SIVARAJAVEL IAS ACADEMY

AN IDEAL INSTITUTE FOR CIVIL SERVICE EXAMS

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METIS

Mentoring and Enabling Through Intelligent Support system

MAINS

ENVIRONMENT BIO DIVERSITY & DISASTER MANAGEMENT

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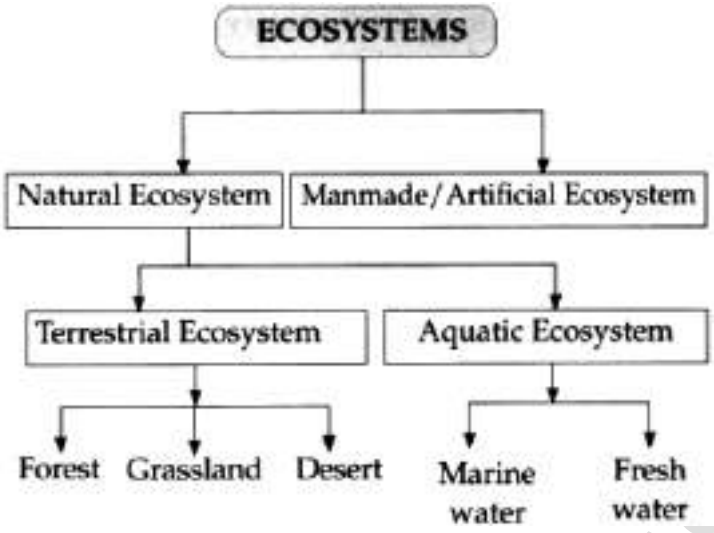
Ecosystem:

Types of Ecosystems:



Natural Ecosystems:

These ecosystems are capable of operating and maintaining themselves without any major interference by man.

A classification based on their habitat can further be made:

- **Terrestrial ecosystems:** forest, grassland, and desert.
- **Aquatic ecosystems:** freshwater ecosystem, viz. pond, lake, river, and marine ecosystems, viz. ocean, sea or estuary. Aquatic ecosystems are ecosystems present in a body of water**.**

These can be further divided into two types, namely:

- **Freshwater Ecosystem**
- **Marine Ecosystem**

Freshwater Ecosystem

- The freshwater ecosystem is an aquatic ecosystem that includes lakes, ponds, rivers, streams, and wetlands.
- These have no salt content in contrast with the marine ecosystem.

Marine Ecosystem:

- The marine ecosystem includes seas and oceans.
- These have a larger salt content and greater biodiversity in comparison to the freshwater ecosystem.

Artificial Ecosystem:

These are maintained by man. These are manipulated by man for different purposes, e.g., croplands, artificial lakes and reservoirs, townships, and cities.

Ecology:

Ecology is the study of the relationships between living organisms, including humans, and their physical environment; it seeks to understand the vital connections between plants and animals and the world around them.

Also, Ecology also provides information about the benefits of ecosystems and how we can use Earth's resources in ways that leave the environment healthy for future generations.

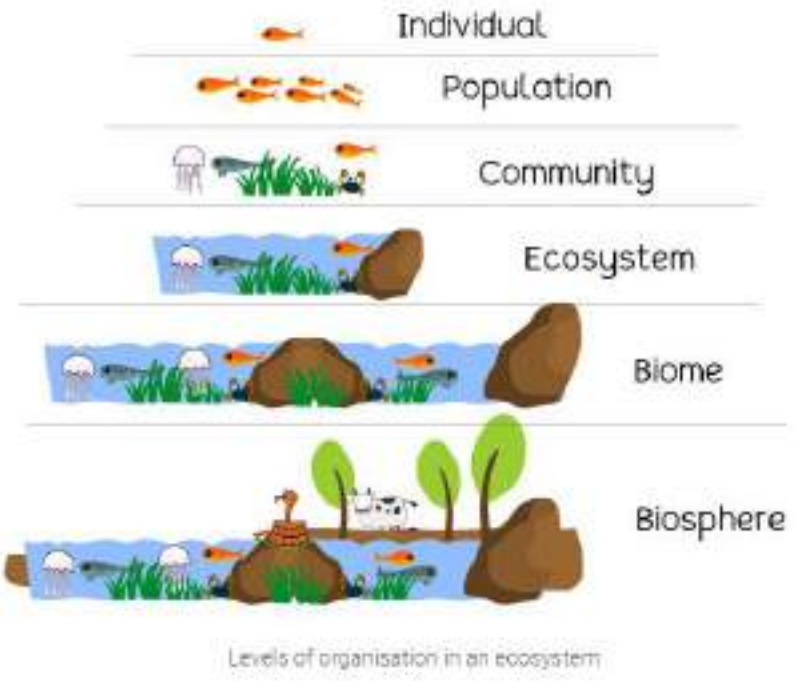
The term **"ecology"** was coined by the **German zoologist, Ernst Haeckel, in 1866**

Also, ancient Indian texts have references to Ecological principles as follows:

The classical texts of the Vedic Period such as the Vedas, the Samhitas, the Brahmanas and the Aranyakas-Upanishads contain references to ecological concepts.

Further, a conceptual understanding of ecology is found in the broader details of study, including:

- life processes explaining adaptations.
- distribution and abundance of organisms
- the movement of materials and energy through living communities
- the successional development of ecosystems, and
- the abundance and distribution of biodiversity in context of the environment



Levels of organisation in an ecosystem

Components:

Ecology mainly involves the study of biotic and abiotic factors with the environment.

Biotic components include the living factors of an ecosystem.

Examples include bacteria, animals, birds, fungi, plants, etc.

Abiotic components include the non-living chemical and physical factors of an ecosystem.

Examples include sunlight, soil, air, moisture minerals etc.

Types of Ecology:

Microbial Ecology:

Microbial ecology looks at the smallest fundamental levels of life, that is, the cellular level.

Here, the connections are made between microbes and their relationships with each other and their environments.

This is particularly important in the analysis of evolutionary connections and events leading to existence.

Organism/Behavioural Ecology:

This is the study of the organism at its fundamental levels and can encompass microbial ecology.

In this type of ecology, the main goal is to understand the organism's behaviours, adaptations for such behaviours, reason for those behaviours as explained through the lens of evolution, and the way all these aspects mesh together.

Population Ecology:

Population ecology focuses on the population, defined as a group of organisms of the same species living in the same area at the same time.

Here, attention is given to things such as population size, its density, the structure of the population, migration patterns, and the interaction between organisms of the same population.

Community Ecology:

Community ecology looks at the community, defined as all the populations that live in each area. This includes all the different species populations.

The focus here is usually on the interactions between the different species and how their numbers and sizes all mesh

together and how change in one population change the dynamic of the whole community.

Ecosystem Ecology:

Ecosystem ecology makes a unique contribution to understanding ecology by adding abiotic (non-living) factors to the items analysed, alongside the biotic (living) factors involved.

This interaction therefore involves all aspects of the environment and how they interact.

Global Ecology (Biosphere):

The global ecology is principally important in understanding all the ecosystems affecting the entire globe.

This includes all the different biomes, with considerations of aspects such as climate and other environmental geography.

Importance of Ecology:

Levels of Organisation

- **Individual, Species, Organism**
  - Organism in this level can act or function independently.
  - Here, Individuals do not breed with individuals from other groups.
- **Population:**
  - A group of individuals of a given species that live in a specific geographic area at a given time.
  - Populations include individuals of the same species but may have different genetic makeup such as hair/eye/skin colour and size between themselves and other populations.
- **Community:**
  - It includes all the populations in a specific area at a given time. A community includes populations of organisms of different species.
  - These are generally named after the dominant plant species.
- **Ecosystem:**
  - Ecosystems include more than a community of living organisms (biotic) interacting with the environment (abiotic)
  - Everything that lives in an ecosystem is dependent on the other species and elements that are also a part of the ecological community.

- **Biome**
  - A Biome is a set of ecosystems sharing similar characteristics with their

abiotic factors adapted to their environments.

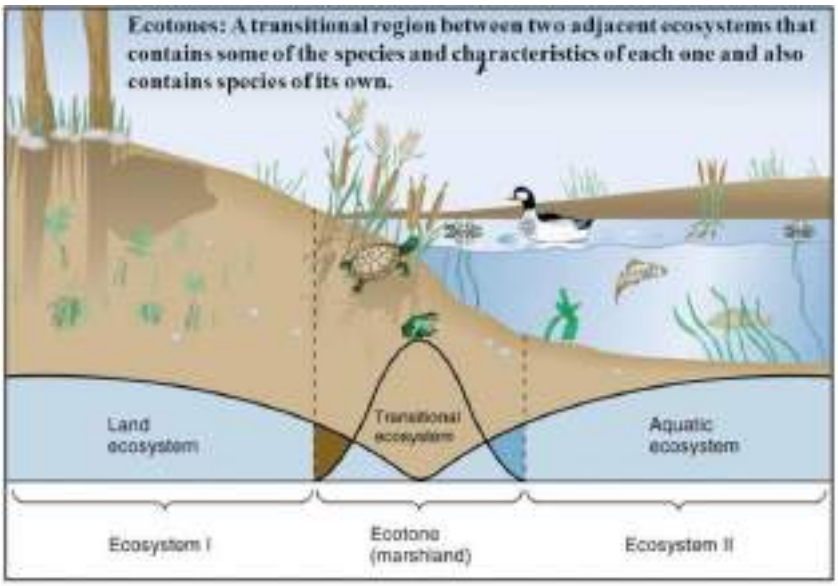
- **Biosphere**
  - When we consider all the different biomes, each blending into the other, with all humans living in many different geographic areas, we form a huge community of humans, animals and plants, and micro-organisms in their defined habitats. A biosphere is the sum of all the ecosystems established on planet Earth.

Principles of Ecology:

- **Evolution organizes ecological systems into hierarchies.**
  - Individual organisms combine into populations, populations combine into species, species combine into higher taxa like genera and phyla.
  - Each can be characterized by its abundance and diversity (number of kinds) in each ecosystem or study plot.
- **The sun is the ultimate source of energy for most ecosystems.**
  - Life runs on the carbon-rich sugars produced by photosynthesis; every ecosystem's sugar output depends on how much solar energy and precipitation it receives.
- **Organisms are chemical machines that run on energy.**
  - The laws of chemistry and physics limit the ways each organism makes a living and provide a basic framework for ecology.
  - The supply of chemical elements and the sugars needed to fuel their assembly into organisms limit the abundance and diversity of life.
- **Chemical nutrients cycle repeatedly while energy flows through an ecosystem.**
  - The atoms of elements like Carbon, Nitrogen and Sodium go back and forth from spending time in living to spending time in dead parts of an ecosystem.
  - But the photons of solar energy can be used only once before they are lost to the universe.
- **Organisms interact—do things to each other—in ways that influence their abundance.**
  - Individual organisms can eat one another, compete for shared resources, and help each other survive.
  - Each pair of species in an ecosystem can be characterized by the kind and strength of these interactions.
- **Ecosystems are organized into webs of interactions.**
  - The abundance of a population is influenced by the chains of interactions that connect it to the other species in its ecosystem.

- This often leads to complex behaviour, and a key challenge in ecology is to determine what patterns of abundance and diversity can be predicted.

- **Human populations have an outsized role in competing with, preying upon, and helping other organisms.**
  - Humans are one of millions of species embedded in Earth's ecosystems. The ability of humans to change the planet, abetted by our large population size and technological prowess, increases our ability to shape the biosphere's future.



- **Ecosystems provide essential services to human populations.**
  - These include products like timber, fibre, and food, regulating water and air quality, and cultural benefits like recreation. A key goal of ecology is to use the above principles to preserve ecosystem services.

Ecotone:

- **An Ecotone is a transitional area of vegetation between two different plant communities, such as forest and grassland.**
  - **It has some of the characteristics of each bordering biological community and often contains species not found in the overlapping communities.**

Features:

- An ecotone can have a sharp vegetation transition, with a distinct line between two communities.
  - For example, a change in colours of grasses or plant life can indicate an ecotone.
- A change in physiognomy (physical appearance of a plant species) can be a key indicator.
  - Example, Water bodies, such as estuaries, can have a region of transition, and the boundary is characterized by the differences in heights of the plant species present in the areas because this distinguishes the two areas' accessibility to light.
- A change of species can signal an ecotone.
  - There will be specific organisms on one side of an ecotone or the other.
- The abundance of introduced species in an ecotone can reveal the type of biome or efficiency of the two communities sharing space.
  - Because an ecotone is the zone in which two communities integrate, many different forms

of life must live together and compete for space.
    - Therefore, an ecotone can create a diverse ecosystem.
- An ecotone may exist along a broad belt or in a small pocket, such as a forest clearing, where two local communities blend together.
    - The influence of the two bordering communities on each other is known as the edge effect.

Examples of Ecotone:

- The Mangrove Forests represent an ecotone between Marine and Terrestrial ecosystem.
- The Grasslands represent an ecotone between desert and forest.
- The Estuaries represent an ecotone between saltwater and freshwater.

Significance of ecotones:

- Ecotones are the biological analogues of buffer states. They act as buffer regions when catastrophic conditions strike and protect the adjacent ecosystem from any prospective dangers.
    - For instance, if a tsunami hits a coast, it's usually the mangrove vegetation that acts as the shock absorbers. It prevents a massive amount of danger from infiltrating the terrestrial region.
- Ecotones act as biodiversity hotspots between two ecosystems. As such, this area is of high environmental and scientific importance.
    - Because this region borders two well-defined ecosystems, it promotes gene flow from one community to another, thereby giving rise to interesting variations. As such, ecotones hold evolutionary significance for researchers.

Ecological Niche:

- An ecological niche refers to the interrelationship of a species with all the biotic and abiotic factors affecting it.
- It describes how an organism or population responds to the distribution of resources and competitors (for example, by growing when resources are abundant, and when predators, parasites and pathogens are scarce) and how it in turn alters those same factors (for example, limiting access to resources by other organisms, acting as a food source for predators and a consumer of prey)
- A Niche is unique for a species, which means no two species have exact identical Niches.

Niche Formation:

- Both **abiotic and biotic factors** help shape the niche of an ecosystem.
    - Abiotic factors, such as temperature, climate, and soil type, of an ecosystem will help form the niches, while **natural selection** works to set which

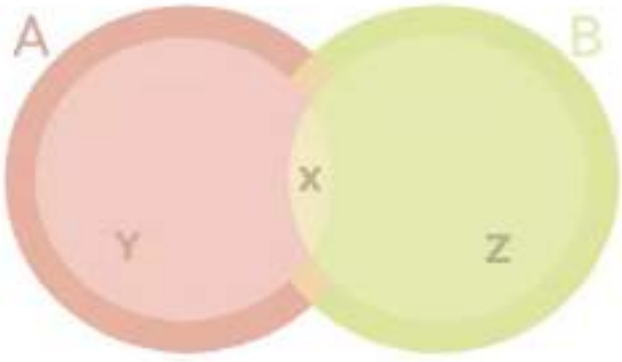


Figure 1: The different ecological niches. A and B represent the fundamental niches of species 1 and species 2, respectively. The Y refers to the realized niche of species 1 and the Z is the realized niche of species 2. The X represents the niche overlap wherein competition occurs among species.

niches would be favoured and not.
- Through time, the species eventually develop special features that help them adapt to their environment.

Examples:

- **Xerophytic plants**
  - These have developed several adaptations to living in dry ecological niches.
  - The adaptations have evolved to help save water stored in the plant and to prevent water loss.
  - Other adaptations that xerophytic plants use include the ability to move or fold up their leaves, dropping their leaves during dry periods, a waxy coating to prevent evaporation (called the cuticle) and thick hairy leaf coverings.
  - Plants usually open their stomata during the day and close them at night. Succulents do the opposite to reduce water loss during the heat of the day.

Functions of Ecosystem:

- **Ecosystem functions** can be defined by "the ecological processes that control the fluxes of energy, nutrients and organic matter through an environment".
- Interaction of biotic and abiotic components result in a **physical structure** that is characteristic for each type of ecosystem.
- The components of the ecosystem are seen to **function as a unit** when following aspects are considered:

1. **PRODUCTIVITY:**

- A constant input of solar energy is the basic requirement for any ecosystem to function and sustain.
- **Primary production** is defined as the amount of biomass or organic matter produced per unit area over a time by plants during photosynthesis. It is expressed in terms of weight energy (kcal m^2).
  - The rate of biomass production is called **productivity.**
- It can be divided into
  - **Gross primary productivity** of an ecosystem is the rate of production of organic matter during photosynthesis. A considerable amount of GPP is utilised by plants in respiration.
  - Gross primary productivity minus respiration losses (R), is the **net primary productivity (NPP).** Net primary productivity is the available biomass for the consumption to heterotrophs (herbivores and decomposers)
- Primary productivity depends on the plant species inhabiting a particular area.

- It also depends on a variety of environmental factors, availability of nutrients and photosynthetic capacity of plants.
- Therefore, it varies in different types of ecosystems. The annual net primary productivity of the whole biosphere is approximately 170 billion tons (dry weight) of organic matter.

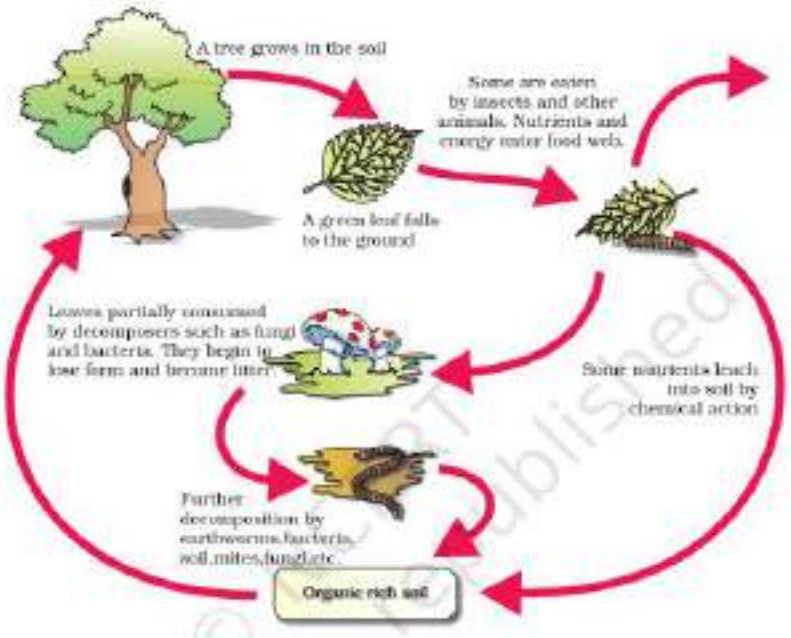
2. **DECOMPOSITION:**
    1. Decomposers break down complex organic matter into inorganic substances like carbon dioxide, water and nutrients and the process is called decomposition.
    2. Dead plant remains such as leaves, bark, flowers and dead remain of animals, including faecal matter, constitute **detritus**, which are the raw material for decomposition.

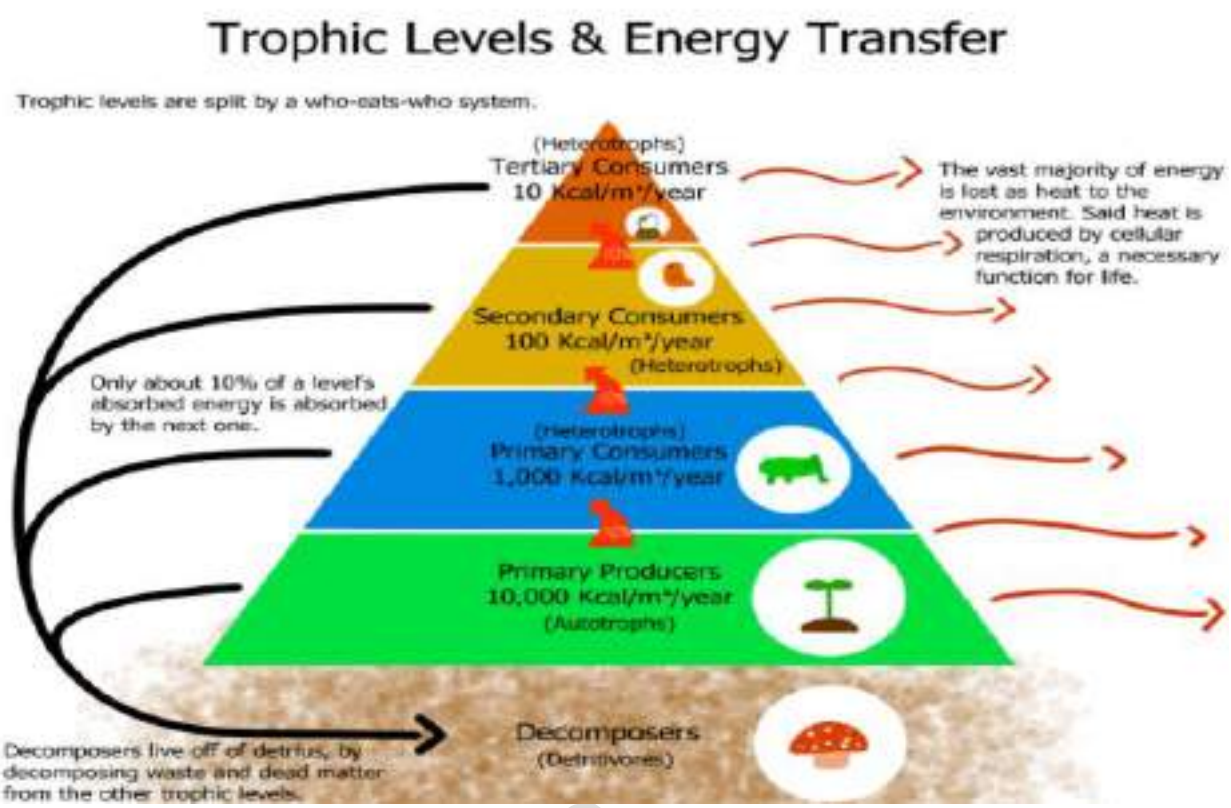
o The important steps in the process of decomposition are fragmentation, leaching, catabolism, humification and mineralisation.

1. Detritivores (e.g., earthworm) break down detritus into smaller particles. This process is called **fragmentation**.
2. By the process of **leaching**, water soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts.
3. Bacterial and fungal enzymes degrade detritus into simpler inorganic substances. This process is called as **catabolism.**
4. Humification and mineralisation occur during decomposition in the soil.

o **Humification** leads to accumulation of a dark coloured amorphous substance called humus that is highly resistant to microbial action and undergoes decomposition at an extremely slow rate.

o The humus is further degraded by some microbes and release of inorganic nutrients occur by the





process known as **mineralisation.**

- Decomposition is largely an oxygen-requiring process.
- **Temperature and soil moisture** are the most important climatic factors that regulate decomposition through their effects on the activities of soil microbes.
- **Warm and moist environment** favour decomposition whereas low temperature and anaerobiosis inhibit decomposition resulting in build-up of organic materials

DECOMPOSITION IN TERRESTRIAL ECOSYSTEM

3.ENERGY FLOW:

- **Except for the deep-sea hydro-thermal ecosystem, Sun is the only source** of energy for all ecosystems on Earth.
- Of the incident solar radiation less than 50 per cent of it is **photosynthetically active radiation (PAR).**
  - Plants and photosynthetic bacteria (autotrophs), fix suns' radiant energy to make food from simple inorganic materials.
  - So, all organisms are dependent for their food on producers, either directly or indirectly.
    - Hence, there exists a unidirectional flow of energy from the sun to producers and then to consumers.
- Hence, starting from the plants (or producers) food chains or rather webs are formed such that an animal feeds on a plant or on another animal and in turn is food for another.

- **The chain or web** is formed because of this **interdependency.**

- All animals depend on plants (directly or indirectly) for their food needs. They are hence called **consumers and also heterotrophs.**
- Further, the **detritus food chain (DFC)** begins with dead organic matter. It is made up of decomposers which are heterotrophic organisms, mainly fungi and bacteria. They meet their energy and nutrient requirements by degrading dead organic matter or detritus.
  - These are also known as **saprotrophs.**
- In this perspective, Organisms occupy a place in the natural surroundings or in a community according to their feeding relationship with other organisms.
  - Based on the source of their nutrition or food, organisms occupy a specific place in the food chain that is known as their trophic level
  - Producers belong to the first trophic level, herbivores (primary consumer) to the second and carnivores (secondary consumer) to the third.
- The **important point** to note is that the amount of energy decreases at successive trophic levels. When any organism dies, it is converted to detritus or dead biomass that serves as an energy source for decomposers.
- Organisms at each trophic level depend on those at the lower trophic level for their energy demands.
  - Each trophic level has a certain mass of living material at a particular time called as the **standing crop**. The standing crop is measured as the mass of living organisms (**biomass**) or the number in a unit area.
- 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.

ENERGY FLOW IN AN ECOSYSTEM

4.ECOLOGICAL PYRAMIDS:

- One gets the shape of a pyramid when food or energy relationship between organisms at different trophic level are expressed.
  - Thus, relationship is expressed in terms of number, biomass, or energy.
- The base of each pyramid represents the producers or the first trophic level while the apex represents tertiary or top-level consumer.
- This concept can be better understood by assessing the following pyramids:

Pyramid of number:

- The below diagram is that of a Grassland Ecosystem. Only the top-three carnivores are supported in an ecosystem, based on production of plants.

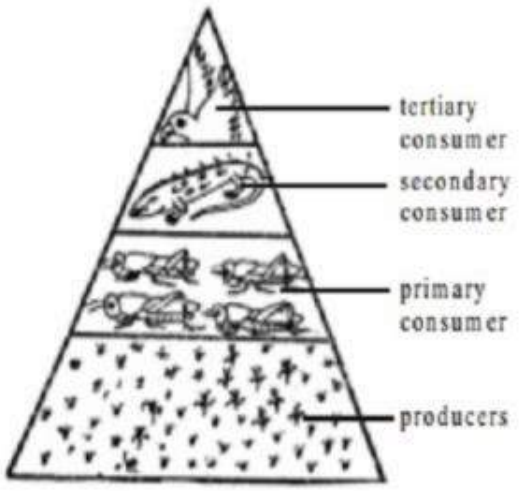
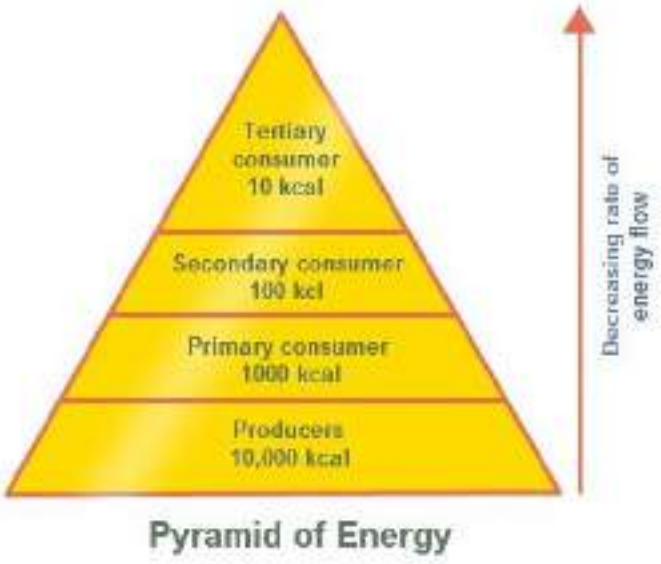
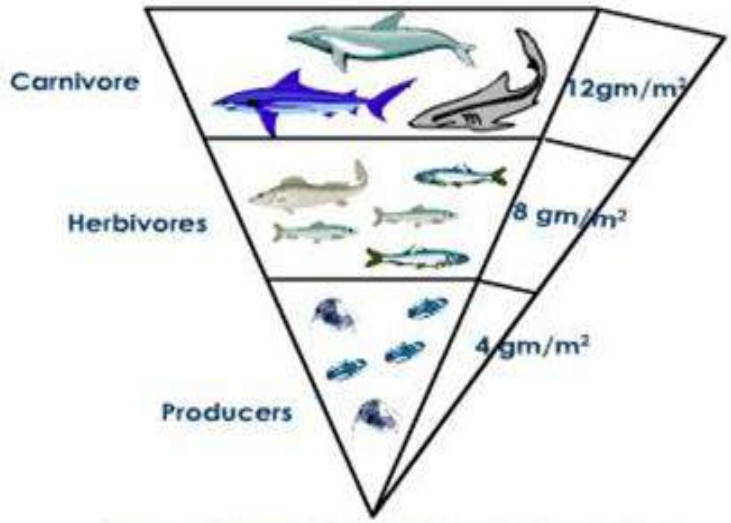


Fig. Pyramid of biomass in a grassland



Pyramid of Energy



Inverted Pyramid in an Aquatic Ecosystem

Pyramid of Biomass:

- This shows a sharp decrease in biomass at higher trophic levels.
- Biomass refers to the total weight of living matter per unit area. In an ecosystem the biomass decreases from the producer level to the consumer level
- In a grassland the biomass of grasses is the maximum and it gradually decreases towards the consumer level.

Inverted Pyramid:

- The pyramid of biomass is inverted in a pond or lake ecosystem.
- The biomass of phytoplankton is less as compared with that of the small herbivorous fish that feed on these producers.
- The biomass of large carnivorous fish that depends on small fishes is still greater.

Pyramid of energy:

- In an ecosystem, the energy flow from the producer to the consumer level will be decreasing. In a grassland, grass plants trap the maximum sun light energy.
- The energy gradually decreases towards the top consumer level.
- The chemical energy is transformed into kinetic energy.

However, there are **certain limitations** of ecological pyramids such as it does not consider the **same species** belonging to two or more trophic levels.

- It assumes a **simple food chain**, something that almost never exists in nature; it does not accommodate a food web.
- Moreover, **saprophytes** are not given any place in ecological pyramids even though they play a vital role in the ecosystem.

Energy Flow:

Energy flow is the flow of energy through living things within an ecosystem.

The flow of energy in ecosystems is vitally important to the thriving of life on Earth.

Nearly all the energy in Earth's ecosystems originates within the Sun. Once this solar energy reaches Earth, it is distributed among ecosystems in an extremely complex manner.

Energy is the basic force responsible for all metabolic activities; and this flow from producer to top consumers is called energy flow and is unidirectional in nature.

The unidirectional flow of energy and the successive loss of energy as it travels up the food web, are patterns in energy flow that are governed by thermodynamics, which is the theory of energy exchange between systems.

Producers are the energy gateway:

Plants, algae, and photosynthetic bacteria act as producers

Producers are autotrophs, or "self-feeding" organisms, that make their own organic molecules from carbon dioxide.

The energy stored in organic molecules can be passed to other organisms in the ecosystem when those organisms eat plants (or eat other organisms that have previously eaten plants)

In this way, all the consumers, or heterotrophs ("other feeding" organisms) of an ecosystem, including herbivores, carnivores, and decomposers, rely on the ecosystem's producers for energy.

If the plants or other producers of an ecosystem were removed, there would be no way for energy to enter the food web, and the ecological community would collapse.

That's because energy isn't recycled: instead, it's dissipated as heat as it moves through the ecosystem and must be constantly replenished.

Terms associated to understand the flow of Energy:

In ecology, productivity is the rate at which energy is added to the bodies of organisms in the form of biomass.

Biomass is simply the amount of matter that's stored in the bodies of a group of organisms.

Productivity can be defined for any trophic level or other group, and it may take units of either energy or biomass.

Gross primary productivity, or GPP, is the rate at which solar energy is captured in sugar molecules during photosynthesis (energy captured per unit area per unit time). Producers such as plants use some

of this energy for metabolism/cellular respiration and some for growth (building tissues)

Net primary productivity, or NPP, is gross primary productivity minus the rate of energy loss to metabolism and maintenance. In other words, it's the rate at which energy is stored as biomass by plants or other primary producers and made available to the consumers in the ecosystem.

How does energy move between trophic levels?

Energy can pass from one trophic level to the next when organic molecules from an organism's body are eaten by another organism.

However, the transfer of energy between trophic levels is not usually very efficient.

Plants typically capture and convert about 1.3-1.6% of the solar energy that reaches Earth's surface and use about a quarter of the captured energy for metabolism and maintenance.

So, around 1% of the solar energy reaching Earth's surface (per unit area and time) ends up as net primary productivity.

On average, only about 10% of the energy stored as biomass in one trophic level (e.g., primary producers) gets stored as biomass in the next trophic level (e.g., primary consumers). Put another way, net productivity usually drops by a factor of ten from one trophic level to the next

energy transfer inefficient

There are several reasons.

One is that not all the organisms at a lower trophic level get eaten by those at a higher trophic level.

Another is that some molecules in the bodies of organisms that do get eaten are not digestible by predators and are lost in the predators' faeces. The dead organisms and faeces become dinner for decomposers.

Finally, of the energy-carrying molecules that do get absorbed by predators, some are used in cellular respiration (instead of being stored as biomass)

Trophic level:

In ecology, a trophic level pertains to a position in a food chain or ecological pyramid occupied by a group of organisms with similar feeding modes.

The trophic level of an organism is the number of steps it is from the start of the chain.

The concept of trophic level was developed by Raymond Lindeman (1942), based on the terminology of August Thienemann (1926)

The trophic levels are shown in a series or a succession to represent the flow of food energy and the feeding relationships between them.

Categories:

The trophic levels have two major categories: the autotrophs and the heterotrophs.

Autotrophs are organisms that can produce organic matter from inorganic matter.

Since they can make their own food and do not need to feed on other organisms, they are also referred to as the producers of an ecosystem.

Heterotrophs are organisms that obtain organic matter directly by consumption.

Unlike autotrophs, they do not have the ability to manufacture their food from inorganic sources. Thus, they hunt or gather food from other organisms. Hence, these are referred to as consumers.

Heterotrophs may be further grouped as:

Primary Consumers: These comprise the plant-eating organisms called herbivores.

Secondary Consumers: These feed on the primary consumers.

Tertiary Consumers: These feed on the secondary consumers and so on

Final Consumers: The final group called reducers feeds on dead organic matter. They include the detritivores and the decomposers.

Trophic Structure:

Trophic structure refers to the partitioning of biomass between different trophic levels.

It is controlled chiefly by the biomass of the primary producers.

The primary producers affect the transfer efficiency between trophic levels as they essentially provide the energy and the nutrient inputs.

Apart from them, another important factor is the top-down component.

This includes the predators.

Their consumption suppresses the lower trophic levels.

In a way, the predators help the primary producers by controlling or limiting excessive herbivory by predation. They serve as biological control of the lower trophic levels.

Trophic Level Pyramid:

An ecological pyramid is often depicted as a trophic level pyramid.

It is a graphical representation in the shape of a pyramid comprised of plants and animals in a certain ecosystem.

The shape indicates that the bottom trophic level is comprised of organisms that can make their own food through available sources from the environment.

They do not feed on other organisms to obtain their nutritional requirements.

Thus, they represent the base. This portion of the pyramid is comprised of producers.

As the trophic levels go up, it tapers towards the peak.

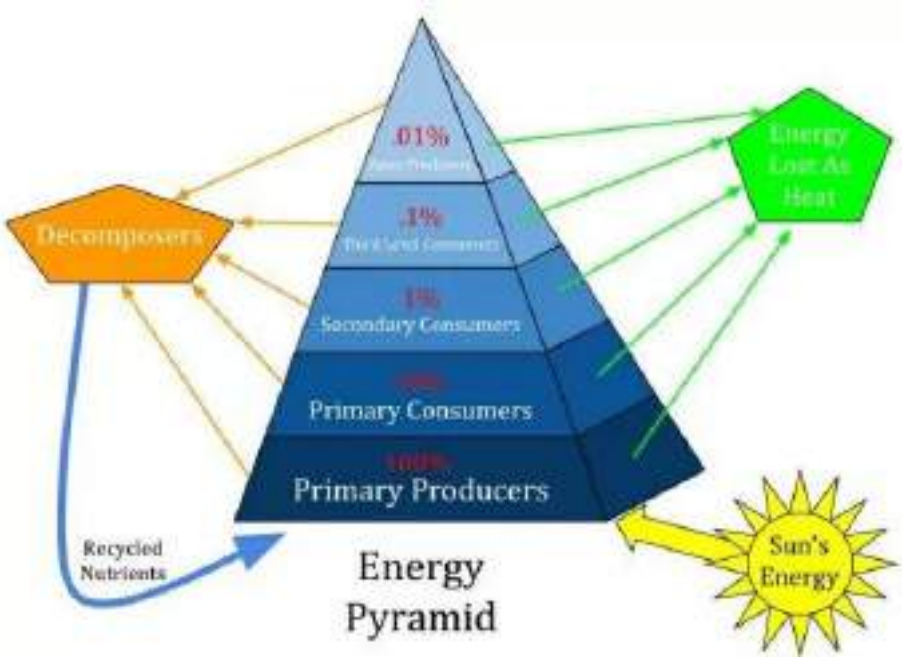
This pyramid shape depicts the biomass in each trophic level.

Biomass is the amount of living or organic matter in an organism. The base shows the largest biomass and then diminishes in amount as it moves up to the apex. This is the most common structure in ecosystems.

However, there are also instances wherein an inverted pyramid occurs.

The latter results when the combined weight of producers is smaller than the combined weight of consumers.

ENERGY_PYRAMID



Trophic level examples

Level 1: producers

This level comprises the primary producers and are found the base of an ecological pyramid.

They are found at the base of an ecological pyramid.

The fundamental feature of organisms in trophic level 1 is their ability to produce their own food from abiotic materials.

Level 2: primary consumers

In this level, the organisms occupying this level feed on the primary producers and are called primary consumers.

Animals that feed on plant materials are called herbivores.

They have anatomical and physiological features that make them adapt to a plant diet.

Examples of herbivores are horses, cattle, and goats.

Level 3: secondary consumers

Secondary consumers are comprised of animals that feed on primary consumers. Organisms that eat other animals are called carnivores (or predators)

Predation is an interaction in an ecosystem where a predator hunts or catches, kills, and eats prey. Thus, Predators are in turn, adapted anatomically and physiologically for an animal diet.

Examples of animals with a predator-prey relationship are spiders and flies, lion and zebra, bear and fish, and fox and rabbit.

Not all predators though have a diet exclusive of meat. Their diet may also include plant materials. Animals that feed on both plants and animals are called omnivores.

Examples of omnivores are chimpanzees, orangutans, gorillas, pigs, most bears, etc.

Other trophic levels

The organism that feeds on a secondary consumer is called a tertiary consumer and the one that eats on a tertiary consumer is referred to as a quaternary consumer.

The tertiary consumers and the quaternary consumers occupy trophic levels 4 and 5, respectively.

Decomposers:

The last of the trophic level is occupied by decomposers, such as detritivores. They feed on dead plants and animal matter.

Detritivores are decomposers that specifically fragment to consume their food.

Examples of detritivores are worms, millipedes, dung flies, woodlice, and slugs. Other decomposers include fungi and bacteria.

Food Chain and Food Web:

- **Food chain** is a **feeding hierarchy** in which organisms in an ecosystem are grouped into **trophic (nutritional) levels** and are **shown in a succession** to represent the **flow of food energy** and the **feeding relationships** between them.
- A **food web** is the natural interconnection of food chains and a graphical representation of what-eats-what in an ecological community
- Food chains **intertwine** locally into a food web because most organisms consume more than one type of animal or plant.
- Major parts of Food Chain
    - **Sun:** This is the initial source of energy, which provides energy for everything on the planet
    - **Producers:** This is the first stage of Food Chain. These are any plant or other organisms that produce their own nutrients through photosynthesis.
    - **Consumers:** These are all organisms that are dependent on plants or other organisms for food. This is the largest part of a food web, as it contains almost all living organisms.
    - **Decomposers:** These are organisms that get energy from dead or waste organic material. This is the last stage in a food chain, and they convert organic waste materials into inorganic materials like nutrient-rich soil or land.
- Because energy, in the form of heat, is lost at each step, or trophic level, chains do not normally encompass more than four or five trophic levels.

Types of Food Chains:

- Two types of food chains are present in ecosystems:

1. **Grazing food chain**
    - Grazing animals play an important role in the transfer of energy to the carnivores in this type of food chain, hence the name grazing food chain.
    - **Green plants** in the **terrestrial ecosystems** and **phytoplankton** in the **aquatic ecosystems** are the producers.
    - The **primary consumers** are the cattle, sheep, rabbits, deer, insects, and snails which feed on the green plants in the terrestrial ecosystems and the zooplankton, fishes and animals which feed on phytoplankton in the aquatic ecosystems.
    - In the soil the unconsumed dead organisms and biological wastes become the

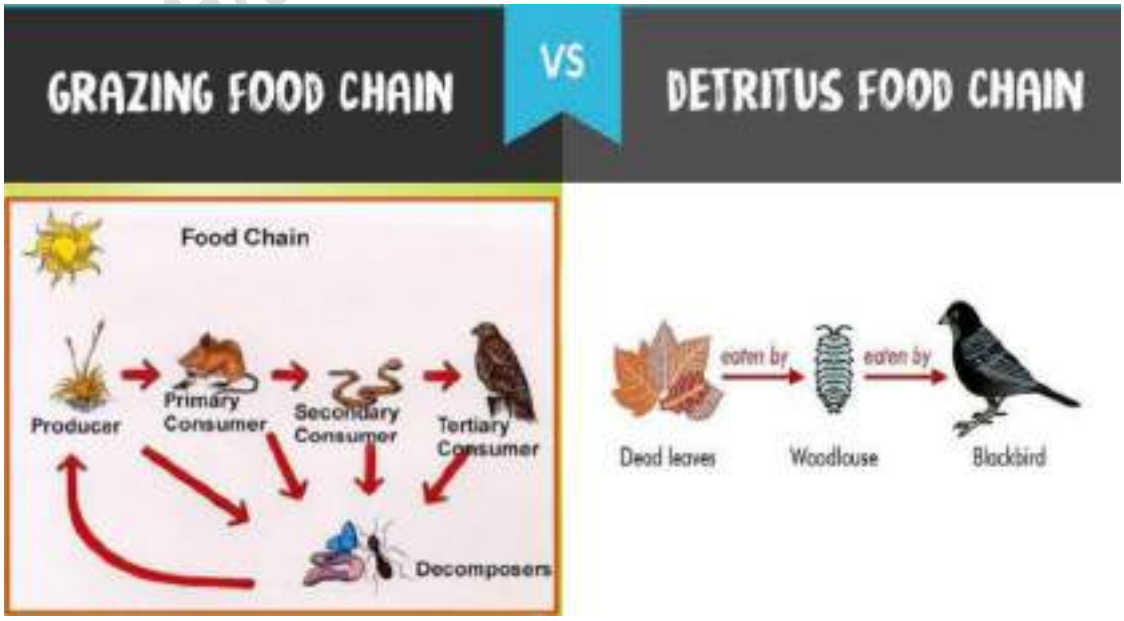
food for the detritivores of the detritus food chain.

- Herbivores (the primary consumers) are eaten by the secondary consumers or primary carnivores.
  - Similarly secondary consumers are eaten by the tertiary consumers or secondary carnivores.
- The **grazing food chains** are **linear** and are usually with 4 to 5 trophic levels in the chain.
- **Examples**
  - **In terrestrial Ecosystem**
    - Grass
    - Grass
  - **In aquatic Ecosystem**
    - Phytoplankton

2. **Detritus Food Chain**
   - It starts from dead organic matter of decaying animals and plant bodies consumed by the micro-organisms and then to detritus feeding organism called Detrivores or Decomposers and to other predators.
   - **Examples**
     - Litter → Earthworms→ Chicken → Hawak

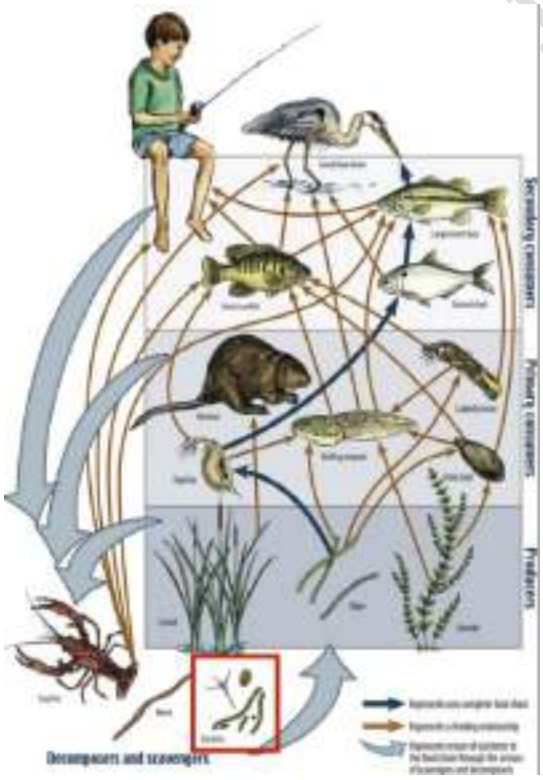
- The **distinction** between these two food chains is the source of energy for the first level consumers.
  - In the grazing food chain, the primary source of energy is living plant Biomass, while in the detritus food chain the source of energy is dead organic matter or detritus.
- The two food chains are **linked** as well.
  - The initial energy source for detritus food chain is the waste materials and dead organic matter from the grazing food chain.

Food Web:



- A food web is a **graphical model** depicting the **many food chains** linked together to show the feeding relationships of organisms in an ecosystem.
- It **differs** from a food chain in a way that the latter is a linear system showing a succession of organisms whereby each species is eaten in turn by another species.
    - While **Food web** is a **more complex network** of what-eats-what in a particular ecosystem
- The diagram below shows an example of a food web.
- In food webs, arrows point from an organism that is eaten to the organism that eats it. As the food web above shows, some species can eat organisms from more than one trophic level.

Food Chain	Food web
It refers to a natural system by which energy is transmitted from one organism to another	It consists of a number of interconnected food chains.
Member of higher trophic level feed upon a single type of organism	Member of higher trophic level feed upon many organisms
It does not have any effect on improving the adaptability and competitiveness of the organism.	Food webs improves the adaptability and competitiveness of the organism.
Example- Carrots --> rabbit --> snake --> eagle	Example- A hawk might also eat a mouse, a squirrel, a frog or some other animal. The snake may eat a beetle,



Energy transfer efficiency limits food chain lengths:

- Energy is transferred between trophic levels when one organism eats another and gets the energy-rich molecules from its prey's body. However, these transfers are **inefficient**, and this inefficiency limits the length of food chains.
- When energy enters a trophic level, some of it is stored as **biomass**, as part of organisms' bodies.
    - This is the energy that's available to the next trophic level since only energy storied as biomass can get eaten.
    - As a rule of thumb, only about 10% of the energy

that's stored as biomass in one trophic level—per unit time—**ends up stored as biomass** in the next trophic level—per the same unit time.

- This pattern of **fractional transfer** limits the length of food chains; after a certain number of trophic levels—generally three to six, there is too little energy flow to support a population at a higher level.

Bioaccumulation:

- **Bioaccumulation**s the gradual accumulation of substances, such as pesticides or other chemicals, in an organism
- It occurs when an organism absorbs a substance at a rate faster than that at which the substance is lost or eliminated by **catabolism and excretion.**
- Thus, the **longer the biological half-life** of a toxic substance, the greater the risk of chronic poisoning, even if environmental levels of the toxin are not very high.

Biomagnification:

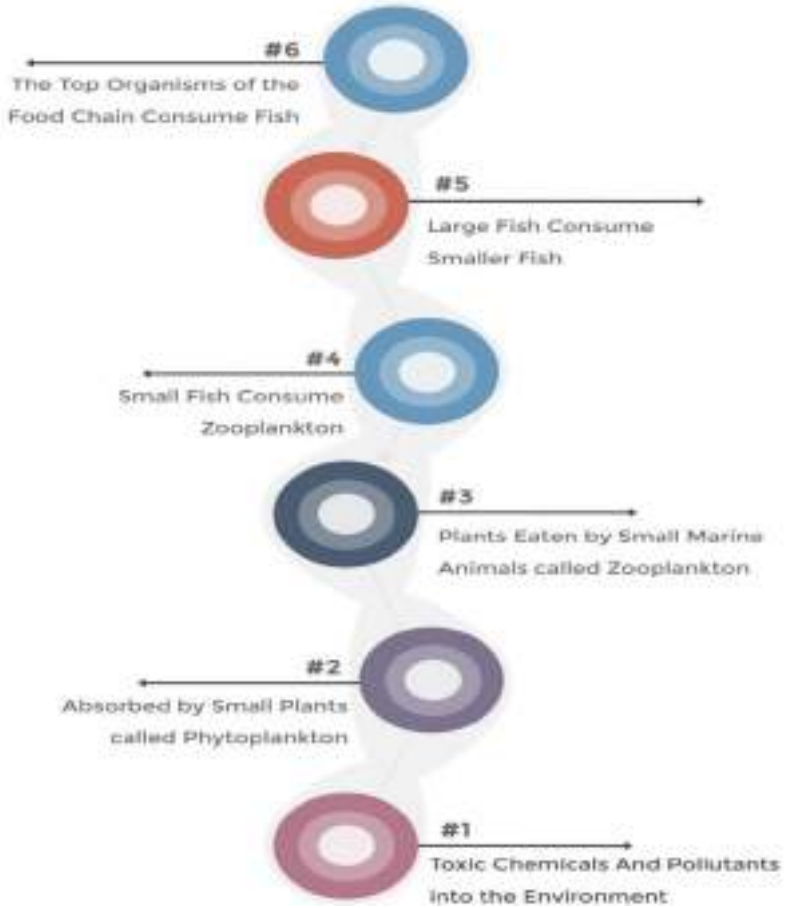
- **Biomagnification**, also known as **bio amplification** or **biological magnification**, is any concentration of a toxin, such as pesticides, in the tissues of tolerant organisms at successively higher levels in a food chain.
-

- This increase can occur because of:
  - Persistence – where the substance cannot be broken down by environmental processes.
  - Food chain energetics – where the substance's concentration increases progressively as it moves up a food chain
  - Low or non-existent rate of internal degradation or excretion of the substance – mainly due to water-insolubility

Example:

- **Case of DDT**
  - When an animal consumes food having DDT residue, the DDT accumulates in the tissue of the animal by a process called **bioaccumulation**.
  - The higher an animal is on the food chain (e.g., tertiary consumer such as seals), the greater the concentration of DDT in their body because of a process called **biomagnification.**

- **Case of Indian Rivers**
  - India's 42 rivers have at least two toxic heavy metals beyond



    the permissible limit, says research conducted by Central Water Commission
  - Ganga, the national river, was found to be polluted with five heavy metals—chromium, copper, nickel, lead, and iron.
  - In this pursuance, the concentrations of toxic metals in grains and vegetables have grown in contaminated soils and have increased at alarming rates.
  - This poses a serious threat to humans and the environment because of its toxicity, non-biodegradability, and **bioaccumulation.**

Process of Bioaccumulation and Biomagnification

This is what happens:

- Small amounts of toxic substances – often pesticides or pollution from human activity – are absorbed by plants.
- These plants are eaten by **primary consumers** in low concentrations.
- The toxin cannot be excreted so when the primary consumers are eaten by secondary consumers all the toxin is **absorbed** by the secondary consumers.
- This repeats as **secondary consumers** are eaten by higher level consumers.
- At each **trophic level** of the food chain, the toxins remain in the tissues of the animals – so the concentration of toxin becomes most concentrated in the body tissues of the animals at the top of the food chain

Causes of Bioaccumulation / Biomagnification:

- **Agricultural Products**
  - The chemicals used in the agricultural sector contain highly toxic substances that mainly result in biomagnification.
  - These chemicals come from herbicides, pesticides, fungicides, and inorganic fertilizers.

- These chemicals penetrate the soil where they accumulate to toxic levels and also find their way into the rivers and lakes through surface runoff.

- **Organic Contaminants**
  - Organic substances such as biosolids and manures have essential nutrients that are used by plants such as nitrogen, phosphorous, and carbon.
  - The biosolids that are used in agriculture farms are treated using toxic chemicals that may contain heavy metals.
  - When these organic substances are released into the farms, they release harmful substances that are absorbed by the primary consumers and later accumulate in other organisms.
- **Plastic Pollution**
  - Disposal of plastic waste near or in water bodies may not only be directly harmful to aquatic organisms but also other animals up the trophic level in general.
    - The pollution in oceans caused by 'Ghost Nets' – these are fishing nets that have been abandoned, lost, or otherwise discarded in the ocean; are also contributing for the issue.
  - Research shows that plastic contains a harmful chemical called **Bisphenol A** which is one of the major contaminants released into the water bodies
- **Mining**
  - When mining substances such as zinc, copper, cobalt, lead, and other chemicals, these mineral deposits may be released into the aquatic and adjacent farm environment where their toxicity levels rise tremendously upon absorption by aquatic and farm animals or crops.
- **Toxic Gases and Air Pollution**
  - The release of gases into the environment can also contribute to Biomagnification. Exhaust gases from vehicles and industries that manufacture and refine oil into the air do not only cause air pollution, but they can be dissolved by the rainwater and fall as **acidic rain.**
  - The chemicals in the acid rain are absorbed by soil and water bodies. They are then absorbed by primary consumers and later find their way up the food chain.

Effects:

- **On Human Health**
  - In recent years, the consumption of seafood has been linked to certain types of **cancer**.
    - This is because of the accumulation of **mercury and the Polycyclic Aromatic Hydrocarbons** in the tissues of marine organisms.
  - In addition, consumption of plants or aquatic animals that have assimilated

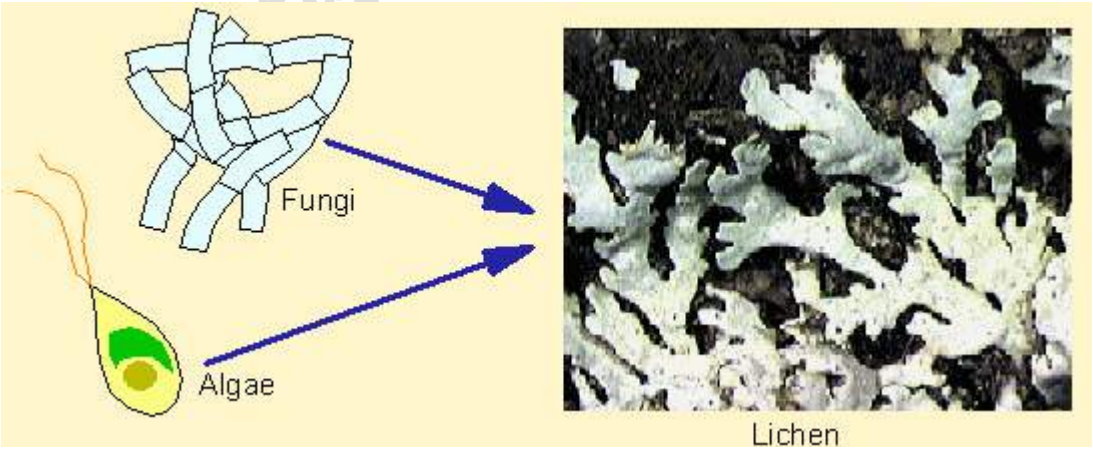
heavy metals and toxic substances may lead to long-term effects such as Kidney failure, respiratory disorders, brain damage, birth defects and heart diseases.

- **On aquatic animals**
  - The ingestion and subsequent accumulation of metals in the tissues of marine organisms have an adverse effect on their **development and reproduction**.
  - Consumption of heavy toxic metals in seabirds influences **egg production**.
    - The seabirds produce eggs with soft and thin shells which easily crashes as they try to incubate them.
  - Other cases that result from contamination of water bodies with toxic chemicals such as Selenium and mercury include effects on reproductive process of fish.
- **Disruption of Food Chain**
  - Accumulation of substances that cause Biomagnification can disrupt the natural food chain that is essential for the survival of all animals in each biosphere.
  - However, if a group of organisms was to die due to the toxic substances the natural flow of the food chains becomes disrupted. This may have a long-term effect which might not be noticed in the short term.
- **Destruction of Coral Reefs**
  - Cyanide that is used in leaching gold and fishing is the main cause of the destruction of coral reefs.
  - Their destruction affects the lives of many aquatic animals, as many of them depend on the coral habitats for their survival.

Biotic Interaction

Introduction:

- In ecology, a biological interaction is the effect that a pair of organisms living together in a community have on each other.



  - They can be either of the same species (intraspecific interactions), or of different species (interspecific interactions).
- These effects may be short-term, like pollination and predation, or

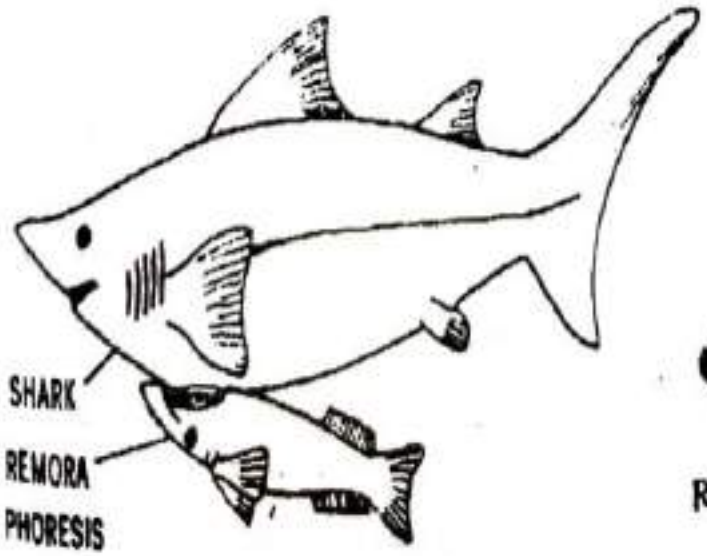
long-term; both often strongly influence the evolution of the species involved.

- Interactions can be indirect, through intermediaries such as shared resources or common enemies.

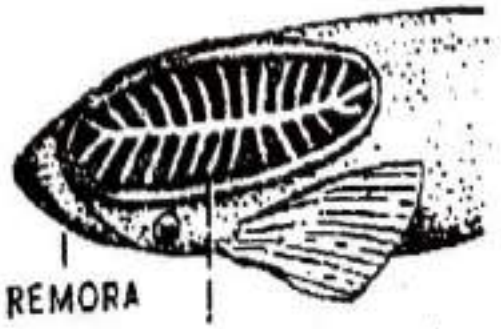
Positive Interaction:

- This term is used for the types of interspecific relationships which are mutually beneficial and where one or both partners are benefited, and no one is harmed.
    - The benefit may be in terms of food, shelter, substratum, or transport.
- This is mainly divided into three categories.
    - **Mutualism**
        - It is mutually beneficial relationship between two organisms; here both species derive benefit.
        - The relationship may be compulsory(obligatory) or facultative(optional)

- **Examples**
    - **Lichens**
        - The term means" living together".
        - This is an example where contact is close and permanent as well as obligatory.
        - The **fungus** provi des moisture as well as minerals and protection to **algae**, whereas alga manufactures food material



COMMENSALISM



- Neither of the two can grow alone independently

Crocodile and Bird association

- Here the bird enters the mouth of crocodile and picks up leaches found between the teeth and feed on them.
- Thus, birds clean the teeth and crocodile is benefited, while the bird gets is nutritional requirement

1. **Commensalism:**
   - In this inter-specific relationship, one of the partners is benefited and another partner is neither benefited nor harmed
   - Here, the partner getting the benefit is called commensal.

Ecto commensalism:

- Here, the commensal lives on the body of the other partner, which may be called host.

Association between suckerfish (or Remora or Echeneids) and shark:

- The sucker fish has the dorsal fin modified as a sucker (or adhesive) disc, with the help of which it is attached to the body of shark so that the suckerfish gets free transportation
- The sucker fish releases the attachment after some time and swims in search of food

o **Endo Commensalism:**

- Here the commensal lives within the body of host
- **Example**
  - **Association between saprophytic bacteria and fungi**
  - A variety of microorganisms, saprophytic bacteria and fungi and protozoans live within the tissues or cavities of higher plants and animals.
  - Many microorganisms like bacteria live as commensals in the digestive system of various animals. The microorganisms use undigested food for their nutritional requirements.
  - **coli** lives in the intestine of humans.

o **Protocooperation:**

- Protocooperation is a form of mutualism, but the cooperating species do not depend on each other for survival.
- **Example**
  - **Flowers and Insects**
  - The flowers of plants that re pollinated by insects and birds benefit from protocooperation.
  - The plants with colourful flowers, experience cross pollination because of insect activities
  - This is beneficial to the insect that has

got its food supply as well.

Negative Interaction:

- These interactions include association where one or both individuals are **harmed**.
- The harm may be caused by eating other organism, competition for food, excretion of harmful wastes, etc.
- These have been sub-divided into

o **Exploitation:**

- In this type of interaction, one species is benefited at the expense of another.
- Predation is an interaction between organisms in which one organism captures biomass from another.
- The term is used as a synonym for carnivory but in its widest definition includes all forms of one organism eating another, regardless of trophic level (e.g., herbivory), closeness of association (e.g., parasitism) and harm done to prey (e.g., grazing)

- **Parasitism:**
  - This is an interaction between two organisms in which one (called parasite) derives synthesised food from another living organism (Called host).
  - A true parasite though obtains its food from the host, seldom kills it
  - **Examples**
    - Among the animals, ticks, mites, and lice are external parasites or ectoparasites.
    - The fungal parasites include Erysiphe (powdery mildew), Ustilago (smut), Puccinia (rust), etc; which cause diseases that result in serious losses of economically important crops.

- **Predation:**
  - In contrast with a parasite which derives nourishment from its host without killing, a predator is **free living** which catches and kills another species for food or predator is a direct food relationship between two individuals in which an animal that remains free living (called predator) catches and kills another animal (called prey) for food.
  - **Examples**
    - Tiger (predator) eating deer (prey), frog eating insects.

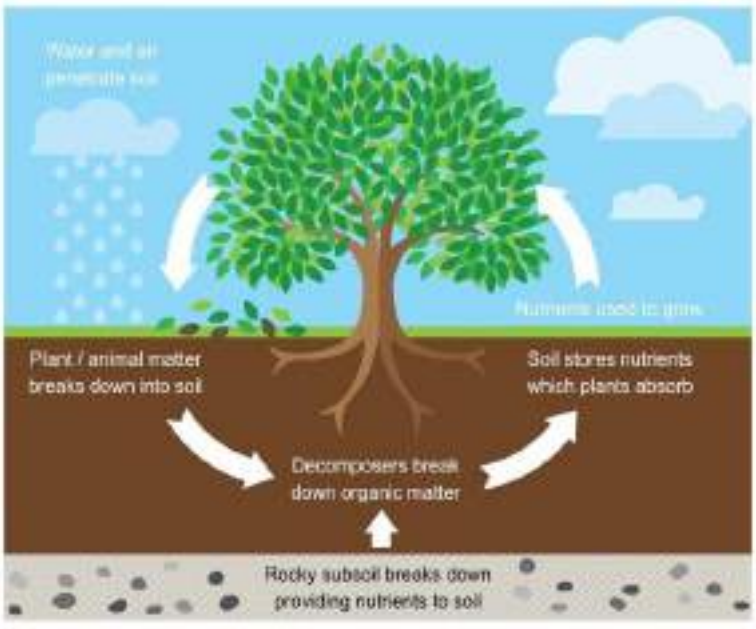
o **Competition:**

- Competition is an interaction between organisms or species in which both the organisms and species are harmed.
- Limited supply of at least one resource (such as food. water and territory) used by both can be a factor.
- Species compete in the following ways.

1. **By mechanism:**
   - Biologists typically recognize two of types of competition interference and exploitative competition.
   - During **interference** co mpetition, organisms interact directly by fighting for scarce resources. For **example**, large aphids defend feeding sites on cottonwood leaves by ejecting smaller aphids from better sites.
   - In contrast, during **exploitative** com petition, organisms interact indirectly by consuming scarce resources. For example, plants consume nitrogen by absorbing it into their roots, making nitrogen unavailable to nearby plants.

2. **By size asymmetry:**
   - Competition varies from **complete symmetric** (all individuals receive the same number of resources, irrespective of their size) to perfectly **size symmetric** (all individuals exploit the same amount of resource per unit biomass) to **size-asymmetric** (the largest individuals exploit all the available resource)
   - The degree of size asymmetry has major effects on the structure and diversity of ecological communities,
   - **Example**, in plant communities' size-asymmetric competition for light has stronger effects on diversity compared with competition for soil resources.

3. **By taxonomic relationship:**
   - Competition can occur between individuals of the same species, called **intraspecific** com petition, or between different species, called **interspecific.**
   - Studies show that intraspecific competition can regulate population dynamics (changes in



population size over time). This occurs because individuals become crowded as population grows.
- Since individuals within a population require the same resources, crowding causes resources to become more limited.
- Some individuals (typically small juveniles) eventually do not acquire enough resources and die or do not reproduce.
  - This reduces population size and slows population growth.
- **An example** among animals could be the case of Cheetah and lions since both species feed on similar prey, they are negatively impacted by the presence of the other because they will have less food, however they persist together, despite the prediction that under competition one will displace the other.

o **Antibiosis:**
- This is a complete or partial inhibition of one organism by another either by secreting some substance or by modifying its immediate environment.
- The substance or conditions produced by an organism are generally harmful for the other organism.
- This phenomenon is very common in micro-organisms which secrete substance called **antibiotic.**
- **Example**
  - Bacteria, actinomycetes and fungi produce several antimicrobial substances which are widespread in nature.
  - Lichens as well as large number of higher plants produce substances that inhibit Molds and bacteria.

Nutrient Cycling
- A nutrient cycle is a repeated pathway of a particular nutrient or element from the environment through one or more organisms and back to the environment.
- **Energy flow** is a **unidirectional** and **noncyclic** p athway, whereas the movement of **mineral** nutrients is **cyclic.**
- Hence, Nutrient cycling occurs as animals and plants consume nutrients found in the soil, and these nutrients are then **released back** into the environment via **death and decomposition.**
- Nutrient cycling is essential for life and is the vital function of the ecology of any region.
  - In any environment, to maintain an organism in a sustained manner, the nutrient cycle must be kept balanced and stable.

Nutrient Cycling

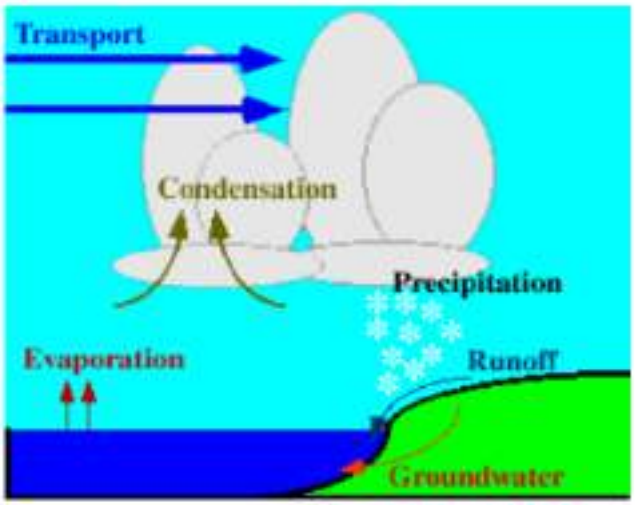
Types of Nutrient Cycle:

- 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 utilised. Most **Gaseous cycles** are considered as perfect cycles.
  - **Sedimentary** cycles are considered imperfect, as some nutrients are lost from the cycle and get locked into sediments and so become unavailable for immediate cycling.
- Based on **nature of the reservoir,** there are two types of cycles:
  - **Gaseous cycle –** where the reservoir is the atmosphere or the hydrosphere.
  - **Sedimentary cycle** – where the reservoir is the Earth's crust.

Gaseous Cycles:

- The most important gaseous cycles are – water, carbon, and nitrogen.

1. **Water Cycle (Hydrologic)**
   - The hydrologic cycle begins with the **evaporation** of water from the surface of the ocean. As moist air is lifted, it cools, and water vapour **condenses** to form clouds. Further, Moisture is transported around the globe until it returns to the surface as **precipitation.**
   - Once the water reaches the ground, one of two processes may occur.
     - some of the water may evaporate back into the atmosphere or
     - the water may penetrate the surface and become **groundwater**.
   - **Groundwater** either seeps its way to into the oceans, rivers, and streams, or is released back into the atmosphere through transpiration.
   - The balance of water that remains on the earth's surface is **runoff**, which empties into lakes, rivers and streams and is carried back to the oceans, where the cycle begins again.



2. **Carbon Cycle**:
   - On Earth, the element carbon is a part of seawater, the atmosphere, rocks such as limestone and coal, soils, as well as all living things.

- Carbon is able to move from one of these realms to another as a part of the carbon cycle.

- Carbon moves from the **atmosphere to plants**. In the atmosphere, carbon is attached to oxygen in a gas called carbon dioxide (CO2).
  - Through the process of **photosynthesis**, carbon dioxide is pulled from the air to produce food made from carbon for plant growth.
- Carbon moves from **plants to animals**.
  - Through food chains, the carbon that is in plants moves to the animals that eat them. Animals that eat other animals get the carbon from their food too.
- Carbon moves from plants and animals to soils.
  - When plants and animals die, their bodies, wood and leaves decays bringing the carbon into the ground. Some is buried and will become fossil fuels in millions and millions of years.
- Carbon moves from living things to the atmosphere.
  - Each time you exhale, you are releasing carbon dioxide gas (CO2) into the atmosphere.
  - Animals and plants need to get rid of carbon dioxide gas through a process called respiration.
- Carbon moves from fossil fuels to the atmosphere when fuels are burned.

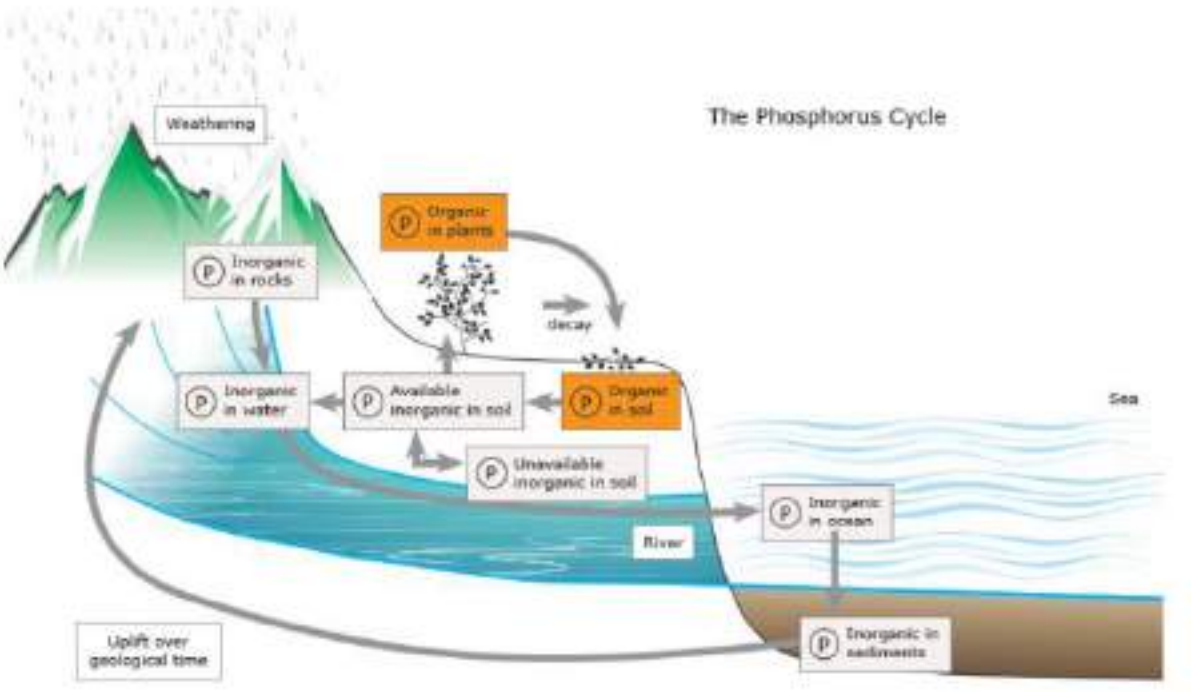
- Further, Carbon moves from the atmosphere to the oceans. The oceans, and other bodies of water, absorb some carbon from the atmosphere. The carbon is dissolved into the water.
- Carbon moves through our planet over longer time scales as well.
  - For example, over millions of years weathering of rocks on land can add carbon to surface water which eventually runs off to the ocean.
  - Over long-time scales, carbon is removed from seawater when the shells and bones of marine animals and plankton collect on the sea floor. These shells and bones are made of limestone, which contains carbon.
  - Also, the carbon can be released back to the atmosphere if the limestone melts or is metamorphosed in a subduction zone.

Nitrogen Cycle:

- Nitrogen is one of the primary nutrients critical for the survival of all living organisms. Although nitrogen is very abundant in the atmosphere, it is largely inaccessible in this form to most organisms.
- The processes in Nitrogen cycle can be explained as follows:
- **Nitrogen fixation**
- Nitrogen fixation is the process wherein N2 is converted to ammonium, or NH4+.
  - This is the only way that organisms can attain nitrogen directly from the atmosphere; the few that can do this are called nitrogen-fixing organisms.
  - Certain bacteria, including those among the genus Rhizobium, can fix nitrogen (or convert it to ammonium) through metabolic processes.
- Nitrogen-fixing bacteria often form symbiotic relationships with host plants.
  - This symbiosis is well-known to occur in the legume family of plants (e.g., beans, peas, and clover).
  - In this relationship, nitrogen-fixing bacteria inhabit legume root nodules and receive carbohydrates and a favourable environment from their host plant in exchange for some of the nitrogen they fix.
- In addition to nitrogen-fixing bacteria, high-energy natural events such as

lightning, forest fires, and even hot lava flows can cause the fixation of smaller, but significant, amounts of nitrogen.

- **Nitrogen uptake**
  - The ammonium (NH_4^+) produced by nitrogen-fixing bacteria is usually quickly taken up by a host plant, the bacteria itself, or another soil organism and incorporated into proteins and other organic nitrogen compounds, like DNA.
- **Nitrogen mineralization**
  - After nitrogen is incorporated into organic matter, it is often converted back into inorganic nitrogen by a process called nitrogen mineralization, otherwise known as decay.
  - When organisms die, decomposers (such as bacteria and fungi) consume the organic matter and lead to the process of decomposition. During this process, a significant amount of the nitrogen contained within the dead organism is converted to ammonium.
  - Once in the form of ammonium, nitrogen is available for use by plants or for further transformation into nitrate (NO_3^-) through the process called nitrification.
- **Nitrification**
  - Nitrification requires the presence of oxygen, so nitrification can happen only in oxygen-rich environments like circulating or flowing waters and the surface layers of soils and sediments.



- The process of nitrification has some important consequences. Ammonium ions (NH4+) are positively charged and therefore stick (are absorbed) to negatively charged clay particles and soil organic matter.

o **Denitrification**

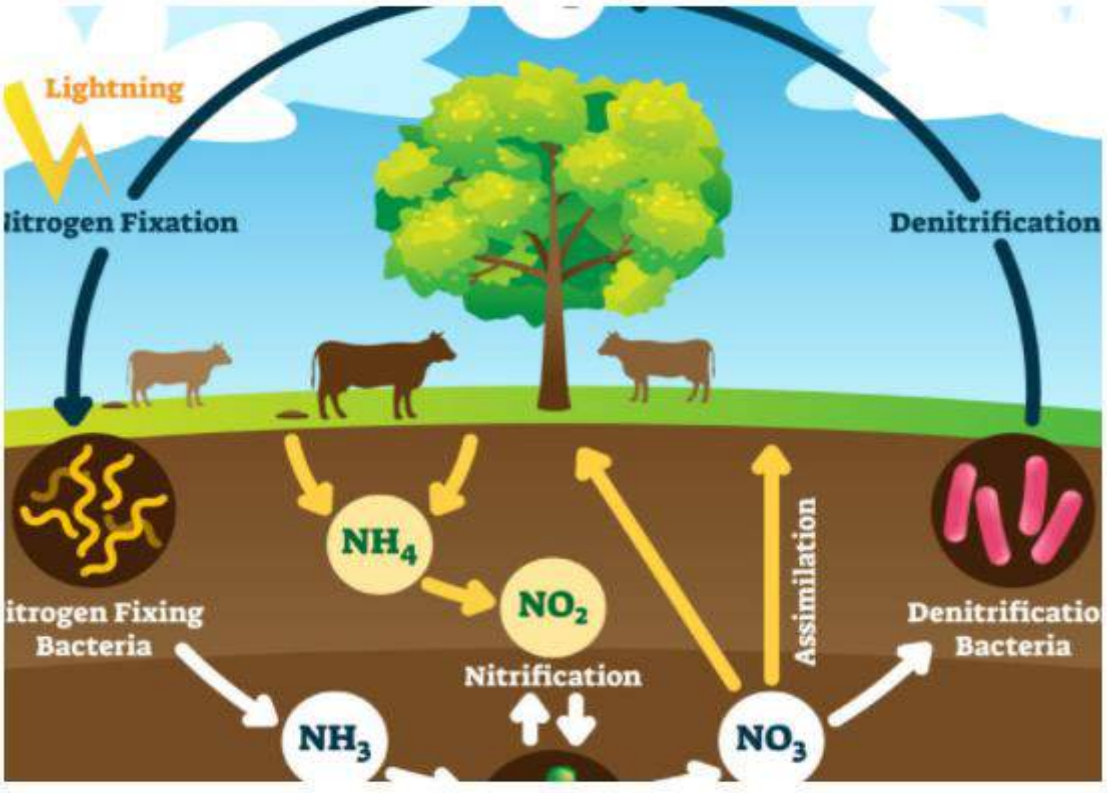
- Through denitrification, oxidized forms of nitrogen such as nitrate (NO3-) and nitrite (NO2-) are converted to dinitrogen (N2) and, to a lesser extent, nitrous oxide gas (NO2)
- Once converted to dinitrogen, nitrogen is unlikely to be reconverted to a biologically available form because it is a gas and is rapidly lost to the atmosphere.
- Denitrification is the only nitrogen transformation that removes nitrogen from ecosystems (essentially irreversibly), and it roughly balances the amount of nitrogen fixed by the nitrogen fixer.

o Thus, a large part of nitrogen is **fixed up and stored** in plants, animals, and microbes. Nitrogen leaves the living system in the same amount it is taken in from the atmosphere and the input and outflow of nitrogen are balanced in the ecosystem.

Sedimentary Cycles:

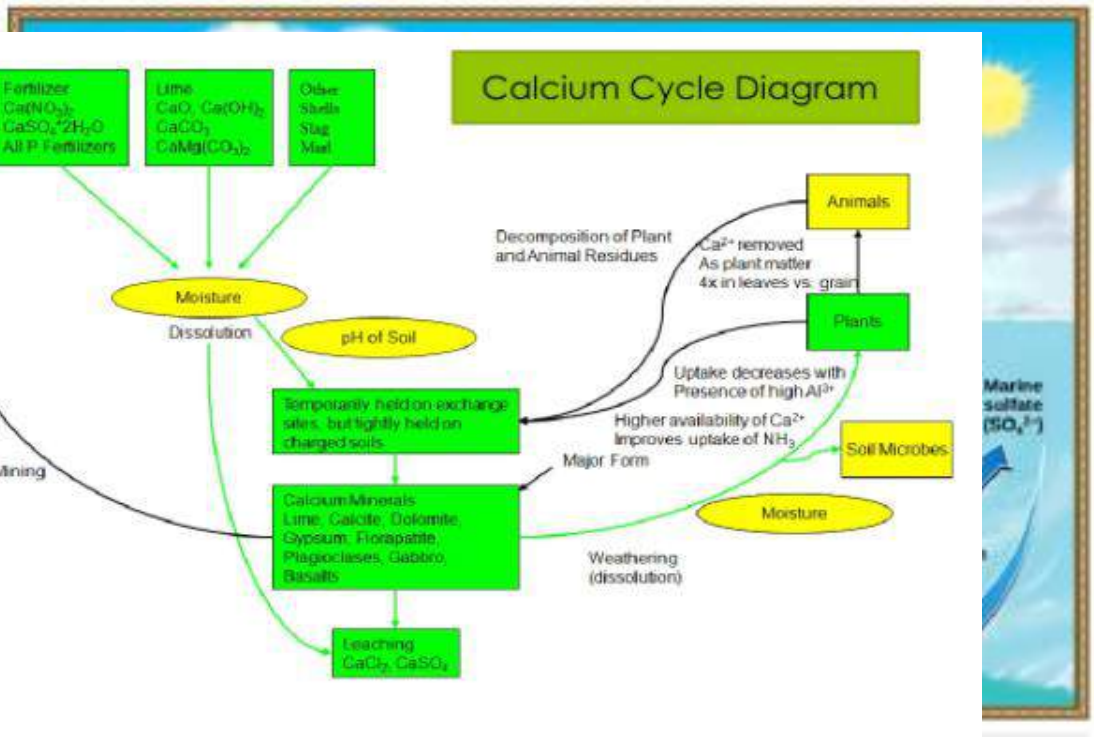
- Sedimentary cycles are a type of biogeochemical cycle, in which the reservoir is Earth's crust.

1. **Phosphorous cycle:**
   - Phosphorus moves in a cycle through rocks, water, soil and sediments and organisms.



- Over time, rain, and weathering cause rocks to release phosphate ions and other minerals. This inorganic phosphate is then distributed in soils and water.
- Plants take up inorganic phosphate from the soil. The plants may then be consumed by animals. Once in the plant or animal, the phosphate is incorporated into organic molecules such as DNA. When the plant or animal dies, it decays, and the organic phosphate is returned to the soil.
- Within the soil, organic forms of phosphate can be made available to plants by bacteria that break down organic matter to inorganic forms of phosphorus. This process is known as mineralisation.
- Phosphorus in soil can end up in waterways and eventually oceans. Once there, it can be incorporated into sediments over time.

2. **Sulphur cycle**:
   - Most of the earth's sulphur is tied up in rocks and salts or buried deep in the ocean in oceanic sediments.
     - Sulphur can also be found in the **atmosphere**. It enters the atmosphere through both natural and human sources.
   - **Natural recourses** can be for instance volcanic eruptions, bacterial processes, evaporation from water, or decaying organisms.
   - When sulphur enters the atmosphere through **human activity**, this is mainly a



consequence of **industrial processes** where sulphur dioxide (SO2) and hydrogen sulphide (H2S) gases are emitted on a wide scale.

- When sulphur dioxide enters the atmosphere, it will react with oxygen to produce sulphur trioxide gas (SO3), or with other chemicals in the atmosphere, to produce **sulphur salts.**
- Sulphur dioxide may also react with water to produce sulphuric acid (H2SO4).
- Sulphuric acid may also be produced from demethylsulphide, which is emitted to the atmosphere by plankton species.
- All these particles will settle back onto earth or react with rain and fall back onto earth as acid deposition.
- The particles will then be absorbed by plants again and are released back into the atmosphere, so that the sulphur cycle will start over again**.**

3. **Calcium Cycle:**
   - Calcium is primarily present as rock, minerals or as structural calcium built into mineral crystal lattices of soil particles and is **not readily available**.
   - Calcium can also be added as fertilizer, lime, or by-products. Water can carry calcium into the soil through weathering and natural dissolution.
   - When in the soil, most of the calcium is in an **insoluble** form until it is 'weathered off' of minerals or when organic matter is broken down by microbes into **soluble calcium.**
     - However, some of the calcium are held loosely or tightly on soil's cation exchange complex (CEC) or in the soil solution and are available to plants and microorganisms.
   - When animals, microorganisms, or plants decay, their bodies **decompose,** and the **calcium is mineralized** and released back into the soil.
   - Roots also regularly leak minerals, sugars, and other compounds back into the soil including calcium.
   - Since calcium is a positively charged ion, it is adsorbed in the soil to the surface of clay and organic particles which are negatively charged. Positively charged ions (cations) adsorb to soil particles and are termed "exchangeable ions" because they can be exchanged by other ions present in the soil solution.
     - When absorbed by plants or microorganisms, calcium enters an organic phase. In this form, calcium is continually recycled between the plant roots, microorganisms, and soil.

- After a plant, animal, or soil fauna dies, decomposers break down the organism and calcium are released back to the soil in a soluble form.
  - Thus, Calcium **routinely moves back** and forth between the soluble (and available) and the insoluble (unavailable) phases.

Ecological Succession:

- An important characteristic of all communities is that their composition and structure constantly change in response to the changing environmental conditions.
- This change is orderly and sequential, parallel with the changes in the physical environment.
- These changes lead finally to a community that is in near equilibrium with the environment and that is called a **climax community.**
- The gradual and predictable change in the species composition of a given area is called **ecological succession.**
- The entire sequence of communities that successively change in each area are called **sere(s)**. The individual transitional communities are termed seral stages or seral communities. In the successive seral stages, there is a change in the diversity of species of organisms, increase in the number of species and organisms as well as an increase in the total biomass.
- Succession is hence a process that starts where no living organisms are there – these could be areas where no living organisms ever existed, say bare rock; or in areas that somehow, lost all the living organisms that existed there. The former is called **primary succession**, while the latter is termed **secondary succession**.
- Examples of areas where primary succession occurs are newly cooled lava, bare rock, newly created pond, or reservoir.
- The species that invade a bare area are called **pioneer species**. In primary succession on rocks these are usually lichens which can secrete acids to dissolve rock, helping in weathering and soil formation. These later pave the way to some very small plants like bryophytes, which can take hold in the small amount of soil.
- They are, with time, succeeded by bigger plants, and after several more stages, ultimately a stable **climax** forest community is formed.
- Secondary succession begins in areas where natural biotic communities have been destroyed such as in abandoned farmlands, burned or cut forests, lands that have been flooded. Since some soil or sediment is present, succession is faster than primary succession.
- **Based on the nature of the habitat** – whether it is water (or very wet areas) or is on very dry areas – succession of plants is called hydrarch or xerarch, respectively
- **Hydrarch succession** takes place in wetter areas and the

successional series progresses from hydric to the mesic conditions.

- **Xerarch succession** takes place in dry areas and the series progress from xeric to mesic conditions.

BIODIVERSITY:

- It relates to the diversity among living organisms on the earth, including the diversity within and between the species and that within and between the ecosystems they form.
- The overall quantity and variety of species in a certain area or region is referred to as the region's biodiversity.
- It covers diversity within and between species as well as diversity in the ecosystem.
- The two main parts of biodiversity are species richness and species evenness. Whittaker carried out the biodiversity measurement.

Species Richness: Species richness refers to the variety of species found in a population. Alpha diversity, beta diversity, and gamma diversity are its three subtypes.

Species Evenness – The measure of species proportion at a particular site is species evenness.

IMPORTANCE OF BIODIVERSITY:

Biodiversity has contributed a lot to the development of human culture, and, in turn, human communities have played an important role in shaping the biodiversity at the genetic, species and ecological levels.

Biodiversity is important in the following ways:

- **Ecological role:** Species of many kinds perform some of the other functions in an ecosystem. Every organism, besides fulfilling its own needs, also contributes something useful to different other organisms in the environment. Species capture, store and utilise energy, produce and decompose organic materials, are part of cycles of water and nutrients throughout the ecosystem, fix gases in the atmosphere and help regulate the climate. Thus, they help in soil formation, reducing pollution, protection of land, water, and air resources. These functions of biodiversity are important for ecosystem functions and stability.
- **Ecosystem services:** Biodiversity underpins the basis of all the ecosystem services on the planet.
- **Provisioning Services:** Various plants, animals and microorganisms which form the biodiversity, provide us with foods such as cereals, fishes etc., fibre for our clothes such as cotton, wool etc., fuelwood for survival as well as pharmaceutical products such as neem, Tulsi etc.
- **Regulating services:** Biodiversity regulates the local as well as global climate, manages the global levels of oxygen, carbon dioxide and other gases, maintains freshwater quality by vegetation slowing runoff, absorbs carbon by acting as carbon sinks etc. Thus, biodiversity regulates the life and life processes on the planet.
- **Supporting services:** Biodiversity helps in pollination, nutrient cycling as well as recycling, greenhouse gas reduction by sequestration.

- **Social and cultural services:** Biodiversity provides us with aesthetic pleasure. It provides recreational avenues and rich biological diversity encourages tourism in the region. Many communities and cultures have co-evolved with the surroundings and the resources provided by a biologically diverse environment. Hence, it performs an important social role as well. Important services which are provided by biodiversity are: Recreation and relaxation Tourism especially ecotourism Art, Design and inspiration Spiritual experiences and a sense of place.
- **Food web maintenance:** Biodiversity helps in maintaining food webs as higher the diversity of an ecosystem, more complex is going to be the food webs because there are so many options to eat. Therefore, higher chances of survival of every species are there. This results in more stable food chains and food webs.
- **Scientific role:** Biodiversity help in scientific research, education, and monitoring. For example, research about new genetic materials with the help of gene pools. Biodiversity, thus, helps in understanding the functioning of life and the role that each species plays in sustaining ecosystems of which we humans are also a part.

TYPES OF BIODIVERSITY:

Based on the **three elements of biodiversity, that is, genes, species and ecosystems**, biodiversity is of **three types:**

- **Genetic diversity:** It can be understood as the diversity of genes within a particular species. This diversity **ensures that** some species can survive disruptions. Thus, genetic diversity gives us beautiful butterflies, roses, corals and fruits in myriad hues, sizes, and shapes.
- **Species diversity:** It refers to the variety of species within a particular geographical region. Species which are different from one another do not interbreed naturally However, closely associated species can have a lot of similarity in their hereditary characteristics. For example, humans and chimpanzees have about 98.4 percent genes which are the same. Species diversity is measured by **species richness**, which means the number of different species per unit area in a region, and species evenness equitably, which refers to the relative abundance of individuals of different species in an area.
- **Ecosystem or Community diversity:** It refers to the diversity of different biological communities or ecosystems like forests, deserts, lakes, corals etc. In a region or on the earth. As the ecosystem changes, species best adapted to that ecosystem becomes predominant. Thus, biodiversity also depends on the nature of the ecosystems.

MEASUREMENT OF BIODIVERSITY:

Measurement of biodiversity was done by **Whittaker**. Biodiversity can be measured by two major components: **Species**

Richness and **Species Evenness**

- **Species Richness:** It refers to the measure of several species found in per unit area of a region or community. It has three components:
    - **Alpha diversity:** It refers to the diversity of species found in a particular area or ecosystem and is usually expressed by the number of species in that ecosystem.
    - **Beta diversity:** It refers to the comparison of the diversity of species between two or more ecosystems, usually measured as the change in the number of species between the ecosystems.
    - **Gamma diversity:** It is the measure of the overall diversity for the different ecosystems in a region. It is highly subjective because of different perceptions about the boundaries of the region.
- **Species Evenness:** It is the measure of relative abundance of individuals of different species in each region. Low evenness in general, means that a few species dominate the region or ecosystem.

LOSS OF BIODIVERSITY:

- The loss of species, ecosystems or genes is termed as a loss of biodiversity. The biological wealth of the planet is declining rapidly. The IUCN Red List documents the extinction of 784 species (including 338 vertebrates, 359 invertebrates and 87 plants) in the last 500 years. In the last 20 years alone, we have witnessed the loss of more than 30 species. As per the Living Planet report:
- The present rate of extinction of species is up to 100 to 1000 species extinction per 10,000 species in a duration of 100 years. This is almost 1000 times more than the natural rate of extinction.
- The living planet index, which measures the biodiversity abundance levels, is showing a persistent downward trend. On average, monitored species population has declined by 58% since the year 1970.
- In tropical forests, there has been a 40% decline of species since the year 1970.
- Whereas in temperate grasslands, species population has declined by 18% and in freshwater habitat, species population has declined by 81% since the year 1970.

Reasons for loss of Biodiversity:

- **Habitat loss and fragmentation:** This is a primary cause which drives animals and plants to extinction. The habitat loss and fragmentation have been through changes of land use the conversion of natural ecosystems to cropland, development of infrastructure projects like rails and roadways, increasing urbanisation and mining activities. As per the **Living Planet report**, there has been about a 30% decline in wetlands in the last 40 years. Wetlands have been primarily reclaimed for agriculture and urbanisation. Also, about 50% of the tropical and subtropical forests

and 45% of the temperate grasslands have been converted for human use. Besides total loss, the degradation of many habitats by pollution also threatens the survival of many species. When large habitats are broken up into smaller fragments because of different human activities, mammals and birds which require large territories and certain animals with migratory habits are adversely affected, causing a decline in their population.

- **Over-exploitation of species:** Unsustainable use of ecosystems and over-exploitation of biodiversity are a major reason behind biodiversity loss. Over-hunting or poaching of species, overfishing, and overharvesting of plant products can quickly lead to a decline in biodiversity. Changing consumption patterns of humans is often cited as the key reason for this unsustainable exploitation of natural resources. Many species which got extinct in the past 5 centuries, like Steller's Sea cow, passenger pigeon, were subject to over-exploitation by humans.
- **Introduction of alien species:** Plants, animals and microorganisms transported deliberately or unintentionally from an outside geographical region can cause great damage to native species by competing with them for food and shelter, spreading diseases unknown to them, causing genetic changes through the process of interbreeding with native species, and disrupting various aspects of their food chains and the physical environment. For example, in India Water hyacinth was introduced by the British for beautification. But over time, it has become an invasive species, clogging rivers, lakes, and other water bodies, thus not allowing any aquatic life to grow and survive.
- **Environmental pollution:** The accumulation of Pollution such phosphorus and nitrogen largely from excess fertilizers running off farmland, harmful chemicals firm urban and suburban runoff, industrial effluents etc. which are discharged into the natural water bodies. For example, oil spill off the port of Ennore in Chennai in 2017. Similarly, plastic pollution causes the death of animals. Also, air pollution from industries and vehicles has resulted in the death of many bird species in urban areas.
- **Global climate change:** Climate change is projected to become a progressively more significant threat to biodiversity in the coming decades. Already, changes in the flowering and migration patterns as well as in the distribution of various species have been observed throughout the world. These changes have altered food chains and created mismatches within ecosystems where different species have evolved synchronised inter-dependence.
- **Co-extinctions:** When a particular species becomes extinct, the plants and animals associated with it in an obligatory way also come under the danger of becoming extinct. For

example, when a host fish species becomes extinct, its unique assemblage of parasites also meets the same fate.

- **Natural causes:** Like floods, earthquakes and other natural disasters also cause loss of biodiversity.

Biodiversity Hotspots in India:

India has six hotspots of biodiversity out of the 36 biodiversity hotspots, making it a country rich in biodiversity. With a great array of flora and animals in India (including endangered species). The Himalayas, the Indo-Burma region, the Terrai-duar Savannah, the Western Ghats, Sunderland, and the Sundarbans are among India's hotspots for biodiversity. India's Sundarbans is another UNESCO World Heritage Site. The following is a detailed summary of India's Hotspots for Biodiversity-

Himalayas:

One of the main Indian hotspots is the Eastern Himalayas. It encompasses the regions of Burma, Nepal, Bhutan, Sikkim, and Arunachal Pradesh. It has an evergreen forest with oak and alpine trees in it. The wildlife includes the fascinating western tragopan, clouded leopard, slow loris, snow cock, heron, tiger, white-winged wood duck, and Indian civet.

Terrai-duar Savannah:

The Terrai-duar Savannah extends to the Indo Gangetic plain of Bhutan, Nepal, and India after forming a brief sliver at the foot of the Himalayas. The Terrai-duar Savannah is home to some of the tallest, richest slits, and rarest grasslands in the entire globe. These perforations are left behind by powerful monsoon floods each year. The one-horned rhinoceros, sloth bears, Asian elephants, and many more animals are among the Terrai-duar Savannah's most notable wildlife.

Indo-Burma region:

One of India's largest hotspots is the Indo-Burma region. The Ganga plains, parts of the Andaman and Nicobar Island, Thailand, Myanmar, Cambodia, Lao PDR, the Brahmaputra River basin, and other areas are also affected. Numerous plant and animal species, like the Annamite muntjac and grey-crowned crucial, can be found there, making it one of the most endangered places. But the region needs legislative protection due to growing dangers from humans.

Sundarbans:

In the Ganga-Brahmaputra delta, there are 104 islands collectively known as the Sundarbans. With the largest mangrove forest in the world, Sunderbans is one of India's UNESCO World Heritage Sites. The Royal Bengal tigers live there. Along with Gangetic dolphins and estuarine crocodiles, as well as several other fish, animal, and bird species, it is home to Royal Bengal tigers. But today, the rise in sea level brought on by global warming poses a serious threat to the local species.

Sundaland:

The Nicobar Islands are home to India's Sundaland hotspot, which reaches the tectonic plates beneath the Indian Ocean. Probscis monkeys, Javan and Sumatran rhinoceros, pig-tailed langurs, and orangutans are among the animals that call it home. Only the probosci's monkeys of this group are

present in the Borneo region. Additionally, the Sundaland hotspot is home to the rafflesia, the largest bloom in the world (it measures one metres long).

Western Ghats:

Beyond India's west coast, the Western Ghats extends from north to south.

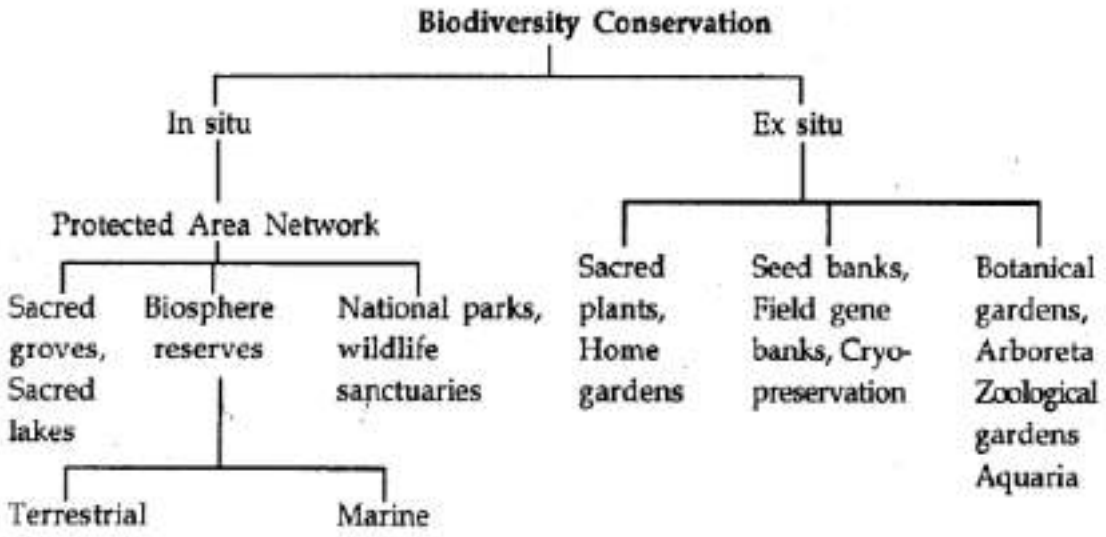


Fig. 1 The in-situ and ex-situ approaches of conserving biodiversity in India

With numerous highland tropical rainforests, it is also one of the UNESCO World Heritage Sites. A wide range of animals and plants can be found in these forests. Tigers, black panthers, and leopards are all part of it. The endangered shy lion-tailed macaques are part of the fauna in the southern Western Ghats. The strange pig-nosed purple frog is seen in the Western Ghats during monsoon season. In the dense forests, new species are continuously being found.

Importance of Biodiversity:

The ecological balance of the ecosystem is significantly maintained by biodiversity. It performs a crucial ecological, economic, and scientific role. The significance of biodiversity can be summed up as follows:

Ecological Role:

There will be a better possibility for a species to survive threats and adversity if the habitat is diversified. As a result, it helps to protect species and keep the ecological equilibrium. By absorbing and storing energy, creating, and digesting organic material, adding to the water cycle, and controlling the climate, it plays a crucial role in ensuring human survival.

Economic Role:

A resource that is vital to daily existence is biodiversity, particularly agro biodiversity. It is important for growing food crops, livestock, fish, and other initial materials for cosmetics, food production, and medicinal resources.

Scientific Role:

The species, whether extinct or still existing, aids in comprehending the idea of evolution. It aids in comprehending the function and role

carried out by a species in a specific ecosystem and demonstrating their various relationships.

Other Roles:

In addition to these responsibilities, maintaining the food web, pollination, nutrient cycling, lowering greenhouse gas emissions, soil formation, etc.

Threats to Biodiversity:

Changes to our land- and water-use:

Numerous diverse ecosystems exist on our land and in our oceans, and business activities have an impact on these ecosystems. For instance, when construction companies drain and fill in wetlands or marshes to make place for housing, they remove the area that normally collects extra rainwater during storms.

Excessive consumption and unsustainable exploitation:

While logging, farming, and fishing can all be done responsibly, they frequently involve overusing resources. The entire web of life in an area can disintegrate if too many species, or even just a few significant species, are removed from the ecosystem.

Climate change:

Already, we are experiencing hotter weather, warmer oceans, and more extreme storms. Since many animals can't adapt to these circumstances, their populations plummet.

Increase in pollution:

For many ecosystems, pollution of the air, soil, and water is a major issue. Fish, birds, and other marine creatures accumulate tiny plastic particles that are suspended in the ocean's water. Many species in rivers and lakes are wiped out by industrial poisons. The soil, leaves, and water are all contaminated by air pollution. Less species, less diversity, and weaker ecosystems are the end results of all of this.

Conservation Methods:

In-situ conservation:

- It means conservation and management of genetic resources in their natural habitats. Here the plant or animal species are protected within the existing habitat. Forest trees, medicinal and aromatic plants under threat are conserved by this method. This is carried out by the community or by the State conservation which include wildlife, National Park, and Biosphere reserve. The ecologically unique and biodiversity rich regions are legally protected as wildlife sanctuaries, National parks, and Biosphere reserves. Megamalai, Sathyamangalam wildlife, Guindy and Periyar National Park, and Western ghats, Nilgiris, Agasthyamalai and Gulf of Mannar are the biosphere reserves of Tamil Nadu.

Sacred groves:

- These are the patches or grove of cultivated trees which are community protected and are based on strong religious belief systems which usually have a significant religious connotation for protecting community. Each grove is an abode of a deity mostly village God or Goddesses like Aiyanar or Amman. 448 grooves were documented

throughout Tamil Nadu, of which 6 groves (Banagudi shola, Thirukurungudi and Udaiyankudikadu, Sittannnavasal, Puthupet and Devadanam) were taken up for detailed floristic and faunistic studies. These groves provide several ecosystem services to the neighbourhood like protecting watershed, fodder, medicinal plants, and microclimate control.

National Parks:

- They are the locations that the government has designated for the preservation of the environment.
- Compared to a wildlife sanctuary, a national park has additional restrictions.
- A national park's primary goals are to conserve biodiversity and the local natural environment.
- Their limits are set and clearly defined. No human activity is permitted here.
- Private tenancy rights and livestock grazing are prohibited in this area.
- Jim Corbett National Park (Uttarakhand), Kanha Tiger National Park (Madhya Pradesh), and Kaziranga National Park (Assam) are a few **examples**.

Wildlife Sanctuaries:

- Wildlife Sanctuaries are like national parks.
- Additionally, it is a protected area set aside for wildlife conservation. At wildlife sanctuaries, endangered species are given special attention.
- It also protects the plant species, allowing for the legalization of human activities like timber harvesting, small forest product production, and private property rights.
- In India, there are **543 wildlife sanctuaries,** 50 of which are Project Tiger-managed tiger reserves.
- In India, further initiatives include Project Rhino, Project Indian Bustard, and a few eco-developmental initiatives have been started.
- On April 1st, 1973, Kailash Sankhala introduced Project Tiger, one of the most effective conservation initiatives, to India.

Biosphere Reserves:

- Protection of wildlife and flora has become crucial. Although it can be difficult, protecting, and conserving animal and plant species is essential if humans are to survive.
- The term "biosphere reserve" refers to a protected area of land or a coastal environment where the land is divided into separate zones for a variety of uses.
- **Core Area:** Unaltered ecosystems are legally protected as part of the natural or core zone.
- **Buffer Zone:** The buffer zone encircles the core region. It supports a wide range of resource use tactics.
- **Transition Zone:** The transition zone is located at the very edge. It is a protected area for the local populations of animals, plants, and people.
- Nanda Devi (Uttarakhand), Manas (Assam), Dibru Saikhowa (Assam), Great Nicobar, Sunderbans (West Bengal), and Pachmarhi (Madhya

Pradesh) are few **examples** of India's biosphere reserves.

In-situ Conservation in Agriculture:

- Using in situ conservation strategies in agriculture is a successful strategy to enhance, preserve, and employ conventional or native kinds of crops.
- Such techniques connect farmers' experience and fieldwork with the beneficial results of scientific study.
- A variety's accessions from a germplasm bank and those that farmers have multiplied are first examined together in a producer's field and a lab, under various conditions and pressures.
- As a result, the scientific understanding of the native variety' production traits is improved.
- Later, reproducible conditions are used to cross, combine, and multiply the best tested accessions. Finally, the producers are given access to these improved accessions.
- So, instead of being encouraged to replace their own kinds with commercial ones or to give up on their crop, farmers are allowed to grow improved choices of their own variety.
- This method of agricultural biodiversity conservation works better in remote places where commercial varieties are impractical because of climatic and soil fertility restrictions, or where the flavor and cooking qualities of traditional varieties makeup for their lower yields.

In-situ Conservation – Advantages:

- **Cost Efficient:** In-situ conservation is an inexpensive and practical strategy to preserve biological variety.
- The species is allowed to develop in its native environment, where it has been developing for a long time, with the elimination of factors that are harmful to the species' survival.
- This significantly lowers the cost of conservation activities.
- **Protection of Entire Ecosystem:** We safeguard the complete ecosystem or natural habitat to guarantee the continued existence of the species.
- Naturally, the system needs enough herbivores to provide food for the predators to protect a population of carnivores.
- There must be plenty of green foliage for herbivores to eat to keep the number of herbivores stable.
- As a result, a high number of organisms are preserved via the process.
- **Free Play of Natural Agents: In a natural system, organisms not only survive and reproduce, but also change with time.**
- A natural ecosystem permits the free play of natural forces, such as drought, storms, snow, temperature fluctuations, heavy rain, fires, diseases, etc., which give organisms the chance to adapt to the environmental conditions and develop into better adapted living forms.

In-situ Conservation – Disadvantages:

- **Survival:** Fragmented endangered habitats may not have enough space to guarantee the survival of these species.
- **Decline in Genetic Diversity:** There may already be a significant decline in genetic diversity.
- **Diseases and Interspecific Competition:** There may still be diseases or interspecific competition, for example, that threaten the local organisms.
- **Poaching And Tourism Activities:** The developing area can present a chance for poachers and ecotourists to do harm.

Ex-situ Conservation:

- This method involves removing threatened animals and plants from their native environment and relocating them to a designated location where they can be protected and given specialised care.
- This is accomplished by zoological parks, botanical gardens, wildlife safari parks, and seed banks.
- Many species of animals are nevertheless kept alive in zoological parks despite going extinct in the wild.
- Ex-situ conservation has recently gone beyond the preservation of vulnerable species.
- Now, utilizing cryopreservation technology, gametes of endangered species can be kept in viable and fertile form for extended periods of time.
- In vitro fertilization of eggs and tissue culture techniques for plant propagation are also possible.
- In seed banks, seeds of several genetic strains of commercially significant plants can be preserved for a long time.
- The key focus of the national gene bank at the National Bureau of Plant Genetic Resources (NBPGR), Delhi, is the long-term preservation of rare accessions as base collections for future generations, particularly in the form of seeds.

Ex-situ Conservation – Facilities:

Botanical Gardens:

- This is a technique for ex-situ conservation of endangered and threatened species in their local habitats.
- Governments at various levels, educational institutions, and international assistance are all involved in maintaining this.
- More than 80,000 species can be found in more than 1500 botanic gardens and arboreta around the globe.
- There are currently tissue culture labs, seed banks, and other ex-situ technologies at many of these botanical gardens.

Zoological Parks (Zoos):

- Around the world, there are more than 800 professionally run zoos that house around 3000 different species of mammals, birds, reptiles, and amphibians.
- These zoos frequently feature advanced captive breeding programmes.
- Breeders and genetic engineers have a ready source of genetic

material thanks to the protection of crop plants', animals', or microbes' wild ancestors.

- Many tropical islands have many indigenous animal species, and they also have a highly spectacular record of agro biodiversity.

Wildlife Safari Parks:

- **A safari park, sometimes known as a wildlife park, is a zoo-like commercial is an ex-situ conservation technique.**
- A zoo-like establishment frequently referred to as a "wildlife park," a safari park is an example of ex-situ conservation.
- It is a drive-in tourist attraction where visitors can ride in vehicles provided by the establishment or drive their own cars while watching animals roam freely.
- A safari park is bigger than a zoo and smaller than a game reserve. For instance, the 750-acre African Lion Safari in Hamilton, Ontario, Canada (3.0 km2).

Seed Banks:

- **Seeds are kept in seed banks to protect genetic variety for the future.**
- They often contain jars of seeds from various plant species and are vaults that are bomb, flood, and radiation proof.
- Seeds must be kept in storage for a variety of reasons. To boost crop output, disease resistance, drought tolerance, nutritional quality, flavor, and other traits, plant breeders need certain genes to be preserved.
- Another is to prevent the genetic diversity of rare or threatened plant species from being lost to ex situ conserve biodiversity.
- The seeds are normally stored in low humidity and cold (about -20°C) conditions.

Techniques for Plants:

Cryopreservation:

Seeds, pollen, tissue, and embryos are all stored in liquid nitrogen during plant cryopreservation. Compared to all other methods of ex situ conservation, this method allows for practically unlimited storage of the material without deterioration over a far longer time frame. Through cryoconservation of animal genetic resources, cryopreservation is also employed to conserve livestock genetics. Many species cannot be cryopreserved due to technical limits, but plants are the subject of several studies in the discipline of cryobiology, which is an area of ongoing research.

Seed Banking:

- The preservation of seeds in a setting with controlled humidity and temperature is called seed banking.
- For taxa with conventional seeds that can withstand desiccation, this method is employed.
- Facilities for seed banks range from climate-controlled walk-in freezers or vaults to sealed boxes.
- Normally, taxa with resistant seeds that cannot tolerate desiccation aren't kept in seed banks for a very long time.

Field Gene Banking:

- Field Gene Banking refers to a sizable open-air planting used to preserve the genetic variety of wild, domesticated, or forest species.

- In most cases, field gene banks conserve species that are either impossible or difficult to conserve in seed banks.
- Field gene banks can be used to cultivate and pick offspring of species preserved via various ex situ methods.

Cultivation Collections:

- Cultivation Collections refers to plants that are cared for horticulturally in a built landscape, usually a botanic garden or arboretum.
- Although plants are kept in their natural habitat, this method is comparable to field gene banks in that collections are often not as large or genetically varied.
- These collections are vulnerable to disease spread, genetic drift, artificial selection, and hybridization. Frequently, cultivated collections contain species that cannot be preserved using other ex situ methods.

Inter situ:

- Horticulture is used to take care of the plants, but the surroundings are kept as close to natural as possible.
- This happens in both semi-natural and restored habitats.
- This method is mainly applied to uncommon taxa or those that are found in severely degraded habitats.

Tissue Culture:

- In tissue culture, somatic tissue can be kept in vitro for a short while.
- This is carried out in a setting with controlled lighting and temperature to manage cell development.
- Tissue culture is mostly utilized for clonal growth of vegetative tissue or immature seeds as an ex-situ conservation strategy.
- This makes it possible for clonal plants to grow from a tiny amount of parent tissue.

Techniques for Animals:

- Similar methods are used to protect endangered animal species and breeds.
- **Gene Banks:** In genebanks, which are composed of cryogenic facilities used to store living sperm, eggs, or embryos, animal species can be conserved.
- **Cryopreservation:** For instance, the Zoological Society of San Diego has created a "frozen zoo" to retain such samples from more than 355 species, including mammals, reptiles, and birds, using cryopreservation techniques.
- **Interspecific Pregnancy:** Interspecific pregnancy is one such method that could help endangered species reproduce.
- It involves implanting embryos of an endangered species into a female of a related species and allowing to bring the embryo to term. For the Spanish ibex, it has been done.

Ex-situ Conservation – Advantages:

- Organisms are completely protected from predators and poachers.
- Individuals' health can be tracked, and medical assistance can be provided as required.

- Populations can be divided more effectively in the case of a disaster.
- Genetic diversity of the population can be measured.
- Selective breeding programmes can be implemented.
- Modern reproductive technology can increase the chances of reproductive success.
- Animals and plants can be bred to increase their numbers if they are in danger of extinction.
- Research on an endangered species' reproductive physiology, way of life, and ecology is made simpler.
- Funds for additional conservation efforts might be raised by using conservation sites as attractions.
- Educational activities can take place at conservation areas.

Ex-situ Conservation – Disadvantages:

- Genetic diversity in captive populations is minimal.
- As the creatures are residing outside of their normal habitat, nutritional problems could occur.
- Animals can be exposed to a wide variety of various diseases.
- Animals might not behave normally.
- Attempting to reproduce at times may become difficult.
- Appropriate environmental conditions for survival could be challenging to attain.
- Acceptance by the species' current wild members may present challenges.

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.

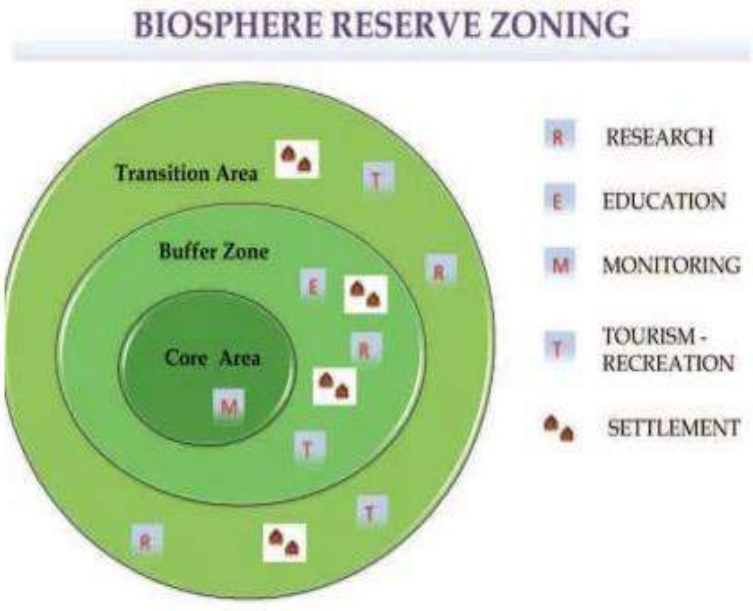
Buffer zone

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

16. Dibru-Saikhowa	Assam	East Himalayas	**Golden langur**
17. Seshachalam Hills	Andhra Pradesh	Eastern Ghats	
18. Panna	Madhya Pradesh	Catchment Area of the Ken River	**Tiger, chital, chinkara, sambhar and sloth bear**

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

- 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

- 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

- 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 Ghat 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.

BIOLOGICAL DIVERSITY ACT, 2002

- It was born out of India's attempt to realise objectives enshrined in UNCBD, 1992 which recognizes the sovereign rights of states to use their own Biological Resources.
- Aims at conservation of biological resources, managing their sustainable use and enabling fair and equitable sharing of benefits arising out of the use and knowledge of biological resources with the local communities.

Biodiversity: Biodiversity means the variability among living organisms from all sources and the ecological complexes of which they are part and includes diversity within species or between species and of ecosystems

Biological Resources: Biological resources means plants, animals and micro-organisms or parts thereof, their genetic material and by-products (excluding value added products) with actual or potential use or value but do not include human genetic material.

Salient Features - Biological Diversity Act

- **Prohibits following activities without prior approval from National Biodiversity Authority:**
  - Any person or organisation (either based in India or not) obtaining any biological resource occurring in India for its research or commercial utilisation.The transfer of the results of any research relating to any biological resources occurring in, or obtained from, India.
  - The claim of any intellectual property rights on any invention based on the research made on the biological resources obtained from India.
- **Three-tier structure to regulate access to biological resources:**
  - National Biodiversity Authority (NBA)State Biodiversity Boards (SBBs)
  - Biodiversity Management Committees (BMCs) (at a local level)
- **Provides these authorities with special funds and a separate budget to carry out any research project dealing with the biological natural resources of the country.**
  - It shall supervise any use of biological resources and the sustainable use of them and

shall take control over the financial investments and their return and dispose of those capitals as correct.

- **Under this act, the Central Government in consultation with the NBA:**
  - Shall notify threatened species and prohibit or regulate their collection, rehabilitation and conservation
  - Designate institutions as repositories for different categories of biological resources.
- **The act stipulates all offences under it as cognizable and non-bailable.**
  - Any grievances relating to the determination of benefit sharing or order of the National Biodiversity Authority or a State Biodiversity Board under this Act shall be taken to the National Green Tribunal (NGT).

Exemptions from the Act

- Excludes Indian biological resources that are normally traded as commodities.
  - Such exemption holds only so far, the biological resources are used as commodities and for no other purpose.
- Excludes traditional uses of Indian biological resources and associated knowledge and when they are used in collaborative research projects between Indian and foreign institutions with the approval of the central government.
- Uses by cultivators and breeds, Ex. farmers, livestock keepers and beekeepers and traditional healers Ex. vaids and hakims are also exempted.

Historic Movements to Conserve Biodiversity:

Chipko Movement:

- It is a social-ecological movement that used **hugging trees to stop them from falling** as a form of **peaceful resistance** and Gandhian satyagraha.
- Early in the 1970s, when awareness of rapid deforestation grew, the contemporary Chipko movement was born in Uttarakhand's Garhwal Himalayas.
- On March 26, 1974, a group of peasant women in Reni village, Hemwalghati, in Chamoli district, Uttarakhand, India, took action to stop the cutting of trees and reclaim their **traditional** forest rights that were threatened by the contractor system of the state Forest Department.
- This action is considered the turning point in this conflict.
- Numerous such acts were sparked by their deeds at the local level around the area.
- By the 1980s, the movement had **extended over all of India**, which helped to shape people-sensitive forest policies that ended open tree-cutting in places like Vindhyas and the Western Ghats.
- However, the first known instance of Chipko was in the village of Khejarli in the Jodhpur area in 1730 AD when 363 Bishnois under the leadership of Amrita Devi gave their lives to hug **green Khejri**

trees, which were revered by the locals.

Appiko Movement:

- In India, the Appiko movement was a groundbreaking **environmental conservation** movement.
- The peasants of the district of **Karnataka** province in southern India started a similar initiative to safeguard their forests after being **inspired by the Chipko** movement in Himalayan Uttarakhand.
- Salkani men, women, and kids "hugged the trees" in Kalase forest in September 1983 (In Kannada, "hugging" is referred to as "appiko").
- Southern India saw a new consciousness because of the Appiko movement.

Biodiversity-related Conventions:

Several international conventions focus on biodiversity issues: the Convention on Biological Diversity (year of entry into force: 1993), the Convention on Conservation of Migratory Species, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1975), the International Treaty on Plant Genetic Resources for Food and Agriculture (2004), the Ramsar Convention on Wetlands (1971), the World Heritage Convention (1972) and the International Plant Protection Convention (1952), the International Whaling Commission (1946).

Convention on Biological Diversity:

The objectives of the CBD are the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising from commercial and other utilization of genetic resources. The agreement covers all ecosystems, species, and genetic resources.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES):

The CITES aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival. Through its three appendices, the Convention accords varying degrees of protection to more than 30,000 plant and animal species.

Convention on the Conservation of Migratory Species of Wild Animals:

The CMS, or the Bonn Convention aims to conserve terrestrial, marine and avian migratory species throughout their range. Parties to the CMS work together to conserve migratory species and their habitats by providing strict protection for the most endangered migratory species, by concluding regional multilateral agreements for the conservation and management of specific species or categories of species, and by undertaking co-operative research and conservation activities.

The International Treaty on Plant Genetic Resources for Food and Agriculture:

The objectives of the Treaty are the conservation and sustainable use of plant genetic resources for food and agriculture and the fair and equitable sharing of the benefits arising out of their use, in harmony with the Convention on Biological Diversity, for sustainable agriculture and food security. The Treaty covers all plant genetic resources for food and agriculture, while its Multilateral System of Access and Benefit-sharing covers a specific list of 64 crops and

forages. The Treaty also includes provisions on Farmers' Rights.

Convention on Wetlands (popularly known as the Ramsar Convention):

The Ramsar Convention provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. The convention covers all aspects of wetland conservation and wise use, recognizing wetlands as ecosystems that are extremely important for biodiversity conservation in general and for the well-being of human communities.

World Heritage Convention (WHC):

The primary mission of the WHC is to identify and conserve the world's cultural and natural heritage, by drawing up a list of sites whose outstanding values should be preserved for all humanity and to ensure their protection through a closer co-operation among nations.

International Whaling Commission (IWC):

The purpose of the IWC is to provide for the proper conservation of whale stocks and thus make possible the orderly development of the whaling industry.

NATIONAL BIODIVERSITY ACTION PLAN

The National Biodiversity Action Plan is a national strategy that provides the framework of actions necessary for the conservation and sustainable use of biodiversity. In other words, it epitomizes plans for the protection of ecosystems, species, and genetic diversity in India, ultimately aimed at integrating biodiversity considerations into all aspects related to management over land and water resources. The NBAP addresses both the current needs in biodiversity conservation and the emerging challenges; it thus acts as a guideline for the policy-framers, stakeholders, and conservationists to work towards putting in place effective management for biodiversity.

Need for National Biodiversity Action Plan

The evolution of NBAP draws its strength from the commitment of India to the Convention on Biological Diversity, which was ratified by it in 1994. Realizing its concern for biodiversity in maintaining ecological stability, food security, climate resilience, and sustainable development, the NBAP was first formulated in 1999; since then, it has undergone periodic evolution to respond to new challenges, global biodiversity targets like Aichi Biodiversity Targets, and national developmental frameworks.

India is one of the 17 megadiverse countries in the world and hosts 7–8% of the recorded species of the world. Indeed, with all its richness and complexity, Indian biodiversity requires a focused and uniform action plan, particularly in view of threats like habitat loss, climate change, over-exploitation of resources, pollution, and invasive species. Thus, NBAP assumes cardinal importance for coordinating national efforts in conservation and sustainable use of biological resources.

Objectives of the National Biodiversity Action Plan

The objectives of NBAP are oriented to three main goals:

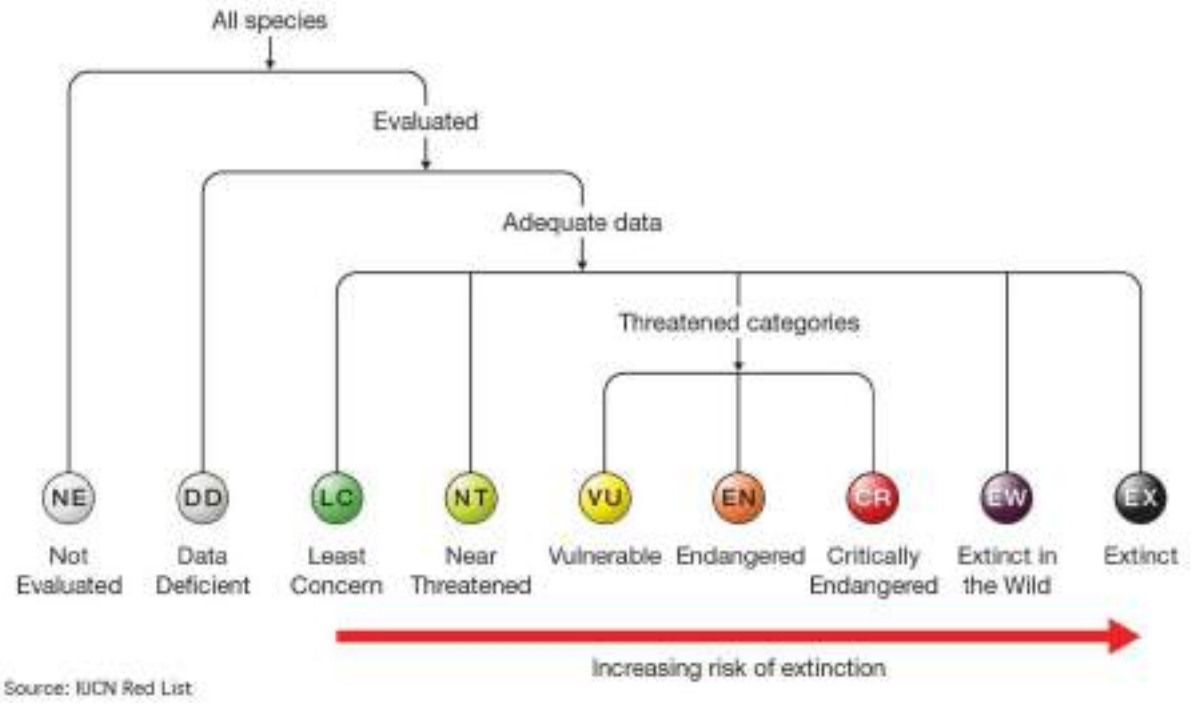
- Conservation of Biodiversity: Network of sites of importance for biodiversity shall be effectively protected and managed; critical habitats and endangered species are safeguarded.

- Sustainable Use of Biological Resources: Ensure that sustainable uses of biodiversity are mainstreamed into agriculture, forestry, fisheries, and all other sectors relying on biodiversity.
- Fair and Equitable Sharing of Benefits: The sharing of benefits emanating from the use of genetic resources has to be according to a fair and equitable basis among all stakeholders, specially the local and indigenous communities.

These objectives are aligned with the CBD and other international agreements, ensuring India's biodiversity conservation efforts are globally coordinated.

Biodiversity Governance in India:

- The **Nagoya Protocol** sought to ensure commercial and research utilisation of genetic resources led to sharing its benefits with the government and the community that conserved such resources.
- India's Biological Diversity Act 2002 (BD Act) is in close synergy with the Nagoya Protocol.
- The BD Act was hailed as an important step towards preserving India's vast biodiversity, as it recognised the sovereign right of countries over its natural resources.
- Under the BD Act, an important regulatory mechanism was the emphasis on **ac cess and benefit sharing (ABS)** to local populations.
- The BD Act seeks to address issues of managing bio-resources in the most decentralised manner possible. The BD Act envisages **three layered structures**: the National Biodiversity Authority **(NBA)** at the national level, the state biodiversity boards **(SSBs)** at the state level and biodiversity management committees **(BMCs)** at the local level.
- It assumes significance because it imposes prohibitions on the transfer of genetic material originating from India without



specific approval from competent authorities.

- The act also strengthens the country's stand with respect to anyone claiming an intellectual property right over biodiversity-related knowledge.

IUCN red list of threatened species:

- It is the world's most comprehensive **inventory of the global conservation status of plant and animal species.**
- ***How are species categorised?*** It uses a set of quantitative criteria to evaluate the extinction risk of thousands of species.

The IUCN Red List Categories:

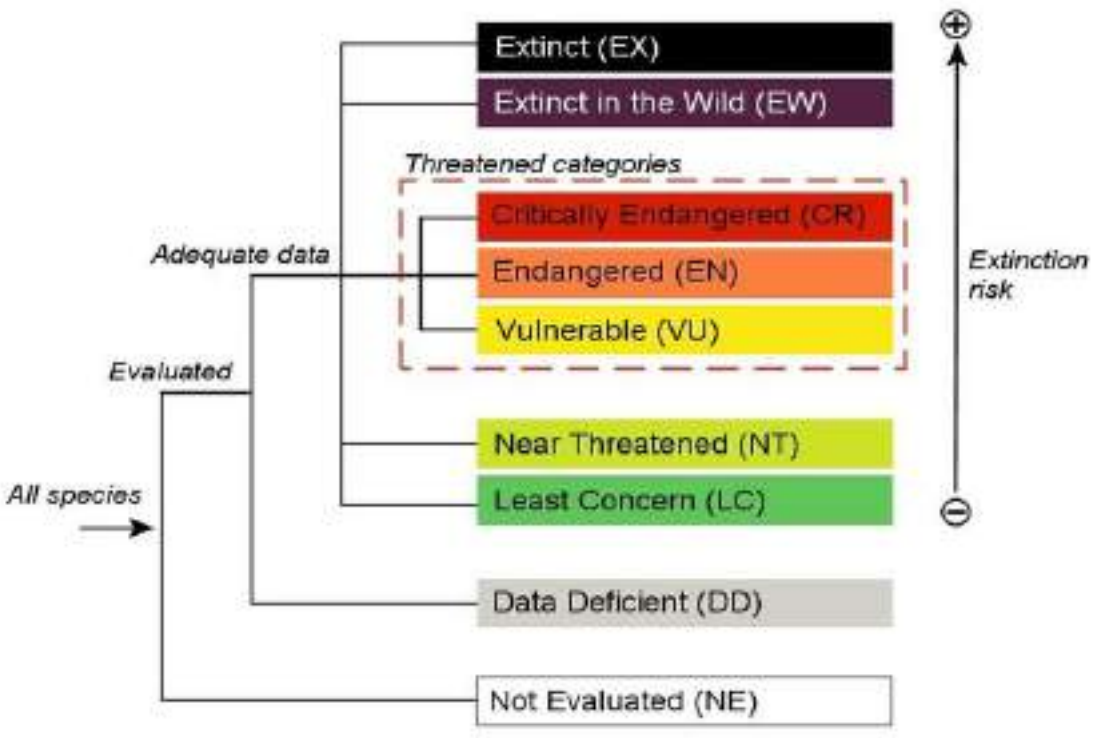
- The IUCN Red List Categories define the extinction risk of species assessed. **Nine categories extend from NE (Not Evaluated) to EX (Extinct).**
- Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) species are threatened with extinction.

The IUCN system uses a set of five quantitative criteria to assess the extinction risk of a given species. In general, these criteria consider:

- The rate of population decline.
- The geographic range.
- Whether the species already possesses a small population size.
- Whether the species is very small or lives in a restricted area.
- Whether the results of a quantitative analysis indicate a high probability of extinction in the wild.

The Biological Diversity Act, 2002:

- The act was enacted in 2002, it **aims at the conservation of biological resources**, managing



its **sustainable use** and **enabling fair and equitable sharing benefits** arising out of the use and knowledge of biological resources with the local communities.

Salient Features of the Act:

- The Act prohibits the following activities without the prior approval from the **National Biodiversity Authority:**
  - Any person or organisation (either based in India or not) obtaining any biological resource occurring in India for its research or commercial utilisation.
  - The transfer of the results of any research relating to any biological resources occurring in, or obtained from, India.
  - The claim of any intellectual property rights on any invention based on the research made on the biological resources obtained from India.
- The act envisaged a three-tier structure to regulate the access to biological resources:
  - **The National Biodiversity Authority** (NBA)
  - **The State Biodiversity Boards** (SBBs)
  - **The Biodiversity Management Committees** (BMCs) (at local level)
- The Act provides these authorities with special funds and a separate budget to carry out any research project dealing with the biological natural resources of the country.
  - It shall supervise any use of biological resources and the sustainable use of them and shall take control over the financial investments and their return and dispose of those capitals as correct.
- Under this act, the Central Government in consultation with the NBA:
  - Shall notify **threatened species** and prohibit or regulate their collection, rehabilitation, and conservation.
  - Designate institutions as repositories for different categories of biological resources
- The act stipulates all offences under it as **cognizable and non-bailable.**
- Any grievances related to the determination of benefit sharing or order of the National Biodiversity Authority or a State Biodiversity Board under this Act, shall be taken to the National Green Tribunal (NGT).

The National Biodiversity Authority:

- The **National Biodiversity Authority (NBA)** was established in **2003** by the Central Government to implement India's Biological Diversity Act (2002).
- It is a **Statutory body** that performs facilitative, regulatory, and advisory functions for the Government of India on the issue of Conservation and sustainable use of biological resources.
- The NBA has its **Headquarters in Chennai,** Tamil Nadu, India.

Structure of the NBA:

- The National Biodiversity Authority consists of the following members to be appointed by the central government, namely:
  - **A Chairperson.**
  - **Three ex officio members,** one representing the Ministry dealing with Tribal Affairs and two representing the Ministry dealing with Environment and Forests.
  - **Seven ex-officio members** to represent respectively the Ministries of the Central Government dealing with:
    - Agricultural Research and Education
    - Biotechnology
    - Ocean Development
    - Agriculture and Cooperation
    - Indian Systems of Medicine and Homoeopathy
    - Science and Technology
    - Scientific and Industrial Research;
  - **Five non-official members** to be appointed from amongst specialists and scientists having special knowledge and experience in the required matters.

Functions of the NBA:

- Creating an enabling environment, as appropriate, to promote conservation and sustainable use of biodiversity.
- **Advising the central government, regulating activities** and **issuing guidelines** for access to biological resources and for fair and equitable benefit sharing in accordance with the Biological Diversity Act, 2002.
- Taking necessary **measures to oppose the grant of intellectual property rights** in any country outside India on any biological resource obtained from India or knowledge associated with such biological resources derived from India illegally.
- **Advising the State Governments** in the selection of areas of biodiversity importance to be notified as heritage sites and suggest measures for their management.

State Biodiversity Boards (SBBs):

- **The SBBs** are established by the State Governments in accordance with **Section 22** of the Act.
- **Structure:** The State Biodiversity Board consists of the following members:
  - **A Chairperson**
  - Not more than **five ex officio members** to represent the concerned Departments of the State Government
  - Not more than **five members from amongst experts** in matters relating to conservation of biological diversity, sustainable use of biological resources and equitable sharing of benefits arising out of the use of biological resources.
  - **All the members of the SBB are appointed by the respective State Governments.**

Functions of SBBs:

- **Advise the State Government,** subject to any guidelines issued by the Central Government, on matters relating to the conservation, sustainable use or sharing equitable benefits.
- **Regulate by granting approvals** or otherwise requests for **commercial utilisation or bio-survey and bio-utilisation** of any biological resource by people.

Biodiversity Management Committees (BMCs):

- According to **Section 41 of the Act,** every local body shall constitute the BMC within its area for the purpose of promoting conservation, sustainable use and documentation of biological diversity including:
  - Preservation of habitats
  - Conservation of Landraces
  - Folk varieties and cultivars
  - Domesticated stocks And breeds of animals
  - Microorganisms And Chronicling Of Knowledge Relating To Biological Diversity

Structure:

- It shall consist of **a chair person** and **not more than six persons** nominated by the local body.
  - Out of total members of a BMC, **not less than one third should be women** and not less than **18% should belong to the Scheduled Castes/ Scheduled Tribes.**
- The Chairperson of the Biodiversity Management Committee shall be elected from amongst the members of the committee in a meeting to be chaired by the Chairperson of the local body.
- The chairperson of the local body shall have the casting votes in case of a tie.

Functions:

- The main function of the BMC is to prepare **People's Biodiversity Register** in consultation with the local people.
- The register shall contain comprehensive information on availability and knowledge of local biological resources, their medicinal or any other use or any other.

Biodiversity Heritage Sites (BHS):

- **Under Section 37 of Biological Diversity Act, 2002** the State Government in consultation with local bodies may notify the areas of biodiversity importance as **Biodiversity Heritage Sites.**
- The Biodiversity Heritage Sites are the well defined areas that are unique, ecologically fragile ecosystems - **terrestrial, coastal and inland waters and, marine** having rich biodiversity comprising of any one or more of the following components:
  - richness of wild as well as domesticated species or intra-specific categories
  - high endemism
  - presence of rare and threatened species
  - keystone species
  - species of evolutionary significance

- wild ancestors of domestic/cultivated species or their varieties
- past preeminence of biological components represented by fossil beds
- having significant cultural, ethical, or aesthetic values; important for the maintenance of cultural diversity (with or without a long history of human association with them)

BIOSPHERE RESERVES IN INDIA

Biosphere reserves are announced by the state or central governments by notification. The Governments can nominate them under the UNESCO's Man and Biosphere (MAB) Programme after its establishment as a biosphere reserve.

There are 18 biosphere reserves in India:

1. Cold Desert, Himachal Pradesh
2. Nanda Devi, Uttrakhand
3. Khangchendzonga, Sikkim
4. Dehang-Debang, Arunachal Pradesh
5. Manas, Assam
6. Dibru-Saikhowa, Assam
7. Nokrek, Meghalaya
8. **Panna, Madhya Pradesh (Smallest Area)**
9. Pachmarhi, Madhya Pradesh
10. Achanakmar-Amarkantak, Madhya Pradesh-Chhattisgarh
11. **Kachchh, Gujarat (Largest Area)**
12. Similipal, Odisha
13. Sundarban, West Bengal
14. Seshachalam, Andhra Pradesh
15. Agasthyamalai, Tamil Nadu-Kerala
16. **Nilgiri, Tamil Nadu-Kerala (First to be Included)**
17. Gulf of Mannar, Tamil Nadu
18. Great Nicobar, Andaman & Nicobar Island

NATURAL AND WORLD HERITAGE SITES

1. Kaziranga National Park – Assam
2. Manas Wildlife Sanctuary – Assam
3. Nanda Devi National Park and Valley of Flowers – Uttarakhand
4. Great Himalayan National Park – Himachal Pradesh
5. Sunderbans National Park – West Bengal
6. Western Ghats
7. Keoladeo Ghana National Park – Rajasthan

WORLD HERITAGE SITES IN INDIA

- A World Heritage Site is a place that is listed by UNESCO for its special cultural or physical significance. The list of World Heritage Sites is maintained by the international 'World Heritage Programme', administered by the UNESCO World Heritage Committee.
  - The **UNESCO World Heritage Committee is composed of 21 UNESCO** member states, elected by the General Assembly.
- The United Nations Educational, Scientific and Cultural Organization **(UNESCO) seeks to encourage the identification, protection, and preservation of cultural** and natural heritage around the world considered to be of outstanding value to humanity.
- This is embodied in an international treaty called the Convention concerning the Protection of the World Cultural and Natural Heritage, adopted by **UNESCO in 1972.**
- As of Sep 2023, **India has 42 world heritage sites that include 34 Cultural properties, 7 Natural properties, and 1 mixed site.**

List of

UNESCO Natural World Heritage sites in India

Natural World Heritage Site	State	Year of Notification
Kaziranga National Park	Assam	1985
Keoladeo Ghana National Park	Rajasthan	1985
Manas Wildlife Sanctuary	Assam	1985
Nanda Devi National Park and Valley of Flowers	Uttarakhand	1988
Sundarbans National Park	West Bengal	1987
Western Ghats	Maharashtra, Goa, Karnataka, Tamil Nadu and, Kerala	2012
Great Himalayan National Park	Himachal Pradesh	2014

List of UNESCO Cultural World Heritage sites in India

Archaeological Site of Nalanda Mahavihara (Nalanda University)	Bihar	2016
Rani-Ki-Vav	Gujarat	2014
Hill Forts of Rajasthan	Rajasthan	2013
The Jantar Mantar	Rajasthan	2010
Red Fort Complex	Delhi	2007
Champaner-Pavagadh Archaeological Park	Gujarat	2004
Chhatrapati Shivaji Terminus	Maharashtra	2004
Rock Shelters of Bhimbetka	Madhya Pradesh	2003
Mahabodhi Temple Complex at Bodh Gaya	Bihar	2002

Group of Monuments at Hampi	Karnataka	1986
Khajuraho Group of Monuments	Madhya Pradesh	1986
Group of Monuments at Mahabalipuram	Tamil Nadu	1984
Sun Temple, Konarak	Orissa	1984
Agra Fort	Uttar Pradesh	1983
Ajanta Caves	Maharashtra	1983
Ellora Caves	Maharashtra	1983
Taj Mahal	Uttar Pradesh	1983
Mountain Railways of India	Tamil Nadu	1999
Humayun's Tomb, Delhi	Delhi	1993
Qutb Minar and its Monuments, Delhi	Delhi	1993
Buddhist Monuments at Sanchi	Madhya Pradesh	1989
Elephanta Caves	Maharashtra	1987
Great Living Chola Temples	Tamil Nadu	1987
Group of Monuments at Pattadakal	Karnataka	1987
Churches and Convents of Goa	Goa	1986
Fatehpur Sikri	Uttar Pradesh	1986

UNESCO Mixed World Heritage Sites

Mixed World Heritage Site	State	Year of Notification
Khangchendzonga National Park	Sikkim	2016

A mixed site comprises components of both natural and cultural importance:

The International Union for Conservation of Nature (IUCN):

The International Union for Conservation of Nature (IUCN) is the world's foremost expert on the condition of natural resources and the steps that must be taken to protect them. Species survival, environmental legislation, protected areas, social and economic policy, ecosystem management, and education and communication are the six commissions into which it has organized its expertise.

The International Union for Conservation of Nature (IUCN) has grown to become the largest and most diversified environmental network in the world. It was established in 1948 by Julian Huxley. The IUCN's headquarters are in Gland, Switzerland.

Objectives & Functions of International Union for Conservation of Nature

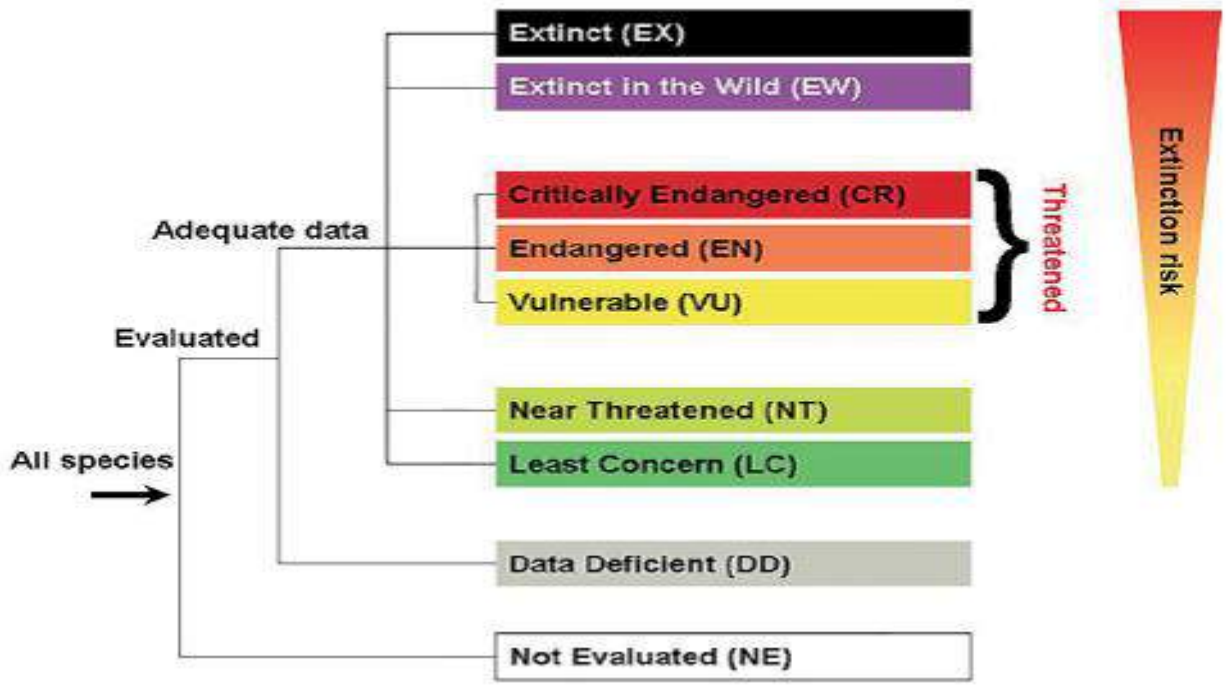
- The expertise and vast network of the International Union for Conservation of Nature provide a solid foundation for large and diverse conservation projects around the world.
- Combining the latest science with the traditional knowledge of local communities, these projects work to restore ecosystems, reverse habitat loss, and improve people's well-being.
- It has divided its experts into six commissions dedicated to species survival, protected areas, environmental law, social and economic policy, ecosystem management, and education and communication.

Classification of Threatened Species under IUCN Red List

The IUCN Red List categorises species into the following nine categories:

India and International Union for Conservation of Nature

- India became a member of the International Union for Conservation of Nature in 1969 through the Ministry of Environment & Forests.



- IUCN India works with Members and Commissions to:
    - Reduce ecosystem and species loss by providing the necessary knowledge and tools to conserve, value, and use biodiversity sustainability;
    - Enhance governance and policy to achieve better management of ecosystems and habitats, including protected areas; and
    - Address challenges related to climate change, food security and poverty alleviation.

The **International Union for Conservation of Nature** remains a cornerstone in global conservation efforts, driving progress towards the protection of biodiversity and the sustainable use of natural resources. Through its comprehensive initiatives, scientific expertise, and influential role in international policy, the International Union for Conservation of Nature continues to play a crucial role in addressing the environmental challenges of the 21st century.

CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora)

CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is an international agreement between governments.

It aims to ensure that international trade in specimens of wild animals and plants does not threaten the survival of the species.

CITES was drafted as a result of a resolution adopted in 1963 at a meeting of members of IUCN (The World Conservation Union).

- It came into force in 1975.
- The CITES Secretariat is administered by UNEP and is located in Geneva, Switzerland.
- India hosted COP-3 in 1981.

What is the CITES?

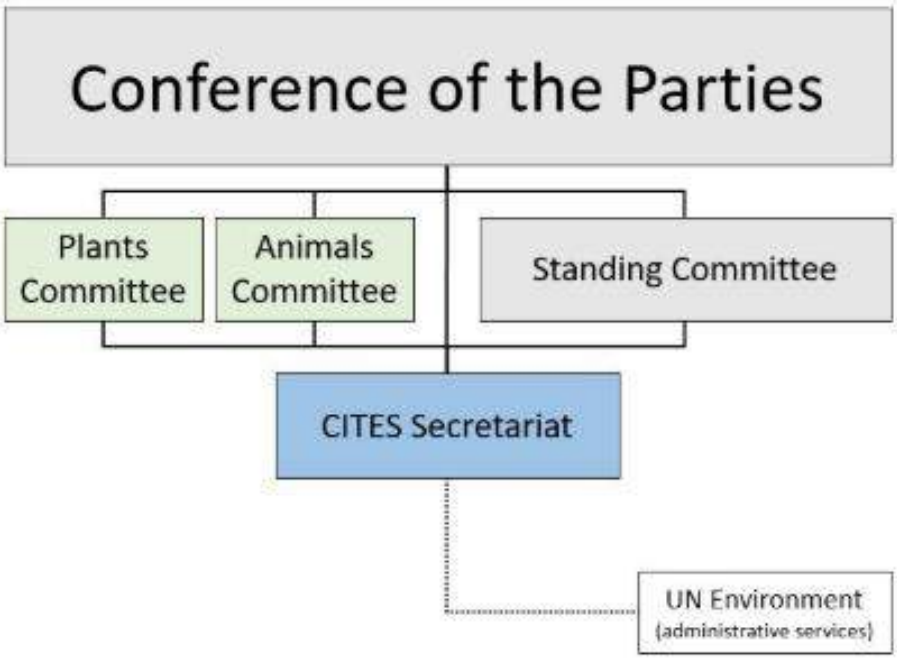
- CITES is an international agreement between governments.
- Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten the survival of the species.
- It accords varying degrees of protection to more than 37,000 species of animals and plants, ranging from live animals and plants to wildlife products derived from them, including food products, exotic leather goods, medicines, etc.
- **Currently, there are 184 parties to the convention, including India**.
- **The CITES Secretariat is administered by UNEP (The United Nations Environment Programme) and is located in Geneva, Switzerland**.
- The Conference of the Parties to CITES is the supreme consensus-based decision-making body of the Convention and comprises all its parties

Structure of CITES

CITES COP

The Conference of the Parties (COP) meet every two to three years. The **latest COP was CITES**

COP18 that took place in August 2019 in Geneva, Switzerland. **CITES COP3 took place in India** in 1981 in New Delhi.



CITES India

- India is a CITES Party since **1976**.
- Due to its extreme diversity, India is recognized all over the world for harbouring up to 7-8% of all the species recorded by CITES.
- Out of 34 global biodiversity hotspots in the world, India has 4 of them: Western Ghats, Sundaland, Himalayas and Indo-Burma region.
- As an active CITES Party, India prohibits the international trade of endangered wild species.
- India has placed several measures to control the threats from invasive alien species.
- This is done by regulating the trade by export certificates and import permits.

contributions of CITES been?

- The CITES **regulates international trade in close to 35,000 species** of plants and animals –
  - with international commercial trade generally **prohibited for 3%** of these species,
  - and with international commercial trade for the **remaining 97% regulated** to ensure the trade is legal, sustainable and traceable.
- CITES has been at the cutting edge of the debate on the sustainable use of biodiversity for the **past 42 years** and it has records of over **12,000,000 international trade transactions in its data-bases** for that period – trade which on many occasions has **benefitted local communities,** such as with the vicuña in South America.
  - The Appendix II of CITES permits the international trade of wool cloth, and other manufactured products (luxury and knitted handicrafts) from the **shearing of live vicuñas.**
- **Illegal trade** is estimated by it to be worth between **USD 5 billion and USD 20 billion per year–**
  - illegal activity that is driving many species **towards extinction,** and depriving local people of development choices and governments of potential revenue.
- **The International Consortium on Combating Wildlife Crime** (ICCWC), a consortium of the **CITES Secretariat, INTERPOL** (International Criminal Police Organization), the **UN Office on Drugs and Crime,** the **World**

Bank and the **World Customs Organization** has been established **to tackle illegal wildlife trade.**

- It brings together the entire enforcement chain to assist national enforcement authorities and regional bodies to combat illicit trade in wildlife.

WORLS WIDE FUND FOR NATURE (WWF)

The **World Wildlife** Fund, commonly known as WWF, is an international non-governmental organization that aims to conserve nature and protect the environment. It was established in 1961, and today, it is one of the largest conservation organizations in the world.

WWF's mission is to stop the degradation of the planet's natural environment and to build a future where people and nature can thrive together. The organization focuses on a broad range of environmental issues, including climate change, deforestation, sustainable agriculture, water scarcity, marine conservation, and wildlife conservation.

Roles of WWF

- WWF operates in more than 100 countries around the world, with a staff of over 6,000 people and a network of millions of supporters and volunteers.
- The organization was originally named the World Wildlife Fund, but in 1986, it changed its name to the World Wide Fund for Nature to reflect its broader conservation focus beyond just wildlife.
- WWF is a member of the International Union for Conservation of Nature (IUCN), a global organization that brings together governments, NGOs, and scientists to address conservation challenges.
- The organization has helped to establish many protected areas around the world, including the Amazon rainforest in Brazil and the Great Barrier Reef in Australia.
- WWF also works to address the root causes of environmental problems, such as unsustainable consumption and production practices, and advocates for policy changes that promote sustainability.

In addition to its conservation work, WWF also engages in disaster relief efforts, particularly in response to natural disasters that affect vulnerable communities.

Need For WWF

There are many reasons why the work of **WWF** is crucial for the future of our planet. Here are a few key reasons why we need organizations like WWF to protect the environment:

Biodiversity: The world's ecosystems are home to an incredible array of plant and animal species, many of which are under threat from habitat loss, climate change, and other factors. WWF's efforts to protect and restore ecosystems help to maintain biodiversity, which is essential for the health of the planet.

Climate change: The impacts of climate change are becoming increasingly severe, with more frequent and intense natural disasters, rising sea levels, and other consequences. WWF's work to reduce greenhouse gas emissions, promote renewable energy, and advocate for policy changes is critical for mitigating the worst effects of climate change.

Natural resources: Many of the world's most important natural resources, such as forests, oceans, and freshwater sources, are under threat from overuse and pollution. WWF's work to promote sustainable resource management practices helps to ensure that these resources are available for future generations.

Human well-being: The health and well-being of people around the world are deeply connected to the health of the natural environment. WWF's efforts to protect ecosystems, reduce pollution, and promote sustainable development help to ensure that people can live healthy and fulfilling lives in harmony with nature.

Collaboration: Addressing environmental challenges requires collaboration between governments, businesses, NGOs, and individuals around the world. WWF's role as a trusted partner and collaborator helps to bring together stakeholders with diverse perspectives and expertise to find solutions to complex environmental challenges.

GLOBAL AND NATIONAL ENVIRONMENTAL ISSUES

Environmental issues are the harmful effects of human activities on the environment. These include pollution, overpopulation, waste disposal, climate change, global warming, the greenhouse effect, etc.

Various environment protection programs are being practised at the individual, organizational and government levels with the aim of establishing a balance between man and the environment.

Climate Change and Global Warming

1. Climate change is defined as a long-term shift in the average weather patterns of the earth.
2. Human activities, notably fossil fuel combustion, are mostly to blame, as they increase heat-trapping greenhouse gas levels in the Earth's atmosphere, elevating the average surface temperature. This is called global warming.
3. Global warming is a phenomenon that has been observed since the industrial age in the 18th century.
4. Climate Change encompasses both human intervention and natural change in climate over longer periods. Global warming focuses primarily on rising temperatures as a result of human activities.
5. Natural causes of climate change are- the intensity of the sun, volcanic eruptions, and changes in naturally existing greenhouse gas concentrations
6. Anthropogenic causes are- burning of fossil fuels, livestock production, industrial development etc.
7. At the 2015 Paris Climate Change Conference, almost all countries resolved to shift away from fossil fuels to cleaner and efficient alternatives.

Ozone Layer Depletion

1. The gradual deterioration of the earth's ozone layer in the upper atmosphere caused by the discharge of chemical compounds containing gaseous bromine or chlorine from factories or other human activities is referred to as ozone layer depletion.

2. The consequent increase in UV rays would lead to an increase in skin cancer among humans and adversely affect plant and crop health
3. Human activities have led to an increase in the amount of carbon dioxide and methane in the atmosphere.
4. These gases along with Ozone (which is 0.0008 % of earth's gases) are called trace gases. They play an important role in maintaining the radiative balance of the earth's atmosphere.
5. Substances such as chlorofluorocarbons, halons, carbon tetrachloride, hydrofluorocarbons, etc. are responsible for the depletion of the ozone layer. They are termed Ozone Depleting Substances.
6. Increased UV levels leading to severe health issues like skin cancer and cataract.

Pollution

- Pollution refers to the introduction of harmful substances or contaminants into the environment, which can cause adverse effects on living organisms, natural resources, and ecosystems.
- It is the presence of pollutants in the air, water, soil, or other parts of the environment that exceed the normal or acceptable levels and can result in environmental degradation, ecological imbalances, and risks to human health

Types of Pollution

There are several types of pollution based on the environmental medium they affect. The main types of pollution include:

AIR POLLUTION

Air pollution is defined as the introduction of pollutants, organic molecules, or other unsafe materials into Earth's atmosphere. This can be in the form of excessive gases like carbon dioxide and other vapours that cannot be effectively removed through natural cycles, such as the carbon cycle or the nitrogen cycle.

Types of Air Pollutants

Primary Pollutants	Secondary Pollutants
The pollutants that directly cause air pollution are known as primary pollutants.	The pollutants formed by the intermingling and reaction of primary pollutants are known as secondary pollutants.

Classification of Pollutants

Particulate Pollutants	Gaseous Pollutants	
1. Lead 2. Fly Ash 3. Metallic Oxides 4. Nanoparticles	1. Carbon monoxide (CO) 2. Carbon dioxide (CO_2) 3. Chlorofluorocarbons (CFCs) 4. Ozone (O_3) 5. Nitrogen oxide (NO_x) 6. Sulphur dioxide (SO_2)	• Volatile organic compounds (VOCs) • Benzene • Ethylene • Biological pollutants • Asbestos • Radon

Gaseous Pollutants

Gaseous Pollutants	Description	Impacts
Carbon monoxide (CO)	• Highly toxic. • Produced from internal combustion engines due to incomplete combustion. • Other sources are volcanoes, forest fires, etc. • Greenhouse gas.	• Carbon monoxide poisoning. • Produces carboxyhemoglobin reducing the oxygen-carrying capacity of the blood.
Carbon dioxide (CO_2)	• Heavier than air. • Source are volcanoes, fire, etc. • Greenhouse gas.	• CO_2 is an asphyxiant gas (asphyxia: a condition arising when the body is deprived of oxygen, causing unconsciousness or death.). • Has other harmful effects if a high concentration of CO_2 is inhaled like dizziness, headache, etc. • Carbonic rain in high polluted areas.
Chlorofluorocarbons (CFCs)	• Used in refrigerators, air conditioners, aerosols, etc.	• Highly destructive to the Ozone layer.
Ozone (O_3)	• Very useful in the Stratosphere but harmful at the ground layer. • It's produced due to industries and vehicles. • Greenhouse gas.	• Has toxic effects. • Causes watery and itchy eyes.

Air (Prevention and Control of Pollution) Act of 1981

- 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.**

The following are the definitions under the Air (Prevention and Control of Pollution) Act.

- **Section 2(a)** defines an '**air pollutants**' **as any solid liquid or gaseous substance which may cause harm or damage the environment, humans, plants, animals, or even damage property**.
- A **1987 amendment to the act also added 'noise' to the list of harmful substances.**
- The air act defines '**air pollution' as the presence of any dangerous pollutant that makes the air unbreathable**
- **Section 2 (g)** of the Act also set up the **Central Pollution Control Board (CPCB)** whose powers extended to the whole of India. To carry out the directives of the CPCB the act also called for the setting up of the State Pollution Control Board (SPCB) for the individual states of India.

National Air Quality Index (AQI)

- The introduction of the National Air Quality Index (NAQI) in **New Delhi in September 2014** was **part of the Swachh Bharat Abhiyan initiative**, aimed at monitoring India's air quality index.

WATER (PREVENTION AND CONTROL OF POLLUTION) ACT OF 1974

- The **Water (Prevention and Control of Pollution) Act was enacted in 1974 to provide for the prevention and control of water pollution, and for the maintaining or restoring of wholesomeness of water** in the country.
- **The Act was amended in 1988.**
- The **Water (Prevention and Control of Pollution) Cess Act was enacted in 1977, to provide for the levy and collection of a cess** on water consumed by persons operating and carrying on certain types of industrial activities.
- 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 formulates policies and coordinates activities of different State Boards.
- The **Act grants power to SPCB and CPCB to test equipment and to take the sample for 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.

Major Water Quality Issues

The main **source of pollution of rivers** is the matter derived **from diverse human activities.**

- Pathogenic (Bacteriological) Pollution
- Oxygen Depleting organic pollution
- Salinity
- Toxicity (micro-pollutants and other industrial pollutants)

Surface Water

- Eutrophication
- Oxygen depletion
- Ecological health

Ground Water

- Fluoride
- Nitrate
- Arsenic
- Iron
- Seawater intrusion

SOIL POLLUTION

Soil pollution is a chemical degradation process that consumes fertile soils, with implications for global food security and human health. As per the 2019-20 Soil Health Survey conducted by the Indian government, 55 percent of the country's soil is deficient in nitrogen, 42 percent in phosphorus and 44 percent in organic carbon.

Causes of Soil Pollution: It is pollution caused by (i) pesticides, herbicides, and fumigants (ii) chemical fertilizers and
(iii) Air pollutants washed down from atmosphere through rain

Effects of Soil Pollution:

- **Agricultural:** Reduced soil fertility, Reduced nitrogen fixation, Increased erodibility, Reduced crop yield
- **Industrial:** Dangerous chemicals entering underground water
- **Ecological imbalance:** Release of pollutant gases, Increased salinity, Reduced vegetation
- **Urban:** Clogging of drains, Inundation of areas, Public health problems, Pollution of drinking water sources,
- Foul smell and release of gases, Waste management problem

Government Measures: Five-pronged strategy for soil conservation.

The components include making soil chemical-free, saving soil biodiversity, enhancing SOM, maintaining soil moisture, mitigating soil degradation and preventing soil erosion.

- **Soil Health Card (SHC) scheme**: Which assess the current status of soil health and guides farmers to make necessary soil amendments.
- **Pradhan Mantri Krishi Sinchayee Yojana**: To prevent soil erosion, regeneration of natural vegetation, rainwater harvesting and recharging of the groundwater table.
- **National Mission on Sustainable Agriculture** to promote sustainable agriculture practices.
- **PM-PRANAM Scheme**: To reduce the use of chemical fertilizers by incentivizing states to adopt alternative fertilizers.
- **Paramparagat Krishi Vikas Yojana (PKVY):** To produce agricultural products free from chemicals and pesticides residues by adopting eco- friendly, low- cost technologies

SDG target 15 on land degradation neutrality mentions, by 2030 to combat

desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.

NOISE POLLUTION

Unwanted sounds are classified as noise. When noises are too loud and persist too long, they become noise pollution. **Noise pollution** is generally defined as **regular exposure to elevated sound levels** that may lead to **adverse effects in humans or other living organisms**.

Various Causes Of Noise Pollution

Transportation: A large number of vehicles on roads, airplanes flying over houses, underground trains etc. produce heavy noise. According to the Frontiers Report, across the European Union, at least 20% of citizens are currently exposed to road traffic noise levels that are considered harmful to health.

Industrialization: Many industries use big machines like compressors, generators, exhaust fans, grinding mills etc., which produce a large amount of noise. The 114 dB measurement in Moradabad was an average of measurements reported from a factory in an industrial zone.

Social Events: Noise is at its peak in most of the social events like marriage, parties, pub, disco or place of worship etc. People normally flout rules set by the local administration and create nuisance in the area.

Harmful Impacts Of Noise Pollution

Hearing Loss: Experts believe that regular exposure to over 85 dB for an 8-hour day or longer can cause permanent hearing damage.

Sleeping Disorders: Loud noise can hamper sleeping patterns and may lead to irritation and uncomfortable situations. Sleeping disorders can further **disturb the body's circadian rhythm**.

Chronic Health Problems: Noise pollution is a risk factor for the development of cardiovascular and metabolic disorders such as elevated blood pressure, arterial hypertension, coronary heart disease and diabetes. A conservative estimate indicates that long-term exposure to environmental noise contributes to 48,000 new cases of ischemic heart disease and causes 12,000 premature deaths annually in Europe.

Productivity Loss: High levels of noise causes extreme discomfort to workers that adversely impacts their mind and reduces their productivity. This in turn enhances cost of production.

Impact on other species: Traffic and other urban noises disturb and endanger the survival of other species. For instance, Acoustic signals are used in a variety of communication contexts by animals like territory defense, warning of danger, locating or attracting a mate, and caring for offspring. However these functions are severely hindered by noise pollution.

Many species **tend to adapt** to the pollution by **altering their behaviour** e.g., modifying their signals by **switching their vocal frequency** or **altering their vocalization timing**. However, these adaptations can have unintended consequences (like altered vocalization patterns may be considered less attractive by potential mating partner, therefore affecting reproductive success). These consequences might eliminate them from

their habitats, with possible significant ecological implications

Steps Taken To Tackle Noise Pollution

Central Pollution Control Board (CPCB): It is mandated to track noise levels, set standards as well as ensure, via the State units, that sources of excessive noise are controlled. The agency has a monitoring system where sensors are installed in major cities and few cities have the facility to track noise levels in real time.

Noise Pollution (Control and Regulation) Rules, 2000: The rules define ambient noise levels for various areas like residential, industrial or commercial places during the day and night time.

National Green Tribunal: It is a dedicated environmental tribunal that was formulated in 2010. Its primary objective is to expeditiously solve environmental cases including violation of noise pollution norms.

Concerns In Tackling Noise Pollution

Narrow meaning of Sound: Policy makers think of sound only in terms of discomfort, such as transport and industrial noise, rather than investigating how to promote sounds that provide comfort. Natural sounds such as flowing water, birdsong, the wind in the trees etc. are soothing sounds that should be promoted.

Reactive Approach: The government on many occasions has adopted a reactive approach where the primary focus is retroactively reducing noise levels. This approach fails to deliver optimum results as manifested by rising sound levels in cities.

Corruption: Prevalence of corruption is a key reason due to which industries and commercial establishments keep on disrespecting environmental norms. They prefer paying a bribe rather than investing huge amounts of money on sound reduction technologies.

THERMAL POLLUTION

- Thermal pollution is defined as a sudden increase or decrease in the temperature of a natural body of water, which may be ocean, lake, river or pond.
- This sudden change in water temperature is mainly due to anthropogenic activities.
  - For example, a power plant takes water from a source, e.g., a river, as a coolant and then discharges the warm water back into the water body.
- Thermal Pollution is a prominent type of Environmental Pollution.

Causes of Thermal Pollution

Some of the prominent causes and sources of thermal pollution can be seen as follows:

- **Power, Manufacturing and Industrial Plants**: These plants draw water from nearby sources as a coolant and then release warmer water back to the source.
- **Soil Erosion**: Consistent soil erosion causes water bodies to rise, which makes them more exposed to sunlight.
- **Deforestation**: Trees and plants prevent sunlight from falling directly on water bodies.
  - With deforestation, these water bodies are directly exposed to more sunlight, thus absorbing more heat

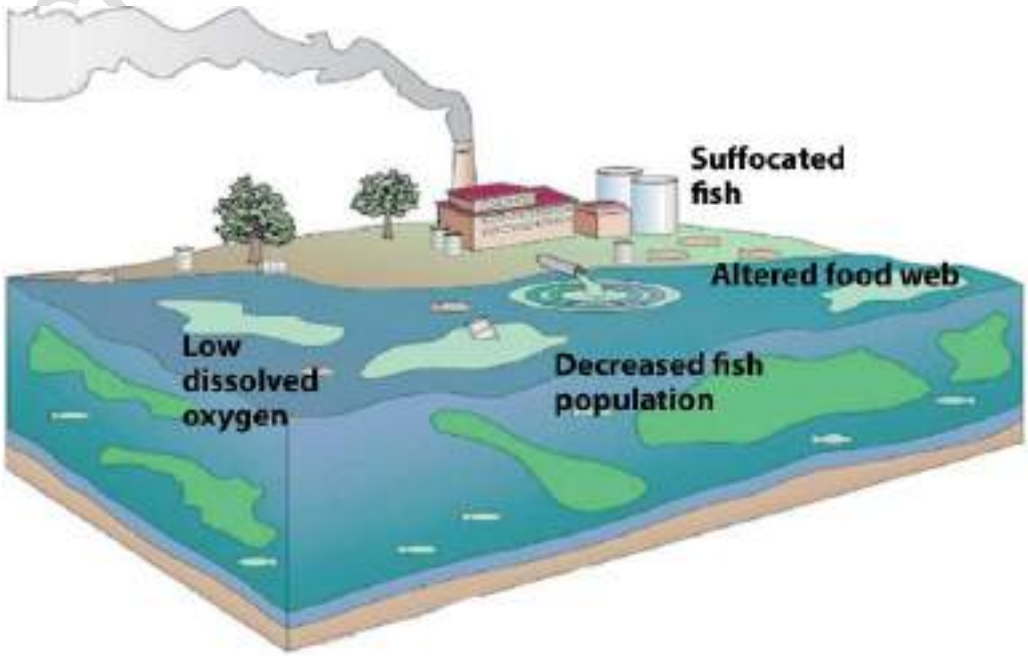
and raising the temperature of water bodies.

- **Runoff from Paved Surfaces**: During summer seasons, Urban pavement gets quite hot, which creates warm runoff that gets into the sewer systems and water bodies, increasing their temperature.
- **Natural Causes**: Volcanoes and geothermal activity beneath the oceans and seas can release warm lava to raise the temperature of water bodies.
    - Lightning is another natural cause that can introduce heat into the oceans.

Effects of Thermal Pollution

Varies effects of thermal pollution can be seen as follows:

- **Decrease in Dissolved Oxygen Levels**: The warm temperature decreases the levels of DO (Dissolved Oxygen) in water.
    - The decrease in oxygen may give rise to anaerobic conditions by suffocating plants and animals.
- **Growth of Algae**: Warmer water allows algae to flourish on surface of water and over the long term growing algae can decrease oxygen levels in the water.
- **Surge in Toxins**: Constant flow of high-temperature water discharge from industries leads to an increase in toxins in the natural water body.
    - These toxins may contain chemicals or radiation that may have a harmful impact on aquatic organisms.
- **Biodiversity Loss**: Changes in the temperature of water bodies may lead to migration to more adaptable surrounding leading to more clash for limited resources leading to death of many organisms.



- **Ecological Impact**: A sudden thermal shock can result in mass killings of organisms.
    - Little increase in water temperature may increase activity level of some organisms while higher increase in water temperature may decrease the activity level of some.
- **Reproductive Systems**: As reproduction better happens within a certain range of temperature. Higher temperature can cause release of immature eggs or can prevent normal development of certain eggs.
- **Metabolic Rate**: Thermal pollution increases the metabolic rate of organisms.
    - It may also disrupt the stability of the food chain and change the composition of species.

Thermal Pollution Control Measures

The following are some of the thermal pollution control measures:

- Storing hot water in cooling ponds and allowing the water to cool before releasing it into any water body or back to the plant.
- Warm effluents can be passed through a cooling tower after it leaves the condenser.
    - The heat is dissipated into the air and the water can then be discharged into the river or pumped back to the plant to be reused for cooling.
- Create storm water management facilities to absorb runoff or direct it into groundwater, such as infiltration basins and bio-retention systems.
- Dams can be designed such that instead of releasing cold water at the bottom of the reservoir, they release water from the top.

E-WASTE

Electronic waste (E-Waste)

- **Electronic waste**, also called **e-waste**, various forms of electric and electronic equipment that have ceased to be of value to their users or no longer satisfy their original purpose.
- 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.

E-Waste in India

- 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).

Ministry of Environment, Forest and Climate Change has notified the E-Waste (Management) Rules, 2022 on 2nd November, 2022. **E-Waste (Management) Rules, 2022 will replace E-waste (Management) Rules, 2016 and will be effective from 1st April, 2023**.

E-Waste (Management) Rules, 2022

Application:

- It will apply to **every manufacturer, producer, refurbisher, dismantler and recycler** involved in manufacturing, sale, transfer, purchase, refurbishing, dismantling, recycling and processing of e-waste or electrical and electronic equipment.
- The rule is applicable to **all electrical devices and radiotherapy equipment, nuclear medicine equipment and accessories, Magnetic Resonance Imaging (MRI), electric toys, air conditioners, microwaves, tablets, washing machine, refrigerator, solar photo-voltaic modules or panels or cells and iPad** among others.

Restrictions:

- The government has **restricted the use of hazardous substances in manufacturing electrical and electronic equipment (EEE)** following deaths due to exposure to radioactive material.
- It mandates the **reduction of the use of lead, mercury, cadmium** among others in the manufacturing of electronic equipment.

Reuse and recycling:

- **Manufacturers shall use the technology or methods so as to make the end product recyclable** and shall ensure that components or parts made by different manufacturers **are compatible with each other** so as to reduce the quantity of e-waste.

Strict monitoring:

- The **Central Pollution Control Board** shall conduct random sampling of electrical and electronic equipment placed on the market to monitor and verify the compliance of reduction of hazardous substances provisions.
- If a product does not comply with the e-waste management rules, the manufacturer will have to **withdraw all samples** from the market.

Extended Producer Responsibility Certificates:

- Draft rules aim **to incentivise registered electronic waste recyclers by introducing EPR** or Extended Producer Responsibility certificates (**which was not part of 2016 Rules**).
- The **Central Pollution Control Board shall generate extended producer responsibility certificate** through the portal in favour of a registered recycler.

E-waste exchange facilities:

- The EPR requires producers to set up e-waste exchange facilities to facilitate collection and recycling, and assign

specific responsibility to bulk consumers of electronic products for safe disposal.

Imports:

- Imports or placement in the market for new electrical and electronic equipment shall be permitted only for those which are **compliant with provisions** laid down by the government.

Disposal:

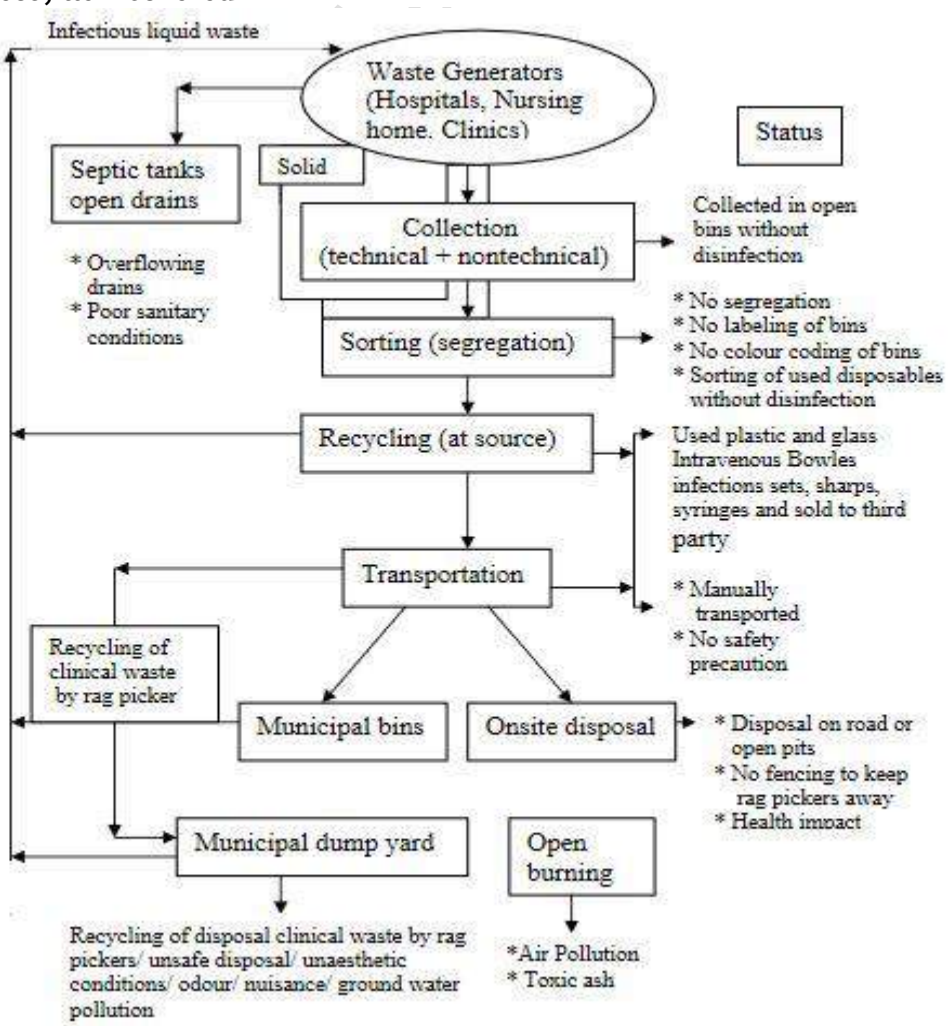
- It is the **responsibility of the manufacturer to collect e-waste** generated during manufacture and to ensure its recycling or disposal.
  - However, **the rule does not apply to waste batteries, packaging plastics, micro enterprises and radio-active waste,** as covered under the provisions of the law.
- The E-Waste (Management) Rules also **provide for recognition and registration, skill development, monitoring and ensuring safety and health, of workers** involved in dismantling and recycling of e-waste.

BIO - MEDICAL WASTE

Biomedical waste/hospital waste is any kind of waste containing infectious materials. It may also include waste associated with the generation of biomedical waste that visually appears to be of medical.

- **Hospital waste:** It refers to all waste, biological or non- biological that is discarded and not intended for further use.
- **Bio-medical waste:** It means any waste, which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biological and including categories mentioned in Schedule I, of the BMW rules, 2016.

How is biomedical waste treated in India?



Who deals with biomedical wastes in India?

- **Central Pollution Control Board:** The CPCB has been following up with all SPCBs/PCCs to ensure effective management of biomedical waste in States/UTs.
- **National Green Tribunal (NGT):** The NGT has been stringent on the application of the BMW 2016.
- **Common Bio-Medical Waste Treatment and Disposal Facilities (CBWTDF):** There are now over 200 licensed CBWTDF or Common Treatment Facility (CTF) in India.

Salient Features of Biomedical Waste Rules, 2016

- **Compulsory pre-treatment:** The method of sterilization/disinfection should be in accordance with National AIDS Control Organization (NACO) or WHO.
- **Phasing out plastic use:** The use of chlorinated plastic bags, gloves, blood bags, etc. should be gradually stopped and this phasing out should be within 2 years from the date of notification of these rules
- **Safe disposal of Liquid waste:** They need to be separated at source by pre-treatment before mixing with other liquid waste
- **Incineration guidelines:** The existing incinerator should be upgraded/modified to achieve the new standard within 2 years from the date of this notification.

International Agreement and Conventions

There are three international agreements and conventions which are particularly pertinent in BMWM. These are-

1. **Basel Convention on Hazardous Waste:** It is the most inclusive global environmental treaty on hazardous and other wastes. It has 170 member countries, and its objectives are to protect human health and the environment against the adverse effects resulting from the generation, management, and disposal of hazardous wastes, specifically clinical wastes from health care in hospitals, health centers, and clinics.
2. **Stockholm Convention on POPs:** It is a global treaty to protect human health and the environment from POPs (POPs – dioxins and furans). POPs are toxic chemicals that accumulate in the fatty tissue of living organisms and cause damage. These chemicals are formed by medical waste incinerators and other combustion processes. It deals with BEP including source reduction, segregation, resource recovery and recycling, training, and proper collection and transport.
3. **Minamata Convention on Mercury:** It is a global treaty to protect human health and the environment from the adverse effects of mercury. On October 10, 2014, in Japan, more than 90 nations signed the first new global convention on environment and health. This treaty includes the phasing out of certain medical equipment in health-care services, including mercury-containing medical items such as thermometers and blood pressure device.

- Safe and effective management of biomedical waste is not only a lawful obligation but also a civil duty.
- The current BMWM 2016 rules are an improvement over earlier rules in terms of improved segregation, transportation, and disposal

methods, to decrease environmental pollution and ensure the safety of the staff, patients, and public.

Deforestation

1. The United States Environmental Protection Agency defines deforestation as the "permanent removal of standing forests."
2. It can be through deliberate, natural, or accidental means
3. It leads to the loss of habitats for a wide variety of species threatening their existence
4. Forests regulate the climate of the regions. If it is destroyed irrationally, the temperature varies more dramatically from day to night, similar to that of a desert, which could be fatal for many inhabitants.
5. The absence of trees also allows for a higher release of greenhouse gases into the atmosphere. Forests absorb CO2 from the atmosphere and serve as major carbon sinks.
6. It can also lead to soil erosion and flooding.
7. Deforestation also threatens the livelihoods of indigenous communities.

SOLID-WASTE MANAGEMENT

Solid waste refers to all non-liquid wastes that include Solid as well as semi-solid wastes, but excluding Human and Animal excreta.

Solid waste can create very serious health problems and an unpleasant living environment if not disposed of in a proper and a safe manner, such waste may then also provide breeding sites for insect-vectors, pests, snakes and vermin that increase the risk of disease transmission. It may also pollute water sources and the environment.

Different categories of solid waste include:

Organic waste: Food waste, Market associated wastes etc.

Dead animals: Carcasses of animals (Cows, Buffaloes, Dogs etc.)

Combustibles: Paper, wood, dried leaves etc. (high organic and low moisture content) Non-combustibles: Metal, tin cans, bottles, etc.

Ashes: Residue from fires used for cooking.

Bulky waste: Tree branches, tyres, etc.

Hazardous waste: Battery acid, medical waste etc.

Construction waste: Roofing, broken concrete, etc.

MANAGEMENT OF SOLID WASTE

Solid waste management can be divided into four key components: Generation Storage and Collection Transportation Disposal

Generation

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

Storage and Collection

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

Whereas under Swacch Bharat Abhiyan, two different dustbins have been provided (Blue and Green Dustbins) which are used to segregate two different kinds of wastes,

the green is meant for wet wastes while the blue one is for Solid dry waste.

Transportation

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

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

Disposal

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

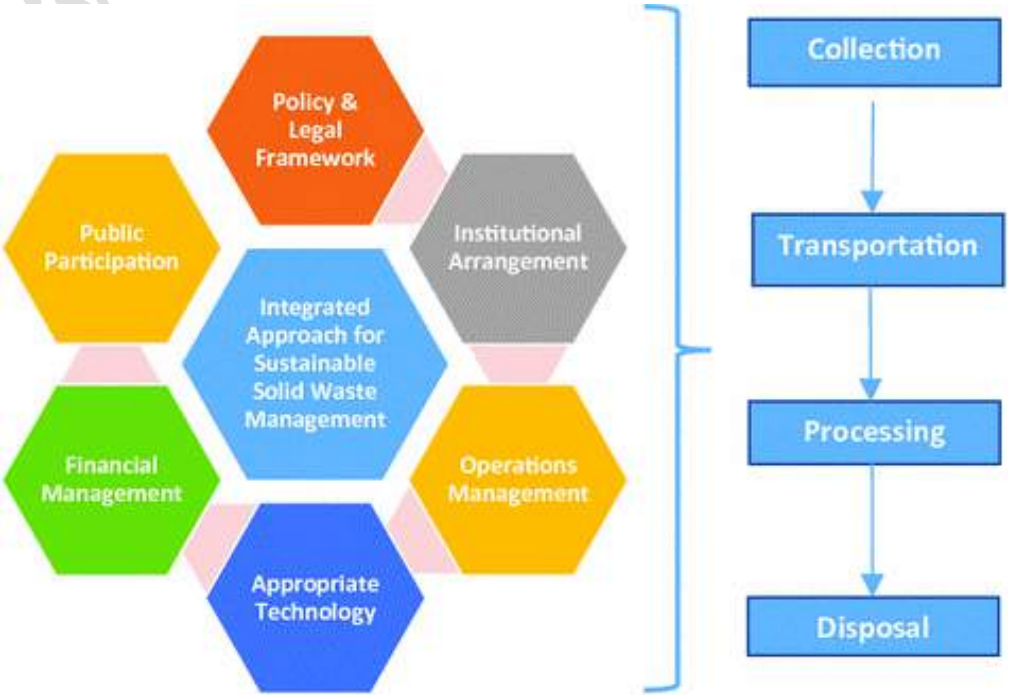
Land application: Open dumps or landfilling, Open dumps and landfills are uncovered/covered areas that are used to dump solid waste of all kinds. The waste is not treated nor it is segregated and thus it is also a place where a lot of insects and other disease causing organisms breed.They are generally located in urban areas. For landfills, a pit is dug where garbage is dumped and the pit is covered with soil everyday thus preventing the breeding of flies and rats.Open dumps are more harmful than landfills as landfills after they are full can be used as a park/parking lot after covering it, but open dumps cannot be treated as such.

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

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

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

Vermiculture:It is also known as Earthworm farming. In this method, Earthworms are added to the compost.



These worms break the solid waste and along with the earthworms excreta, the compost becomes rich in nutrients.

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

Legislation in India

- Solid Waste Management Rules 2016:
- These rules replace the Municipal Solid Wastes (Management and Handling) Rules, 2000, are now applicable beyond municipal areas and have included urban agglomerations, census towns, notified industrial townships etc.
- They focus on segregation of waste at source, responsibility on the manufacturer to dispose of sanitary and packaging wastes, user fees for collection, disposal and processing from the bulk generator.
- It has also been advised that the bio-degradable waste should be processed, treated and disposed of through composting or bio-methanation within the premises as far as possible and the residual waste shall be given to the waste collectors or agency as directed by the local authority.
- The rules promote the use of compost, conversion of waste into energy, revision of parameters for landfills location and capacity.
- The government has also constituted a Central Monitoring Committee under the chairmanship of Secretary, MoEF&CC to monitor the overall implementation of the rules.
- The Rules for the Safe Treatment of Legacy Waste prescribe bio-remediation and bio-mining in all open dumpsites and existing operational dumpsites in India.
- Apart from this, Article 51 A (g) of the Constitution of India makes it a fundamental duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers, and wildlife, and to have compassion for living creatures.

CENTRAL POLLUTION CONTROL BOARD (CPCB)

- The Central Pollution Control Board (CPCB), the **statutory organization**, was constituted in September **1974 under the Water (Prevention and Control of Pollution) Act, 1974.**
- Further, **CPCB was entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981.**
- The **board is led by its chairman**, **who is nominated by the Central Government.**

Functions

It serves as a **field formation and also provides technical services to the Ministry of Environment and Forests of the provisions of the Environment (Protection) Act, 1986.**

Principal Functions of the CPCB, as spelled out in the Water (Prevention and Control of Pollution) Act, 1974, and the Air

(Prevention and Control of Pollution) Act, 1981,

1. **to promote cleanliness of streams and wells** in different areas of the States by prevention, control, and abatement of water pollution, and
2. **to improve the quality of air and to prevent, control, or abate air pollution** in the country.

Air Quality Monitoring

- Air Quality Monitoring is an important part of air quality management.
- The **National Air Monitoring Programme (NAMP) has been established with objectives to determine the present air quality status and trends and to control and regulate pollution** from industries and other sources to meet the air quality standards.
- It also **provides background air quality data** needed for industrial siting and town planning.
- Besides this, **CPCB has an automatic monitoring station at ITO Intersection in New Delhi. At this station, Respirable Suspended Particulate Matter (RSPM), Carbon Monoxide (CO), Ozone (O3), Sulphur Dioxide (SO2), Nitrogen Dioxide (NO2), and Suspended Particulate Matter (SPM) are being monitored regularly.** This information on Air Quality at ITO is updated every week.

Water Quality Monitoring (WQM)

- Freshwater is a finite resource essential for use in agriculture, industry, propagation of wildlife & fisheries, and for human existence.
- **India is a riverine country**. It has 14 major rivers, 44 medium rivers, and 55 minor rivers besides numerous lakes, ponds, and wells which are used as primary sources of drinking water even without treatment.
- **Most of the rivers being fed by monsoon rains**, **which is limited to only three months of the year, run dry throughout the rest of the year** often carrying wastewater discharges from industries or cities/towns endangering the quality of our scarce water resources.
- The parliament of India in its wisdom enacted the Water (Prevention and Control of Pollution) Act, 1974 with a view to maintaining and restoring wholesomeness of our water bodies.
- One of the mandates of CPCB is to collect, collate and disseminate technical and statistical data relating to water pollution.

Hence, Water Quality Monitoring (WQM) and Surveillance are of utmost importance

THE NATIONAL GREEN TRIBUNAL ACT, 2010

- The **National Green Tribunal (NGT)** is a **statutory body** that was **established in 2010** by the **National Green Tribunal Act**.
  - It was set up to handle cases and speed up the cases related to environmental issues.
  - The Tribunal **shall not be bound by the procedure** laid down **under the Code of Civil Procedure, 1908**, but shall

be **guided by principles of natural justice**.

- **New Delhi** is the **Principal Place of Sitting** of the Tribunal and **Bhopal, Pune, Kolkata,** and **Chennai** shall be the **other 4 places** of sitting of the Tribunal.

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CLIMATE CHANGE

Climate Change is a reality. It has changed in Past, is changing in Present and will change in Future. Atmosphere is always in a state of turmoil and instability leading to variation in weather and climatic conditions. Thus the variation and shifts in weather conditions over space and time of different scales and magnitude resulting into changes of Climatic Type is defined as Climate Change. For example, from warm and moist climate to warm and dry climate. The rate of climatic changes depends on the nature of causal factor. This may be gradually or rapidly, partly or drastically, short term or long term, Local, regional, or global scale. The Climate change which occurred during Jurassic Period leading to mass extinction of Dinosaurs due to sudden onset of Cold Climate was rapid and instantaneous.

Factors Factors affecting Climate Change

Earth's temperature is influence by the energy entering and leaving the planet's system. When incoming energy from the sun is absorbed by the Earth system, Earth is warmed. When the sun's energy is reflected back into space, Earth cools. Both natural and anthropogenic factors can cause changes in Earth's energy balance.

Natural Factors

The Earth's climate can be affected by a number of natural factors. The prominent ones are continental drift, volcanoes, ocean currents, the earth's tilt, and comets and meteorites. The natural factors affect the climate change in a long term and persist for thousand to millions of years.

Continental drift

- The continents, what we are seeing today, were not alike before 200 million years. It is formed when the landmass began gradually drifting apart millions of years back, due to Plate displacement.
- This drift also had an impact on the climate because it changed the physical features of the landmass,

their position and the position of water bodies like changed the flow of ocean currents and winds, which affected the climate.

- The drift process is still continued today, the Himalayan range is rising by about 1 mm (millimetre) every year because the Indian land mass is moving towards the Asian land mass, slowly but steadily.

Variation in the earth's orbit

- The seasonal distribution of sunlight reaching the Earth's surface is directly related to Earth's Orbit and a slight variation in Earth's orbit leads to variation in distribution across the globe.
- There are very little changes to the annually averaged sunshine; but there can be strong changes in the geographical and seasonal distribution.
- There are three types of orbital variations namely variations in Earth's eccentricity, changes in the tilt angle of Earth's axis of rotation and precession of Earth's axis. Combined together, these produce Milankovitch cycles which have large impact on climate and are notable for their correlation to glacial and interglacial periods. The IPCC finding shows that Milankovitch cycles drove the ice age cycles

Plate tectonics

Due to temperature variation in the core of the Earth, the mantle plumes and convection currents force the Plates of the Earth to adjust which causes the reconfiguration of the earth Plate. This can affect both global and local patterns of climate and atmosphere.

- The position of the continents also influences patterns of ocean circulation as it determines the geometry of the oceans. The locations of the seas are important in controlling the transfer of heat and moisture across the globe, and therefore, in determining global climate.
- A recent example of tectonic control on ocean circulation is the formation of the Isthmus of Panama about 5 million years ago, which shut off direct mixing between the Atlantic and pacific oceans.

Volcanic activity

- When the Volcano erupts, the outburst of gases and dust particles partially block the incoming rays of the Sun which lead to the cooling of the weather.
- Sulphur dioxide combines with the water to form tiny droplets of Sulphuric acid and these droplets are so small that many of them can stay aloft for several years.
- Although the volcanic activity may last only a few days yet the large volumes of gases and ash can influence the climatic pattern over the several years.

Ocean currents

- Ocean currents are the major component of the climatic system which is driven by the horizontal wind forces causing the displacement of the water against the sea surface. Due to temperature variation of the water, the climate of the region is largely influenced.
- On longer time scales, alterations to ocean processes such as thermohaline circulation play a key role in redistributing heat by carrying out a very slow and extremely deep movement deep of water, and the long term redistribution of heat in the world's ocean.
- Much of the heat that escapes from the oceans is in the form of water

vapour, the most abundant green house gases on the earth. Yet, water vapour also contributes to the formation of the clouds, which shade the surfaces and have a net cooling effect.

GREENHOUSE GASES

- The Earth is endowed with a natural greenhouse effect where certain gases (known as greenhouse gases) in the atmosphere permit the sunlight to enter but absorb the heat
- radiation. They keep the average surface temperature on Earth around 14°C. Without the natural greenhouse effect, the Earth's average surface temperature would be around -19°C.
- As the human activity has increased due to onset of industrial revolution, the emission of huge amount of Green House Gases is also increased which led to more absorption of heat being retained in the atmosphere thus an increase in global Temperature.
- Green house gases while largely transparent to incoming solar radiation, absorbs most of the infrared emitted by the earth's surface.

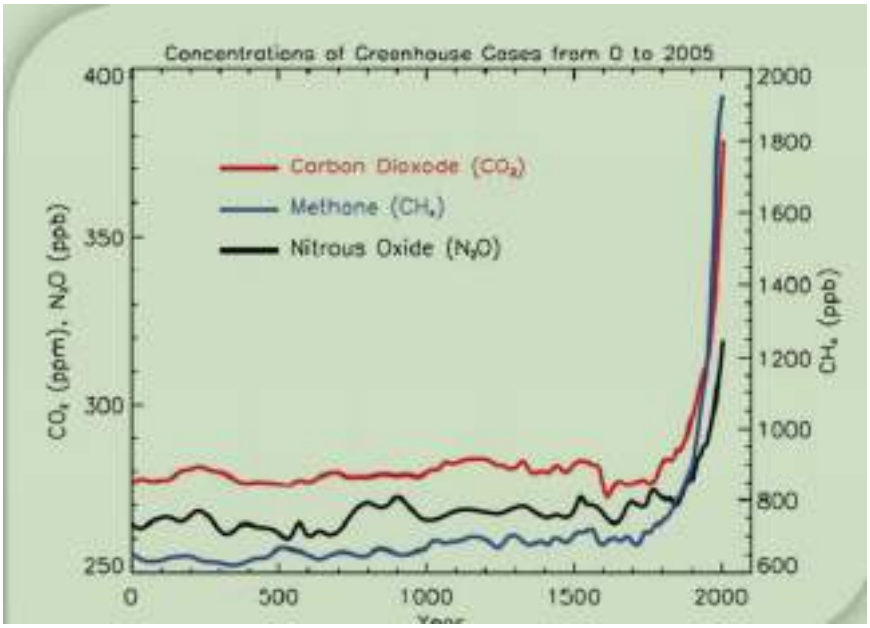
The main greenhouse gases include:

Water vapour: It is the most abundant greenhouse gas (GHG), however it spends just a short time in the atmosphere. The amount of water vapour varies drastically with time, region and altitude. It is not considered the most important GHG.

Carbon dioxide (CO2): It is the most important GHG and is produced both naturally and through human activities. Naturally CO2 is released into the atmosphere through volcanic eruptions and animal respiration. It is also released through human activities such as deforestation and the burning of fossil fuels for energy. CO2 spends a long time in the atmosphere increasing its impact. Since the industrial revolution, humans have increased atmospheric CO2 concentration by 30%. Deforestation contributes to global warming as fewer plants are available to take up carbon dioxide from the atmosphere.

Methane: The large sources of Methane come from the decomposition of organic matter e.g. in landfills and in agriculture and from the digestion of ruminants (cows, goats etc). It is a stronger GHG than CO2 because it can absorb more heat. However it is much less abundant in the atmosphere.

Nitrous oxide: It is considered as a very powerful greenhouse gas which is abundantly produced in the agriculture sector, specifically in the production and use of organic fertilizers. It is also produced when burning fossil fuels.



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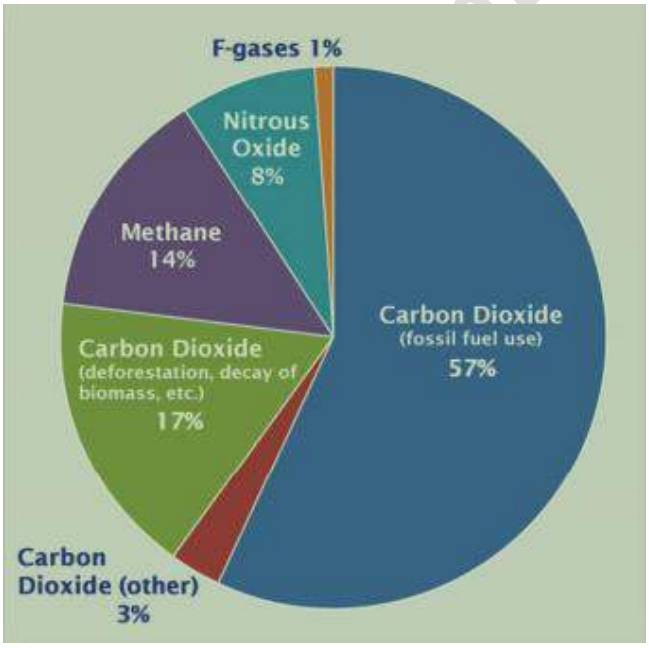

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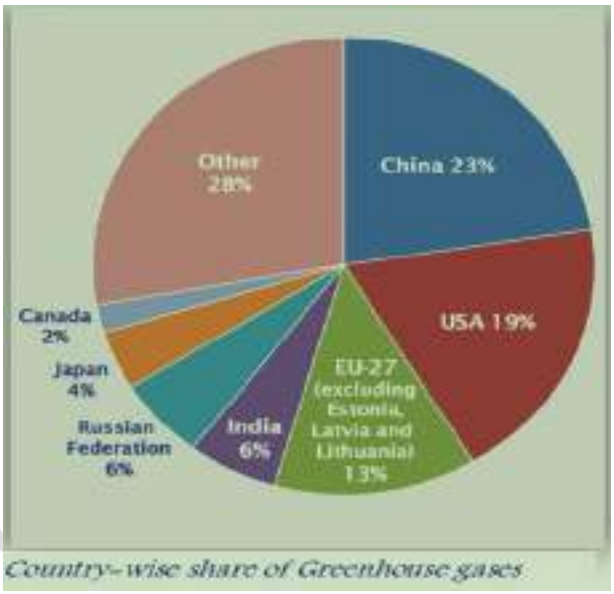

Country-wise share of Greenhouse gases

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The overall warming from 1850 to the end of the 20th century was equivalent to about 2.5 W/m². CO2 contributed around 60 per cent of this figure and CH4 about 25 per cent, with N2O and halocarbons providing the remainder. This has resulted in Earth's average temperature increasing from 15.5°C to 16.2°C in the last 100 years. The warming effect that would result from a doubling of CO2 from pre-industrial levels is estimated to be 4 W/m².

Impacts of climate change

- **Extreme Heat**: India is already experiencing a warming climate. Unusual and unprecedented spells of hot weather are expected to occur far more frequently and cover much larger areas. Under 4°C warming, the west coast and southern India are projected to shift to new, high-temperature climatic regimes with significant impacts on agriculture.
- **Changing Rainfall Patterns**: A decline in monsoon rainfall since the 1950s has already been observed. A 2°C rise in the world's average temperatures will make India's summer monsoon highly unpredictable. At 4°C warming, an extremely wet monsoon that currently has a chance of occurring only once in 100 years is projected to occur every 10 years by the end of the century. Dry years are expected to be drier and wet years wetter.
- **Droughts**: Evidence indicates that parts of South Asia have become drier since the 1970s with an increase in the number of droughts. Droughts have major consequences. In 1987 and 2002-2003, droughts affected more than half of India's crop area and led to a huge fall in crop production. Droughts are expected to be more frequent in some areas, especially in north-western India, Jharkhand, Orissa, and Chhattisgarh. Crop yields are expected to fall significantly because of extreme heat by the 2040s.
- **Groundwater:** Even without climate change, 15% of India's groundwater resources are overexploited. Falling water tables can be expected to reduce further on account of increasing demand for water from a growing population, more affluent lifestyles, as well as from the services sector and industry.
- **Glacier Melt**: Most Himalayan glaciers have been retreating over the past century. At 2.5°C warming, melting glaciers and the loss of snow cover over the Himalayas are expected to threaten the stability and reliability of northern India's primarily glacier-fed rivers. Alterations in the flows of the Indus, Ganges, and Brahmaputra rivers could significantly impact irrigation, affecting the amount of food that can be produced in their basins as well as the livelihoods of millions of people
- **Sea level rise:** With India close to the equator, the sub-continent would see much higher rises in sea levels than higher latitudes. Sea-

level rise and storm surges would lead to saltwater intrusion in the coastal areas, impacting agriculture, degrading groundwater quality, contaminating drinking water, and possibly causing a rise in diarrhoea cases and cholera outbreaks, as the cholera bacterium survives longer in saline water. Kolkata and Mumbai, both densely populated cities, are particularly vulnerable to the impacts of sea-level rise, tropical cyclones, and riverine flooding.

- Apart from this food and energy security are also major concerns. Water scarcity, health hazards among the masses, and migration and political conflicts are expected to grow.

India's response to Climate Change

- **National Action Plan on Climate Change (NAPCC)**: outlines existing and future policies and programs addressing climate mitigation and adaptation. The Action Plan identifies eight core "national missions" running through to 2017: Solar Energy; Enhanced Energy Efficiency; Sustainable Habitat; Water; Sustaining the Himalayan Ecosystem; Green India; Sustainable Agriculture; and Strategic Knowledge for Climate Change. Most of these missions have strong adaptation imperatives.
- **National Clean Energy Fund:** The Government of India created the National Clean Energy Fund (NCEF) in 2010 for financing and promoting clean energy initiatives and funding research in the area of clean energy in the country. The corpus of the fund is built by levying a cess of INR 50 (subsequently increased to INR 100 in 2014) per tonne of coal produced domestically or imported.
- **Paris Agreement:** Under the Paris Agreement, India has made three commitments. India's greenhouse gas emission intensity of its GDP will be reduced by 33-35% below 2005 levels by 2030. Alongside, 40% of India's power capacity would be based on non-fossil fuel sources. At the same time, India will create an additional 'carbon sink' of 2.5 to 3 billion tonnes of Co2 equivalent through additional forest and tree cover by 2030.
- **International Solar Alliance:** ISA was launched at the United Nations Climate Change Conference in Paris on 30 November 2015 by India and France, in the presence of Mr. Ban Ki Moon, former Secretary-General of the United Nations.
- **Bharat Stage (BS) Emission Norms:** Emissions from vehicles are one of the top contributors to air pollution, which led the government at the time to introduce the BS 2000 (Bharat Stage 1) vehicle emission norms from April 2000, followed by BS-II in 2005. BS-III was implemented nationwide in 2010. However, in 2016, the government decided to meet the global best practices and leapfrog to BS-VI norms by skipping BS V altogether.

Global Warming

Global warming is the phenomenon of a gradual increase in the temperature near the earth's surface. This phenomenon has been observed over the past one or two centuries. This change has disturbed the climatic pattern of the earth. However, the concept of global warming is quite controversial but the scientists have provided relevant data in support of the fact that the temperature of the earth is rising constantly.

There are several causes of global warming, which have a negative effect on humans, plants and animals. These causes may be natural or might be the outcome of human activities. In order to curb the issues, it is very important to understand the negative impacts of global warming.

Global Warming Effects

Increase in the Average Temperature of the Earth

According to IPCC reports, human-induced global warming is responsible for nearly 1 degree Celsius temperature rise vis a vis pre-industrial level. Data from NASA suggest that 2016 has been the hottest year on record.

Frequency of Extreme Weather Events is Increasing

Extreme weather events are happening more often around the world. For example, forest fires in California are now a yearly occurrence and are getting more frequent. We've also seen heat waves in Antarctica recently, and cyclones in the Bay of Bengal are becoming stronger. Similarly, the frequency of occurrence of El Niño and La Niña has reduced from once in 8–10 years to once in 3–4 years now. More frequent episodes of floods and drought are being recorded every year across the world.

Melting of Ice

According to IPCC, there is 10% less permafrost in North Hemisphere at present compared to the 1900s. Remote sensing data suggest Arctic ice is melting fast. Experts suggest that not only will the sea level rise with the melting of glaciers, but there is also a danger of new bacteria and viruses being released into the environment which has so far been trapped in ice sheets. This may lead to outbreaks of disease and pandemics which are beyond the control of human medical sciences.

Sea Level Rise and Acidification of Ocean

A report published by WMO, suggests that the rate of sea level rise has doubled for the period between 2013 and 2021 compared to the rate for the period between 1993 and 2002. Earth scientists warn that if this continues, many coastal areas where people live could be underwater in the coming years. Rising carbon dioxide levels are also causing oceans to absorb more CO2, leading to ocean acidification. This can be harmful to ocean life, especially coral reefs.

Global Warming Solutions

Global Cooperation for Reduction of Emissions

We need to take the goal of keeping the global temperature rise within 1.5 degrees Celsius seriously. Global efforts should recognize that all countries have different responsibilities. This means acknowledging past injustices faced by developing countries and giving them a fair chance to grow. Countries must work quickly to reach Net Zero Emissions as soon as possible.

Transition to Cleaner and Greener Forms of Energy

Coal-based power plants should be made more efficient, and the inefficient ones should be closed down. We should promote the use of renewable energy like solar power and explore hydrogen as a fuel. Also, we need to look into nuclear fusion for energy and make nuclear fission safer.

Changes in Agricultural Practices and Land Use

Agriculture based on the use of nitrogenous fertilizers must be replaced with organic farming techniques. We should capture methane gas from farms and animal waste to use as biogas at home. There should be large tree-planting efforts, and city governments need to make sure to include green spaces in their plans.

Improving Transportation System

The rise of electric vehicles is great, but we need better batteries for them. City planners should focus on improving public transportation and design cities to encourage more walking and cycling.

Behavioural Changes

All the above discussions will have no meaning if we as individuals are not sensitive enough. We need to make reducing, reusing and recycling a mantra of our living. It should be our civic duty to save water, and wildlife and raise awareness among others.

CARBON CAPTURE AND STORAGE (CCS):

- It is a climate change mitigation technology **where CO2 is captured from power plants** and other industrial processes instead of being emitted to the atmosphere.
- The captured CO2 is then stored in the subsurface with the goal of keeping it out of the atmosphere indefinitely.
- CCS can be seen as a bridge technology, allowing for the continued use of fossil fuels in electricity generation and industry until low-carbon alternatives can be implemented.
- CCS may also be necessary to achieve the negative CO2 emissions required for the 1.5°C and 2°C climate goals

CCS Operations

Three major parts:

1. CO2 capture at a large stationary source (e.g., coal-fired power plant)
2. Transport of the captured CO2 to a storage site
3. Injection of CO2 into the subsurface for permanent storage.

Capture occurs either through chemical transformation before the fossil fuel is combusted (precombustion) or through physiochemical processes (e.g., adsorption) from the flue gas.

Applications of CCS:

- **Industrial sectors:** CCS can significantly reduce CO2 emissions from large-scale industrial facilities, such as **cement factories, and steel mills.**
- **Enhancing Energy Security:** CCS can be applied to fossil fuel power plants, allowing for continued use of these resources while minimising their environmental impact
- **Agriculture:** Capturing CO2 from biogenic sources such as plants and soil to boost crop growth in a greenhouse.

Climate Smart Agriculture (CSA):

- **According to the World bank**, Climate-smart agriculture (CSA) is an **integrated approach to managing landscapes – cropland, livestock, forests and fisheries – that address the interlinked challenges of food security and climate change.**
- Climate Smart Agriculture also known as Climate Resilient Agriculture. It is the development of agriculture under new realities of climate change.

Benefits of Climate Smart Agriculture:

- **Resilience to Climate Change:** Climate-smart agriculture practices build resilience in farming systems, enabling farmers to cope with the impacts of climate change, such as **droughts, floods, and extreme temperatures.**
- **Increased Crop Yields**: Efficient use of resources and adoption of climate-resilient crop varieties can lead to higher crop yields, contributing to improved livelihoods for farmers and increased income.
- **Sustainable Resource Management**: Climate-smart practices focus on sustainable management of natural resources**, including water, soil, and biodiversity.** This leads to reduced environmental degradation and conservation of ecosystem services.
- **Improved Food Security**: By optimizing resource use and enhancing agricultural productivity, climate-smart agriculture contributes to improved food security, ensuring a stable supply of food even under changing climatic conditions.
- **Mitigation of Greenhouse Gas Emissions:** Certain climate-smart agricultural practices, such as **agroforestry and reduced tillage**, can contribute to reducing

Figure 1. Green and climate-resilient agriculture

greenhouse gas emissions from the agricultural sector, supporting climate change mitigation efforts.

- **Social and Economic Benefits:** Climate-smart agriculture promotes inclusivity and gender equity by empowering women farmers and vulnerable communities. It also enhances rural livelihoods by creating new income-generating opportunities and promoting sustainable rural development.
- **Adoption of Innovative Technologies:** Climate-smart agriculture drives innovation and the adoption of advanced technologies in farming, facilitating increased efficiency and productivity.

Government Initiatives for Climate Smart Agriculture:

- **National Innovation on Climate Resilient Agriculture (NICRA):**
  - Launched in 2011 by the Indian Council of Agricultural Research (ICAR).
  - Aims: To increase the resilience of Indian agriculture, including crops, animals, and fisheries, to climate variability and change.
- **National Action Plan on Climate Change (NAPCC):** It **launched in 2008** to mitigate and adapt to the adverse impact of climate change. It includes various "National Missions" focusing on climate change awareness, adaptation and mitigation, energy efficiency, and natural resource conservation.
- **National Mission on Sustainable Agriculture (NMSA):** It is one of the eight Missions under the NAPCC seeks to address issues regarding 'Sustainable Agriculture' in the context of risks associated with climate change by devising appropriate adaptation and mitigation measures.
- **National Adaptation Fund for Climate Change (NAFCC):** It was established in 2015 to meet the cost of adaptation to climate change for the State and Union Territories of India that are particularly vulnerable to the adverse effects of climate change.
- **Climate-Smart Villages (CSV):** CSV is an institutional strategy to implement and promote CSA at the local level, enhancing farmers' ability to adapt to climate change. CSVs undertake a portfolio of actions to address climate challenges, covering various farm activities.
- **Pradhan Mantri Krishi Sinchayee Yojna (PMSKY):** Launched to prioritize water conservation and management in agriculture, PMSKY aims to expand irrigated areas.
  - It focuses on "More crop per drop" by offering end-to-end water solutions, from source generation to delivery networks.

NATURAL CALAMITIES IN TAMIL NADU

Tamil Nadu covers an area of 13, 00,582 kms and has a coastline of about 1,076 kms which is about 15% of the coastline of India. More than 40% of the fisher population lives within 1km of coast and 50% of them live within 2km of the coast. The geographical setting of Tamil Nadu makes the state vulnerable to natural disasters such as cyclones floods and earthquake-induced tsunami.

About 8% of the state is affected by five to six cyclones every year, of which two to three are severe. Cyclonic activities on the east coast are more severe than on the west coast, and occur mainly between April-May and October-November.

Tamil Nadu is also subjected to annual flooding, including flash floods, cloudburst floods, monsoon floods of single and multiple events, cyclonic floods, and those due to dam bursts or failure. Every year, on average thousands of people are affected, a few hundred lives are lost, thousands are rendered homeless and several hectares of crops are damaged.

Tamil Nadu is also prone to very severe damaging earthquakes. Its people feel much more vulnerable to earthquake-induced tsunamis since the 2004 Indian Ocean tsunami, which affected the coast of Tamil Nadu is destroying much of the marine biology and severely damaging the ecosystem. Crops, settlements, trees, birds, fishes, wildlife, and properties were destroyed. Precious coral reefs and mangrove areas were crushed by the huge tsunami waves that devastated South India, an environmental and economic setback that could take years to reverse. Power and communications were totally disrupted. The damage to humans, especially women and children, and animal life, was tremendous, resulting in emotional and mental trauma.

Tamil Nadu faces several natural calamities, including:

- **Cyclones**
- Tamil Nadu is vulnerable to cyclones, with about 8% of the state affected by five to six cyclones annually. Cyclonic activity is more severe on the east coast and usually occurs between October and December.
- **Floods**
- Tamil Nadu is prone to flooding, with heavy rainfall causing flooding and inundation in vulnerable areas. Some notable flood events in Tamil Nadu include the 1943 Madras floods, the 2005 Chennai floods, and the 2015 South India floods.
- **Heat waves**
- Tamil Nadu experiences heat waves, which are periods of abnormally high temperatures that usually occur between March and June. Heat waves can cause physiological stress and sometimes result in death.
- **Earthquakes**
- Tamil Nadu is also vulnerable to earthquakes, which can trigger tsunamis.
- Other natural calamities that can affect Tamil Nadu include:
  - Landslides
  - Hailstorms
  - Cloud bursts
  - Snow avalanches
  - Thunder and lightning
  - Sea erosion
  - Droughts
  - Dam bursts and failures
  - Mine fires

FLOODS IN TAMILANDU

Because of its location and climate, the southern Indian state of Tamil Nadu frequently experiences flooding. Heavy rain causes flooding and other problems in several sections of the state every year during the monsoon season. There has been a history of disastrous floods in the state, resulting in human and material casualties. In this article, we'll talk about what causes floods in Tamil Nadu, their

effects, and what can be done to prevent them.

Flood

When water from a river, lake, or the ocean spills over onto dry land, it is called a flood. Storms along the coast, melting snow, and excessive precipitation all contribute to rising sea levels, which can lead to flooding. Rapid or slow-moving floods both pose significant dangers to people and property. Floods not only ruin property, but also threaten people's lives and force them to leave their homes. One of the most widespread and frequent natural calamities is flooding.

Causes of Flooding in Tamil Nadu

There are a number of reasons why it floods in Tamil Nadu. The following are some of the common causes of floods, and in some cases, floods can also be caused by a combination of these factors:

- **Monsoon Rainfall:** From October to December and from April to June, Tamil Nadu gets a lot of rain. Flooding can happen when rivers, lakes, and other sources of water overflow because of too much rain.
- **Topography:** Tamil Nadu has a varied landscape, with some places in the foothills of the Western Ghats and others in the coastal plains. Because of the way the land is shaped, water can flow quickly when it rains a lot, which can cause floods.
- **Drainage systems:** In many places and towns in Tamil Nadu, the drainage systems aren't good enough to handle heavy rain. This can cause low-lying places to get waterlogged and flood.
- **Deforestation and urbanization:** Deforestation and urbanization have led to the loss of natural flora and the paving over of land, which can cause more rainwater to run off and less rainwater to soak into the ground. This can make cities more likely to flood.
- **Climate change:** Because of climate change, there are more extreme weather events, like heavy rain and flooding, in many places of the world, including Tamil Nadu.

Effects of Flooding in Tamil Nadu

People, buildings, and the environment can all be hurt by flooding in different ways. The damage caused by floods in Tamil Nadu can be severe. The most significant effects of flooding include:

- Deaths, injuries, and property damage due to flooding and the resulting breakdown of essential infrastructure including highways, bridges, and electrical lines.
- Flooding can force people to flee their homes and towns, necessitating the construction of makeshift shelters and the provision of other forms of aid.
- The economy can take a hit as a result of flooding. Crop and livestock loss, corporate revenue decline, and recovery and rehabilitation expenses can all add up quickly.
- Floodwaters may contain pollution and other toxins, which can have lasting effects on water quality, animals, and ecosystems. These environmental damages make the flooded area inhabitable for not just humans but a variety of other species.

- Water-borne diseases including cholera and typhoid fever, as well as respiratory difficulties and skin infections, can proliferate after a flood.

Overall, floods in Tamil Nadu can have serious and long-lasting effects, hurting both persons and communities and necessitating substantial funds for recovery and reconstruction.

Flood prone Areas in Tamil Nadu

There are several areas in Tamil Nadu that are prone to flooding during the monsoon season. Some of the major areas are:

1. **Chennai:** The capital city of Tamil Nadu is located on the coast and is prone to flooding due to its flat topography, poor drainage systems, and encroachment of water bodies.
2. **Cuddalore:** This coastal town is located on the banks of the Kedilam River and is prone to flooding due to its low-lying areas and poor drainage systems.
3. **Kancheepuram:** This district is located on the banks of the Palar River and is prone to flooding due to heavy rainfall and inadequate drainage systems.
4. **Thanjavur:** This district is located in the delta region of the Cauvery River and is prone to flooding due to heavy rainfall and the river's tendency to overflow during the monsoon season.
5. **Tiruchirappalli:** This city is located on the banks of the Kaveri River and is prone to flooding due to heavy rainfall and the river's tendency to overflow during the monsoon season.
6. **Nagapattinam:** This coastal district is prone to flooding due to its low-lying areas and proximity to the Bay of Bengal.

These are some of the major areas in Tamil Nadu that are prone to flooding. However, flooding can occur in other parts of the state as well, particularly in areas with poor drainage systems or that are located near water bodies.

Flood prone Waterbodies in Tamil Nadu

Numerous large rivers and other bodies of water in Tamil Nadu are frequently inundated during the monsoons. The following are examples of some of Tamil Nadu's more dangerous bodies of water:

- **The Kaveri River** One of Tamil Nadu's biggest rivers, often overflows its banks after severe rain. Thanjavur, Tiruchirappalli, and Karur are only some of the districts the river traverses in Tamil Nadu.
- **The Palar River**, another large river in Tamil Nadu that frequently floods during the monsoons. Both Kanchipuram and Vellore are located in the river's path, among others in Tamil Nadu.
- **The Adyar River** is a little river that flows through the heart of Chennai but can become dangerously flooded during downpours. The river begins its journey in the Western Ghats and winds its way through many neighborhoods of Chennai before finally emptying into the Bay of Bengal.
- **The Buckingham Canal** is a man-made waterway that is vulnerable to flooding during heavy rainfall since it runs parallel to the coast of Tamil Nadu. Chennai, Kanchipuram, and Cuddalore are

just a few of the cities and towns the canal passes through on its way to the Bay of Bengal.

- **Chembarambakkam Lake** is a significant reservoir outside of Chennai city that often floods when there is a lot of precipitation. One of Chennai and its surrounding territories' primary water supplies comes from this lake.

When it rains a lot, these large bodies of water in Tamil Nadu often flood. It's not just rivers and lakes that can flood; other bodies of water might too, especially if they have poor drainage or are near the coast.

Flood Management Techniques used in Tamil Nadu

In order to lessen the damage caused by floods, the government of Tamil Nadu employs a number of flood management strategies. Among these techniques are:

- One successful method of flood management in Tamil Nadu is the building of dams and reservoirs. During the monsoon season, these structures can collect and slowly discharge surplus water, protecting lower elevations from flooding.
- The government is making an effort to upgrade the drainage systems in flood-prone areas, which is a step in the right direction. Desilting, cleaning canals, and constructing storm drains are all part of this process.
- The government is emphasizing the construction of flood-resistant infrastructure such bridges, roads, and buildings to lessen the impact of floods.
- Government-implemented early warning systems to inform citizens of impending flooding. These systems provide early warning to people living in flood-prone areas by using weather monitoring equipment and other resources.
- The government strongly suggests that people living in flood-prone areas purchase flood insurance. This can assist in lessening the blow to people's wallets that floods can cause.
- Another effective strategy employed in Tamil Nadu to lessen the effects of floods is afforestation. The risk of floods can be mitigated by the presence of trees since they help to prevent soil erosion and increase soil quality.
- The government supports community involvement in flood management. Sustainable land-use practices, flood risk education, and emergency planning are all part of this effort.

In Tamil Nadu, several strategies are employed together to mitigate the effects of flooding.

SOUTHWEST MONSOON IN INDIA

The* SouthWest Monsoon in India *is a major seasonal wind system that brings substantial rainfall to the Indian subcontinent from June to September. Its significance lies in its critical role in replenishing water resources and supporting agriculture across the region.

Tamil Nadu receives significantly less rainfall by the southwest monsoon because the Western Ghats blocks the southwest monsoon winds from blowing over the state. Due to this, Coimbatore plateau receives only 50 cm of rain while

Nilgiri hills receive nearly 50 cm to 100 cm of rain.

North East Monsoon in Tamilandu: Features, Mechanism & Impact

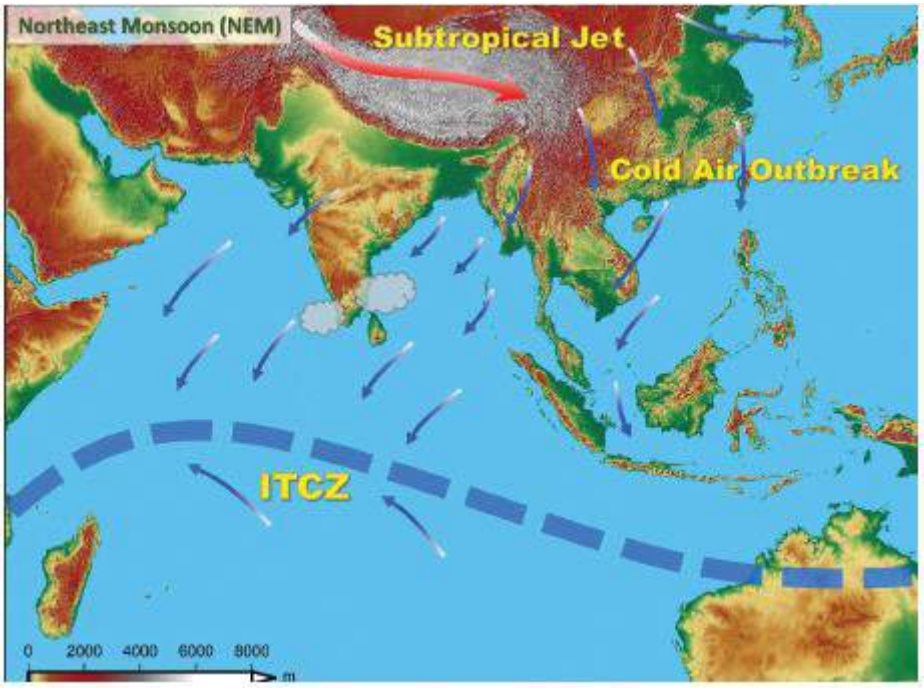
***The* North East Monsoon *is a key climatic feature influencing southeastern India from October to December. It plays a crucial role in providing vital rainfall, especially in Tamil Nadu and adjoining areas, and helps moderate temperatures during the transition from the rainy season to winter. This article explores in detail the characteristics, impacts, and mechanisms of the Northeast Monsoon, along with its effects on regional weather patterns*North East Monsoon**

- **The Northeast Monsoon,** also known as the **Retreating Monsoon,** occurs from **October to December** and is characterized by winds blowing from the northeast.
- This monsoon primarily affects southeastern India, including **Tamil Nadu,** and parts of the eastern coast.
- During this period, the **northeast trade winds** bring moisture from the Bay of Bengal, resulting in rainfall.
- The Northeast Monsoon is crucial for replenishing water supplies in regions with less rain during the Southwest Monsoon.

Characteristics of North East Monsoon

The features of North East Monsoon are:

- **Timing and Duration** – It occurs from **October to December.**
    - It follows the Southwest Monsoon and marks the transition from the rainy season to the winter season.
- **Wind Direction** – It is characterised by **northeast trade winds** that blow from the northeastern directions towards the Indian subcontinent.
- **Rainfall Distribution** – It primarily affects the **southeastern coast of India,** including **Tamil Nadu** and parts of **Andhra Pradesh.**
    - Rainfall is often less than the Southwest Monsoon but can be substantial in the affected regions.
- **Impact on Weather** – It brings **cooler temperatures** and helps reduce the heat of the preceding summer.
    - It **replenishes water resources** in areas with little rain during the Southwest Monsoon.
- **Rain Shadow Effect** – The eastern coast of India, particularly Tamil Nadu, receives significant rainfall, while the



regions to the west may experience dry conditions.

- **Seasonal Variability** – Rainfall can be **variable**, with some years experiencing heavier rains and others receiving less.

Cyclones during North East Monsoon

- After October 15, the mercury begins to fall rapidly, particularly in Northern India.
- **Low-pressure conditions** prevailing over north-western India get transferred to the **Bay of Bengal** by early November.
- This shift is associated with **cyclonic depressions,** commonly known as **tropical cyclones.**
- They originate over the **Andaman Sea** and the **Bay of Bengal**. Sometimes, they cross the eastern coasts of India, causing heavy and widespread rains.
- They are often very destructive and sometimes cause immense damage to life and property.
- Thickly populated deltas of the **Godavari**, the **Krishna**, and the **Kaveri** are frequently struck by these cyclones.

Impact of North East Monsoon on Tamil Nadu and Adjoining Areas

- **The Northeast Monsoon** also causes rainfall in **Tamil Nadu** and adjoining areas of **Andhra Pradesh** to the south of the **Krishna Delta** and **Kerala** (also called the **second rainy period of Kerala).**
- The **retreating monsoon** absorbs moisture while passing over the **Bay of Bengal** and causes this rainfall in the regions.
- Due to winter rainfall, **Tamil Nadu** coastal areas have developed dry evergreen forests.

The **Northeast Monsoon**, occurring from October to December, significantly affects southeastern India by bringing crucial rainfall and cooler temperatures. While it helps replenish water resources, it also introduces variability and can cause cyclonic depressions with heavy rains. Understanding this monsoon is essential for effective management and preparation, particularly in regions impacted by its unpredictable nature.

Aspects	South-West Monsoon	North-East Monsoon
Season	June to September	October to December
Wind Direction	Southwest to Northeast (SW -> NE)	Northeast to Southwest (NE -> SW)
Source of Moisture	Indian Ocean	Bay of Bengal
Regions Affected	Most of India	South Eastern Coast of India, esp. Andhra Pradesh and Tamil Nadu
Type of Rainfall	Heavy Rainfall	Moderate Rainfall

Difference between South West Monsoon and North East Monsoon

CHANGE IN MONSOON PATTERN IN TAMIL NADU

Increased rainfall

Tamil Nadu has seen an increase in southwest monsoon rainfall, especially in the traditionally dry regions of the state.

Intensified northeast monsoon

The northeast monsoon has intensified in Tamil Nadu.

Delayed monsoon withdrawal

The monsoon withdrawal has been delayed in recent years, often to the end of September or early October.

More frequent dry spells and intense wet spells

There has been a shift towards more frequent dry spells and more intense wet spells during the summer monsoon season.

Unpredictable monsoon seasons

Climate change has led to increased variability in rainfall patterns, resulting in unpredictable monsoon seasons.

Heavier rainfall over shorter periods

The monsoon has become more intense, with heavier rainfall over shorter periods, causing flash floods and waterlogging.

The normal annual rainfall of Tamil Nadu is about 945 mm (37.2 in). The state is fully dependent on rains for recharging its water resources, so monsoon failures can lead to acute water scarcity and severe drought.

Impact of Changing Monsoon

Depletion of Water Table: In India, a little over 50% of India's net sown area is under rainfed farming, and a large part of the irrigated area depends on groundwater extraction through borewells, which needs to be recharged with the groundwater.

These aquifers may need to be adequately recharged in a poor monsoon, leading to a water crisis.

Further, according to a NITI Aayog's report, nearly 21 Indian cities — including New Delhi, Hyderabad and Chennai — could run out of groundwater by 2020.

Fiscal Burden: Multiple crop failures may require the government to support farmers actively. It likely prompts the government to raise minimum support prices for the current season's crops to help support farmers' incomes.

This will have a diminishing effect on investments into agricultural investments.

Impacting Electricity Generation: Monsoon rains can be harnessed as hydro power, a valuable energy resource. Hydropower currently provides 25% of India's electricity.

Reservoirs are filled during the southwest monsoon rains, and then the water is gradually released through dams, turning turbines to create electricity year-round.

During years when there is little monsoon rainfall, the reservoirs are not replenished, limiting the amount of hydroelectric power produced during the year.

Impacting Inflation: Normal monsoon rains keep a check on food inflation due to the availability of food products. However, in a situation of drought, prices soar significantly.

Also, if poor monsoon results in less crop output, the country may need to import.

It also impacts as many as a dozen sectors that depend on Monsoons directly or indirectly.

TAMIL NADU CLIMATE CHANGE MISSION

Tamil Nadu became the first state in India to launch its own climate change mission.

The objective of the mission is to make Tamil Nadu a "climate smart state".

Key highlights of the Tamil Nadu Climate Change Mission

- The Tamil Nadu Government has proposed 13 goals for the climate change mission, along with 11 focal areas for climate action as part of the Tamil Nadu State Action Plan on Climate Change 2.0 (TNSAPCC 2.0). The first version of the TNSAPCC was implemented in 2015 based on the National Action Plan for Climate Change for 2015-2020. It was revised based on the recommendation by the Central Government, involving the creation of new short term plans for 2023 and long term plans up to 2030.
- The climate change mission document emphasized that climate change is an undisputed reality having severe impact on the natural environment, human lives, economic assets and activities.
- It underlined the fact that Tamil Nadu accounts for 172.83 metric tons of carbon dioxide equivalent emissions (MtCO2e) out of the 2953 MtCO2e emissions at the national level, with the power sector accounting for 67 percent of the MtCO2e.
- The mission document provided a comprehensive study of climate risks and their impacts based on the Sustainable Development Goals (SDGs) of Tamil Nadu. It revealed that Ariyalur is the most vulnerable district to climate risks because of high sensitivity and low adaptive capability. Other districts vulnerable to climate risk are Nagapattinam, Ramanathapuram, Thiruvarur, Thiruvallur, Thanjavur, Perambalur, Pudukottai, and Thiruvannamalai.
- It has several key goals, including the 10-year goal to enhance the green cover in the state from 23.7 per cent to 33 per cent.
- It also seeks to create smarter infrastructure systems to minimise disasters and respond to them effectively.
- The document recognizes the vulnerability of women to the climate crisis and seeks to ensure gender-mainstreaming in climate action for women and children.
- It seeks to increase the understanding of climate change impact across different sectors of the society and how they are inter-related.
- It proposes adoption of the "one health approach" to climate change response and bring about deeper insights into its impacts on environment, animal and human health.

The goals of the mission document cover aspects such as:

1. Promoting green technology to generate green jobs
2. Reducing greenhouse gas emissions using efficient public transport systems, clean and green energy, alternative fuel sources, and improved monitoring mechanisms.
3. Bringing in eco-alternative solutions to single use plastic
4. Promoting sustainable practices for the disposal of solid waste, including sewage, e-waste, bio-medical waste etc.
    - The mission document calls for the effective utilization of expertise and experience of universities, research agencies and academic institutions involved in the climate adaptation and mitigation strategies.

- It also recommends the incorporation of climate courses in curricula.
- While recognising the high cost of climate action, the document seeks to augment resources from various funding options like the National Adaptation Fund for Climate Change (NAFCC) and Green Climate Fund (GCF).

Expected outcomes of the Tamil Nadu Climate Change Mission

1. Framing of specific climate adaptation and mitigation strategies.
2. Identification of vulnerable and eco-sensitive regions along Tamil Nadu's coasts.
3. Protection of coastal regions, reduction of soil erosion, salinity control, and improvement of biodiversity.
4. Improving coastal defense with the help of mangroves
5. Solutions to improve the resilience to drought and shore protection through palmyrah and cashew plantations.
6. Reduction in greenhouse gas emissions due to the promotion of energy-efficient technologies.
7. Increased understanding of climate risks to generate local assistance for decision-making.

DISASTER MANAGEMENT

The United Nations International Strategy for Disaster Reduction (UNISDR) defines disaster risk management as the systematic process of using administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters.

Institutional Level	Authority	Chairman	Institutions
Central Government ↓	National Disaster Management Authority (NDMA)	Prime Minister	National Executive Committee (NEC) National Disaster Response Fund (Sec. 46 Dis Mgt Act 2005)
	Ministry of Home Affairs (MHA)	Home Minister	National Disaster Response Force (NDRF) National Institute of Disaster Management (NIDM)
State Government ↓	State Disaster Management Authority (SDMA)	Chief Minister	State Executive Committee (SEC) State Disaster Response Fund (Sec. 48 Dis Mgt Act 2005)
	Disaster Management Department (DMD)	Minister-in-Charge	State Disaster Response Force (SDRF)
District Government • Panchayats • Municipalities	District Disaster Management Authority (DDMA)	District Magistrate/ Chairman Zila Parishad	State Executive Committee (SEC)

National Level Decision Making Bodies for Disaster Management

Cabinet committee on Security

- **Composition**
- Prime Minister
- Minister of Defence, Minister of
- Finance
- Minister of Home Affairs
- Minister of External Affairs

National Crisis Management Committee (NCMC)

- **Composition**
- Cabinet Secretary (Chairperson).
- Secretaries of Ministries / Departments and agencies with specific Disaster Management responsibilities.
- **Vital Role**
- Oversee the Command, Control and Coordination of the disaster response.
- Give direction to the Crisis Management Group as deemed necessary.
- Give direction for specific actions to face crisis situations.

National Disaster Management Authority (NDMA)

- **Composition**
- Prime Minister (Chairperson).
- Members (not exceeding nine, nominated by the Chairperson).

National Executive Committee (NEC)

- **Composition**
- Union Home Secretary (Chairperson).
- Secretaries to the GOI in the Ministries / Departments of Agriculture, Atomic Energy, Defence, Drinking Water and sanitation, Environment, Forests and Climate Change Finance (Expenditure), Health and Family Welfare, Power, Rural Development, Science and Technology, Space, Telecommunications, Urban Development, Water Resources, River Development and Ganga Rejuvenation, The Chief of the Integrated Defence Staff of the Chiefs of Staff Committee, ex officio as members.
- Secretaries in the Ministry of External Affairs, Earth Sciences, Human Resource Development, Mines, Shipping, Road Transport and Highways and Secretary, NDMA are special invitees to the meetings of the NEC.

National Disaster Response Force (NDRF)

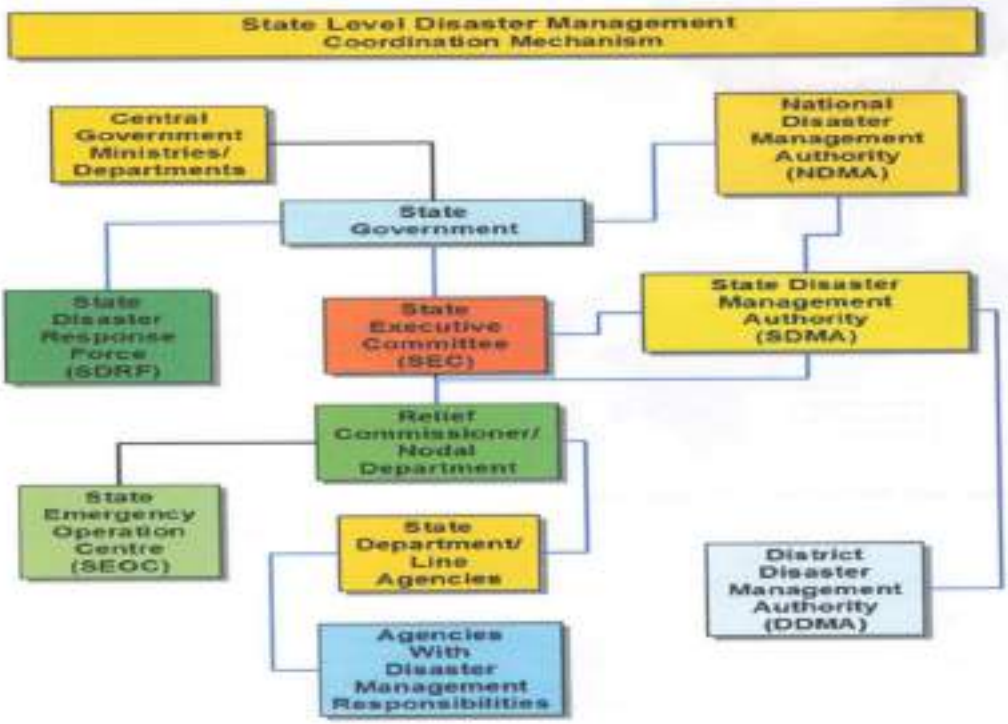
- **Composition**
- Specially trained force headed by a Director General Structured like para military forces for rapid deployment.
- **Vital Role**
- Provide assistance to the relevant State Government/District Administration in the event of an imminent hazard event or in its aftermath.

National Institute of Disaster Management (NIDM)

- **Composition**
- Union Home Minister
- Vice Chairman, NDMA

Members including Secretaries of various nodal Ministries and Departments of Government of India and State Governments and heads of national levels scientific,

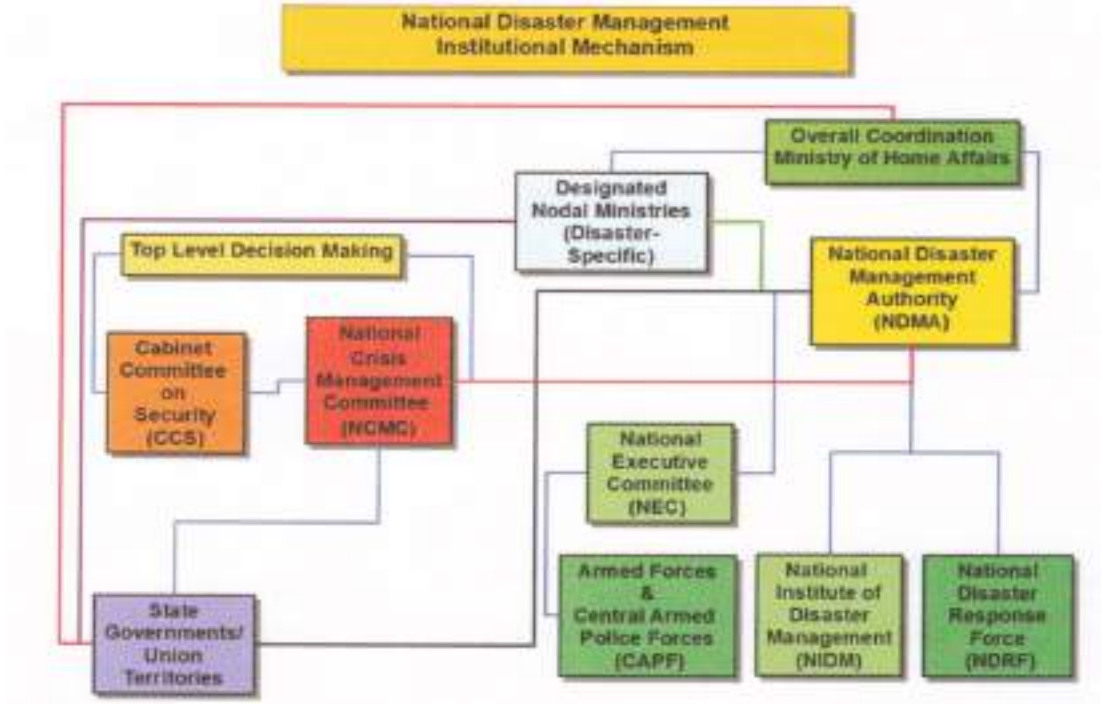
- research and technical organizations, besides eminent scholars, scientists and practitioners.



2. State Level

The Disaster Management Act 2005 mandates that:

- Each state in India shall have its own institutional framework for disaster management.
- Each State Government shall take necessary steps for the preparation of state Disaster Management plans, integration of measures for prevention of disasters or mitigation into state development plans, allocation of funds.
- The State Government shall also assist the Central Government and central agencies in various aspects of



Disaster Management.

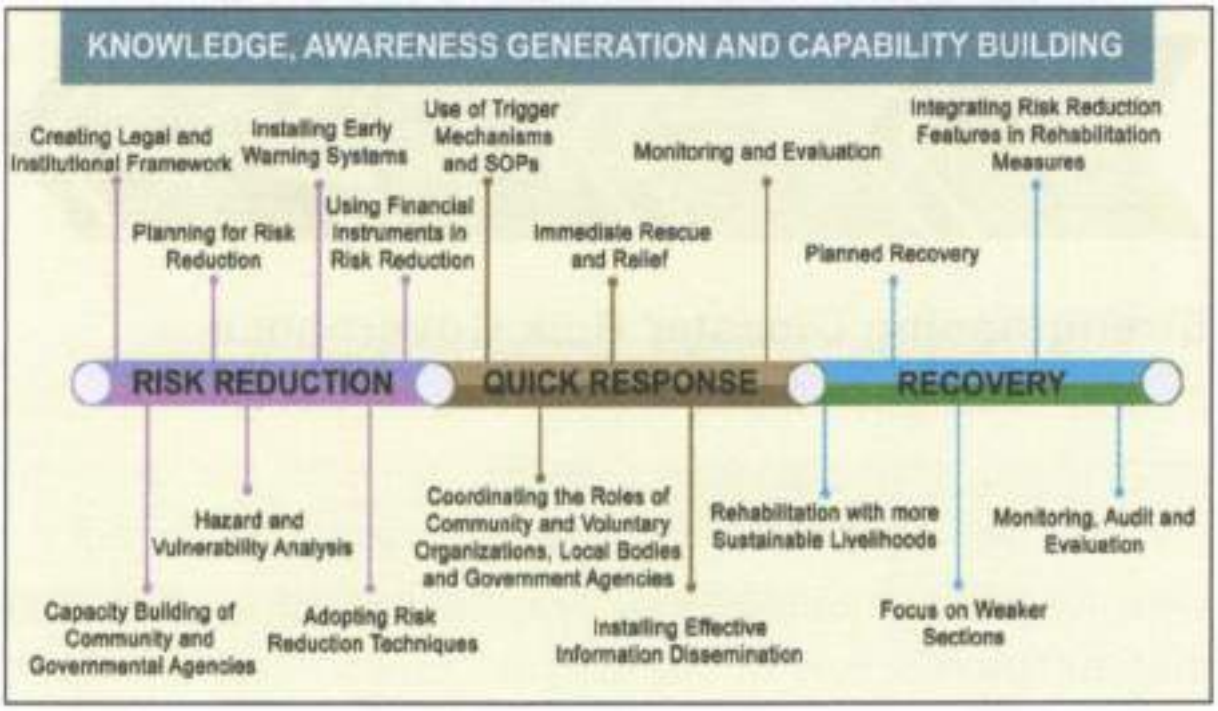
- Each state shall prepare its own State Disaster Management Plan.
- Setting up of a State Disaster Management Authority with the Chief Minister as the ex officio Chairperson. Similar system will function in each Union Territory with Lieutenant Governor as the Chairperson.

3. District Level

The Disaster Management Act mandates that

- At the district level, District Disaster Management Authority (DDMA), the District Collector or District Magistrate or the Deputy Commissioner, as applicable, will be responsible for overall coordination of the disaster management efforts and planning
- Detailed Disaster Management Plan will be developed, subject to periodic review and revision, at the levels of state, district, towns and blocks (taluka).
- Each State Government shall establish a District Disaster Management Authority for every district in the State.
- The District Disaster Management Authority will act as the planning, coordinating and implementing body for DM at the District level and take all necessary measures for the purposes of DM in accordance with the guidelines laid down by the NDMA and SDMA.

Elements of Crisis Management



Acts and Policies Related to Disaster Management

National Disaster Management Act, 2005

Evolution of the Act

The Government of India (GOI) set up a High-Powered Committee (HPC) in August 1999 and a National Committee after the Gujarat earthquake, for making recommendations on the preparation of

Disaster Management plans and suggesting effective mitigation mechanisms. Also the tenth five year plan document for the first time contained a detailed chapter on disaster management. Thus all the efforts finally culminated in 2005 by enactment of the National Disaster Management Act.

Functions and Responsibilities

NDMA, as the apex body, is mandated to lay down the policies, plans and guidelines for Disaster Management to ensure timely and effective response to disasters.

It is entrusted with the following responsibilities:

- Lay down policies on disaster management ;
- Approve the National Plan and plans prepared by the Ministries or Departments of the Government of India in accordance with the National Plan;
- Lay down guidelines to be followed by the State Authorities in drawing up the State Plan and Coordinate the enforcement and implementation of the policy and plans for disaster management.
- Recommend provision of funds for the purpose of mitigation.
- Provide such support to other countries affected by major disasters as may be determined by the Central Government.

International Cooperation on Disaster Management

International Organisation and Frameworks

Yokohama Strategy (1994)

The need to mitigate the impact of natural disaster in terms of human and economic losses was felt by the United Nations and other countries. So they held World conference on natural Disaster reduction in the city of yokohama in 1994. It was accepted that these disaster affected the poor and disadvantageous group the worst, particularly in the developing countries, which are ill equipped to cope with them.

United Nations office for disaster Risk Reduction (1999)

The UN General Assembly adopted the International Strategy for Disaster Reduction as asuccessor arrangement of the International Decade for Natural Disaster Reduction in December 1999 and established United Nations International Strategy for Disaster Reduction (UNISDR). Its mandate was expanded in 2001 to serve as the focal point in the United Nations system to ensure coordination and synergies among disaster risk reduction activities of the United Nations system and regional organizations.

Hyogo Framework (2005)

The world conference on Disaster Reduction which was held Kobe, Hyogo Japan in 2005 adopted the framework for action 2005-2015.

Sendai Framework (2015)

The Sendai Framework is a 15-year (2015-2030), voluntary, non-binding agreement which recognizes that the State has the primary role to reduce disaster risk but that responsibility should be shared with other stakeholders including local government, the private sector and other stakeholders. The Sendai Framework was adopted by UN Member States on 18 March 2015 at the Third UN World Conference on Disaster Risk Reduction in Sendai City, Miyagi Prefecture, Japan as a follow up of the hyogo framework.

The Sendai Framework Readiness Review, UNISDR 2017: Critical data gaps exist in specific areas of disaster loss, in all areas of international cooperation, and for many aspects of early warning, risk information and disaster risk reduction strategies. The Review confirms that unless gaps in data availability, quality and accessibility are addressed, countries' ability to assure accurate, timely and high quality monitoring and reporting of implementation across all Targets and Priorities of the Sendai Framework will be severely impaired.

A Global Partnership for Disaster-related Data for Sustainable Development would facilitate a collaborative, multi-stakeholder effort (bringing together governments, international organizations, the private sector, civil society groups, and the statistics and data communities), to optimize and operationalize existing and future disaster-related data in support of national and sub-national disaster risk reduction efforts.

2030 Agenda for Sustainable Development: In the 2030 Agenda for Sustainable Development, ten of the seventeen Sustainable Development Goals (SDGs) have targets related to disaster risk, firmly establishing the role of disaster risk reduction in realizing the 2030 Agenda for Sustainable Development.

Paris Agreement at CoP 21: In the Paris Agreement, adopted at the 21st Conference of Parties to United Nations Framework Convention on Climate Change in 2015, Member States committed to holding the global average temperature increase to well below 2°C above pre-industrial levels and to pursue efforts to limit the increase to 1.5°C, with the aim to "significantly reduce the risks and impacts of climate change".

Tamil Nadu State Disaster Management Authority

Tamil Nadu State Disaster Management Authority is a government agency in the Indian state of Tamil Nadu. Established in 2003, it is responsible for disaster management, planning and recovery.

Constituent
Chief Minister of Tamil Nadu
Minister for Revenue
Chief Secretary of Tamil Nadu
Secretary of Revenue
Secretary of Finance
Secretary of Home
Secretary of School Education
Secretary of Higher Education
State relief commissioner and Commissioner of Revenue Administration
Director, Centre for Disaster Management and Mitigation, Anna University
Head, Department of Civil Engineering, Indian Institute of Technology, Madras

SDMA is constituted of a chairperson and ten members

TAMILANADU DISASTER MANAGEMENT PLAN

The Tamil Nadu State Disaster Management Policy 2023 was released by Chief Minister M.K. Stalin in March 2023. The policy aims to reduce the impact of disasters on the state by:

Building a disaster-resilient state

The policy aims to make Tamil Nadu safer by integrating disaster risk reduction into the state's sustainable development ethos.

Developing a proactive approach

The policy aims to replace reactive relief with a proactive approach to risk reduction and mitigation.

Creating a culture of preparedness

The policy aims to develop a culture of prevention, preparedness, and quick response to disasters.

Establishing a chain of command

The policy aims to establish a clear chain of command with well-defined authority and responsibility for various stakeholders.

Working together

The policy aims to create a consistent institutional framework that enables the state, local governments, Central government, and the private sector to work together.

The policy includes action plans for dealing with a variety of disasters, including:

- Earthquakes
- Cyclones
- Tsunamis
- Floods
- Urban floods
- Industrial and chemical disasters
- Biological and public health emergencies
- Nuclear and radiological disasters
- Fires

The State Disaster Management Authority (SDMA) is responsible for coordinating the response to disasters and reducing risks. The SDMA approves the State Disaster Management Plan and District Disaster Management Plans.

MANAGEMENT AND MITIGATION IN TAMILNADU.

Non-governmental organizations (NGOs) and civil society organizations play a vital role in disaster management and mitigation in Tamil Nadu and other parts of India:

Pre-disaster preparation

NGOs help communities prepare for disasters by providing training, raising awareness, and conducting mock exercises. They also help communities develop early warning systems.

Disaster response

NGOs provide immediate assistance, including rescue, first aid, and sanitation. They also help with damage assessment and distribute supplies like food, water, medicine, and shelter.

Post-disaster recovery

NGOs help with reconstruction and recovery by providing technical and material support. They also help communities learn from each other and share best practices.

Collaboration

NGOs collaborate with governments, international organizations, and other people to promote policies and procedures that reduce disaster risk.

Community-based systems

Civil society organizations can create informal community-based systems to help with disaster management. For example, in flood-prone areas, community

groups can operate flood early warning systems.

NGOs can be effective in disaster management because of their established networks and grassroots connections. This allows them to mobilize quickly during emergencies and provide immediate assistance.

Empowering Communities: Preparing for a Safer Tomorrow

Natural disasters such as earthquakes, floods, and other climate-related disasters are getting more and more recurrent and serious. The same is the case with diseases and pandemics. People living in vulnerable conditions are often the ones who suffer the most – physically, financially, and psychologically. Disaster relief NGOs are taking the lead in reducing disaster risk and are working hard to build resilient and prepared communities.

- Indigenous and local communities are well versed about the places they live, and the risks they are exposed to. It is important to use their knowledge to help in disaster management training in the best way possible.
- After a disaster has occurred, help in terms of resources and manpower may not be available immediately, especially when it happens in a remote area. In such places, empowered communities can help by providing first aid, running search and rescue, and getting help from their neighbors right away.
- In order to empower communities, it is important to teach them how to build resilient infrastructure that would help to reduce risk. This way, communities can build safer homes, strengthen existing structures, and create early warning systems to help reduce the chances of disasters happening to people and properties.
- When people know what to do and how to be prepared, they can take the right actions and protect themselves and their loved ones. This can save lives and reduce the long-term financial and social effects of disasters - all thanks to community empowerment.
- Working together to be prepared for disasters helps build relationships based on trust, collaboration, and a sense of responsibility in communities. These relationships are really crucial in times of disaster, especially for people in need, like seniors and people with disabilities, to get the help they need.
- Communities that have the power to manage disasters better are better prepared to recover and rebuild. They can get the support they need to restore their lives and take care of their community as well. This helps recovery and restoration happen faster and reduces the financial losses caused by disasters.

Putting communities at the center of disaster management is a multi-faceted responsibility. It's an investment in people's lives, livelihoods, and sustainable development, recognizing that the real power to create a safer tomorrow lies in the hands of the communities that are most affected by disasters.

Role of NGOs in Empowering Communities in Disaster Management

NGOs are really important in helping communities get ready for and respond to disasters. They help build resilient communities that can handle any kind of disaster. Here's a quick look at what they do and how they can help:

- NGOs help people in need by giving them the training they need to be prepared for disasters. This includes things like assessing risks, making emergency plans, running search and rescue, giving first aid, and organizing evacuation.
- They help people set up systems that let people know when something bad is about to happen, like an early warning, so that they can plan ahead and get ready.
- NGOs work with communities to create awareness about disaster risks and build resilience, through awareness programs that get people involved in disaster management.
- NGOs often collaborate with communities to build resilient infrastructure. This includes creating infrastructure that is critical for reducing casualties and property damage during disasters.
- NGOs help to arrange for and distribute food, water, medicine, and shelter supplies on the ground after disasters. They work together to make sure these supplies get to the people who need them the most right away.
- They provide counseling and help to people to deal with the grief and stress caused by disasters.
- They work to promote policies and procedures that focus on reducing disaster risk and empowering communities by collaborating with governments, international organizations, and other people.
- They work to make sure that everyone has a fair shot at dealing with disasters. They ensure that vulnerable people such as children, seniors, and people with disabilities, have sufficient access to resources and information.
- NGOs conduct surveys and tests to see how successful their disaster management programs are. This feedback helps them come up with better plans and make sure their communities get the most helpful and beneficial help.
- They help communities and regions share best practices and learn from each other. This way, communities can learn from each other's experiences and adjust successful strategies to fit their specific needs.

NGOs are all about building resilience in the long run, and understanding that disaster management is a continuous process. They work with communities to create sustainable solutions that help reduce risks and vulnerabilities in the long run. They are catalysts for community empowerment in disaster management.

Disaster Management NGOs in India – Leading the Way

In a country as diverse and vibrant as India, Give Discover applauds the NGOs that are acting as a shining examples of compassion, commitment, and creativity. Their tireless efforts to make a difference in the lives of the people they serve, help them get their lives back on track. Here

are some NGOs that are creating success stories of resilience and restoration:

- Save the Children (registered as Bal Raksha Bharat): Established in 2008 at Gurgaon, Save the Children is a big name in the world when it comes to helping kids. They work towards providing kids with a good life – proper education, protection from abuse, and adequate health facilities. They focus on the holistic development of the community, by providing proper health, food, education, disaster relief, and making sure India's kids have a better future. They have more than 60 projects currently running in over 15 states, helping thousands of people all around India.
- Responsenet: Having a presence in the whole country, Responsenet, is all about making sure Indian communities have the rights they deserve. When it comes to disaster response, they have a strong presence across the country through multiple partnerships and networks. They also help the underprivileged become economically empowered, provide them with health facilities, provide education for children, protect them from abuse, and ensure everyone has adequate access to basic amenities such as housing and sanitation.
- AJSA India: AJSA helps communities cope with the effects of climate change, natural disasters, and a lot more. They do so through programs for raising awareness, adapting, mitigating, and building resilience. They root for initiatives like smart agriculture, water management, renewable energy, and disaster preparedness. They also manage schools and health centers in rural areas, to make sure everyone has access to good education and proper health care.
- United Way Of Chennai: United Way Chennai is all about giving back to the community and making a difference. They work with corporations and other organizations to tackle important social issues and make a difference in Chennai and the surrounding areas. They act as a connection between the corporate world and the governmental and non-governmental organizations, promoting various corporate social responsibility activities.
- Humanitarian Aid International: Humanitarian Aid International helps communities to ease the suffering of people. They help with disaster recovery after natural disasters, Covid response, and helping refugees in India. They use cutting-edge tech to scan the ground before and after a disaster. They help with surveillance, tracking supplies, and getting ambulances to the scene. They also help with air-dropping aid and mapping weak zones. They are all about providing humanitarian aid, especially in disaster areas. They provide relief, healthcare, and rehabilitation to help communities rebuild after disasters and crises.

When we reflect on all the efforts these NGOs put in during times of distress, let's not forget that the fight for a more resilient India is something we all should be a part of. Let's keep working together to empower, lift, and change lives!

ENVIRONMENT IMPACT ASSESSMENT

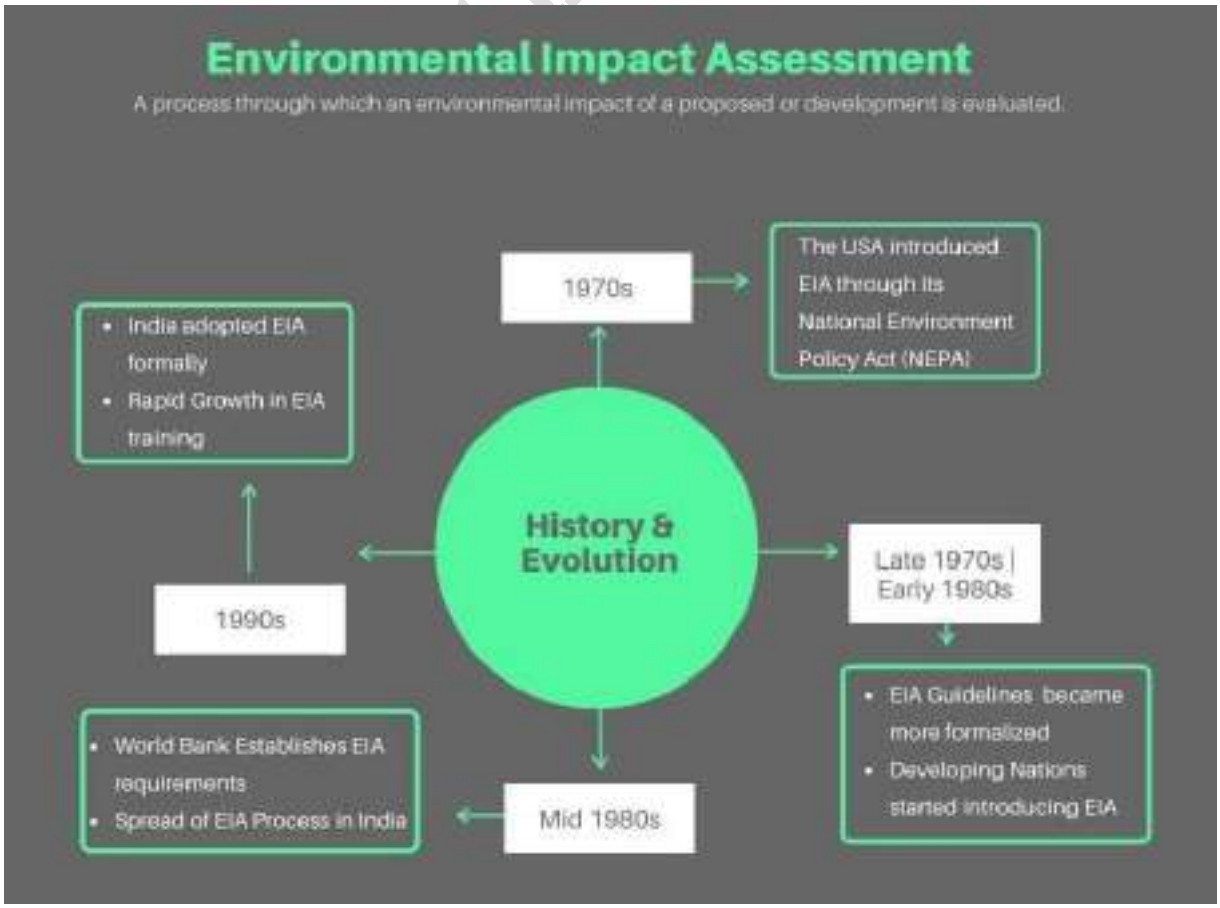
Environmental Impact Assessment (EIA)

Environmental Impact Assessment or EIA is **the process or study which predicts the effect of a proposed**

industrial/infrastructural project on the environment.

Environmental Impact Assessment (EIA) is a tool available to the planners to achieve the goal of environmental preservation along with ensuring developmental activities.

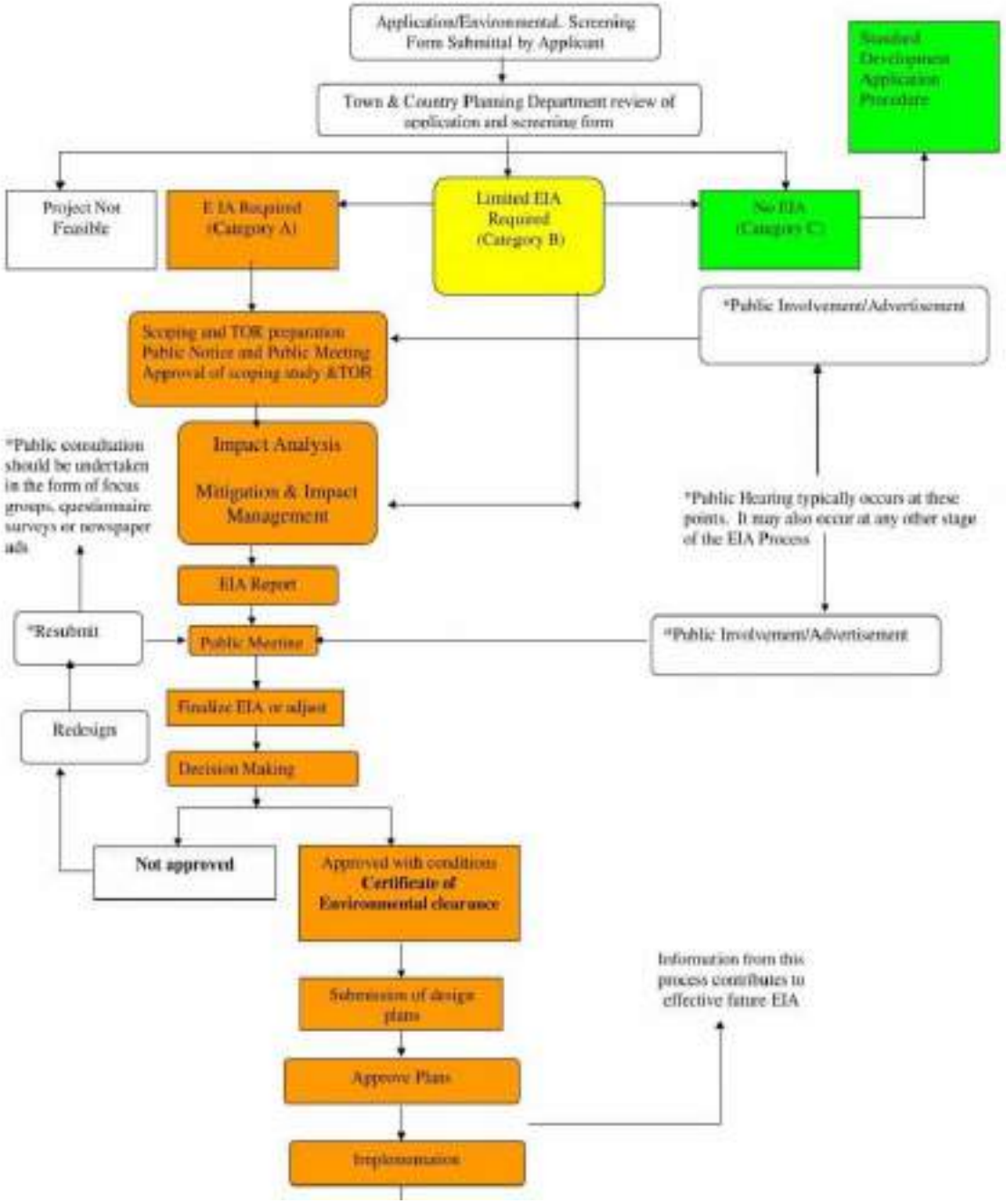
- **UNEP defines Environmental Impact Assessment (EIA)** as a tool used to **identify the environmental, social, and economic impacts of a project prior to decision-making.** It aims to predict environmental impacts at an early stage in project planning and design, find ways and means to reduce adverse impacts, shape projects to suit the local environment, and present the predictions and options to decision-makers.
- **EIA 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 the **Environment (Protection) Act 1986** issued a number of other notifications, which are related to environmental impact assessment.
- **Environmental clearance** or the **'go-ahead'** signal is granted by the **Impact Assessment Agency** in



the **Ministry of Environment and Forests**, Government of India.

- The Ministry of Environment, Forests and Climate Change (MoEFCC) notified **new EIA legislation in September 2006.**
- The notification makes it **mandatory for various projects** such as mining, thermal power plants, river valley, infrastructure (road, highway, ports, harbours, and airports), and industries including very small electroplating or foundry units **to get environment clearance.**

Generalized EIA Process Flowchart



Environmental Components of EIA

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 the 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 a proposed project on water resources.

Biological environment

- **Flora and fauna** in the 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 sites**.

Steps in Preparation of EIA report

- **Collection of baseline data** from primary and secondary sources;
- **Prediction of impacts** based on past experience and mathematical modeling;
- **Evolution of impacts** versus evaluation of net cost-benefit;
- **Preparation of environmental management plan**s to reduce the impacts to the minimum;
- **Quantitative estimation of financial cost of the 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 projects, environmental clearance is accorded subject to the implementation of the stipulated environmental safeguards.
- In the 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 to monitor 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 the 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 the diversion of forestland, the case is processed only for environmental clearance.

PARIVESH

PARIVESH – (Pro-Active and Responsive facilitation by Interactive and Virtuous **Environmental Single-window Hub**)

It is an environmental single window hub for Environment, Forest, Wildlife and CRZ clearances.

This Single-Window Integrated Environmental Management System has been **developed in pursuance of the spirit of 'Digital India' initiated** by the Prime Minister and capturing the essence of Minimum Government and Maximum Governance.

Key features:

- "PARIVESH" is a workflow-based application, based on the concept of web architecture. **It has been rolled out for online submission, monitoring, and management of proposals submitted by Project Proponents to the Ministry of Environment, Forest and Climate Change (MOEFCC), as well as to the State Level Environmental Impact Assessment Authorities (SEIAA)**.
- It seeks **to give various types of clearances** (e.g. Environment, Forest, Wildlife, and Coastal Regulation Zone Clearances) from Central, State, and district-level authorities.
- **The system has been designed, developed, and hosted by the Ministry of Environment, Forest and Climate Change, with technical support from National Informatics Centre, (NIC)**.
- **It provides** single registration and single sign-in for all types of clearances (i.e. Environment, Forest, Wildlife, and CRZ), unique-ID for all types of clearances required for a particular project, and a single Window interface for the proponent to submit applications for getting all types of clearances (i.e. Environment, Forests, Wildlife and CRZ clearances).

Composition of the expert committees for EIA

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 Amendments to EIA Notification

- 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 the national level by Impact Assessment Agency (IAA) and the Expert Appraisal Committee (EAC) and Category B projects are appraised at the 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 the 2006 Amendment the EIA cycle comprises of four stages:**
  - Screening
  - Scoping
  - Public hearing
  - Appraisal
- **Category A projects** require mandatory environmental clearance and thus they do not undergo the screening process.
- **Category B projects** undergoes a screening process and they are classified into two types.
  - **Category B1 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 the complete EIA process.

Importance of EIA

- **EIA links the 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 analyze 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 the limits of the capacity of assimilation and regeneration of the ecosystem.

SUSTAINABLE GOALS

Background

- The SDGs build upon previous initiatives and agreements that have aimed to promote sustainable development. In **1992, Agenda 21** was adopted at the **Earth Summit in Rio de Janeiro, Brazil**, as a global plan of action for sustainable development.
- **The Millennium Development Goals (MDGs)** were then established in 2000, focusing on reducing extreme poverty by 2015.
- **The Johannesburg Declaration on Sustainable Development and the Plan of Implementation**, adopted in 2002, further emphasized poverty eradication and environmental protection.
- **In 2012, at the United Nations Conference on Sustainable Development (Rio+20)**, member states decided to develop a set of SDGs to build upon the MDGs and established the UN High-level Political Forum on Sustainable Development.
- This process led to the adoption of the 2030 Agenda for Sustainable Development in 2015 during the UN Sustainable Development Summit.

The SDGs, otherwise known as the Global Goals, are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity.

The SDGs were adopted by the United Nations in 2015 with a vision to achieve a better and more sustainable future for all. The 17 SDGs came into force with effect from 1st January 2016 as a part of 2030 Agenda for Sustainable Development.

India is one of the signatory countries that has committed to achieving these goals by 2030.

Though not legally binding, the SDGs have become de facto international obligations and have the potential to reorient domestic

spending priorities of the countries during the next fifteen years.

Countries are expected to take ownership and establish a national framework for achieving these goals.

Agreements shaping SDG

- Several significant agreements were reached in 2015 that shaped international policy and multilateralism:
  - The Sendai Framework for Disaster Risk Reduction
  - The Addis Ababa Action Agenda on Financing for Development
  - The Paris Agreement on Climate Change
  - The 2030 Agenda for Sustainable Development itself.

Monitoring

- The annual High-level Political Forum on Sustainable Development now serves as the central platform for reviewing and monitoring progress towards the SDGs.
- The Division for Sustainable Development Goals (DSDG) within the United Nations Department of Economic and Social Affairs (UNDESA) provides support for the SDGs and related issues, such as water, energy, climate, and urbanization.
- DSDG plays a vital role in evaluating the implementation of the 2030 Agenda across the UN system and conducts advocacy and outreach activities to promote the SDGs.

Targets set for each of the SDGs

No Poverty: By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day.

Zero Hunger: By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round.

Quality Education: By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes.

Gender Equality: End all forms of discrimination, violence, harmful practices against all women and girls everywhere. Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic, and public life.

India's progress towards achieving SDGs so far

SDG 1 (No Poverty): India has made significant progress in reducing poverty, with the poverty rate declining from 21.9% in 2011-12 to 4.4% in 2020. The government's efforts to provide financial inclusion and social protection schemes have contributed to this progress.

SDG 2 (Zero Hunger): India has made progress in reducing hunger, with the prevalence of undernourishment declining from 17.3% in 2004-06 to 14% in 2017-19. The government's initiatives such as the National Food Security Act and the Pradhan Mantri Garib Kalyan Anna Yojana have contributed to this progress.

SDG 3 (Good Health and Well-being): India has made progress in improving maternal and child health, with maternal mortality ratio declining from 167 per 100,000 live births in 2011-13 to 113 in 2016-18. The

government's efforts to strengthen health systems and increase access to healthcare services have contributed to this progress.

SDG 4 (Quality Education): India has made progress in improving access to education, with the gross enrolment ratio for primary education increasing from 93.4% in 2014-15 to 94.3% in 2019-20. The government's initiatives such as the Sarva Shiksha Abhiyan and the Right to Education Act have contributed to this progress.

SDG 5 (Gender Equality): India has made progress in improving gender equality, with the sex ratio at birth increasing from 918 in 2011 to 934 in 2020. The government's initiatives such as the Beti Bachao Beti Padhao and the Maternity Benefit Programme have contributed to this progress.

Recent findings by National Family Health Survey

Multidimensional poverty declined: At a compounded annual average rate of 4.8 per cent per year in 2005-2011 and more than double that pace at 10.3 per cent a year during 2011-2021.

Declining child mortality: There are some issues with the 2011 child-mortality data, but for each of the 10 components of the MPI index, the rate of decline in 2011-2021 is considerably faster than in 2005-2011.

Average decline in overall indicators: The average equally weighted decline for nine indicators was 1.9 per cent per annum in 2005-2011 and a rate of 16.6 per cent per annum, more than eight times higher in 2011-2021.

Consumption inequality decline: Every single household survey or analysis has shown that consumption inequality declined during 2011-2021. This is consistent with the above finding of highly inclusive growth during 2011-2021.

The analysis provides a valuable tool for policymakers to address the gaps and focus on the indicators that require more attention, thereby improving the well-being of its citizens and creating a sustainable future for all.

SOME OF OUR TNPSC TOPPERS

1400+ SELECTIONS

OUR RECENT GROUP -1 TOPPERS 2022

Ms.Sathyanandhi.G
Rank -2
Deputy Collector

Ms.Subhalakshmi.S
Rank -4
Deputy Collector

Ms.Krithika.K
Rank -18
Assistant Commissioner Commercial Tax

Ms.K.Ramali Ramalakshmi
Rank -22
Deputy Superintendent of police

Mr.Vignesh.C
Rank -25
Assistant Director of Rural Development

OUR RECENT GROUP -1 TOPPERS 2024

MARUTHIP PRIYA.R RANK 01

DEEPIKA. A RANK 20

BHAVADHARANI.R RANK 30

PECHIYAAMMAL. M RANK 34

NALINI. S RANK 43