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# ENVIRONMENT

*for* CIVIL SERVICES EXAM

-  **360° coverage of the syllabus of Environment for Prelims including Hidden Dimensions**
-  **Crisp Material and Innovative Presentation for Quick Revision**
-  **Coverage of dynamic areas with Contemporary Approach Decoding the demand of exam**
-  **Previous Year Questions to Map the trends and be exam ready.**

## VOL-I

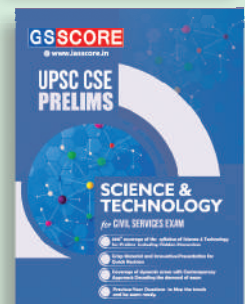
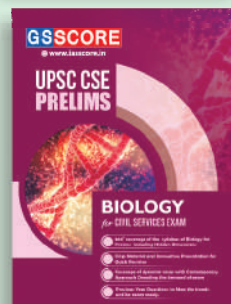
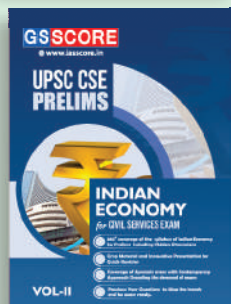
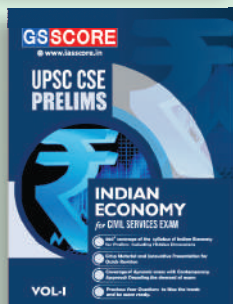
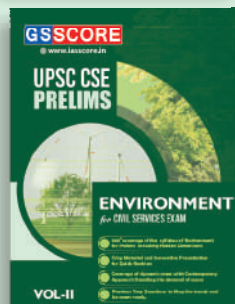
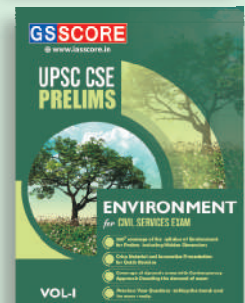
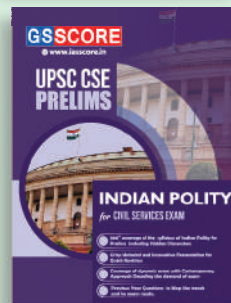
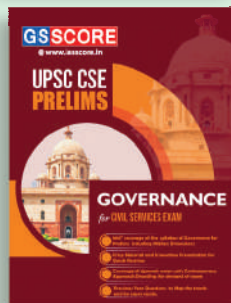
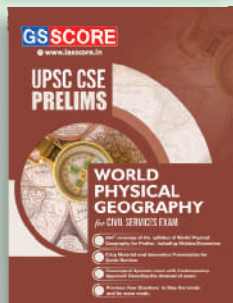
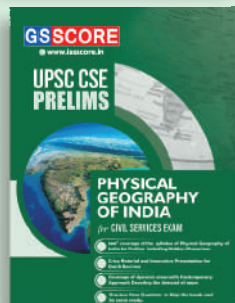
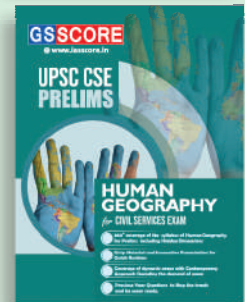
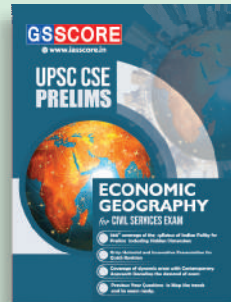
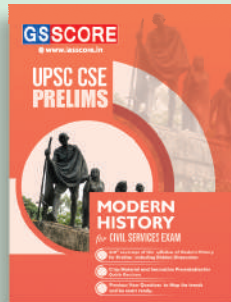
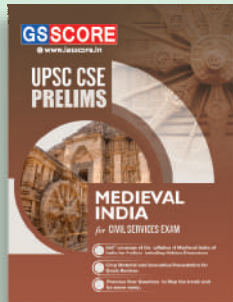
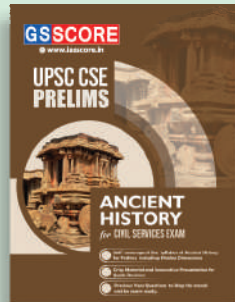
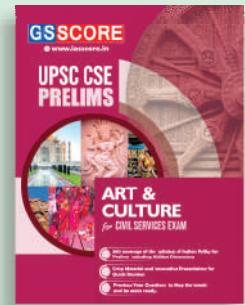
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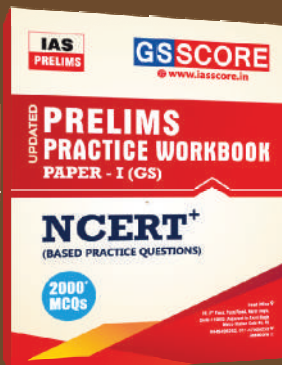
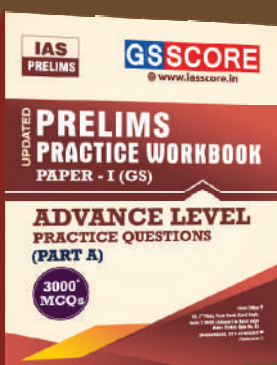
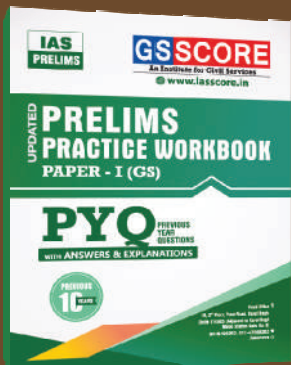
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# **ENVIRONMENT**

## **(VOL: I)**

### *for* **UPSC PRELIMS**

**First Edition 2022**

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**Published and Distributed by:**

**Basix Education PVT. LTD**

8/3, 2<sup>nd</sup> Floor, Abdul Aziz Road (Near PNB Bank)

Karol Bagh, New Delhi, Delhi -110005

All disputes will be subject to Delhi jurisdiction.

# Preface

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In the last decade Environment and Ecology has created a niche for itself. Every year at least 8-10 questions are asked in prelims examination. 8-10 questions can be a game changer and hence one should focus on not getting these questions wrong. For this purpose, the present book has been written in two parts in order to provide a holistic coverage of the syllabus. We have also assimilated previous Year questions in the book in order to keep the preparation as per the UPSC framework.

The part I of the book comprises of Topics related to Ecology and Ecosystem, Functions of an Ecosystem, Population Ecology, Interaction and Adaptation of Species, Types of Ecosystems, Nutrient Cycling, Biodiversity, Biodiversity Conservation, Estuaries, Mangroves, and Wetlands, Coral Reefs, and Forest Resources, etc. All these topics and their subtopics have been comprehensively covered under the book.

One of the distinguishing characteristics of the book is that it covers a wide canvas of Environment. The text of the book has been written in a lucid, cogent, and convincing style, documented with interesting data, diagrams, and illustrations with apt and appropriate examples. The material covers all important and relevant facts and material required to be studied by aspirants in a single booklet. This helps to ease their preparation and provides consolidated and complete UPSC notes at one place.

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**UNIT**  
**1**

**ECOLOGY**  
**& ECOSYSTEM**

# ORIGIN OF LIFE FORMS

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## ■ Evolution of Earth

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- Geologists estimate that the earth is somewhat **4.5 billion year old**.
- The beginning of geological era, the Precambrian, which extended from **4.5 to 0.5 billion** year's ago, witnessed the production of an atmosphere and a hydrosphere. The evolution of preliving components and their autotrophic life takes place thereafter.
- The internal reorganization of Earth and the development of ocean basins and continents took place simultaneously.
- On the whole over the years of the geological past, the Earth's geomorphology, climate and biotic community changed gradually. In early Paleozoic era (just after Precambrian) some million years ago, there were separate land masses existed in earth viz Asia, North America and Europe and Gondwanaland (which includes present day Africa, South America, Australia, New Zealand and Antarctica).
- During late Palaeozoic era around **420 million** years ago, North America and Africa lay close together around the south pole and the rest of Gondwanaland lay on the far side of the south pole, pointing towards the equator. Subsequently such land mass slowly moved northward by carboniferous period (**340 millions years ago**).
- During the Permian periods, however, all three blocks of land masses joined together forming a single landmass called "**Pangaea**", which further moved north ward, and began to break apart slowly by mid Mesozoic period.
- Subsequently, by the mid-cretaceous (about 100 million years ago), Africa and South America had split apart and also by the end of cretaceous period, Gondwanaland had broken up. But North America land remained intact till lower Eocene period.
- Then it split into North America and Europe connected by Greenland and Scandinavia. Thus the formation, breakup and northward drift of continents resulted in broad climate changes and the formation of geological barriers that affected evolving plant and animal's life.

## ■ Origin of Life Forms

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- Aerobic life cannot exist without oxygen, which was not a part of the original atmosphere. However, life in the form of primeval bacteria and algae evolved without oxygen; these life-forms consumed carbon dioxide and nitrogen, which were in the original atmosphere, and emitted oxygen as a waste.
- In addition to adding oxygen to the atmosphere, this process also formed the ozone layer, which filters out harmful ultraviolet radiation from the sun. The first life-forms evolved in the seas.
- As indicated in Table, there is evidence of life-forms as early as **3,500 mya**, of an **ozone layer 2,500 mya**, and of a **breathable oxygenated atmosphere 1,700 mya**. Such early life-forms were not affected by the absence of an ozone layer because they lived below the surface of the water.

- Oxygen-breathing life, initially single and later multi-celled, appeared following the creation of a suitable atmosphere. **Soft-bodied** animals, comparable to jellyfish, evolved **650 mya**, and **shelled animals** about **70 million years** later.
- Human ancestors diverged from the **ape line** approximately **6 mya**. The most compelling evidence of a common origin is that humans and chimpanzees differ in only about 1 per cent of their genes; this means that these species could not have been evolving separately for more than about 6 million years.

Eons	Era	Period	Epoch	Age/Years Before Present	Life/Major Events	
	<b>Cainozoic</b> (From 65 million years to the present times)	Quaternary	Holocene	0 - 10,000	Modern Man	
			Pleistocene	10,000 - 2 Million	Homo Sapiens	
		Tertiary	Pliocene	2 - 5 Million	Early Human Ancestor	
			Miocene	5 - 24 Million	Ape: Flowering Plants and Trees	
			Oligocene	24 - 37 Million	Anthropoid Ape	
			Eocene	37 - 58 Million	Rabbits and Hare	
			Palaeocene	57 - 65 Million	Small Mammals: Rats - Mice	
	<b>Mesozoic</b> 65-245 Million	Cretaceous		65 - 144 Million	Extinction of Dinosaurs	
		Jurassic		144 - 208 Million	Age of Dinosaurs	
		Triassic		208 - 245 Million	Frogs and turtles	
	<b>Palaeozoic</b> 245 - 570 Million	Permian		245 - 286 Million	Reptile dominate-replace amphibians	
		Carboniferous		286 - 360 Million	First Reptiles: Vertebrates: Coal beds	
		Devonian		360 - 408 Million	Amphibians	
		Silurian		408 - 438 Million	First trace of life on land: Plants	
		Ordovician		438 - 505 Million	First Fish	
		Cambria		505 - 570 Million	No terrestrial Life: Marine Invertebrate	
	<b>Proterozoic</b>	<b>Pre Cambrian</b> 570 Million - 4.800 Million			570 - 2,500 Million	Soft-bodied arthropods
	<b>Archean</b>				2,500 - 3,800 Million	Blue green Algae: Unicellular bacteria
<b>Hadean</b>	3,800 - 4,800 Million				Oceans and Continents form - Ocean and Atmosphere are rich in Carbon dioxide	

<b>Origin of Stars</b>	5,000 - 13,700 Million			5,000 Million	Origin of the sun
<b>Supernova</b>				12,000 Million	Origin of the universe
<b>Big Bang</b>				13,700 Million	

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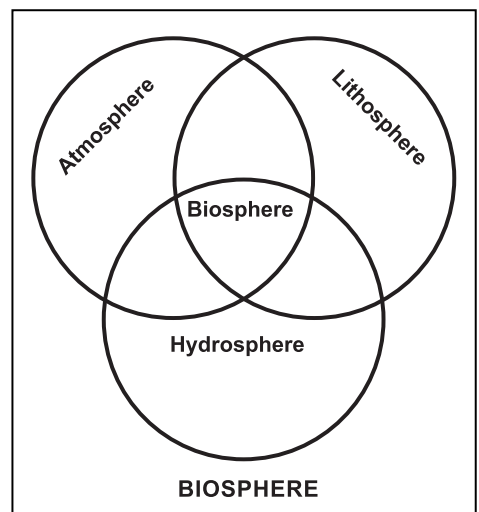
# ECOLOGY & ECOSYSTEM

## ■ Environment

- The environment is defined as 'the sum total of living, nonliving components; influences and events, surrounding an organism'.
- Everything that surrounds or affects an organism during its life time is collectively known as its environment which comprises both living (biotic) and nonliving (abiotic) components.
- **Components of Environment:**
  - ▶ Abiotic Components: Soil, Topography, Water, Atmosphere etc.
  - ▶ Biotic Components: Green Plants, Non-Green Plants, Animals, Parasites, Decomposers etc.
  - ▶ The environment is not static. Both biotic and abiotic factors are in a flux and keeps changing.

## ■ What is Biosphere?

- Biosphere is the life supporting layer which surrounds the earth and makes existence of life possible without any protective layer.
- The biosphere consists of living organisms, physical environment and energy. It is the zone of assemblage of lithosphere, atmosphere, hydrosphere and living organisms together.
- There are three components of biosphere, are:
  - ▶ **Biotic or organic components:** It includes micro- organisms, plants and animals including man.
  - ▶ **Inorganic or abiotic component:** It includes physical environment of soil, water, air, temperature and sunlight.
  - ▶ **Energy component:** Solar and geothermal energy etc.
- Biosphere is termed as an open system as there is continuous inward and outward flow of energy and matter.
- Biosphere always tends to maintain an equilibrium between flow of energy and output of the matter. If this equilibrium is maintained environmental and ecological balances are also maintained. Disturbances in the biosphere equilibrium bring ecological and environmental disturbances which have long term or short term effects on the very existence of living beings.
- Biosphere is affected and modified by certain factors directly or indirectly. These factors are called as **modifiers**. Three types of biosphere modifiers are known:



- ▶ **Physical modifiers:** They affect the biosphere by change in air quality, air flow, temperature changes, water flow, fire, excavation and construction works.
- ▶ **Chemical modifiers:** It alters the chemical composition of air, water and soil. It may be brought in due to multitude of pollutants.
- ▶ **Biological modifiers:** Biological factors like cropping patterns, population pressures, manipulations of species density or distribution and species genetics can also modify the biosphere equilibrium.

## ■ What is Ecology?

- Ecology deals with the inter-relationships amongst organisms and interactions between organisms and their environment. In other words, Ecology is the study of organism in relation with the surrounding in which they live. The surrounding is the environment of the living organisms and nonliving things in the vicinity.
- The term Ecology is being derived from two Greek words namely, '**Oikos**' meaning **home or place to live in** and '**logos**' means **study**. It means the study of the home of nature.

### Difference between Ecology, Environment and Ecosystem

- **Ecology** is the scientific study of the reciprocal relation between organisms, including microbes, plants, animals as well as man, with their environment.
- The term **Environment** is defined as "the sum total of living, nonliving components; influences and events, surrounding an organism".
- The complex natural organisation with their living and non-living environments that controls them and from which the living organisms derive their sustenance are technically called as '**Ecosystem**' or an '**ecological system**'.

### ○ Types of Ecology

- ▶ **Autecology/Species Ecology:** The study of reciprocal relationships between every stage of development of a population/species and its environment is called autecology.
- ▶ **Synecology:** It is the study of reciprocal relationships between composition, organization and development of communities and their environment. Synecology is further divided into following:
  - ▶ **Population Ecology:** Study of interactions of individuals- population of single species with each other.
  - ▶ **Community Ecology:** The study of inter-relationships and inter-dependencies of groups of individuals of distinct species of plants, animals and micro-organisms together.
  - ▶ **Biome Ecology:** The study of interactions and interrelationships of more than one biological communities in various stages of succession under similar climatic condition of the area concerned in the study.
  - ▶ **Ecosystem Ecology:** The study of interactions and inter-relationships of all organisms among themselves and with their environment.
  - ▶ **Habitat Ecology:** Habitat is an ecological area which is inhabited by a species of living being. Habitat ecology studies variation in habitats in terms of their physical characteristics like topography, soils, insolation, temperature, water, minerals, weather and climate etc. Habitat ecology is further divided on the basis of different habitats and their mutual relationship with their inhabitants into forest ecology, grassland ecology, fresh water ecology, estuarine ecology, island ecology, marine ecology, coral reef ecology etc.

- ▶ **Applied Ecology:** It is the study of specialized field of ecology which are concerned with conservation and economic exploitation of organisms e.g., agronomy, agriculture, animal husbandry, forestry, wildlife management, conservation ecology, pollution ecology.
- ▶ **Systems Ecology:** Branch of ecology dealing with interpretation of ecological concepts and processes in terms of mathematical models and formulae.
- ▶ **Genecology:** Study of genetic composition and changes in relation to the origin of ecotypes, new species, etc.
- ▶ **Social Ecology:** It is a critical social theory of American socialist **Murray Bookchin**. It advocates a constructive and transformative outlook on current social and environmental issues. It suggests that the roots of the current ecological and social problems can be traced in the unordered modes of social organization. It says that apart from the natural disasters, majority of the concurrent ecological dislocations have ethnic, economic, cultural and gender conflicts among others. It also says that the present ecological problems cannot be resolved without dealing with the problems of society.

## ◉ Levels of Organisations in Ecology

### ▶ Individual (Organism):

- It is the basic unit of ecological hierarchy.
- Every individual functions separate from those in other individuals. It continuously exchanges materials and information with its environment.
- New individuals develop from pre-existing ones. Hereditary characters are transferred during this process. The constituents of an individual cannot survive independently.

### ▶ Population:

- It is a grouping of similar individuals in a geographical area or space during specific time.
- The different populations of the same organism present in any geographical area are called **local populations/ demes**.
- A local population adapted genetically to its environment is called **ecotype**. There may be several ecotypes of the same organism which show variations amongst them.

## ◉ Biological or Biotic Community:

- ▶ It is an assemblage of populations of distinct species of plants, animals, bacteria and fungi which live in a particular area and interact with one another through several positive and negative interactions among them.
- ▶ Each biotic community has a specific composition and structure, e.g., pond community.
- ▶ On the basis of size and degree of relative independence communities may be divided into two types: Major Communities and Minor Communities.
  - **Major Communities:** These are large sized, well organized and relatively independent. They depend only on the sun's energy from outside. Eg: Tropical evergreen forests.
  - **Minor Communities:** These are dependent on neighbouring communities and are often called societies. They are secondary aggregations within a major community and therefore are not completely independent. Eg: A mat of lichen on a cow dung pad.

## ◉ Ecosystem:

- ▶ It is a segment of nature consisting of a biological community and its physical environment both interacting and exchanging materials as well as energy, e.g., pond ecosystem.

◉ **Biome:**

- ▶ A large regional unit delimited by a specific climatic zone, having a particular major vegetation zone and its associated fauna, e.g., tundra desert, temperature deciduous forest, tropical rain forest, ocean.
- ▶ **No two biomes are alike.** The climate determines the boundaries of biomes and abundance of plants and animals found in each one of them. The most important climatic factors are temperature and precipitation.

◉ **Biosphere:**

- ▶ It is biologically inhabited part of earth along with its physical environment consisting of lower atmosphere, land and water bodies.

**UPSC CSE PRELIMS, 2017**

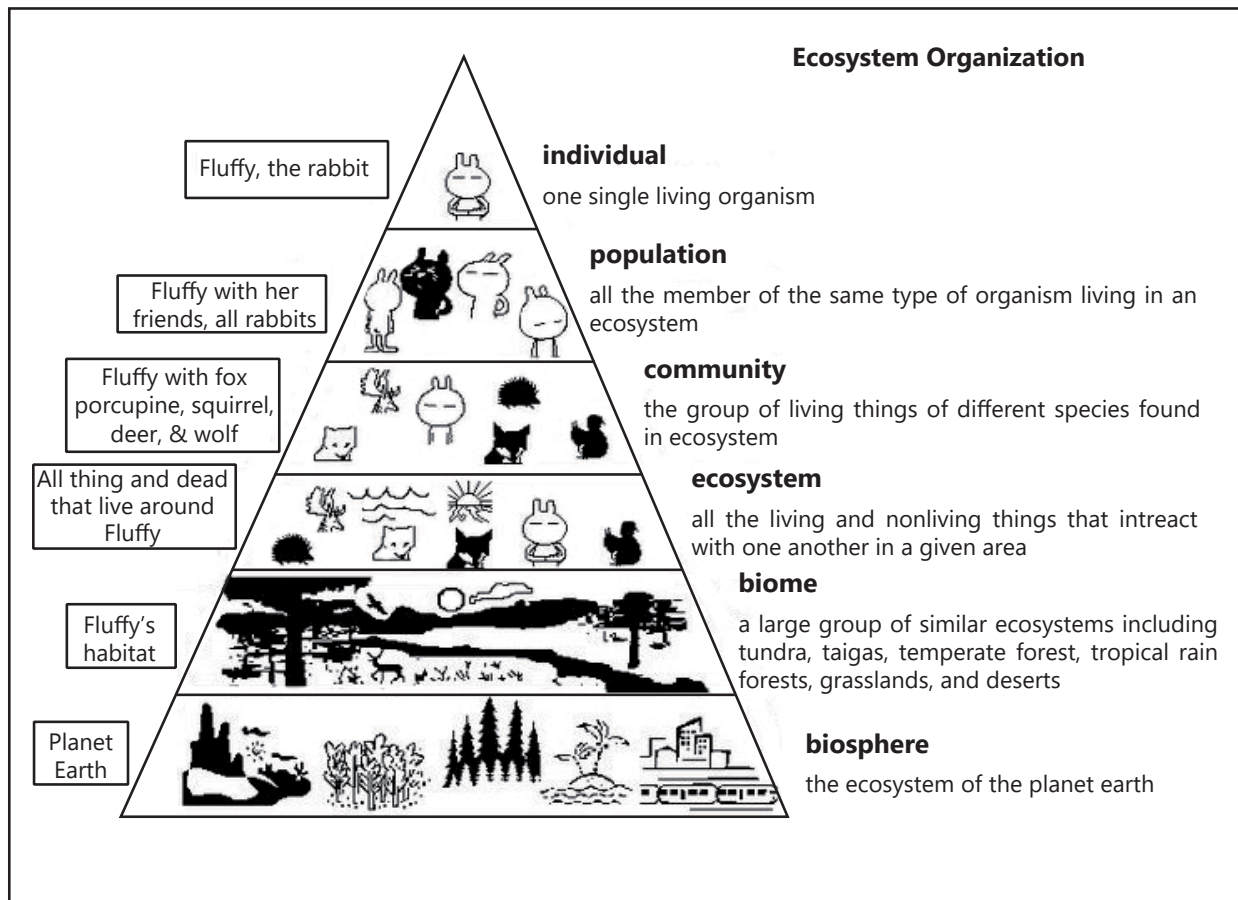
**Q1: Which one of the following is the best description of the term "ecosystem"?**

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

**Correct Option: (c)**

**What is Ecosystem?**

- ◉ An ecosystem is defined as a structural and functional unit of biosphere consisting of community of living beings and physical environment, both interacting and exchanging materials between them. Ecosystem is a self-contained, dynamic system composed of a natural community along with its physical environment.



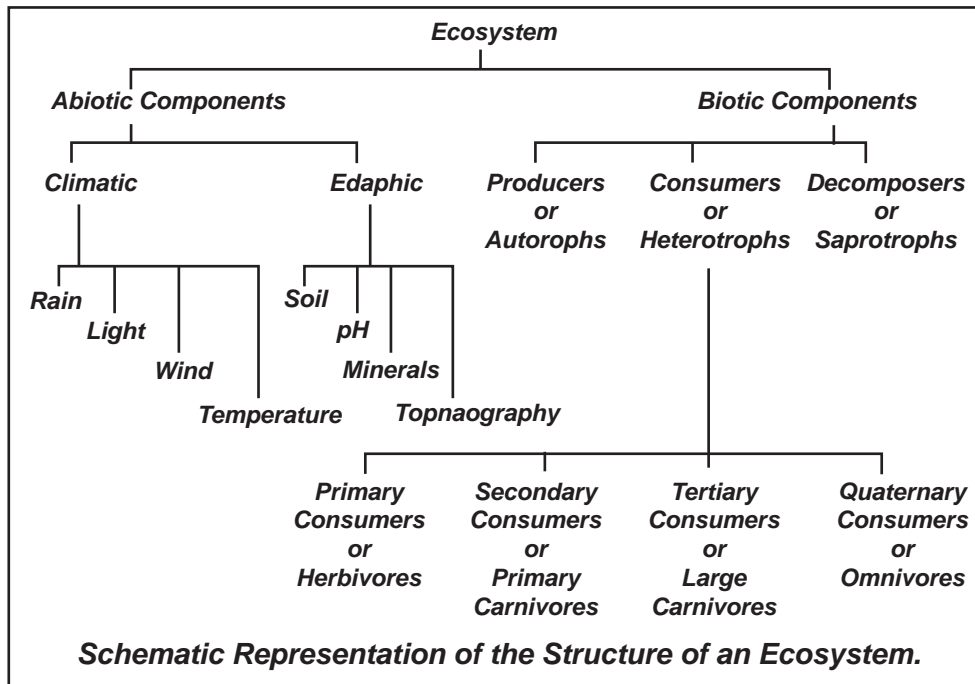


## ○ Classification of Ecosystem:

- ▶ **Terrestrial ecosystems:** Forest, grassland and desert are some examples of terrestrial ecosystems
- ▶ **Aquatic ecosystems:** Pond, lake, wetland, river and estuary are some examples of aquatic ecosystems.
- ▶ **Human-made ecosystems:** Crop fields and an aquarium are human-made ecosystems.

## ○ Components of Ecosystem

- ▶ The components of the ecosystem are divided as:



### ▶ Abiotic Components

- Abiotic components are non-living chemical and physical factors on an ecosystem. The non-living factors are either resources or conditions. Important abiotic components can be listed as follows:
- **Physical factors:** They sustain and limit the growth of organisms in an ecosystem.
  - ♦ **Light:** Light energy (sunlight) is the primary source of energy in nearly all ecosystems. It is the energy that is used by green plants (which contain chlorophyll) during the process of photosynthesis; a process during which plants manufacture organic substances by combining inorganic substances.
  - ♦ **Temperature:** The distribution of plants and animals is greatly influenced by extremes in temperature.
  - ♦ **Water:** The life on earth originated in water and is unsustainable without water.
  - ♦ **Atmospheric gases:** The most important gases used by plants and animals are oxygen, carbon dioxide and nitrogen. Oxygen is used by all living organisms during respiration. Carbon dioxide is used by green plants during photosynthesis. Nitrogen is made available to plants by certain bacteria and through the action of lightning.
  - ♦ **Soil:** Various characteristics of the soil such as soil composition, grain size and aggregation determine the percolation and water holding capacity of the soils. These characteristics along with parameters such as pH, mineral composition and topography determine to a large extent the vegetation in any area. This in turn dictates the type of animals that can be supported.

- **Organic compounds:** They are the building blocks of living systems and therefore, make a link between the biotic and abiotic components. Examples are: Carbohydrates, proteins, lipids and humic substances.
- **Inorganic compounds:** Such as carbon, carbon dioxide, sulphur, nitrates, phosphates and ions of other metals are necessary for survival.

► **Biotic Components**

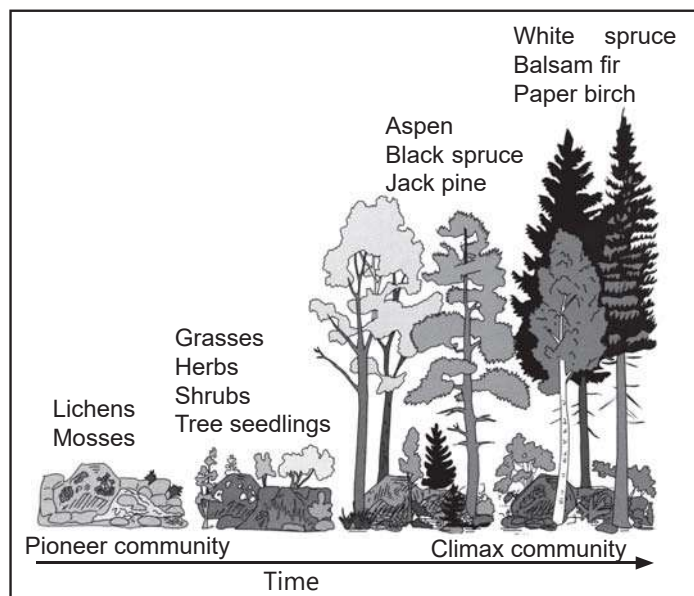
- The biotic components in an ecosystem include the living organisms. They are grouped into 3 classes based on the organism's role in the flow of material and energy within the ecosystem:
- **Producers (Autotrophs):**
  - ◆ Autotrophs produce organic compounds from carbon dioxide as a carbon source. They take energy from the sun (or from inorganic sources in some cases) to convert it into organic molecules or food, e.g., plants, algae, bacteria, etc.
  - ◆ A portion of food synthesized, is used by autotrophs for their growth and other biological functions and remaining is stored for future use. This stored food in autotrophs is utilized as food by other organisms (called heterotrophs).
- **Consumers (Heterotrophs):**
  - ◆ They are called heterotrophs and they consume food synthesized by the autotrophs. Based on food preferences they can be grouped into three broad categories:
    - » Herbivores (e.g. cow, deer and rabbit etc.) feed directly on plants, carnivores are animals which eat other animals (eg. lion, cat, dog etc.) and omnivores organisms feeding upon both plants and animals e.g. human, pigs and sparrow.
- **Decomposers:**
  - ◆ Decomposers are organisms (often fungi or bacteria) that break down organic materials to gain nutrients and energy. Decomposition is a natural process but decomposers accelerate it. The role that decomposers perform in an ecosystem is extremely important.
  - ◆ When an organism dies, it leaves behind nutrients that are locked together.
  - ◆ Decomposers unlock these nutrient and release as raw nutrients (such as nitrogen, phosphorus, and magnesium) in a form which are usable for plants. Decomposers also convert organic carbon into Carbon dioxide, which can be trapped by photosynthesizers.

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## ■ Ecological Succession

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- **Ecological Succession** is the process by which a natural community moves, through a sequential change in the structure and composition, from a simpler level of organization to a more complex community.
- Succession is a long-term cumulative, directional and largely predictable process of natural development of different communities at the same site in a definite sequence over a period of time. Such changes occur either in response to an environmental change or induced by the intrinsic properties of the community itself.



- Succession continues till a community develops maximum equilibrium to the environment. It is called **Climax Community**.

## Features of Succession

- Succession is characterised by the following: increased productivity, the shift of nutrients from the reservoirs, increased diversity of organisms with increased niche development, and a gradual increase in the complexity of food webs.

## Types of Succession

- Ecological Successions have been described using several criteria. Accordingly, there are several types of succession.

### Autogenic and Allogenic Succession

- When succession is brought by living inhabitants of that community is called Autogenic Succession, while changes brought by outside forces is known as Allogenic Succession.

### Induced Succession

- Man has controlled succession in such a way as to obtain a managed steady state in which good amount of organic matter can be harvested. It is called induced succession. In induced succession, like agriculture, a young state is maintained by various types of inputs and protective measures.

### Deflected Succession

- It is a succession in which the vegetation does not pass through the normal stages of development but either adds or replaces a succession type, e.g., ABB'CDE or AB'CDE instead of the normal ABCDE.

### Primary Succession

- It is the succession that takes on a primary bare area or an area which was not previously inhabited by plants. Such an area is biologically sterile and is, therefore, quite hostile in starting. Succession is also slow.

### Secondary Succession

- It occurs on a site which has become bare secondarily due to destruction of previous vegetation. The area is biologically fertile and hence favourable for reappearance of plant life. Succession is quite rapid.

### Autotrophic and Heterotrophic Succession

- Succession in which initially the green plants are much greater in quantity is known as Autotrophic Succession; and the ones in which the heterotrophs are in greater in quantity is known as Heterotrophic Succession.

### Cyclic Succession

- A pattern of succession where the climax community is destroyed again and again and a similar pattern of secondary succession repeats itself every time.

Primary Succession	Secondary Succession
Begins with no life	Follows removal of existing biota
No Soil present	Soil already present
New area (e.g. volcanic island)	Old area (e.g. following a bush fire)
Lichen and moss come first	Seeds and roots already present
Biomass is low	Biomass is higher

## o The Process of Succession

- o The characteristic sequence of the successional stages includes 8 elementary processes, namely:

- ▶ **Nudation**

It is the creation of bare area. Nudation can occur due to physiographic, climatic or biotic agents.

- ▶ **Migration**

- Migration starts when gemmule moves from the parent area and arrive in a new area. A gemmule consists of reproductive structure like seed, spore or propagule. Migration is influenced by four factors—mobility, agent, distance and topography.

- ▶ **Colonization**

- The nature of topography of the bare area also determines the type of the initial vegetation. For example, on bare rock only the spores of some cyanophytes or the soredia of lichens can stick and germinate while in a saline area only the seeds of some halophytes can grow. The first arrivals in a bare area are called **Pioneers** or **pioneer colonizers**. The occupation of a bare area by the pioneers and other invaders is called **colonization**.

- ▶ **Ecesis**

- The establishment of plants in a new place is called **ecesis**. It consists of three processes- germination, growth and reproduction.

- ▶ **Aggregation**

- It is the increase in number of the colonizing individuals. In the beginning the pioneers are few in number and grow far from one another. They produce a large number of disseminules which spread in the open areas and increase the number of pioneers. If invasion continues and the invaders are also able to multiply, the phenomenon is called **Mixed Aggregation**.

- ▶ **Competition**

- It may be intra-specific (among individuals of the same species) or inter-specific (among individuals of the different species). Competition occurs when the availability of a necessity becomes inadequate to meet the optimum requirement of all the individuals growing in that area.

- ▶ **Invasion**

- Various other types of plants try to establish in the space left by the elimination of plants due to competition.

- ▶ **Reaction**

- It is the change brought about by colonizers in the habitats. The first reaction is localized. It consists of such changes as bindings of soil particles, assisting in weathering or building soil at the bottom of a water reservoir. Death of roots produces channels in the soil for quick absorption of rain water. Humus produced by the death of older or weak plants increases water retention, aeration and nutrition of the soil. The reaction of the early colonizers is such as to make the habitat less favourable to them and more favourable to invaders.

- ▶ **Stabilization**

- Continuous competition invasion and reaction give rise to continuous changes in the environment and structure of vegetation. After a long interval some individuals arise which are in complete harmony with the climate of the area. This is termed as stabilization.
- The sequence of the above stages is termed as **seres**.
- Depending upon the nature of the habitat on which the plant succession begins seven types of seres may be distinguished:
  - 1. **Hydrosere**, 2. **Xerosere**, 3. **Lithosere**, 4. **Psammose**, 5. **Halosere**, 6. **Senile**, 7. **Eosere** or **Geosere**

## ■ Ecotone

- An ecotone is a zone of junction or a transition area between two biomes (diverse ecosystems). It is the zone where two communities meet and integrate. For e.g. the mangrove forests represent an ecotone between marine and terrestrial ecosystem.
- **Characteristics of Ecotone:**
  - ▶ It may be narrow (between grassland and forest) or wide (between forest and desert).
  - ▶ It has conditions intermediate to the adjacent ecosystems. Hence it is a zone of tension.
  - ▶ It is linear as it shows progressive increase in species composition of one in-coming community and a simultaneous decrease in species of the other out-going adjoining community.
  - ▶ A well-developed ecotone contains some organisms which are entirely different from that of the adjoining communities.
  - ▶ Sometimes the number of species and the population density of some of the species are much greater in this zone than either community. This is called edge effect.
  - ▶ The organisms which occur primarily or most abundantly in this zone are known as edge species. In the terrestrial ecosystems edge effect is especially applicable to birds. For example, the density of birds is greater in the ecotone between the forest and the desert.

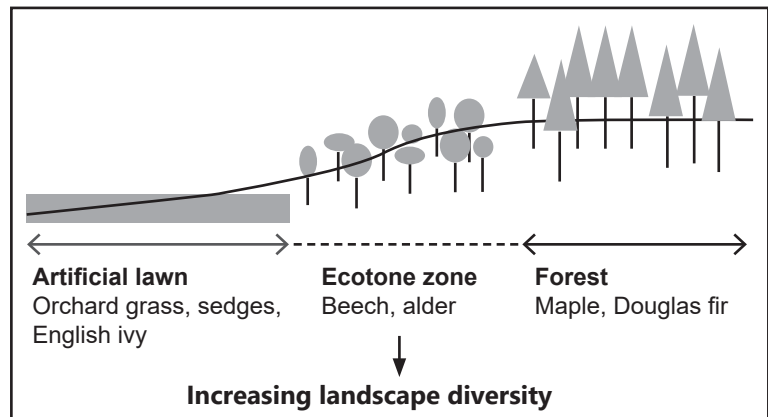
### Edge Effect

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.
- ▶ 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**.

### ○ Ecocline

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



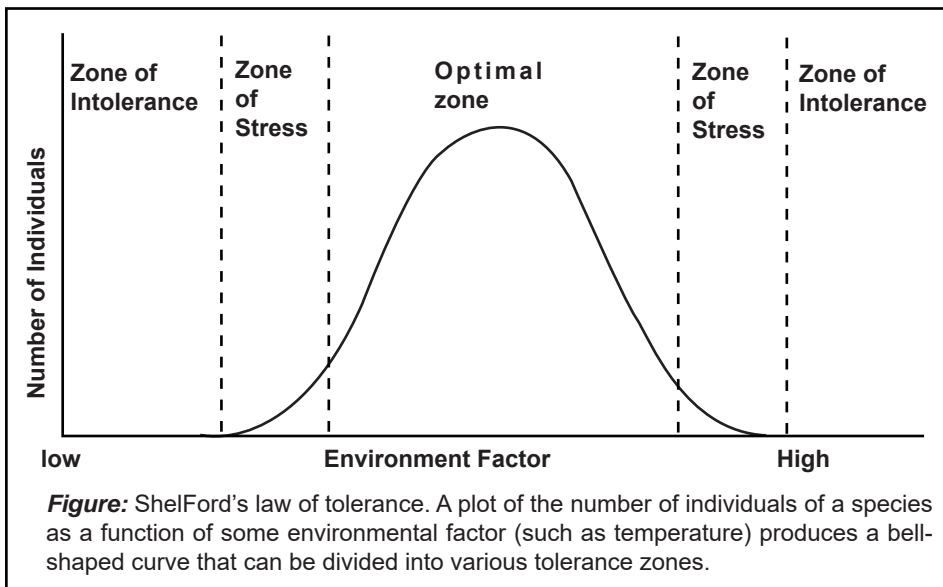
### ○ Niche

- ▶ It refers to the unique functional role and position of a species in its habitat or ecosystem.
- ▶ The functional characteristics of a species in its habitat are referred to as "niche" in that common habitat.
- ▶ In nature, many species occupy the same habitat, but they perform different functions:

- Habitat niche – where it lives,
  - Food niche – what it eats or decomposes & what species it competes with,
  - Reproductive niche – how and when it reproduces,
  - Physical & Chemical niche – temperature, land shape, land slope, humidity & another requirement.
- ▶ Niche plays an important role in the conservation of organisms. If we have to conserve species in its native habitat, we should have knowledge about the niche requirements of the species.

### Range of Tolerance (Maximum Range)

- ▶ A factor that limits growth, development, reproduction or activity of an organism by its deficiency or excess is called **limiting factor** while the unfavourable impact of limiting factor is called **limiting functions**. Low temperature is a limiting factor for growth at high altitude, water availability in deserts and low phosphorus for phytoplankton growth in deep lakes.
- ▶ **Range of tolerance** is the range between critical minimum and critical maximum limits of environmental factor/factors influencing an organism.
- ▶ According to law of tolerance, the abundance and distribution of organisms is controlled by their limits of tolerance (critical minimum and critical maximum) to ecological factors.



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**FUNCTIONS  
OF AN  
ECOSYSTEM**

# FUNCTIONS OF AN ECOSYSTEM

- The function of an ecosystem is a broad, vast and complete dynamic system. It can be studied under the following three heads:
- Energy flow
- Nutrient cycling (Biogeochemical cycles)
- Ecological succession or ecosystem development.

## ■ Energy Flow

- Energy is the basic force responsible for all metabolic activities. The flow of energy from producer to top consumers is called energy flow which is unidirectional.
- Energy flows through the trophic levels: from producers to subsequent trophic levels.
- There is a loss of some energy in the form of unusable heat at each trophic level.
- The trophic level interaction involves three concepts namely:
  - ▶ Food Chain
  - ▶ Food Web
  - ▶ Ecological Pyramids

### ◦ Food Chain

- ▶ The **unidirectional transfer** of food energy from the producers, through a series of organisms (herbivores to carnivores to decomposers) with repeated eating and being eaten, is known as **food chain**. It is the movement of organic matter and energy from the producer level through various consumer levels.
- ▶ The various steps in a food chain are called **trophic levels** and transfer of energy in term of food from one trophic level to another is called **energy flow**. Energy flow is always unidirectional.

## UPSC CSE PRELIMS, 2013

**Q1: With reference to food chains in ecosystems, consider the following statements:**

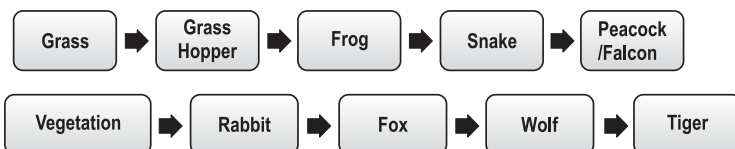
1. A food chain illustrates the order in which a chain of organisms feed upon each other
2. Food chains are found within the populations of a species
3. A food chain illustrates the numbers of each organism which are eaten by others

Which of the statements given above is/are correct?

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

**Correct Option: (a)**

### Examples of Some Common Food Chains



### Food Chains in Water (Pond)



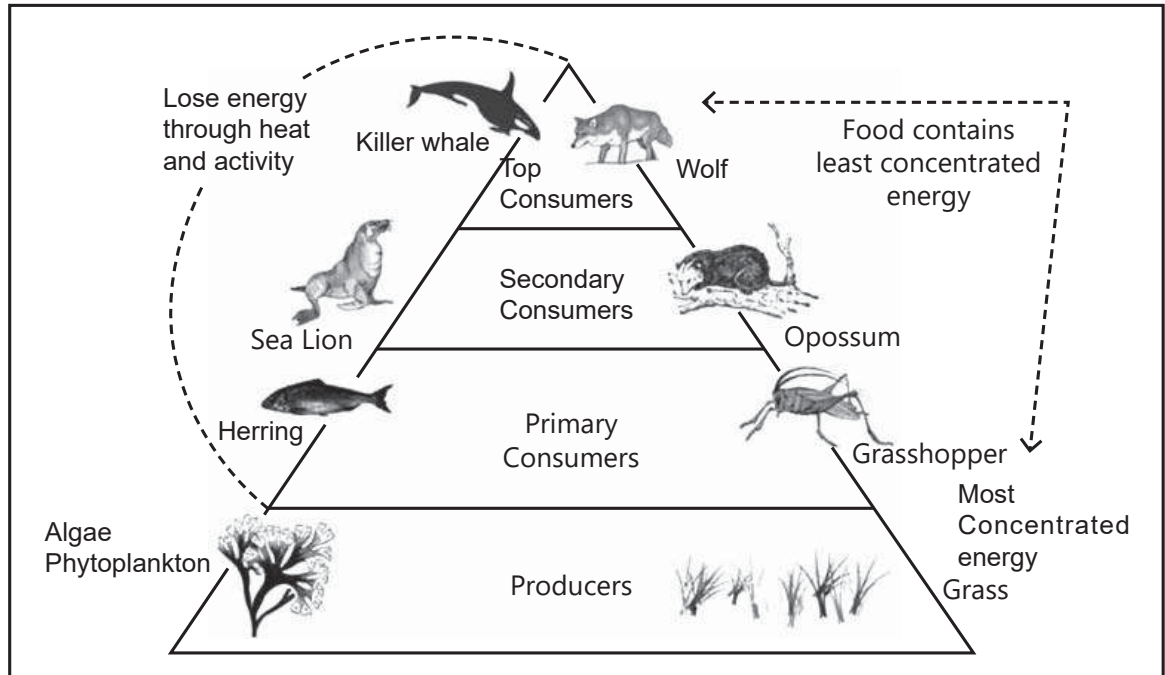


## ◉ Types of Food Chains

### ► Grazing Food Chain

It is the most common food chain. It is also called predator food chain as predation occurs at every step.

- The consumers which start the food chain, utilizing the plant or plant part as their food, constitute the grazing food chain. This food chain begins from green plants at the base and the primary consumer is herbivore.



### ► Detritus Food Chain

- It begins with detritus or dead organic matter.
- The food energy present in detritus passes into detritivores and decomposers who feed over it.
- Detritivores and decomposers are consumed by smaller carnivores which in turn become food for larger carnivores and so on.
- **Examples of detritivores are :** Earthworms, Jellyfish, Seahorse, Woodlice, Mites etc.

## UPSC CSE PRELIMS, 2021

**Q1: Which of the following are detritivores?**

1. Earthworms
2. Jellyfish
3. Seahorse
4. Woodlice

Select the correct answer using the code given below

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

**Correct Option: (c)**

## LEVELS OF FOODCHAIN

- ▶ The distinction between these 2 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 detritus food chain the source of energy is dead organic matter or detritus.
- ▶ The 2 food chains are linked. The initial energy source for detritus food chain is the waste materials and dead organic matter from the grazing food chain.
- ▶ There could be four different types of consumers which are herbivore, carnivores, omnivores, and scavengers.
- ▶ Same species can have a different trophic level in two different food chains. It completely depends on all the species included in that food chain.
- ▶ If a single level of a food chain is missing then the whole balance will be lost.
- ▶ Food chains exist not only on land but under water as well. These chains start with a microscopic organism called plankton.
- ▶ **Food-chain efficiency** is the ratio between the energy value (the nutritional value, discounting indigestible parts such as hair or feathers) of prey consumed by a predator and the energy value of the food eaten by that prey. Maximum food-chain efficiency (gross ecological efficiency) occurs when the yield of prey to the predator is such that the surviving prey just consumes all the available food: this implies that the food of the prey is being exploited to the best advantage by the predator.

### ◉ Significance of Food Chain

- ▶ Food chain is significant to represent many ecological dynamic like
- ▶ It helps in understanding the feeding relations and interactions among different organisms of an ecosystem.
- ▶ It explains the flow of energy and circulation of materials in ecosystems.
- ▶ It helps in understanding the concept of biomagnification in ecosystems

### ◉ Flow of Energy in the Food Chain

- ▶ Flow of energy in an ecosystem is always **unidirectional** or one way that is, it passes from solar radiations to producers, then to herbivores and then to carnivores and omnivores. As there is gradual increase in the trophic level of food chain, there is decrease in the content and flow of energy. This happens because:
  - **Approx. 20%** of the energy captured by producers is dissipated in respiration and metabolic activity.
  - Rest energy stored in producers goes down to herbivores in the form of food through food chain.
  - In the herbivores, a lot of the energy assimilated from the food is dissipated in ingestion and digestion of food, respiration and metabolism, body functions, egestion and heat. **Only 10% of this energy** is stored by herbivores in the form of building material of body.
  - Herbivores are eaten by carnivores; the 10% stored energy of herbivores goes down to carnivores. Carnivores dissipate a majority of this assimilated energy in digestion, respiration, body functions and heat. **Only 10% of the energy** is stored in carnivores.
  - Higher carnivores and omnivores are similarly able to store only 10% of the carnivores' energy.
  - Hence flow of energy in a food chain follows a **Ten Percent Law**. This was proposed by **Lindeman in 1942**.

## ◉ Food Web

- ▶ Simple food chains are very rare in nature because each organism may obtain food from more than one trophic level. Thus in an ecosystem, the various food chains are interconnected to each other to form a network called **food web**. The concept of food web was introduced by Charles Elton in 1927.
- ▶ A food web illustrates all possible transfers of energy and nutrients among the organisms in an ecosystem, whereas a food chain traces only one pathway of the food. Food webs are very important in maintaining the stability of an ecosystem.

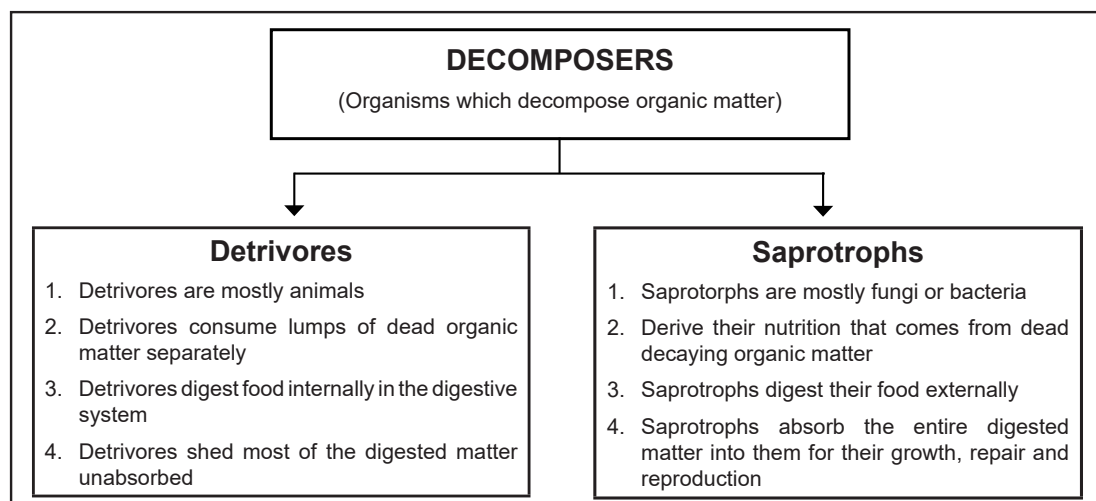
## ◉ Composition of Food Web

- ▶ A food web operates according to food preferences of the organisms at each trophic level. However, availability of food source and other compulsions are equally important. In Sunderbans, the tigers eat fish and crab in the absence of their natural preys.
- ▶ Some organism normally operates at more than one trophic level. Thus human beings are not only herbivores but also carnivores of various levels. Jackals are both carnivores and scavengers. Snakes feed on mice (herbivores) as well as frogs (carnivores). Wild cats prey upon mice as well as birds and squirrels. A wolf eats fox as well as rabbit and deer.

## ◉ Difference between Food Chain and Food Web

Food Chain	Food Web
▶ It is a straight single pathway through which food energy travels in the ecosystems.	▶ It consists of number of interconnected food chain through which food energy passes in the ecosystems.
▶ Members of higher trophic level feed upon a single type of organisms of lower trophic level.	▶ Members of higher trophic level can feed upon a number of alternative organisms of the lower trophic level.
▶ Presence of separate or isolated food chains adds to the instability of the ecosystem.	▶ Presence of food webs increases the stability of the ecosystem.
▶ It does not add to adaptability and competitiveness of the organisms.	▶ Food webs increase adaptability and competitiveness of the organisms.

## Difference between Decomposers: Detritivores and Saprotrophs



## Difference between Producer, Consumer and Decomposer

PRODUCER	CONSUMER
<ul style="list-style-type: none"> <li>Producers are autophyte i.e. they are capable of producing food by the process of photosynthesis.</li> </ul>	<ul style="list-style-type: none"> <li>Consumers are heterophyte i.e. they are not capable of manufacturing their own food and depend on producer for their food.</li> </ul>
<ul style="list-style-type: none"> <li>Producers have chlorophyll, i.e. pigment.</li> </ul>	<ul style="list-style-type: none"> <li>Consumers have no chlorophyll.</li> </ul>
<ul style="list-style-type: none"> <li>Producers entrap the solar energy in their produced food.</li> </ul>	<ul style="list-style-type: none"> <li>Consumers can not entrap the solar energy.</li> </ul>
<ul style="list-style-type: none"> <li>Producers produce oxygen by the process of photosynthesis.</li> </ul> <p><b>Example:</b> Green plant, bacteria (e.g. Euglena, Cryso-meoba etc.)</p>	<ul style="list-style-type: none"> <li>Consumers are not capable of producing Oxygen.</li> </ul> <p><b>Example:</b> Animals (Herbivores, carnivores etc.)</p>
CONSUMER	DECOMPOSER
<ul style="list-style-type: none"> <li>Consumers depend on producer for their food.</li> </ul>	<ul style="list-style-type: none"> <li>Decomposers depend on the dead body of producer and consumer.</li> </ul>
<ul style="list-style-type: none"> <li>Consumers are herbivores and carnivores.</li> </ul>	<ul style="list-style-type: none"> <li>Decomposers are saprophyte.</li> </ul>
<ul style="list-style-type: none"> <li>Consumers take complex food.</li> </ul>	<ul style="list-style-type: none"> <li>Decomposers take simple food.</li> </ul>
<ul style="list-style-type: none"> <li>Consumers are of three types according to their food habit such as Primary consumer, Secondary consumer and Tertiary consumer.</li> </ul> <p><b>Example:</b> Animals etc.</p>	<ul style="list-style-type: none"> <li>Decomposers have not classification like Consumer.</li> </ul> <p><b>Example:</b> Saprophytic bacteria, fungi etc.</p>
PRODUCER	DECOMPOSER
<ul style="list-style-type: none"> <li>Producers are self sufficient in nutrition.</li> </ul>	<ul style="list-style-type: none"> <li>Decomposers depend on dead body of producer and consumers.</li> </ul>
<ul style="list-style-type: none"> <li>Producers produce food by the process of Photosynthesis</li> </ul>	<ul style="list-style-type: none"> <li>Decomposers cannot produce food in their body.</li> </ul>
<ul style="list-style-type: none"> <li>Producers obtain the elements from air and soil necessary for manufacturing food except sunlight.</li> </ul> <p><b>Example:</b> Green plant, some bacteria (e.g. Euglena, Cryso-moeba etc.)</p>	<ul style="list-style-type: none"> <li>Decomposers provide food elements to the producer for manufacturing food.</li> </ul> <p><b>Example:</b> Saprophytic bacteria, fungi etc.</p>

### ◉ Ecological Pyramids

- Ecological pyramids are the graphic representations of trophic levels in an ecosystem. The producers make the base of the pyramid and the subsequent tiers of the pyramid represent herbivore, carnivore and top carnivore levels. They are pyramidal in shape and they are of three types:

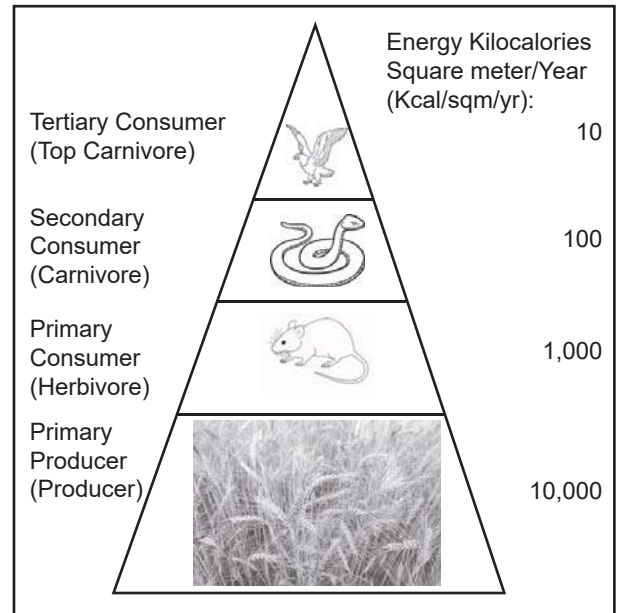
#### ■ Pyramid of Energy

- The pyramid of energy or the energy pyramid describes the overall nature of the ecosystem. During the flow of energy from organism to other, there is considerable loss of energy in the form of heat. The primary producers like the autotrophs there is more amount of energy available. The least energy is available in the tertiary consumers. Thus, shorter food chain has more amount of energy available even at the highest trophic level.

- The energy pyramid always upright and vertical.
- An energy pyramid reflects the laws of thermodynamics with the conversion of solar energy to chemical energy and heat energy at each trophic level and with the loss of energy being depicted at each transfer to another trophic level. Hence the pyramid is always upward, with large energy base at the bottom.

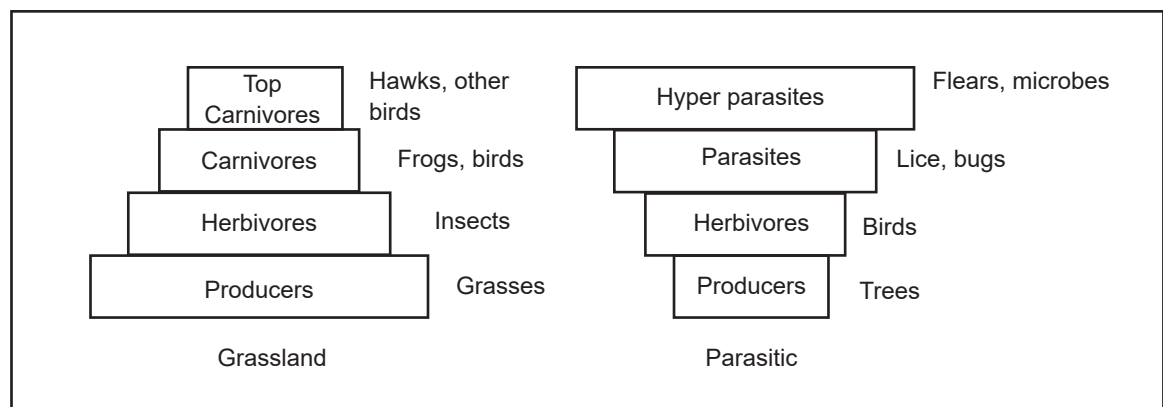
### ■ Pyramid of Numbers

- It is a graphic representation of the number of individuals per unit area of various trophic levels stepwise with producers being kept at the base and top carnivores kept at the tip. In most cases, the pyramid of number is upright with members of successive higher trophic level being less than the previous one.
- The maximum number of individuals occurs at the producer level. The producers support comparatively fewer numbers of herbivores, the latter fewer number of primary carnivores and so on. Top carnivores are very few in number.
- In grassland, a larger number of grass plants or herbs support a fewer number of grasshoppers that support a still smaller number of frogs, the latter still smaller number of snakes and the snakes support very few peacocks or falcons.



**Example: pyramid of numbers**

- A similar case is found in a pond ecosystem where a large number phytoplankton support comparatively smaller number of zooplanktons the latter fewer number of small-sized fishes, the small-sized fishes become food of still fewer larger-sized fishes or water birds.
- The number of pyramids in a higher trophic level is generally smaller than that of the lower trophic level because the organisms of the higher trophic level are dependent for their food and energy on the organisms of the lower trophic level.



**Fig. Grassland and Parasitic Ecosystem**

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

## ■ Pyramid of Biomass

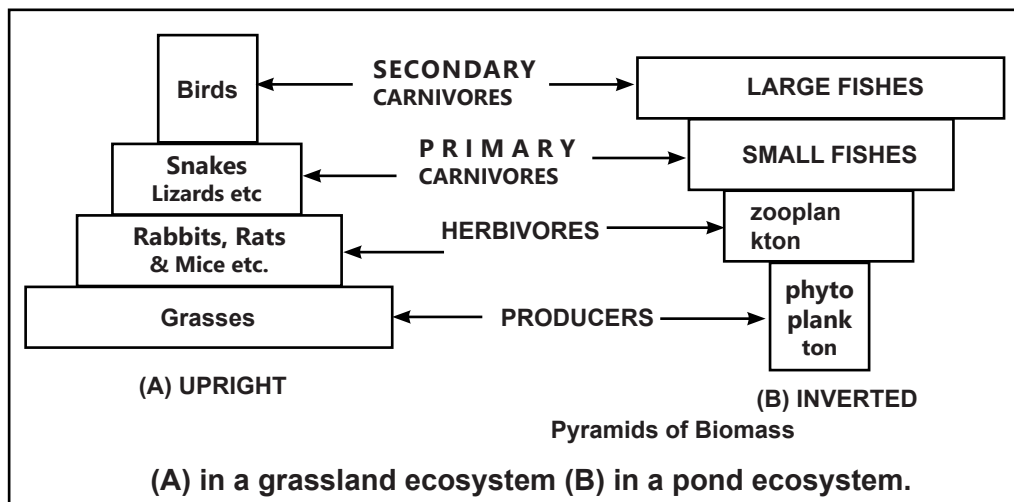
- Pyramid of biomass is usually determined by collecting all organisms occupying each trophic level separately and measuring their dry weight.
- This overcomes the size difference problem because all kinds of organisms at a trophic level are weighed.
- Each trophic level has a certain mass of living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

### ● Pyramid of Biomass – Upright

- For most ecosystems on land, the pyramid of biomass has a large base of primary producers with a smaller trophic level perched on top.
- The biomass of producers (autotrophs) is at the maximum. The biomass of next trophic level i.e. primary consumers is less than the producers. The biomass of next higher trophic level i.e. secondary consumers is less than the primary consumers. The top, high trophic level has very less amount of biomass.

### ● Pyramid of Biomass – Inverted

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



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## ■ Pollutant and Trophic levels

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- Pollutants especially non-degradable ones move through the various trophic levels in an ecosystem.
- Non-degradable pollutants mean materials, which cannot be metabolized by the living organisms.
- Example: chlorinated hydrocarbons.

We are concerned about these phenomena because, together they enable even small concentrations of chemicals in the environment to find their way into organisms in high enough dosages to cause problems.

## o **Movement of these pollutants involves two main processes:**

- ▶ Bioaccumulation
- ▶ Bio-magnification.

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## ■ **Bioaccumulation**

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- o It is the process of accumulation of persistent and toxic substances or chemicals in an organism. It occurs when any substance assimilated by any organism does not get metabolised or egested at the equivalent rate of its absorption. This is usually seen with substances with higher biological self-life like pesticides, insecticides and other persistent non- degradable pollutants. The longer the self-life of the substance, the greater would be the risk poisoning from the substance, even if the level of substance in the surrounding is under control.
- o **Examples of Bioaccumulation**
  - ▶ Accumulation of the mercury used in industrial processes of the stiffening of the hats in the brain cells of humans caused Mercury poisoning.
  - ▶ Accumulation of strontium-90 in the atomic bomb affected areas where it causes problems in bone formation.
  - ▶ Eating of coastal fishes in heavily polluted area can lead to accumulation of heavy metals in the human body.

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## ■ **Biomagnification**

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- o It is a phenomenon of gradual increase in the concentration of chemicals and toxic substances accumulated in the tissues of organisms at successively higher trophic levels of food chain. It refers to a process where persistent pollutants like pesticides and heavy metals move up in the food chain and get accumulated at the top most trophic level of the food chain.
- o **Process of Biomagnification**
  - ▶ Pesticides like DDT and other industrial pollutants like mercury etc. degrade very slowly in the ecosystem, thus these substances remain for a longer time and interfere with the dynamics of food chain.
  - ▶ These substances are washed away from agricultural field or from water bodies and get accumulated on the producers of the food chain.
  - ▶ Since these are slow metabolizing, so they are transferred from one trophic level to other with the biomass.
  - ▶ As in a food chain, the number of individual decrease per trophic level successively so, the net amount of these persistent substances per individual keeps on increasing successively with the higher trophic levels of food chain.
  - ▶ In this way, the maximum bioaccumulation of these persistent pollutants is seen at the top most trophic level of the food chain, this gradual increase in the relative amount of persistent pollutants per individual in any food chain with successive trophic levels is Biomagnification.
  - ▶ The increase in concentration is due to
    - Persistent nature of pollutants
    - Food chain dynamics
    - Slow rate of degradation of certain substances
  - ▶ Due to biomagnification, worst impacts of pollutants are seen in the top most consumers or secondary carnivore or omnivore in a food chain. These top consumers include Humans, Tigers, Vultures etc.

## ◉ Examples of Biomagnification

- ▶ The great **Indian Bengal Vultures** are pushed to extinction due to bioaccumulation and biomagnification of anti-inflammatory Drug Diclofenac. Diclofenac entered in the vulture's food chain from humans and beef industries. Diclofenac is excessively used in Dairies to counter the effects of oxytocin. Oxytocin is a human hormone which helps in child birth and milk production. It is inappropriately used in dairies to induce milking, with extreme abdominal as a side effect. Diclofenac injected frequently in cattle to counter pain gets accumulated in cattle's and is transferred to vultures from beef remains.
- ▶ Maximum accumulation of agricultural pesticide and insecticide DDT, DDE etc. is seen in Humans.

## ◉ Bioaccumulation vs. Biomagnifications

- ▶ The following is a list of some of the differences between both these processes:
- ▶ The first and major difference or points of comparison between these processes is that where on one hand, bioaccumulation is the increase in the concentration of a substance inside an organism, on the other hand, biomagnification is the increase in the level as one goes higher up in the food chain.
- ▶ Another difference between these two processes is that bioaccumulation takes place or occurs within a given tropic level whereas on the other hand, biomagnification takes place between two given tropic levels.

## ◉ Bioconcentration

- ▶ It is the process of accumulation of chemicals or toxic substances dissolved solely in water in any organism. It is useful in toxicology and is determined using parameters like octanol-water partition coefficient, bioconcentration factors and biota sedimentation accumulation factors.

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**UNIT**  
**3**

**POPULATION**  
**ECOLOGY**

# POPULATION ECOLOGY

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- Population ecology is an important area of ecology because it links ecology to population genetics and evolution. A population has certain attributes that an individual organism does not.
  - An individual may have births and deaths, but a population has birth rates and death rates. In a population these rates refer to per capita births and deaths, respectively. The rates, hence, expressed is change in numbers (increase or decrease) with respect to members of the population.
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## ■ Types of Species

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- **Species:** A species is defined as; "a group of similar populations of organisms whose members are capable of interbreeding, and to produce fertile offspring (children)". A tiger, a lion, a lotus and a rose are examples of different species.
- **Speciation:** Speciation is the process by which new species are formed and evolution is the mechanism by which speciation is brought about.

**The species according to their role are divided as:**

### ◦ Dominant Species

- ▶ These are species with substantially higher abundance or biomass than other species in a community. They exert a powerful control over the occurrence and distribution of other species.
- ▶ For example: Tidal swamps in the tropics are usually dominated by species of mangrove (Rhizophoraceae).

### ◦ Keystone Species

- ▶ These are species that is not necessarily abundant in a community yet exerts strong control on community structure by the nature of its ecological role or niche.
- ▶ A keystone species' disappearance would start a **domino effect**. Other species in the habitat would also disappear and become extinct.
- ▶ For example, the population of deer or rabbits would explode without the presence of a predator. The ecosystem cannot support an unlimited number of animals, and the deer soon compete with each other for food and water resources. Their population usually declines without a predator such as a mountain lion.

### ◦ Foundation Species

- ▶ Foundation species play a major role in creating or maintaining a habitat that supports other species.
- ▶ Corals are one example of a foundation species in many islands in the South Pacific Ocean. Corals produce the reef structures on which countless other organisms, including human beings, live.

## ◉ **Umbrella Species**

- ▶ An umbrella species is a large animal or other organism on which many other species depend.
- ▶ Protection of umbrella species is thought to automatically protect a host of other species.
- ▶ Tigers are an example of an umbrella species. Efforts to save wild tigers in forests in the Indian state of Rajasthan also accomplish the goal of saving other species there, such as leopards, boars, hares, antelopes, and monkeys.

## ◉ **Critical Link Species**

- ▶ They are species that play an important role in supporting network species as pollinators, dispersal agents, absorption or circulation of nutrients, etc. Mycorrhizal fungi help the vascular plants in obtaining inorganic nutrients from soil and organic residues.

## ◉ **Flagship Species**

- ▶ Flagship species are species that have the ability to capture the imagination of the public and induce people to support conservation action and/or to donate funds.
- ▶ These are popular, charismatic species that serve as symbols and rallying points to stimulate conservation awareness and action.
- ▶ Flagship species can represent an environmental feature (e.g. a species or ecosystem), cause (e.g. climate change or ocean acidification), organization (e.g. NGO or government department) or geographic region (e.g. state or protected area).
- ▶ Examples of flagship species include the Bengal tiger, the giant panda, Asian elephant (*Elephas maximus*), etc.

## ◉ **Indicator Species**

- ▶ An indicator species is an organism whose presence, absence or abundance reflects a specific environmental condition.
- ▶ Indicator species can signal a change in the biological condition of a particular ecosystem, and thus may be used as a proxy to diagnose the health of an ecosystem.
- ▶ For example, plants or lichens sensitive to heavy metals or acids in precipitation may be indicators of air pollution. Indicator species can also reflect a unique set of environmental qualities or characteristics found in a specific place, such as a unique microclimate.

## ◉ **Edge Species**

- ▶ The species which are found abundantly in ecotone boundary are known as edge species.

## ◉ **Surrogate Species**

- ▶ Surrogate species encompass flagship, indicator, and umbrella species concepts. A surrogate species is substituted into a conservation strategy to represent species or biotas that more poorly understood. Such species provide conservation managers who have limited resources with a shortcut for making decisions on conservation priorities and problems.

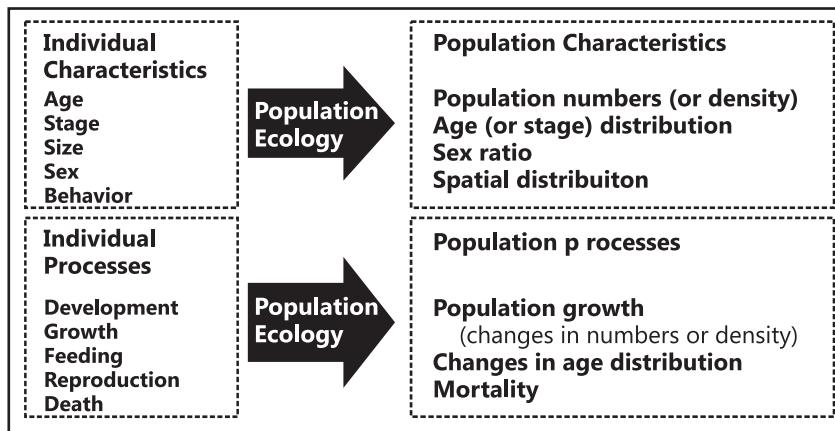
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## ■ **Characteristics of Population**

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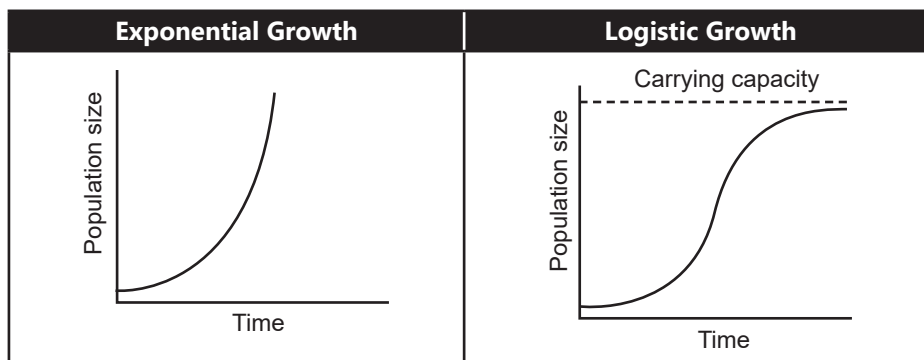
- ▶ Populations have a number of attributes. Different populations can be compared by measuring these attributes. A population has following group characteristics:

- **Density**
  - ♦ The size of population is represented by its density. Density is expressed as the total number of individuals present per unit area or volume at given time. Density varies from time to time and from one area to another. For example, greater density of plants during rainy season as compared to dry season.
- **Natality**
  - ♦ The increase in the number of individuals in a population under given environmental conditions is called natality. Birth, hatching, germination, vegetative propagation, etc are account for natality. When the increase in individuals is expressed per unit time, it is called natality rate.
- **Mortality**
  - ♦ The loss of individuals due to death in a population under given environmental conditions is termed mortality. When the number of individual dying is expressed per unit time, it is called mortality rate.
  - ♦ It is typically expressed in unite of deaths per 1,000 individuals per year.
- **Dispersal**
  - ♦ The majority of organisms dispersed at one time or the other during their life cycles. The individuals move into (immigration) and move out of the population (emigration), and these movements affect the size of the population.
- **Age Distribution**
  - ♦ Various age groups in a population determine its reproductive status. The three ages referred as ecological ages in a population are:
    - » Pre-reproductive
    - » Reproductive
    - » Post-reproductive
  - ♦ Distribution of age groups influences the population growth. Populations with more young members grow rapidly, while the declining populations have a large proportion of older individuals. The age structure in a population is also linked to births and deaths.
- **Sex Ratio**
  - ♦ It is an important aspect of population. It refers to the ratio between female and male individuals in a population.
- **Biotic Potential**
  - ♦ It is the capability for growth of a given population under hypothetical optimum conditions, in an environment without limiting factors for such growth. Under such conditions, the population tends to grow indefinitely.
- **Environmental Resistance**
  - ♦ It is the effect of limiting abiotic and biotic factors that prevent a population from growing as it would normally grow according to its biotic potential. In reality, each ecosystem is able to sustain a limited number of individuals of a given species.
  - ♦ The factors that limit the growth of a population can be divided into biotic factors and abiotic factors. The main abiotic limiting factors are the availability of water and light and the availability of shelter. The main limiting biotic factors are population density and inharmonious (negative) ecological interactions (competition, predatism, parasitism, ammensalism).



## ■ Population Growth Models

- In **exponential growth**, a population's per capita (per individual) growth rate stays the same regardless of population size, making the population grow faster and faster as it gets larger.
- In nature, populations may grow exponentially for some period, but they will ultimately be limited by resource availability.
- In **logistic growth**, a population's per capita growth rate gets smaller and smaller as population size approaches a maximum imposed by limited resources in the environment, known as the **carrying capacity**.
- **Exponential population growth:** When resources are unlimited, populations exhibit exponential growth, resulting in a **J-shaped curve**. When resources are limited, populations exhibit **logistic growth**. In logistic growth, population expansion decreases as resources become scarce. It levels off when the carrying capacity of the environment is reached, resulting in an **S-shaped curve**.



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**UNIT  
4**

**ADAPTATION &  
INTERACTIONS OF  
SPECIES**

# ADAPTATION & INTERACTION OF SPECIES

## ■ Adaptation

- An adaptation is “the appearance or behaviour or structure or mode of life of an organism that allows it to survive in a particular environment”.
- Some adaptations are **structural**. Structural adaptations are physical features of an organism like the bill on a bird or the fur on a bear. Other adaptations are **behavioral**. Behavioral adaptations are the things organisms do to survive. For example, bird calls and migration are behavioral adaptations.

### ◦ Types of Adaptation

- ▶ **Heliophyte:** They are plants adapted to grow in bright light. They have following adaptations to survive:
  - Shorter and thicker internodes
  - Smaller and thicker leaves, leaves are pale green in colour with shining surface or hairy growth
  - Root system is extensive
  - Stomata are small and sunken
- ▶ **Sciophytes:** They are plants adapted to grow in partial shade or low intensity of light. They have following adaptations to survive:
  - Stems are soft
  - Leaves are thin and large sized, they have bright green colour.
  - Cuticle is thin.
  - Stomata are in level with the surface.
- ▶ **Xerophytes:** They are plants adapted to grow in scarcity of water and excess heat. They grow in arid and desert areas. They have following adaptations to survive:
  - Leaves are reduced to spines
  - Stem are thick, green and photosynthetic. They have a wax coating on them to reduce water loss.
  - Stomata are sunken and open during night
  - Root system is extensive
  - Cuticle is thick.

### Other Terms Associated

- ▶ **Coadaptation:** Mutual dependence between members of two species.
- ▶ **Evolution:** The theory that all plants and animals developed gradually from earlier forms over a long period of time and that variations within a species are the result of adaptive traits passed on from generation to generation.
- ▶ **Exaptation:** Any adapted trait that performs a beneficial function different from the one it originally evolved to serve.
- ▶ **Natural selection:** A natural process that results in the survival of individuals or groups best adapted to the conditions in which they must exist.

- They are adapted to use less water and perform high rate of photosynthesis.
- ▶ **Hydrophytes:** They are plants growing in aquatic environment. They have following adaptations to survive:
  - They are covered with mucilage which protects them from pathogens and animals.
  - Roots are absent or poorly developed
  - Special air storing organs occur in floating plant
  - Submerged leaves are thin, small, linear or finely dissected. Floating leaves are large, having stomata and waxy coating on the upper surface.
- ▶ **Halophytes:** They are plants growing in saline habitats. They have not only the ability to tolerate high concentration of salts in their rooting medium but are able to obtain their water supply from the same. Halophytes grow in saline soils, mangroves, coastal dunes and tidal marshes.
- ▶ **Mycorrhizae:** Plants growing in nutrient deficient soils or Oligotropic soil have special adaptations in their roots. The roots of these plant form association with the fungi for absorption of minerals and water from the soil. This association between plant root and fungi is called as **Mycorrhizae**.
- ▶ Mammals from colder climates have **shorter ears and limbs** to reduce heat loss. This is called **Allen's Rule**.

### ◉ **Acclimatization:**

- ▶ It is the process by which an organism tries to accommodate itself against the change in physical environment like changes in altitude, temperature, humidity, photoperiod or pH etc. It involves development of a favourable, morphological and physiological response to a change. It is achieved by a slight change in the morphological (physical appearance) or biochemical process.

## ■ **Homeostasis**

- ◉ **Homeostasis** is the process by which an organism maintains a constant internal environment in respect to changing external environment.

### ◉ **Strategies for Homeostasis:**

- ▶ **Regulate:** Certain animals have the ability to maintain a constant temperature and constant osmolarity to keep up their homeostasis. E.g. **Mammals** have a constant body temperature (37°C) irrespective of the outside temperature. In summers, to maintain the temperature, we sweat and in winters we shiver to produce heat.
- ▶ **Conform:** 99% of animals and nearly all plants cannot maintain a constant internal environment. Their body temperature or osmotic concentration change with the surrounding conditions. They are called **conformers**. Hence, the internal environment of conformers changes with external environment.
- ▶ Small animals have a larger surface area relative to their volume so they tend to lose body heat very fast when it is cold outside; then has to expend much energy to generate body heat through metabolism. This is **why very small animals are rarely found in Polar Regions**.
- ▶ **Migrate:** Many animals like birds move away temporarily from stressful habitat to a more hospitable area and return when stressful condition is over. For example, during winter, **Keoladeo National Park (Bharatpur, Rajasthan)** hosts migratory birds coming from **Siberia** and other extremely cold northern regions.
- ▶ **Suspend:** In bacteria, fungi and lower plants, thick walled spores are formed which help them to overcome stressful, unfavourable conditions. Spores germinate when conditions are favourable.



## ◦ In Higher Organism

### ▶ In higher Plants

- seeds and some other vegetative reproductive structures serve to tide over periods of stress. They reduce their metabolic activity and go into a state of '**dormancy**'. They germinate under favourable moisture and temperature.

### ▶ In Animals:

- **Hibernation or winter sleep** is a resting stage wherein animals escape **winters (cold)** by hiding themselves in their shelters. They escape the **winter** season by entering a state of inactivity **by slowing their** metabolism. The phenomenon of **hibernation is exhibited** by **bats, squirrels, bears** and other **rodents**.
- **Aestivation**: It is the state of dormancy characterized by inactivity and decrease rate of metabolism during an extreme unfavorable state of very high temperature and arid conditions. It is called as summer sleep. It takes place during times of heat and dryness often during summer months. e.g. Crocodiles, salamander, tropical toad and frogs etc.
- **Diapause** is a stage of suspended development to cope with unfavorable conditions. Many species of **zooplankton** and insects exhibit diapauses to tide over adverse conditions during their development. **Diapause** of many zooplanktons in lakes and ponds.

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## ■ Interaction between Species

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- The biological community of an area or ecosystem is a complex network of interactions. The interaction that occurs among different individuals of the same species is called **intra-specific interaction** while the interaction among individuals of different species in a community is termed as **inter-specific interaction**.
- Interactions between organisms belonging to the same trophic level often involve competition. Individuals of population may compete for food, space and mates.
- Interspecific relationship may be direct and close as between a lion and deer or indirect and remote as between an elephant and a beetle.

## ◦ Types of Interactions

- ▶ **Neutralism**, in which neither population is affected by association with the other. Ex: Rabbits, deer, frogs, live together in a grassland with no interaction between them.
- ▶ **Amensalism**, is a negative association between two species in which one species harms or restricts the other species without itself being adversely affected or harmed by the presence of the other species. Organisms that secrete antibiotics and the species that get inhibited by the antibiotics are examples of amensalism.
- ▶ **Commensalism**, in which one population is benefited, but the other is not affected.
  - **Example: Sucker fish**, remora often attaches to a shark by means of its sucker which is present on the top side of its head. This helps the remora get protection, a free ride as well as meal from the left over of the shark's meal. The shark does not however get any benefit nor is it adversely affected by this association.
- ▶ **Parasitism** in which one species is harmed and the other benefits. Parasitism involves parasite usually a small size organism living in or on another living species called the host from which the parasite gets its nourishment and often shelter. The parasite is benefited and the host is harmed.
  - **Example, ticks and lice (parasites)** present on the human body represent this interaction where in the parasites receive benefit (as they derive nourishment by feeding on the blood of humans). On the other hand, these parasites reduce host fitness and cause harm to the human body.

- ▶ **Predation** in which predator captures, kills and eats an animal of another species called the prey. The predator naturally benefits from this relationship, while the prey is harmed. Predators like leopards, tigers and cheetahs use speed, teeth and claws to hunt and kill their prey.
- ▶ **Proto-cooperation** (also frequently referred to as facultative cooperation), in which both populations benefit by the association but their relations are not obligatory; and
- ▶ **Mutualism** in which the growth and survival of both populations is benefited, and neither can survive under natural conditions without the other.
  - **Example: Lichen:** It is an intimate mutualistic relationship between a **fungus** and **photosynthesizing algae** or Cyanobacteria.
- ▶ **Competition** is an interaction between two populations in which both species are harmed to some extent. Competition occurs when two populations or species, both need a vital resource that is in short supply. The vital resource could be food, water, shelter, nesting site, mates or space. Such competition can be: (i) inter-specific competition-occurring between individuals of two different species occurring in a habitat and (ii) intra-specific competition-occurs between individuals of same species. Example: A scrub jay and a grey squirrel compete for nuts and seeds within the oak forest.
- ▶ **Symbiosis** is the interaction in which the species can no longer live without each other as they depend totally on each other to survive.

### Two-species Population Interactions (E.P. Odum, 1983)

	<i>Type of Interaction</i>	<i>Species</i>		<i>General nature of interaction</i>
		1	2	
	<b>1. Neutralism</b>	0	0	<i>Neither population affects the other</i>
“Negative interaction”, types 2 through 4	<b>2. Competition: direct interference type</b>	-	-	<i>Direct inhibition when common resources are in short supply</i>
	<b>3. Competition: resource use type</b>	-	-	<i>Indirect inhibition when common resources is in short supply</i>
	<b>4. Amensalism</b>	-	0	<i>Population 1 inhibited, 2 not affected</i>
Both “positive interactions” and “negative interactions”, types 5 and 6	<b>5. Parasitism</b>	+	-	<i>Population 1, the parasite generally smaller than 2, the host</i>
	<b>6. Predation (including herbivory)</b>	+	-	<i>Population 1, the predator generally larger than 2, the prey</i>
“Positive interactions”, types 7 through 9	<b>7. Commensalism</b>	+	0	<i>Population 1, the commensal, benefits while 2, the host is not affected</i>
	<b>8. Protocooperation</b>	+	+	<i>Interaction favorable to both but not obligatory</i>
	<b>9. Mutualism</b>	+	+	<i>Interaction favorable to both and obligatory</i>

Legend:

0 indicates no significant interaction;

+ indicates growth, survival or other population attribute benefited (positive term added to growth equation)

- indicated population growth or other attribute inhibited (negative term added to growth equation)

#### Gause’s ‘Competitive Exclusion Principle’

It states that two closely related species competing for the same resources cannot co-exist indefinitely and the competitively inferior one will be eliminated eventually.

This may be true in limited resources, but not otherwise.

Species facing competition may evolve mechanisms that promote co-existence rather than exclusion. E.g. 'resource partitioning'.

- ▶ **Resource partitioning:** If two species compete for the same resource, they could avoid competition by choosing different times for feeding or different foraging patterns. For e.g., MacArthur showed that five closely related species of warblers living on the same tree were able to avoid competition and co-exist due to behavioural differences in their foraging activities.

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**UNIT**  
**5**

**TYPES OF  
ECOSYSTEMS**

## TYPES OF ECOSYSTEM

- An ecosystem is a common term and is widely used in biology and environmental studies. In general, it is known as a system or community that consists of all living organisms and their related non-living components in nature. All such components are directly or indirectly associated with each other to create ecological balance. Therefore, it is necessary to know the different types of ecosystems and what they specifically contain.

Principal Characteristics, Structure, functions and productivity of major classes of ecosystems						
Fea- tures	Forest Ecosystem	Grassland Ecosystem	Desert Ecosys- tem	Lake Ecosys- tem (Fresh Water)	Estuarine Ecosystem (Brackish Water)	Sea/Ocean Ecosystem (Marine)
Characteristic Features	This is the most important terrestrial ecosystem in which over 40% of land area is covered by forests. This ecosystem varies with the types of forest, regional climate and land forms. Major part of the global population depends on this ecosystem as resource materials necessary for livelihood.	This is an unique ecosystem of the land, where grasses and legumes forms the producer class. There may be isolated trees, sparsely distributed. The ecosystem provides biomass food for herbivores.	This ecosystem is very much stressed ecosystem with low plant and animal diversity. These are thorny forests with special animals. The biomass yield and energy utilization potential is low.	This is unique fresh water lentic ecosystem. There is distinct stratification of water bodies in tropics. The productivity is moderate.	This is a brackish water aquatic ecosystem. The species diversity is very high. There is a land and aquatic system transitional stages.	Marine aquatic ecosystem is a very significant one. Species richness and diversity is very much high.
Structure and Species types	As usual this ecosystem have producers, herbivores, carnivores and decomposers. However, the species composition varies widely in different places. The species richness and diversity in forest ecosystem is extremely high. Ecosystem structure is complex and stable. Species stratification is fairly prominent.	All the ecosystem components are known in this system, but herbivores are mostly prominent consumer. Species diversity is comparatively poorer. Species stratification is not prominent.	Principally all components of trophic level is known in this ecosystem. Herbivores are poorly represented species wise. Stratification of community is less pronounced.	All components of trophic level are seen. Herbivores are predominant. Dissolved oxygen plays a crucial role in species distribution.	All trophic levels are prominent. Carnivores are very conspicuous. Species diversity is prominent.	All trophic states are distinct. biodiversity is unique in all stages.

Functions- (Energy flow, food chain and productivity)	The flow of energy takes place from producer to consumer through complex food chain, this is one the most productive ecosystems in terrestrial habitat. The energy is stored as biomass.	The energy flow path is comparatively simpler. The productivity is comparatively low. This ecosystem add nutrient to the soil moist. It helps in soil erosion control too.	The energy flow path is distinct, energy trapping process is poor and as such productivity is fairly low.	Energy flow path is straight and less complex. The productivity is moderate.	Energy flow path, food chain is complex. The productivity is fairly high	Energy flow path and food chain is complex. The productivity is moderate.
Development process	The ecosystem formed through successional process which is fairly moderate to fast. Light and water are the major abiotic factors that regulates the process of community build up process.	The ecosystem development is moderately faster. It could be primary community of secondary community formed after fire.	The ecosystem survives in drought state, there are many species which are fast growing. There is no stratification. Water is the major factor of community development.	The ecosystem is developed with time. Water quality and depth are major governing factors for species richness.	A complex set of successional process is involved. A number of abiotic factors regulates the process.	The ecosystem is developed through time and space. Species extinction took place over the years due to marine pollution.

## ■ Terrestrial Ecosystem

- A **terrestrial ecosystem** is an ecosystem found only on landforms. Six primary terrestrial ecosystems exist: tundra, taiga, temperate deciduous forest, tropical rain forest, grassland and desert.

### ◦ Taiga

- ▶ Taigas are cold-climate forests found in the northern latitudes.
- ▶ Taigas are the world's largest terrestrial ecosystem and account for about **29% of the Earth's forests**. The largest taiga ecosystems are found in Canada and Russia.
- ▶ Taigas are known for their sub-arctic climate with extremely cold winters and mild summers.
- ▶ They primarily consist of coniferous trees, such as pines, although there are some other deciduous trees, such as spruce and elm, that have adapted to live in these areas that receive little direct sunlight for much of the year.
- ▶ Taigas are home to large herbivores, such as moose, elk, and bison, as well as omnivores, such as bears.

### ◦ Tundra

- ▶ The tundra ecosystems of the world are found primarily north of the Arctic Circle.
- ▶ They consist of short vegetation and essentially no trees.
- ▶ The soil is frozen and covered with permafrost for a large portion of the year.
- ▶ Caribou, polar bears, and musk ox are some of the notable species who call the tundra home.

## ◉ Temperate Forests

- ▶ Temperate forests are the regions which have seasonal variation in climate i.e., the climate changes a lot from summer to winter.
- ▶ The annual rainfall is about **750- 2000 mm** and soil is rich. Such types of forests are found in western and central Europe, Eastern Asia and eastern North America.
- ▶ These forests have deciduous trees (oaks, maples etc.) and coniferous trees (pines).
- ▶ These forests contain abundant micro-organisms, mammals (hares, deer, feres, coyotesetc). Birds (warblers, wood peckers, owls etc.) snakes, frogs, salamanders etc.

## ◉ Tropical Rain Forests

- ▶ Tropical rain forests are special ecosystems which accommodate thousands of species of animals and plants.
- ▶ These are usually densely packed tall trees those form a ceiling from the sun above. The filing prevents the growth of smaller plants.
- ▶ The temperature remains almost same throughout the year.
- ▶ Such types of forests are found in Brazil of South America (Neotropic) and Central and West Africa. The area is always warm and muggy.

## ◉ Grasslands

- ▶ Grasslands are areas dominated by grasses. They occupy **about 20% of the land on the earth surface**.
- ▶ Grasslands occur in both in tropical and temperate regions where rainfall is not enough to support the growth of trees.
- ▶ Grasslands are found in areas having well defined hot and dry, warm and rainy seasons.

## ◉ Deserts

- ▶ Deserts are hot and low rain areas suffering from water shortage and high wind velocity.
- ▶ They show extremes of temperature. Globally deserts occupy about **1/7<sup>th</sup>** of the earth's surface.
- ▶ Desert animals include shrew, fox, wood rats, rabbits, camels and goat are common mammals in desert.
- ▶ Other prominent desert animals are, reptiles, and burrowing rodents insects.

### UPSC CSE PRELIMS, 2020

**Q1: With references to India's Desert National Park, which of the following statements are Correct?**

1. It is spread over two districts.
2. There is no human habitation inside the Park.
3. It is one of the natural habitats of the Great Indian Bustard.

Select the correct answer using the code given below:

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

**Correct Option: (c)**

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## ■ Forest Ecosystem in India

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### ◉ Tropical Wet Evergreen Forests

- ▶ These are the typical rain forests of India.

- ▶ **Annual rainfall: above 250 cm.**
- ▶ **Mean annual temperature: 27°C.**
- ▶ Dry season is very brief.
- ▶ Western Ghats, parts of Karnataka (Anamalai Hills, Coorg, Mysore Plateau), Cachar and Brahmaputra valley of Assam and Andaman-Nicobar islands.

### ◉ **Tropical Moist Semi-Evergreen Forests**

- ▶ These forests are intermediate between the evergreen and the deciduous forms.
- ▶ **Annual rainfall: between 200-250 cm.**
- ▶ **Mean annual temperature: 26°C.**
- ▶ Some trees shed their leaves for brief periods in winter and spring.
- ▶ Western Ghats, parts of upper Assam, Bengal, Bihar, Odisha and Andamans.

### ◉ **Tropical Moist Deciduous Forests**

- ▶ **Annual rainfall: 150-200 cm.**
- ▶ **Drought period is for 1-2 months.**
- ▶ Eastern side of Western Ghats, Chhota Nagpur, Khasi Hills and a narrow belt along the foothills of Himalayas.
- ▶ Based on dominant species, they are generally of 3 types: Sandal, Teak and Sal forests.

### ◉ **Littoral and Swamp Forests**

- ▶ They are subdivided into 3 types: beach, tidal and fresh water swamp forests.
- ▶ **Beach Forests**
  - These are distributed all along the sandy sea beaches and sandy flats of river deltas.
- ▶ **Tidal Forests**
  - These grow over the deltas of various rivers, creeks along the coast and swampy margins of islands.
  - The plants often have prop roots with well developed pneumatophores for support and aeration.
- ▶ **Fresh Water Swamp Forests**
  - They grow in depressions where rainwater or swollen river-water collects for some period.
  - Elephant grass (Typha species) is quite common in these forests.

### ◉ **Tropical Dry Deciduous Forests**

- ▶ **They cover about 40% of total land in India.**
- ▶ **Annual rainfall: 75-125 cm.**
- ▶ Dry season extends for about 6 months.
- ▶ They spread from foot of Himalayas to extreme South (except Western Ghats, Rajasthan, Kashmir, Bengal and other Eastern States).

### ◉ **Tropical Thorn Forests**

- ▶ They occur on rocky substrata.
- ▶ **Annual rainfall: 25-75 cm.**
- ▶ The vegetation is dominated by Acacia and Euphorbia (thorny plants).



- ▶ Punjab, Haryana, Rajasthan, Gujarat, Delhi, Bundelkhand part of Uttar Pradesh, parts of Madhya Pradesh, Maharashtra and Tamil Nadu.

### ◉ Tropical Dry Evergreen Forests

- ▶ They receive rain from retreating monsoon.
- ▶ Parts of Andhra Pradesh and Tamil Nadu.

### ◉ Montane Subtropical Forests

- ▶ These are intermediate between tropical and temperate forest and therefore, exhibit mixed vegetation of both types.
- ▶ They are divisible into three sub-types:
  - **Broad-leaved hill forests:** Nilgiri and Palni Hills of South, Mahabaleshwar and other areas of Maharashtra, Mount Abu, Pachmarhi in M.P., Parasnath in Bihar, Kalimpong and Darjeeling.
  - **Pine forests:** Foothills of Himalayas and in the East over Khasi, Naga, Manipur and Lushai hills.
  - **Dry evergreen forests:** Shiwalik Hills, Punjab, Haryana, Himachal Pradesh and Jammu and Kashmir.

### ◉ Montane Temperate Forests

- ▶ These forests develop at a **height of 1700 metres** in the hills of both North and South.
- ▶ They are not humid.
- ▶ They are of three types:
  - **Montane Wet Temperate Forests:** These are found in both North and South. The Southern wet temperate forests are called Shola. They occur in Nilgiris, Annamalai, Palni, Tinnevely hills of both Tamil Nadu and Kerala.

- ▶ **Shola Forest:** It is the name of a particular kind of forest in South India. The characteristics of Shola forests are:
  - ▶ **Type:** Evergreen stunted tropical montane forest; isolated patches found in the valleys, separated by grasslands
  - ▶ **Occurrence:** Higher ranges of the Western Ghats in Tamil Nadu, Kerala, and Karnataka; particularly in the Nilgiris.
  - ▶ **Name:** Probably derived from the Tamil word for grove
  - ▶ **Fauna:** Many threatened and endemic species such as the endangered Nilgiri tahr, tigers, leopard, elephants, guar and birds such as laughing thrushes and Nilgiri wood pigeons
  - ▶ **Threat:** Invasive species through plantation and afforestation projects.

- **Himalayan Moist Temperate Forests:** Western and central Himalayas.
- **Himalayan Dry Temperate Forests:** Inner Himalayas.

### ◉ Sub-Alpine Forests

- ▶ They are found throughout Himalayas till the timber line.
- ▶ It spreads from Ladakh in west to Arunachal Pradesh in East.
- ▶ **Annual rainfall is less than 65 cm.**
- ▶ Snowfall occurs for several weeks in a year.

- ▶ It has two types of forests: Silver fir-Birch Forest and Birch-Rhododendron Forest.

### ◉ **Alpine Forest**

- ▶ These are found above the timber line and upto snow line in Himalayas.
- ▶ Rainfall is almost absent.
- ▶ Snowfall is common.
- ▶ The vegetation is commonly known as elfin scrub (short stems; branches come out of soil and creep along the ground and form tangled masses).
- ▶ This vegetation is divided into four types: moist alpine scrub, dry alpine scrub, alpine stony deserts and alpine meadows.

### ◉ **Grassland Vegetation**

- ▶ Natural grasslands are hardly present in India but have developed secondarily by the destruction of forests. This is known as secondary development.
- ▶ Indian grasslands are of three major types:
  - Xerophilous (North-West India under semi-desert conditions).
  - Mesophilous (Savannahs) are typical of moist deciduous forests of UP.
  - Hygrophilous (Wet Savannahs).

### ◉ **Desert Vegetation**

- ▶ Rainfall is scanty, infrequent and irregular (10cm)
- ▶ The vegetation cover is sparse.
- ▶ Vegetation is of thorn forest type.
  - Natural vegetation contributes to productivity of trees like Khejri (*Prosopis cineraria*).

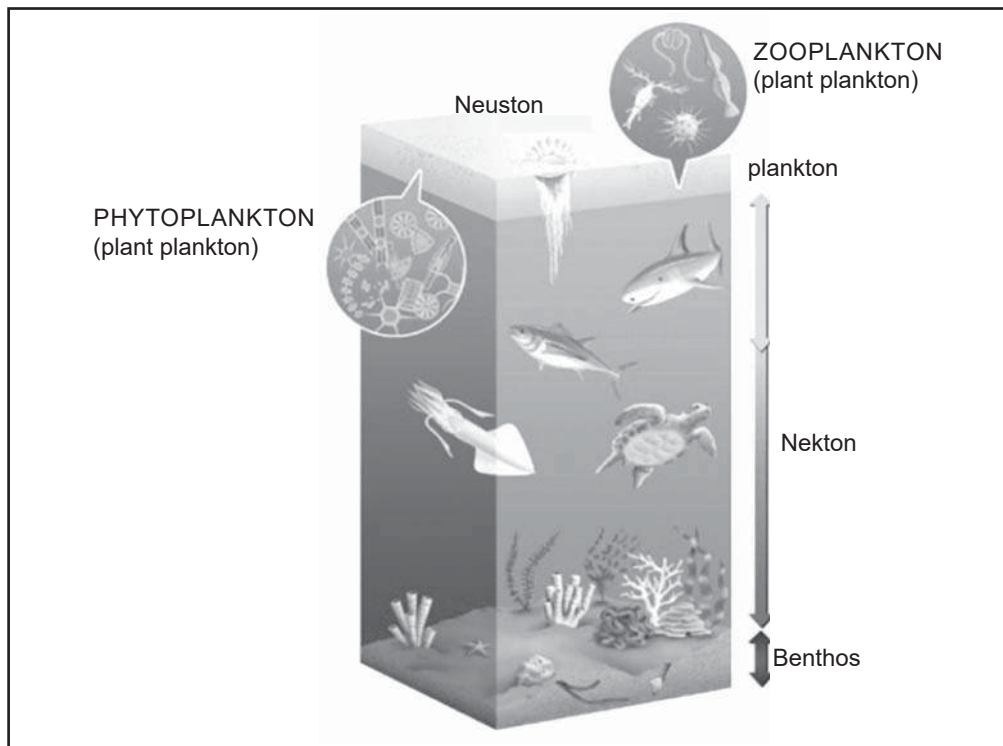
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# AQUATIC ECOSYSTEM

## ■ Aquatic Ecosystem

### ○ Fresh Water Ecosystem

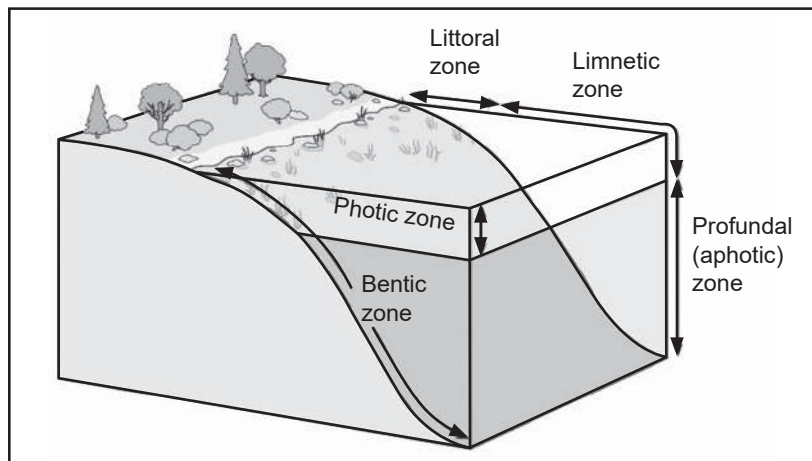
- ▶ Water on land which is continuously cycling and has low salt content is known as fresh water and its study is called limnology.
- ▶ Static or still water (Lentic) e.g. pond, lake, bogs and swamps.
- ▶ Running water (Lotic) e.g. springs, mountain brooks, streams and rivers.
- ▶ **Lentic Ecosystem**
  - Lentic aquatic systems are those which contain stagnant waters. These are usually formed in small or large depressions on earth's surface which possess no exit for the water to flow out.
  - It has to decay, decompose or persist as such within the lentic body. Natural processes in the long run change such a body into a swamp or a marsh, a wetland and finally to dry land. Small puddles, ponds and lakes are familiar examples of such systems.
  - **The zones of a lentic water body:**
    - ◆ A lentic aquatic body can be divided into four major zones, each of which has its own characteristics.
    - ◆ The zone around the margins of the aquatic body which consists of shallow waters is known as the **Littoral zone**. Plenty of light is available and rooted plants grow in this zone only.
    - ◆ **Limnetic zone** is the zone of open waters which are deeper as well. Availability of plenty of light promotes active photosynthesis and growth of free floating autotrophs - the planktons.
    - ◆ Under the limnetic zone occurs **Profundal zone** which receives very little light. Hence this zone may be referred to as aphotic zone in contrast to euphotic zone (limnetic and littoral regions) which are well illuminated.
    - ◆ Under the profundal zone lays the **Benthic Zone** - the region near the bottom of the aquatic body. Both profundal and benthic zones are characterized by presence of heterotrophs which live on dead and decaying organic material falling down from the limnetic zone above.
- ▶ **The organisms living in water may be classified into the following types:**
  - The surface living organisms, which are called as **Planktons**, whose movements are mostly controlled by the currents. Algae, protozoa, rotifers, copepods and cladocera belong to this group.



- Animals living at the bottom of water bodies are called as **Benthos**. These are further divided according to the mode of feeding into filter feeders and deposit-feeders (or sediment feeders). Midge larvae, clams and other microscopic organisms thrive as benthos.
- Active swimming forms called as **Nektons**. Fishes, aquatic insects, water beetles, amphibians, turtles, water snakes, tadpoles of frogs and Tilapia live as nektons.
- Organisms (both plants and animals) attached or clinging to stems and leaves of rooted plants or projected surfaces. These are called as **Periphytons**. Sessile algae, fungi, protozoa, hydra, microcrustacea, rotifera and snails come under this category.
- The organisms which are resting and swimming on the surface of water, are called as **Neustons**. Insects, mosquito larvae, some bacteria and algae come under this group.

► **Lotic Ecosystem**

- Lotic aquatic systems are those systems which contain flowing waters. The mass of water in these systems is in a state of perpetual motion. Streams and rivers are familiar examples of such systems.
- The basic function of these lotic bodies of water is to carry the surplus rain water back to the sea.
- The major abiotic factors controlling the lotic ecosystems are:
  - ♦ Slope and geomorphic conditions including the nature of substratum.



- ◆ Physico-chemical properties of water. Temperature, color, alkalinity, pH and dissolved oxygen.
- ◆ Flow velocity and quantity.
- ◆ Type and amount of suspended and bed-load sediments.
- ◆ Turbidity.
- ◆ Thickness of water column and the depth of light penetration.
- ◆ The climatological factors like atmospheric temperature, humidity, sun shine hours, evapotranspiration and wind.

## o Marine Ecosystem

- ▶ Marine ecosystems cover **approximately 71% of the Earth's surface and contain approximately 97% of the planet's water. They generate 32% of the world's net primary production.**
- ▶ They are distinguished from freshwater ecosystems by the presence of dissolved compounds, especially salts, in the water. **Approximately 85% of the dissolved materials in seawater are sodium and chlorine. Seawater has an average salinity of 35 parts per thousand (ppt) of water.** Actual salinity varies among different marine ecosystems.

- ▶ Marine ecosystems can be divided into many zones depending upon water depth and shoreline features:

- **The oceanic zone** is the vast open part of the ocean where animals such as whales, sharks, and tuna live.

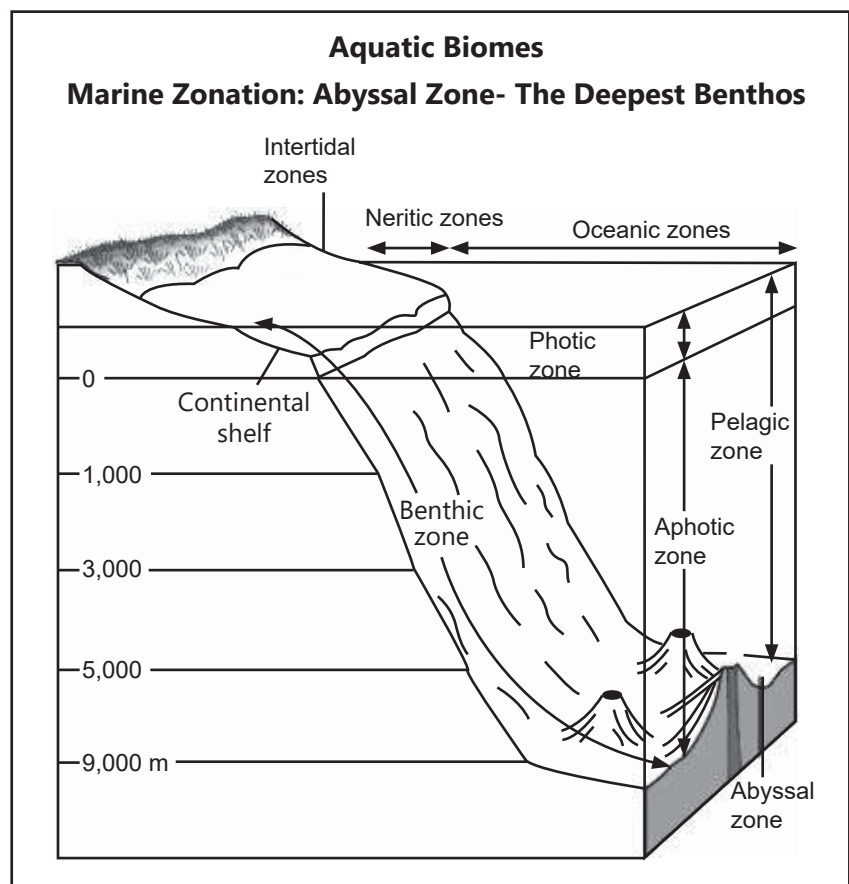
- **The benthic zone** consists of substrates below water where many invertebrates live.

- **The intertidal zone** is the area between high and low tides.

- **Other near-shore (neritic) zones** can include estuaries, salt marshes, coral reefs, lagoons and mangrove swamps.

- In the deep water, hydrothermal vents may occur where chemosynthetic sulfur bacteria form the base of the food web.

- Aquatic ecosystems perform many important environmental functions. For example, they recycle nutrients, purify water, attenuate floods, recharge ground water and provide habitats for wildlife.



## o Brackish Water Ecosystem

- ▶ These are water bodies that have salt content in between 5 to 35 ppt. Eg: Estuaries, Salt Marshes, Mangrove Swamps and forests.

### Associated Terminology

- ▶ **Riparian zone** is the interface between land and a flowing surface water body. Plant communities along the river margins are called riparian vegetation, characterized by hydrophilic plants.
- ▶ A **pond** is typically a man made body of water smaller than a lake. Typically, a pond has no surface outflow draining off water and ponds are often spring-fed. Hence, because of the closed environment of ponds, such small bodies of water normally develop self contained eco-systems.
- ▶ **Kelp forests** are a type of marine ecosystem established around colonies of kelp. Kelp forests are found in **temperate ocean waters** around the globe wherever water conditions are conducive to the successful establishment of kelp colonies. Kelp favors clear waters **between about 4 and 20 degrees Celsius**; various species of kelp favor different ranges of temperatures, but none grow in waters where the temperature is consistently warm.

- ▶ Aquatic ecosystems are water-based ecosystems. Lakes, ponds, estuaries, saltwater marshes, oceans, and thermal vents are all examples of aquatic ecosystems, but each has different characteristics.

### Factors Limiting the Productivity of Aquatic Habitats

#### Sunlight

- Sunlight penetration rapidly diminishes as it passes down the column of water.
- The depth to which light penetrates a lake determines the extent of plant distribution.
- Suspended particulate matters such as clay, silt, phytoplankton, etc. make the water turbid.
- Turbidity limits the extent of light penetration and photosynthetic activity in a significant way.
- Based on light penetration and plant distribution they are classified as photic and aphotic zones.
  - ♦ **Photic Zone**
    - » **Photic (or "euphotic") zone** is the portion that extends from the lake surface down to where the light level is 1% of that at the surface. The depth of this zone depends on the transparency of water.
    - » Photosynthetic activity is confined to the photic zone.
    - » Both photosynthesis and respiration activity takes place.
  - ♦ **Aphotic Zone**
    - » The lower layers of the aquatic ecosystems, where light penetration and plant growth are restricted form the aphotic zone (profundal zone). Only respiration activity takes place in this zone.
    - » The aphotic zone extends from the end of the photic zones to bottom of the lake.

#### Dissolved Oxygen

- In freshwater the average concentration of dissolved oxygen is 10 parts per million by weight.
- This is 150 times lower than the concentration of oxygen in an equivalent volume of air.
- Oxygen enters the aquatic ecosystem through the air-water interface and by the photosynthetic activities of aquatic plants.

### UPSC CSE PRELIMS, 2017

**Q1: Biological Oxygen Demand (BOD) is a standard criteria for**

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

**Correct Option: (c)**

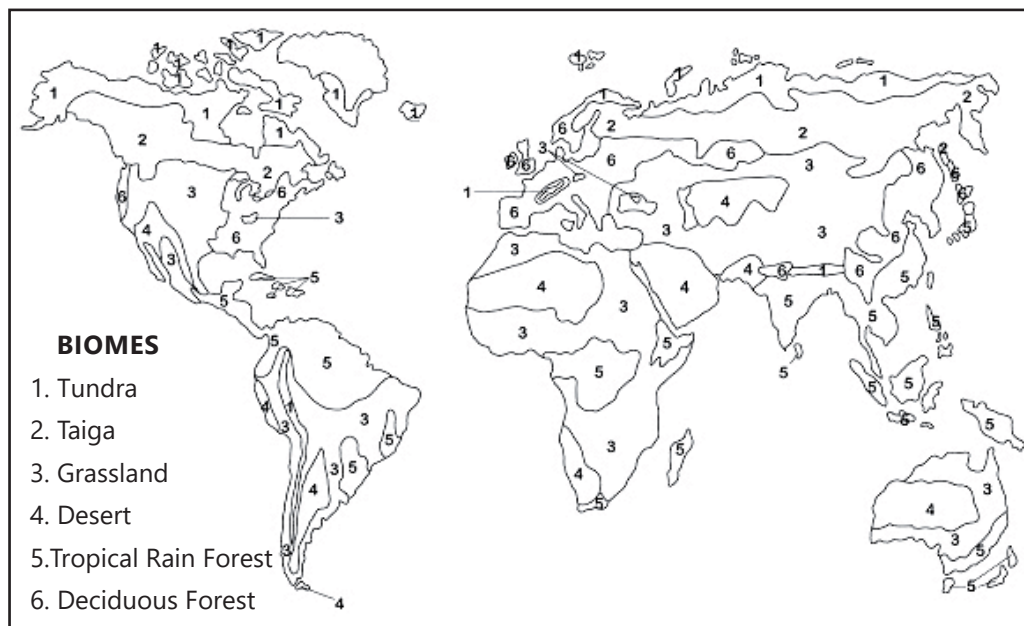
- Dissolved oxygen escapes the water body through the air-water interface and respiration of organisms (fish, decomposers, zooplankton, etc.).
  - The amount of dissolved oxygen retained in water is also influenced by temperature.
  - Oxygen is less soluble in warm water. Warm water also enhances decomposer activity. Therefore, increasing the temperature of a water body increases the rate at which oxygen is depleted from the water.
  - When the dissolved oxygen level falls below 3-5 ppm, many aquatic organisms are likely to die.
- **Winterkill**
- An ice layer on the top of a water body can effectively cut off light. Photosynthesis stops but respiration continues in such water body.
  - If the water body is shallow, the oxygen gets depleted, and the fish die. This condition is known as winterkill.
- **Temperature**
- Since water temperatures are less subject to change, the aquatic organisms have narrow temperature tolerance limit.
  - As a result, even small changes in water temperature are a great threat to the survival of aquatic organisms when compared to the changes in air temperatures in the terrestrial organisms.

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## BIOMES OF THE WORLD

A biome is a large area characterized by its vegetation, soil, climate, and wildlife. There are five major types of biomes: aquatic, grassland, forest, desert, and tundra, though some of these biomes can be further divided into more specific categories, such as freshwater, marine, savanna, tropical rainforest, temperate rainforest, and taiga.

### Major Terrestrial Biomes of the World



### ■ Tundra

- Tundra biome is the coldest of all the biomes. It is among the harshest biome and they are found in the arctic region and on top of mountains where the climate is cold and windy and the rainfall is scanty. The tundra regions are covered with snow most of the year and summer brings blooms of wild flowers.

#### ○ Arctic Tundra Biome

- ▶ The arctic tundra is located in the northern hemisphere.
- ▶ It encircles the North Pole and extends south to the coniferous forest of the taiga.
- ▶ The arctic has cold, desert like conditions.
- ▶ The **growing season** in the tundra region is about **50 to 60 days**.



- ▶ The **average winter temperature is about -34°C**, the **average summer temperature is about 3 to 12°C**, and this enables the biome to sustain life.
- ▶ Rainfall varies in different regions of the arctic.
- ▶ There is about **15 cm to 25 cm** of yearly precipitation which includes melting snow.
- ▶ Soil formation is slow.
- ▶ A layer of permanently frozen subsoil known as **permafrost** exists and consists mostly of gravel and finer material.
- ▶ When there is saturation of the upper surface, there may be formation of bogs and ponds which provide moisture for plants.
- ▶ In this region there is no deep root system vegetation, though there are a wide variety of plants that can resist the cold climate.

### ○ **Alpine Tundra Biome**

- ▶ The Alpine tundra is located on the mountain regions throughout the world, there are at the high altitudes where trees cannot grow.
- ▶ The **growing season** in these regions is about **180 days**.
- ▶ The temperature during the night is below freezing.
- ▶ The soil in the alpine is well drained.
- ▶ The vegetation in the alpine tundra is similar to the arctic tundra.
- ▶ The vegetation includes plants like tussock grasses, small-leafed shrubs, dwarf trees and heaths.
- ▶ The fauna of the alpine tundra are well adapted to its climate, the animals of the alpine include mammals like marmots, pikas, mountain goats, elk and sheep; birds like grouse like birds and insects like butterflies, grasshoppers, beetles, springtails, etc.

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## ■ **Taiga**

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- **Taiga** is the largest land biome and it makes up of about **29% of the world's forest cover**; a large part of this biome is located in Russia and Canada.
- The boreal forest occurs between 50 and 60 degrees of the north latitudes.
- It can be found along the broad belt of Eurasia and North America, **2/3<sup>rd</sup> of it is in Siberia**, the rest of it in Scandinavia, Alaska and Canada.
- Taiga is found in the northern parts of North America, Europe and Asia.
- The climate of the taiga is very cold.
- The taiga has a **subarctic climate** and the temperature ranges between seasons, but the dominant feature of the taiga is the long and cold winters.
- The summers are short, temperature is about **10°C** and it lasts around for 1-3 months.
- The winter temperatures are below freezing and reaches and it lasts for five to seven months. Throughout the whole year the temperature vary from **-54°C to 30°C**.
- The summers are short, warm and humid.
- Precipitation in this region varies from **20cm to over 200 cm**, the precipitation is mostly in the form of snow.
- During the growing season the ground is moist.

- The summers have extremely long day length.
- There is explosive plant growth in the summer, and yet the growing season is short and less.

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## ■ Grassland

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- Grasslands are characterized as lands dominated by grasses rather than large shrubs or trees.
- Very few trees or tall large plants grow in the grasslands. Forest or bush fires can also eradicate the sparse tree population. The lack of trees is mainly due to soil type and precipitation.
- Grassland biomes are normally situated between a forest and a desert. In fact, grasslands surround every desert in Asia.
- Twenty-five percent of the Earth is covered by the grassland biome.
- There is a grassland biome on each continent with the exception of Antarctica.
- Tropical and temperate are the two kinds of grasslands. Tropical grasslands experience warm weather all year long while temperate grasslands have hot summers and cold winters.
- Grasslands are perfect for cropping and pasturing because its soil runs deep and is extremely fertile.
- Periodic fires, whether they are human induced or occur spontaneously, are very important to the grassland to ensure that invasive plants do not take over.

### ◦ Savanna Grassland

- ▶ Savanna is grassland with scattered individual trees.
- ▶ Savannas of one sort or another cover almost half the surface of Africa (about five million square miles, generally central Africa) and large areas of Australia, South America, and India.
- ▶ Savannas are always found in warm or hot climates where the **annual rainfall is from about 50.8 to 127 cm (20-50 inches) per year**. It is **crucial that the rainfall** is concentrated in six or eight months of the year, followed by a long period of drought when fires can occur. If the rain were well distributed throughout the year, many such areas would become tropical forest.

### ◦ Temperate Grassland

- ▶ Temperate grasslands are characterized as having grasses as the dominant vegetation. Trees and large shrubs are absent.
- ▶ Temperatures vary more from summer to winter, and the amount of rainfall is less in temperate grasslands than in savannas.
- ▶ The major manifestations are the velds of South Africa, the puszta of Hungary, the pampas of Argentina and Uruguay, the steppes of the former Soviet Union, and the plains and prairies of central North America.
- ▶ Temperate grasslands have hot summers and cold winters.
- ▶ Rainfall is moderate. The amount of annual rainfall influences the height of grassland vegetation, with taller grasses in wetter regions.

### Nomenclature for Grassland

Grassland are known by different names in different parts of the world: –

- ▶ **'Steppes'** in Asia;
- ▶ **'Prairies'** in North America;
- ▶ **'Pampas', 'Llanos'** and **'Cerrados'** in South America;
- ▶ **'Savannahs'** and **'Velds'** in Africa; and
- ▶ **'Rangelands'** in Australia.

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## ■ Tropical Rainforest Biome

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- **The Tropical Rainforest can be found in three major geographical areas around the world:**
- Central America in the Amazon river basin.
- Africa - Zaire basin, with a small area in West Africa; also eastern Madagascar.
- Indo-Malaysia - west coast of India, Assam, Southeast Asia, New Guinea and Queensland, Australia.
- **Characteristics**
  - ▶ Rainforests only cover around **2 percent the total surface area of the Earth**, but really about 50 percent of the plants and animals on the earth live in the rainforest.
  - ▶ Rainforests are found on all of the different continents, except for Antarctica because it is far too cold there for the environment to be conducive.
  - ▶ Rainforests help to regulate the temperatures around the world and the weather patterns as well.
  - ▶ Tropical rainforest get lots of rain; in one year they typically **receive between 50 and 260 inches (125 to 660 centimeters) of rain.**
  - ▶ The tropical rainforest biome is hot, it has an average temperatures of about 77 degrees Fahrenheit (25 degrees Celsius). The temperature never falls below 64 degrees Fahrenheit (17.8 degrees Celsius).
  - ▶ Tropical Rainforest are extremely humid, due to all the rainfall, the average humidity is between 77 and 88 percent.
  - ▶ The Amazon Rainforest in South America is the largest tropical rainforest in the world, however these forest are also located in Africa, Central America, Australia, Asia, Mexico and on numerous Caribbean, Pacific, and Indian Ocean islands.
  - ▶ Tropical rainforest biomes are generally located near the equator, this is why they are said to have an equatorial climate.

### Tribes in Rainforests

- ▶ **The Pygmy Tribe:** They live scattered over a huge area in central and western Africa, the Democratic Republic of Congo, Congo, Cameroon, Gabon, Central African Republic, Rwanda, Burundi and Uganda.
- ▶ **Huli Tribe:** Papua New Guinea
- ▶ **Yanomami Tribe:** They live in the Rainforests and Mountains of Northern Brazil and Southern Venezuela

## Layers in Tropical Rainforest

### ► Forest Floor

- Very little light reaches the floor
- Ground is covered with leaves, rotting branches, shallow roots

### ► Understory

- Low light conditions
- Quite open; only dense vegetation along rivers
- Birds, butterflies, frogs, snakes and insects live here

### ► Canopy

- Second highest layer (30-40 metres)
- The crowns of trees knit together to form a dense canopy
- It blocks the sun's rays to reach the ground
- Birds, monkeys, frogs, sloths, lizards snakes live here

### ► Emergent Layer

- Tallest layer
- Plants are made for living in dry conditions (exposed to sun's rays)
- Plants have small, waxy leaves to prevent drying
- Eagles, butterflies, bats and small monkeys live here

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## ■ Desert Biome

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- Deserts are dry or arid areas that **receive less than 250 mm of rain each year**. Deserts can be hot or cold. They contain plants and animals that are specially adapted to these extremely dry conditions.

### ◦ Locations

- Hot deserts are located at the Sahara, Arabian, Australian, Australia, Arabian, Peninsula, Mexico/ S.W. USA, S.W. Africa, S.W USA. Others include Argentina, South America, North Africa, Indian, Pakistan and Kalahari deserts.
- Coastal deserts are found at Peru and Chile
- Cold deserts are located at China, Mongolia, Iran, Afghanistan, S.W Africa, W. China, Argentina, South America, Middle East, Antarctica and USA.
- Semi-arid deserts/ Steppes or moderately dry lands are located at USA, Canada, Ukraine and China.

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## ■ Deciduous Forest Biome

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- Forests in which majority of trees lose their vegetative parts, such as leaves, after a particular season are called as deciduous forests. A deciduous forest supports diverse ecological types. Plants usually grow in the warm temperate climate with abundant moisture and produces new leaves and flowers in spring. In summer, long trees support the growth of shade-tolerant trees and plants by casting their shade. Leaves fall off in autumn and provide required material for decomposers, soil bacteria.

## ◉ Tropical Deciduous Forest Features

- ▶ Area has warm summer and moderately cold winter.
- ▶ **Precipitation is abundant ranging from 75 cm to 150 cm.**
- ▶ Temperature remains moderate **20 - 27oC** in summer and - **12oC in winter.**
- ▶ Soil is rich in minerals and organic matter.
- ▶ Bamboo, Sal, Shisham, Sandalwood, Khair, Kusum, Aijun, Mulberry are other commercially important species, grown in most deciduous forests.
- ▶ The dry forest is found in areas of rainfall ranging between 100 cm and 70 cm.

## ◉ Temperate Deciduous Forest features

- ▶ Temperate deciduous forests can be found in the eastern part of the United States and Canada, most of Europe and parts of China and Japan.
- ▶ Temperate deciduous forests get between 30 and 60 inches of precipitation a year. Precipitation in this biome happens year round.
- ▶ Deciduous forests have a long, warm growing season as one of four distinct seasons.
- ▶ There is abundant moisture.
- ▶ The soil typically is rich. The leaves dropped from trees provide a steady source of organic material for the soil. Many species live in the soil and break down the organic matter.
- ▶ Tree leaves are arranged in strata: canopy, understory, shrub, and ground. A great deal of light is therefore filtered out before it reaches the ground.
- ▶ With the dropping of their leaves during one season, trees stop photosynthesis and enter a dormant period.
- ▶ Three main types of trees are characteristic of these forests: northern hardwood, central hardwood, and southeast pine and oak.

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# MARINE ORGANISMS

## ■ Plankton

- The term '**plankton**' refers to the group of organisms which float in the surface waters of the rivers, lakes and oceans.
- Includes both microscopic plants like algae (phytoplankton) and animals like crustaceans and protozoans (zooplankton) found in all aquatic ecosystems, except certain swift moving waters.
- The locomotory power of the planktons is limited so that their distribution is controlled, largely, by currents in the aquatic ecosystems.
- The growth rate, productivity and species diversity of plankton in tropical waters especially in mangrove waters are high.

### ◦ Phytoplankton

- ▶ Phytoplankton are microscopic plant organisms that live in aquatic environments, both salty and fresh.
- ▶ Some phytoplankton are bacteria, some are protists, and most are single-celled plants. Among the common kinds are cyanobacteria, silica-encased diatoms, dinoflagellates, green algae, and chalk-coated coccolithophores.
- ▶ Phytoplankton produce more than 60% of oxygen produced from all plants.
- ▶ Like land plants, all phytoplankton have chlorophyll to capture sunlight, and they use photosynthesis to turn it into chemical energy. They consume carbon dioxide, and release oxygen. All phytoplankton photosynthesize, but some get additional energy by consuming other organisms.
- ▶ These micro-algae are present throughout the lighted regions of all the seas and oceans including the Polar Regions.
- ▶ Their total biomass is many times greater than that of the total plants on land and they serve as the "**pasture grounds**" in the aquatic environment.
- ▶ **Some of the Factors Affecting Phytoplanktons Biodiversity**
  - **Light**
    - ◆ Phytoplanktons are limited to the uppermost layers of the ocean where light intensity is sufficient for photosynthesis to take place.
    - ◆ The photosynthetic rate varies with light intensity.
  - **Nutrients**
    - ◆ The major inorganic nutrients required by phytoplankton for growth and reproduction are nitrogen and phosphorus.
    - ◆ Diatoms and silicoflagellates also require silicate ( $\text{SiO}_2$ ) in significant amounts.
    - ◆ Some phytoplankton can fix nitrogen and can grow in areas where nitrate concentrations are low.

- ◆ They also require trace amounts of iron which limits phytoplankton growth in large areas of the ocean because iron concentrations are very low.
- **Temperature**
  - ◆ Temperature acts along with other factors in influencing the variation of photosynthetic production.
  - ◆ Generally, the rate of photosynthesis increases with an increase in temperature, but diminishes sharply after a point is reached.
  - ◆ Temperature, together with illumination, influences the seasonal variation of phytoplankton production in the temperate latitudes.
- **Salinity**
  - ◆ Besides light and temperature, salinity also is known to influence primary production.
- **Grazing by Zooplankton**
  - ◆ The grazing rate of zooplankton is one of the major factors influencing the size of the standing crop of phytoplankton, and thereby the rate of production.
- ▶ **Distribution**
  - Marine phytoplankton are not uniformly distributed throughout the oceans of the world. the highest concentrations are found at high latitudes, with the exception of upwelling areas on the continental shelves, while the tropics and subtropics have **10 to 100 times lower concentrations**.
  - In addition to nutrients, temperature, salinity and light availability; the high levels of exposure to solar UV-B radiation that normally occur within the tropics and subtropics may play a role in phytoplankton distributions.
  - Phytoplankton productivity is limited to the euphotic zone, the upper layer of the water column in which there is sufficient sunlight to support net productivity.
  - The position of the organisms in the euphotic zone is influenced by the action of wind and waves.
- ▶ **Importance of Phytoplankton**
  - **The Food Web**
    - ◆ Phytoplankton are the foundation of the aquatic food web, the primary producers, it feeds everything from microscopic animal-like zooplankton to whales. Small fish and invertebrates graze on the phytoplanktons, and then those smaller animals are eaten by bigger ones.
  - **Phytoplankton – The Carbon Cycle and Climate Change**
    - ◆ Phytoplankton are responsible for most of the transfer of carbon dioxide from the atmosphere to the ocean. Carbon dioxide is consumed during photosynthesis, and the carbon is incorporated in the phytoplankton, just as carbon is stored in the wood and leaves of a tree. Most of the carbon is returned to near-surface waters when phytoplankton are eaten or decompose, but some falls into the ocean depths.
    - ◆ Worldwide, this “**biological carbon pump**” transfers about **10 gigatonnes of carbon** from the atmosphere to the deep ocean each year. Even small changes in the growth of phytoplankton may affect atmospheric carbon dioxide concentrations, which would feed back to global surface temperatures.
- **Zooplankton**
  - ▶ Zooplankton play vital role in food web of the food chain, nutrient recycling, and in transfer of organic matter from primary producers to secondary consumers like fishes.
  - ▶ They are more abundant within mangrove water-ways than in adjacent coastal waters, and a large proportion of the juvenile fish of mangrove habitat are zooplank-tivorous.

- ▶ The zooplankton determine the quantum of fish stock. Hence, zooplankton communities, based on their quality and species diversity, are used for assessing the productivity vis-à-vis fishery resource, fertility and health status of the ecosystem.
- ▶ Tiny flagellates, giant jellyfish (>500m)

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## ■ Sea-grass

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- Sea grasses are (angiosperms) marine flowering plants that resemble grass in appearance.
- They produce flowers; have strap-like or oval leaves and a root system.
- They grow in shallow coastal waters with sandy or muddy bottoms and require comparatively calm areas.
- They are the only group of higher plants adapted to life in the salt water.
- Major Sea grass meadows in India occur along the south east coast of Tamil Nadu and in the lagoons of a few Lakshadweep Islands. There are few grass beds around Andaman and Nicobar islands also.
- The rich growth of seagrasses along the Tamil Nadu coast and Lakshadweep islands is mainly due to high salinity, clarity of the water and sandy substratum.

### ○ Functions

- ▶ Sea grass beds physically help
  - To reduce wave and current energy,
  - To filter suspended sediments from the water and
  - Stabilize bottom sediments to control erosion.
- ▶ Provides habitat for marine invertebrates and fishes.
- ▶ Seagrass beds are widespread in lagoon and in such areas, the population of fish and migratory birds are also higher due to the availability of food and shelter.
- ▶ Sea grasses on reef flats and near estuaries are also nutrient sinks, buffering or filtering nutrient and chemical inputs to the marine environment.

#### **NOTE:**

- ▶ IUCN has accorded high priority for the conservation of sea grass.
- ▶ Out of 58 species found in the world, Fourteen species of seagrasses have been recorded from Indian coast.
- ▶ They are commonly distributed from inter-tidal to sub-tidal region down to 8 m depth.
- ▶ Dugong, a mammal dependent on sea grass for food, is also on the verge of extinction.

### ○ Threats to Sea Grass Beds

- ▶ Eutrophication, siltation, trawling, coastal engineering constructions and over exploitation for commercial purposes are the major threats for sea grass beds.

### ○ Management

- ▶ The major seagrass beds should be mapped and areas has to be identified for preservation.
- ▶ Dredging should be carried out far away from seagrass beds as siltation/turbidity destroys seagrass beds.



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## ■ Seaweeds

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- Seaweeds are (thalloid plants) macroscopic algae, which mean they have no differentiation of true tissues such as roots, stems and leaves. They have leaf-like appendages.
- Seaweeds, the larger and visible marine plants are found attached to rocks, corals and other submerged strata in the intertidal and shallow sub tidal zones of the sea.
- Seaweeds grow in shallow coastal waters wherever sizable substrata is available.
- Based on the colour of their pigmentation, sea weeds are broadly classified into different classes such as: Blue-green, Green, Brown, Red etc.
  
- **Functions of seaweeds**
  - ▶ Food for marine organism,
  - ▶ Habitat for fish breeding grounds,
  - ▶ Source of sediment.
  
- **Uses of seaweeds**
  - ▶ Seaweeds are important as food for humans, feed for animals, and fertilizer for plants.
  - ▶ Seaweeds are used as a drug for goiter treatment, intestinal and stomach disorders.
  - ▶ Products like agar-agar and alginates, iodine which are of commercial value, are extracted from seaweeds.
  - ▶ By the biodegradation of seaweeds methane like economically important gases can be produced in large quantities.
  - ▶ Extracts of some seaweed species show antibacterial activity.
  - ▶ Seaweeds are also used as the potential indicators of pollution in coastal ecosystem, particularly heavy metal pollution due to their ability to bind and accumulate metals strongly.
  
- **Harmful effects of Seaweeds**
  - ▶ Rotting seaweed is a potent source of hydrogen sulfide, a highly toxic gas, and has been implicated in some incidents of apparent hydrogen-sulphide poisoning. It can cause vomiting and diarrhea.
  
- **Threats to Seaweeds**
  - ▶ Threats are similar to that of sea grass.

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**UNIT**  
**6**

**NUTRIENT**  
**CYCLING**

# CONCEPT OF BIOGEOCHEMICAL

## ■ Concept of Bio-Geochemical Cycles

- The cyclical path of elements from abiotic system to the biotic system and back is called **Biogeochemical cycle**. The chemical elements, including all the essential elements of life, tend to circulate in the biosphere in characteristic pathways from environment to organisms and back to the environment. These more or less circular pathways are known as biogeochemical cycles. In other words, a biogeochemical cycle is a circuit or pathway by which a chemical element or molecule moves through both biotic ("bio-") and abiotic ("geo-") compartments of an ecosystem. In effect, the element is recycled, although in some such cycles there may be places (**called sinks**) where the element is accumulated or held for a long period of time. The movement of these elements and inorganic compounds that are essential to life can be conveniently designated as nutrient cycling. The dissipation of energy in some form is always necessary to drive material cycles.
- **Sink:** In a biogeochemical cycle, the element is recycled, but in some such cycles there may be places where the element is accumulated or held for a long period of time. Such places are called sinks. Such a place is also called a reservoir.
- This cycle contains any of the natural pathways by which essential elements of living matter are circulated. Biogeochemical cycles are named for the cycling of biological, geological and chemical elements through Earth and its atmosphere.
- The cycles move substances through the biosphere, lithosphere, atmosphere and hydrosphere. Cycles are gaseous and sedimentary.
  - ▶ **Gaseous cycles** includes nitrogen, oxygen, carbon and water.
  - ▶ **Sedimentary cycles** includes phosphorus and sulphur.
- These elements cycle through evaporation, absorption by plants and dispersion by wind. Sedimentary cycles include the leaching of minerals and salts from the Earth's crust, which then settle as sediment or rock before the cycle repeats.
- Energy flows through an ecosystem and is dissipated as heat, but chemical elements are recycled.
- For the living components of a major ecosystem (e.g., a lake or a forest) to survive, all the chemical elements that make up living cells must be recycled continuously.
- Energy flows directionally through Earth's ecosystems, typically entering in the form of sunlight and exiting in the form of heat. However, the chemical components that make up living organisms are different (they get recycled).
- Elements within biogeochemical cycles flow in various forms from the nonliving (a biotic) components of the biosphere to the living (biotic) components and back.
- Repetition of the cycles is important. Plants absorb carbon dioxide and release oxygen, making the air breathable. Plants also acquire nutrients from sediment. Animals acquire nutrients from plants and other animals, and the death of plants and animals returns these nutrients to the sediment as they decay. The cycle then repeats and allows other living things to benefit.

- The simplest example of biogeochemical cycles at work includes water. Water evaporates from the oceans, condenses as clouds and precipitates as rain, which returns the water back to the earth in a cycle.
- Many elements cycle through ecosystems, organisms, air, water, and soil. Many of these are trace elements. Other elements, including carbon, nitrogen, oxygen, hydrogen, sulfur, and phosphorus is critical components of all biological life.
- Each biogeochemical cycle can be considered as having a reservoir (nutrient) pool a larger, slow-moving, usually abiotic portion and an exchange (cycling) pool a smaller but more-active portion concerned with the rapid exchange between the biotic and abiotic aspects of an ecosystem.

### Basic Terminology

- ▶ **Exchange pools:** When chemicals are held for only short periods of time, they are said being held in exchange pools.
- ▶ **Reservoirs** are abiotic factors while exchange pools are biotic factors. Examples of exchange pools include plants and animals, which temporarily use carbon in their systems and release it back into the air or surrounding medium. On the other hand, coal deposits are the reservoirs or sinks of carbon. Carbon is held for a relatively short time in plants and animals when compared to coal deposits.
- ▶ **Residence:** The amount of time that a chemical is held in one place is called its residence.

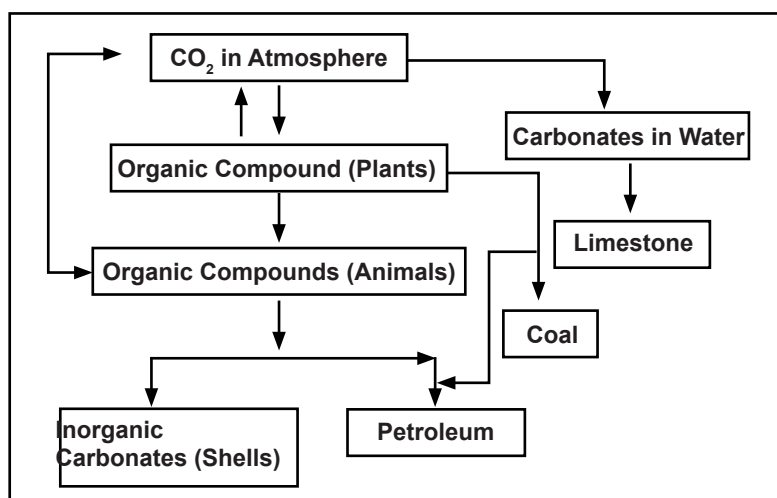
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# CARBON CYCLE

- Carbon is a constituent of all organic compounds, many of which are essential to life on Earth. Carbon dioxide is an atmospheric constituent that plays several vital roles in the environment. It is a greenhouse gas that traps infrared radiation heat in the atmosphere. It plays a crucial role in the weathering of rocks. It is the carbon source for plants. It is stored in biomass, organic matter in sediments, and in carbonate rocks like limestone.

## Steps in Carbon Cycle

- Carbon enters the atmosphere as carbon dioxide from respiration and combustion.
- Carbon dioxide is absorbed by producers to make carbohydrates in photosynthesis.
- Animals feed on the plant passing the carbon compounds along the food chain. Most of the carbon they consume is exhaled as carbon dioxide formed during respiration. The animals and plants eventually die.
- The dead organisms are eaten by decomposers and the carbon in their bodies is returned to the atmosphere as carbon dioxide. In some conditions decomposition is blocked. The plant and animal material may then be available as fossil fuel in the future for combustion.



### Major reservoirs of carbon

- ▶ The atmosphere
- ▶ The terrestrial biosphere (which usually includes freshwater systems and non-living organic material, such as soil carbon)
- ▶ The oceans (which includes dissolved inorganic carbon and living and non-living marine biota).
- ▶ The sediments (which includes fossil fuels).
- ▶ The annual movements of carbon, the carbon exchanges between reservoirs, occur because of various chemical, physical, geological, and biological processes.

## CO<sub>2</sub> in atmosphere

The amount of carbon dioxide in the atmosphere is controlled by the carbon cycle.

Processes that remove carbon dioxide from the air:

- ▶ photosynthesis by plants
- ▶ dissolving in the oceans.

Processes that return carbon dioxide from the air:

- ▶ respiration by plants, animals and microbes
- ▶ combustion i.e. burning wood and fossil fuels such as coal, oil and gas
- ▶ thermal decomposition of limestone, for example, in the manufacture of iron, steel and cement.

## ◉ Carbon Cycle: Long term and Short term

- ▶ The carbon cycle is composed of two reservoirs: a long-term and a short-term:
- ▶ The long-term reservoir contains about 99.9 percent of the total carbon which is found mainly in rocks and fossil fuels and takes up to millions of years to recycle carbon dioxide. In the long-term reservoir atmospheric carbon dioxide reacts with water and minerals in rocks to form calcium bicarbonate which enters rivers and ends up in the ocean where it becomes shells of various marine organisms. When these organisms die the shells accumulate on the ocean floor and are eventually transformed into rocks and petroleum. Over millions of years this transformed material is buried at depths of thousands of feet and the heat and pressure melts the rocks and converts the carbonate back to carbon dioxide. Some of these rocks become part of volcanoes and the carbonate is released as carbon dioxide via volcanic eruptions.
- ▶ In the short-term reservoir, carbon is stored in the atmosphere, oceans and biosphere with the ocean containing the largest amount of carbon. It takes months to centuries to recycle carbon dioxide through the short-term reservoir. The ocean is the primary regulator of atmospheric carbon dioxide in the short-term reservoir because atmospheric and ocean carbon dioxide are in chemical equilibrium. If there is an increase in atmospheric carbon dioxide there is a corresponding increase in oceanic carbon dioxide and vice versa. There are two main ways in the short-term reservoir that carbon dioxide is removed from the atmosphere and enters the ocean.
- ▶ In the first mechanism, atmospheric carbon dioxide enters the ocean by the growth and death of plants, animals and microbes. Secondly, atmospheric carbon dioxide is dissolved in the ocean which helps maintain a stable pH for life.

## ◉ Carbon act as Climate Buffer

- ▶ Because of the role of CO<sub>2</sub> in climate, feedbacks in the carbon cycle act to maintain global temperatures within certain bounds so that the climate never gets too hot or too cold to support life on Earth.
- ▶ The process is a large-scale example of **LeChatelier's Principle**. This chemical principle states that if a reaction at equilibrium is perturbed by the addition or removal of a product or reactant, the reaction will adjust so as to attempt to bring that chemical species back to its original concentration.
- ▶ For example, as carbonic acid is removed from solution by weathering of rocks, the reaction will adjust by producing more carbonic acid. And since the dissolved CO<sub>2</sub> is in equilibrium with atmospheric CO<sub>2</sub>, more CO<sub>2</sub> is removed from the atmosphere to replace that removed from solution by weathering.

## Terminologies

### ► Carbon Fertilization

It is also known as **Carbon Dioxide Fertilisation**. It is the phenomena that the increase of carbon dioxide in the atmosphere increases the rate of photosynthesis in plants.

CO<sub>2</sub> fertilization also increases plant water use efficiency. At higher CO<sub>2</sub>, plants maintain narrower openings on leaf surfaces because they can achieve the same internal CO<sub>2</sub> concentration inside leaves at the site of photosynthesis with their pores more closed.

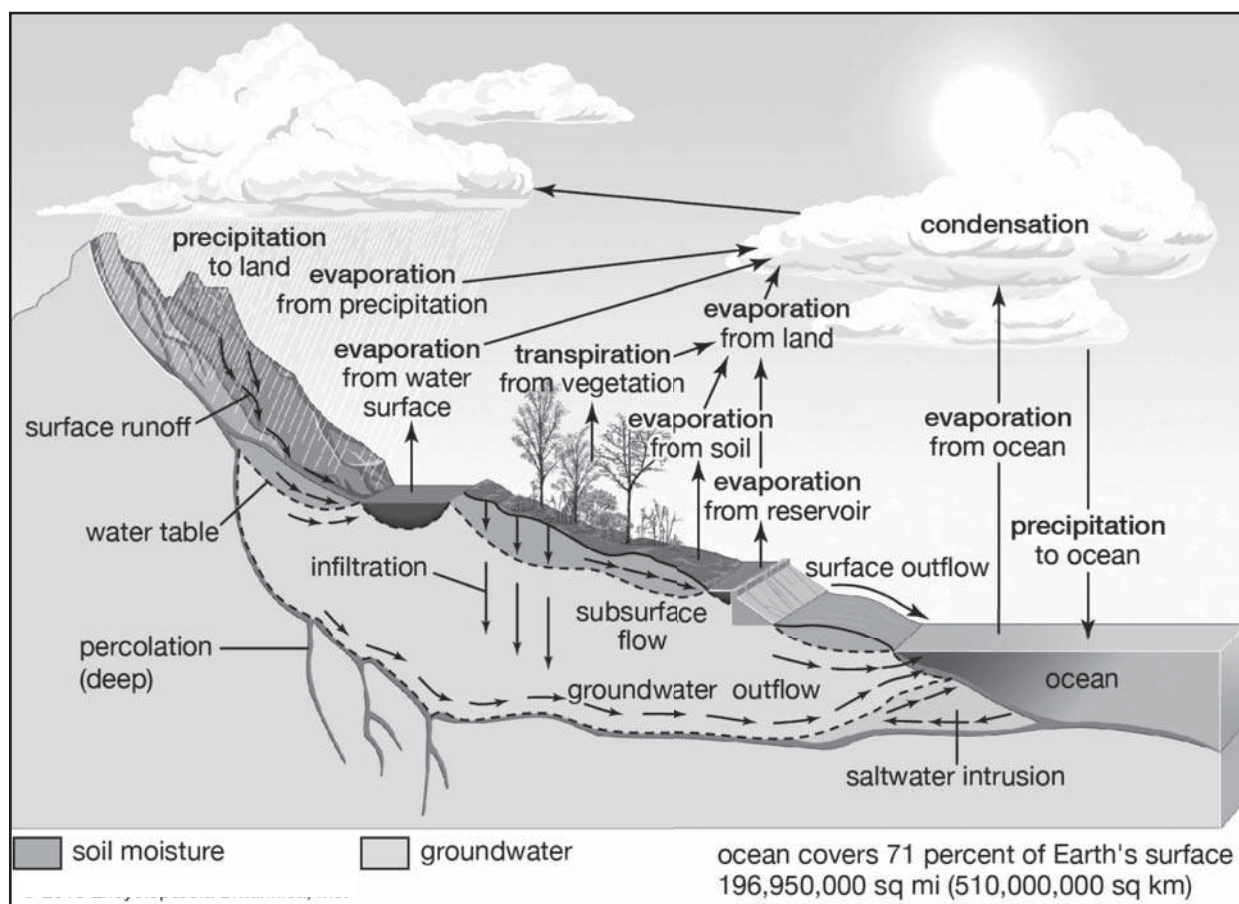
### ► Carbon Sequestration

It is the process involved in carbon capture and the long-term storage of atmospheric carbon dioxide or other forms of carbon to mitigate or defer global warming. It has been proposed as a way to slow the atmospheric and marine accumulation of greenhouse gases, which are released by burning fossil fuels.

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## HYDROLOGICAL CYCLE

- **Water cycle, also called hydrologic cycle**, cycle that involves the continuous circulation of water in the Earth-atmosphere system. Of the many processes involved in the water cycle, the most important are evaporation, transpiration, condensation, precipitation, and runoff. Although the total amount of water within the cycle remains essentially constant, its distribution among the various processes is continually changing.



## ■ Different Steps of the Hydrological Cycle

### ◦ Evaporation

- ▶ Evaporation, one of the major processes in the cycle, is the transfer of water from the surface of the Earth to the atmosphere. By evaporation, water in the liquid state is transferred to the gaseous, or vapour, state.



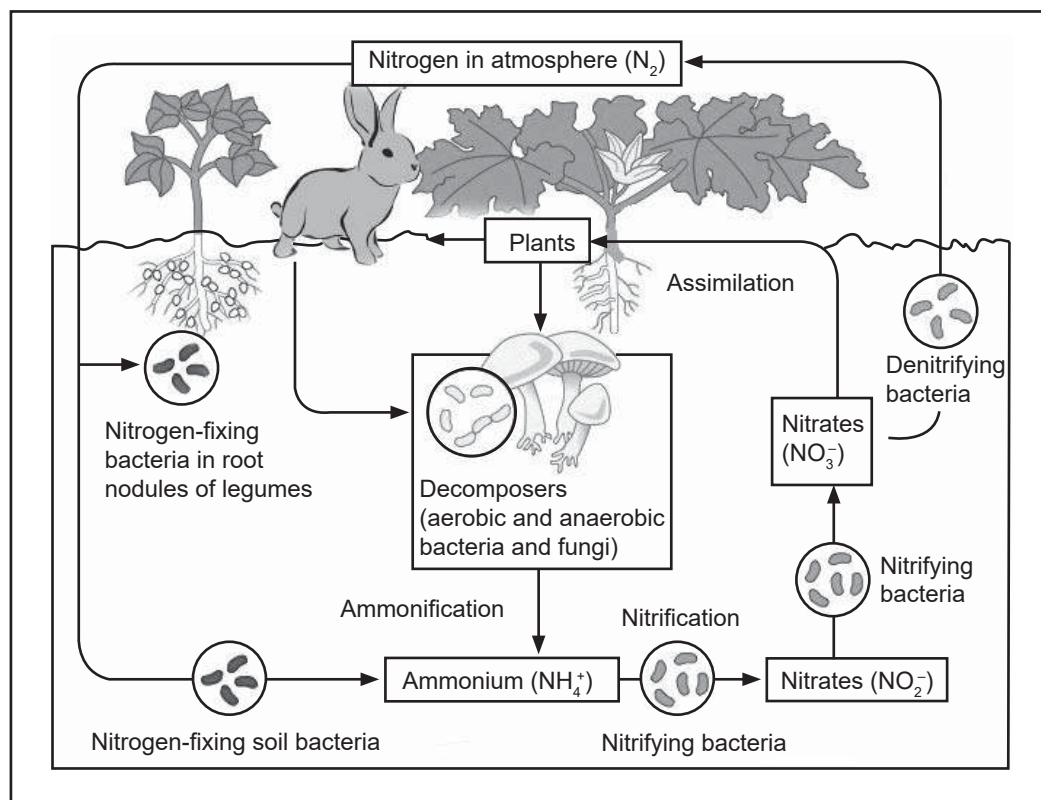
- ▶ This transfer occurs when some molecules in water mass have attained sufficient kinetic energy to eject themselves from the water surface. The main factors affecting evaporation are temperature, humidity, wind speed, and solar radiation.
- ◉ **Transpiration**
  - ▶ When water vapour is also discharged from plant leaves by a process called transpiration.
- ◉ **Sublimation**
  - ▶ Evaporation from snow and ice, the direct conversion from solid to vapor is known as sublimation.
- ◉ **Condensation**
  - ▶ When water vapour rises, it cools slightly and condenses. Generally, the water condenses on dust particles in the air and becomes liquid. Sometimes the water skips the liquid phase and turns directly into a solid - in the form of ice, hail, or snow. In the liquid form the particles collect and form clouds.
  - ▶ Condensation may take place as soon as the air contains more water vapour than it can receive from a free water surface through evaporation at the prevailing temperature. This condition occurs as the consequence of either cooling or the mixing of air masses of different temperatures. By condensation, water vapour in the atmosphere is released to form precipitation.
- ◉ **Precipitation**
  - ▶ The condensed water vapor falling to the surface of the Earth is known as precipitation.
  - ▶ It occurs in the form of snow, hail and rain.
- ◉ **Infiltration and Percolation**
  - ▶ When precipitation falls on the ground, some of it moves downwards into cracks, joints, and pores in the soil. The entry of water into the subsurface is termed **infiltration**.
  - ▶ The process of percolation refers to the subsequent movement of water through subsurface soil pores until it reaches the water table. At this point it becomes groundwater. This is a slow process, which is why more water flows back to the ocean through surface runoff than groundwater discharge
- ◉ **Groundwater Flow**
  - ▶ Groundwater is water that is held in cracks and pore spaces below ground. This water can be tapped by water supply wells or continue moving below the ground until it eventually returns to the surface.
  - ▶ The process by which groundwater exits the ground is known as **groundwater discharge**. This groundwater can either discharge directly into oceans, or more commonly, it discharges to surface water (lakes and rivers) and then travels to the ocean as surface runoff.
- ◉ **Role of Ice**
  - ▶ Ice also plays a role in the water cycle. Ice and snow on the Earth's surface occur in various forms such as frost, sea ice, and glacier ice. When soil moisture freezes, ice also occurs beneath the Earth's surface, forming permafrost in tundra climates. **About 18,000 years ago** glaciers and ice caps covered approximately one-third of the Earth's land surface. Today **about 12 percent of the land surface remains covered by ice masses**.
- ◉ **Storage**
  - ▶ There are three basic locations of water storage that occur in the planetary water cycle. Water is stored in the atmosphere; water is stored on the surface of the earth, and water stored in the ground.

- ▶ Water stored in the atmosphere can be moved relatively quickly from one part of the planet to another part of the planet.
- ▶ The type of storage that occurs on the land surface and under the ground largely depend on the geologic features related to the types of soil and the types of rocks present at the storage locations. Storage occurs as surface storage in oceans, lakes, reservoirs, and glaciers; underground storage occurs in the soil, in aquifers, and in the crevices of rock formations.

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## NITROGEN CYCLE

- Nitrogen is an essential component of protein and required by all living organisms including human beings. Nitrogen is needed for our DNA, RNA and proteins and is critical to human agriculture. Nitrogen, a component of proteins and nucleic acids, is essential to life on Earth.
- Although 78% by volume of the atmosphere is nitrogen gas, this abundant reservoir exists in a form unusable by most organisms. Through a series of microbial transformations, however, nitrogen is made available to plants, which in turn ultimately sustain all animal life.
- **Steps for Nitrogen Fixation**



► **Nitrogen Fixation**

- Nitrogen enters the living world by way of bacteria and other single-celled prokaryotes, which convert atmospheric nitrogen  $N_2$ —into biologically usable forms in a process called **nitrogen fixation**. Some species of nitrogen-fixing bacteria are free-living in soil or water, while others are beneficial symbionts that live inside of plants.
- Nitrogen-fixing microorganisms capture atmospheric nitrogen by converting it to ammonia ( $NH_3$ ) which can be taken up by plants and used to make organic molecules. The nitrogen-containing molecules are passed to animals when the plants are eaten. They may be incorporated into the animal's body or broken down and excreted as waste, such as the urea found in urine.

- Nitrogen fixation, in which nitrogen gas is converted into inorganic nitrogen compounds, is mostly (90 percent) accomplished by certain bacteria and blue-green algae (see nitrogen fixation). A much smaller amount of free nitrogen is fixed by abiotic means (e.g., lightning, ultraviolet radiation, electrical equipment) and by conversion to ammonia through the Haber-Bosch process
  - Nitrates and ammonia resulting from nitrogen fixation are assimilated into the specific tissue compounds of algae and higher plants. Animals then ingest these algae and plants, converting them into their own body compounds.
- **Ammonification**
- When plants or animal die organic nitrogen is again released back into the soil. Bacteria or fungi present in the soil convert them back into ammonium. This process is also called as **mineralization**.
  - The remains of all living things and their waste products are decomposed by microorganisms in the process of **ammonification**, which yields ammonia. (Under anaerobic, or oxygen-free, conditions foul-smelling putrefactive products may appear, but they too are converted to ammonia in time.) Ammonia can leave the soil or be converted into other nitrogen compounds, depending in part on soil conditions.
- **Nitrification**
- In this process, the ammonia is converted into nitrate by the presence of bacteria in the soil. Ammonia is oxidized to form nitrites by bacteria such as **Nitrosomonas species**. Nitrates are converted into nitrates by **Nitrobacter**. This conversion is very important as ammonia gas is toxic for plants.
- **Denitrification**
- Denitrification is the process that converts nitrate to nitrogen gas, thus removing bioavailable nitrogen and returning it to the atmosphere. Dinitrogen gas ( $N_2$ ) is the ultimate end product of denitrification, but other intermediate gaseous forms of nitrogen exists. Some of these gases, such as nitrous oxide ( $N_2O$ ), are considered greenhouse gases, reacting with ozone and contributing to air pollution.
  - Unlike nitrification, denitrification is an anaerobic process, occurring mostly in soils and sediments and anoxic zones in lakes and oceans.

## UPSC CSE PRELIMS, 2022

**Q1: Which of the following are nitrogen-fixing plants?**

1. Alfalfa
2. Amaranth
3. Chickpea
4. Clover
5. Purslane (Kulfa)
6. Spinach

Select the correct answer using the code given below:

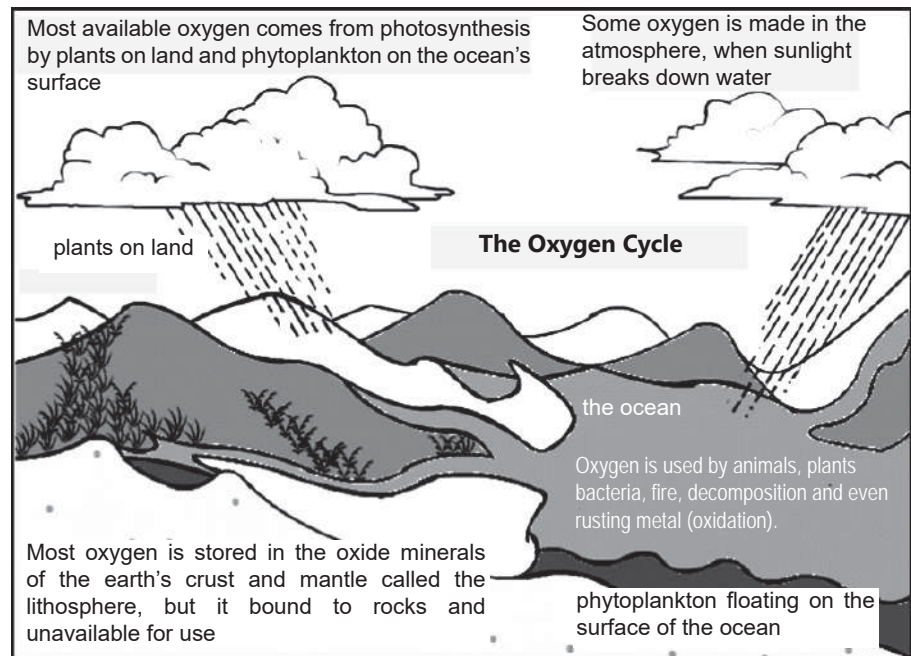
- (a) 1, 3 and 4 only      (b) 1, 3, 5 and 6 only  
 (c) 2, 4, 5 and 6 only      (d) 1, 2, 4, 5 and 6

**Correct Option: (a)**

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## OXYGEN CYCLE

- **Oxygen in the atmosphere is about 21%**, and it is the second most abundant gas after nitrogen. It is mostly utilized by living organisms, especially man and animals in respiration.
- Oxygen is also the most common element of human body.
- Oxygen is also used during combustion, decomposition, and oxidation. The circulation of oxygen is through three main flow systems including the (air) atmosphere, the biosphere, and the earth's crust.



- In the oxygen cycle, the main driving factor is photosynthesis which is the process whereby green plants and algae make their own food by use of solar energy, water, and carbon dioxide to give off oxygen as a by-product.
- Hence, for oxygen to remain in the atmosphere, it has to circulate through various forms of nature which is essentially termed as the oxygen cycle. The circulation depends on the various activities on Earth.

**Oxygen is Produced by:**

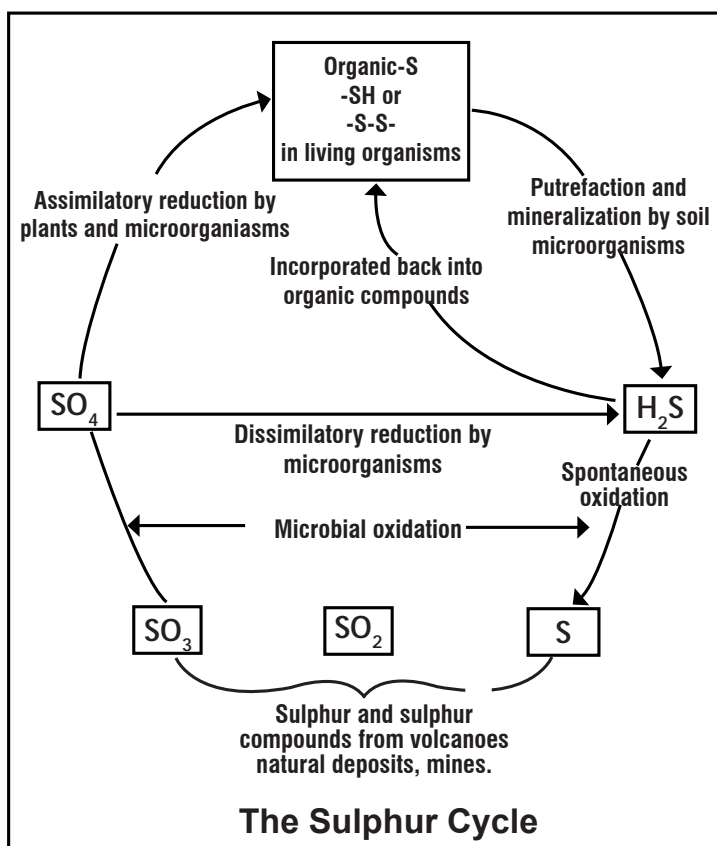
- ▶ **Plants** – Plants produce oxygen via photosynthesis
- ▶ **Sunlight** – Some oxygen is produced when sunlight reacts with water vapour in the atmosphere.

**Oxygen is used up in:**

- ▶ **Respiration** – All organisms use oxygen for respiration.
- ▶ **Decomposing** – When plants and animals die, they decompose. This process uses up oxygen and releases carbon dioxide into the air.
- ▶ **Rusting** – Also called oxidation, this process causes metals to rust. Also a process which uses up oxygen.
- ▶ **Combustion** – The process by which fire is generated also requires oxygen, along with heat and fuel. This process also uses up oxygen and releases carbon dioxide into the atmosphere.

## SULPHUR CYCLE

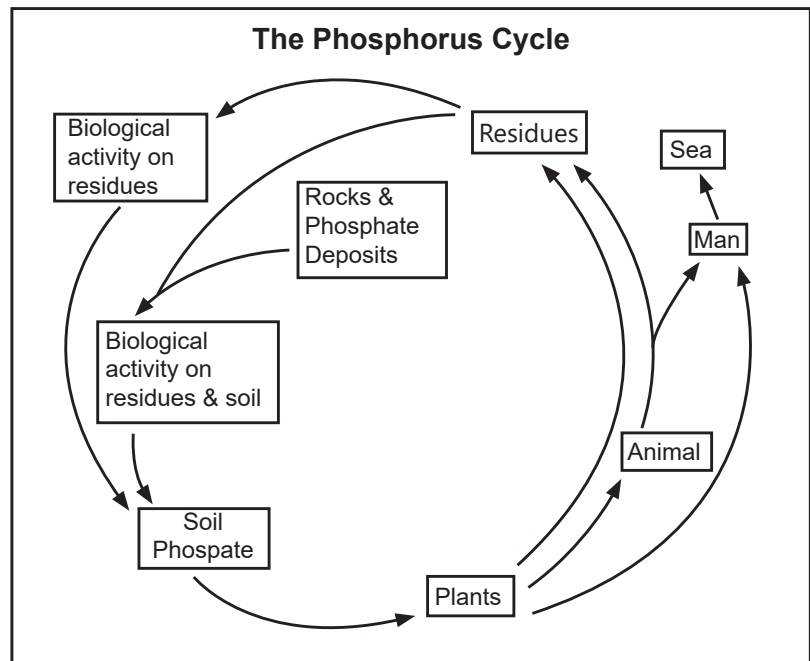
- The sulphur reservoir is in the soil and sediments where it is locked in organic (coal, oil and peat) and inorganic deposits (pyrite rock and sulphur rock) in the form of sulphates, sulphides and organic sulphur.
- It is released by weathering of rocks, erosional runoff and decomposition of organic matter and is carried to terrestrial and aquatic ecosystems in salt solution.
- The sulphur cycle is mostly sedimentary except two of its compounds, hydrogen sulphide ( $H_2S$ ) and sulphur dioxide ( $SO_2$ ), which add a gaseous component.
- Sulphur enters the atmosphere from several sources like volcanic eruptions, combustion of fossil fuels (coal, diesel etc.), from the surface of the ocean and gases released by decomposition.
- Atmospheric hydrogen sulphide also gets oxidised into sulphur dioxide.
- Atmospheric sulphur dioxide is carried back to the earth after being dissolved in rainwater as weak sulphuric acid (acid rain).
- Whatever the source, sulphur in the form of sulphates is taken up by plants and incorporated through a series of metabolic processes into sulphur bearing amino acid which is incorporated in the proteins of autotroph tissues. It then passes through the grazing food chain.
- Sulphur bound in a living organism is carried back to the soil, to the bottom of ponds and lakes and seas through excretion and decomposition of dead organic material.



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## PHOSPHORUS CYCLE

- Phosphorus is an essential nutrient for plants and animals in the form of ions  $\text{PO}_4^{3-}$  and  $\text{HPO}_4^{2-}$ . It is a part of DNA-molecules, of molecules that store energy (ATP and ADP) and of fats of cell membranes. Phosphorus is also a building block of certain parts of the human and animal body, such as the bones and teeth.
- Phosphorus can be found on earth in water, soil and sediments. Unlike the compounds of other matter cycles phosphorus cannot be found in air in the gaseous state. This is because phosphorus is usually liquid at normal temperatures and pressures. It is mainly cycling through water, soil and sediments. In the atmosphere phosphorus can mainly be found as very small dust particles.
- Phosphorus moves slowly from deposits on land and in sediments, to living organisms, and then much more slowly back into the soil and water sediment. The phosphorus cycle is the slowest one of the matter cycles. The phosphorus cycle appears somewhat simpler than the nitrogen cycle, because phosphorus occurs in fewer chemical forms.



### UPSC CSE PRELIMS, 2021

**Q1: In the case of which of the following biogeochemical cycles, the weathering of rocks is the main source of release of nutrients to enter the cycle?**

- Carbon Cycle
- Nitrogen cycle
- Phosphorus cycle
- Sulphur cycle

**Correct Option: (c)**

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## ■ Parts of the Cycle

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- As shown in the Figure, phosphorus, a necessary constituent of protoplasm, tends to circulate with organic compounds in the form of phosphates ( $\text{PO}_4$ ), which are again available to plants.
- The great reservoir of phosphorus is not the air, however, but in apatite mineral deposits formed in past geological ages (that is, in the lithosphere). Atmospheric dust and aerosols return a large amount of phosphorus (not phosphate) to the land yearly, but phosphate continually returns to the sea, where part of it is deposited in the shallow sediments and part of it is lost to the deep sediments.
- Contrary to popular belief, seabirds play only a limited role in returning phosphorus to the cycle (as shown by the guano deposits located on the coast of Peru). This transfer of phosphorus and other materials by birds from the sea to the land is continuing, likely at the same rate at which it occurred in the past - but these guano deposits have been mined out.

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# **BIODIVERSITY**

## ■ Biodiversity

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- The word “biodiversity” is an abbreviated version of “biological diversity”.
- The **Convention on Biological Diversity** defines biodiversity as: “the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species, and of ecosystems.”
- Thus, Biodiversity refers to the variety of forms - the different plants, animals and micro-organisms. It also includes the genes they contain and the ecosystem they form. It deals essentially with dynamic processes and increases when new genetic variation is produced and decreases on the loss of genetic variation or species extinction.

### ○ Types of Biodiversity

#### ▶ Genetic Diversity

- It refers to variation of genes within species.
- This variation can exist between different populations of the same species as well as between individuals within a population.
- Genetic diversity provides organisms and ecosystems with capacity to recuperate after change has occurred.
- Thus Genetic diversity is a level of biodiversity that refers to the total number of genetic characteristics in the genetic makeup of a species. It is distinguished from genetic variability, which describes the tendency of genetic characteristics to vary.
- Genetic diversity plays a great role in the adaptability and survival of a species. A species that has a large degree of genetic diversity among its individuals will have more variations from which to choose the most fitting allele.

#### ▶ Species Diversity

- Species diversity is a measure of the diversity within an ecological community that incorporates both species richness (the number of species in a community) and the evenness of species' abundance.
- Species diversity can be measured in terms of:
  - ◆ **Species richness** – refers to the number of various species in a defined area.
  - ◆ **Species abundance** – refers to the relative numbers among species. For example, the number of species of plants, animals and microorganisms may be more in an area than that recorded in another area.
  - ◆ **Taxonomic or phylogenetic diversity** – refers to the genetic relationships between different groups of species.

- Species diversity is not evenly distributed across the globe. The overall richness of species is concentrated in equatorial regions and tends to decrease as one moves from equatorial to polar regions.
- In addition, biodiversity in land ecosystems generally decreases with increasing altitude. The other factors that influence biodiversity are amount of rainfall and nutrient level in soil. In marine ecosystems, species richness tends to be much higher in continental shelves.

► **Ecosystem Diversity**

- It refers to the presence of different types of ecosystems. For instance, the tropical south India with rich species diversity will have altogether different structure compared to the desert ecosystem which has far less number of plant and animal species.
- Likewise, the marine ecosystem although has many types of fishes, yet it differs from the freshwater ecosystem of rivers and lakes in terms of its characteristics. So such variations at ecosystem level are termed as ecosystem diversity.

► **Functional Diversity**

- Functional diversity refers to the diversity of ecological processes that maintain and are dependent upon the other components of diversity.
- It includes the many ecological interactions among species e.g. competition, predation, parasitism, mutualism, etc. as well as ecological processes such as nutrient retention and recycling.
- It also includes the varying tempos and intensities of natural disturbances that many species and communities require if they are to persist.

**Measures of Biodiversity**

Biodiversity can be measured and monitored at several spatial scales:

- **Alpha Diversity** - refers to the average species diversity in a habitat or specific area. Alpha diversity is a local measure.
- **Beta Diversity** - refers to the ratio between local or alpha diversity and regional diversity. This is the diversity of species between two habitats or regions
- **Gamma Diversity** - is the total diversity of a landscape and is a combination of both alpha and beta diversity.

## Scales of Diversity

- Alpha Diversity
  - w/in habitat
- Beta Diversity
  - b/w habitat
- Gamma Diversity
  - Total diversity

## Patterns of Biodiversity

- ▶ **Biodiversity** is not uniform throughout the world but **varies with latitude and altitude**.
- ▶ Favourable environmental conditions favour speciation and make it possible for a larger number of species to exist there, i.e., biodiversity is more in such areas than the others.
- ▶ Species diversity decreases from the equator towards the poles. Tropics (**latitudinal range of 23.5°S**) have more species than temperate or polar areas.
- ▶ There are three different hypothesis proposed by scientists for explaining species richness in the Tropical region:
  - **Tropical latitude receives** more solar energy than temperate regions, which lead to high productivity and high species diversity.
  - **Tropical regions** have less seasonal variations and have more or less constant environment. This promotes the niche specialization and thus, high species richness.
  - **Temperate regions** were subjected to glaciations during ice age, while Tropical regions remained undisturbed which led to an increase in the species diversity in this region.

### Facts related to Biodiversity

- ▶ **Tropical ecosystems** support higher levels of biodiversity than temperate or boreal ecosystems. Tropical rainforests and coral reefs are the most diverse ecosystems on the planet. **50-90% of Earth's plant and animal species** are found in tropical regions. (World Resources Institute)
- ▶ Biodiversity "**hotspots**" are areas of the world with a high number of endemic species (that is, species found only in that place).
- ▶ Over **50% of the world's plant species** and **42% of all terrestrial vertebrate species are native to a specific country and do not naturally exist elsewhere. (Conservation International)**
- ▶ Species density is greatest in the **Southern Hemisphere**.
- ▶ Seventy per cent of the world's species is found in just **12 countries**: Australia, Brazil, China, Colombia, Costa Rica, the Democratic Republic of Congo, Ecuador, India, Indonesia, Madagascar, Mexico and Peru.
- ▶ The entire **Hindu Kush–Himalayan** belt has an estimated **25,000 plant species**, comprising **10 per cent of the world's flora**.
- ▶ A square kilometre of coastal ecosystem such as mangroves forests can store up to five times more carbon than the equivalent area of mature tropical forests. But these areas are being destroyed three to four times faster than forests, releasing substantial amounts of carbon dioxide into the atmosphere and the ocean, and contributing to climate change.

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## ■ Bio-Geographical Classification of World

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- On the basis of the type of fauna found in a region, the world is divided into the following five geographical regions:
- **Oriental Region** – Tiger, Neelgai, rabbit, flying fox, gharial, hedgehog, peacocks, etc., are the animals found in this region. The region is characterized by plain forests as well as elevated areas. Rainfalls is sufficient in most parts of this region.
- **Australian Region** – The region consists of Australia, New Zealand, Tasmania, etc. There are deserts and dry plains in this region, but freshwater ecosystems are rare. Kangaroo, honey eaters, crowed pigeons, owl, parrots, scale-footed lizards, etc., are important fauna of this region.
- **Neotropical Region** – This region includes South America, Central America, some parts of Mexico, West

Indies, etc. Main fauna of this region includes Americas monkeys, dogs, deer, cattle, squirrels, electric eel, monkey birds, humming birds, etc.

- **Nearctic Region** – This region covers Greenland and North America except Mexico. There are coniferous forests, islands, lakes, and seas, coniferous forests, and tundra in this region. The fauna of this region includes flying squirrel, vultures, kingfishers, ducks flamingo, alligators, rattle snake, cranes, pelicans, etc.
- **Palaearctic Region** – This is the largest geographical region and includes Europe, northern part of Africa, and Asia. Fauna is represented by 135 families of terrestrial vertebrates.

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## ■ Bio-Geographical Classification of India

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- India has different climate and topography in different parts and hence is termed as a mega diverse country. India occupies **10<sup>th</sup> place among plant rich countries of the world**. It is essential to acquire knowledge about the distribution and environmental interaction of flora and fauna of India.
- Biogeographers have classified India into ten biogeographic zones with each zone having characteristic climate, soil and biodiversity.
- These zones are described below:
- **Trans-Himalayas:** The Trans-Himalayas is an extension to the Tibetan plateau. This region harbors the high-altitude cold desert in Ladakh (Jammu and Kashmir) and Lahaul Spiti (Himachal Pradesh). It accounts for **5.7% of the country's landmass**.
- **Himalayas:** The Himalayas are the northern boundaries of India. The entire mountain chain is running from Kashmir in the North-west to Assam in the north-east. The Himalayas comprise of a diverse range of biotic provinces and biomes. The Himalayas cover **7.2% of the country's landmass**
- **Desert:** The extremely dry area west of the Aravalli hill range, is comprising both the salty desert of Gujarat and the sandy desert of Rajasthan. Deserts occupy around **6.9% of the country's land mass**. The kinds of deserts found in India are:
  - ▶ The desert of western Rajasthan
  - ▶ The desert of Gujarat
  - ▶ The high-altitude cold desert of Jammu & Kashmir and Himachal Pradesh. The Indian deserts have more diversified fauna.
- **Semi-arid:** This zone lies between the desert and the Deccan plateau. It includes the Aravalli hill range. It covers approximately **15.6% of the country's landmass**.
- **Western Ghats:** The Western Ghats are a mountain range that runs along the western coast of India. They are a range extending north-south from southern tip of Gujarat in the north to Kanyakumari in the south. The mountains cover an area of about **160,000 sq. km**. This ghat section covers an extremely diverse range of biotic provinces and biomes. It covers about **5.8% of the country's landmass**.
- **Deccan Plateau:** It is a large triangular plateau south of the Narmada valley. Three sides of the plateau are covered by mountains slopes towards east. Satpura mountains cover the north while western ghats cover the west side and eastern ghats cover the eastern side of the plateau. It is the one of largest zones covering the southern and south-central plateau with mostly deciduous trees. It covers **4.3% of the country's land mass**.
- **Gangetic Plain:** This plain covers the area between the South Himalayas to the Tropic of Cancer. These plains were formed by the Ganges river system and are relatively homogeneous. This region experience **600 mm rainfall annually**. **Sunderbans forests** are located in this region and it covers **11% of the country's land mass**.
- **North-East India:** These are non-himalayan ranges of northeastern India and have a wide variety of vegetation. It covers around **5.2% of the country's land mass**.

- **Islands:** The Andaman and Nicobar Islands in the Bay of Bengal has almost 300 big and small islands. Among these, only five islands are inhabited. Only tribes are found in the island of Nicobar. These islands have a highly diverse set of biomes and occupy **0.03%** of the country's biomass.
- **Coasts:** India has a large coastline distributed both to the east and west with distinct differences between the two. The Lakshadweep islands are included in this but the area of these islands is negligible.

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## ■ Biodiversity Hotspots

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- **Norman Myers**, a British Ecologist, developed the **concept of Hot spots in 1988** to designate priority areas for in situ conservation. According to him, the hot spots are the richest and the most threatened reservoirs of biodiversity on the earth.
- **To qualify as a biodiversity hotspot, a region must meet two strict criteria:**
- It must have **at least 1,500** vascular plants as endemics — which is to say, it must have a high percentage of plant life found nowhere else on the planet. A hotspot, in other words, is irreplaceable.
- It must have **30% or less** of its original natural vegetation. In other words, it must be threatened.

### ◦ Importance of Hotspots

- ▶ Biodiversity underpins all life on Earth. Without species, there would be no air to breathe, no food to eat, no water to drink. There would be no human society at all. And as the places on Earth where the most biodiversity is under the most threat, hotspots are critical to human survival.
- ▶ The map of hotspots overlaps extraordinarily well with the map of the natural places that most benefit people. That's because hotspots are among the richest and most important ecosystems in the world — and they are home to many vulnerable populations who are directly dependent on nature to survive. By one estimate, despite comprising **2.3% of Earth's land surface**, forests, wetlands and other ecosystems in hotspots account for **35% of the "ecosystem services"** that vulnerable human populations depend on.

### ◦ Biodiversity Hotspots in India

#### ▶ The Eastern Himalayas Hot Spot

- The eastern Himalayas is the region encompassing Bhutan, northeastern India, and southern, central and eastern Nepal. The region is geologically young and shows high altitudinal variation.
- The abrupt rise of the Himalayan Mountains from **less than 500 meters to more than 8,000 meters results in a diversity of ecosystems** that range from alluvial grasslands and subtropical broad leaf forests along the foot hills to temperate broad leaf forests in the mid hills, mixed conifer and conifer forests in the higher hills, and alpine meadows above the tree line.

#### ▶ Indo-Burma

- The Indo-Burma region encompasses several countries.
- It is spread out from Eastern Bangladesh to Malaysia and includes North-Eastern India south of Brahmaputra river, Myanmar, the southern part of China's Yunnan province, Lao people's Democratic Republic, Cambodia, Vietnam and Thailand.

#### ▶ Western Ghats and Sri Lanka

- Western Ghats, also known as the **"Sahyadri Hills"** encompasses the mountain forests in the southwestern parts of India and highlands of southwestern Sri Lanka.
- The entire extent of hotspot was originally about **1,82,500 square kms**, but due to tremendous population pressure, now only **12,445 square km or 6.8% is in pristine condition**.

- The wide variation of rainfall patterns in the Western Ghats, coupled with the region's complex geography, produces a great variety of vegetation types.
- These include scrub forests in the low-lying rainshadow areas and the plains, deciduous and tropical rainforests up to about **1,500 meters, and a unique mosaic of montane forests and rolling grasslands above 1,500 meters.**
- In Sri Lanka diversity includes dry evergreen forests to dipterocarpus dominated rainforests to tropical montane cloud forest.

World's 36 Biodiversity Hotspots	
<ul style="list-style-type: none"> <li>▶ <b>Africa</b> <ul style="list-style-type: none"> <li>• Cape Floristic Region</li> <li>• Coastal Forests of Eastern Africa</li> <li>• Eastern Afromontane</li> <li>• Guinean Forests of West Africa</li> <li>• Horn of Africa</li> <li>• Madagascar and the Indian Ocean Islands</li> <li>• Maputaland-Pondoland-Albany</li> <li>• Succulent Karoo</li> </ul> </li> <li>▶ <b>East Asia</b> <ul style="list-style-type: none"> <li>• Japan</li> <li>• Mountains of Southwest China</li> <li>• New Caledonia</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>▶ <b>Europe, West Asia and Central Asia</b> <ul style="list-style-type: none"> <li>• Caucasus</li> <li>• Irano-Anatolian</li> <li>• Mediterranean Basin</li> <li>• Mountains of Central Asia</li> </ul> </li> <li>▶ <b>North and Central America</b> <ul style="list-style-type: none"> <li>• California Floristic Province</li> <li>• Caribbean Islands</li> <li>• Madrean Pine-Oak Woodlands</li> <li>• Mesoamerica</li> </ul> </li> <li>▶ <b>South America Atlantic Forest</b> <ul style="list-style-type: none"> <li>• Cerrado</li> <li>• Chilean Winter Rainfall-Valdivian Forests</li> <li>• Atlantic forests</li> <li>• Tumbes-Choco-Magdalena</li> <li>• Tropical Andes</li> <li>• The Caribbean Islands</li> </ul> </li> </ul>
<ul style="list-style-type: none"> <li>▶ <b>South East Asia and Asia-Pacific</b> <ul style="list-style-type: none"> <li>• East Melanesian Islands</li> <li>• Himalaya</li> <li>• Indo-Burma</li> <li>• New Zealand</li> <li>• Philippines</li> <li>• Polynesia-Micronesia</li> <li>• Southwest Australia</li> <li>• Forests of Eastern Australia (new)</li> <li>• Sundaland</li> <li>• Wallacea</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>▶ <b>South Asia</b> <ul style="list-style-type: none"> <li>• Eastern Himalayas, Nepal.</li> <li>• Indo-Burma, India and Myanmar</li> <li>• Western Ghats , India</li> <li>• Srilanka</li> </ul> </li> </ul>

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## THREATS TO BIODIVERSITY

- Threat to biodiversity stems mainly from: habitat fragmentation, degradation and loss; shrinking genetic diversity; invasive alien species; declining forest resource base; climate change and desertification; over exploitation of resources; impact of development projects; and impact of pollution.

### ■ Causes of Biodiversity Losses ('The Evil Quartet')

- **Habitat loss and fragmentation:** Habitat of various organisms are altered or destroyed by **uncontrolled and unsustainable human activities** such as deforestation, slash, and burn agricultural, mining and urbanization. This results in the breaking up of the habitat into small species, which effects the movement of migratory animals and also, decreases the genetic exchange between populations leading to a declination of species. E.g.
  - ▶ **Tropical rain forests (loss from 14% to 6%).** Thousands hectares of rain forests is being lost within hours.
  - ▶ **The Amazon rain forest** is being cut for cultivating soya beans or for conversion of grasslands for cattle.
  - ▶ **Due to fragmentation,** animals requiring large territories and migratory animals are badly affected.
- **Over-exploitation:** Due to over-hunting and over-exploitation of various plants and animals by humans, many species have become endangered or extinct. **Many species like Stellar's sea cow, Passenger pigeon etc.** are extinct due to over-exploitation.
- **Alien species invasions:** Accidental or intentional introduction of non-native species into a habitat has led to the declination or extinction of indigenous species. Alien species cause decline or extinction of indigenous species. E.g.
  - ▶ The **Nile Perch** introduced in Lake Victoria (East Africa) caused extinction of more than 200 species of native fish, cichlid fish in the lake.
  - ▶ Invasive weed species like carrot grass (**Parthenium**), **Lantana** and water hyacinth (**Eicchornia**) caused damage to our native species.
  - ▶ The illegal introduction of the **African Catfish (Clarias gariepinus)** for aquaculture is posing a threat to the indigenous catfishes in our rivers.
- **Co-extinction:** In a native habitat, one species is connected to the other in an intricate network. The extinction of one species causes the extinction of other species, which is associated with it in an obligatory way. E.g.
  - ▶ Extinction of the parasites when the host is extinct.
  - ▶ Co-evolved plant-pollinator mutualism where extinction of one leads to the extinction of the other.



## The table below summarizes the main threats

Main threats	Some underlying causes
<b>Threats in terrestrial areas</b>	
Degradation, destruction and fragmentation of natural habitats	Spread of the urbanised areas, road network and industrial areas and associated problems (noise, pollution); abandon of former agricultural practices that were favourable to biodiversity
Decrease in the capacity of the agricultural areas to host wildlife	Intensification of agricultural practices (yielding pollution and disturbance) and disappearance of landscape elements that provide food and shelter that are exploitable by wildlife (such as hedges, trees, ponds, etc.)
Pollution of soils, air and water	Excess of heavy metals (industry, roads), manure and pesticides (agriculture) and other pollutants
Invasions by alien species	International trade and transport (roads, railways, rivers), gardening practices, exotic trees in forestry, exotic pests released in the wild, climate change, etc.
Epidemics affecting wildlife	Arrivals of pathogens that are favoured by the introduction of exotic species, pollution and the destruction of habitats
Climate change	Carbon emissions, deforestation and other land use changes due to human activities
Dessication of soils and wetlands	Excess pumping of underground water tables
Recreation and leisure	Overuse of green open spaces and wild areas, little respect for nature, mountain biking and motor sports in fragile areas, dogs not on leash
<b>Threats in marine areas</b>	
Overfishing and decline of species	Industrial fishing, overexploitation of target species, by-catch species
Pollution and eutrophication	Land-based activities (river run-off), atmospheric deposition, maritime traffic
Degradation and destruction of the sea floor	Beam trawling, dredging, sand and gravel extraction
Alien species introductions	Maritime trade (ballast waters, fouling), leisure navigation, mariculture, climate change
Leisure and tourism	Coastal development, water quality in summer (high population), mechanical beach cleaning, noise and other perturbations due to the high population

## ■ Invasive Species

- Invasive species, also called introduced species, alien species, or exotic species, any non-native species that significantly modifies or disrupts the ecosystems it colonizes.

- Such species may arrive in new areas through natural migration, but they are often introduced by the activities of other species.
- Human activities, such as those involved in global commerce and the pet trade, are considered to be the most common ways invasive plants, animals, microbes, and other organisms are transported to new habitats.
- The most common characteristics of invasive species are rapid reproduction and growth, high dispersal ability, ability to survive on various food types and in a wide range of environmental conditions and the ability to adapt physiologically to new conditions, called **phenotypic plasticity**.

### ◦ **What are their Impacts?**

- ▶ The direct threats of invasive species include preying on native species, outcompeting native species for food or other resources, causing or carrying disease, and preventing native species from reproducing or killing a native species' young.
- ▶ There are indirect threats of invasive species as well. Invasive species can change the food web in an ecosystem by destroying or replacing native food sources. The invasive species may provide little to no food value for wildlife. Invasive species can also alter the abundance or diversity of species that are important habitat for native wildlife.
- ▶ Invasive alien species are a major driver of biodiversity loss. In fact, an analysis of the **IUCN Red List** shows that they are the second most common threat associated with species that have gone completely extinct, and are the most common threat associated with extinctions of amphibians, reptiles and mammals.

An example is the **Micronesian Kingfisher *Todiramphus cinnamominus* which was endemic to the island of Guam**, but following predation by invasive alien snakes (Brown tree snake *Boiga irregularis*) it became Extinct in the Wild in 1986 when the last remaining wild birds were taken into captivity for captive breeding. In fact the Brown tree snake has caused many extinctions on Guam, including the local extinction of over half of Guam's native bird and lizard species as well as two out of three of Guam's native bat species.

- ▶ Invasive alien species can also lead to changes in the structure and composition of ecosystems leading to significant detrimental impacts to ecosystem services, affecting economies and human wellbeing.

For example the **Water Hyacinth *Eichhornia Crassipes*, a native to South America** is spreading across Africa, Asia, Oceania and North America. It is a fast growing floating aquatic plant forming dense mats on the water surface, limiting oxygen and preventing sunlight reaching the water column. Infestations have led to reduced fisheries, blocked navigation routes, increased cases of vector borne diseases, reduced hydropower capacity and affecting access to water.

### ◦ **Invasive Species in India**

- ▶ **Some Commonly Found Alien Species:**
- ▶ **African apple snail (*Achatina fulica*):** The most invasive among all alien fauna in India, this mollusc was first reported in the Andaman and Nicobar Islands. It is now found across country and is threatening the habitat of several native species.
- ▶ **Papaya Mealy Bug (*Paracoccus marginatus*):** Native of Mexico and Central America, it is believed to have destroyed huge crops of papaya in Assam, West Bengal and Tamil Nadu.
- ▶ **Cotton Mealy Bug (*Phenacoccus solenopsis*):** Native to North America, it has severely affected cotton crops in Deccan

- ▶ **Amazon sailfin catfish (*Pterygoplichthys pardalis*):** This species is responsible for destroying the fish population in the wetlands of Kolkata.

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## ■ Effects of Loss of Bio-Diversity

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- **Loss of cultural diversity:** The loss of both genetic and ecosystem diversities result in a loss of cultural diversity. As new strains and systems are introduced, they result in an overall change, the extinction of many species embedded in religion, mythology and folklore etc.
- **Ecosystem breakdown:** The loss of a species can have deleterious effects on the remaining species in an ecosystem. The loss of even one species can ruin an entire forest ecosystem of plants and animals.
- **Food insecurity:** Reduced biodiversity means millions of people face a future where food supplies are more vulnerable to pests and disease and where water is in irregular or short supply.
- **Economic impact:** The loss of plant species also means the loss of unknown economic potential, as extinct plants can hardly be harvested for food crops, fibers, medicines, and other products that forests, especially rainforests, provide.

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## ■ Extinction of Species

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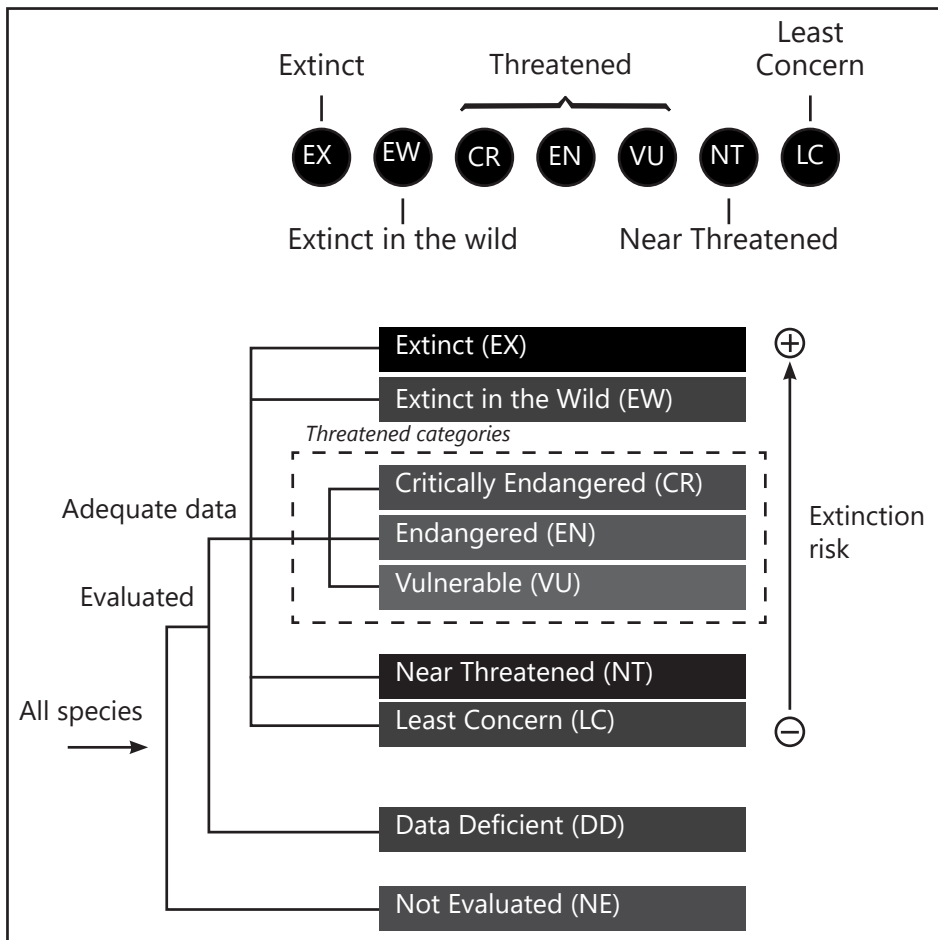
- Extinction of Species is a natural process. Species have disappeared and new ones have evolved to take their place over the long geological history of the earth. It is useful to distinguish three types of extinction processes.
- **Natural extinction:** With the change in environmental conditions, some species disappear and others, which are more adapted to changed conditions, take their place. This loss of species which occurred in the geological past at a very slow rate is called natural or background extinction.
- **Mass extinction:** There have been several periods in the earth's geological history when large number of species became extinct because of catastrophes. Mass extinctions occur in millions of years.
- **Anthropogenic extinction:** An increasing number of species is disappearing from the face of the earth due to the human activities. This man-made mass extinction represents a very severe depletion of biodiversity, particularly because it is occurring within a short period of time.

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## ■ IUCN Red List

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- The IUCN Red List is a rich compendium of information on threats, ecological requirements, and habitats of species; and on conservation actions that can be taken to reduce or prevent extinctions. It is based on an objective system for assessing the risk of extinction of a species based on past, present, and projected threats.
- The **IUCN Red List Index (RLI)** reveals trends in the overall extinction risk of species and provides an indicator that is used by governments to track their progress in achieving targets that reduce biodiversity loss. The Red List Index had been adopted by the United Nations as one of the indicators for the **2015 Millennium Development Goal 7** on environmental sustainability.
- The different categories of existing plants and animal species based on the International Union for Conservation of Nature and Natural Resources (IUCN) are –



### ◉ Extinct (EX)

- ▶ A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.

### ◉ Extinct in the Wild (EW)

- ▶ A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a period appropriate to the taxon's life cycle and life form.

### ◉ Critically Endangered (CR)

- ▶ A taxon is Critically Endangered when the best available evidence indicates that it is not Extinct and it is considered to be facing an extremely high risk of extinction in the wild. Survey should be over a time appropriate to the taxon's life cycle and life form.

#### ▶ Criteria:

- Reduction in population (> 90% over the last 10 years),
- Population size (number less than 50 mature individuals),

- Quantitative analysis showing the probability of extinction in wild is at least 50% in their 10 years) and
- It is therefore considered to be facing an extremely high risk of extinction in the wild.

### ◉ **Endangered (EN)**

- ▶ A taxon is endangered when the best available evidence indicates that it is not Critically Endangered but is considered to be facing a very high risk of extinction in the wild in the near future, as defined by any of the criteria.

### ◉ **Criteria:**

- ▶ Reduction in population (70% over the last 10 years),
- ▶ Population size (number less than 250 mature individuals),
- ▶ Quantitative analysis showing the probability of extinction in wild is at least 20% in their 20 years) and
- ▶ It is therefore considered to be facing a very high risk of extinction in the wild.

### ◉ **Vulnerable (VU)**

- ▶ A taxon is Vulnerable when the best available evidence indicates that it is not Critically Endangered or Endangered but is therefore considered to be facing a high risk of extinction in the wild in the medium-term future, as defined by any of the criteria.

#### ▶ **Criteria:**

- Reduction in population (> 50% over the last 10 years),
- Population size estimated to number less than 10,000 mature individuals,
- Probability of extinction in wild is at least 10% in their 100 years and
- It is therefore considered to be facing a high risk of extinction in the wild.

### ◉ **Near Threatened (NT)**

- ▶ A taxon is Near Threatened when it has evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

### ◉ **Least Concern (LC)**

- ▶ A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

### ◉ **Data Deficient (DD)**

- ▶ A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/ or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate.

### ◉ **Not Evaluated (NE)**

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

### **Red Data Book of IUCN**

Complete information of endangered species

The International Union for Conservation of Nature – IUCN, which was established in the year **1964** maintains **Red Data Book**.

The Red Data Book contains color-coded information sheets, which are arranged according to the dangerous species.

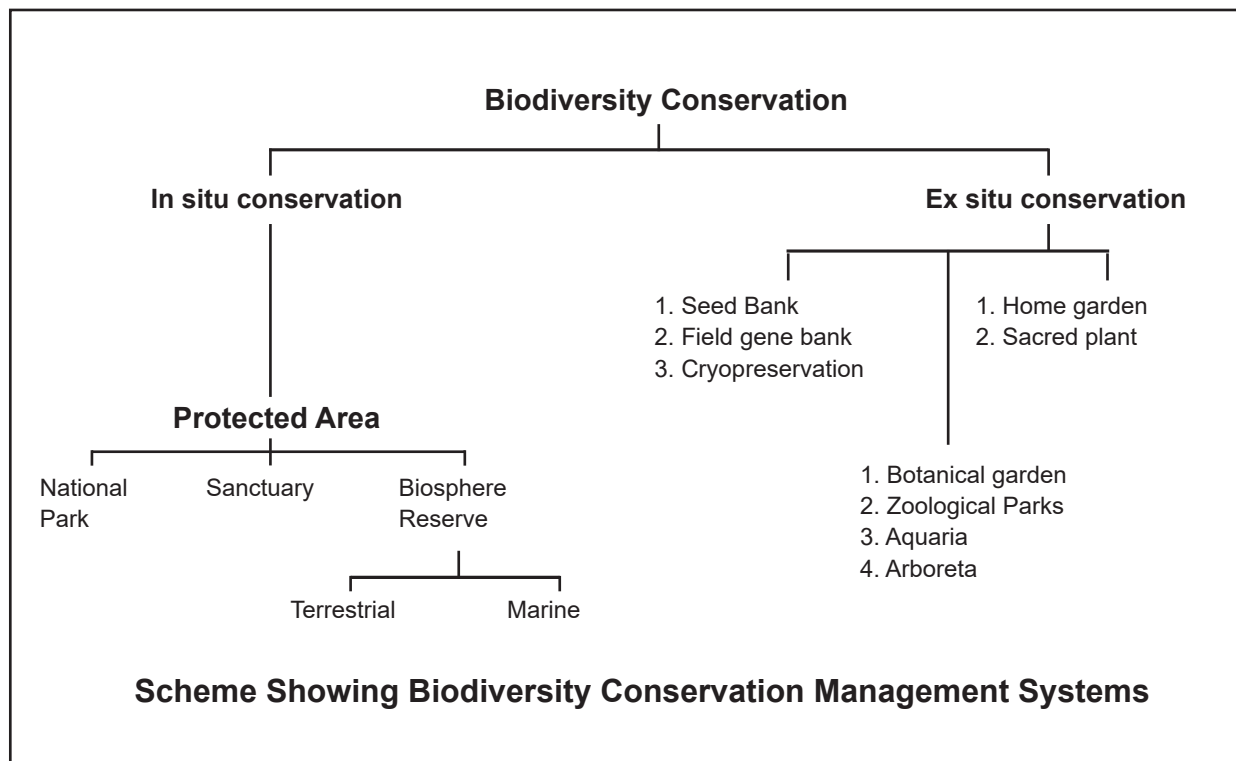
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# **BIODIVERSITY CONSERVATION**

# BIODIVERSITY CONSERVATION

## ■ Biodiversity Conservation

- Biodiversity is being depleted by the loss of habitat, fragmentation of habitat, over exploitation of resources, human sponsored ecosystems, climatic changes, pollution, invasive exotic species, diseases, shifting cultivation, poaching of wild life etc.
- The biodiversity conservation methodology is divided as In-situ and Ex-situ.



### ○ In-situ Methods of Conservation of Biodiversity

- ▶ The in-situ strategy emphasizes protection of total ecosystems. The in-situ approach includes protection of a group of typical ecosystems through a network of protected areas.
- ▶ In-situ management approaches can either be targeted at populations of selected species (species-centered) or whole ecosystems (ecosystem-based).
- ▶ Traditionally, protected areas have been seen as the cornerstone of in-situ conservation.



## o Protected Area Categories

	Objective	Features	Zone
<b>National Park</b>	Conservation of species of a habitat with minimal or very low intensity of human activity.	No person resides in the park other than public servants on duty and persons permitted by the chief wildlife warden.	Core
<b>Wildlife Sanctuary</b>	Conservation of species and habitats by manipulative management	No person resides in the park other than public servants on duty and persons permitted by the chief wildlife warden.	Core, Buffer, and Restoration
<b>Biosphere Reserve</b>	Conservation of the natural resource and the improvement of the relationship between humans and the environment	Both natural and human influenced ecosystem; substantial human settlement	Core, Buffer, Restoration, and Transition

## o What are Protected Areas?

**Protected areas have been established under the following categories defined by the IUCN:**

- ▶ **Category I - Strict Protection:** Sometimes called strict nature reserve/wilderness areas. Protected areas managed mainly for science or wilderness protection. Generally smaller areas where the preservation of important natural values with minimum human disturbance are emphasized.
- ▶ **Category II - Ecosystem Conservation and Tourism:** Sometimes called national parks. Generally larger areas with a range of outstanding features and ecosystems that people may visit for education, recreation, and inspiration as long as they do not threaten the area's values.
- ▶ **Category III - Conservation of Natural Features:** Sometimes called natural monuments. Similar to National Parks, but usually smaller areas protecting a single spectacular natural feature or historic site.
- ▶ **Category IV - Conservation through Active Management:** Sometimes called habitat and wildlife (species) management areas. Areas managed to protect and utilise wildlife species.
- ▶ **Category V - Landscape/Seascape Conservation and Recreation:** Sometimes called protected landscapes/seascapes.
- ▶ **Category VI - Sustainable Use of Natural Ecosystems:** Sometimes called managed resource protected areas. Protected areas managed mainly for the sustainable use of natural ecosystems.

## o Forms of Protected Areas

### ▶ National Parks:

- An area, whether within a sanctuary or not, can be notified by the state government to be constituted as a **National Park**, by reason of its ecological, faunal, floral, geomorphological, or zoological association or importance, needed to for the purpose of protecting & propagating or developing wildlife therein or its environment.
- No human activity is permitted inside the national park except for the ones permitted by the Chief Wildlife Warden of the state under special conditions.
- An international organization, the **International Union for Conservation of Nature (IUCN)**, and **its World Commission on Protected Areas**, has defined "National Park" as its **Category II type of protected areas**.

- **According to Wildlife Protection Act, 1972** - National park is an area which is strictly reserved for the betterment of the wildlife & biodiversity, and where activities like developmental, forestry, poaching, hunting and grazing on cultivation are not permitted.
- National Park declared by the Central Government such animal or any article, trophy, uncured trophy or meat [derived from such animal or any vehicle, vessel, weapon, trap, or tool used in such hunting,] shall be the property of **Central Government**. In these parks, even private ownership rights are not allowed.
- No alteration of the boundaries of a National Park shall be made except on a resolution passed by the **Legislature of the State**.
- No grazing of any [livestock] shall be permitted in a National Park and no livestock shall be allowed to enter except where such [livestock] is used as a vehicle by a person authorized to enter such National Park.

► **Wildlife Sanctuaries:**

- A sanctuary is a protected area which is reserved for the conservation of only animal and human activities like harvesting of timber, collecting minor forest products and private ownership rights are allowed as long as they do not interfere with well-being of animals. Boundaries of sanctuaries are not well defined and controlled biotic interference is permitted.
- The **State Government** may, by notification, declare its intention to constitute any area other than area comprised with any reserve forest or the territorial waters as a sanctuary if it considers that such area is of adequate ecological, faunal, floral, geomorphological, natural. or zoological significance, for the purpose of protecting, propagating or developing wildlife or its environment.
- Certain rights of people living inside the Sanctuary could be permitted. Further, during the settlement of claims, before finally notifying the Sanctuary, the Collector may, in consultation with the **Chief Wildlife Warden**, allow the continuation of any right of any person in or over any land within the limits of the Sanctuary.
- Wildlife sanctuaries are established by **IUCN category IV protected areas**.

► **Biosphere Reserves**

- The UNESCO's '**Man and Biosphere**' (**MAB**) programme was launched in 1971. It aimed to 'develop within the natural and social sciences a basis for the rational use and conservation of the resources of the biosphere and for the improvement of the relationship between man and the environment'.

**Critical Wildlife Habitat**

- Critical 'tiger' habitats (CTHs), also known as core areas of tiger reserves—are identified under the Wild Life Protection Act (WLPA), 1972 based on scientific evidence that such areas are required to be kept as inviolate for the purpose of tiger conservation, without affecting the rights of the Scheduled Tribes or such other forest dwellers.

**UPSC CSE PRELIMS, 2022**

**Q1: With reference to Indian laws about wildlife protection, consider the following statements:**

1. Wild animals are the sole property of the government.
2. When a wild animal is declared protected, such animal is entitled for equal protection whether it is found in protected areas or outside.
3. Apprehension of a protected wild animal becoming a danger to human life is sufficient ground for its capture or killing.

Which of the statements given above is/are correct?

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

**Correct option: (a)**

- ▶ The notification of CTH is done by the state government in consultation with the expert committee constituted for the purpose. Critical 'wildlife' habitats (CWLHs) are defined only in the Forest Rights Act, 2006.

- Biosphere reserves are areas comprising terrestrial, marine and coastal ecosystems.
- Biosphere reserves are internationally recognized, nominated by national governments and remain under sovereign jurisdiction of the states where they are located. Their status is internationally recognized.

### Eco-sensitive Zones

- ▶ As per the National Wildlife Action Plan (2002-2016), issued by the Union Ministry of Environment, Forest and Climate Change, land within 10 km of the boundaries of national parks and wildlife sanctuaries is to be notified as eco-fragile zones or Eco-Sensitive Zones (ESZ).
- ▶ While the 10-km rule is implemented as a general principle, the extent of its application can vary.
- ▶ Areas beyond 10-km can also be notified by the Union government as ESZs, if they hold larger ecologically important "sensitive corridors".

### Criteria for designation of Biosphere Reserves

- ◆ A site that must contain an effectively protected and minimally disturbed core area of value of nature conservation.
- ◆ The core area should be typical of a biogeographical unit and large enough to sustain viable populations representing all trophic levels in the ecosystem.
- ◆ The management authority to ensure the involvement/cooperation of local communities to bring variety of knowledge and experiences to link biodiversity conservation and socio-economic development while managing and containing the conflicts.
- ◆ Areas potential for preservation of traditional tribal or rural modes of living for harmonious use of environment.

### Structure and Functions of Biosphere Reserves:

- ◆ Biosphere reserves are demarcated into following 3 inter-related zones:

#### ◆ Core Zone

- » Core zone must contain suitable habitat for numerous plant and animal species, including higher order predators and may contain centres of endemism. Core areas often conserve the wild relatives of economic species and also represent important genetic reservoirs having exceptional scientific interest. A core zone being National Park or Sanctuary/protected/regulated mostly under the Wildlife (Protection) Act, 1972. Whilst realizing that perturbation is an ingredient of ecosystem functioning, the core zone is to be kept free from human pressures external to the system.

### UPSC CSE PRELIMS, 2018

**Q1: Consider the following statements?**

1. The definition of "Critical Wildlife Habitat" is incorporated in the forest rights act 2006
2. For the first time in India, Baigas have been given habitat rights
3. Union Ministry of Environment Forest and Climate Change officially decides and declares Habitat Rights for Primitive and Vulnerable Tribal Groups in any part of India

Which of the statements given above is/are correct?

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

**Correct Option: (a)**

- ◆ **Buffer Zone**

- » The buffer zone, adjoins or surrounds core zone, uses and activities are managed in this area in the ways that help in protection of core zone in its natural condition. These uses and activities include restoration, demonstration sites for enhancing value addition to the resources, limited recreation, tourism, fishing, grazing, etc; which are permitted to reduce its effect on core zone. Research and educational activities are to be encouraged. Human activities, if natural within BR, are likely to continue if these do not adversely affect the ecological diversity.

- ◆ **Transition Zone**

- » The transition area is the outermost part of a biosphere reserve. This is usually not delimited one and is a zone of cooperation where conservation knowledge and management skills are applied and uses are managed in harmony with the purpose of the biosphere reserve. This includes settlements, crop lands, managed forests and area for intensive recreation and other economic uses characteristics of the region.

- **Tripartite functions of Biosphere Reserves (Conservation, Development and logistic support)**

- ◆ To conserve the diversity and integrity of plants and animals within natural ecosystems.
- ◆ To safeguard genetic diversity of species on which their continuing evolution depends.
- ◆ To ensure sustainable use of natural resources through most appropriate technology for improvement of economic well-being of the local people.
- ◆ To provide areas for multi-faceted research and monitoring.
- ◆ To provide facilities for education and training.

- **Management**

- ◆ 100% grant-in-aid is provided under the Biosphere Reserve scheme for the approved items of activities for implementation of **Management Action Plans** submitted by the concerned States/UT. The activities permitted under the scheme are broadly under the following areas:
  - » Value addition activities
  - » Sustainable use of threatened resources
  - » Rehabilitation of landscapes of threatened species and ecosystems
  - » Socio-economic upliftment of local communities
  - » Maintenance and protection of corridor areas
  - » Development of communication system and Networking
  - » Development of Eco-tourism
- ◆ BR scheme is different from other conservation related schemes. It has the focus on the welfare of local inhabitants through provision of supplementary and alternate livelihood support to the people in the buffer and transition zones in order to reduce biotic pressure on biodiversity of the natural reserves of core zone.

- **Marine Protected Areas**

- ▶ **Marine protected areas (MPA)** are protected areas of seas, oceans, estuaries or large lakes.
- ▶ It is a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values”.
- ▶ MPAs restrict human activity for a conservation purpose, typically to protect natural or cultural resources. Such marine resources are protected by local, state, territorial, native, regional, national, or international authorities and differ substantially among and between nations.

- ▶ This variation includes different limitations on development, fishing practices, fishing seasons and catch limits, moorings and bans on removing or disrupting marine life.
- ▶ MPA is an umbrella term to describe a wide range of protected areas for marine conservation around the world.

▶ **Marine Protected Areas in India**

- India has at present following designated Marine Protected Areas:
- **Gulf of Mannar National Park, Tamil Nadu:** Gulf of Mannar Marine National Park consists of 21 small islands and coral reefs in the Gulf of Mannar in the Indian Ocean of Tamil Nadu. The park has a high diversity of plants and animals in its marine and shore habitats. Dugong (Sea Cow), a vulnerable marine mammal is also found here.
- **Gulf of Kutch Marine National Park, Gujarat:** It is the first national marine park of India with 42 islands on Jamnagar coast in the Marine National Park.
- **Malvan (Marine) Wildlife Sanctuary, Maharashtra:** The Malvan Wildlife Sanctuary includes Padamged Island and other submerged rocky structures.
- **Mahatma Gandhi Marine National Park, Andaman & Nicobar Islands:** Most of the coral reefs in the park are fringing reefs and the park is an important breeding ground for turtles.
- **Gahirmatha Sanctuary, Odisha:** Gahirmatha Beach separates the Bhitarkanika Mangroves from the Bay of Bengal and is the world's most important nesting beach for Olive Ridley Sea Turtles.

▶ **Monitoring Mechanism**

- In India, all marine protected areas fall under the **Ministry of Environment, Forest and Climate Change (MoEFCC)**. It is the nodal agency at the central level and responsible for: Planning, Promotion, Co-ordination and Overseeing the implementation of environmental and forestry programmes (Integrated Coastal Zone Management Project, 2012).
- **At the state level the Department of Forests** (under the MoEFCC) acts as the nodal agency for the same.
- **Departments of Fisheries** are responsible for managing the fisheries resources in their particular state.
- **The Ministry of Earth Sciences (MoES)** deals with the science and technology research of exploitation of ocean resources (living and non-living).

○ **Conservation and Community Reserves**

- ▶ Conservation reserves and community reserves in India are terms denoting protected areas of India which typically act as buffer zones to or connectors and migration corridors between established national parks, wildlife sanctuaries and reserved and protected forests of India. Such areas are designated as conservation areas if they are uninhabited and completely owned by the Government of India but used for subsistence by communities and community areas if part of the lands are privately owned.
- ▶ These protected area categories were first introduced in the **Wildlife (Protection) Amendment Act of 2002** – the amendment to the Wildlife Protection Act of 1972. These categories were added because of reduced protection in and around existing or proposed protected areas due to private ownership of land, and land use.

List of Designated Biosphere Reserves			
S. No	Name of the BR & total geographical area (Km <sup>2</sup> )	Date of Designation	Location in the State (s)/Union Territory
1.	Nilgiri (5520)	1 1.8.1986	Part of Wynad, Nagarhole, Bandipur and Madumalai, Nilambur, Silent Valley and Siruvani hills in Tamil Nadu, Kerala and Karnataka.

2.	<b>Nanda Devi (5860.69)</b>	18.1.1988	Part of Chamoli, Pithoragarh and Almora districts in Uttarakhand.
3.	<b>Nokrek (820)</b>	1.9.1988	Part of East West and South Garo Hill districts in Meghalaya.
4.	<b>Manas (2837)</b>	14.3.1989	Part of Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamrup and Darang districts in Assam.
5.	<b>Sunderban (9630)</b>	29.3.1989	Part of delta of Ganges & Brahmaputra river system in West Bengal.
6.	<b>Gulf of Mannar (10500)</b>	18.2.1989	India part of Gulf of Mannar extending from Rameswaram island in the North to Kanyakumari in the South of Tamil Nadu.
7.	<b>Great Nicobar (885)</b>	6.1.1989	Southern most island of Andaman and Nicobar Islands.
8.	<b>Similipal (4374)</b>	21.6.1994	Part of Mayurbhanj district in Odisha.
9.	Dibru-Saikhowa (765)	28.7.1997	Part of Dibrugarh and Tinsukia districts In Assam.
10.	Dehang•Dibang (5111.5)	2.9.1998	Part of Upper Siang, West Slang and Dibang Valley districts in Arunachal Pradesh.
11.	<b>Pachmarhi (4981.72)</b>	3.3.1999	Part of Betul, Hoshangabad and Chhindwara districts in Madhya Pradesh.
12.	Khangchendzonga (2619.92)	7.2.2000	Part of North and West districts in Sikkim.
13.	Agasthyamalai (3500.36)	12.11.2001	Part of Thirunelveli and Kanyakumari districts in Tamil Nadu and Thiruvanthapuram, Kollam and Pathanamthitta districts in Kerala.
14.	<b>Achanakmar- Amarkantak (3,835. 51)</b>	30.3.2005	Part of Anuppur and Dindori districts of Madhya Pradesh and Bilaspur district of Chattisgarh.
15.	<b>Kachchh (12,454)</b>	29.1.2008	Part of Kachchh, Rajkot, Surendranagar and Patan districts in Gujarat.
16.	<b>Cold Desert (7,770)</b>	28.8.2009	Pin Valley National Park and surroundings; Chandratal & Sarchu; and Kibbe, Wildlife sanctuary in Himachal Pradesh.
17.	<b>Seshachalam (4755.997)</b>	20.9.2010	Seshachalam hill ranges in Eastern Ghats encompassing part of Chittoor and Kadapa districts in Andhra Pradesh.
18.	<b>Panna (2998.98)</b>	25.2.2011	Part of Panna and Chhattarpur districts in Madhya Pradesh
*Sites with bold letters have been included in the World Wide Network of BRs of UNESCO.			

## o Sacred Forests and Sacred Lakes

- ▶ A traditional strategy for the protection of biodiversity has been in practice in India and some other Asian countries in the form of sacred forests. These are forest patches of varying dimensions protected

by tribal communities due to religious sanctity accorded to these forest patches. In India sacred forests are located in several parts, e.g. Karnataka, Maharashtra, Kerala, Meghalaya, etc., and are serving as refugia for a number of rare, endangered and endemic taxa. Similarly, several water bodies (e.g. Khecheopalri Lake in Sikkim) have been declared sacred by the people leading to protection of aquatic flora and fauna.

► **Ecological Significance**

- **Conservation of Biodiversity** - The sacred groves are important repositories of floral and faunal diversity that have been conserved by local communities in a sustainable manner. They are often the last refuge of endemic species in the geographical region.
- **Recharge of aquifers** - The groves are often associated with ponds, streams or springs, which help meet the water requirements of the local people. The vegetative cover also helps in the recharging the aquifers.
- **Soil conservation** - The vegetation cover of the sacred groves improves the soil stability of the area and also prevents soil erosion.

○ **World Heritage Sites**

- A World Heritage site is a landmark or area which is selected by the **United Nations Educational, Scientific and Cultural Organization (UNESCO)** as having cultural, historical, scientific or other form of significance, and is legally protected by international treaties. The sites are judged important to the collective interests of humanity.

► **Selection Criteria**

● **Cultural criteria**

- ◆ "Represents a masterpiece of human creative genius and cultural significance"
- ◆ "Exhibits an important interchange of human values, over a span of time, or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning, or landscape design"
- ◆ "To bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared"
- ◆ "Is an outstanding example of a type of building, architectural, or technological ensemble or landscape which illustrates a significant stage in human history"
- ◆ "Is an outstanding example of a traditional human settlement, land-use, or sea-use which is representative of a culture, or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change"
- ◆ "Is directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance"

● **Natural criteria**

- ◆ "Contains superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance"
- ◆ "Is an outstanding example representing major stages of Earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features"
- ◆ "Is an outstanding example representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems, and communities of plants and animals"
- ◆ "Contains the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation"

## ◉ Legal Status of Designated Sites

- ▶ UNESCO designation as a World Heritage Site provides prima facie evidence that such culturally sensitive sites are legally protected pursuant to the Law of War, under the Geneva Convention, its articles, protocols and customs, together with other treaties including the Hague Convention for the Protection of Cultural Property in the Event of Armed Conflict and international law.

## ◉ Geo-Heritage Sites

- ▶ **Geological Survey of India (GSI)** declares geo-heritage sites/ national geological monuments for protection and maintenance.
- ▶ GSI or the respective State governments take necessary measures to protect these sites.

### Hope Spots:

They are ecologically unique areas of the ocean designated for protection under a global conservation campaign overseen by Mission Blue, a non-profit organization founded **by Sylvia Earle with her 2009 TED prize wish.**

**Hope Spots** can be **Marine Protected Areas (MPA)** that need attention or new sites. They are chosen for their contributions to biodiversity, the carbon sink, and important habitat. Hope Spot status is intended to alleviate the pressures human resource extraction places on the ocean by making the site higher priority to become an MPA, where resource extraction, like fishing and drilling, may be forbidden under law.

**Andaman and Nicobar Islands and Lakshadweep islands** have recently been named as the new **“hope spots”** by the **International Union for Conservation of Nature (IUCN)** and Mission Blue, an organization involved in the study of oceans.

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- Ex-situ conservation is the preservation of components of biological diversity outside their natural habitats. This involves conservation of genetic resources, as well as wild and cultivated or species, and draws on a diverse body of techniques and facilities.

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## ■ Ex-situ Methods of Conservation of Biodiversity

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- **Zoos:** Zoos or zoological gardens or zoological parks are the place in which animals are confined within enclosures or semi-natural and open areas, displayed to the public, and in which they may also breed. Zoos breed many endangered species to increase their numbers. Such captive breeding in zoos has helped to save several species from extinction.
- **Botanical Gardens:** Botanical gardens can be defined as “public gardens which maintain collections of live plants mainly for study, scientific research, conservation and education.  
**Botanic gardens are able to:**
  - ▶ Rehabilitate indigenous and threatened species and restore them to protected portions of their former habitats;
  - ▶ Exploit commercially those species which are plentiful; and
  - ▶ Promote wildlife education to a broad range of target groups such as politicians, school and college students, and communities living in and around wildlife areas.
- **Translocations:** Sometimes conservation of faunal species involves or necessitates translocation of animals. This means the movement of individuals from its natural habitat, or from captivity, to another habitat. Translocations are carried out in connection with introductions or reintroductions, and should be handled with extreme caution. These operations are carried out often with support from international captive breeding programs and receive the cooperation of zoos, aquaria, etc.
- **Artificial Insemination:** Artificial insemination, or AI, is the process by which sperm is placed into the reproductive tract of a female for the purpose of impregnating the female by using means other than sexual intercourse or natural insemination.
- **Somatic Cell Cloning:** Somatic Cell Cloning holds some promise for propagating from one or a few survivors of an almost extinct species. The nucleus of a somatic cell is removed and kept, and the host’s egg cell is kept and nucleus removed and discarded. The lone nucleus is then fused with the ‘deprogrammed’ egg cell. After being inserted into the egg, the lone (somatic-cell) nucleus is reprogrammed by the host egg cell. The egg, now containing the somatic cell’s nucleus, is stimulated with a shock and will begin to divide.

- ◉ **Seed Bank:** The preservation of plant germplasm in seed banks, (or gene-banks), is one of the techniques of ex-situ conservation of plant species. Storing germplasm in seed banks is both inexpensive and space efficient. It allows preservation of large populations with little genetic erosion. Seed banks also offer good sources of plant material for biological research, and avoid disturbance or damage of natural populations.
- ◉ **Reintroduction:** Reintroduction of an animal or plant into the habitat from where it has become extinct is another form of ex situ conservation. For example, the Gangetic Gharial has been reintroduced in the rivers of Uttar Pradesh, Madhya Pradesh and Rajasthan where it had become extinct.
- ◉ **Cryopreservation:** The storage of seeds, pollen, tissue, or embryos in liquid nitrogen. This method can be used for virtually indefinite storage of material without deterioration over a much greater time-period relative to all other methods of ex situ conservation. Cryopreservation is also used for the conservation of livestock genetics through Cryo-conservation of animal genetic resources. Technical limitations prevent the cryopreservation of many species, but cryobiology is a field of active research, and many studies concerning plants are underway.
- ◉ **Tissue Culture (Storage and Propagation):** Somatic tissue can be stored in vitro for short periods of time. This is done in a light and temperature controlled environment that regulates the growth of cells. As a ex situ conservation technique tissue culture is primary used for clonal propagation of vegetative tissue or immature seeds. This allows for the proliferation of clonal plants from a relatively small amount of parent tissue.
- ◉ **Long Term Captive Breeding:** The method involves capture, maintenance and captive breeding on long term basis of individuals of the endangered species which have lost their habitat permanently or certain highly unfavorable conditions are present in their habitat.
  - **Captive breeding is generally carried out for one of these main purposes:**
    - To produce animals for commercial purposes (pets, food, fibre, medicine, and other human uses).
    - To produce animals for zoos, aquaria, research institutions, and other public facilities.
    - To increase captive population numbers of threatened or endangered species. In some cases, these individuals are part of a management programme aimed at eventually reintroducing captive-bred animals into wild habitats and populations. In other cases, captive facilities claim to be breeding animals for such purposes -but the animals may not be suitable - or they are not part of a legitimate conservation and management programme.

In situ Conservation	Ex situ Conservation
This method involves protection of endangered species in their natural habitat.	It involves placing of threatened animals and plants in special care unit for their protection.
It helps in recovering populations in the surroundings where they have developed their distinct features.	It helps in recovering populations or preventing their extinction under stimulated conditions that closely resemble their natural habitats.
e.g. national parks, biosphere reserves, wildlife sanctuaries, etc.	e.g. botanical garden, zoological parks.

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## NATIONAL PARKS

A National Park is a protected area used for conservation purposes. It preserves biodiversity and also helps in protecting endangered species. It is an area of natural, semi-natural, or planted space set aside for recreation and protection.

In India, National Parks are designated and maintained by state governments. Human activities such as grazing and settlement inside such a park are not allowed. There are 108 National Parks in India covering more than 50,000 sq. km of area.

National Park	Location	Famous for
<b>Nandadevi National Park</b>	Uttarakhand	<ul style="list-style-type: none"> <li>▶ The National Park was inscribed a <b>World Heritage Site by UNESCO in 1988</b>.The latter was expanded and renamed to Nanda Devi and Valley of Flowers National Parks in 2005.</li> <li>▶ Asiatic black bear, snow leopard, brown bear and blue sheep are found</li> <li>▶ Common trees in the Nanda Devi National Park are fir, birch and rhododendron.</li> <li>▶ Characterized by temperate to arctic type of climate</li> </ul>
<b>Khangchendzonga National Park</b>	Sikkim	<ul style="list-style-type: none"> <li>▶ Inscribed to the <b>UNESCO World Heritage Sites</b> list, becoming the first "<b>Mixed Heritage</b>" site of India.</li> <li>▶ Fauna: Musk Deer, Snow Leopard, Clouded Leopard, Himalayan tahr are found.</li> <li>▶ Flora: The vegetation of the park include temperate broadleaf and mixed forests consisting of oaks, fir, birch, maple, willow etc. The vegetation of the park also includes alpine grasses and shrubs at higher altitudes.</li> <li>▶ Characterized by temperate to arctic type of climate</li> <li>▶ <b>Lepcha tribal settlements</b></li> <li>▶ Park contains <b>Tholung Monastery</b></li> </ul>
<b>Neora valley National Park</b>	Kalimpong, West Bengal	<ul style="list-style-type: none"> <li>▶ Land of the elegant red panda</li> <li>▶ Primary biomes corresponding to the ecozone are:               <ul style="list-style-type: none"> <li>◦ Sino-Himalayan Temperate Forest of the Eastern Himalayan broadleaf forests Biome 7</li> <li>◦ Sino-Himalayan Subtropical Forest of the Himalayan subtropical broadleaf forests Biome 8</li> <li>◦ Indo-Chinese Tropical Moist Forest of the Himalayan subtropical pine forests Biome 9</li> </ul> </li> </ul>

		<ul style="list-style-type: none"> <li>▶ Flora: Rhododendron, bamboo, oak, ferns, sal</li> <li>▶ Fauna: Indian leopard, wild boar, leopard cat, goral, serow, barking deer, sambar, Himalayan flying squirrel and thar. The most exotic of all is Red Panda.</li> <li>▶ The highest point of this park is Rachel Pass, where it forms a boundary with Sikkim in the North and Bhutan in the North East.</li> </ul>
<b>Namdapha National Park (Tiger Reserve)</b>	Arunachal Pradesh	<ul style="list-style-type: none"> <li>▶ The land cover changes with increasing elevation from tropical evergreen forest to temperate broadleaf and mixed forest.</li> <li>▶ The area falls under both the Palearctic and Indo Malayan biogeographic areas.</li> <li>▶ Park has extensive bamboo forests</li> <li>▶ Vegetation zones vary from evergreen, moist deciduous to temperate broadleaved and coniferous forest types to alpine vegetation</li> </ul>
<b>Bhitarkanika National Park</b>	Odisha	<ul style="list-style-type: none"> <li>▶ It is a <b>Ramsar Site</b></li> <li>▶ Gahirmatha Beach and Marine Sanctuary lies to the east, and separates swamp region cover with canopy of mangroves from the Bay of Bengal.</li> <li>▶ The national park is home to <b>Saltwater crocodile</b></li> <li>▶ It is the second largest mangrove ecosystem in India.</li> <li>▶ Rivers: Brahmani, Baitarani, Dhamra, Pathsala.</li> <li>▶ Olive ridley turtles nest on Gahirmatha and other nearby beaches.</li> </ul>
<b>Keibul Lamjao National Park</b>	Manipur	<ul style="list-style-type: none"> <li>▶ It is the <b>only floating park in India</b></li> <li>▶ The national park is characterized by many floating decomposed plant materials locally <b>called phumdis</b>.</li> <li>▶ It is home to Manipur brow-antlered deer also popularly known as the <b>Sangai</b>.</li> <li>▶ Loktak Lake is the largest natural freshwater lake in the north-eastern region of India</li> <li>▶ Sangai deer is state animal of Manipur</li> </ul>
<b>Keoladeo Ghana National Park</b>	Rajasthan	<ul style="list-style-type: none"> <li>▶ It is a <b>World Heritage Site</b></li> <li>▶ It is a man-made and man-managed wetland</li> <li>▶ It is home to deer, nilgai (antelope) and boar</li> <li>▶ Keoladeo National Park is placed on the Montreux Record under the <b>Ramsar Convention</b>.</li> <li>▶ It is also the only regular wintering area in India for the critically endangered Siberian crane.</li> <li>▶ It has effective legal protection under the provisions of <b>Wildlife (Protection) Act, 1972 and Indian Forest Act, 1927</b>.</li> </ul>
<b>Dampa Tiger Reserve</b>	Mizoram	<ul style="list-style-type: none"> <li>▶ Dampa tiger reserve in Mizoram is located in the Lushai Hills of western Mizoram, along a transitional zone with the Chittagong Hill Tracts of Bangladesh.</li> <li>▶ <b>Dampa Tiger Reserve is a part of Project Tiger</b></li> </ul>

		<ul style="list-style-type: none"> <li>▶ Fauna: Leopards, Indian bison, barking deer, sloth bear, gibbons, langurs, slow loris, rhesus macaque, Indian Python (Python Molurus Molurus), wild boar and a variety of birds.</li> <li>▶ The forests (tropical evergreen and semi-evergreen forests, tropical moist deciduous forests, sub-montane type) boast some great bamboos, canes and some gorgeous orchids.</li> <li>▶ It has nurtured two incredibly rare ginger species, Globba spathulata and Hemiorchis pantlingii.</li> </ul>
<b>Nokrek Biosphere Reserve</b>	Meghalaya	<ul style="list-style-type: none"> <li>▶ Along with Balphakram national park, <b>Nokrek is a hotspot of biodiversity in Meghalaya.</b></li> <li>▶ Nokrek is also an important bird area.</li> <li>▶ The soils in the Biosphere Reserve are rich in organic matter and nitrogen but deficient in phosphate and potash.</li> <li>▶ Simsang River flows through it.</li> <li>▶ Evergreen and semi-evergreen deciduous forests dominate the landscape</li> <li>▶ Fauna: tigers, leopards, elephants and Hoolock gibbons, Red Panda</li> <li>▶ Siju Cave is located near to it.</li> </ul>
<b>Corbett National Park</b>	Uttarakhand	<ul style="list-style-type: none"> <li>▶ Corbett National Park, established in 1936 with the name Hailey National Park and renamed as Ramganga National Park in 1952, got its present name in 1957 after Jim Corbett</li> <li>▶ It is also being honored as the place where <b>Project Tiger was first launched in 1973.</b></li> <li>▶ The program aims to protect three of the five terrestrial flagship species, the tiger, the Asian elephant and the great one-horned rhinoceros.</li> <li>▶ Dense moist deciduous forest mainly consists of sal, haldu, peepal, rohini and mango trees.</li> <li>▶ It protects parts of the Upper Gangetic Plains moist deciduous forests and Himalayan subtropical pine forests ecoregions.</li> <li>▶ <b>River:</b> Ramganga River, Kosi, Sonanadi</li> <li>▶ Following are the conservation programs which were started in Jim Corbett National Park: <ul style="list-style-type: none"> <li>● <b>Project Tiger:</b> Started in 1973 by the Government of India</li> <li>● <b>Crocodile Conservation Project:</b> Initiated in 1976 with the support from United Nations Development Programme and Food and Agriculture Organization.</li> </ul> </li> </ul>
<b>Silent Valley National Park</b>	Kerala	<ul style="list-style-type: none"> <li>▶ It has been declared as <b>World Heritage Site, recognised by UNESCO.</b></li> <li>▶ Silent Valley is home to the largest population of lion-tailed macaques, an endangered species of primate.</li> <li>▶ Other rare animal is Nilgiri Tahr.</li> </ul>

		<ul style="list-style-type: none"> <li>▶ <b>River:</b> Kunthi</li> <li>▶ The <b>Kuntipuzha</b> River drains the entire 15 km length of the park from north to south into the Bharathapuzha River.</li> <li>▶ <b>Mudugar and Irula tribal people</b> are indigenous to the area.</li> <li>▶ The valley areas of the park are in a Tropical and subtropical moist broadleaf forests Ecoregion.</li> </ul>
<b>Simlipal National Park</b>	Odisha	<ul style="list-style-type: none"> <li>▶ It is <b>Tiger Reserve</b></li> <li>▶ It derives its name from the abundance of semul (red silk cotton trees) that bloom here.</li> <li>▶ It is the second largest national park in India</li> <li>▶ Waterfalls: Joranda and Barehipani.</li> <li>▶ Simlipal falls under a high cerebral malaria-prone zone.</li> <li>▶ The major mammals include tiger, leopard, Asian elephant, sambar, barking deer, gaur, jungle cat, wild boar, chausingha (four horned antelope), giant squirrel and common langur.</li> <li>▶ The “<b>Mugger Crocodile Management Programme</b>” has helped the Mugger crocodile (<i>Crocodylus palustris</i>) to survive and flourish on the banks of Khairi river.</li> </ul>
<b>Rajaji National Park</b>	Uttarakhand	<ul style="list-style-type: none"> <li>▶ It is a <b>Tiger Reserve.</b></li> <li>▶ Rajaji National Park has been named after C. Rajagopalachari.</li> <li>▶ Broadleaved deciduous forests, riverine vegetation, scrubland, grasslands and pine forests form the range of flora in this park.</li> </ul>
<b>Indravati National Park</b>	Chattisgarh	<ul style="list-style-type: none"> <li>▶ Indravati River flows through it.</li> <li>▶ It is a <b>tiger reserve</b></li> <li>▶ The vegetation of the Indravati National Park is mainly of the tropical moist and dry deciduous type with predominance of the sal, teak and bamboo trees.</li> <li>▶ It has one of the last populations of the endangered wild Asian buffalo and Hill Mynas.</li> <li>▶ It is also known as <b>Kutru National Park.</b></li> </ul>
<b>Kaziranga National Park</b>	Assam	<ul style="list-style-type: none"> <li>▶ It is a <b>World Heritage Site (1985)</b></li> <li>▶ The sanctuary hosts two-thirds of the world’s great one-horned rhinoceroses.</li> <li>▶ It was declared a Tiger Reserve in 2006.</li> <li>▶ Other animals are: elephants, wild water buffalo, and swamp deer</li> <li>▶ Kaziranga is recognized as an Important Bird Area by BirdLife International for conservation of avifaunal species.</li> <li>▶ It has tall elephant grass, marshland, and dense tropical moist broadleaf forests.</li> <li>▶ The park is located in the <b>Indomalaya ecozone</b></li> <li>▶ Surrounded by Brahmaputra River on the North and the Karbi Anglong mounts in the South</li> </ul>

## ■ Other National Parks

S.No	National parks	State	Rivers	Key Species
1.	Kaziranga National Park	Assam	Brahmaputra, Diphlu, Mora Diphlu and Mora Dhansiri	Endangered Rhinos One-Horned
2.	Bandipur National Park	Karnataka	Kabini River, Moyar River	Elephants
3	Bandhavgarh National Park	Madhya Pradesh	Son River, Johilla River and Umrar River.	Tiger
4.	Periyar National Park	Kerala	Periyar and Pamba Rivers	Elephants
5.	Gir National Park	Gujarat	Hiran, Shetrunji, Datardi, Shingoda, Machhundri, Godavari and Raval	Lion
6.	Kanha National Park	Madhya Pradesh	Banjar and Halon	Swamp Deer
7	Ranthambore National Park	Rajasthan	Banas and Chambal River	Tiger
8.	Manas National Park	Assam	Manas River	Wild water buffalo

## ■ MISCELLANEOUS

### ■ Bandipur National Park

- Established in **1974** as a tiger reserve under **Project Tiger**, is a national park located in the south Karnataka, which is the **state with the highest tiger population in India**. It is one of the premier Tiger Reserves in the country along with the **adjoining Nagarhole national park**.
- Bandipur is known for its wildlife and has many types of biomes, but **dry deciduous forest is dominant**.
- The Bandipur Tiger Reserve was established under **Project Tiger in 1973** by adding nearly 800 km<sup>2</sup> to the **Venugopala Wildlife Park**.
- Bandipur supports a good population of endangered and vulnerable species like Indian elephants, gaurs, tigers, sloth bears, muggers, Indian rock pythons, four-horned antelopes, jackals and dholes.
- **Location**
  - Bandipur National Park is situated in Mysore, Karnataka.
  - National Park's total area is 874 sq. km.
  - Altitude is between 680 meters-145 meters

- ▶ Near to Northern edge of Nilgiri Foot Hills

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## ■ New Wildlife Sanctuary at Ghodazari

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- The **Maharashtra Government** has approved Ghodazari in Chandrapur district as new wildlife sanctuary in the state.
- The sanctuary, located in the North East of Tadoba, will include 159 sq km of **Brahmapuri forest**. The wildlife sanctuary located North East of Tadoba Tiger Reserve will be carved out in total of 159 sq km area covering Nagbhir, Talodhi and Chimur forest areas. It will include hilly terrain, Saatbahini hills, Ghodazari lake, Muktai Deosthan, waterfall etc. The area is rich with flora and fauna.
- This will help in saving the forest, and will also improve tourism in nearly 40 villages in the area.

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## ■ Approval for the Trishna Gas project of ONGC which falls in the Trishna Wildlife Sanctuary

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The National Wildlife Board has given its approval for the Trishna Gas project of ONGC which falls in the Trishna Wildlife Sanctuary in the Gomati district of Tripura.

- ONGC has discovered 10-12 gas bearing wells in the Trishna Wildlife sanctuary.
- Oil and Natural Gas Corporation (ONGC) Tripura Asset would soon start extracting natural gas from Trishna Wildlife Sanctuary in Belonia subdivision of Gomati district following National Wildlife Board's clearance of its proposal.
- The gas extracted from Trishna Wildlife Sanctuary would be transported to the **North Eastern Electric Power Corporation Ltd (NEEPCO)** owned **100 MW gas-based thermal power project** at Monarchak in Sonamura subdivision of Sipahijala district.

### Trishna Wildlife Sanctuary

Trishna Wildlife Sanctuary is a **Wildlife Sanctuary** in Tripura, India.

It covers an area of about **163.08 square kilometers**.

This sanctuary is **situated in South Tripura District**.

This sanctuary has a number of perennial water rivulets, water bodies, and grass land.

**Indian Gaur (Bison)** is an attraction of this sanctuary.

Apart from it, there are varieties of Birds, Deers, Hollock Gibbon, Golden Langur, Capped Langur, Pheasant and many other animals and reptiles.

## Recent Developments

- As per the database, Raimona National Park is the latest addition to National Parks in India. Dehing Patkai Wildlife Sanctuary is also under consideration of upgrading to the national park status.
- Raimona National Park is the 6th national park in Assam. It is in the western buffer to the Manas National Park. Pekua River forms a boundary to the park.
- There are a total of six marine national parks in India.

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## SPECIES BASED CONSERVATION PROGRAMS

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- Biodiversity conservation is **the protection and management of biodiversity to obtain resources for sustainable development**. Biodiversity conservation has three main objectives:
  - To preserve the diversity of species.
  - Sustainable utilization of species and ecosystem.
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### ■ Project Tiger

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- **Launched in:** 1973
- **First location of project:** Jim Corbett Park
- **Objectives:** The objectives are:
  - ▶ To limit factors that leads to reduction of tiger habitats and to mitigate them by suitable management. The damages done to the habitat were to be rectified so as to facilitate the recovery of the ecosystem to the maximum possible extent.
  - ▶ To ensure a viable population of tigers for economic, scientific, cultural, aesthetic and ecological values.
- **Principles:** Tiger reserves were created in the country based on the '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. It is kept free of biotic disturbances and forestry operations like collection of minor forest produce, grazing, and other human disturbances are not allowed within.
  - ▶ **Buffer areas:** The buffer areas are subjected to 'conservation-oriented land use'. They comprise forest and non-forest land. It is a multi-purpose use area with twin objectives of providing habitat supplement to spillover population of wild animals from core conservation unit and to provide site specific co-developmental inputs to surrounding villages for relieving their impact on core area.
- **Administration:** National Tiger Conservation Authority
  - ▶ **Objective of the NTCA**
    - Providing statutory authority to Project Tiger so that compliance of its directives become legal.
    - Fostering accountability of Center-State in management of Tiger Reserves, by providing a basis for MoU with States within our federal structure.
    - Providing for an oversight by Parliament.
    - Addressing livelihood interests of local people in areas surrounding Tiger Reserves.
- **Role of Central Government:**

Under Project Tiger, 100% central assistance is provided for non-recurring items of expenditure to the States, besides 50% matching grant for recurring items (90% for North Eastern States), based on the Annual Plan of Operations of tiger reserve, proposed by the State vis-à-vis the Tiger Conservation Plan.

◦ **Challenges:**

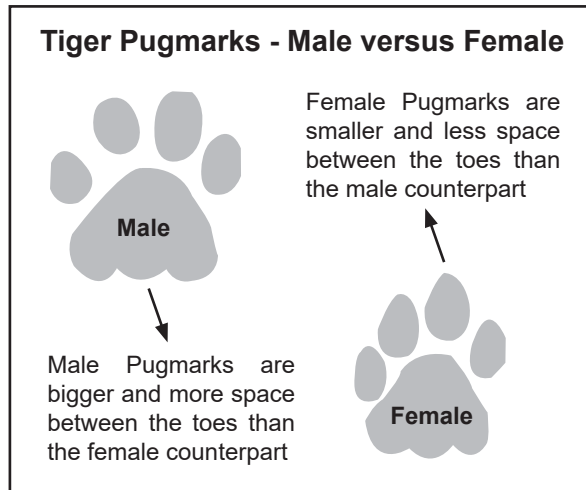
- ▶ The challenges include: protection against poaching, fragmentation of habitat, securing inviolate space for tiger to facilitate its social dynamics, addressing tiger-human interface, restoration of corridors and eliciting public support of local people by providing ecologically sustainable options.

◦ **Methodology of Tiger Census**

▶ **Different methods for Tiger Census are:**

▶ **Pugmark Technique**

- It has been one of the most popular ways of counting tigers. Each tiger is known to leave a distinct pugmark on the ground and these are different from the others in the big cat family. Photographs or plaster casts of these pugmarks are then analysed to assess the tiger numbers.
- Study of pug marks can provide the following information reliably if analyzed skillfully:
  - ◆ Presence of different species in the area of study.
  - ◆ Identification of individual animals.
  - ◆ Sex ratio and age (young or adult) of large cats



▶ **Installation of Cameras**

- Cameras could be left in dense forests for several days to capture images of individual tigers. But it is not possible to install cameras at every place that is likely to have tigers, and even in places where they are installed, there is no certainty that the tiger would walk into a camera's range.

▶ **Double-Sampling Method**

- This is the new method adopted by **Wildlife Institute of India in Tiger Census 2015**. The first stage involved ground survey by the forest department. Under this forest department staff collect evidences of tiger presence such as pugmarks, scat, scratches on trees or other such unmistakable signs of tiger presence.
- The next stage involved camera trapping. Based on the ground surveys locations were chosen for installing cameras. These cameras are heat and motion sensitive. They lie idle till they detect any motion or a sudden change in temperature which means, they capture just about anything that moves — other animals, even birds. All these get captured by the camera.
- Each tiger is known to have a very unique stripe pattern. This is used to differentiate one tiger from the other.

**NOTE:**

**1. Tiger Numbers in Past Census:**

2006	2010	2014	2018
1,411	1,706	2,226	2,967

**2. Occupancy Area (Sq. km)**

2006	2010	2014
93,000	81,906	89,164

▶ **M-STripES**

- **M-STripES, short for Monitoring System for Tigers - Intensive Patrolling and Ecological Status** is a software-based monitoring system launched across Indian tiger reserves by the Indian government's **National Tiger Conservation Authority (NTCA) in 2010**.

- The system's objective is to strengthen patrolling and surveillance of the Endangered Bengal tiger. Forest guards in tiger reserves are equipped with personal digital assistants and GPS devices to capture data relating to tiger sightings, deaths, wild life crime and ecological observations while patrolling
- The system uses a holistic approach by integrating ecological insights obtained through the standardized tiger, prey, and habitat assessment protocols (Phase I) to guide protection and management. It enables managers to assess intensity and spatial coverage of patrols in a GIS based tool.

## UPSC CSE PRELIMS, 2017

**Q1: The term M-Stripes' is sometimes seen in news in the context of**

- (a) Captive breeding of Wild Fauna
- (b) Maintenance of Tiger Reservoirs
- (c) Indigenous Satellite Navigation System
- (d) Security of National Highways

**Correct Option: (b)**

## TIGER RESERVES IN INDIA (State wise)

1.	Manas (Assam)	21.	Bandhavgarh (Madhya Pradesh)
2.	Kaziranga (Assam)	22.	Kanha (Madhya Pradesh)
3.	Nameri (Assam)	23.	Satpura (Madhya Pradesh)
4.	Nagarjunasagar (Andhra Pradesh)	24.	Panna (Madhya Pradesh)
5.	Namdapha (Arunachal Pradesh)	25.	SanjayOubri (Madhya Pradesh)
6.	Pakke (Arunachal Pradesh)	26.	Pench (Madhya Pradesh)
7.	Valmiki (Bihar)	27.	Dampa (Mizoram)
8.	Indravati (Chhattisgarh)	28.	Satkosia (Odisha)
9.	Undanti-Sitandadi (Chhattisgarh)	29.	Simlipal (Odisha)
10.	Achanakmar (Chhattisgarh)	30.	Ranthambhore (Rajasthan)
11.	Palamau (Jharkhand)	31.	Sariska (Rajasthan)
12.	Periyar (Kerala)	32.	Kalakad-Mundanthurai (Tamil Nadu)
13.	Parambikulam (Kerala)	33.	Mudumalai (Tamil Nadu)
14.	Bandipur (Karnataka)	34.	Anamalai (Tamil Nadu)
15.	Bhadra (Karnataka)	35.	Corbett (Uttarakhand)
16.	Dandeli-Anshi (Karnataka)	36.	Dudhwa (Uttar Pradesh)
17.	Nagarhole (Karnataka)	37.	Buxa (West Bengal)
18.	Tadoba-Andhari (Maharashtra)	38.	Sunderbans (West Bengal)
19.	Pench (Maharashtra)	39.	Sahyadri (Maharashtra)
20.	Melghat (Maharashtra)		

### o Critical Tiger Habitat

- Critical Tiger habitats are wildlife habitat that are created in areas of National Parks and Sanctuaries which are required to be kept as inviolate for the purposes of wildlife conservation.

- ▶ It is determined and notified by the **Ministry of Environment and Forest**.
- ▶ The community and dwelling rights in the region are notified by the Ministry of Tribal Affairs.
- ▶ **The Wildlife Protection Act, 1972** provides for conservation and Management of Wildlife in the National parks and Sanctuaries.
- ▶ A critical habitat is based on **parameters** like estimated tiger population over the years, size of the territory and population viability analysis.

## UPSC CSE PRELIMS, 2020

**Q2: Among the following Tiger Reserves, which one has the largest area under "Critical Tiger habitat"?**

- (a) Corbett
- (b) Ranthambore
- (c) Nagarjunsagar-Srisaïlam
- (d) Sunderbans

**Correct Option: (c)**

### ◉ Other steps for Tiger Conservation

- ▶ The **Special Tiger Protection Force (STPF)** has been made operational in the States of Karnataka (Bandipur), Maharashtra (Pench and Tadoba-Andhari) and Odisha (Similipal), out of 13 initially selected tiger reserves, with 60% central assistance under the ongoing Centrally Sponsored Scheme of Project Tiger. In-principle approval has been accorded for creation of the said force in Nawegoan-Nagzira, Melghat (Maharashtra), Kawal and Amrabad (erstwhile Nagarjunasagar Srisaïlam Tiger Reserve portion) Tiger Reserves (Telangana).
- ▶ The **Global Tiger Initiative (GTI)** was launched in 2008 as a global alliance of governments, international organizations, civil society, the conservation and scientific communities and the private sector, with the aim of working together to save wild tigers from extinction. In 2013, the scope was broadened to include Snow Leopards.
- ▶ **Global Tiger Forum objectives:**
  - Promoting global campaigns to save the Tiger, its prey and its habitat.
  - Increasing the number of secure habitats for Tigers.
  - Promoting comprehensive legal frameworks for Tiger conservation.
  - Providing financial and infrastructural capabilities for Tiger Conservation.
  - Promoting training and research.
  - Eliciting support from Governments, Inter- governmental organizations and individuals.
  - Promoting bilateral co-operation.
  - Establishing a trust fund to enable the implementation of agreed programmes.
  - Calling upon Range Countries to prepare and update their National Action Plans for Tiger conservation.
  - To urge countries to enter into relevant conventions for conservation and elimination of illegal trade.
- ▶ Tiger Range countries are: Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Lao PDR, Malaysia, Myanmar, Nepal, Russia, Thailand, and Vietnam.

## ○ TRAFFIC

- ▶ TRAFFIC, the wildlife trade monitoring network, is the leading non-governmental organization working globally on trade in wild animals and plants in the context of both biodiversity conservation and sustainable development.
- ▶ **It was founded by WWF and IUCN.**
- ▶ TRAFFIC specializes in:
  - **Investigating and analysing** wildlife trade trends, patterns, impacts and drivers to provide the leading knowledge base on trade in wild animals and plants;
  - **Informing, supporting and encouraging** action by governments, individually and through inter-governmental cooperation to adopt, implement and enforce effective policies and laws;
  - **Providing information, encouragement and advice to the private sector** on effective approaches to ensure that sourcing of wildlife uses sustainability standards and best practice;
  - **Developing insight** into consumer attitudes and purchasing motivation and guiding the design of effective communication interventions aimed to dissuade purchasing of illicit wildlife goods.

## ○ Tx2 Goal

- ▶ An ambitious and visionary species conservation goal was set by the governments of the 13 tiger range countries: to double the number of wild tigers by 2022 – the next Chinese year of the tiger.
- ▶ The **Ranger Federation of Asia (RFA)** was founded in 2013 as a way to connect and improve the working standards of the frontline staff who protect Asia's wildlife.
- ▶ India has a Memorandum of Understanding with Nepal on controlling trans-boundary illegal trade in wildlife and conservation, apart from a protocol on tiger conservation with China.

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## ■ Project Elephant

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- **Launched in:** 1992
- **Objectives:** It's objectives are:
  - ▶ To protect elephants, their habitat & corridors
  - ▶ To address issues of man-animal conflict
  - ▶ Welfare of captive elephants
- **States where implemented:**

The Project is being mainly implemented in 16 States / UTs , viz. Andhra Pradesh, Arunachal Pradesh, Assam, Chhattisgarh, Jharkhand, Karnataka, Kerala, Maharashtra, Meghalaya, Nagaland, Odisha, Tamil Nadu, Tripura, Uttarakhand, Uttar Pradesh, West Bengal.
- **Main activities under the Project are as follows:**
  - ▶ Ecological restoration of existing natural habitats and migratory routes of elephants;
  - ▶ Development of scientific and planned management for conservation of elephant habitats and viable population of Wild Asiatic elephants in India;
  - ▶ Promotion of measures for mitigation of man elephant conflict in crucial habitats and moderating pressures of human and domestic stock activities in crucial elephant habitats;
  - ▶ Strengthening of measures for protection of Wild elephants form poachers and unnatural causes of death;
  - ▶ Research on Elephant management related issues;

- ▶ Public education and awareness programmes;
- ▶ Eco-development
- ▶ Veterinary care
- ▶ Elephant Rehabilitation/Rescue Centers
- **Elephant Corridors:** An elephant corridor is defined as a stretch/narrow strips of forested (or otherwise) land that connects larger habitats with elephant populations and forms a conduit for animal movement between the habitats. This movement helps enhance species survival and birth rate
- **National Elephant Corridor Project**
  - ▶ The Project uses three basic approaches in securing elephant corridors throughout the country. In addition to land purchase and facilitating voluntary relocation as one of the approaches, the Wildlife Trust of India also assists the state Forest Departments to secure corridors by mediating between the authorities and locals settled in the corridors.
  - ▶ The third approach involves community participation. Deploying this approach, WTI has encouraged the local communities in Garo Hills to set aside about 1,250 hectares of community (A'khing) land for conservation. It has successfully assisted the authorities in Garo Hills, Meghalaya, in securing the Siju-Rewak elephant corridor, connecting Balpharkam National Park and Siju Wildlife Sanctuary with Rewak Reserve Forest leading to Nokrek National Park. Eco-development support is provided to these communities and habitat restoration activities are carried out in jhum-cultivated land, employing local population.

## ○ **Monitoring of Illegal Killing of Elephants ( MIKE ) Programme**

- ▶ Mandated by COP resolution of CITES , MIKE program started in South Asia in the year 2003 with following purpose –
- ▶ To provide information needed for elephant range States to make appropriate management and enforcement decisions, and to build institutional capacity within the range States for the long-term management of their elephant populations
- ▶ The main objectives of the MIKE are:
  - to measure levels and trends in the illegal hunting of elephants;
  - to determine changes in these trends over time; and
  - to determine the factors causing or associated with such changes, and to try and assess in particular to what extent observed trends are a result of any decisions taken by the Conference of the Parties to CITES
- ▶ Under the programme data are being collected from all sites on monthly basis in specified MIKE patrol form and submitted to Sub Regional Support Office for South Asia Programme located in Delhi who are assisting Ministry in the implementation of the programme.
- ▶ **MIKE Sites in India:** Chirang Ripu (Assam); Dhang Patki (Assam); Eastern Dooars (WB); Deomali (Arun Pradesh); Garo Hills (Meghalaya); Mayurbhanj (Odisha); Mysore (Karnataka); Nilgiri (T N); Shivalik (Uttarakhand); Wayanad (Kerala)

## ○ **Awareness campaign under Gaj Yatra**

- ▶ In a bid to raise awareness about the shrinking space for wild elephants in the country, a 'gaj yatra' campaign has been launched by the Wildlife Trust of India. The campaign is planned to cover 12 elephant range states.
- ▶ Over the next 15 months of the launch artists and craftsmen created life-size works on the theme of elephants in places along the route of the roadshow, covering 12 states that have wild elephants, using local art and craft.

- ▶ Specially fabricated vehicles was deployed to display these on pre-determined routes with campaigners
- ▶ The 'Gaju' mascot, which was released by the Ministry in 2012, was the helm of the campaign
- ▶ Besides, a "gaj mahotsav" was organized at different venues along the way, with concerts, parades, street plays and activities for children in particular.

### World Elephant Day

**It is an annual global event celebrated across the world on August 12**, dedicated to the preservation and protection of elephants. The goal of World Elephant Day is to create awareness about the plight of elephants and to share knowledge and positive solutions for the better care and management of captive and wild elephants. **African elephants are listed as "vulnerable"** and **Asian elephants as "endangered"** in the IUCN Red List of threatened species. As per the available population estimates, there are about 400,000 African elephants and 40,000 Asian elephants.

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## ■ Project Snow Leopard

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- **Launched in:** 2009
- **Listed in Schedule I of Wildlife (Protection) Act 1972, in Appendix I of CITES and as Vulnerable on IUCN Red List**
- **Location:** All biologically important landscapes in the Himalayan high altitudes in the states of Jammu & Kashmir, Himachal Pradesh, Uttaranchal, Sikkim, and Arunachal Pradesh.
- **Objective:**
  - ▶ It aims at promoting a knowledge-based and adaptive conservation framework that fully involves the local communities, who share the snow leopard's range, in conservation efforts.
  - ▶ The project will encourage focused conservation and recovery programmes for endangered species, promote stronger measures for wildlife protection and law enforcement and better understand and manage human-wildlife conflict. It will reduce existing anthropogenic pressures on natural resources and promote conservation education.
- **Administrative mechanism:** The project has been divided into four tiers
  - ▶ **Tier 1: Central Level:** Steering Committee (It will be headed by Director General of Forests and Special Secretary to the government of India)
  - ▶ **Tier 2: State Level:** State Snow Leopard Conservation Society
  - ▶ **Tier 3: Area Level:** Landscape Level Implementation Committees
  - ▶ **Tier 4: Village Level:** Village Wildlife Conservation Committees.
- **Other species:** Other species will also be benefitted from this like Asiatic Ibex, Tibetan Argali, Ladakh Urial, Chiru, Takin, Serow and Musk Deer.
- **Snow leopards inhabit the following protected areas:**
  - ▶ Hemis National Park, in Ladakh, Jammu and Kashmir, India
  - ▶ Nanda Devi National Park, in Uttarakhand, India, a UNESCO Natural World Heritage Site
  - ▶ Valley of Flowers National Park, Uttarakhand, India, a UNESCO Natural World Heritage Site
  - ▶ Dibang Wildlife Sanctuary, Arunachal Pradesh, India
  - ▶ Kibber Wildlife Sanctuary, LahaulSpiti, Himachal Pradesh, India
  - ▶ Pin Valley National Park, LahaulSpiti, Himachal Pradesh, India
  - ▶ Great Himalayan National Park, Kullu, Himachal Pradesh, India
  - ▶ Khangchendzonga National Park, Sikkim

- Snow Leopard is found in 11 countries such as Afghanistan, Bhutan, China, India, Kazakhstan, Kyrgyz Republic, Mongolia, Pakistan, Russia, Tajikistan, and Uzbekistan. These countries formed the Global Snow Leopard Forum (GSLF) and signed the **Bishkek Declaration** to acknowledge its importance as the indicator of the health and sustainability of mountain ecosystems.
- It is the State animal of **Himachal Pradesh**.

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## ■ Vulture Conservation Project

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### ◦ Status in India

- ▶ India has nine species of vultures in the wild. These are the Oriental White-backed Vulture (*Gyps bengalensis*), Slender billed Vulture (*Gyps tenuirostris*), Long billed Vulture (*Gyps indicus*), Egyptian Vulture (*Neophron percnopterus*), Red Headed Vulture (*Sarcogyps calvus*), Indian Griffon Vulture (*Gyps fulvus*), Himalayan Griffon (*Gyps himalayensis*), Cinereous Vulture (*Aegypius monachus*) and Bearded Vulture or Lammergeier (*Gypaetus barbatus*).
- ▶ The population of three species i.e. White-backed Vulture, Slender billed Vulture and Long billed Vulture in the wild has declined drastically over the past decade. The decline of *Gyps* genus in India has been put at 97% by 2005.
- ▶ **IUCN has placed them at 'Critically Endangered' status.**

### ◦ Government Measures

- ▶ **Protection status of White backed, Long Billed and Slender Billed Vultures has been upgraded from Schedule IV to Schedule I of the Wild Life (Protection) Act, 1972.**
- ▶ Bombay Natural History Society in collaboration with the Haryana State Forest Department has taken up a project on conservation breeding of vultures. A '**Vulture Captive Care facility**' has been established at Panchkula. The aim of the vulture programme is to viably increase the number of all the three critically endangered species by minimizing and eliminating risks and potential threats to their survival through a capacity-building and multi-stakeholder engagement approach.
- ▶ **Captive breeding centres** at Zoos at Bhopal, Bhubaneswar, Junagarh and Hyderabad have also been set up through Central Zoo Authority.

### ◦ Vulture Safe Zones

- ▶ A **Vulture Safe Zone (VSZ)** is a geographical area, the natural habitat of wild vultures, of at **least 100 Km radius** made free of the presence of the drug diclofenac in animal carcasses, the major food of vultures.
- ▶ VSZs aim at conservation in key geographical areas to protect and increase remaining vulture populations and act as future release sites for the captive-bred vultures.
- ▶ In order to declare an area a VSZ, there is need for government support, awareness activities among local stakeholders, and periodic monitoring through sample testing of animal carcasses to detect presence of veterinary drugs toxic to vultures.
- ▶ With concerted efforts of BNHS, currently five states - Gujarat, Jharkhand, Uttarakhand, Uttar Pradesh and Assam have declared VSZs across seven locations.

### ◦ Sustainable plan for future (2014 – 2025) for vultures

In order to make the vulture conservation programme sustainable, BNHS has identified a set of action points as part of its India blueprint. This includes the following:

- ▶ Intensifying policy and public advocacy for drug ban enforcement
- ▶ Continued research for safer alternatives to the banned drugs



- ▶ Ensuring survival and scaling up of conservation breeding initiative
  - ▶ Exploring a sustainable livestock sourcing project for feeding captive vultures through a community-based livelihood initiative
  - ▶ Viable expansion of vulture safe zones
  - ▶ Releasing captive-bred birds in safe zones
  - ▶ Strengthening sensitization and monitoring activities
- **Save**
- ▶ **Saving Asia's Vulture from Extinction**, is a consortium of likeminded, regional and international organisations, created to oversee, coordinate conservation, campaigning and fundraising activities to help the plight of South Asia's vultures.
  - ▶ SAVE has established captive breeding of vultures at centres in India, Nepal and Pakistan.
  - ▶ SAVE is also pursuing mandatory safety testing for all current and future NSAIDs (non-steroidal anti-inflammatory drugs) in India, with a mechanism to immediately ban all but small vials of those found to be vulture-toxic.
- **Vulture Restaurants**
- ▶ A Vulture restaurant is a site, where carrion is deposited for endangered vultures to feed on. Carrion is the decaying dead flesh of an animal. **Maharastra was the first state to start vulture restaurants.**
- **Captive Breeding**
- ▶ Captive breeding is the process of breeding animals in controlled environment within well-defined settings, such as wildlife reserves, zoos and other conservation facilities.

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## ■ Crocodile Conservation Project

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- **Launched in:** 1975
- **Reason:** Crocodilians were threatened in India due to indiscriminate killing for commercial purpose and severe habitat loss until enactment of the Wildlife (Protection) Act, 1972.
  - ▶ **Gharial - Gavialis gangeticus** - found in rivers of North India, it was considered in danger of extinction due to habitat destruction, incidental catches in fishing nets and poaching.
  - ▶ **Estuarine crocodile Crocodylus porosus** - considered formerly common along shores and rivers, by 1974 it had become extinct in the States of Kerala, Tamil Nadu and Andhra Pradesh. Small populations persisted in deltaic areas of Odisha, the Sunderbans (West Bengal) and the Andamans.
  - ▶ **Mugger Crocodylus palustris** - formerly widespread and abundant, by 1974 it was considered very depleted in numbers and rare in most, if not all, of its former range.
  - ▶ **The gharial is listed as Critically Endangered on the IUCN Red List.**
- **Objective:** Primary project aims were:
  - ▶ to boost reproductive output by collection of wild-laid eggs with subsequent incubation and rearing of young until of a size (less vulnerable to predation) suitable for release in the wild;
  - ▶ to locate, establish and manage a series of crocodile rehabilitation centres and sanctuaries in suitable habitats.
- **Other measures:**
  - ▶ A Crocodile Breeding and Management Training Institute were established in Hyderabad in 1980.

## ◉ Action Plan for Vulture Conservation in India: 2020-2025

- ▶ The MoEFCC has prepared the APVC 2020-2025 and would be responsible for its implementation. The MoEFCC will implement the Action Plan with the help and cooperation of various stakeholders in Vulture Conservation

## ◉ Proposed Objectives

- ▶ Prevention of poisoning of cattle carcasses, the principal food of vultures
- ▶ Enhancement of Conservation Breeding Programme in the country
- ▶ Regular monitoring of vultures across the country
- ▶ Enhancing the vulture safe zone network by creating at least one vulture safe zone in each state and continuing to work on the existing efforts of vulture safe zone
- ▶ Determining and preventing other causes of mortality in vultures

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## ■ Ganges Dolphin Project

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- ◉ The **Gangetic River Dolphin** is primarily found in the Ganges and Brahmaputra Rivers and their tributaries in Bangladesh, India and Nepal. Ganga dolphins can live only in Fresh water.
- ◉ **Gangetic Dolphins** are blind and they also known as **Susu and shushuk** because of the sound it produces when breathing.
- ◉ Gangetic Dolphin has been recognised as the **National Aquatic Animal** by the Government of India.
- ◉ The Ganges River dolphin, or susu, inhabits the **Ganges-Brahmaputra-Meghna** and **Karnaphuli-Sangu river** systems of Nepal, India, and Bangladesh.
- ◉ This dolphin is among the four “obligate” freshwater dolphins – the other three are the **baiji** -Yangtze river in **China**, bhulan-Indus in Pakistan and **boto**-Amazon River in Latin America.
- ◉ They are generally found alone or in pairs, and occasionally in small groups.
- ◉ It is listed on **Appendix I of the CITES**. It is **protected under the Indian Wildlife Act**. Listed by the **IUCN** as **endangered on their Red List of Threatened Species**.
- ◉ Threats:
  - ▶ River water pollution
  - ▶ Siltation in river
  - ▶ Entanglement in fishing nets
  - ▶ Reduction in river flow due to construction of dams
  - ▶ Poaching for its oil.
- ◉ Being a mammal, the Ganges River dolphin cannot breathe in the water and must surface every **30-120 seconds**. Because of the sound it produces when breathing, the animal is popularly referred to as the ‘Susu’.
- ◉ **WWF-India adopted Ganges River Dolphin as a species of special concern.**
- ◉ **A Ganges River Dolphin Conservation Programme** was initiated in 1997 to build a scientific database of the population status of the species and study the habitat quality of the dolphins’ distribution range.
- ◉ **India’s First Dolphin Community Reserve:**

The West Bengal government established India’s first Dolphin Community Reserve in the state at Hooghly River between Malda and Sundarbans.

### ◉ **Other River Dolphins:**

- ▶ Further, the **Irrawady River Dolphins** can survive in both fresh and marine waters.
- ▶ **Indus River Dolphin** (*Platanista minor minor*) is found in Indus river in Pakistan and also in Beas and Sutlej rivers in India. Both Ganges River Dolphin and Indus river Dolphin are now taxonomically considered one species since 1998.
- ▶ **The Amazon River Dolphins** are found in plenty number in Amazon river. The Yangtze river dolphins have not been seen in last one decade and it is believed that they have gone extinct.
- ▶ The Irrawady river dolphins, which can survive both in fresh water and marine water are found in Myanmar, Indonesia and the Mekong river delta in south-east Asia. Some of the Irrawady River Dolphins are also found in Bangladesh and India's Chilka Lake in Odisha.

### ◉ **National Dolphin Research Centre**

- ▶ **Habitat:** The Gangetic Dolphin is endemic to the Indian sub-continent and has a fairly extensive distribution range.
- ▶ It is found in the **Ganga -Brahmaputra - Meghna** and **Karnaphuli-Sangu** river systems of India and Bangladesh, while a few individuals survive in the Karnali, and the Saptakosi Rivers in Nepal.
- ▶ India's and Asia's **first National Dolphin Research Centre (NDRC)** will be in the premises of Patna University, Bihar.
- ▶ The centre is being set up on banks of Ganges, as per recommendation of a steering committee constituted for implementation of **Project Dolphin**.
- ▶ As per the committee, Bihar had a natural advantage as it accounted for **50%** of the world's river dolphin population.
- ▶ It was first time proposed in **2011**.

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## ■ **Other Projects**

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### ◉ **Project Cheetah**

- ▶ Just as the tiger is the flagship species of the forest, the cheetah is the flagship species of the grasslands, scrublands and open forests. Therefore, with the reintroduction of the cheetah, these dryland ecosystems of India will have a chance to return to their natural state. Being a top carnivore, the cheetah is a major evolutionary force that shapes ecosystem functions and enhances species diversity.
- ▶ A cheetah (*Acinonyx jubatus*) is a big cat like the leopard, and is a member of the family Felidae. As a sprinter capable of reaching speeds of 30 m/s, it is the fastest land animal and specialises in running down its prey.
- ▶ The cheetah is part of our heritage - It is the **only large mammal** that has been declared extinct in India in recent history.
- ▶ The cheetah is found only in the arid regions of eastern Iran in Asia, and in Africa, it is found in isolated populations in grasslands, scrublands and open forests across the continent, especially in the countries of Botswana, Namibia and South Africa.

### ◉ **Project Hangul**

- ▶ The **Kashmir stag (*Cervus affinis hanglu*)** also called **Hangul** is a subspecies of Central Asian Red Deer native to northern India.

- ▶ This deer lives in groups of two to 18 individuals in dense riverine forests, high valleys, and mountains of the Kashmir valley and northern Chamba in Himachal Pradesh. In Kashmir, it's found in **Dachigam National Park** at elevations of 3,035 meters.
- ▶ These deer once numbered from about 5,000 animals in the beginning of the 20<sup>th</sup> century.
- ▶ Unfortunately, they were **threatened**, due to habitat destruction, over-grazing by domestic livestock, and poaching. This dwindled to as low as 150 animals by 1970.
- ▶ However, the state of Jammu & Kashmir, along with the IUCN and the WWF prepared a project for the protection of these animals. It became known as Project Hangul. This brought great results and the population increased to over 340 by 1980.

## ◉ GOI – UNDP Sea Turtle Project

- ▶ A significant proportion of world's **Olive Ridley Turtle** population migrates every winter to Indian coastal waters for nesting mainly at eastern coast.
- ▶ With the objective of conservation of olive ridley turtles and other endangered marine turtles. **Ministry of Environment, Forests and Climate Change (MoEFCC)** initiated the **Sea Turtle Conservation Project** in collaboration of **UNDP** in November, 1999 with Wildlife Institute of India, Dehradun as the Implementing Agency. The project is being implemented in 10 coastal States of the country with special emphasis in State of Odisha.
- ▶ The project has helped in preparation of inventory map of breeding sites of Sea Turtles, identification of nesting and breeding habitats along the shore line, and migratory routes taken by Sea Turtles, development of guidelines to safeguard and minimize turtle mortality, development of national and international cooperative and collaborative action for Sea Turtle Conservation, developing guideline plans for tourism in sea turtle areas and developing infrastructure and human resources for Sea Turtle Conservation.
- ▶ One of the important achievements have been demonstration of use of **Satellite Telemetry** to locate the migratory route of Olive Ridley Turtles in the sea and sensitizing the fishermen and State Government for the use of **Turtle Exclusion Device (TED)** in fishing trawlers to check turtle mortality in fishing net.
- ▶ **Other Steps**
  - The **Wildlife (Protection) Act, 1972** has been amended and made more stringent. The punishments in cases of offences have been enhanced. The Act also provides for forfeiture of any equipment, vehicle or weapon that are used for committing wildlife offences. Wide publicity is given on provisions of the Wildlife (Protection) Act, 1972 against poaching.
  - The Central Government provides financial & technical assistance to the State Governments under the various Centrally Sponsored Schemes.
  - The main nesting grounds of Olive Ridley Turtles have been declared as **Protected Areas**.
  - Regular patrolling in the sea is carried out by Wildlife Department in collaboration with the **State Fisheries Department and Indian Coast Guard**.

### UPSC CSE PRELIMS, 2020

**Q1: Q. If a particular plant species is placed under Schedule VI of The Wildlife Protection Act, 1972, what is the implication?**

- (a) A licence is required to cultivate that plant
- (b) Such a plant cannot be cultivated under any circumstances
- (c) It is a Genetically Modified crop plant
- (d) Such a plant is invasive and harmful to the ecosystem

**Correct option: (a)**

- Co-ordination meetings have been organized with local fishing communities regularly to gain their support in protection of Olive Ridley Turtles. Hoardings have been installed at important fishing bases for generating public awareness.
- A **Central Monitoring Unit** in the office of the **Chief Wildlife Warden, Odisha**, is functioning with the responsibility of monitoring the operation carried out in each camp on a day to day basis. It is receiving and compiling information from the concerned Divisions.
- A **High Level Committee** has been constituted by the State Government under the **Chairmanship of the Chief Secretary, Odisha** for reviewing the sea turtle protection activities from time to time for coordinating among various departments and the **Indian Coast Guards**. The Assistant Conservators of Forests of coastal forest divisions have been declared as authorized officers under the Odisha marine Fishing Regulation Act, 1981 to check illegal fishing vessels entering in to the prohibited fishing zones in the Odisha coastal waters.

Species based programme	Year		Year
Project Red Panda	1966	Project Manipur Thamin	1977
Project Hangul	1970	Project Rhino	1987
Project Gir	1972	Project Elephant	1992
Project Tiger	1973	Project Vulture	2006
Project Olive Ridley Turtle	1975	Project Snow Leopard	2006
Project Crocodile	1975		

### ◉ India adopts SAWEN

- ▶ India has adopted the **Statute of the South Asia Wildlife Enforcement Network (SAWEN)** and India became its formal member in order to strengthen ties with the member countries in controlling the trans-boundary wildlife crime through communication, coordination, collaboration, capacity building and cooperation in the region.
- ▶ **SAWEN**, a Regional network is comprised of eight countries in South Asia: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. It aims at working as a strong regional intergovernmental body for combating wildlife crime by attempting common goals and approaches for combating illegal trade in the region.

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## ■ Recent Initiatives

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### ◉ The Kunming Declaration

- ▶ The Kunming Declaration was adopted by over 100 countries in October 2021 at the 15th meeting of the Conference of the Parties to the United Nations Convention (COP15) on Biological Diversity.
- ▶ It calls upon the parties to “mainstream” biodiversity protection in decision-making and recognize the importance of conservation in protecting human health.
- ▶ By adopting this, the nations have committed themselves to support the development, adoption and implementation of an effective post-2020 implementation plan, capacity building action plan for the Cartagena Protocol on biosafety.

## ◉ **Protection of plant varieties and farmer's Act**

- ▶ **Aim:** the act to provide for the establishment of an effective system for protection of plant varieties, the rights of farmers and plant breeders and to encourage the development of new varieties of plants.
- ▶ For accelerated agricultural development in the country, it is necessary to protect plant breeders' rights to stimulate investment for research and development, both in the public and private sector, for the development of new plant varieties.
- ▶ Such protection will facilitate the growth of the seed industry in the country which will ensure the availability of high quality seeds and planting material to the farmers.

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**AQUATIC  
ECOSYSTEMS  
& FOREST  
RESOURCES**

# ESTUARIES

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## ■ What are Estuaries?

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- Estuaries are partially enclosed bodies of water along coastlines where fresh water and salt water meet and mix. They act as a transition zone between oceans and continents.
- **Definition:** "An estuary is a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage."

## ■ Characteristics of Estuaries

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- An estuary is a semi enclosed coastal body of water with one or more rivers or streams flowing into it.
- It has free connection with open sea
- The complete salinity range from 0-35 PPT is seen from the head to the mouth of an estuary.
- Estuaries are typically classified by their geomorphological features or by water circulation patterns and can be referred by many different names such as bays, harbors, lagoons, inlets, etc.
- Estuaries are usually biologically highly productive zones

## ■ Types of Estuaries

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### ◦ Coastal Plain Estuary

- ▶ Coastal plain estuaries were formed at the end of the last ice age. As the ice melted and the waters warmed, sea level rose. The rising seas invaded low-lying coastal river valleys. These valleys are usually shallow with gentle sloping bottoms.

### ◦ Tectonic Estuary

- ▶ The earth's crust is constantly in motion. This motion causes large cracks or faults and folds to form in the crust. Often due to folding and faulting, the land sinks or subsides. Tectonic estuaries are created when the sea fills in the "hole" or basin that was formed by the sinking land.

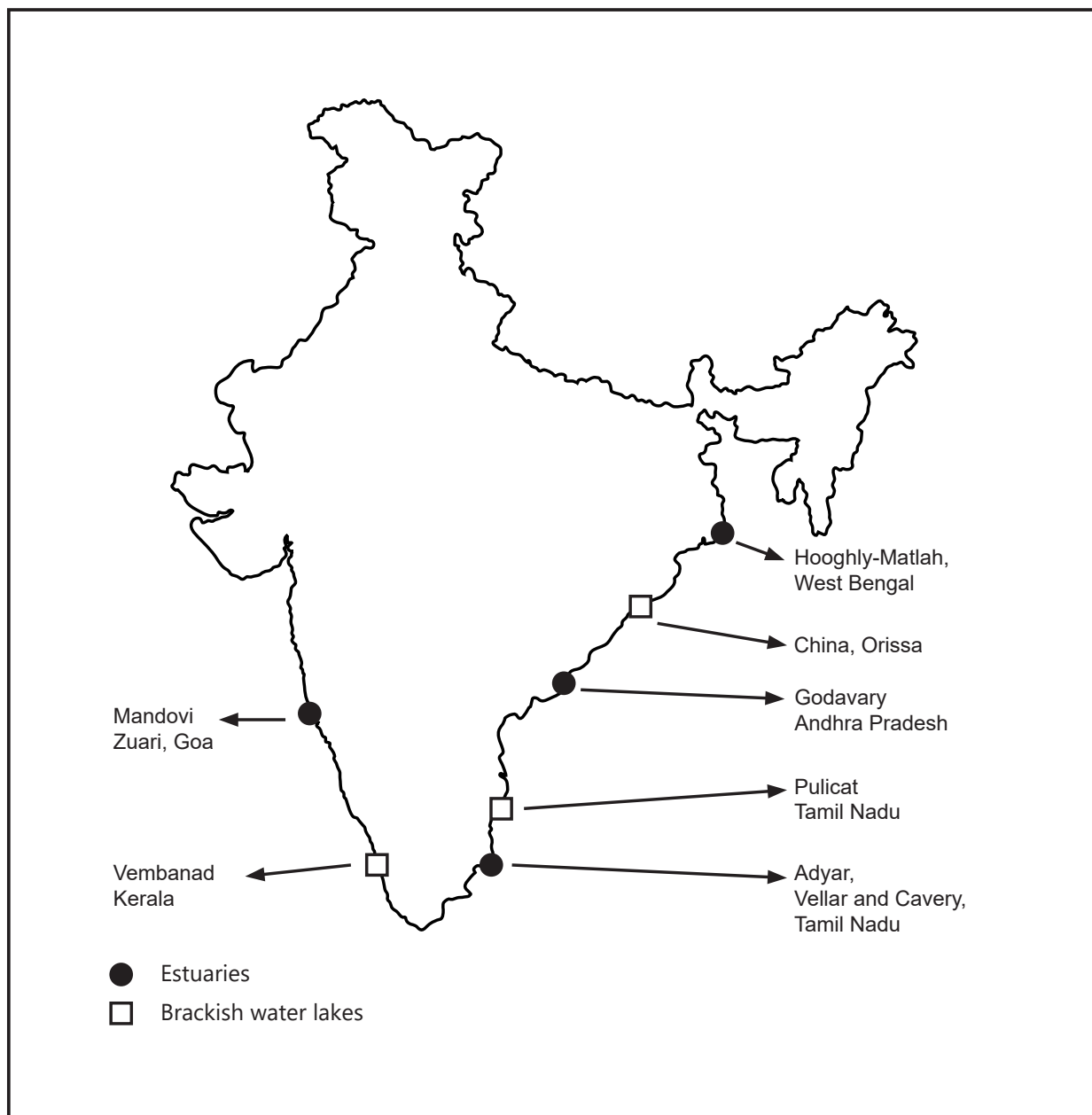
### ◦ Bar-Built Estuary

- ▶ Bar-built estuaries are formed when sandbars build up along the coastline. These sand bars partially cut off the waters behind them from the sea. Bar-built estuaries are usually shallow, with reduced tidal action.



## ■ Major Estuaries in Indian coastal states

Indian Coastal States	Estuaries	Avg. discharge (m <sup>3</sup> /sec/day)
Gujarat	Ambica	1
	Bhadar	16
	Daman ganga	93
	Dhatarwadi	2
	Gulf of Kutch	< 1
	Machhundri	3
	Madhuvanti	1
	Mahi	383
	Meghal	7
	Narmada	190
	Prabhas Patan	4
	Sabarmati	33
	Singoda	3
	Tapi	210
Maharashtra	Daman ganga	93
	Narmada	190
Karnataka	Karwar	128
	Mandovi	56
Kerala	Periar Estuary	8
Tamil Nadu	Cauvery	600
	Ponnaiyar	21
	Vaigai	28
Andhra Pradesh	Godavari	3, 500
	Krishna	2, 100
	Pennar	200
Odisha	Mahanadi	2,100
West Bengal	Ganges delta	35, 217



### Monitoring of Marine Pollution through Coastal Ocean Monitoring and Prediction System (COMAPS) Programme:

- The Ministry of Earth Sciences (formerly Ministry of Ocean Development) has been monitoring the levels of marine pollution at several locations along the coastline of the country from the year 1991-92 onwards.

**Estuarine water circulation** is controlled by the inflow of rivers, the tides, rainfall and evaporation, the wind, and other oceanic events such as an upwelling, an eddy, and storms. Estuarine water circulation patterns are influenced by vertical mixing and stratification, and can affect residence time and exposure time.

## ■ Difference between Lagoon and Estuary

S No	Criteria	Lagoon	Estuaries
1.	Depth	Shallow	Usually deeper than lagoons
2.	Rivers flowing into it	Usually no large rivers	Always has a inflow of freshwater from a river
3.	Flow dynamics	Flow of water sluggish and slow	Flow of water fast and strong
4.	Flushing time	Long in choked lagoons, less in restricted lagoons and fast in leaky lagoons	Varies widely. Flushing time is dependent on the tide and/or upstream freshwater inflows
5.	Reasons for formation	Lagoons are formed due to fall in sea levels (coastline of emergence. E.g. Kerala Coast)	Estuaries are mostly formed due to rise in sea levels (coastline of submergence. E.g. Konkan coast)

### Organisms in Saline Water

- ▶ Organisms that live only in freshwater or saltwater are known as **Stenohaline**.
- ▶ In contrast, plants and animals that are able to tolerate a wide range of salinities are called **Euryhaline**.
- ▶ Mangroves plants — supremely adapted to changeable salinities — have a range of adaptations. Mangrove have the capability of selectively absorbing water from the soil, through their roots, while leaving behind salt. This process is called ultrafiltration.

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# MANGROVES

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## ■ What are Mangroves?

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- Mangroves are plants that survive high salinity, tidal regimes, strong wind velocity, high temperature and muddy anaerobic soil – a combination of conditions hostile for other plants.
- Mangrove forests can be found around the world in the tropics and in subtropical areas between **25° N and 25° S** of the Equator. Mangroves can't withstand freezing temperatures so are limited to areas within these latitudes.
- The mangrove ecosystems constitute a symbiotic link or bridge between terrestrial and marine ecosystems.
- They are found in the **inter-tidal zones** of sheltered shore, estuaries, creeks, backwaters, lagoons, marshes and mud-flats.
- Mangroves constitute a heterogeneous group of plants with similar adaptations to a particular environment. They colonize tidal shores and brackish waters in the tropics and subtropics and in doing so not only stabilize shorelines but also create new land by trapping debris, silt and mud along their interlacing roots.

## ■ Legal and Regulatory Approaches for Protection

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### ◦ Legislations

- ▶ At present, the mangroves are protected through a range of regulatory measures such as Coastal Regulation Zone Notification, 1991; Environment Impact Assessment (EIA) studies under the EIA Notification, 1994 for specialized industries; monitoring of compliance, with conditions imposed while according Environmental Clearance, by Regional Offices of the Ministry and State Pollution Control Boards; enforcement of emission and effluent standards by industries and other entities, and recourse to legal action against the defaulters. Mangroves located within the notified forest areas are also covered under the Indian Forest Act, 1927 and Forest (Conservation) Act, 1980.

### ◦ Mangroves for the Future Initiative

- ▶ **Mangroves for the Future (MFF)** is a unique multi- country, multi sectoral, partner- led initiative which builds on the long history of coastal management interventions and lessons learned during the course of post- tsunami reconstruction and rehabilitation.
- ▶ The initiative is founded on a vision for a more healthy, prosperous and secures future for all Indian Ocean Coastal communities, where all the ecosystems are conserved and managed sustainably and seeks to promote investment and action in ecosystem conservation for sustainable coastal development.

- ▶ MFF is being coordinated by **International Union for Conservation of Nature, IUCN** covering, initially, six Tsunami affected countries namely India, Indonesia, Maldives, Seychelles, Srilanka and Thailand. India has agreed to participate in the IUCN- MFF Initiative.
- ▶ Mangroves for the Future have two objectives:
  - To strengthen the environmental sustainability of coastal development.
  - To promote the investment of funds and effort in coastal ecosystem management for sustainable development.
- ▶ The initiative seeks to effect demonstrable changes and results across four key areas of influence: regional cooperation, national programme support, private sector engagement and community action using a strategy of generating knowledge, empowering institutions and people to use that knowledge and, thereby promoting good governance in coastal areas.

### ◉ **Mangrove Restoration project**

- ▶ WTI, in partnership with Apollo Tyres, announced the launch of a critical mangrove restoration project in the Kannur district of Kerala.
- ▶ Under this Mangrove forest purchased by **Wildlife Trust of India (WTI) with World Land Trust (WLT)** support will become the hub for a new Mangrove Restoration project supported by Apollo Tyres, a leading tyre manufacturer in India.
- ▶ This land will now be used as a base for mangrove research and education, contributing to the greater mission of promoting mangrove restoration through community and government participation in Kerala and beyond.

### ◉ **Global Mangrove Alliance**

- ▶ The **Global Mangrove Alliance** brings together technical experts, civil society organizations, governments, local communities, businesses, funding agencies and foundations to accelerate a comprehensive, coordinated, global approach to mangrove conservation and restoration at a scale that matters.

### ◉ **International Day for the Conservation of the Mangrove Ecosystem**

- ▶ The International Day for the Conservation of the Mangrove Ecosystem, which was adopted on **6 November 2015 by the General Conference of UNESCO**, underlined the importance of mangrove ecosystems as “a unique, special and vulnerable ecosystem, providing by virtue of their existence, biomass and productivity substantial benefits to human beings, providing forestry, fishery goods and services as well as contributing to the protection of the coastline and being particularly relevant in terms of mitigation of the effects of climate change and food security for local communities.”

### ◉ **UNESCO Designated Sites**

- ▶ The inclusion of mangroves in Biosphere Reserves, World Heritage sites and UNESCO Global Geoparks contributes to improving the knowledge, management and conservation of mangrove ecosystems throughout the world.

### ◉ **International Blue Carbon Initiative**

- ▶ The International Blue Carbon Initiative is a coordinated, global programme focused on mitigating climate change through the conservation and restoration of coastal and marine ecosystems. It was created by the **Intergovernmental Oceanographic Commission (IOC-UNESCO)**, together with **Conservation International (CI) and the International Union for Conservation of Nature (IUCN)**, as an initial step in advancing scientific, management and policy actions.

- ▶ The Blue Carbon Initiative works to develop management approaches, financial incentives and policy mechanisms for ensuring the conservation, restoration and sustainable use of coastal blue carbon ecosystems. It engages local, national, and international governments in order to promote policies that support coastal blue carbon conservation, management and financing.
- ▶ The goal is to develop comprehensive methods for assessing blue carbon stocks and emissions, which will be implemented by projects around the world to demonstrate the feasibility of blue carbon accounting, management and incentive agreements.
- ▶ The Initiative also aims to support scientific research into the role of coastal blue carbon ecosystems for climate change mitigation.

### ◉ Community Based Mangrove Regeneration

- ▶ The community-based mangrove regeneration and protection model works on the basis of the following objectives through a multi-stakeholder approach:
  - Enhanced capacity of communities to regenerate and manage mangrove resources in a sustainable manner for increased livelihood opportunities.
  - Increased support from industry in conserving and regenerating mangroves
  - More proactive involvement of the government in community based regeneration and conservation of mangroves

## ■ Mangroves in India

As per Indian State of Forest Report 2017, mangrove forests have increased by 181 sq kms. Maharashtra (82 sq kms), Andhra Pradesh (37 sq kms) and Gujarat (33 sq kms) are the top three gainers in terms of mangrove cover. 7 out of the 12 mangrove states have shown an increase in mangrove cover and none of them show any negative change.

### ◉ Reasons for increase in Mangrove Cover:

- ▶ **Andhra Pradesh:** The positive change of 37 sq km in Andhra Pradesh is mainly due to plantation and regeneration.
- ▶ **Gujarat:** The positive change of 33 sq km in the mangrove is mainly due to conservational effort such as plantation and regeneration particularly in Bhavnagar, Jamnagar, Kutch and Junagarh.
- ▶ **Maharashtra:** The positive change of 82 sq km in Maharashtra is mainly due to plantation and regeneration of mangroves.
- ▶ **Odisha:** The positive change of total 12 sq Km is reflected in the Mangroves in Balasore, Bhadrak & Kendrapara districts. The change is mainly due to mangrove plantation, natural regeneration and growing of mangroves in some newly formed island.
- ▶ **West Bengal:** The positive change of 8 sq km is reflected in the mangroves of Purba Medinipur and South 24 Pargana districts. The change is mainly due to mangrove plantation in some islands and along the river creeks and natural regeneration at few places.

State	Mangrove
<b>East Coast</b>	
West Bengal	Sunderbans
Odisha	Mahanadi, Bhitarkanika

State	Mangrove
Andhra Pradesh	Godavari, Krishna
Tamil Nadu	Pichavaram, Muthupet, Point Calimere
<b>West Coast</b>	
Gujarat	Gulf of Kutch, Gulf of Khambat
Goa	Goa
Karnataka	Coondapur
Maharashtra	Achra/Ratnagiri
Kerala	Vembanad
<b>Other mangroves</b>	
Andaman & Nicobar Islands	Andaman islands & Nicobar islands



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# WETLANDS

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## ■ What are Wetlands?

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- The **Ramsar Conservation** defines wetlands as area of marsh, peat-land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six meters.

- **Attributes of the Wetland**

- ▶ At least periodically the land supports predominantly hydrophytes
- ▶ The substrate predominantly un drained hydric soil
- ▶ The substrate is non-soil and is saturated with water or covered by shallow

**Basic Feature:** Wetlands are Land areas that are saturated or flooded with water either permanently or seasonally.

- **The three essential characteristics that wetlands share are:**

- ▶ **Hydrology:** An abundance of water. Prolonged saturation is what creates a wetland
- ▶ **Hydrophytes:** The wetland vegetation or plants which have special adaptations for life in permanently- or seasonally-saturated soils
- ▶ **Hydric soils:** The saturated soil that forms distinctive, visible characteristics

## ■ Types of Wetlands

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- **Geographical Classification of wetlands**

- ▶ **Inland wetlands** include marshes, ponds, lakes, fens, rivers, floodplains, and swamps.
- ▶ **Coastal wetlands** include saltwater marshes, estuaries, mangroves, lagoons and even coral reefs.
- ▶ Fish ponds, rice paddies, and salt pans are human-made wetlands.
- **Riparian (streamside) Wetlands** are found along the floodplains.
- **Forested Bogs** include areas dominated by closed black spruce woods, alders and various wetland-adapted understory species and mosses.
- **Open Shrub Bogs** are sites that lack forest cover and appears as meadows with scattered short trees (<15') and often dense shrubs.
- **Open Water/Emergent Marshes** encompass wide open fresh water ponds and lakes and are dominated by grasses, sedges and other aquatic plant species.



Comparison between Lake and Wetlands			
S. No.	Characteristic	Lake	Wetland (Shallow Lake)
1.	Origin	Various process	Fluvial/geomorphic processes
2.	Water turnover	Permanent	Permanent for temporary
3.	Water level changes	Relatively small	Relatively large
4.	Littoral: Pelagial ratio	Small	Large
5.	Thermal stratification	Yes	No
6.	Vertical mixing	Thermally regulated	Wind regulated
7.	Dominant Producer	Phytoplankton	Macrophytes
8.	Food chain	Grazing pathway	Detritus pathway
9.	Nutrient Cycles	Microbial loops less important	Microbial loop dominant
10.	Productivity	Low	High
11.	Trophic status	Oligo trophic	Mostly Eutrophic (Except desirable in bogs)
12.	Biodiversity	Generally low	Generally high
13.	Functions-Flood control	Less Significant	Significant
14.	Groundwater recharge	Negligible/low	Low-high
15.	Waste treatment	No	Yes
16.	Management objectives	Control of eutrophication High Water quality	Biodiversity conservation Specific Functions

### o What are Ecosystem services by wetlands?

The benefits provided by wetlands are called their '**Ecosystem services**'. It includes;

- ▶ They provide critical food supplies including rice and freshwater and coastal fish, and fresh water, fibre and fuel.
- ▶ Regulating services influence climate and hydrological regimes, and reduce both pollution and disaster risk.
- ▶ Natural features of wetlands often have cultural and spiritual importance.
- ▶ Wetlands offer recreational possibilities and tourism benefits.
- ▶ Storage and sequestration of carbon by wetlands play an important role in regulating the global climate. Peatlands and vegetated coastal wetlands are large carbon sinks.

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## ■ Wetlands in India

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- Wetlands in India occupy 58.2 million ha, including areas under wet paddy cultivation (Directory of Indian Wetlands). The majority of the inland wetlands are directly or indirectly dependent on the major rivers like Ganga, Brahmaputra, Narmada, Godavari, Krishna, Kaveri and Tapti. They occur in the hot arid regions of Gujarat and Rajasthan, the deltaic regions of the east and west coasts, highlands of central India, wet humid zones of south peninsular India and the Andaman and Nicobar and Lakshwadeep Islands.
- Indian wetlands are grouped as:
  - **Himalayan Wetlands:**
    - ▶ Ladakh and Zaskar: Pangong Tso, Tso Morad, Chantau, Noorichan, Chushul and Hanlay marshes
    - ▶ Kashmir Valley: Dal, Anchar, Wular, Haigam, Malgam, Haukersar and Kranchu lakes
    - ▶ Central Himalayas: Nainital, Bhimtal and Naukuchital
    - ▶ Eastern Himalayas: Numerous wetlands in Sikkim, Assam, Arunachal Pradesh, Meghalaya, Nagaland and Manipur, Beels in the Brahmaputra and Barak valley.
  - **Indo-Gangetic Wetlands:** The Indo-Gangetic flood plain is the largest wetland system in India, extending from the river Indus in the west to Brahmaputra in the east. This includes the wetlands of the Himalayan terai and the Indo-Gangetic plains.
  - **Coastal Wetlands:** The vast intertidal areas, mangroves and lagoons along the 7500 km long coastline in West Bengal, Odisha, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Goa, Maharashtra. and Gujarat. Mangrove forests of Sunderbans, West Bengal and Andaman and Nicobar Islands. Offshore coral reefs of Gulf of Kutch, Gulf of Mannar, Lakshwadeep and Andaman and Nicobar Islands.
  - **Deccan Wetlands:** A few natural wetlands, but innumerable small and large reservoirs and several water storage tanks in almost every village in the region.

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## ■ Conservation of Wetlands in India

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- Some of the legal tools that have relevance for wetland conservation include:
  - ▶ Indian Fisheries Act, 1857
  - ▶ Indian Forest Act, 1927
  - ▶ Wildlife (Protection) Act, 1972
  - ▶ Water (Prevention and Control of Pollution) Act, 1974
  - ▶ Marine Zones Act, 1976
  - ▶ Water (Prevention and Control of Pollution) Act, 1977
  - ▶ Forest (Conservation Act), 1980
  - ▶ Coastal Zone Regulation Notification, 1991
  - ▶ Wildlife (Protection) Amendment Act, 1991
- Besides these, some states have their own set of laws concerning wetlands:
  - ▶ **Kerala Conservation of Paddy Land and Wetland Act 2008:** Provides for no transfer of land, no reclamation of paddies or wetlands
  - ▶ **Andhra Pradesh Water, Land and Trees Act, 2002:** Provides for conservation, preservation of lakes, ponds and tanks, permanent demarcation of area around these wetlands and obligations to remove encroachments

- ▶ **Jammu and Kashmir Wildlife (Protection) (Amendment) Act, 2002:** Wetland reserves declared as “conservation reserves”
- ▶ **West Bengal Wetlands and Water Bodies Conservation Policy (2012):** Recommends that no wetlands and water bodies can be filled up, degraded, drained, converted or subjected to any kind of activity that is incompatible with the ecological integrity of the wetlands.

## ■ Ramsar Convention

- **Ramsar Convention on Wetlands,** is an intergovernmental treaty with more than 150 member-countries that deals with conservation aspects of inland waters and the near-shore coastal areas. It provides a framework for voluntary international cooperation for wetland conservation. It is not, however, a regulating entity and does not impose restrictions on nations and landowners. It is named after the city of Ramsar in Iran where the convention was signed on **February 2, 1971 and came into force on December 21, 1975.**

- **What are Ramsar sites? How can these be identified?**

- ▶ Ramsar sites are wetlands of international importance designated under Ramsar Convention. To be designated as a Ramsar site, the nominated wetland must fulfil at least one of the nine criteria designated by the Ramsar Convention.

- **What is the objective of Ramsar Convention?**

- ▶ Its mission is “the conservation and wise use of all wetlands through local, regional and national actions and international cooperation as a contribution towards achieving sustainable development throughout the world”.

- **How many countries have joined this convention? What are the obligations of countries that join Ramsar Convention?**

- ▶ There are 169 member countries in the convention. The obligations of the countries that join the convention are:
- ▶ Designate wetlands for inclusion in the List of Wetlands of International Importance
- ▶ Promote, as far as possible, the wise use of wetlands in their territory
- ▶ Promote international cooperation especially with regard to transboundary wetlands, shared water systems, and shared species
- ▶ Create wetland reserves

### UPSC CSE PRELIMS, 2019

**Q1: Consider the following statements:**

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

Which of the statements given above is/are correct?

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

**Correct Option: (b)**

## ◉ Is India a part of this Convention?

- ▶ India joined the convention on February 1, 1982. When a country accedes to the convention, it must designate at least one wetland site as a Wetland of International Importance or Ramsar site. In 1981, Chilika lake in Odisha, was designated the first Indian wetland of international importance under the Ramsar Convention.
- ▶ The Ramsar Convention works closely with six other organisations known as International Organization Partners (IOPs). These are:
- ▶ Birdlife International; International Union for Conservation of Nature (IUCN); International Water Management Institute (IWMI); Wetlands International; World Wildlife Fund (WWF); International Wildfowl & Wetlands Trust (WWT). Wildfowl & Wetlands Trust (WWT)
- ▶ **Other partners who they work with include:**
  - Convention on Biological Diversity (CBD); Convention to Combat Desertification (UNCCD); Convention on the Conservation of Migratory Species of Wild Animals; World Heritage Convention (WHC); Convention on International Trade in Endangered Species (CITES).

## ◉ What is the Montreux Record?

- ▶ **Montreux Record** is a register of wetland sites on the **Ramsar** list, which are facing immediate challenges. The listed sites are threatened by changes that affect their ecosystem components, processes, benefits and services which characterise the said wetland at a given point in time. These changes in the ecological character of the wetland are a result of technological developments, pollution or other human interference. All this helps identify priority sites for positive national and international conservation attention.

## ◉ Which Indian wetlands are in the Montreux Record?

- ▶ Two wetlands in the country find a place in the Montreux Record. They are:
  - **Keoladeo National Park**, of an area 2,873 ha, in Rajasthan was designated a Ramsar site in 01/10/81 and listed in the Montreux Record on 04/07/90
  - **Loktak Lake in Manipur**, area 26,600 ha, was declared a Ramsar site on 23/03/90, and indexed in the Montreux Record on 16/06/93

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## ■ National Wetland Inventory and Assessment (NWIA) Project

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- ◉ **National Wetland Inventory and Assessment (NWIA)** Project is the first step towards evolving scientific management plan for wise use of wetlands. Space Applications Centre with its experience in use of Remote Sensing and Geographic Information System in the field of wetland studies took up the task.
- ◉ The main objectives of the project are:
  - ▶ To map the wetlands on 1:50000 scale using two-date (pre- and post-monsoon) IRS LISS III digital data following a standard wetland classification system;
  - ▶ Integration of ancillary theme layers ( road, rail, settlements, drainage, administrative boundaries);
  - ▶ Creation of a seamless database of the states and country in GIS environment, and Preparation of State-wise wetland atlases.

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## ■ National Plan for Conservation of Aquatic Eco-systems

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- ◉ Government has merged National Lake Conservation Plan (NLCP) and National Wetlands Conservation Programme (NWCP) into a new scheme called the '**National Plan for Conservation of Aquatic Eco-systems**' (NPCA).

- The merged scheme shall be operational during the XII Plan Period at an estimated cost of Rs.900 crore on 70:30 cost sharing between the Central Government and respective State Governments **(90:10 for North-East States)**.
- The principal objectives of the new scheme will be holistic conservation and restoration of lakes and wetlands for achieving desired water quality enhancement, besides improvement in biodiversity and the ecosystem, through an integrated and multidisciplinary approach with a common regulatory framework, The scheme would contribute to reduction of pollution loads and improvement in goods and services provided by these water bodies to stakeholders.

### **World Wetland Day**

- ▶ **It is celebrated each year on 2<sup>nd</sup> February**, marks the date of the adoption of the Convention on Wetlands on 2 February 1971, in the Iranian city of Ramsar on the shores of the Caspian Sea. **World Wetlands Day was celebrated for the first time on February 2, 1997**, on the 16<sup>th</sup> anniversary of the Ramsar Convention. Each year since 1997, government agencies, non-governmental organizations, and groups of citizens at all levels of the community have taken advantage of the opportunity to undertake actions aimed at raising public awareness of wetland values and benefits in general and the Ramsar Convention in particular.

### **Salim Ali Centre for Ornithology and Natural History (SACON)**

- ▶ It is a Society registered in 1990 under the Societies registration Act, with the object of establishing and developing a Centre of Excellence to assist, institute, conduct and promote scientific research in ornithology, and of species, habitats and ecosystems with and within which avifauna coexist, and developing scientific solutions to species, habitat and landscape conservation problems that are sensitive to the socio-economic realities and aspirations of the people.

### **Asian Waterbird Census**

It is an international programme that focuses on monitoring the status of waterbirds and wetlands. It also aims to increase public awareness on issues related to wetland and waterbird conservation. The census is carried out each January as a voluntary activity at national and local level.

The AWC is co-coordinated by Wetlands International- as part of global programme, the **“International Waterbird Census”**.

The census has three major objectives:\

- ▶ To obtain information on an annual basis of waterbird populations at wetlands in the region during the non-breeding period (January), of most species as a basis for evaluation of sites and monitoring of populations
- ▶ To monitor on an annual basis the status and condition of wetlands
- ▶ To encourage greater interest in waterbirds and wetlands amongst people, and thereby promote the conservation of wetlands and waterbirds in the region.

In India, the AWC is annually coordinated by the Bombay Natural History Society (BNHS) and Wetlands International.

### **Bombay Natural History Society (BNHS)**

- ▶ BNHS is a Non-Government Organisation (NGO) founded in the year 1883. It engages itself in the conservation of nature and natural resources and also in the research and conservation of endangered species. Its mission is to conserve nature, primarily biological diversity through action based on research, education and public awareness.

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## ■ Wetland (Conservation and Management) Rules, 2017

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- Following are important provisions in new rules 2017:
- **State Wetlands Authority (SWA):** New rules decentralize wetlands management by giving states powers to not only identify and notify wetlands within their jurisdictions but also keep a watch on prohibited activities. It stipulates setting up of SWA in each State/UTs headed by State's environment minister and include range of government officials. State government will also nominate one expert each in fields of wetland ecology, hydrology, fisheries, landscape planning and socio-economics.
- SWA will develop comprehensive list of activities to be regulated and permitted within notified wetlands and their zone of influence. It will also recommend additional prohibited activities for specific wetlands, define strategies for wise use of wetlands and its conservation and undertake measures to enhance awareness within stakeholders and local communities on values and functions of wetlands.
- It also indirectly widens the ambit of permitted activities by inserting the '**wise use**' principle, giving powers to state-level wetland authorities to decide what can be allowed in larger interest.
- The new rules prohibit activities like conversion of wetland for non-wetland uses including encroachment of any kind, setting up and expansion of industries, waste dumping and discharge of untreated wastes and effluents from industries, cities, towns, villages and other human settlements.
- It makes mandatory for state authorities to prepare list of all wetlands and list of wetlands to be notified **within six months**. Based on it, a comprehensive digital inventory of all wetlands will be created and will be **updated every ten years**.
- It seeks to protect over 2 lakh wetlands across the country, the Centre has come out with rules to identify and manage these ecologically fragile areas which play an important role in flood control, groundwater recharge, preserving plant varieties, supporting migratory birds and protecting coastlines.
- The rules stipulates for setting up of NWC, headed by **MoEFCC Secretary**, to monitor implementation of these rules and oversee work carried out by States. NWC will also advise Central Government on appropriate policies and action programmes for conservation and wise use of wetlands, recommend designation of wetlands of international importance under Ramsar Convention, advice on collaboration with international agencies on issues related to wetlands etc.
- The Centre's role under the **Wetlands (Conservation and Management) Rules, 2017**, will be restricted to monitoring its implementation by states/UTs, recommending trans-boundary wetlands for notification and reviewing integrated management of selected wetlands under the Ramsar Convention.

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## ■ MISCELLANEOUS

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### ■ Floating Treatment Wetland

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- The Floating Treatment Wetland (FTW) was inaugurated on World Wetlands Day, February 2 in Nekkampur Lake in Hyderabad to clean and purify the polluted water body.
- FTW is **joint effort of NGO Dhruvansh, Hyderabad Metropolitan Development Authority (HMDA), district administration and other organisation**
- FTW comprises **four layers viz. floatable bamboo at base, Styrofoam cubicles above it. The third layer consists of gunny bags and gravels on final layer to support cleaning agents plants.**
- Cleaning agents planted on FTW include vetivers, cattalis, canna, bulrush, citronella, hibiscus, fountain grass, flowering herbs, tulsi and ashvagandha.

- FTW's **working is based on soil-less hydroponics technique. Hydroponics permits plants to grow only on sunlight and water only.**
- Micro-organisms growing on FTW and plant root systems of cleaning agents break down and consume organic matter in water through microbial decomposition. The root systems filter out sediments and pollutants, reduce content of these chemicals from water body.

### ○ Ramsar Sites in India

- ▶ India has 49 wetlands, the highest in South Asia, with two more added to the list of recognised sites of international importance under the treaty of Ramsar Convention.

### ○ Latest Sites included in the List

- ▶ Sunderban Reserve Forest- West Bengal
- ▶ Sultanpur National Park- Haryana
- ▶ Bhindawas Wildlife Sanctuary- Haryana
- ▶ Wadhvana wetland- Gujarat
- ▶ Khijadia Wildlife Sanctuary- Gujarat
- ▶ Bakhira Wildlife Sanctuary- Uttar Pradesh

### ○ List of all the Ramsar sites of India

Sites Name	Places	Sites Name	Places
Ashtamudi Wetland	Kerala	Pong Dam Lake	Himachal Pradesh
Beas Conservation Reserve	Punjab	Renuka Lake	Himachal Pradesh
Bhoj Wetland	Madhya Pradesh	Ropar Wetland	Punjab
Chnadra Taak	Himachal Pradesh	Rudrasagar Lake	Tripura
Bhitarkanika Mangroves	Odisha	Saman Bird Sanctuary	Uttar Pradesh
Chilika Lake	Odisha	Samaspur Bird Sanctuary	Uttar Pradesh
Deepor Beel	Assam	Sambhar Lake	Rajasthan
East Kolkata Wetlands	West Bengal	Sandi Bird Sanctuar	Uttar Pradesh
Harike Wetland	Punjab	Sarsai Nawar Jheel	Uttar Pradesh
Hokera Wetland	Jammu and Kashmir	Sasthamkotta Lake	Kerala
Kanjli Wetland	Punjab	Sundarban Wetland	West Bengal
Keshopur-Miani Community Reserve	Punjab	Surinsar-Mansar Lakes	Jammu and Kashmir
Keoladeo National Park	Rajasthan	Tsomoriri	Ladakh
Kolleru Lake	Andhra Pradesh	Upper Ganga River (Brijghat to Narora Stretch)	Uttar Pradesh
Loktak Lake	Manipur	Vembanad-Kol Wetland	Kerala

Nalsarovar Bird Sanctuary	Gujarat	Wular Lake	Jammu and Kashmir
Nandur Madhameshwar	Maharashtra	Asan Barrage	Uttarakhand
Nangal Wildlife Sanctuary	Punjab	Kanwar Taal or Kabar Taal Lake	Bihar
Nawabganj Bird Sanctuary	Uttar Pradesh	Sur Sarovar	Uttar Pradesh, Agra district
Parvati Aranga Bird Sanctuary	Uttar Pradesh	Lonar Lake	Maharashtra
Point Calimere Wildlife and Bird Sanctuary	Tamil Nadu		

### o Global Wetland Outlook

- ▶ The **Global Wetland Outlook** builds on analyses such as the **Millennium Ecosystem Assessment** (MEA 2005), the Global Biodiversity Outlook (Convention on Biological Diversity 2014), Global Land Outlook (UNCCD 2017), Land Degradation and Restoration Assessment (IPBES 2018), and The Economics of Ecosystems and Biodiversity.
- ▶ These all noted the **loss and degradation of wetlands** and the importance of wetlands for ecosystem services and supporting local communities.
- ▶ It draws on a **large body of published literature**, including that developed and compiled by the Convention's Scientific and Technical Review Panel since its inception **in 1993**.

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# CORAL REEFS

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## ■ What are Coral Reefs?

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- Coral reefs are hard, intricate, and colourful three-dimensional structures with hiding, places, nurseries, and habitats for thousands of species of fish, invertebrates like clams, shrimp, sea stars, sponges, anemones, sea turtles, and many other animals.
- **It is said that coral reefs are habitats for 25% of all marine species.** It is a whole ecosystem in which each of these animals play a unique role to keep it functioning and in balance.
- Coral reefs are mostly found in the **shallow coastal zones of tropical and sub-tropical oceans**, where light can penetrate. They are among the world's most diverse and most productive ecosystems. No other ecosystem matches the coral reef in richness and complexity.
- Corals are built by very large colonies of tiny organisms called **polyps**. They secrete layers of calcium carbonate to form a protective crust around their soft bodies. These layers harden and become coral reefs. When the polyps die, their reefs remain as a platform for others to continue the building process. Many other organisms also contribute to the building of coral reefs. Many species of algae, seaweed, sponges, giant clams, oysters, etc., add to the architecture of coral reefs.
- The coral polyps that build the reefs survive by forming a symbiotic relationship with microscopic algae called **zooxanthellae**. The polyps provide shelter to the zooxanthellae, while the latter produce food for the polyps through photosynthesis. The waste products of the polyps also become food for the zooxanthellae.
- **The incredibly beautiful colours of the coral reefs also come from the zooxanthellae.**

### ○ Types of Reefs

- ▶ **Fringing Reefs** lie near emergent land. They are fairly shallow, narrow and recently formed. They can be separated from the coast by a navigable channel (which is sometimes incorrectly termed a "lagoon").
- ▶ **Barrier Reefs** are broader and lie farther away from the coast. They are separated from the coast by a stretch of water which can be up to several miles wide and several tens of metres deep. Sandy islands covered with a characteristic pattern of vegetation have sometimes formed on top of a barrier reef. The coastline of these islands is broken by passes, which have occupied the beds of former rivers.
- ▶ **Atolls** are large, ring-shaped reefs lying off the coast, with a lagoon in their middle. The emergent part of the reef is often covered with accumulated sediments and the most characteristic vegetation growing on these reefs consists of coconut trees. Atolls develop near the sea surface on underwater islands or on islands that sink, or subside

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## ■ Coral Reefs of Distribution?

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- Coral reefs are located in more than 100 countries, mostly between the Tropics of Cancer and Capricorn, in the Pacific Ocean, the Indian Ocean, the Caribbean Sea, the Red Sea, and the Persian Gulf. Some corals are also found in Florida and Southern Japan. Coral reefs cover an estimated area of 284,000 sq. km.
- There are three major regions of coral reef development:
  - ▶ Indo-Pacific: Western Pacific and most of the Indian Ocean (except the Red Sea).
  - ▶ Wider Caribbean: Includes Florida, The Bahamas, the Caribbean Sea proper, and the coastal waters off north-eastern South America.
  - ▶ Red Sea.

### Cold water corals

- ▶ Like warm-water corals, cold-water ones have a **beautiful hard skeleton**, and can form huge reef structures on which many animals depend.
- ▶ Unlike tropical reef-building corals, cold-water corals can grow in the dark, deep and cold water, catching their own food.
- ▶ **Lopheliapertusa is the only reef-forming coral in British waters.**
- ▶ Around Scotland, reefs form mainly on continental slopes off the west coast, at a depth of **200 to 400m.**
- ▶ Some coral colonies appear to be relatively young (less than five years old), which suggests that they are still growing.
- ▶ The **United Nations Environment Programme** reports that there are **more** cold-water coral reefs worldwide than tropical reefs.

- **Coral reefs are found in India:**

- ▶ Gulf of Mannar and Palk Bay
- ▶ Gulf of Kachchh
- ▶ Andaman and Nicobar Islands
- ▶ Lakshadweep Islands
- ▶ Patches of reefs off the Malvan coast (Maharashtra), Netrani Island and Gaveshani bank, off the Mangalore coast (Karnataka)

- **Factors affecting Reefs**

- ▶ **Sunlight:** Corals need to grow in shallow water where sunlight can reach them. Corals depend on the zooxanthellae (algae) that grow inside of them for oxygen and other things, and since these algae needs sunlight to survive, corals also need sunlight to survive. Corals rarely develop in water deeper than 165 feet (50 meters).
- ▶ **Clear water:** Corals need clear water that lets sunlight through; they don't thrive well when the water is opaque. Sediment and plankton can cloud water, which decreases the amount of sunlight that reaches the zooxanthellae.

### UPSC CSE PRELIMS, 2022

**Q1: "Biorock technology" is talked about in which one of the following situations?**

- (a) Restoration of damaged coral reefs
- (b) Development of building materials using plant residues
- (c) Identification of areas for exploration/extraction of shale gas
- (d) Providing salt licks for wild animals in forests/protected areas

**Correct Option: (a)**

- ▶ **Warm water temperature:** Reef-building corals require warm water conditions to survive. Different corals living in different regions can withstand various temperature fluctuations. However, corals generally live in water temperatures of 68–90° F or 20–32° C.
- ▶ **Clean water:** Corals are sensitive to pollution and sediments. Sediment can create cloudy water and be deposited on corals, blocking out the sun and harming the polyps. Wastewater discharged into the ocean near the reef can contain too many nutrients that cause seaweeds to overgrow the reef.
- ▶ **Saltwater:** Corals need saltwater to survive and require a certain balance in the ratio of salt to water. This is why corals don't live in areas where rivers drain fresh water into the ocean ("estuaries").

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## ■ What steps are being taken in India to conserve coral reefs?

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- **Environment (Protection) Act, 1986** prohibits the use of corals and sands from the beaches and coastal water for construction and other purposes.
- Coastal Regulation Zone Rules ban the collection and destruction of corals along with dredging and underwater blasting in and around coral formations.
- Under the Marine Protected Area Network
- The Gulf of Mannar and Great Nicobar have been declared as Biosphere Reserves,
- While the Gulf of Kachchh (Gujarat), the Mahatma Gandhi Marine National Park (Andamans) and the Rani Jhansi Marine National Park (Andamans) have been declared as **Marine National Parks** to provide protection for coral reefs.

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## ■ Threats to Coral Reefs

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- Coral reefs are very vulnerable to damage because they grow very slowly, get disrupted easily, and are very sensitive to variations in temperature and salinity.
- **Coral reefs face many threats, mostly due to human activities:**
  - ▶ Coral bleaching: As the ocean warms, coral reefs are unable to adapt quickly enough to the resulting changing conditions. They become stressed, eject the zooxanthellae, and thus lose their food and die. This is called bleaching, because they turn white. Even now, coral bleaching has become common in many parts of the world.
  - ▶ Sea-level rise: The vertical growth rate of coral is likely to be slower than the of sea-level rise. Consequently, corals will be deeper, receive less sunlight, and grow more slowly.
  - ▶ Ocean acidification: A more acidic ocean makes it difficult for polyps to create their reefs. With greater acidification, corals may also form weaker reefs, making them more vulnerable to storm damage, careless tourists, and destructive fishing practices.
  - ▶ Storms: More frequent storms that are expected may also damage reef structure more significantly and the coral's regrowth may not be able to keep pace.
  - ▶ Other threats to corals come from destructive fishing, water pollution, unsustainable tourism, coastal development, smothering by sediment run-offs, and coral mining.
- **Some causes of Coral Bleaching:**
  - ▶ **Solar Irradiance:** Bleaching during the summer months, during seasonal temperature a irradiance maxima often occurs disproportionately in shallow-living corals and on the exposed summits of colonies.

- ▶ **Sub-aerial Exposure:** Sudden exposure of reef flat corals to the atmosphere during events such as extreme low tides, ENSO-related sea level drops or tectonic uplift can potentially induced bleaching.
- ▶ **Sedimentation:** Relatively few instances of coral bleaching have been linked solely to sediment. It is possible, but has not been demonstrated, that sediment loading could make zooxanthellate species more likely to bleach.
- ▶ **Fresh Water Dilution:** Rapid dilution of reef waters from storm-generated precipitation and runoff has been demonstrated to cause coral reef bleaching. Generally, such bleaching events are rare and confined to relatively small, near shore areas.
- ▶ **Inorganic Nutrients:** Rather than causing coral reef bleaching, an increase in ambient elemental nutrient concentrations (e.g. ammonia and nitrate) actually increases zooxanthella densities 2-3 times.

### What are Epizootics?

- ▶ Pathogen induced bleaching is different from other sorts of bleaching.
- ▶ Most coral diseases cause patchy or whole colony death and sloughing of soft tissues, resulting in a white skeleton (not to be confused with bleached corals).
- ▶ A few pathogens have been identified the cause translucent white tissues, a protozoan.

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# FOREST RESOURCE

## ■ Definition of Forests by FSI

- All lands which are **more than 1 hectare** in area and with a **Canopy density** of **more than 10%** irrespective of the ownership and legal status is called **Forest Cover**.
- The forest ecosystem has two components- the non-living (abiotic) and the living (biotic) component.
- Climate, soil types are part of the non-living component and the living component includes plants, animals and other life forms.

## ■ Types of Forest Cover

- **Scrubs:** The degraded forest land with canopy density of **less than 10%** is called scrubs.
- **Open Forest:** The lands with **canopy density of 10-40%** are called open forest.
- **Moderately Dense Forest (MDF):** The lands with canopy density of 40- 70% are called MDF.
- **Very Dense Forest (VDF):** The lands with **canopy density of 70%** and above are called VDF.
- **Carbon Sink:** It is defined as the carbon stored in the ecosystem of the forest especially in living biomass and soil.
- **Tree Outside Forest:** It refers to all trees growing **outside the recorded** forest areas irrespective of size of patch.

## ■ Deforestation

### ○ Causes of Deforestation

- ▶ Important Agents Leading to Deforestation, Degradation and Fragmentation

No.	Agents	Links to Deforestation, Degradation and Fragmentation
1.	Slash-and-burn farmers	clear forest to grow subsistence and cash crops
2.	Commercial farmers	clear the forest to plant commercial cash crops, sometimes displace slash and burn farmers who then move to the forest
3.	Cattle ranchers	clear the forest to plant pasture, sometimes displace slash-and-burn farmers who then move to the forest

4.	Livestock herders	intensification of herding activities can lead to deforestation
5.	Loggers	remove commercial timber, logging roads provide access to other land users
6.	Commercial tree planters	clear mostly forest fallow or previously logged forests to establish plantations to supply fibre to the pulp and paper industry
7.	Firewood collectors	intensification of firewood collection can lead to deforestation
8.	Mining and petroleum industrialists	roads and seismic lines provide access to other land users, localized deforestation related to their operations
9.	Land settlement planners	relocation of people into forested areas as well as settlement projects displacing local people who then move to the forest
10.	Infrastructure developers	new access for other land users from road and highway construction through forested areas, flooding by hydroelectric dams

#### ► Immediate Causes of Deforestation

- **Logging:** Traditionally, forests have been viewed primarily as a source of timber. Logging is undertaken due to the heavy demand for wood. In the past, logging was carried out indiscriminately by clear cutting a forest, resulting in its total destruction. In recent times, selective logging causes less damage.
- **Fuelwood/Firewood:** Wood is a major source of energy, and more than half the world population depend on it for their principal source of heating and cooking food. In the developed countries, **fire wood provides less than 1% of the total commercial energy**; While in the developing countries, it provides **25% energy**.
- **Landuse changes:** Conversion of forestland to agricultural land dates back to the introduction of agriculture. Nowadays forests are converted into mono-culture farms or plantations.
- **Shifting cultivation:** Also known as '**Swidden**', '**Slash and burn**' cultivation or '**Jhum**', it is a primitive agricultural system ,in which parts of a forest are repeatedly cleared, cultivated and then abandoned for regeneration over a period of many years. This was used in Europe, during the Neolithic period, and is still widely practised by tribal and indigenous communities of South America and Africa.

#### ► Indirect Deforestation

- **Indirect Deforestation** is caused by human activities, by accident or by design. Such human inter-freeness combined with some natural processes may sometimes turn into disasters for forest ecosystem.
- **Forest fires:** Wreck havoc in many parts of the world almost every year, although all forest fires do not involve a human element, and 'some are even considered beneficial for regeneration purpose.
- Pest infestation and outbreak of diseases in forests may occur due to natural causes.
- **Forest death (Waldsterben):** Pollution of environment sometimes causes forest death or forest decline. It was first noticed in early 1970's in the **German coniferous forests**. By 1986 it had spread across 19 European countries. In Germany, 52% of its forests were affected. Recently the pine forests of **China's Sichuan province** have also experienced similar damage.

## o Strategies for Reducing Deforestation

► The strategies should be such that on one hand they should recognize the critical roles of national, state and municipal governments and on other hand empower the civil society and the private sector to take a pro-active role in reducing deforestation, often working in conjunction with government.

### • The three strategies are:

- ◆ To enhance transparency, dissemination, and effective use of deforestation data by government agencies and civil society.
- ◆ To develop and implement functional, credible market mechanisms that provides financial incentives for conservation and sustainable use of tropical forests.
- ◆ To contribute to the development of public policies that will “scale up” the incentives for conservation and sustainable use of tropical forests.

CHRONOLOGY OF LEGISLATIONS: FOREST & ENVIRONMENT	
1865	Indian Forest Act Passed
1878	Act revised. Provision of “Reserve” and protected forest made.
1927	The act of 1878 was revised. Indian forest Act 1927 with various amendments by the states.
1972	Wildlife Protection Act 1972 passed to provides greater attention to conservation of wildlife.
1976	Tree Protection Act 1976 for protection of trees in rural and urban areas of hills.
1980	Forest conservation Act 1980 passed to prohibit non-forestry use of forest land without prior approval of Government.
1991	Wildlife (Protection) Act 1991 (Amendment) to make 1972 Act more comprehensive.

Features of Classical Forest Management	Features of Joint Forest Management
► Large areas equivalent to a forest division are considered as one unit for planning to manage the forest	► Comparatively very small blocks, which are small portions of the whole forest division, is considered as individual units of the forest management.
► The major objective of the management was to produce timber to cater to the national needs and to raise maximum revenue consistent with the sustainability of the forest, protection of the soil and conservation of water.	► The objective of the management is to generate products, which are locally needed, as a first charge and the balance products marketed to fetch maximum revenue. Production also has to be sustainable and satisfactory for soil protection and water conservation.
► The management is by the government officials.	► The management is jointly by the government and the fringe people.
► The forest revenue is collected by the government fully and investments also done from the government funds.	► The revenue is shared with the people in different ratios in different states. Investments however are from the government funds.
► Working Plan prescribes management operations of a large forest area for 5-10 years.	► Micro-plan prescribes operations for each individual small forest blocks for 5 years.

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## ■ Government Programmes for Conservation of Forests

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### ○ Compensatory Afforestation

- ▶ Compensatory afforestation is one of the most important conditions stipulated by the Central Government while approving proposals for dereservation or diversion of forest land for non-forest uses. It is essential that with all such proposals, a comprehensive scheme for compensatory afforestation is formulated and submitted to the Central Government.
- ▶ Compensatory afforestation shall be done over equivalent area of **non-forest land**.
- ▶ As far as possible, the non-forest land for compensatory afforestation should be identified contiguous to or in the proximity of **Reserved Forest or Protected Forest** to enable the Forest Department to effectively manage the newly planted area.
- ▶ In the event that non-forest land of compensatory afforestation is not available in the same district, non-forest land for compensatory afforestation may be identified anywhere else in the State/UT as near as possible to the site of diversion, so as to minimise adverse impact on the micro-ecology of the area.
- ▶ Where non-forest lands are not available or non-forest land is available in less extent to the forest area being diverted, compensatory afforestation may be carried out over degraded forest twice in extent to the area being diverted or to the difference between forest land being diverted and available non-forest land as the case may be.

### ○ CAMPA

- ▶ With a cover of 23% of Geographical area of the country, forest in India comprise of a number of diverse forest types and reserved areas designated as National Parks and Wildlife Sanctuaries. In India, forest meet the livelihood needs of people living in and adjoining the forests in about 1, 73,000 villages. Forests also act as carbon sinks and regulators of water regime.
- ▶ The Hon'ble Supreme Court on 10th July 2009 issued orders that there will be a Compensatory Afforestation Fund Management and Planning Authority (CAMPA) as National Advisory Council under the chairmanship of the Union Minister of Environment & Forests for monitoring, technical assistance and evaluation of compensatory afforestation activities.
- ▶ **Objectives of CAMPA**
  - Compensatory Afforestation Fund Management and Planning Authority (CAMPA) are meant to promote afforestation and regeneration activities as a way of compensating for forest land diverted to non-forest uses.
  - National CAMPA Advisory Council has been established as per orders of The Hon'ble Supreme Court with the following mandate:
    - ◆ Lay down broad guidelines for State CAMPA.
    - ◆ Facilitate scientific, technological and other assistance that may be required by State CAMPA.
    - ◆ Make recommendations to State CAMPA based on a review of their plans and programmes.
    - ◆ Provide a mechanism to State CAMPA to resolve issues of an inter-state or Centre-State character.
- ▶ **State CAMPA**
  - The Hon'ble Supreme Court also approved the guidelines prepared by the MoEF for utilizing CAMPA funds by an agency to be constituted in the states and to be known as The State CAMPA.

### ○ Forest Conservation Act

- ▶ The **Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006**, recognizes the rights of forest-dwelling Scheduled Tribes and other traditional forest dwellers over the forest areas inhabited by them and provides a framework for according the same.



- ▶ The **Forest Conservation Act 1980** was enacted to help conserve the country's forests. It strictly restricts and regulates the de-reservation of forests or use of forest land for non-forest purposes without the prior approval of Central Government. To this end the Act lays down the pre-requisites for the diversion of forest land for non-forest purposes.
- ▶ The **Indian Forest Act, 1927** consolidates the law relating to forests, the transit of forest-produce and the duty leviable on timber and other forest-produce.

## o New York Declaration on Forests

- ▶ The **New York Declaration on Forests** is a voluntary and non-legally binding political declaration which grew out of dialogue among governments, companies and civil society, spurred by the **United Nations Secretary-General's Climate Summit held in New York in 2014**.
- ▶ The Declaration pledges to halve the rate of deforestation by 2020, to **end it by 2030**, and to restore hundreds of millions of acres of degraded land. The proposed land restoration is described as covering "an **area larger than India**".
- ▶ A **voluntary Action Agenda** accompanies the Declaration, providing "a guide to governments, companies, and organizations regarding the diverse set of actions that can achieve transformational goals".
- ▶ A Washington-based consulting firm, Climate Advisers, wrote the draft of the Declaration.
- ▶ These included the **EU member states, Canada, Japan, Kenya and Ethiopia**.

## o Social Forestry

- ▶ Social forestry as an instrument of sustainable development has the potential of resolving the three basic issues of rural poor simultaneously i.e. to provide food security, fuel security and livelihood security with eco-friendly approach to development.
- ▶ Social forestry is a programme governed by the principle-of the people, for the people, and by the people.
- ▶ **The objectives of the programme are:**
  - Afforestation in lands outside forest areas.
  - Increasing the number of trees in India.
  - Promoting the participation of institutions and people in the field of growing of trees.
  - Increasing the yield of timber and other non-timber forest produce like fruit, firewood, fodder, etc to ensure easy supply to people.
  - Putting less fertile and unproductive land to productive use
  - Augmenting the income of people by tree planting.
  - Increasing the employment opportunities of rural poor.

### UPSC CSE PRELIMS, 2021

**Q1: With reference to the "New York Declaration on Forests", which of the following statements are correct?**

1. It was first endorsed at the United Nations Climate Summit in 2014
2. It endorses a global timeline to end the loss of forests
3. It is a legally binding international declaration
4. It is endorsed by governments, big companies and indigenous communities.
5. India was one of the signatories at its inception

Select the correct answer using the code given below

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

**Correct Option :(d)**

## ◉ Social forestry scheme can be categorized as:

- ▶ **Farm forestry:** Under this programme individual farmers are being encouraged to plant trees on their own farmland to meet the domestic needs of the family. In many areas this tradition of growing trees on the farmland already existed. **Non-commercial farm forestry** is the main thrust of most of the social forestry projects in the country today. It is not always necessary that the farmer grows trees for fuelwood, but very often they are interested in growing trees without any economic motive. They may want it to provide shade for the agricultural crops; as wind shelters; soil conservation or to use wasteland.
- ▶ **Community forestry:** Another scheme taken up under the social forestry programme, is the raising of trees on community land and not on private land as in farm forestry. The government has the responsibility of providing seedlings, fertilizers but the community has to take responsibility of protecting the trees
- ▶ **Extension forestry**” Planting of trees on the sides of roads, canals and railways, along with planting on wastelands is known as ‘extension’ forestry, increasing the boundaries of forests. Under this project there has been creation of wood lots in the village common lands, government wastelands and panchayat lands.

## ◉ Agroforestry

- ▶ Agroforestry is defined as a land use system which integrate trees and shrubs on farmlands and rural landscapes to enhance productivity, profitability, diversity and ecosystem sustainability.
- ▶ Agroforestry is practiced in both irrigated and rain fed conditions where it produces food, fuel, fodder, timber, fertilizer and fibre, contributes to food, nutritional and ecological security, sustains livelihoods, alleviates poverty and promotes productive and resilient cropping and farming environments.
- ▶ Agroforestry also has the potential to enhance ecosystem services through carbon storage, prevention of deforestation, biodiversity conservation, and soil and water conservation. In addition, when strategically applied on a large scale, with appropriate mix of species, agroforestry enables agricultural land to withstand extreme weather events, such as floods and droughts, and climate change.

## ◉ Various Forms of Agroforestry

- ▶ **Agri-silviculture system:** Concurrent production of agricultural crops & forest trees.
- ▶ **Silvipastoral System:** Forest based livestock production system where production of wood and rearing of domestic animals are done simultaneously.
- ▶ **Agro-silvipastoral system:** Land is utilized simultaneously for the production of agricultural crops, forest trees and rearing of domestic animals.
- ▶ **Multipurpose forest tree production system:** In this system trees are grown not only for wood but also for leaves, fruits, fodder and other useful by-products, including soil cover crops and intercropping with high value spices in man-made plantations.

## ◉ National Green Highways Mission

- ▶ **Union Road Transport and Highways Ministry begins** initial plantation drive along **1,500km of national highways at a cost of about Rs.300 crore** .
- ▶ The mission aims to provide a green canopy along **100,000km of highways** and create jobs for 1 million youth.
- ▶ Green corridors sustain biodiversity, regenerate natural habitat, benefit all stakeholders, from road users to local communities and spur eco-friendly economic growth and development.
- ▶ The policy when implemented in letter and spirit will result into India being a **“Nation with Natural Highways”**.

## National Agroforestry Policy, 2014

Agroforestry is defined as a land use system which integrate trees and shrubs on farmlands and rural landscapes to enhance productivity, profitability, diversity and ecosystem sustainability.

- ▶ **India becomes first country to adopt an agroforestry policy.**

### ○ Objectives:

- ▶ Encourage and expand tree plantation in complementarity and integrated manner with crops and livestock to improve productivity, employment, income and livelihoods of rural households, especially the small holder farmers.
- ▶ Protect and stabilize ecosystems, and promote resilient cropping and farming systems to minimize the risk during extreme climatic events.
- ▶ Meet the raw material requirements of wood based industries and reduce import of wood and wood products to save foreign exchange.
- ▶ Supplement the availability of agroforestry products (AFPs), such as the fuel-wood, fodder, non-timber forest produce and small timber of the rural and tribal populations, thereby reducing the pressure on existing forests.
- ▶ Complement achieving the target of increasing forest/tree cover to promote ecological stability, especially in the vulnerable regions.
- ▶ Develop capacity and strengthen research in agroforestry and create a massive people's movement for achieving these objectives and to minimize pressure on existing forests.

### ○ Strategies

- ▶ Establishment of Institutional Setup at National level to promote Agroforestry
- ▶ An institutional mechanism, such as a Mission or Board is to be established for implementing the agroforestry policy. It will provide the platform for the multi-stakeholders to jointly plan and identify the priorities and strategies, for inter-ministerial coordination, programmatic convergence, financial resources mobilization and leveraging, capacity building facilitation, and technical and management support.
- ▶ The **Ministry of Agriculture** has the mandate for agroforestry. Agroforestry Mission / Board will be located in the **Department of Agriculture and Cooperation (DAC) in the Ministry of Agriculture (MoA)**.
- ▶ The actual implementation may involve convergence and dovetailing with a number of programmes.
- ▶ Agroforestry research and development (R&D), including capacity development and pilot studies / testing and action research should be the responsibility of the ICAR
- ▶ In the proposed institutional arrangement the current stakes of the key ministries are to be respected and utilized.
- ▶ Simple regulatory mechanism - There is a need to create simple mechanisms/procedures to regulate the harvesting and transit of agroforestry produce within the State, as well as in various States forming an ecological region. There is also the need to simplify procedures, with permissions extended on automatic route as well as approval mode through a transparent system within a given time schedule.

## ■ MISCELLANEOUS

### ○ Recent Developments

- ▶ PARIVESH is a web based, role based workflow application which has been developed for online submission and monitoring of the proposals submitted by the proponents for seeking Environment, Forest, Wildlife and CRZ Clearances from Central, State and district level authorities. It automates the entire tracking of proposals which includes online submission of a new proposal, editing/updating the details of proposals and displays status of the proposals at each stage of the workflow.

## ◉ Ecosystem Services

- ▶ They are “the benefits people derive from ecosystems”.
- ▶ Besides provisioning services or goods like food, wood and other raw materials, plants, animals, fungi and micro-organisms; the natural environment also provide essential regulating services such as pollination of crops, prevention of soil erosion and water purification, and a vast array of cultural services, like recreation and a sense of place.
- ▶ **These services can be categorized in**
  - Provisioning services.
  - Regulating services.
  - Support services.
  - Cultural services.

## ◉ LEAF coalition

LEAF (Lowering Emissions by Accelerating Forest Finance) Coalition was announced at the Leaders’ Summit on Climate, 2021.

- ▶ LEAF coalition will be one of the largest ever **public-private efforts to protect tropical forests** and **intend to mobilize at least USD 1 billion in financing** to countries committed to protecting their tropical forests.

### **About LEAF Coalition:**

- ▶ It is a **collective of the governments of the USA, United Kingdom and Norway.**
- ▶ As it is a public-private effort, thus **also supported by transnational corporations (TNCs)** like Unilever plc. Amazon.com, Nestle, Airbnb etc.
- ▶ A country willing to participate would need to fulfil certain predetermined conditions laid down by the Coalition.

## ◉ WHO BioHub System

- ▶ The WHO Bio-Hub System will offer a **reliable, safe, and transparent mechanism** for WHO Member States to voluntarily **share novel biological materials**, without replacing or competing with existing systems.
- ▶ Sharing of biological materials with epidemic or pandemic potential will be done through one (or more) of the laboratories designated as a **WHO BioHub Facility.**
- ▶ This will allow WHO Member States and partners to work in a better and faster way, to advance research, and to be more prepared for health emergencies as well as ensure fairness in access to benefits arising from this sharing.

## ◉ List of Artificial Lakes in India

- ▶ **Guru Gobind Sagar Lake- Punjab**
- ▶ Waddepally Lake- Warangal
- ▶ Saroornagar Lake- Hyderabad
- ▶ Sanjay Lake- Delhi
- ▶ Pashan Lake- Pune
- ▶ **Bhojtal Lake- Bhopal**
- ▶ **HussainSagar- Hyderabad**
- ▶ Hazaribagh Jheel- Hazaribagh
- ▶ Kodaikanal – Tamil Nadu

### **UPSC CSE PRELIMS, 2018**

**Q1: Which one of the following is an artificial lake?**

- (a) Kodaikanal (Tamil Nadu)
- (b) Kolleru (Andhra Pradesh)
- (c) Nainital (Uttarakhand)
- (d) Renuka (Himachal Pradesh)

**Correct Option: (a)**

## ◉ **Environmental Information System**

- ▶ It is a Central Sector Scheme of the Ministry has been implemented since **1982**.
- ▶ The purpose of the scheme is to integrate country-wide efforts in environmental information collection, collation, storage, retrieval and dissemination through ENVIS websites, which are dedicated to different interesting themes.

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3. Internal Security
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