGREI is about bringing similar benefits to **eastern India** that largely remained untouched of the wonder that converted the north-west into a 'grain bowl'.
- BGREI is flagship programme under **Rashtriya Krishi Vikas Yojana (RKVY)**.
- It is intended to address the constraints limiting the productivity of "**rice based cropping systems**".
- The BGREI program was announced in the Union Budget, 2010-11.
- BGREI focuses on bringing the second Green Revolution in eastern region, which has rich water resources.
- **Assam, Bihar, Chhattisgarh, Jharkhand, Odisha, West Bengal and eastern Uttar Pradesh (Purvanchal)** are the seven states.

## **Objectives of BGREI**

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- Harness the water potential for enhancing agriculture production in Eastern India which was hitherto underutilized.
- Yield maximization of rice and wheat per unit area by improving agronomy, water harvesting and conservation; and water utilization.
- Promotion of recommended agriculture technologies.

## **Government Initiatives to Strengthen BGREI**

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

## **Making Second Green Revolution a Success**

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### **Precision Agriculture**

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- 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 agriculture approach.

### **Efficient Use of Water**

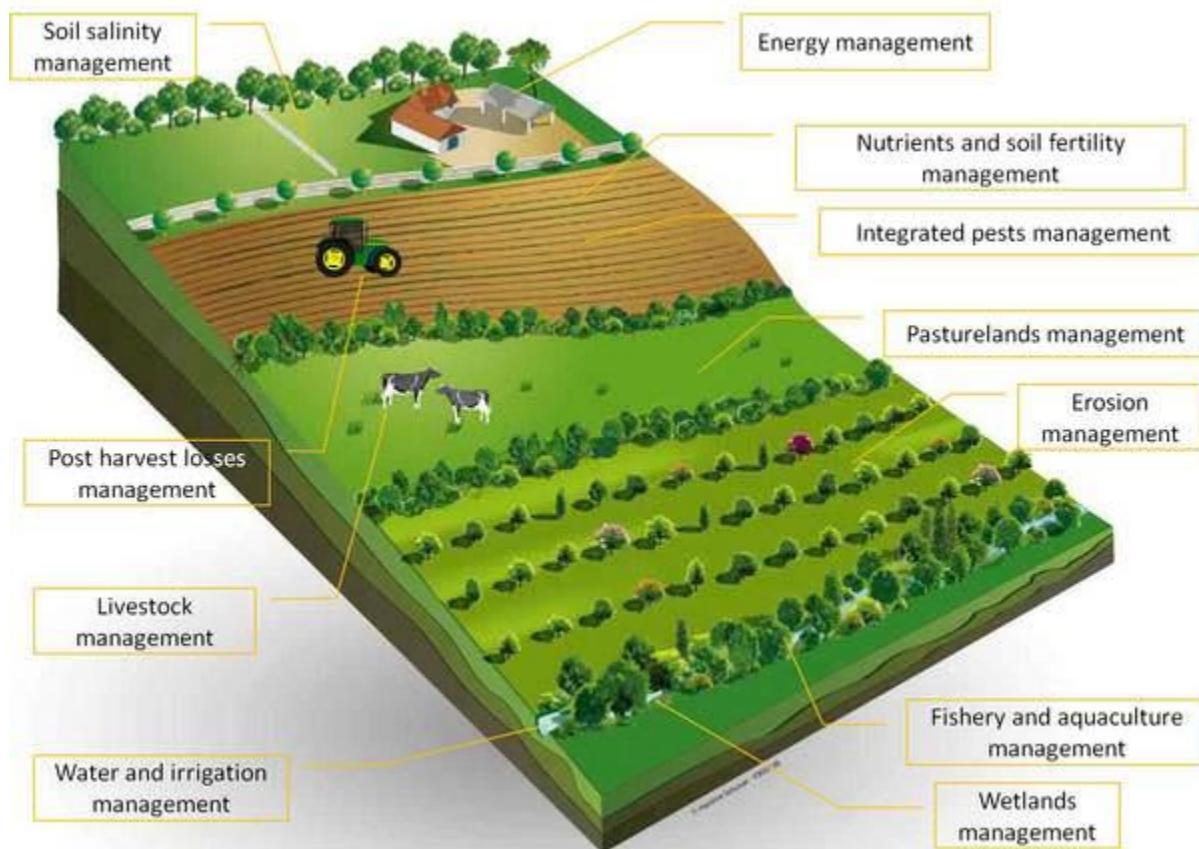
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- Laser levelling is a technology that can grade an agricultural field to a flat surface by using a laser-guided scraper.
- Laser levelling has been shown to improve crop yields, reduce labour time spent weeding, and, in particular, reduce water use 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.
- Use of Drum seeders for timely planting of direct seeded rice.

## Sustainable Agricultural Practices

- Cultivation practices to increase biological and economic stability.
- Selection of improved varieties to suit the need.
- Soil management by proper method of tillage.
- Organic farming.

### 10.3 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 have increased by using new technologies, mechanization, increased use of fertilizers 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 the positive effect, they also caused some serious environmental and social problems such as erosion of top soil, depletion and pollution of groundwater and other water resources, unemployment of farm laborers due to their replacement by farm machinery.
- 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 innovative and economically viable opportunities for farmers, laborers, consumers, policymakers and many 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.
- Thus, sustainable agriculture is one that,
  - ✓ **supports profitable production;**
  - ✓ **protects environmental quality;**
  - ✓ **uses natural resources efficiently;**
  - ✓ **provides consumers with affordable, high-quality products;**
  - ✓ **decreases dependency on non-renewable resources;**
  - ✓ **enhances the quality of life for farmers and rural communities; and**
  - ✓ **will last for generations to come.**

## Methods of Sustainable Agriculture

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- At the planning level one must take into account the local geography (topography), soil condition and nature, local climate, pests, local inputs and the farmer's goals.
- The grower (farmer) must then select appropriate practices.
- Several methods adopted in sustainable agriculture are:
  - ✓ **cultivation practices to increase biological and economic stability.**

- ✓ **selection of improved varieties to suit the need.**
- ✓ **soil management by proper method of tillage.**

### **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.**

**Q. With reference to the 'Global Alliance for Climate Smart Agriculture (GACSA)', which of the following statements is/are correct? (2018)**

- 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

### **Mixed cropping or diverse cropping**

- In mixed cropping or 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 that both get sufficient nutrition at the time of maturity.
- Generally, a leguminous crop is grown along with the main crop.
- Legumes helps to increase soil fertility by fixing atmospheric nitrogen.
- The various plans followed in diverse or mixed cropping practices are:
  - ✓ **polyvarietal cultivation** where **several genetic varieties** of the same crop are planted.

- ✓ **intercropping** where two or more different crops are grown at the same time, like carbohydrate rich cereal that uses soil nitrogen and nitrogen fixing legume that puts back the nitrogen in the soil.
- ✓ **polyculture**, in which different **plants maturing at various times** are planted together.

## Advantages of Mixed cropping

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- This practice has many advantages because fertilizer and water requirement of plants are different so there is less need of these inputs.
- Pests are controlled naturally because their natural predators find multiple habitats to survive.
- It has been found that this practice produces much higher yield per hectare compared to monoculture.

### Monoculture

- Large scale mechanization lead to the spread of monoculture i.e. only one crop variety is sown in the entire area when only one cultivator is planted in a large area.
- This system (monoculture) uses lot of fertilizer, pesticide, water. T
- his practice may be productive for some time but causes environmental and economic problems.
- E.g. Paddy and wheat cultivation.

### Strip Farming

- This involves planting the main crops in widely spaced rows and filling in the spaces with another crop to ensure complete ground cover.
- The ground is completely covered so it retards water flow which thus soaks down into the soil, consequently **reducing erosion problems**.

## Crop rotation

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- It is practice of growing **different crops in regular succession** in the same field.
- This practice controls insects and diseases, increases soil fertility and decreases soil erosion.
- Generally, soil cannot sustain continuous cropping with high yielding single crop because certain nutrients required by the crop get exhausted totally while others remain unutilized leading to serious **nutrients imbalance** in soil 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 level in the soil, reduces the need for chemical nitrogen fertilizer**.

- It is possible to grow two or sometimes three different crops in succession on the same land within a year is known as **multiple cropping**.
- This practice can go on for some time, but the land cannot maintain high yield in the long run.

### Crop rotation takes into account the following factors:

- **Leguminous crop should be grown after non-leguminous crop.**
- **Crops require less water (irrigation) should be grown after one that requires more water.**
- **Crops requiring less manure should be sown after one that requires more manure.**

## Mixed Farming

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- Optimum diversity may be obtained by integrating **both crops and livestock** in the same farming operation.
- Mixed crop along with livestock operations have several advantages.
- 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

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- A healthy soil is a key component of sustainable agriculture. That is healthy soil along with water and nutrients produces healthy crops that are less susceptible to pests and diseases.
- Accordingly, soil must be protected and nurtured to ensure long term productivity and stability.
- Methods of protection include using cover crops, compost, reducing tillage, conserving soil moisture by dead mulches, this increases water hold capacity of the soil.

## Nutrient Management

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- There are **sixteen nutrients** which are essential for plants.
- Air supplies carbon and oxygen, hydrogen comes from water, and soil supplies the other thirteen nutrients to plants.

- Amongst these **thirteen nutrients, six are required in large quantities** and are therefore called **macronutrients**.
- The other seven nutrients are used by plants in small quantities and are therefore called **micronutrients**.
- Deficiency of these nutrients affects physiological processes in plants including reproduction, growth and susceptibility to diseases.

Source	Nutrient
Air	<b>carbon, oxygen</b>
Water	<b>hydrogen, oxygen</b>
Soil	<b>⇒ Macronutrients: Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sulphur</b> <b>⇒ Micronutrients: Iron, Manganese, Boron, Zinc, Copper, Molybdenum, Chlorine</b>

### **Nitrogen (N)**

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- N is an essential constituent of proteins and is present in many other compounds of great physiological importance in plant metabolism.
- N is an **integral part of chlorophyll**, which is primary observer of light energy needed for photosynthesis.
- N also imparts **vigorous vegetative growth** and **dark green colour to plants**.

### **Phosphorus (P)**

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- Phosphorus (P) is an essential part of the enzymes which help the crop to **fix light energy**.
- It forms an integral part of nucleic acids, the carriers of genetic information, and is important in **stimulating root growth**.

### **Potassium (K)**

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- Potassium (K) is involved in processes which ensure **carbon assimilation and the transportation** throughout the plant for growth and the storage of sugars and proteins.
- The potassium ion is also important for **water regulation and uptake**.
- Furthermore, the presence of potassium in sufficient amounts ensures resistance to frost, drought and certain diseases

### **Others**

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- **Magnesium** occurs in chlorophyll and is also an **activator of enzymes**.

- **Sulphur** forms part of two **essential amino acids** which are among the many building blocks of protein. It is also found in vitamin B1 and in several important enzymes.
- **Calcium** is required for plant growth, **cell division and enlargement**.
- The **growth of root and shoot tips and storage organs** is also affected by calcium as it is a component of cell membranes. Calcium is also vital for pollen growth and to prevent leaf fall.

## Bio-Fertilizers and Their Use In Agriculture

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- For a sustainable agriculture system, it is essential to use renewable inputs (fertilizer, pesticides, water etc.) which can benefit the plant and cause no or minimal damage to the environment.
- One of the energy efficient and pollution free method is to exploit the ability of certain microorganisms like **bacteria, algae and fungi** to **fix atmospheric nitrogen, solubilize phosphorus, decompose organic material or oxidize sulphur** in the soil.
- When they are applied in the soil, they enhance growth and yield of crops, improve soil fertility and reduce pollution. They are known as "**bio fertilizers**".
- Thus bio-fertilizers are living or biologically active products or microbial inoculants of bacteria, algae and fungi (separately or in combination) which are able to enrich the soil with nitrogen, phosphorus, organic matter etc.
- Following are some of the important types of bio fertilizers which can be considered for agro based industries.

### Rhizobium biofertilizer

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- 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<sub>2</sub>)** than needed by legume plant and the bacteria.
- The surplus fixed nitrogen is then secreted and fertilizes the soil.
- Rhizobium is **more efficient** than-free living nitrogen-fixing bacteria.

### Azotobacter biofertilizer

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- Azotobacter are **aerobic free living nitrogen fixers**.
- They grow in the **rhizosphere (around the roots)** and **fix atmospheric nitrogen non-symbiotically** and make it available to the particular cereals.
- These bacteria produce **growth promoting hormones** which helps in enhancing growth and yield of the plant.

## Azospirillum biofertilizer

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- These are **aerobic free living nitrogen fixers** which live in associative symbiosis.
- In this type of association bacteria live on the root surface of the host plant and **do not form any nodule** 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

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- Blue green algae (BGA or 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.

### Q. Consider the following organisms

- Agaricus
- Nostoc
- Spirogyra

Which of the above is/are used as biofertilizer/biofertilizers

- 1 and 2
- 2 only
- 2 and 3
- 3 only

Answer: b) 2 only

## Azolla biofertilizers

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- 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 biofertilizer is used all over the world.
- The only constraint in Azolla is that it is an aquatic plant and **water becomes limiting factor** in growing it particularly in summer.

## **Phosphorus solubilizing biofertilizer**

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- Phosphorus is an important element required for plant growth.
- This element is also **needed for nodulation by rhizobium**.
- Some microorganisms are capable of solubilizing immobilized phosphorus making it available to plants for absorption.

## **Mycorrhizal fungi biofertilizer**

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- **Mycorrhizal fungi** acts as biofertilizer and are known to occur naturally on roots of forest trees and crop plants.
- Mycorrhizal fungi **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.

**Q. 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**

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- Compost Tea is a liquid fertilizer for flowers, vegetables and houseplants.
- Compost tea 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 numbers of beneficial organisms as an organic approach to plant/soil care.
- Air is sent through the water to keep the water oxygenated, as this favours the beneficial bacteria and fungi over the pathogens.
- At the end of the brewing cycle, what you have is a concentrated liquid full of billions of microorganisms (bacteria, fungi, protozoa, nematodes) that can then be **sprayed directly** onto the leaf surface.
- The liquid fertilizer occupies the infection sites on the leaf surface and 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

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- Bio char is found in soils around the world as a result of vegetation fires and historic soil management practices.
- Intensive study of bio char-rich dark earths in the Amazon (terra preta), has led to a wider appreciation of bio char's unique properties as a **soil enhancer**.
- Bio char is charcoal that is used as soil amendment (minor improvement).
- It is created using a pyrolysis 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 and incorporated into the top layer of soil.
- The syngas and excess heat can be used directly or employed to produce a variety of biofuels.

## Agricultural Benefits of Bio char

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- It increases crop yields, sometimes substantially if the soil is in poor condition.
- It helps to prevent fertilizer runoff and leaching, allowing the use of less fertilizers.
- It retains moisture, helping plants through periods of drought more easily.
- Most importantly, it replenishes exhausted or marginal soils with organic carbon
- It fosters the growth of soil microbes essential for nutrient absorption, particularly **mycorrhizal fungi**.
- Bio char can increase soil fertility of acidic soils. (The **most fertile soils are slightly acidic**)
- Bio-char reduces the acidity of the soil, protects the plants from diseases, promotes growth of friendly microorganisms, and reduces the loss of micro nutrients apart from increasing water retainability.

**Kollam, Kerala, is famous for fishing and fishery-related activities; as an agricultural sector, it does not evoke any enthusiasm. Why?**

- With the prevailing soil and climatic conditions which favours leaching and draining of soil nutrients into the Arabian sea and Ashtamudi Lake, the **soil has high acidity** making it unfit for cultivation of any kind (friendly microorganisms don't like acidic medium. They like slightly alkaline or basic medium).
- Bio char can make a difference to the agriculture of the region.

### **Other Environmental Benefits**

- Most carbon in the soil is lost as greenhouse gas (carbon dioxide, CO<sub>2</sub>) into the atmosphere if natural ecosystems are converted to agricultural land.
- 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 right management is applied.
- The use of crop residues for bio-energy production reduces the carbon stocks in cropland.
- Further the dedication of cropland to bio-fuel production increases the area of cultivated land and thus carbon loss from soils and vegetation.
- Bio char** remains stable for millennia, providing a simple means to **sequester carbon emissions**.
- If bio char is returned to agricultural land it can increase the soil's carbon content permanently and would establish a carbon sink for atmospheric CO<sub>2</sub>.

## **Organic Farming**

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- Organic farming is a type of agriculture or farming which **avoids the use of synthetic fertilizers, pesticides, growth regulators, and livestock feed additives.**
- Organic farming systems rely on **crop rotation, crop residues, animal manures, legumes, green manure, off-farm organic wastes and biofertilizers**, mechanical cultivation, mineral bearing rocks to maintain soil productivity to supply plant nutrients and biological pest control, controlling weeds, insects and other pests.
- All kinds of agricultural products can be produced organically, including grains, meat, dairy, eggs, fibres such as cotton, jute, flowers etc.
- Organic farmers build healthy soils by nourishing the microbial inhabitants that release, transform, and transfer nutrients. Soil organic matter contributes to good soil structure and **water-holding capacity**.
- Organic farmers feed soil biota and build soil organic matter with cover crops, compost, and biologically based soil amendments.
- Organic farmers' primary strategy in controlling pests and diseases is prevention through good plant nutrition and management.
- Organic farmers use cover crops and sophisticated crop rotations to change the field ecology, effectively **disrupting habitat for weeds, insects, and disease organisms.**
- Weeds are controlled through crop rotation, mechanical tillage, and hand-weeding, as well as through cover crops, mulches, flame weeding, and other management methods.
- Organic farmers 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.

## **Vermicomposting**

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- Vermicomposting is an appropriate technique for efficient recycling of animal wastes, crop residues and agro-industrial wastes.
- The process of conversion of organic materials into manure is chiefly microbiological.
- **Earthworms** are important for producing vermicompost from organic wastes.
- 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.

### **National Programme for Organic Production (NPOP)**

- **Ministry of Industries and Commerce** has implemented the NPOP since 2001.

### What it does?

- Certification programme for organic agriculture and products as per the approved criteria.
- Accredit certification programmes of Certification Bodies seeking accreditation.
- Facilitate certification of organic products in conformity with the prescribed standards.
- Facilitate certification of organic products in conformity with the importing countries organic standards.
- Encourage the development of organic farming and organic processing.

Organic products are traded only through issuance of Transaction Certificates (TCs) wherein the product identity and traceability are maintained.

The testing is to be carried out in ISO 17025 accredited and preferably APEDA approved laboratories.

### APEDA

- The Agricultural and Processed Food Products Export Development Authority (APEDA) was established by APEDA Act in 1985. It came into effect in 1986.
- APEDA functions under **Ministry of Industries and Commerce**.

### Q. With reference to organic farming in India, consider the following statements: (2018)

- 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

### 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 with the proper timing.
- The aim of IPM is not to eradicate the pest population completely but to keep the crop damage to 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 insecticides derived from plants as a last resort.

## **Biological control includes**

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- Natural predators, parasites and pathogens of the pests are used.
- Example: Pest on cucumber plant called red spider mite is controlled by using a predatory mite that feed on red spider mite.

## **Cultivation practices**

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- A variety of cultivation practices like crop rotation, polyculture and 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. Example is Bt cotton, insecticidal for bacterial gene (**Bacillus thuringiensis**) introduced into cotton plant making cotton plant resistant to pest.

## **Disadvantages of Integrated Pest Management (IPM)**

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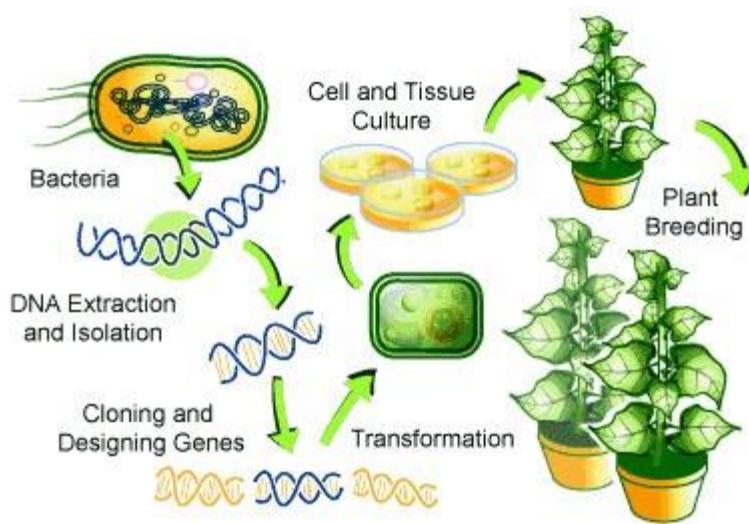
- Farmer should have an expert knowledge about each pest.
- It acts more slowly than conventional pesticides.
- Methods developed for a crop in one area might not apply to areas with even slightest different growing conditions.
- Initial cost may be higher but in the long-term cost become very low.

## **Biotechnology – Genetically Modified (GM)**

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- By using the technique of genetic engineering, it has been possible to genetically transform large number of agricultural and ornamental crops.

- The crop plants produced by the technique of genetic engineering are called “**transgenic**” or **genetically modified (GM)** plants or genetically modified organisms (GMOs).



### The purpose of transgenics

- Crop resistance to herbicides.
- Crop resistance to insects and diseases.
- Atmospheric nitrogen fixation by cereal crops.
- Tolerance to high salt soils and to flooding in crops.
- Drought resistance in crops.
- Improving nutritional quality of crops.
- Prolonging shelf life and commercial value of fruits and vegetables.

### Important examples of transgenics or GMOs

- Bt cotton** is produced by incorporating Bt gene which encodes for **BT toxin** (insecticidal protein in **Bacillus thuringiensis**) in the cotton plant.
- The plant becomes insect resistant and this gene has been incorporated in corn, potato, tomato, tobacco etc. making them insect resistant (bio pesticides).
- Golden Rice** a transgenic with enhanced **vitamin A** content producing nutritionally rich rice.
- Salt and flood tolerance genes have been incorporated in rice so that Bt rice in China shows higher yield and a huge reduction in pesticide use. Such rice can be grown on saline soil.
- Introducing a bacterial gene that **prevents ethylene formation** that delays ripening in tomatoes. Such tomatoes are easy to handle during transportation and remains on the shelf for a long time.

- Cold damage to crop plants can be minimized by introducing genes for **antifreeze proteins (AFPs)** found in the blood of artic fishes.
- Frost resistant tomatoes have been produced by introducing gene for antifreeze proteins from polar fish living in ice water.

## **Benefits of GM Crops**

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### **Crops**

- Enhanced taste and quality.
- Reduced maturation time.
- Increased nutrients, yields, and stress tolerance.
- Improved resistance to disease, pests, and herbicides.
- New products and growing techniques.

### **Animals**

- Increased resistance, productivity, hardness, and feed efficiency.
- Better yields of meat, eggs, and milk.
- Improved animal health and diagnostic methods.

### **Environment**

- "Friendly" bioherbicides and bioinsecticides.
- Conservation of soil, water and energy.
- Bioprocessing for forestry products.
- Better natural waste management.
- More efficient processing.

### **Society**

- Increased food security for growing population.

## **Controversies Surrounding GM crops**

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## Safety

- Potential human health impact: allergens, transfer of antibiotic resistance markers, unknown effects.
- Potential environmental impact: unintended transfer of transgenes through crosspollination, unknown effects on other organisms (e.g., soil microbes) and loss of flora and fauna biodiversity

## Access and intellectual property

- Domination of world food production by a few companies.
- Increasing dependence on industrialized nations by developing countries.
- **Biopiracy** — foreign exploitation of natural resources.

## Ethics

- Violation of natural organisms' intrinsic values.
- Tampering with nature by mixing genes among species.
- Objections to transferring animal genes in plants and vice versa.
- Stress for animal.

## Labelling

- Not mandatory in some countries (e.g. United States).
- Mixing GM crops with non-GM confounds labelling attempts.

## Society

- New advances may be skewed to interests of rich countries.

## Effectiveness

- The ineffectiveness of genetically modified (GM) cotton against whitefly attack in Punjab and Haryana raised more questions regarding the effectiveness of GMO.
- The whitefly attack in Punjab damaged over 75 per cent crop across the cotton belt.
- This has raised concern among agricultural experts and farmers over the growing dependency on Bt cotton.
- Strains of the **bacterium Bacillus thuringiensis** produce over 200 different Bt toxins, each harmful to different insects.
- Most notably, Bt toxins are insecticidal to the larvae of moths and butterflies, beetles, cotton bollworms but are harmless to other forms of life. (this is why Bt cotton failed against whitefly).

## Newer Agricultural Practices

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- Modern agriculture includes animal husbandry, poultry farming, apiculture, fisheries and mushroom culture etc. to provide additional food supplements like milk, meat, fish, egg, mushroom etc.
- In addition to provide nutritional food for the masses, they also reduce load on the consumption of cereals and pulses.

## Revolutions in Agriculture

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Revolution	Economic Activity
Green	<b>Food grain Production</b>
Golden	<b>Horticulture, Fruit, Honey Production</b>
Golden fibre	<b>Jute cultivation</b>
Grey	<b>Fertilizer Production</b>
Blue	<b>Fish Production</b>
Black	<b>Petroleum Production</b>
Brown	<b>Leather production</b>
Pink	<b>Prawn Production / Onion production</b>
Round	<b>Potato Production</b>
Red	<b>Meat / Tomato Production</b>
Silver	<b>Egg / Poultry Production</b>
White	<b>Milk Production</b>
Yellow	<b>Oil seeds Production</b>

## Various Agricultural Activities

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Name	Agricultural Activity
<b>Silviculture</b>	• cultivating forest trees
<b>Sericulture</b>	• rearing of silkworms for the production of raw silk
<b>Apiculture</b>	• maintenance of honey bee colonies, commonly in hives, by humans
<b>Olericulture</b>	• science of vegetable growing, non-woody (herbaceous) plants for food
<b>Viticulture</b>	• science, production and study of grapes
<b>Floriculture</b>	• flowering and ornamental plants for gardens
<b>Arboriculture</b>	• cultivation and study of individual trees, shrubs, and other woody plants
<b>Pomology</b>	• focuses on the cultivation, production, harvest, and storage of fruit, etc.
<b>Aeroponics</b>	• growing plants in mist environment without the use of soil medium
<b>Hydroponics</b>	• growing plants using mineral nutrient solutions, in water, without soil.
<b>Geponic</b>	• refers to growing plants in normal soil
<b>Aquaponics</b>	• symbiotic environment of aquaculture and hydroponics

## Mushroom culture

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- Mushrooms are kind of **fungus** with a short stem and a cap which opens like an umbrella later.
- They lack chlorophyll and grow on organic matter or waste materials from farms or factories.
- Out of the large number of mushroom species only some are edible.
- Mushrooms are good source of high quality **proteins** and are rich in vitamins and minerals.
- Like fruits and vegetables mushrooms are perishables.