

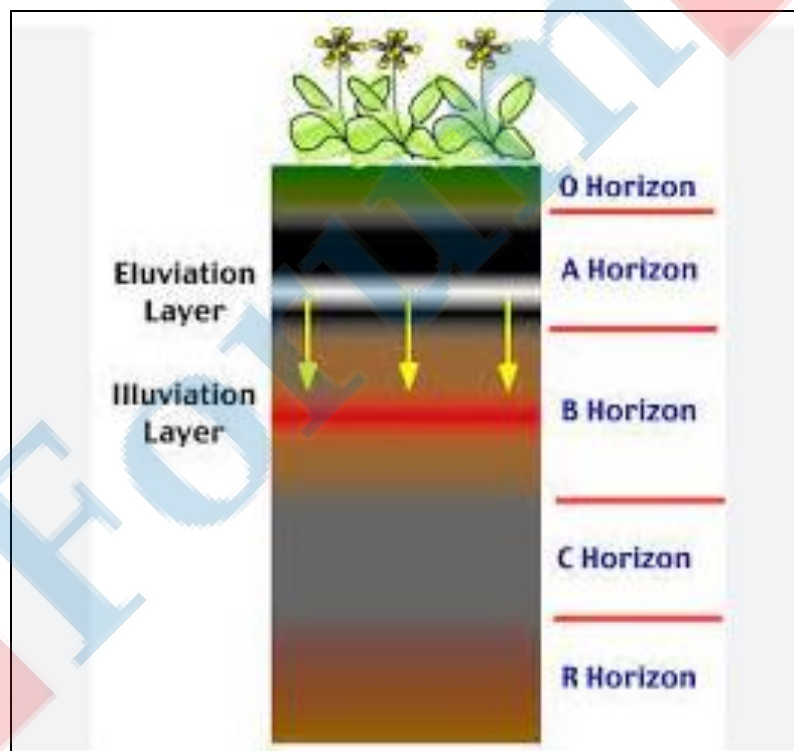
PRRC 2023

Environment
(Class Handouts)

 **Forum** **IAS**

SOILS OF INDIA

- Soil is the mixture of rock debris and organic materials which develop on the earth's surface. A dynamic medium where biotic and abiotic factors are constantly interacting.
- The major factors affecting the formation of soil are:
 - Relief
 - Parent material
 - Climate
 - Vegetation other life-forms
 - Time.
 - Besides these, human activities also influence it to a large extent.
- Components of the soil are mineral particles, humus, water and air.
- Soil Horizon – Soil consists of layers called Horizons.
 - Horizon A – the Top most layer, consists of organic matter necessary for the survival of plants.
 - Horizon B – Transition zone, some organic matter and minerals are weathered.
 - Horizon C – Composed of loose parent material
- Soil Profile



Different types of soils in India

- The ICAR has classified the Indian soils on the basis of their nature and character as per the United States Department of Agriculture (USDA) Soil Taxonomy.

SOILS OF INDIA

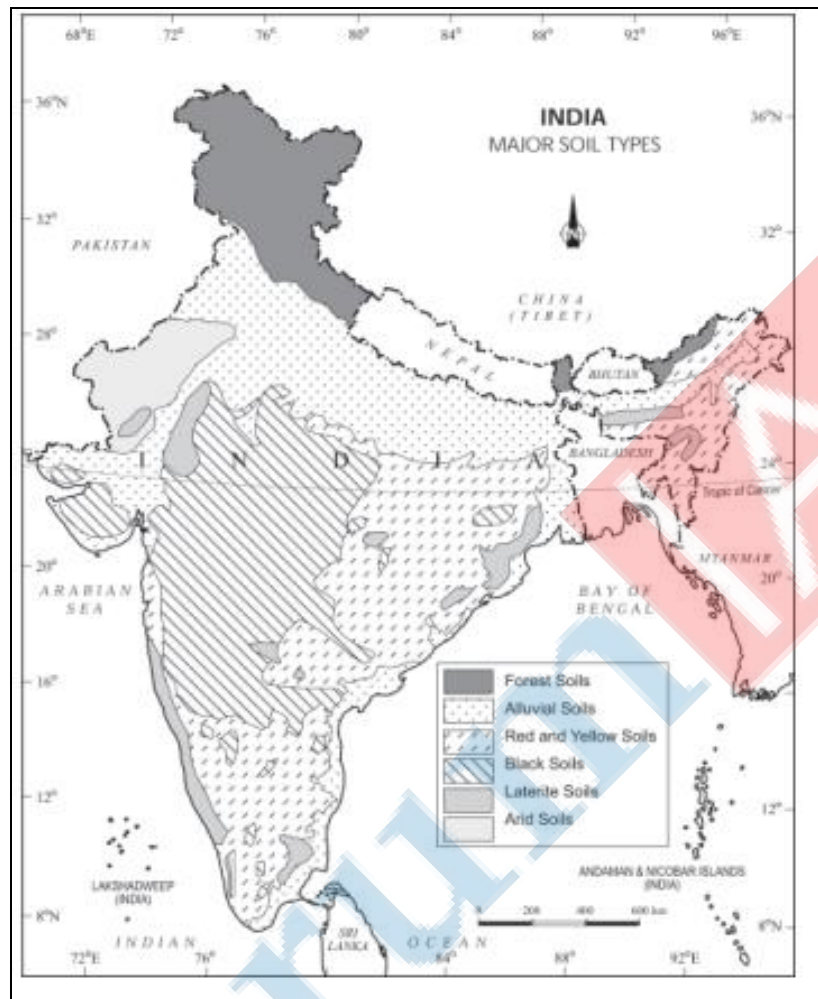
ICAR has classified the soils of India into the following order as per the USDA soil taxonomy

Sl No.	Order	Area (in Thousand Hectares)	Percentage
(i)	Inceptisols	130372.90	39.74
(ii)	Entisols	92131.71	28.08
(iii)	Alfisols	44448.68	13.55
(iv)	Vertisols	27960.00	8.52
(v)	Aridisols	14069.00	4.28
(vi)	Ultisols	8250.00	2.51
(vi)	Mollisols	1320.00	0.40
(viii)	Others	9503.10	2.92
Total			100

Source : Soils of India, National Bureau of Soil Survey and Land Use Planning, Publication Number 94

- On the basis of genesis, color, composition and location, the soils of India have been classified into:
 - Alluvial soils
 - Black soils
 - Red and Yellow soils
 - Laterite soils
 - Arid soils
 - Saline soils
 - Peaty soils
 - Forest soils.

SOILS OF INDIA



Alluvial Soils

- Coverage – 45.6% of the total land area.
- Genesis – Derived from sediments deposited by the rivers, thus, the parent material is of transported origin.
- Characteristics
 - Immature soils have thin profiles.
 - At a few locations, Kankar beds are present (Bhangar soils).
 - Very fertile soil
 - Low in nitrogen content
 - Rich in potash but poor in phosphorus
 - Divided into Bhangar and Khadar
 - Colour varies from light grey to ash grey.
 - These soils are loamy and clayey in the lower and middle Ganga plain and the Brahmaputra valley.
 - The sand content decreases from west to east.
- Economic Importance
 - Intensively cultivated for rice, sugarcane, wheat, etc.

SOILS OF INDIA

Black Soils

- Genesis – formed due to weathering of the solidified lava.
- Characteristics
 - Known as the ‘Regur Soil’ or the ‘Black Cotton Soil’.
 - Black colour – the presence of a small proportion of titaniferous magnetite.
 - Generally clayey, deep and impermeable.
 - Highly retentive of moisture.
 - They swell and become sticky when wet and shrink when dried. So, during the dry season, these soil develop wide cracks. Thus, there occurs a kind of ‘self-ploughing’.
 - Deep cracks permit oxygenation of the soil – improve fertility.
 - Highly argillaceous - >62% is clay.
 - Rich in lime, magnesia, iron and alumina and potash.
 - Poor in nitrogen, phosphorous and organic matter.
- Economic Importance
 - Major crops grown are – cotton, wheat, jowar, linseed, Virginia tobacco, castor, sunflower and millet.
 - Large varieties of fruits and vegetables are also grown.
 - Rice and sugarcane are grown with irrigation facilities.

Red Soils

- Genesis – weathering of ancient crystalline igneous and metamorphic rocks.
- Characteristics
 - The red colour is due to wide diffusion rather than a high percentage of iron content.
 - It looks yellow when found in hydrated form.
 - Poor in nitrogen, humus and phosphorus.
- Economic Importance
 - Proper use of irrigation and fertilizers give excellent yields of cotton, wheat, rice, pulses, millets, tobacco and oilseeds.

Laterite Soils

- Genesis – Develops in upland in areas of high rainfall and high temperature where leaching phenomena are prominent. Lime and silica are leached away whereas iron oxide and aluminium are left behind.
- Characteristics
 - Poor in nitrogen, phosphorus and organic matter.
 - Not suitable for cultivation.
- Economic Importance
 - Good for tree crops like areca nut.
 - Used for bricks in house construction.

Forest and Mountain Soils

- Genesis – formed in forest areas where sufficient rainfall occurs.
- Characteristics
 - They are loamy and silty on valley sides and coarse-grained on the upper slopes.

SOILS OF INDIA

- In the snow-bound areas of the Himalayas, they experience denudation and are acidic with low humus content.
- The soils found in the lower valleys are fertile.

Arid Soils

- Arid soils range from red to brown in colour.
- They are generally sandy in structure and saline in nature.
- In some areas, the salt content is so high that common salt is obtained by evaporating the saline water.
- Poor in nitrogen and humus and phosphorus.
- Potash is in normal quantity.
- Lower horizons of the soil are occupied by 'kankar' layers because of the increasing calcium content downwards.
- If irrigation is provided, cultivation becomes possible.

Saline Soils

- Called Usara Soils
- Contain a larger proportion of sodium, potassium and magnesium, and thus, they are infertile.
- They occur in arid and semi-arid regions, and in waterlogged and swampy areas.
- They lack nitrogen, humus and phosphorus.
- Reasons for formation
 - Runn of Kutchch - Southwest Monsoon brings salt particles and deposits there as a crust
 - Seawater intrusions in the deltas promote the occurrence of saline soils
 - In areas of intensive cultivation with excessive use of irrigation, especially in areas of the green revolution, the fertile alluvial soils are becoming saline. Excessive irrigation with dry climatic conditions promotes capillary action.

Peaty Soils

- They are found in areas of heavy rainfall and high humidity.
- A large quantity of dead organic matter accumulates in these areas, and this gives a rich humus and organic content to the soil.
- Organic matter in these soils may go even up to 40-50 per cent.
- The soils are black in colour.

Environment and Ecology

TOPICS COVERED – ECOSYSTEM

1. Ecology

- Ecology, which is the scientific study of the interactions between populations or between organisms and the environment, can be viewed at the level of an individual, a population, a community, or an ecosystem.
 - Ecology at the level of individuals is concerned chiefly with the individual organism's physiology, reproduction, and development.
 - At the level of population, ecology deals primarily with the attributes and the various factors affecting the population.
 - At the level of community, ecology studies the interactions between populations and community patterns.
 - At the level of an ecosystem, ecology puts all of them together to understand how the system operates as a unit. Thus, an ecosystem ecology would be more concerned about energy flow and nutrient cycles than about individual species.

2. Ecosystem

Definition

- The structural and functional unit of ecological studies.
- An ecosystem is a community plus the environment.
- AG Tansley - An ecosystem includes all the living things (plants, animals and organisms) in a given area, interacting with each other, and with their non-living environments (weather, earth, sun, soil, climate, and atmosphere). In an ecosystem, each organism has its own niche or role to play.

Benefits

1. Freshwater
2. Food – Fishes, Crustaceans, Seaweeds, Sea grasses
 - Two marine eukaryotic photosynthetic organisms.
 - Seaweed is an alga which belongs to the kingdom Protista. It is a plant-like organism. But it lacks true stem, roots, leaves and vascular tissues.
 - In contrast, sea grass is a marine flowering plant which is a true vascular plant. It has a true stem, roots and leaves.
 - Sea grass produces fruits and seeds, unlike seaweeds.
3. Fuel – Firewood, biofuels,
4. Genetic resources
 - Microorganisms, plant varieties, animal breeds, genetic sequences, nucleotide and amino acid sequence information, traits, molecular events, plasmids, and vectors.
5. Natural medicines
 - Marine pharmacology
 - Covering the period from 1981 to 2008, around 68% of all the drugs used to curb infection (including antibacterial, antiviral, anti-parasitic, and antifungal compounds) and 63% of anti-cancer drugs were naturally derived. (NCBI Report)

Ecosystem Services

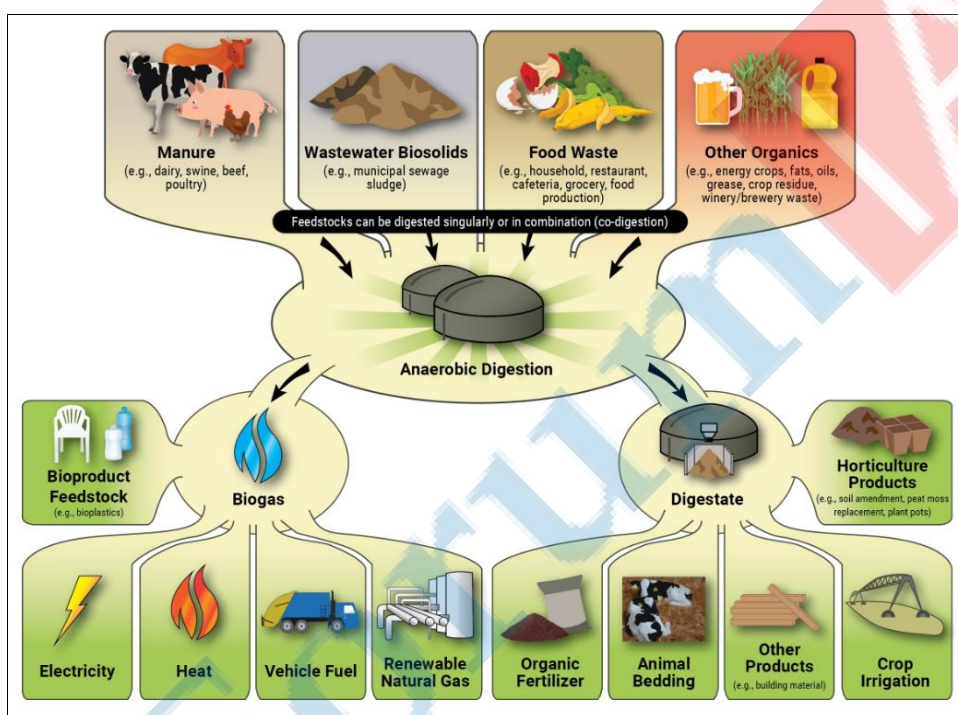
- Provisioning Services - Any type of benefit to people that can be extracted from nature

Environment and Ecology

1. Fisheries
 2. Fruits and vegetables
 3. Drinking water
 4. Timber and Fuel wood
 5. Natural gas and oils
 6. Plants and organisms that can be used in industries – textile, food, chemicals, petroleum, etc.
- Regulating Services – Benefit provided by ecosystem processes that moderate natural phenomena. All these processes work together to make ecosystems clean, sustainable, functional, and resilient to change.
 1. Pollination
 - Act of transferring pollen grains from the male anther of a flower to the female stigma.
 - With adequate pollination, wildflowers:
 1. Reproduce and produce enough seeds for dispersal and propagation
 2. Maintain genetic diversity within a population
 3. Develop adequate fruits to entice seed dispersers
 - Without pollinators, the human race and all of earth's terrestrial ecosystems would not survive.
 - Of the 1,400 crop plants grown around the world, i.e., those that produce all of our food and plant-based industrial products, almost 80% require pollination by animals.
 - Importance
 1. Food Security - More than half of the world's diet of fats and oils comes from animal-pollinated plants (oil palm, canola, sunflowers, etc.).
 2. Preserve genetic diversity – enhances links in the food web – strengthens homeostatic mechanism of the ecosystem
 3. Carbon Sequestration – Mitigate Climate Change
 4. Prevents soil and water erosion – Flowering plants help to purify water and prevent erosion through roots that hold the soil in place, and foliage that buffers the impact of rain as it falls to the earth.
 5. Cultural importance
 6. Decomposition and waste assimilation
 - a. Breaking Down complex organic matter into simpler inorganic matter.
 - b. Bacteria and Fungi – Initiate the process of decomposition as they feed on dead organisms.
 - c. Processes involved –
 - i. Fragmentation – Breakdown of detritus into smaller pieces.
 - ii. Leaching – water-soluble nutrients get dissolved in water and seep into the soil.
 - iii. Catabolism – Enzymes react with detritus to break down into simpler inorganic compounds

Environment and Ecology

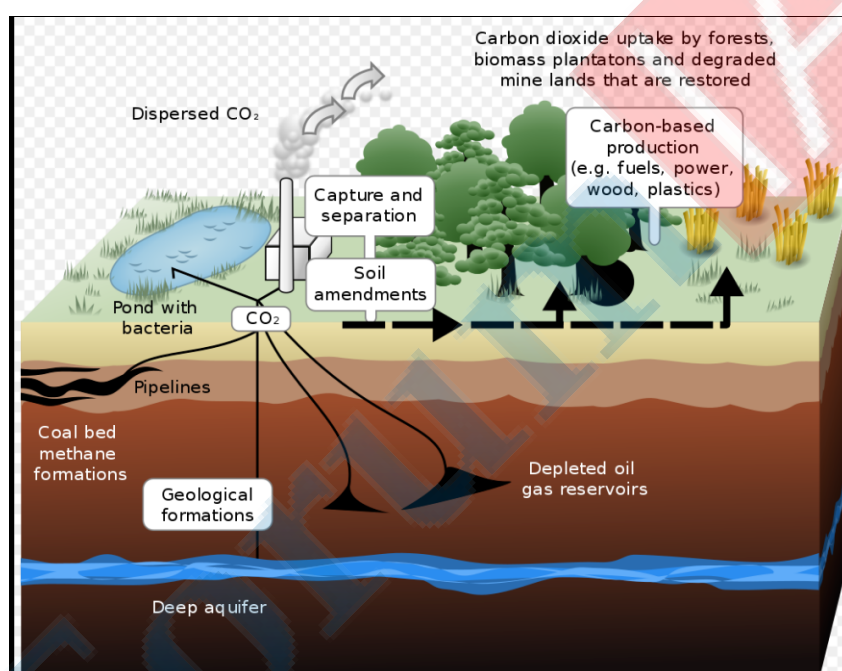
- iv. Humification - Formation of a dark-colored layer of an amorphous substance called humus. Does not decompose easily as it is resistant to microbial activities.
 - v. Mineralization - Degradation of humus to release inorganic nutrients.
- d. Factors affecting decomposition
- i. Litter quality - structural and chemical properties
 - ii. Temperature - Regulates the growth and activity of microorganisms.
 - iii. Aeration - Aerobic and anaerobic decomposition



- iv. Soil pH - Affects microbial growth
 1. Acidic soils (pH 3.0-5.5) are dominated by fungal communities
 2. Neutral soils (pH 5.5-7.5) - Bacteria have a competitive advantage.
 - v. Inorganic chemical - Chemicals released during decomposition are used for growth
 - vi. Moisture - Responsible for various physiological processes of microorganisms. It depends on the moisture content
 1. >60% = Slow decomposition, leaching,
 2. 50-60% = Decomposition occurs rapidly over thin liquid films formed over organic particles.
 3. <30% = Inhibits bacterial growth
7. Carbon storage and climate regulations
- a. Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide.

Environment and Ecology

- b. Two major types of carbon sequestration: geologic and biologic.
- Geologic Sequestration – CO₂ is pressurized – converted to liquid – injected into porous rock formations – basalt, depleted oil and gas field, coal seams, and saline aquifers.
 - a. Enhances oil recovery – CO₂ reduces the viscosity of oil and allows it to flow more easily.
 - Biologic Sequestration – storage of atmospheric carbon in vegetation, soils, woody products, and aquatic environments.
 - a. Iron Fertilization – Intentional introduction of iron to iron-poor areas of the ocean surface to stimulate phytoplankton production.

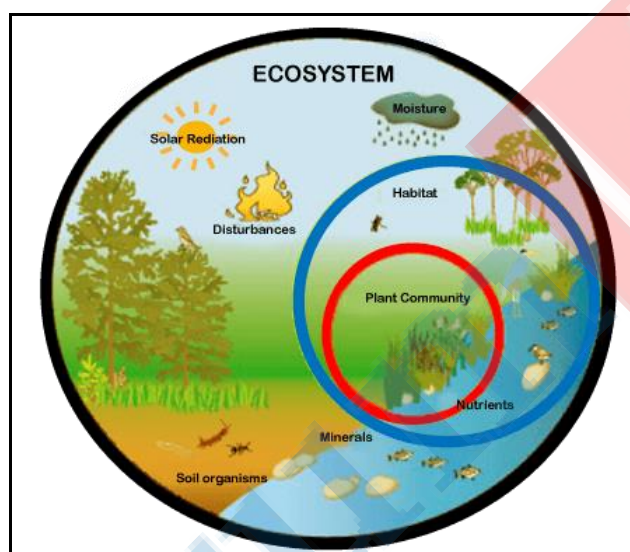


8. Prevention of erosion and flood control
 9. Moderation of extreme events – cyclones, storm surges, heat waves, etc.
- Supporting Services – Ecosystems themselves couldn't be sustained without the consistency of underlying natural processes, such as photosynthesis, nutrient cycling, the creation of soils, and the water cycle. These processes allow the Earth to sustain basic life forms, let alone whole ecosystems and people. Without supporting services, provisional, regulating, and cultural services wouldn't exist.
 1. Primary production through photosynthesis
 2. Element and Nutrient cycling (Biogeochemical cycles)
 3. Water cycling
 - Cultural Services – A cultural service is a non-material benefit that contributes to the development and cultural advancement of people, including how ecosystems play a role in local, national, and global cultures; the building of knowledge and the spreading of ideas; creativity born from interactions with nature (music, art, architecture); and recreation.
 - Tourism and Recreational

Environment and Ecology Principles

1. An ecosystem is a fundamental unit of ecological study

- a. Ecosystem being a monistic concept brings the physical environment, plants and animals together in a single framework, which facilitates the study of the interaction between biotic and abiotic components.
- b. Autotrophic components - green plants - food preparation through photosynthesis
- c. Heterotrophic components - Animals and micro-organisms - use, rearrange and decompose organic substances which are made available from the primary producers of autotrophic components.



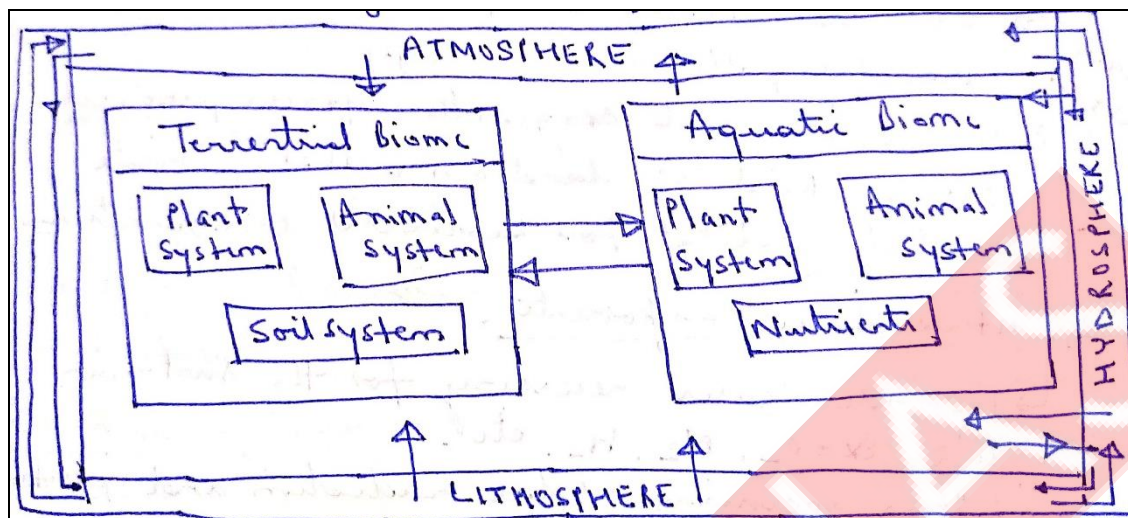
2. Principle of Uniformitarianism

- a. The physical and biological processes and laws that operate today also operated throughout the geological time scale and will continue to do so in future although the intensity of functioning may vary.
- b. The magnitude and frequency of these processes vary over the geological time scale as the environment is influenced by both natural and human factors.
- c. Human-induced climate changes will have a great impact on the physical and biological processes that will operate in future. Example - Modifications in the hydrological cycle due to deforestation and Rising Sea surface temperature.

3. At the largest scale, the whole biosphere becomes an ecosystem.

- a. The biosphere, also known as the ecosphere is the worldwide sum of all ecosystems. The Biosphere behaves as a closed system for the input and output of matter but as an open system for energy.
- b. It becomes the largest ecosystem because it consists of:
 - i. Biotic components - plants, animals, micro-organisms.
 - ii. Abiotic components - land, soil, air water and sunlight
 - iii. Energy component - solar energy and geo-thermal energy
- c. These biotic and abiotic components are intimately inter-related through a series of large scale cyclic mechanisms, collectively called as biogeochemical cycles.

Environment and Ecology Principles



4. Principle of Mutual Reaction

- Living organisms interact among themselves and affect each other.
- Living organisms also interact with the physical environment and in turn, are interrelated through reciprocal relationships.
- Example
 - The symbiotic relationship between coral polyps and zooxanthellae
 - Deforestation, burning of fossil fuels and land use change – These interactions with the physical environment have resulted in global warming and climate change.
 - Examples – rising sea levels, incidences of heat waves, and intensification of tropical cyclones.

5. Principle of Energetics

- a. Energy is the driving force of an ecosystem.
- b. The ecosystem functions through the input of energy mainly solar radiation
- c. Energy flow is unidirectional and is non-cyclic

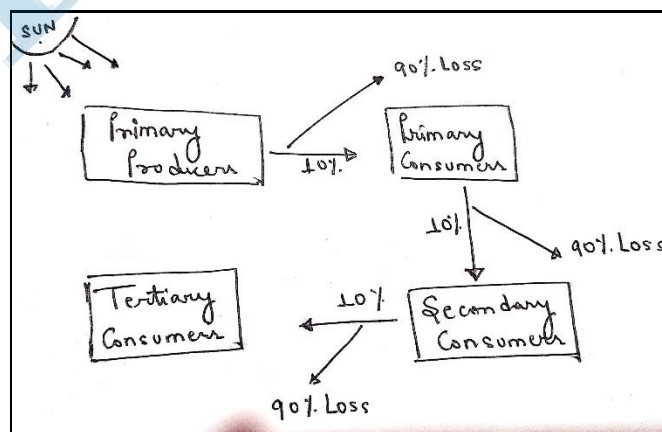


Figure: Depiction of energy flow in the food chain.

Environment and Ecology Principles

- d. The energy pattern and flow are governed by the first two laws of thermodynamics
 - i. Law I – In any system of constant mass, energy is neither created nor destroyed but it can be transformed from one type to another type.
 - ii. Law II – When work is done, energy is dissipated and the work is done when one form of energy is transformed into another form.
- e. RL Lindeman has formulated 4 principles about the relationship between 4 trophic levels within a natural ecosystem.
 - i. Principle 1 – As the distance between the organisms of a given trophic level and the trophic level 1 increases, the probability of the organism depending exclusively on the preceding trophic level for energy decreases. (Species at higher trophic levels tend to be more generalist rather than a specialist)
 - ii. Principle 2 – The relative loss of energy due to respiration is progressively greater at higher trophic levels
 - iii. Principle 3 – Species at higher trophic levels appears to be progressively more efficient in using their available food supply.
 - iv. Principle 4 – Food chains tend to be reasonably short.

6. Principle of Biogeochemical Cycles

- a. The chemical (inorganic) and organic substances are circulated among the various components of the biosphere through a series of closed systems of cycles collectively known as 'biogeochemical cycles.
- b. The circulation occurs in such a fashion that the total amount of substances remains the same throughout the cycles and is always available to the organisms.

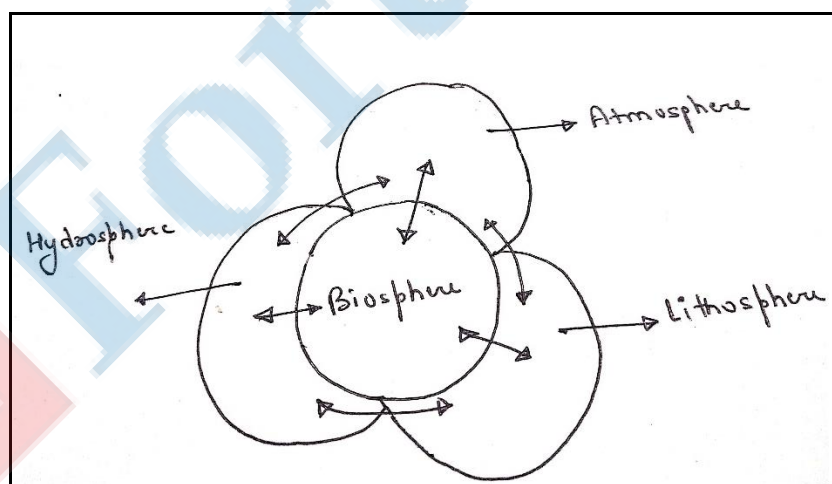


Figure: Representation of nutrient flow.

- c. These substances are required by the organisms as nutrients for the sustenance of their lives.
- d. There are 3 primary types of bio-geochemical cycles:
 - i. Gaseous cycle – oxygen, carbon and nitrogen
 - ii. Sedimentary cycle – Sulphur and phosphorous
 - iii. Hydrological cycle

Environment and Ecology Principles

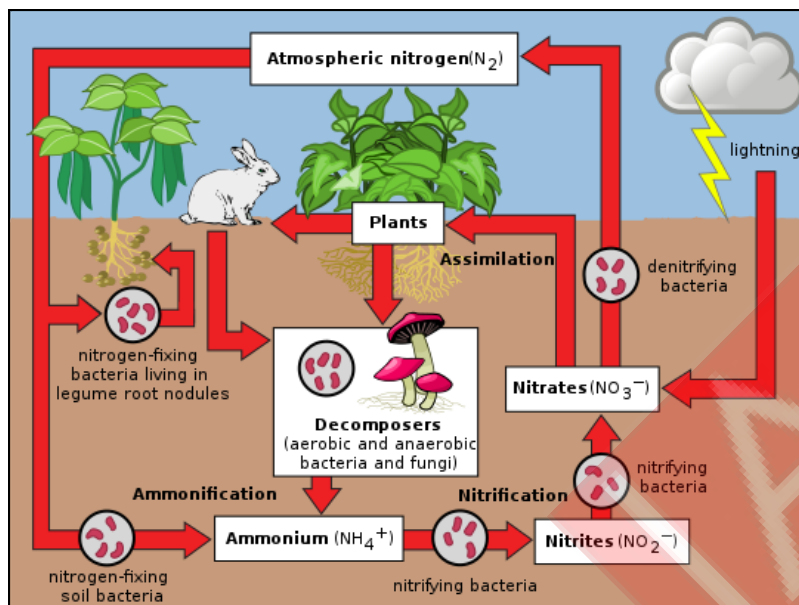
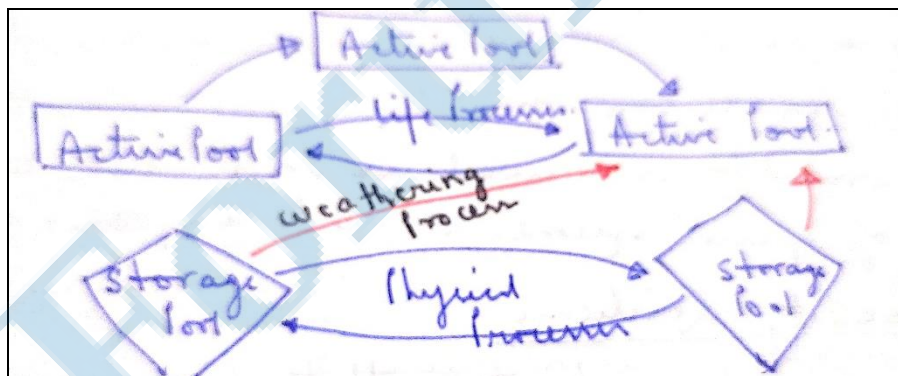


Figure: Diagrammatic representation of the Nitrogen Cycle

- e. The flow of matter generally occurs through 2 major pools
- Active Pool/Exchange pool
 - Passive pool/Reservoir pool



7. Principle of Productivity

- Rate of growth of energy or organic matter per unit time by autotrophs at trophic level 1
- It depends on two factors
 - The availability of the amount of solar radiation to the primary producers at trophic level 1
 - The efficiency of plants to convert solar energy into chemical energy
- There is a marked positive correlation between primary productivity and solar radiation.
- Primary productivity – The rate at which energy is converted to organic substances by photosynthetic producers (photoautotrophs).
- Secondary productivity – The production of organic matter by consumers is called secondary productivity.

Environment and Ecology Principles

- f. Net Primary productivity (NPP) = Gross Primary productivity (GPP) – Respiration

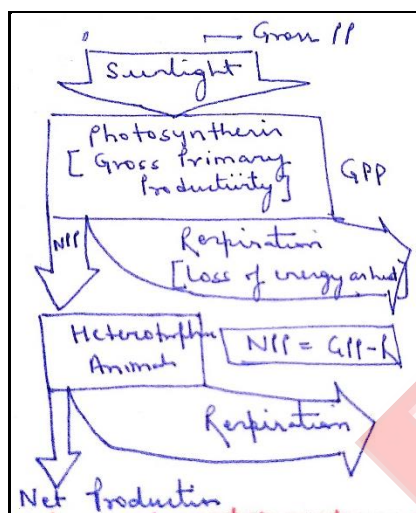


Figure: Ecological production and energy flow.

- g. Odum has identified three levels of productivity
- Regions of higher ecological productivity – Examples – coral reefs, alluvial plains
 - Regions with low ecological productivity – Examples – deserts. Deep oceans, arctic permafrost region
 - Regions of intermediate productivity – Example – grasslands

8. Sustained life on earth is a characteristic of the ecosystem and not of individual organisms or populations.

- Principle of Energetics + Principle of Productivity + Principle of Biogeochemical cycles
- Ecosystem services – Pollination, groundwater recharge, soil formation
- Inter-specific competition and predation
- Symbiotic relationships
- Keystone species, processes and ecosystems.

9. Principle of Natural Selection

- Proposed by Charles Darwin in 1859 – Origin of Species
- Natural selection is a simple mechanism that causes populations of living things to change over time.
- There are four principles at work in evolution—variation, inheritance, selection and time.
- Natural selection is the process through which populations of living organisms adapt and change.
- Individuals in a population are naturally variable, meaning that they are all different in some ways. This variation means that some individuals have traits better suited to the environment than others.
- Individuals with adaptive traits—traits that give them some advantage—are more likely to survive and reproduce.

Environment and Ecology Principles

- g. These individuals then pass the adaptive traits on to their offspring. Over time, these advantageous traits become more common in the population.
- h. Through this process of natural selection, favourable traits are transmitted through generations.
- i. Natural selection can lead to speciation, where one species gives rise to a new and distinctly different species. It is one of the processes that drive evolution and helps to explain the diversity of life on Earth.

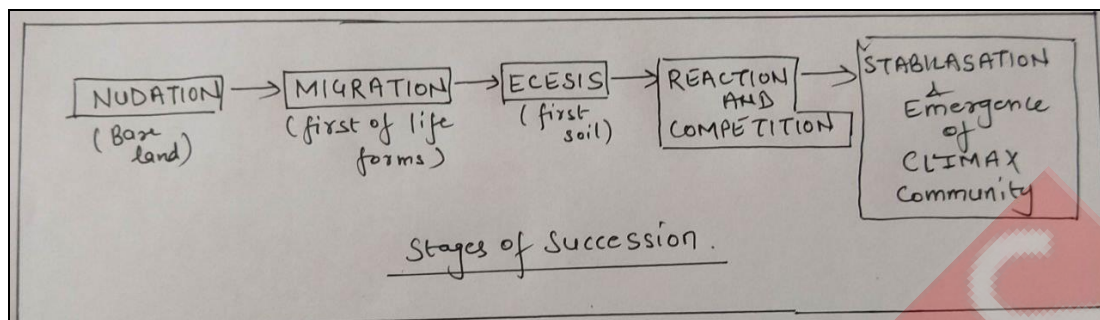
10. Principle of Mutation

- a. Given by De Vries
- b. He challenged the Darwinian concept of evolution.
- c. New species are formed from the sudden and unexpected emergence of alterations in their defining traits.
- d. Sometimes the offspring differ so drastically from their parents that an entirely new species may evolve within a single generation.
- e. The process of spontaneous evolutionary change is termed 'mutation'.

11. Principle of Succession

- a. Ecological succession (Clement) is the process of change in the species structure of an ecological community over time. The time scale can be decades (after a wildfire), or even millions of years after a mass extinction (Permian, Triassic, cretaceous).
- b. The development of vegetation community in any ecosystem or habitat is affected and controlled by:
 - i. Climate
 - ii. Edaphic factors
 - iii. Biotic factors
 - iv. Physiographic factors
 - v. Fire factors
- c. Characteristics:
 - i. It results from the modification of the physical environment of the community
 - ii. It is an orderly process of community development.
 - iii. Nutrient variation determines the settlement of a new community.
- d. Phases of biotic succession:
 - i. The phase of Nudation: the creation of a bare area devoid of vegetation. Ex. The newly emerged volcanic island
 - ii. The phase of migration: Arrival of seeds into the new bare area
 - iii. The phase of Ecesis: Process of successful adjustment of specie to the prevailing conditions - Seeds are germinated
 - iv. The phase of reaction: Competition between plants and the physical environment
 - v. The phase of stabilization: Equilibrium condition of populations of plant species.

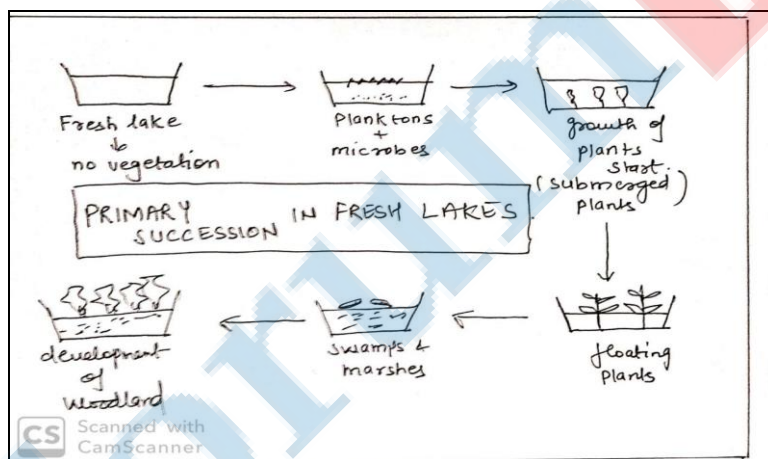
Environment and Ecology Principles



e. Clements has divided succession into two types:

i. Primary Succession:

1. Primary succession refers to a developmental sequence of vegetation in those bare areas where there were no vegetation and animals earlier. Ex. Newly emerged sea floor, the island of Krakatoa, etc.



ii. Secondary Succession:

1. Secondary succession refers to the developmental sequences of vegetation in those areas which had vegetation earlier but now have been rendered nude due to destruction by:
2. Natural processes: Lava flow, forest fires, catastrophic floods, etc.
3. Anthropogenic processes: Jhuming cultivation, overgrazing, etc.

f. Climax communities:

- i. The vegetation community developed at the last stage of biotic succession. The time required for the development of climax vegetation in secondary succession is much less than in primary succession.
- ii. At climax vegetation:
 1. The ecosystem is stable and self-perpetuating
 2. Biomass increases to maximum
 3. Net community production decreases
 4. The food chain becomes highly complex changing the food web.

g. Plagioclimax community: An ecosystem where the influences of man have prevented the ecosystem from developing further.

Environment and Ecology Principles

- i. Arrested climax
- ii. Deflected climax
- h. Fire climax community: Some communities never reach their stable climax in the traditional sense because they are characterized by and adapted to periodic disruptions. Ex. Savannah
- i. Factors that affect biotic succession:
- j. The development of vegetation community in any ecosystem or habitat is affected and controlled by the following factors:-
 - i. Climatic factors: Temperature, Sunlight, soil moisture, humidity, etc. are the major climatic factors which affect succession. It may be pointed out that the macro climatic conditions of a particular region are not as effective in the successional development of vegetation of that region as are the effects of microclimatic conditions of the neighborhood of the plants covering a few square meters of area.
 - ii. Edaphic factors: Include such soil properties which are important to plant life, e.g. nutrient contents in the soils, soil texture, soil structure, soil solution, soil temperature, etc.
 - iii. Biotic factors: Influence of living organisms of a given habitat on the plant life of that habitat mainly the influences of animals in general and man in particular.
 - iv. Physiographic factors: Include the nature of the ground, reliefs (mountains, plateau, plains, and faults), altitude, depths, slope angle, slope aspect, etc.
 - v. Fire factors: Include both natural forest fires through lightning and man-caused forest fires due to deliberate actions or inadvertent actions. Such forest fires destroy the vegetation community on a very large scale.

12. Principle of Homeostasis

- a. The inbuilt self-regulation mechanism in a natural ecosystem through which any change caused by external factors in the ecosystem is counter-balanced by the responses of the system to the change in such a way that ultimately ecosystem of ecological stability is restored.
- b. Ecological diversity and complexity are manifested in three forms:
 - i. According to Elton – an Increase in the diversity of the food webs promotes ecosystem stability as it increases the resilience of the system to outside invasions and reduces the fluctuations in the population within a given ecosystem.
 - ii. According to Mac Arthur – Ecosystem stability increases with an increase in the number of links in the food web. Greater the number of trophic levels, the greater the link.
 - 1. It provides alternative channels of energy flow and thus provides a wide range of adjustments to environmental danger and stresses within the ecosystem.
 - iii. According to Odum – High species diversity in a mature ecosystem representing a ‘climax community’ makes the natural ecosystem more stable and resilient. The homeostatic mechanism further strengthens and more protection is available to the member of the community against external environmental change.

Ecology

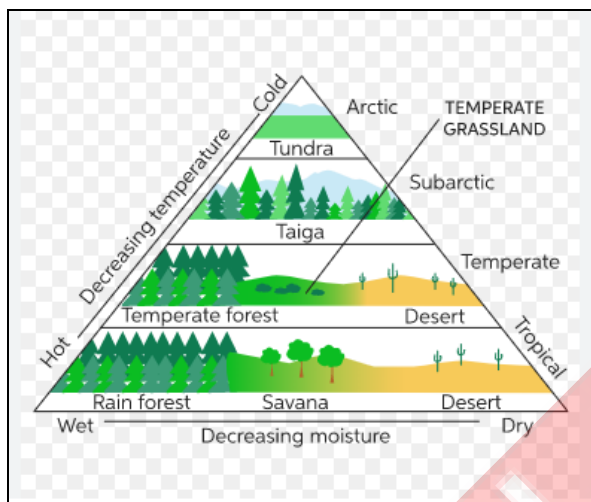
1. ECOLOGY

- Ecology – Scientific study of the relationship of living organisms with each other and with their environment. The study includes intra-relationships among living organisms and the inter-relationships between other living organisms and the environment.
 - Levels of organization in ecology
 - Individual – An organism that has the ability to act or function independently.
 - Population – Group of organisms of the same species occupying in a defined area during a specific time.
 - Community – Group or association of populations of two or more different species occupying the same geographical area at the same time.
 - Ecosystem
 - Biome
 - Biosphere
- Ecosystem – Structural and functional unit of biosphere consisting of a community of living beings and the physical environment, both interacting and exchanging materials between them. Term coined by AG Tansley.
 - Components of an ecosystem
 - Abiotic Components
 - Energy
 - Rainfall
 - Temperature
 - Atmosphere
 - Lithosphere
 - Materials – Organic compounds and Inorganic compounds
 - Biotic Components
 - Primary producers/Autotrophs – Basically green plants – they synthesise carbon
 - Consumers – Heterotrophs or Phagotrophs – Incapable of producing their own food –
 - Macro consumers
 - Herbivores/Primary consumers – Feed mainly on plants
 - Secondary consumers – feed on primary consumers - fox
 - Carnivores/Tertiary consumers – Feed on secondary consumers - Tiger
 - Omnivores – Feed on both plants and animals – Man and Monkey
 - Micro consumers/Saprotrophs/Decomposers
 - Bacteria and Fungi
 - Obtain nutrients from the decomposition of dead organic substances.
- Classification of Ecosystem
 - Terrestrial Ecosystems
 - Forests

Ecology

- Grasslands
 - Deserts
 - Aquatic Ecosystems
 - Freshwaters
 - Saline waters
 - Marine waters
- Ecosystem Functions
 - Provisioning
 - Regulating
 - Supporting
 - Cultural
- Homeostatic Mechanism – Capacity of the ecosystems to self-regulate in order to remain stable and resilient to environmental stresses.
- Ecotone
 - A transition zone between two ecosystems – Mangroves, Estuaries
 - Characteristics
 - Very narrow or quite wide
 - Linear – progressive increase in species composition
 - Zone of Tension
 - Contains organisms which are entirely different from that of adjoining communities.
 - Edge Effect – Sometimes the number of species and the population density of some species is much greater in the ecotone than in either community.
 - Edge Species – An organism which occurs most abundantly in this zone.
- Niche
 - Functional role or place of specie in an ecosystem
 - Description of all the biological, physical and chemical factors that a specie needs to survive, and stay healthy.
 - Types
 - Habitat Niche
 - Food Niche
 - Reproductive Niche
 - Physical and Chemical Niche
- Biome
 - The terrestrial part of the Biosphere is divided into zones called Biomes
 - Characterized by vegetation, climate, animal life and soil type.
 - Aquatic systems are not called Biomes
 - Aquatic zones differ from each other through salinity, levels of dissolved nutrients, temperature, depth, penetration of sunlight, etc.

Ecology



- Biosphere
 - Part of the earth's surface where life can exist.
 - Highly integrated zone of lithosphere, hydrosphere and atmosphere.

2. Functions of an ECOSYSTEM

- **Energy Flow**
 - Energy is the driving force of an ecosystem.
 - The ecosystem functions through the input of energy mainly solar radiation
 - Energy flow is unidirectional and is non-cyclic. It never flows in reverse direction.

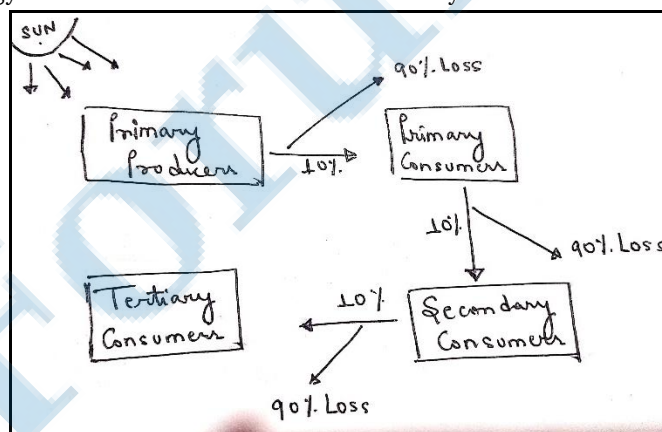


Figure: Depiction of energy flow in the food chain.

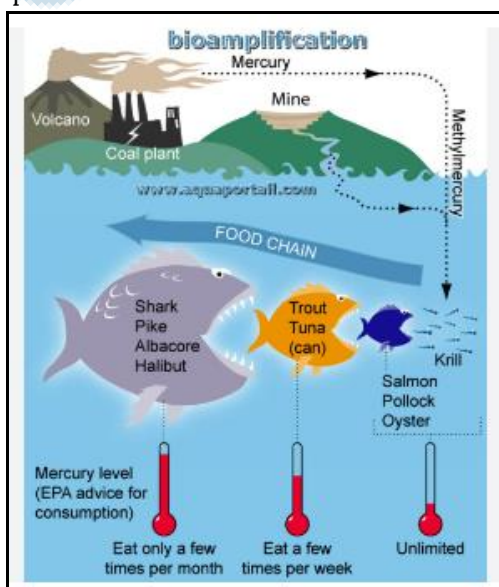
- The energy pattern and flow are governed by the first two laws of thermodynamics
 - Law I – In any system of constant mass, energy is neither created nor destroyed but it can be transformed from one type to another type.
 - Law II – When work is done, energy is dissipated and the work is done when one form of energy is transformed into another form.
- RL Lindeman has formulated 4 principles about the relationship between 4 trophic levels within a natural ecosystem.
 - Principle 1 - As the distance between the organisms of a given trophic level and the trophic level 1 increases, the probability of the organism depending

Ecology

- exclusively on the preceding trophic level for energy decreases. (Species at higher trophic levels tend to be more generalist rather than specialist)
- Principle 2 – The relative loss of energy due to respiration is progressively greater at higher trophic levels
 - Principle 3 – Species at higher trophic levels appear to be progressively more efficient in using their available food supply.
 - Principle 4 – Food chains tend to be reasonably short.
- Usually, there are 4-5 trophic levels and seldom more than 6.
 - Trophic-level interactions involve three concepts
 - Food Chain – sequence of eaten and being eaten leads to the flow of food energy.
 - Grazing Food Chain
 - Food chain where plants act as food
 - Begins from green plants at the base and the primary consumer is an herbivore
 - Both aquatic and terrestrial
 - Phytoplanktons – zooplanktons- nektons (fishes) – Birds (Siberian Crane)
 - Source of energy - plants
 - Detritus Food Chain
 - Starts from dead organic matter of decaying animals
 - Litter – Earthworms – Chicken – Eagle
 - Source of energy – dead organic matter
 - Food Web
 - All possible transfers of energy and nutrients among the organism in an ecosystem whereas food chain traces only one pathway.
 - Alternative paths for transfer of energy makes the ecosystem more resilient.
 - Ecological Pyramids.
 - Steps of trophic levels expressed in a diagrammatic way
 - The length of each bar represents the total number of individuals
 - Three types
 - Pyramid of Numbers – total number of individuals of different species belonging to each trophic level. It does not take into account the size of organisms at different trophic levels.
 - Upright
 - The number of individuals decreases from lower to higher trophic levels.
 - Grassland ecosystem – Grasses – grasshoppers – rats – snakes – Hawk
 - Inverted
 - The number of individuals increases
 - Tree Ecosystem – Trees – Birds – Parasites – Hyperparasites
 - Pyramid of Biomass

Ecology

- Individuals at each trophic level are weighed instead of being counted
- Total dry mass of all organisms at each trophic level at a particular time.
- Upward
 - Terrestrial ecosystems - (Biomass of autotrophs is maximum)
- Inverted
 - Aquatic ecosystem - (Producers are tiny phytoplankton whereas carnivores are Blue Whales)
- Pyramid of Energy and productivity
 - Always upward
 - Usable energy decreases from herbivores to carnivores.
 - They help in explaining the phenomena of biological magnification.
- Pollutants and Trophic Level
 - Non-degradable pollutants move up the trophic level.
 - Bio-accumulation - Pollutants entering the food chain through soil, air or water
 - Bio-concentration - Pollutants entering the food chain through water
 - Bio-magnification -
 - The tendency of pollutants to concentrate as they move from one trophic level to the next.
 - Increase in concentration of pollutants.
 - Characteristics of pollutants
 - Long-lived
 - Mobile
 - Soluble in fats
 - Biologically active
 - Example - DDT



Ecology

- Biotic Interaction
 - Mutualism
 - Both species benefit
 - Pollination
 - Clownfish + Anemones
 - Commensalism
 - One species benefit and the other is unaffected
 - Cow dung + beetles (food and shelter)
 - Bird making a nest in a tree
 - Amensalism
 - One species is harmed and the other is unaffected.
 - A large tree shades smaller plants.
 - Penicillin is secreted by bread mould *Penicillium*, which kills bacteria.
 - Competition
 - Both are harmed
 - Competition for the same food resources, same mating partners, etc.
 - Predator
 - One specie benefits and the other is harmed
 - Intense physical effort is involved.
 - Lion eating Chital
 - Parasitism
 - One specie benefits and the other is harmed
 - Passive in progression
 - Ticks sucking blood from cows
 - Neutralism
 - No net benefit of harm to either species.
 - Interaction between rainbow trout and dandelions living in a mountain valley.
- Bio-geo-chemical Cycles
 - The chemical (inorganic) and organic substances are circulated among the various components of the biosphere through a series of closed systems of cycles collectively known as 'biogeochemical cycles.
 - The circulation occurs in such a fashion that the total amount of substances remains the same throughout the cycles and is always available to the organisms.

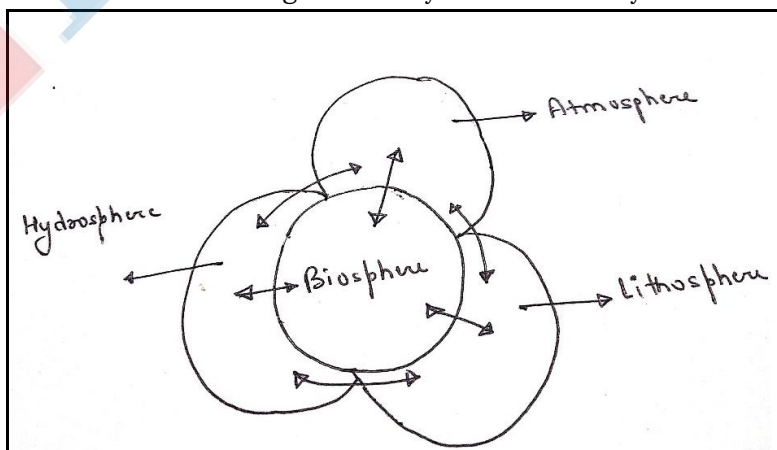


Figure: Representation of nutrient flow.

Ecology

- These substances are required by the organisms as nutrients for the sustenance of their lives.
- There are 3 primary types of bio-geochemical cycles:
 - Gaseous cycle
 - oxygen, carbon and nitrogen
 - Reservoir is atmosphere or hydrosphere
 - Perfect cycle – nutrients are replaced as fast as they are utilized.
 - Sedimentary cycle
 - Sulphur and phosphorous
 - Reservoir is earth crust
 - Imperfect cycle – some nutrients are lost from the cycle and get locked into sediments.
 - Hydrological cycle

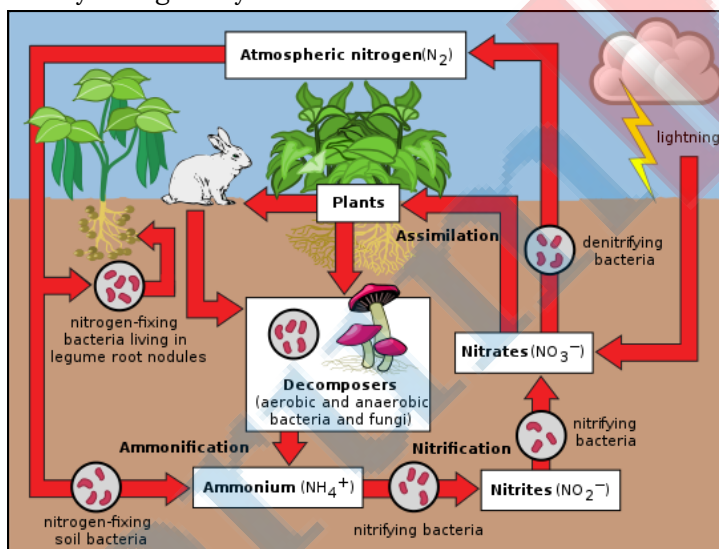
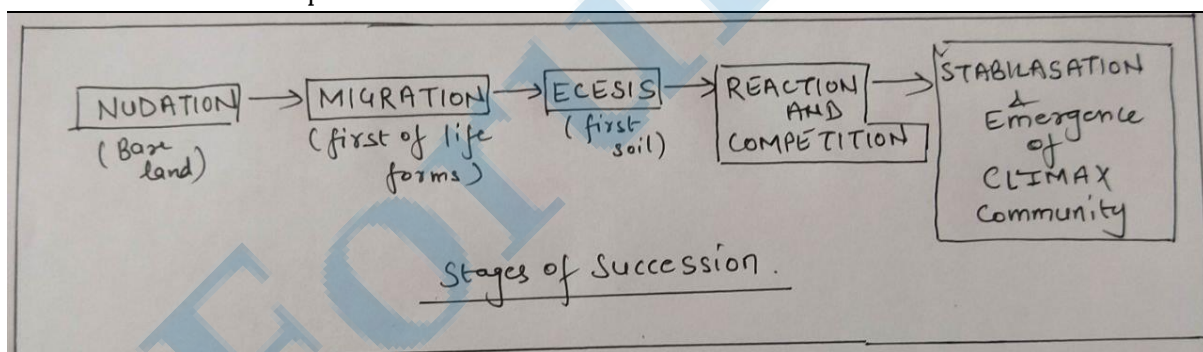


Figure: Diagrammatic representation of the Nitrogen Cycle

- Nutrient recycling – It is a process that describes how nutrients move from the physical environment to the living organism and are subsequently recycled back to the physical environment.
- Sedimentary cycles
 - Phosphorus Cycle
 - Main storage of earth's crust – phosphatic rocks
 - Enter cycle through erosion and mining activities
 - Main nutrient for causing excessive growth of microscopic plants in lakes.
 - Sulphur Cycle
 - Locked in organic (coal, oil and peat) and inorganic deposits (pyrite rocks and sulphur rocks)
- Ecological Succession
 - Ecological succession (Clement) is the process of change in the species structure of an ecological community over time. The time scale can be decades (after a wildfire), or even millions of years after a mass extinction (Permian, Triassic, cretaceous).

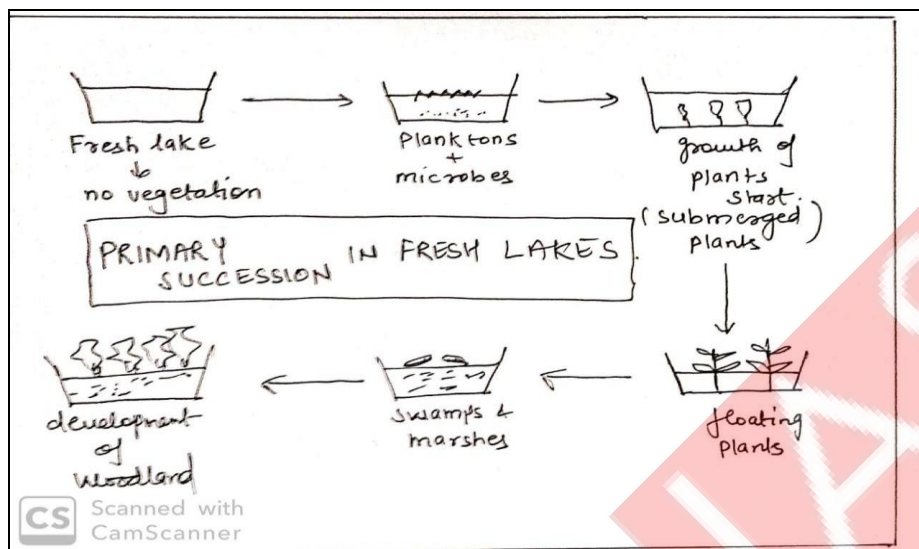
Ecology

- The development of vegetation community in any ecosystem or habitat is affected and controlled by:
 - Climate
 - Edaphic factors
 - Biotic factors
 - Physiographic factors
 - Fire factors
- Characteristics:
 - It results from the modification of the physical environment of the community
 - It is an orderly process of community development.
 - Nutrient variation determines the settlement of a new community.
- Phases of biotic succession:
 - The phase of Nudation: the creation of a bare area devoid of vegetation. Ex. The newly emerged volcanic island
 - The phase of migration: Arrival of seeds into the new bare area
 - The phase of Ecesis: Process of successful adjustment of specie to the prevailing conditions - Seeds are germinated
 - The phase of reaction: Competition between plants and the physical environment
 - The phase of stabilization: Equilibrium condition of populations of plant species.



- Clements has divided succession into two types:
 - Primary Succession:
 - Primary succession refers to a developmental sequence of vegetation in those bare areas where there were no vegetation and animals earlier. Ex. Newly emerged sea floor, the island of Krakatoa, etc.

Ecology



- Secondary Succession:
 - Secondary succession refers to the developmental sequences of vegetation in those areas which had vegetation earlier but now have been rendered nude due to destruction by:
 - Natural processes: Lava flow, forest fires, catastrophic floods, etc.
 - Anthropogenic processes: Jhuming cultivation, overgrazing, etc.
- Climax communities:
 - The vegetation community developed at the last stage of biotic succession. The time required for the development of climax vegetation in secondary succession is much less than in primary succession.
 - At climax vegetation:
 - The ecosystem is stable and self-perpetuating
 - Biomass increases to a maximum
 - Net community production decreases
 - The food chain becomes highly complex changing the food web.
- Plagioclimax community: An ecosystem where the influences of man have prevented the ecosystem from developing further.
 - Arrested climax
 - Deflected climax
- Fire climax community: Some communities never reach their stable climax in the traditional sense because they are characterized by and adapted to periodic disruptions. Ex. Savannah
- Autogenic Succession – Succession brought by living inhabitants of the community itself
- Allogenic succession – change brought by outside forces
- Autotrophic succession – Green plants are much greater in quantity
- Heterotrophic succession – Heterotrophs are in greater quantity.
- Productivity
 - Rate of growth of energy or organic matter per unit time by autotrophs at trophic level 1
 - It depends on two factors

Ecology

- The availability of the amount of solar radiation to the primary producers at trophic level 1
- The efficiency of plants to convert solar energy into chemical energy
- There is a marked positive correlation between primary productivity and solar radiation.
- Primary productivity - The rate at which energy is converted to organic substances by photosynthetic producers (photoautotrophs).
- Secondary productivity - The production of organic matter by consumers is called secondary productivity.
- Net Primary productivity (NPP) = Gross Primary productivity (GPP) - Respiration

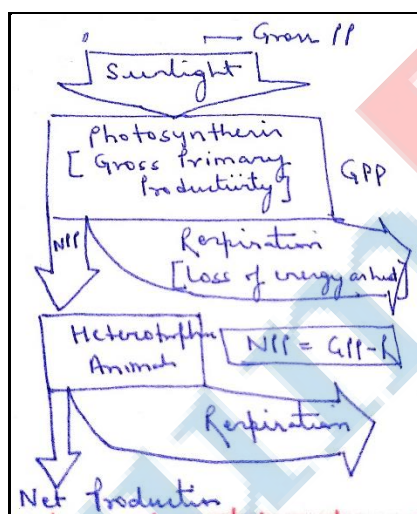


Figure: Ecological production and energy flow.

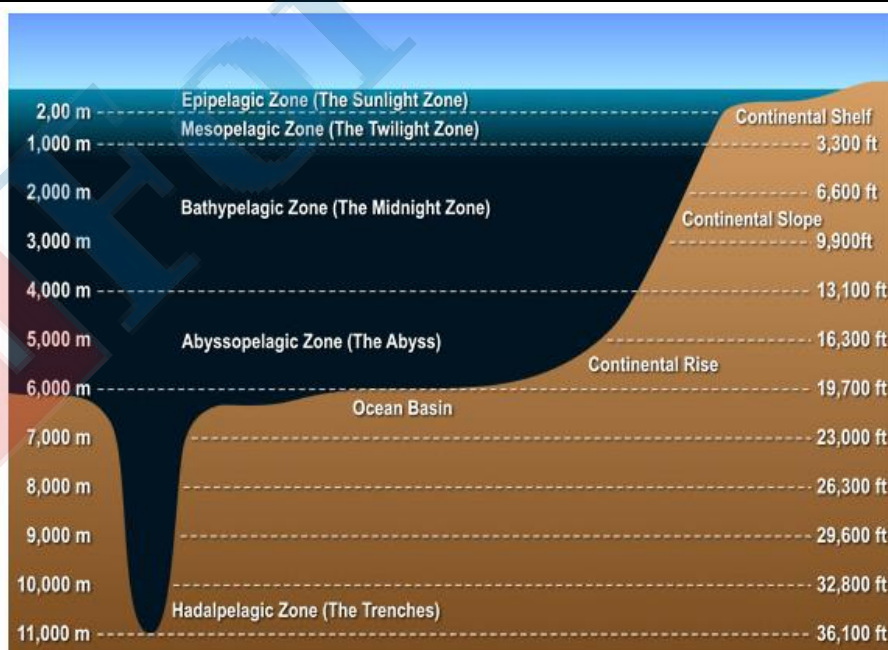
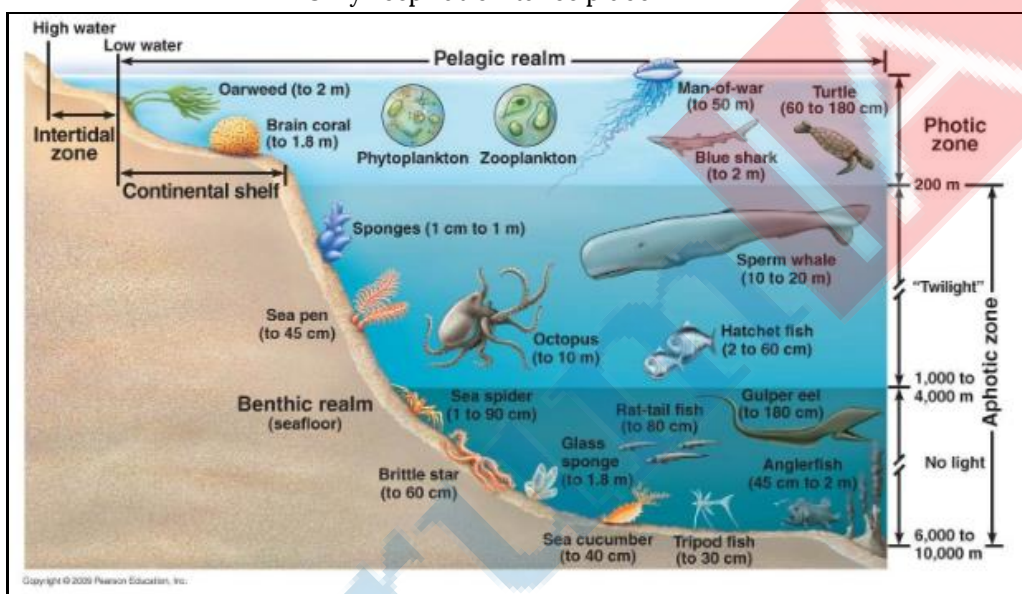
- Odum has identified three levels of productivity
 - Regions of higher ecological productivity - Examples - coral reefs, alluvial plains
 - Regions with low ecological productivity - Examples - deserts. Deep oceans, arctic permafrost region
 - Regions of intermediate productivity - Example - grasslands

3. Aquatic Ecosystems

- Freshwater Ecosystem (salt content < 5 ppt)
- Marine Ecosystem (salt concentration ≥ 35 ppt)
- Brackish Water Ecosystem (salt concentration 5 ppt to 35 ppt) - Estuaries, salt marshes, mangroves, etc.
- Aquatic Organisms
 - Neuston - unattached organisms, for example - floating plants
 - Periphyton - organisms which remain attached to stems and leaves of rooted plants
 - Plankton - microscopic plants like algae (phytoplanktons) and animals like crustaceans and protozoans (zooplanktons)
 - Distribution is controlled by currents as their locomotive power is limited.
 - Nekton - organisms which are swimmers - fishes

Ecology

- Benthos – organisms which are found living at the bottom of the water mass
- Factors affecting the productivity of aquatic habitats
 - Sunlight
 - Photic/Euphotic Zone
 - Light penetrates
 - Both photosynthesis and respiration
 - Lowermost boundary – light level is 1% of that of the surface.
 - Aphotic Zone
 - Light penetration and plant growth are restricted.
 - Only respiration takes place



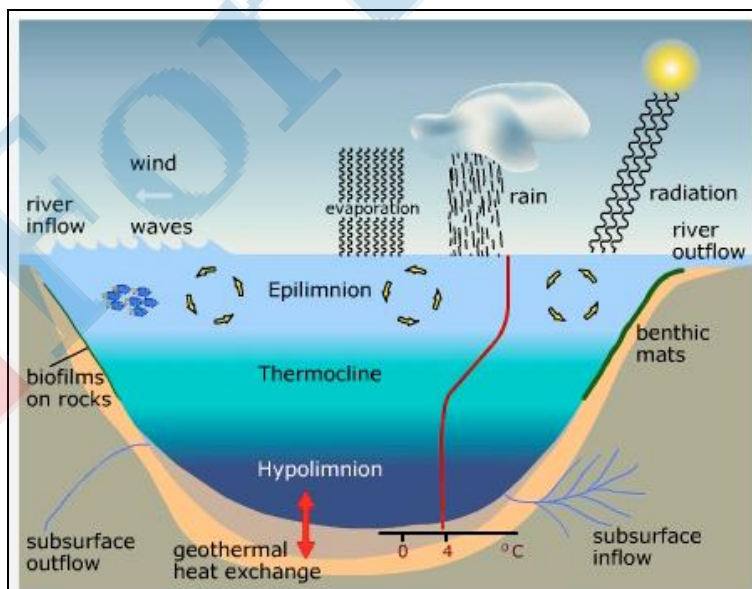
- Dissolved Oxygen
 - Oxygen enters the system through

Ecology

- Air water interface
- Photosynthetic activities of aquatic plants.
 - It is influenced by temperature - oxygen is less dissolved in warm waters.
- Transparency
 - Affects the extent of light penetration.
- Temperature
 - Aquatic organisms have narrow range of tolerance
- Lake Ecology
 - Types of Lakes based on nutrient content
 - Oligotrophic - very low nutrient
 - Mesotrophic - moderate nutrients
 - Eutrophic - High nutrients.

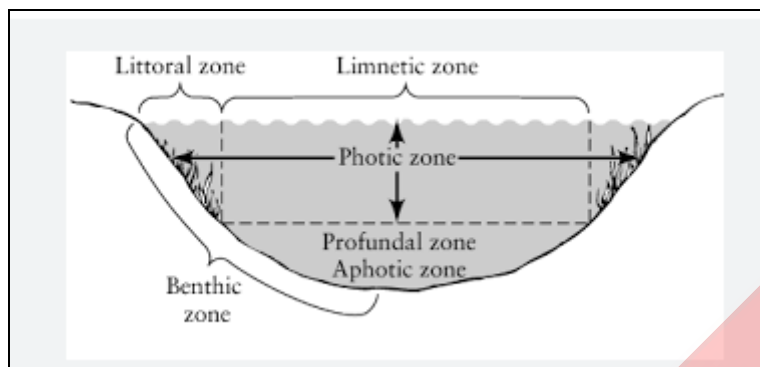
Parameters	Oligotrophic Lake	Eutrophic Lakes
Aquatic Plant Production	Low	Eliminated due to eutrophication
Aquatic animal production	Low	Eliminated due to eutrophication
Nutrient Flux	Low	High
Oxygen in the hypolimnion layer	Present	Absent
Depth	Deeper	Shallow
Number of plant and animal species	Many	Fewer

- Thermal Stratification of Lakes



- Stratification of lakes as per penetration of light

Ecology



- Eutrophication
 - Addition of artificial or natural nutrients such as phosphates, nitrates, etc.
 - Algae and blue-green bacteria (Cyanobacteria) thrive on nutrients and there is a population explosion – leading to algal bloom.
 - As algal bloom covers the entire surface, it restricts the penetration of sunlight and diffusion of oxygen.
 - Due to limited oxygen, aquatic organisms suffocate due to limited oxygen content and they die.
 - Types
 - Natural
 - Cultural
 - Consequences
 - Change in the ecosystem – lake to marshy land ultimately terrestrial ecosystem
 - Decreased biodiversity
 - New Species Invasion
 - Toxicity – Harmful algal blooms release neuro and hepatotoxins which kill aquatic organisms – Shellfish poisoning
 - Affects navigation
 - Loss of coral reefs
- Sources of Pollution
 - Point Source
 - Nutrient waste directly travels from source to water.
 - Factories, drainage systems.
 - Easy to regulate
 - Non-point source
 - Ill-defined and diffused sources.
 - Difficult to regulate
- Harmful algal blooms
 - Population explosion in the numbers of algae due to nutrient enrichment – algal bloom.
 - The blooms are commonly referred to as red or brown tides.
 - Those blooms which produce toxins are called harmful algal blooms.
 - Red Tides – harmful algal blooms.
 - Causes of blooms
 - Nutrient enrichment

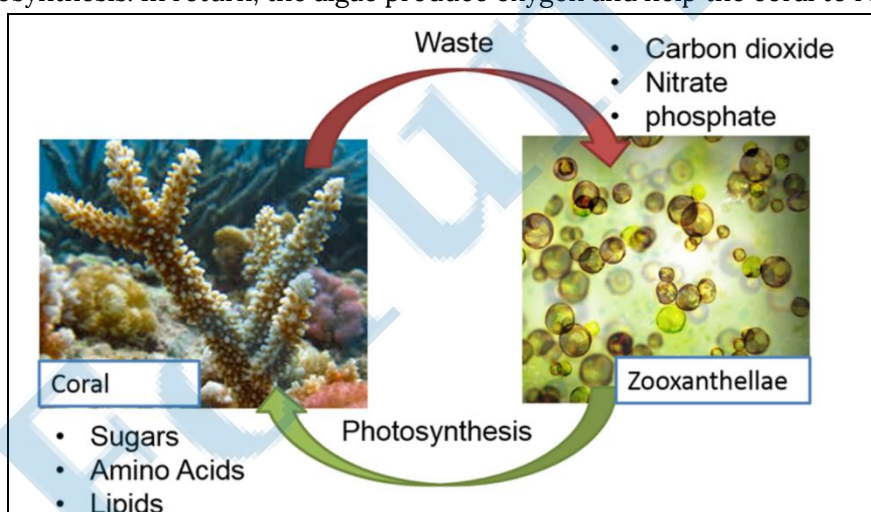
Ecology

- Warm waters – climate change.
 - Sea Snot outbreak in Turkey
 - A slimy layer of grey or green sludge formed when algae are overloaded with nutrients is called sea snot.
 - It is a marine mucilage and is harmful to water bodies.
- Biological Oxygen Demand (BOD)
 - It represents the amount of oxygen consumed by bacteria and other microorganisms while they decompose organic matter under aerobic (oxygen is present) conditions at a specified temperature.
- Chemical Oxygen Demand (COD)
 - Amount of oxygen required to chemically oxidize the organic material and inorganic nutrients, such as Ammonia or Nitrate, present in water.
- Wetland Ecosystem
- Coral Reefs

Coral reefs are submarine landforms formed due to accumulation and compaction of lime secreting organism called coral polyps.

Characteristics:

- The coral provides the algae with a protected environment and compounds they need for photosynthesis. In return, the algae produce oxygen and help the coral to remove wastes.



Conditions for growth:

1. Sea Surface temperature = 23-29C i.e. tropical oceans and seas (Latitudes = Between 30 N and S)
2. Most corals are within 200-250 feet in depth.
3. Not found in upwelling zones, mouth of rivers and fresh water.
4. Ocean salinity = 33 – 38 ppm
5. Constant supply of nutrients and hence flowing water.

Types of coral reefs:

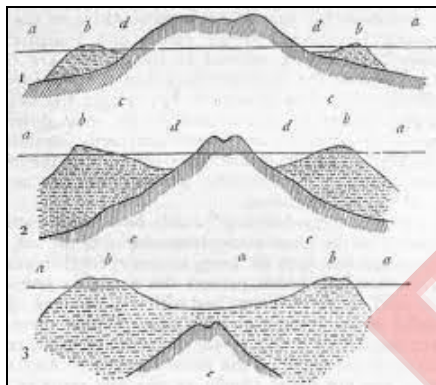
- Fringing Reef: Develops along the continental margins or along the islands. Ex. Caribbean Sea, Red Sea, Bahamas, etc.
- Barrier Reef: The largest coral reefs off the coastal platforms but parallel to them. Ex. Great Barrier Reef (Australia)

Ecology

- **Atolls:** A ring of narrow growing corals of horseshoe shape and crowned with palm trees.
Ex. Funfutti Atoll of Ellice Island, Raja Ampat Island, etc.

Subsidence Theory of Darwin:

Coral reef accumulations are actually three stages in the reef development associated with gradual subsidence of land



Significance of Coral Reefs:

- Coastal Protection
 - Protects beach erosion from strong currents and waves
 - Also protect from cyclones and storms
- Food source
 - Corals are rich in fish nurseries.
 - Healthy source of protein
- Medicinal Properties
 - They are called medicine chest of the Sea
 - Important sources of new medicines being developed to treat cancer, arthritis, human bacterial infections, Alzheimer's disease, heart disease, viruses, and other diseases
- Tourism

Threats to coral Reefs

- Global Warming – Coral Bleaching
 - Oceans are getting warmer – corals have narrow range of tolerance of temperature – coral bleaching.
- climate change
 - Sea Level Rise
 - Ocean Acidification
 - Intensification of Tropical Storms
- Marine Pollution
- Deep Sea Mining
- Ozone Depletion

Coral Bleaching:

- It refer to loss of algae from the corals resulting into white color. If the bleaching event is less intense and stress is removed in time, coral polyps can be recolonized.
- It occurs when
 - Densities of zooxanthalae decline

Ecology

- Concentration of photosynthetic pigments within the zooxanthalae fall.
- According to Clive Wilkinson Report global warming is the major factor. Ex. Year 1998, 2002, 2012-13.
- Coral reefs are forced to expel the symbiotic microalgae from their tissues under various natural to man-made stresses.
- Causes
 - Temperature Change due to Global Warming -
 - Solar Irradiance – An increase in insolation can lead to coral bleaching.
 - A sudden lowering of sea level – Sudden lowering due to tectonic activities, etc. can expose coral reefs to the atmosphere leading to bleaching.
 - Change on salinity
 - Excess sedimentation – Blocks pores
 - Freshwater dilution
 - Eutrophication due to inorganic nutrients
 - Diseases and Infections (Xenobiotics and Epizootics) – Pollution and harmful chemicals can induce coral bleaching.
- Schemes related to Coral Reefs
 - Coastal Regulation Zone Notification under EPA 1986 - It provides protection to all coral reefs under the CRZ1 category of the law. Specific Section 7 (2) of the CRZ states that no hotels or resorts are to be made on coral reefs.
 - Coral Reef Triangle
 - The Coral Triangle is a marine area located in the western Pacific Ocean.
 - It includes the waters of Indonesia, Malaysia, the Philippines, Papua New Guinea, Timor Leste and Solomon Islands.
 - Created by WWF
 - Global Coral Reef Monitoring Network (GCRMN)
 - The International Coral Reef Initiative (ICRI) is an informal partnership between Nations and organizations which strives to preserve coral reefs and related ecosystems around the world.
 - Established by the International Coral Reef Initiative (ICRI) in 1995
 - International Coral Reef Initiative (ICRI)
 - The International Coral Reef Initiative (ICRI) is a global partnership between Nations and organizations which strives to preserve coral reefs and related ecosystems around the world.
 - Although the Initiative is an informal group whose decisions are not binding on its members.
 - India not a founding member
 - The Initiative was founded in 1994.
 - It was announced at the First Conference of the Parties of the Convention on Biological Diversity in December 1994, and at the high level segment of the Intersessional Meeting of the U.N. Commission on Sustainable Development
- Important Terms
 - Microbeads
 - Yellow Band Disease
 - Biorock Technology.
 - Mangroves

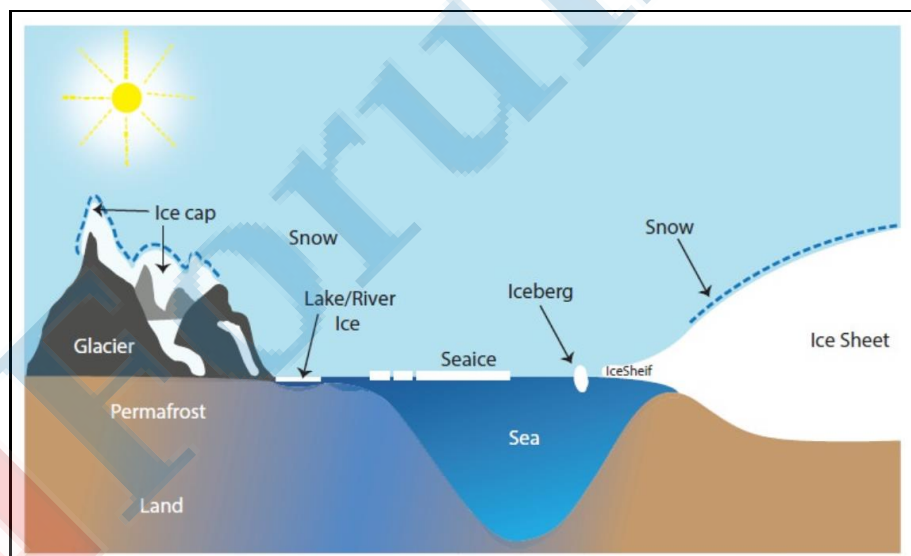
- Mangroves
 - Littoral Plant formation of tropical and subtropical sheltered coastlines.
 - Trees and bushes growing below the level of spring tides exhibit a remarkable capacity for saltwater tolerance.
 - Characteristics
 - Evergreen
 - Areas where abundant silt is brought down by rivers
 - Adaptations to salinity stress
 - Absorb fresh water from saline/brackish water
 - Pneumatophores (blind roots)
 - Leaves are thick and contain salt-secreting glands.
 - Viviparity mode of production
 - Adventitious roots/stilt roots
 - Mangrove Profile of India
 - West Bengal>Andaman and Nicobar Islands> Gujarat
 - Open Mangroves>Dense Mangroves>Moderately dense mangroves
 - As per the ISFR 2021, the mangrove cover in the country has increased by 17 sq. km. in year 2021 as compared to the mangrove cover assessed in year 2019.
 - Initiatives
 - Regulatory measures are implemented through Coastal Regulation Zone (CRZ) Notification (2019) under the Environment (Protection) Act, 1986; the Wild Life (Protection) Act, 1972; the Indian Forest Act, 1927; the Biological Diversity Act, 2002
 - Central Sector Scheme under National Coastal Mission Programme on 'Conservation and Management of Mangroves and Coral Reefs' – Implemented in all states.
 - Budget 2023 - Mangrove Initiative for Shoreline Habitats & Tangible Incomes, MISHTI, will be taken up for mangrove plantation along the coastline and on salt pan lands, wherever feasible, through convergence between MGNREGS, CAMPA Fund and other sources.
 - Mangrove Alliance for Climate (MAC)
 - Launched at the 27th session of Conference of Parties (COP27) UN climate summit, with India as a partner.
 - An initiative led by the United Arab Emirates (UAE) and Indonesia, the Mangrove Alliance for Climate (MAC) includes India, Sri Lanka, Australia, Japan, and Spain.
 - It seeks to educate and spread awareness worldwide on the role of mangroves in curbing global warming and its potential as a solution for climate change.
 - Current Status
 - South Asia houses some of the most extensive areas of mangroves globally, while Indonesia hosts one-fifth of the overall amount.
 - India holds around 3 per cent of South Asia's mangrove population.
- Indian State of Forest Report 2021
 - Released by the Ministry of Environment, Forests and Climate Change (MoEFCC).

- It is an assessment of India's forest and tree cover, published every two years by the Forest Survey of India (FSI) under the Ministry of Environment, Forests and Climate Change.
- The first survey was published in 1987, and ISFR 2021 is the 17th report.
- Key Findings
 - The total forest and tree cover of the country is 80.9 million hectares, which is 24.62% of the geographical area of the country.
 - Increase in forest and tree cover: As compared to the assessment of 2019, there is an increase of 0.28% in the total forest and tree cover of the country.
 - An increase in forest cover has been observed in the open forest followed by very dense forests, while moderately dense forests (natural forests) have declined.
 - States in the North East have recorded the highest loss in forest cover. This is due to numerous natural calamities, particularly landslides and heavy rains, and anthropogenic activities such as shifting agriculture, pressure of developmental activities and felling of trees.
 - There has been an increase of 79.4 million tonnes in the carbon stock of the country, as compared to the last assessment of 2019.
 - Area-wise Madhya Pradesh has the largest forest cover in the country followed by Arunachal Pradesh, Chhattisgarh, Odisha and Maharashtra.
 - The forest cover in tiger corridors has increased between 2011-2021, but decreased by 0.04% in tiger reserves. Pakke Tiger Reserve in Arunachal Pradesh has the highest forest cover, at nearly 97%.
- Ramsar Wetlands
 - Ramsar Convention on Wetlands defines wetlands as “areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt including areas of marine water the depth of which at low tide does not exceed six meters.”
 - However, the Indian government's definition of wetland excludes river channels, paddy fields and other areas where commercial activity takes place.
 - In India, wetlands make up 4.63% of the total geographical area of the country. Among them, inland-natural wetlands account for 43.4% and coastal-natural wetlands 24.3%.
 - In the state-wise distribution of wetlands, Gujarat is at the top with 22.7% of total wetlands areas of the country. It is followed by Andhra Pradesh, Uttar Pradesh and West Bengal.
 - Total number of Ramsar sites to 75.
 - India is one of the Contracting Parties to Ramsar Convention, signed in Ramsar, Iran, in 1971.
 - India signed it on 1st Feb 1982. During 1982 to 2013, a total of 26 sites were added to the list of Ramsar sites, however, during 2014 to 2022, the country has added 49 new wetlands to the list of Ramsar sites.
 - During this year itself (2022) a total of 28 sites have been declared as Ramsar sites. Based on the date of designation mentioned on Ramsar Certificate, the number is 19 for this year (2022) and 14 for previous year (2021).
 - Tamil Nadu has maximum no. of Ramsar sites (14 nos), followed by UP which has 10 nos. of Ramsar sites.

- The five new Ramsar sites are Karikili Bird Sanctuary, Pallikaranai Marsh Reserve Forest and Pichavaram Mangrove in Tamil Nadu, Sakhya Sagar in Madhya Pradesh and Pala Wetlands in Mizoram.
- Khijadia Wildlife Sanctuary in Gujarat and Bakhira Wildlife Sanctuary in Uttar Pradesh were announced as Ramsar sites (Wetlands of International Importance) on the occasion of World Wetland day 2022 (2nd February 2022) held at Sultanpur National Park, a Ramsar site in Haryana.
- Haiderpur Wetland in Uttar Pradesh has been added as the 47th Ramsar Site in December 2021.
- The site to Refer - <https://pib.gov.in/PressReleasePage.aspx?PRID=1851484>
- India gets its first “Centre for Wetland Conservation and Management (CWCM)
 - Chennai
 - The Centre has been established as a part of the National Centre for Sustainable Coastal Management (NCSCM).
 - This centre comes under the Minister of Environment, Forest, and Climate Change.

4. CRYOSPHERE

- The cryosphere is the part of the Earth's climate system that includes solid precipitation, snow, sea ice, lake and river ice, icebergs, glaciers and ice caps, ice sheets, ice shelves, permafrost, and seasonally frozen ground.
- The term “cryosphere” traces its origins to the Greek word ‘kryos’ for frost or ice cold.



Impact of Climate Change on the Cryosphere

- The Intergovernmental Panel on Climate Change (IPCC) Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) states that “over the last decades, global warming has led to a
 - Widespread shrinking of the cryosphere
 - Mass Balance loss from ice sheets and glaciers
 - Reduction in snow cover

- Arctic sea ice extent and thickness
- Increased permafrost temperatures.

Importance of Cryosphere

- Maintains planet heat balance - High albedo/High surface reflectivity – 70-90% - Reflects the greater amount of incoming solar radiation – mitigates global warming by influencing the amount of heat absorbed by the Ocean and land.
- Maintains the global sea level
- Thermohaline circulations – As the cryosphere melts, a large amount of cold fresh water empties into the sea. It will change the salinity and temperature of the ocean, and affect the global thermohaline circulation and climate change.
- Water Resources for Rivers
- Drinking water for humans.
- Water for Agriculture (Irrigation) and Industries
- Ecosystem and biodiversity preservation – Penguins, polar bears, snow leopards, etc.
- Livelihood for millions - In high mountains and the Arctic, around 700 million people live in close contact with the cryosphere.

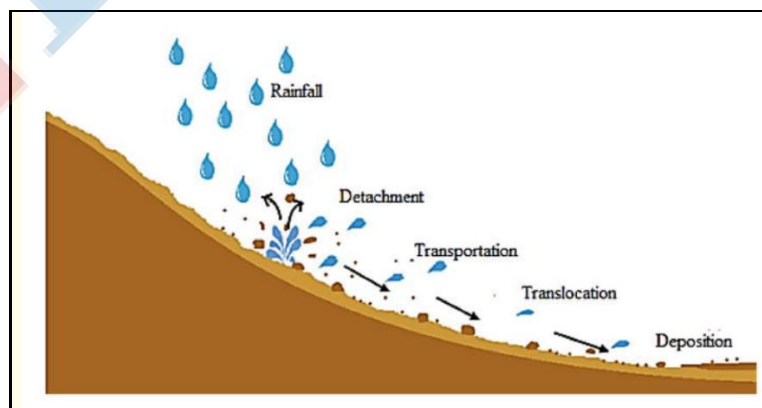
5. DESERTIFICATION

Desertification

Meaning/Definition

- Desertification is not the natural expansion of existing deserts but the degradation of land in
 - Arid
 - Semi-arid
 - Dry sub-humid areas.
- The gradual process of
 - Soil productivity loss – Loss of topsoil
 - Thinning out of the vegetative cover because of:
 - Human activities and Climatic variations such as
 - Prolonged droughts and
 - Floods

Process of Desertification: Removal of the top layer through denudational agents (The process of denudation will take place).



Undertaken Measures:

- International
 - UNCCD – The UNCCD’s goal is a future that avoids, reduces, and reverses desertification to achieve a land degradation-neutral world consistent with the UN’s 2030 Agenda for Sustainable Development.
 - Under the UNCCD, over 100 countries have pledged to reduce and reverse degradation on more than 450 million hectares of land by 2030, of which 250 million hectares is agricultural land.
 - The Great Green Wall – it is an African-led initiative to restore biodiversity, rehabilitate Africa’s degraded landscapes, and transform millions of lives in the Sahel, by restoring 100 million hectares of land.
 - Initiative of GEF
 - 11 countries of Sahel Belt are participants
 - International Drought Resilience Alliance – It was first announced by Spain at the 77th session of the UN General Assembly in September 2022 and was officially launched at the UNFCCC COP27 in November 2022.
 - Changwon Initiative – More than 100 countries participate in the Changwon Initiative, which supports national voluntary target-setting processes to achieve land degradation neutrality (LDN).
 - Bonn Challenge – The Bonn Challenge is a global goal to bring 150 million hectares of degraded and deforested landscapes into restoration by 2020 and 350 million hectares by 2030. Launched by the Government of Germany and IUCN in 2011.
 - International coalition for action on Sand and Dust storms (SDS): The coalition will develop an SDS source base map with the goal of improving monitoring and response to these storms
 - An initiative of Sustainability, Stability and Security (3S): Launched by 14 African countries to address migration driven by land degradation. It aims at restoring land and creating green jobs for migrants and vulnerable groups.
- National:
 - India hosted CoP 14 of UNCCD - Delhi Declaration: Commitment for a range of issues, including gender and health, ecosystem restoration, taking action on climate change, private sector engagement, Peace Forest Initiative and recovery of five million hectares of degraded land in India.
 - The government of India is a signatory to the Bonn Challenge by pledging to restore 13 MHA of degraded land by 2020 and 21 MHA by 2030 in India.
 - To bring 150 million hectares of the world’s deforested and degraded land into restoration by 2020, and 350 million hectares by 2030.
 - The United Nations Convention to Combat Desertification (UNCCD) welcomes a major step taken by India in using the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) to fund work to reverse land degradation in all its states.
 - Pradhan Mantri Fasal Bima Yojana (PMFBY), Soil Health Card Scheme, Soil Health Management Scheme, Pradhan Mantri Krishi Sinchayee Yojna (PKSY), Per Drop More Crop, , etc. which are helping to reduce land degradation.
 - National Action Plan to Combat Desertification
 - National Afforestation Programme

- Desert Development Programme
- National Mission on Green India
- UNCCD CoP 15
 - Recently, the Union Minister for Environment, Forest and Climate Change addressed the fifteenth session of the Conference of the Parties (COP15) of the United Nations Convention to Combat Desertification (UNCCD) in Cote d'Ivoire (Western Africa).
 - Theme: 'Land. Life. Legacy: From scarcity to prosperity'
- UNCCD
 - Established in 1994.
 - It is the sole legally binding international agreement linking environment and development to sustainable land management.
 - It is the only convention stemming from a direct recommendation of the Rio Conference's Agenda 21.
 - Focus areas: The Convention addresses specifically the arid, semi-arid and dry sub-humid areas, known as the drylands, where some of the most vulnerable ecosystems and peoples can be found.
- LDN
 - India is on track to achieve its national commitment to Land Degradation Neutrality (LDN) (Sustainable Development Goal target 15.3).
 - LDN is a state whereby the amount and quality of land resources, necessary to support ecosystem functions and services and enhance food security, remains stable or increases within specified temporal and spatial scales and ecosystems.
 - Working to restore 26 million hectares of degraded land by 2030

CLIMATE CHANGE

What is Climate Change?

- Climate change refers to long-term shifts in temperatures and weather patterns. These shifts may be natural, such as through variations in the solar cycle.
- But since the 1800s, human activities have been the main driver of climate change, primarily due to burning fossil fuels like coal, oil and gas.
- Burning fossil fuels generates greenhouse gas emissions that act like a blanket wrapped around the Earth, trapping the sun's heat and raising temperatures.
- The IPCC's Sixth Assessment report, published in 2021, found that human emissions of heat-trapping gases have already warmed the climate by nearly 2 degrees Fahrenheit (1.1 degrees Celsius) since pre-Industrial times (starting in 1750).
- The last decade (2011-2020) was the warmest on record.
- The consequences of climate change now include, among others, intense droughts, water scarcity, severe fires, rising sea levels, flooding, melting polar ice, catastrophic storms and declining biodiversity.

What is Global Warming?

- It refers to an average increase in the temperature of the atmosphere near the earth's surface and in the troposphere, which can contribute to changes in global climate patterns.
- It can be due to both natural and human-induced factors.

- However, in present times, global warming often refers to the warming caused due to emissions of greenhouse gases from human activities.

Factors affecting Climate Change

Natural Factors

- **Continental drift** had an impact on the climate because it changes the physical features of the landmass, their position and the position of water bodies like changing the flow of ocean currents and winds, which affected the climate.
- **Variation in the earth's orbit**- There are three types of orbital variations namely:
 - Variations in Earth's eccentricity
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Anthropogenic Factors

Anthropogenic factors involve the changes in the energy balance of the Earth - atmosphere system leading to changes in weather and climate.

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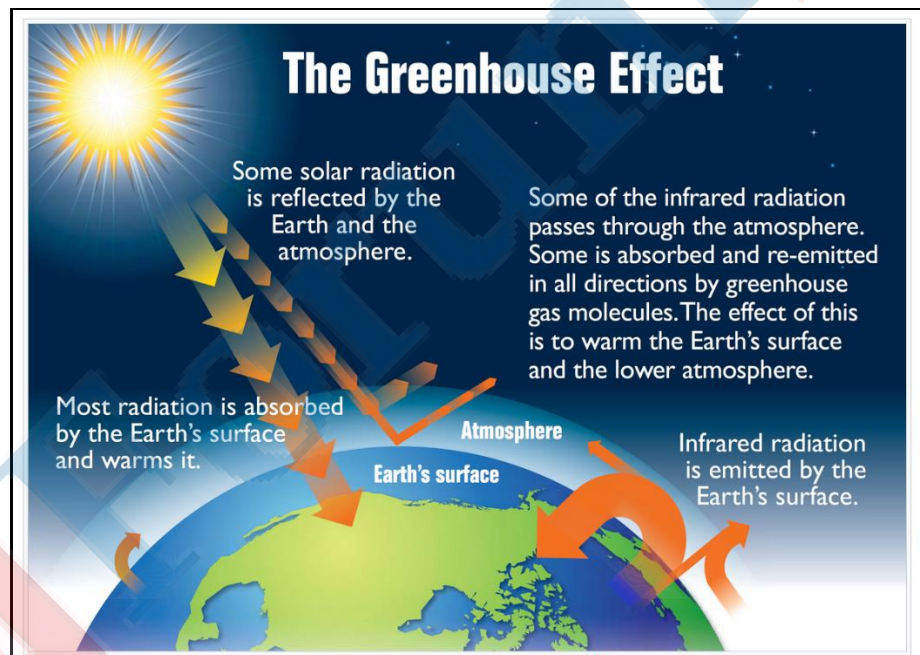
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- Naturally occurring phenomena that blanket the earth's lower atmosphere and warm it and maintain the average temperature for the survival of living beings.



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Greenhouse Gases

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 - Biggest overall contributor

- The amount has increased due to greater evaporation resulting from increased temperature – greater concentration of CO₂
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 - Human activities have altered the carbon cycle in 2 ways:
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 - Wetlands are the largest source due to anaerobic decomposition.
 - 70% comes from paddy fields – Agriculture sector is the primary source of CH₄ emissions.
- Nitrous Oxide (N₂O)
 - Breaking down of nitrogen in the soils – Denitrification
 - Usage of synthetic fertilizers
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 - They have very high Global Warming Potential.
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Climate Forcing's

- These factors in the climate system either increase or decrease the effects on the climate system.
- Positive forcings – warm the earth – Dark aerosols absorb sunlight and warm the atmosphere
- Negative forcings – cool the earth – Light aerosols reflect the incoming solar radiation – cool the atmosphere.

Global Warming Potential

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- It depends on
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- It is a measure of the total energy that a gas absorbs over a particular period of time (usually 100 years) compared to CO₂.

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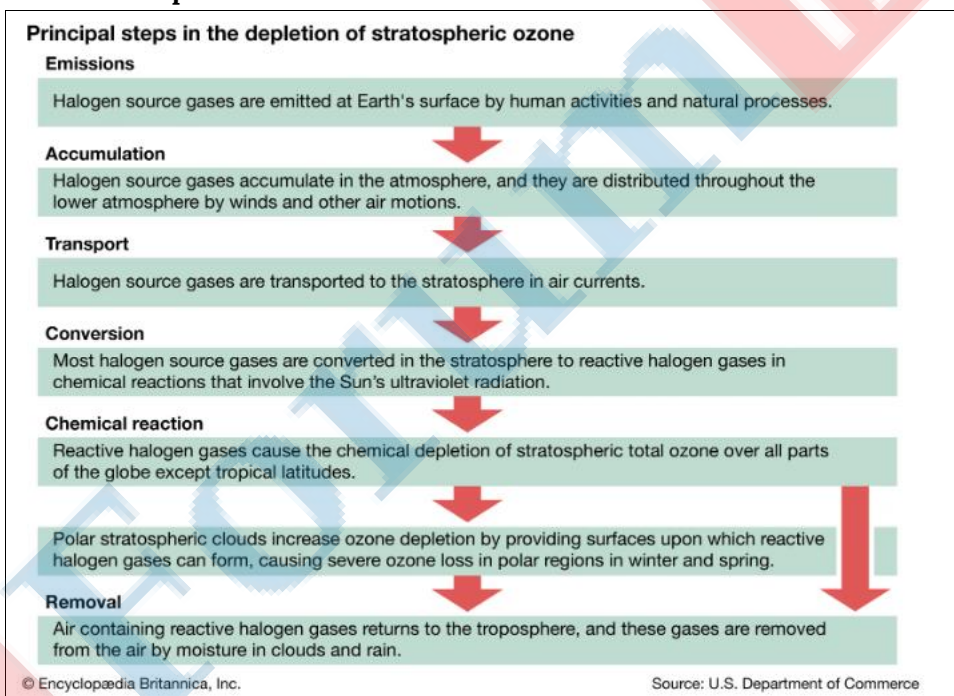
OZONE DEPLETION

- The stratospheric ozone layer is Earth's "sunscreen" – protecting living things from too much ultraviolet radiation from the sun.
- The equilibrium between the formation and destruction of ozone has been upset by the influx of man-made substances.
- As a result, the rate at which ozone is being destroyed is faster than the rate at which it is formed.
- The significant decrease in the concentration of ozone in a particular area of the ozonosphere (15-35 km) in the stratosphere is called Ozone Depletion.
- Ozone layer depletion is the gradual thinning of the earth's ozone layer present in the upper atmosphere.
- Ozone depletion also consists of a much larger springtime decrease in stratospheric ozone around Earth's Polar Regions, which is referred to as the ozone hole.
- Example: ozone hole over Antarctica.

Sources of Ozone Depletion

- Chlorofluorocarbons (CFCs), HCFCs
 - The main cause of ozone depletion and the ozone hole is manufactured chemicals, especially manufactured halocarbon refrigerants, solvents, propellants, and foam-blowing agents.
- Nitrogen oxides
 - N₂O is photolytically destroyed to yield nitric oxide (NO) which in turn destroys Ozone.
- Bromine-containing compounds – Halons and HBFCs.
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- Carbon tetrachloride (CCl₄) and Methyl Chloroform (CH₃CCl₃) – adhesives, solvents for cleaning clothes, etc.
- ODS substances have a lifetime of about 100 years.

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- Role of Polar Stratospheric Clouds in ozone depletion
 - Types of clouds
 - Nacreous clouds or mother of pearl clouds due to their glow
 - Clouds containing nitric acid instead of pure water

- The ice particles of the clouds provide substrates for chemical reactions which free chlorine from its reservoirs.
- Over the substrate, the reaction occurs at a faster pace.
 - $\text{HCl} + \text{ClNO}_3 \rightarrow \text{Free chlorine} + \text{Nitric Acid}$.

Why is Ozone Depletion prominent over Antarctica?

- Low Polar Temperature - The winter temperatures are low enough for PSCs to form somewhere in the Antarctic for nearly the entire winter (about 5 months) and in the Arctic for only limited periods (10–60 days) in most winters
- Longevity of the Antarctica polar vortex - it remains throughout the year - favourable condition for the formation of PSCs.
- Isolated conditions - The polar vortex at the poles are isolated due to fast-moving air in the vortex - This circulation strengthens in winter as stratospheric temperatures decrease, with the result that the isolation of air in the vortex is much more effective in the Antarctic than the Arctic.
- Polar Stratospheric Clouds - With a temperature threshold of -78°C , PSCs exist in larger regions and for longer time periods in the Antarctic than in the Arctic.
- June - Temperature falls and vortex strengthens
- July and August - Hydrochloric acid and chlorine nitrate react on cloud surfaces to free chlorine and winter temperatures drop to their lowest point.
- September - Spring - Sunlight returns and the reaction to destroy ozone begins.
- During October lowest levels of ozone are reached.

Impact of Ozone Depletion

- Effect on animal and human health
 - Decreases the immune response to skin cancer
 - Damage cornea and lens of the eye
- Effect on terrestrial plants
 - The developmental processes of plants are affected
- Effect on aquatic ecosystem
 - High mortality in phytoplankton, coral reefs, etc.
 - Decreased productive capacity
 - Cause damage to the early development of fish.
- Effect on bio-geochemical cycles - An increase in UV radiation may change the carbon cycle by altering the sources and sinks of carbon dioxide.
- Effect on air quality - UV-B radiation penetrating into the lower atmosphere results in higher photodissociation of trace gases such as CO_2 , CH_4 , etc.

Measures

1. Montreal protocol to Vienna Convention
 - a. The Montreal Protocol on Substances that Deplete the Ozone Layer is the landmark multilateral environmental agreement that regulates the production and consumption of nearly 100 man-made chemicals referred to as ozone-depleting substances (ODS).
 - b. Under this treaty, all parties have specific responsibilities related to the phase-out of the different groups of ODS, control of ODS trade, annual reporting of data, national licensing systems to control ODS imports and exports, and other matters.

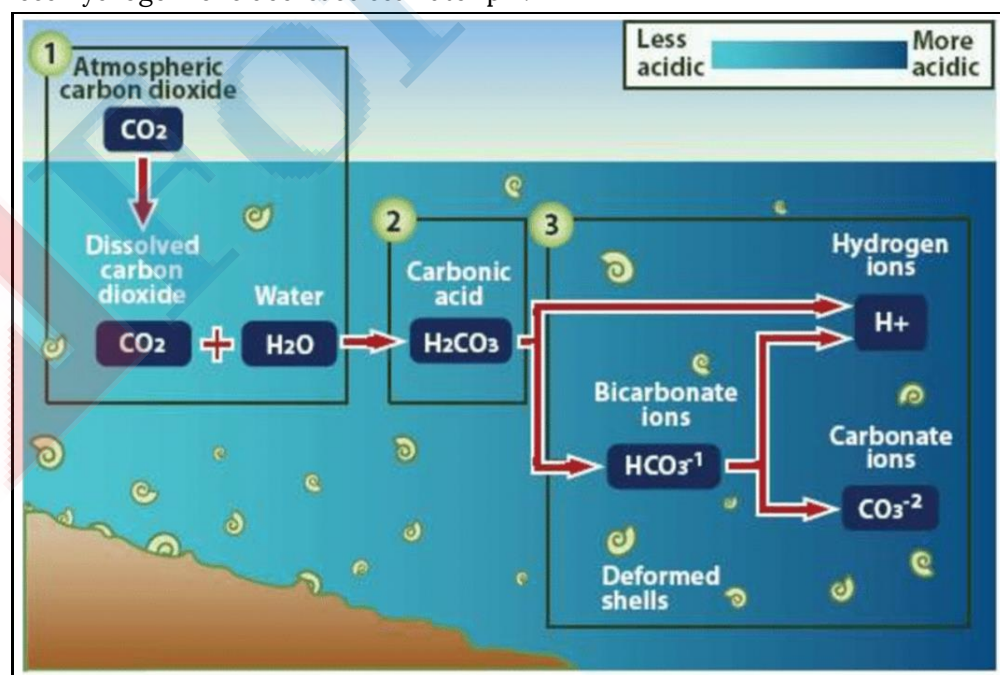
- c. The Parties are assisted by the Ozone Secretariat, which is based at UN Environment Programme headquarters in Nairobi, Kenya.
2. Kigali Agreement
 - a. Under the Kigali Amendment; Parties to the Montreal Protocol will phase down production and consumption of Hydrofluorocarbons, commonly known as HFCs.
 - b. Hydrofluorocarbons were introduced as non-ozone depleting alternative to Hydrofluorocarbons (HFCs). While HFCs do not deplete the stratospheric ozone layer, they have high global warming potential ranging from 12 to 14,000, which have adverse impact on climate.
 - c. Recognizing the growth in the use of HFCs, especially in Refrigeration and Air-conditioning sector the Parties to the Montreal Protocol, reached agreement at their 28th Meeting of the Parties (MOP) held in October 2016 in Kigali, Rwanda to add HFCs to the list of controlled substances and approved a timeline for their gradual reduction by 80-85 per cent by the late 2040s.
 - d. India will complete its phase-down of HFCs in 4 steps from 2032 onwards with a cumulative reduction of 10% in 2032, 20% in 2037, 30% in 2042 and 85% in 2047.

Ocean Acidification

- It is the change in ocean chemistry.
- Lowering of Ocean pH – Increase in concentration of Hydrogen ions.
- It is driven by the uptake of carbon compounds by the ocean from the atmosphere.

Mechanism of Ocean Acidification

- Ocean acidification occurs when carbon dioxide (CO₂) is absorbed rapidly into the ocean.
- It reacts with water molecules (H₂O) to form carbonic acid (H₂CO₃).
- This compound then breaks down into a hydrogen ion (H⁺) and bicarbonate (HCO₃⁻).
- These hydrogen ions decrease seawater pH.



Reasons for Ocean Acidification

- Increase in concentration of CO₂ in the atmosphere due to factors such as
 - Burning of fossil fuels
 - Emissions from industries and thermal power plants
 - Stubble burning
 - Deforestation – Jhum cultivation and felling of rainforest for agriculture.
- Acid Rain – pH between 1 and 6
- Eutrophication – Respiration of bacteria decomposing the algae leads to a decrease in the seawater oxygen and an increase in CO₂.
- Melting of glaciers – greenhouse gases entrapped within them are released into the atmosphere.

Impacts of Ocean Acidification

- Loss of biodiversity
 - The narrow range of tolerance of marine organisms – Shelford's Law – Coral Reefs
 - The calcification process among marine organisms decreases – Carbonate ions are important for calcification – to build their calcium carbonate shells – coral polyps, molluscs, crustaceans, sea urchins, lobsters, etc.
- Loss of food supply to humans –
 - Coral reefs are home to the nursery of many fishes.
 - In places like the Pacific Coast of the United States, warming waters and ocean acidification are expected to reduce the Dungeness crab populations, the highest-revenue fishery in Oregon and Washington.
- Saturation Horizon to rise vertically in the water column.
 - Upper layers – unsaturated
 - Lower layers – saturated
 - The vertical rise will expose more organisms to under-saturated water and make them vulnerable to the dissolution of their shells.
 - Calcite – less soluble – saturation horizon occurs at greater depth than aragonite – more soluble.
- More incidences of coastal erosion – coral reefs protect shorelines
- Tourism will get hampered.
- Loss of livelihoods for fishermen.

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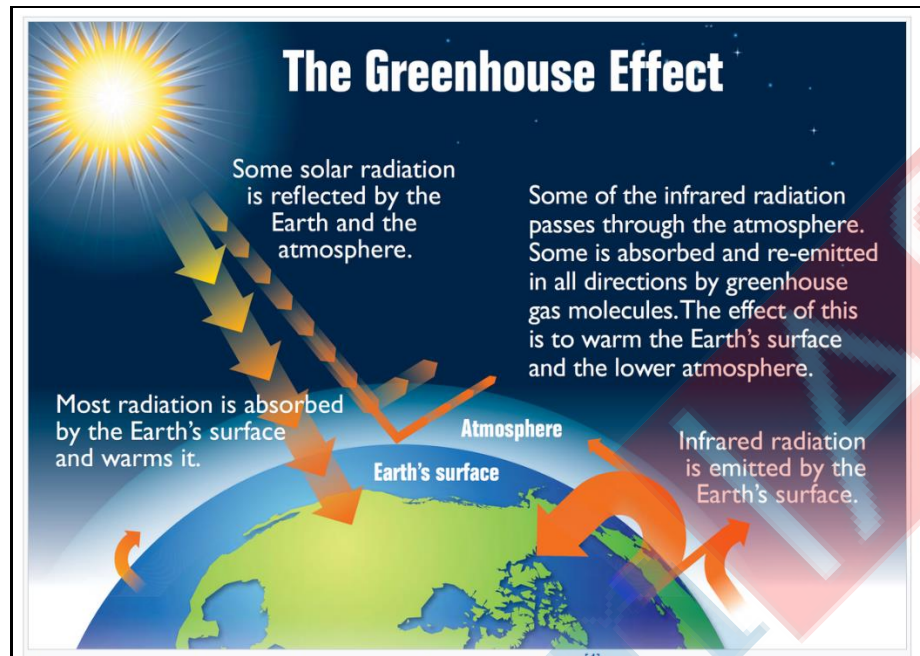
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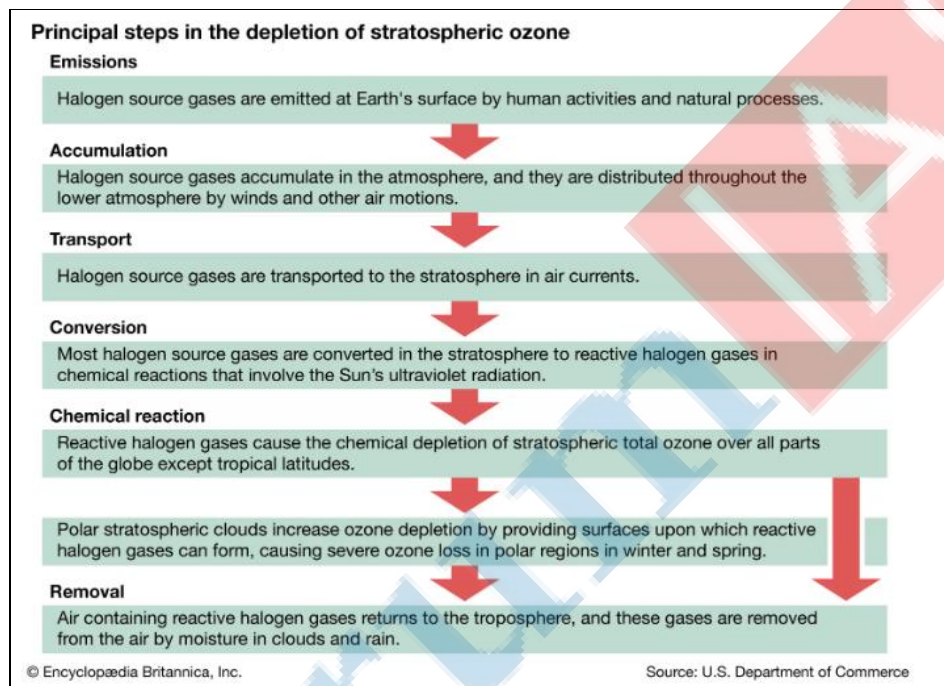
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CLIMATE CHANGE

- Longevity of the Antarctica polar vortex – it remains throughout the year – favourable condition for the formation of PSCs.
- Isolated conditions – The polar vortex at the poles are isolated due to fast-moving air in the vortex – This circulation strengthens in winter as stratospheric temperatures decrease, with the result that the isolation of air in the vortex is much more effective in the Antarctic than the Arctic.
- Polar Stratospheric Clouds – With a temperature threshold of -78°C , PSCs exist in larger regions and for longer time periods in the Antarctic than in the Arctic.
- June – Temperature falls and vortex strengthens
- July and August – Hydrochloric acid and chlorine nitrate react on cloud surfaces to free chlorine and winter temperatures drop to their lowest point.
- September – Spring – Sunlight returns and the reaction to destroy ozone begins.
- During October lowest levels of ozone are reached.

Impact of Ozone Depletion

- Effect on animal and human health
 - Decreases the immune response to skin cancer
 - Damage cornea and lens of the eye
- Effect on terrestrial plants
 - The developmental processes of plants are affected
- Effect on aquatic ecosystem
 - High mortality in phytoplankton, coral reefs, etc.
 - Decreased productive capacity
 - Cause damage to the early development of fish.
- Effect on bio-geochemical cycles – An increase in UV radiation may change the carbon cycle by altering the sources and sinks of carbon dioxide.
- Effect on air quality – UV-B radiation penetrating into the lower atmosphere results in higher photodissociation of trace gases such as CO_2 , CH_4 , etc.

Measures

1. Montreal protocol to Vienna Convention
 - a. The Montreal Protocol on Substances that Deplete the Ozone Layer is the landmark multilateral environmental agreement that regulates the production and consumption of nearly 100 man-made chemicals referred to as ozone-depleting substances (ODS).
 - b. Under this treaty, all parties have specific responsibilities related to the phase-out of the different groups of ODS, control of ODS trade, annual reporting of data, national licensing systems to control ODS imports and exports, and other matters.
 - c. The Parties are assisted by the Ozone Secretariat, which is based at UN Environment Programme headquarters in Nairobi, Kenya.
2. Kigali Agreement
 - a. Under the Kigali Amendment; Parties to the Montreal Protocol will phase down the production and consumption of Hydrofluorocarbons, commonly known as HFCs.

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- b. Hydrofluorocarbons were introduced as non-ozone depleting alternative to Chlorofluorocarbons (CFCs). While HFCs do not deplete the stratospheric ozone layer, they have a high global warming potential ranging from 12 to 14,000, which has adverse impact on climate.
- c. Recognizing the growth in the use of HFCs, especially in the Refrigeration and Air-conditioning sector the Parties to the Montreal Protocol, reached an agreement at their 28th Meeting of the Parties (MOP) held in October 2016 in Kigali, Rwanda to add HFCs to the list of controlled substances and approved a timeline for their gradual reduction by 80-85 per cent by the late 2040s.
- d. India will complete its phase-down of HFCs in 4 steps from 2032 onwards with a cumulative reduction of 10% in 2032, 20% in 2037, 30% in 2042 and 85% in 2047.

Vienna Convention and Montreal Protocol

- The Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer are international treaties for the protection of the Ozone layer.
- India became Party to the Vienna Convention and the Montreal Protocol on 18th March, 1991 and 19th June 1992 respectively.
- The Montreal Protocol has been recognized as the most successful international environmental treaty in history.
- It has been universally ratified and all 197 countries of the world are Parties to the Vienna Convention and its Montreal Protocol.

India

- India has successfully achieved the complete phase-out of Hydrochlorofluorocarbon (HCFC)-141 b, which is a chemical used by foam manufacturing enterprises and one of the most potent ozone-depleting chemicals after Chlorofluorocarbons (CFCs).
- (HCFC)-141 b is used mainly as a blowing agent in the production of rigid polyurethane (PU) foams.
- Ozone Depleting Substances (Regulation and Control) Amendment Rules, 2019 are issued under the Environment (Protection) Act, 1986.
- HCFC-141b is not produced in the country and all the domestic requirements are met through imports.
- With this notification, prohibiting the import of HCFC-141 b, the country has completely phased out the important ozone-depleting chemicals.
- Nearly, 50 % of the consumption of ozone-depleting chemicals in the country was attributable to HCFC-141 b in the foam sector.
- The Ministry of EF&CC has set up an Ozone Cell as a National Ozone Unit (NOU) to render necessary services for the effective and timely implementation of the Montreal Protocol and its ODS phase-out program in India.

Ocean Acidification

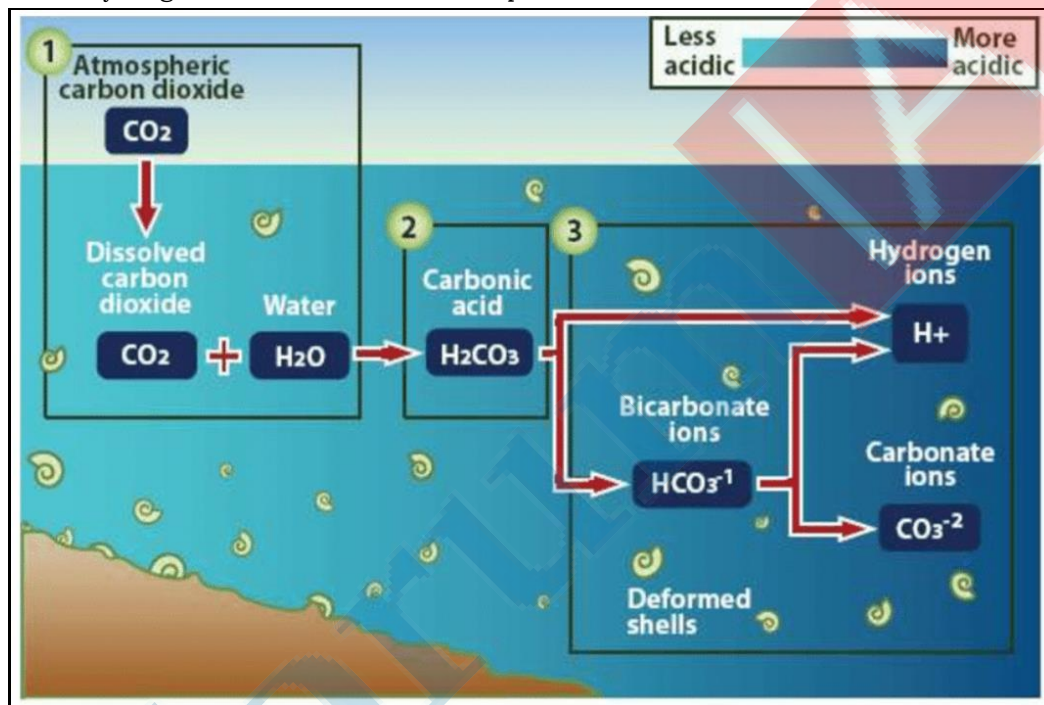
- It is the change in ocean chemistry.

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- Lowering of Ocean pH – Increase in concentration of Hydrogen ions.
- It is driven by the uptake of carbon compounds by the ocean from the atmosphere.

Mechanism of Ocean Acidification

- Ocean acidification occurs when carbon dioxide (CO₂) is absorbed rapidly into the ocean.
- It reacts with water molecules (H₂O) to form carbonic acid (H₂CO₃).
- This compound then breaks down into a hydrogen ion (H⁺) and bicarbonate (HCO₃⁻).
- These hydrogen ions decrease seawater pH.



Reasons for Ocean Acidification

- Increase in concentration of CO₂ in the atmosphere due to factors such as
 - Burning of fossil fuels
 - Emissions from industries and thermal power plants
 - Stubble burning
 - Deforestation – Jhum cultivation and felling of rainforest for agriculture.
- Acid Rain – pH between 1 and 6
- Eutrophication – Respiration of bacteria decomposing the algae leads to a decrease in the seawater oxygen and an increase in CO₂.
- Melting of glaciers – greenhouse gases entrapped within them are released into the atmosphere.

Impacts of Ocean Acidification

- Loss of biodiversity
 - The narrow range of tolerance of marine organisms – Shelford's Law – Coral Reefs

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- The calcification process among marine organisms decreases – Carbonate ions are important for calcification – to build their calcium carbonate shells – coral polyps, molluscs, crustaceans, sea urchins, lobsters, etc.
- Loss of food supply to humans –
 - Coral reefs are home to the nursery of many fishes.
 - In places like the Pacific Coast of the United States, warming waters and ocean acidification are expected to reduce the Dungeness crab populations, the highest-revenue fishery in Oregon and Washington.
- Saturation Horizon to rise vertically in the water column.
 - Upper layers – saturated
 - Lower layers – unsaturated
 - The vertical rise will expose more organisms to under-saturated water and make them vulnerable to the dissolution of their shells.
 - Calcite – less soluble – saturation horizon occurs at greater depth than aragonite – more soluble.
- More incidences of coastal erosion – coral reefs protect shorelines
- Tourism will get hampered.
- Loss of livelihoods for fishermen.

Mitigation Strategies

- Carbon Sequestration
 - Ocean sequestration
 - Carbon fertilization
 - Geologic Sequestration
 - Hydrodynamic Trapping – trapped as gas
 - Solubility trapping – trapped as liquid
 - Mineral carbonation – CO_2 reacts with minerals to form stable compounds
 - Terrestrial sequestration
 - Soils and vegetation.
- Carbon Sink
 - Green Carbon
 - Removed by photosynthesis and stored in the plants and soil of natural ecosystems.
 - Blue Carbon
 - Coastal, aquatic and marine carbon sinks
 - Coastal ecology such as – tidal marshes, mangroves and seagrasses
 - These ecosystems are found in all continents except Antarctica.
 - Blue Carbon Initiative
 - First integrated programme – focusses on mitigating climate change through conservation and restoration of coastal marine ecosystems.
 - Conservation International (CI) + IUCN + Intergovernmental Oceanic Commission (IOC-UNESCO)
 - Develop blue carbon accounting methods

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- Develop carbon payment schemes for Blue Carbon Projects.
- Carbon Credit
 - Tradeable certificate or permit representing the right to emit one tonne of carbon or CO₂ equivalent.
 - Countries signatories to Kyoto Protocol under the UNFCCC – two ways to meet the targets
 - Adoption of new technology or improvement in the new technology
 - Collaboration with developing countries and help them establish eco-friendly new technologies – credit becomes the permit for the company to emit GHGs.
 - China is currently the largest seller of carbon credits.
- Carbon Offsetting
 - These are credits for reductions in GHGs
 - Carbon offsets are quantified and sold in metric tonnes of carbon dioxide equivalent.
 - Example
- Carbon Tax
 - Tax is based on the carbon content in the fuel
 - Aim is to reduce the usage of fossil fuel
 - India – Initially clean energy cess was there but after GST, it was abolished and GST compensation cess has taken the place.
 - INR 400 per tonne.
 - National Clean Energy and Environment Fund
 - The National Clean Energy Fund (NCEF) is a fund created in 2010-11.
 - The Fund has been created out of cess on coal produced / imported under the “polluter pays” principle.
 - For funding research and innovative projects in clean energy technologies of public sector or private sector entities, up to the extent of 40% of the total project cost.
 - The Fund is designed as a non-lapsable fund under Public Accounts and with its secretariat in Department of Expenditure, Ministry of Finance.
 - An Inter-Ministerial Group, chaired by the Finance Secretary in Ministry of Finance recommends projects eligible for funding under NCEF.
- Geo-Engineering
 - Copying a volcano
 - Shoot mirrors into space
 - Seed the sea with iron (Carbon fertilization)
 - Whitening of clouds
 - Thinning of cirrus clouds

Climate Change Organizations

- Un Summit Conference on Environment and Development (UNCED) – Rio De Janeiro in 1992 – adopted by consensus the first multilateral legal instrument on climate change – UNFCCC
- 195 countries are parties to it.
- Legally binding.

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Conference of Parties

- CoP 3 – Kyoto Protocol
 - Adopted in 1997
 - Came into force in 2005
 - It only binds developed countries
 - Places heavier burden on developed countries under the principle – Common but differentiated Responsibilities.
 - The Protocol applied to 6 greenhouse gases:
 - carbon dioxide
 - methane
 - nitrous oxide
 - hydrofluorocarbons
 - perfluorocarbons
 - Sulfur hexafluoride.
 - In its Annex B, the Kyoto Protocol sets binding emission reduction targets for 37 industrialized countries and economies in transition and the European Union.
 - After becoming a signatory in 2013, Afghanistan became the 192nd and last signatory of the Kyoto Protocol. As of 2022, there remain 192 signatories.
 - In Doha, Qatar, on 8 December 2012, the Doha Amendment to the Kyoto Protocol was adopted for a second commitment period, starting in 2013 and lasting until 2020.
 - Annexes of Kyoto Protocol
 - Annex I Countries – (Developed Nations and Nations with Economies in Transition (EIT))
 - Annex II countries – Developed countries that provide financial and technical support to the economies in transition and developing countries.
 - Annex B countries – The first-round targets apply over the years 2008–2012 and the second-round Kyoto targets, which apply from 2013–2020. Compulsory binding targets to reduce GHG emissions.
 - Non-Annex I countries – Developing countries with non-binding agreements.
 - Kyoto Mechanisms
 - Joint Implementation
 - Develop – Develop
 - Countries in Annex B could collaborate with another country in Annex B for reduction.
 - Clean Development Mechanism
 - Annex B Party to implement an emission reduction project in developing countries.
 - Develop-Developing
 - Emission Trading
 - Emission Trading – A country/company is assigned fixed amount of carbon emissions – if emits less than permitted emissions – it earns carbon credits which it can sell to the companies which are unable to reduce their emissions.

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- Offset Trading – Carbon credits are earned when some emissions are reduced by implementing carbon projects. Example – Wind power project
- Adaptation Fund
 - The Adaptation Fund (AF) was established in 2001 to finance concrete adaptation projects and programmes in developing country Parties to the Kyoto Protocol that are particularly vulnerable to the adverse effects of climate change.
 - The Fund is financed in part by government and private donors, and also from a two percent share of proceeds of Certified Emission Reductions (CERs) issued under the Protocol's Clean Development Mechanism projects.
 - The Fund is supervised and managed by the Adaptation Fund Board (AFB).
 - The AFB is composed of 16 members and 16 alternates and meets at least twice a year.
 - The World Bank serves as trustee of the Adaptation Fund on an interim basis.
 - Global Environment Facility provides Secretariat.
- Green Climate Fund
 - Mooted in CoP 15 - Copenhagen Accord (2009) but was established in CoP 16 - 2010 at Cancun Summit.
 - Equal focus on adaptation and mitigation
 - Independent Secretariat at Songdo, South Korea
 - At CoP 21, GCF decided that it will mobilise \$100 billion under Paris Agreement.
- CoP 17 – Durban Summit
 - Green Climate Fund launched.
- CoP 18 – Doha Outcomes(2012)
 - 8 year second commitment period was finalized from 2013-2020.
- CoP 20 – LIMA outcomes (2014)
 - Lima Ministerial Declaration on Education and Awareness
 - Lima Adaptation Knowledge Initiative.
 - Peru launched Nazca Climate Action Portal with support from UNFCCC
 - Lima Work Programme on gender was launched.
 - NAMA – Nationally appropriate mitigation actions (NAMAs)
 - UNFCCC Secretariat – Momentum for Change Initiative – Awards are presented for the best examples.
- CoP 21 – Paris Agreement (2015)
 - It is a legally binding international treaty on climate change.
 - It was adopted by 196 countries at the Conference of the Parties COP 21 in Paris in December 2015.
 - Goal: To limit global warming to well below 2° Celsius, and preferably limit it to 1.5° Celsius, compared to pre-industrial levels.
 - In their NDCs, countries communicate actions they will take to reduce their greenhouse gas emissions in order to reach the goals of the Paris Agreement.
 - To better frame the efforts towards the long-term goal, the Paris Agreement invites countries to formulate and submit **long-term low greenhouse gas emission development strategies (LT-LEDS)**.

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- With the Paris Agreement, countries established an **enhanced transparency framework (ETF)**. Under ETF, starting in 2024, countries will report transparently on actions taken and progress in climate change mitigation, adaptation measures and support provided or received.
- Mission Innovation - Mission Innovation is a global initiative to accelerate public and private clean energy innovation to address climate change, make clean energy affordable to consumers, and create green jobs and commercial opportunities
 - India is a member.
 - An initiative of the United Nations.
- CoP 22 – Marrakesh
 - 2050 Pathway Platform – Long Term Goals.
 - Climate Vulnerable Forum
 - It is an international partnership of countries highly vulnerable to a warming planet.
 - The Forum serves as a South-South cooperation platform for participating governments to act together to deal with global climate change.
 - The Marrakech Communique decided to support CVF.
 - Triple A Initiative – Adaptation for African Agriculture.
- CoP 23 – Bonn (Presidency Fiji)
 - Koronivia Joint Work on Agriculture was established.
 - Powering Past Coal Alliance was established
 - Launched by the UK and Canada
 - To advance the transition from coal power across the world.
 - Launch of Talanoa Dialogue, a process designed to assist nations in the implementation of their Nationally Determined Contributions by 2020.
- CoP 24 – Katowice Rulebook (Poland)
 - COP24 aimed to bring a set of rules to implement the Paris Agreement.
 - It is a rulebook that enables the implementation of 29 articles of the Paris Agreement
- CoP 25 – Madrid (Spain)
 - Corporate Climate Movement – 177 companies at COP25 pledged to cut emissions in line with the 1.5C target as part of the Climate Ambition Alliance.
 - Global Carbon Project Report - The Global Carbon Project is a Global Research Project of Future Earth and a research partner of the World Climate Research Programme.
 - Reiteration of the Paris Ratchet Mechanism, also known as the Paris Ambition Mechanism ensures that member nations reflect and progress their NDCs by raising ambitions to fight climate change over time.
- CoP 26 – Glasgow
 - India revised its INDC targets
 - To reduce Emissions Intensity of its GDP by 45 percent by 2030, from 2005 level
 - To achieve about 5 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030.

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- To create an additional carbon sink of 2.5 to 3 billion tonnes of CO₂ equivalent through additional forest and tree cover by 2030.
 - India has launched the Infrastructure for Resilient Island States (IRIS) initiative for developing the infrastructure of small island nations.
 - The IRIS is a part of the Coalition for Disaster Resilient Infrastructure (CDRI) initiative.
 - One Sun, One World, One Grid:
 - The new Global Green Grids Initiative One Sun One World One Grid (GGI-OSOWOG) has been announced at the ongoing COP26.
 - The new GGI-OSOWOG is an evolution of the International Solar Alliance's OSOWOG multilateral drive to foster interconnected solar energy infrastructure at a global scale.
 - India will achieve net-zero emissions latest by 2070.
 - India plans to generate 500 GW of renewable energy by 2030. This marks a 50 GW increase from its current target of 450 GW.
- CoP 27 – Sharm El Sheikh Declaration
 - The United Nations Climate Change Conference COP27 signed an agreement to provide "loss and damage" funding to vulnerable countries.
 - A new five-year work program was launched to promote climate technology solutions in developing countries.
 - Sharm-El-Sheikh Adaptation Agenda:
 - It outlines 30 Adaptation Outcomes to enhance resilience for 4 billion people living in the most climate-vulnerable communities by 2030.
 - Action on Water Adaptation and Resilience Initiative (AWARE):
 - It has been launched to reflect the importance of water as both a key climate change problem and a potential solution.
 - African Carbon Market Initiative (ACMI):
 - It was launched to support the growth of carbon credit production and create jobs in Africa.
 - The Global Renewables Alliance:
 - It brings together, for the first time, all the technologies required for the energy transition in order to ensure an accelerated energy transition.

Funds and Mechanisms under UNFCCC

- Special Climate Change Fund
 - Established in 2001
 - GEF is an operating entity.
 - Adaptation, technology transfer and capacity building
- REDD and REDD+
 - Reducing emissions from deforestation and forest degradation
 - REDD+ goes beyond merely checking deforestation and includes incentives for conservation, sustainable management and enhancement of forest carbon stocks.
 - Countries receive funds.

CLIMATE CHANGE

- Global Environment Facility
 - It is an independently operating financial organization
 - GEF is multilateral financial mechanism that provides grants to developing countries for projects that benefit global environment and promote sustainable livelihoods in local communities.
 - It was set up as a fund under World Bank in 1991
 - In 1992, at the Rio Earth Summit, the GEF was restructured and moved out of the World Bank system to become a permanent, separate institution.
 - Since 1994, however, the World Bank has served as the Trustee of the GEF Trust Fund.
 - It is based in Washington DC, United States.
 - It addresses six designated focal areas:
 - biodiversity,
 - climate change,
 - international waters,
 - ozone depletion,
 - land degradation and
 - Persistent Organic Pollutants.
 - GEF serves as a financial mechanism for :
 - Convention on Biological Diversity (CBD)
 - United Nations Framework Convention on Climate Change (UNFCCC)
 - UN Convention to Combat Desertification (UNCCD)
 - Stockholm Convention on Persistent Organic Pollutants (POPs)
 - Minamata Convention on Mercury
 - India is both donor and recipient of GEF.
- Intergovernmental Panel on Climate Change (IPCC)
 - Established by UNEP and WMO
 - Open to all members of the UNs
 - They do not conduct any research rather they assess the reports published worldwide and provide feedback.
- National Green House Gas Inventories Programme (NGGIP)
 - Established by IPCC
 - To provide methods for estimating national inventories of greenhouse gas emissions.
- The Economics of Ecosystems and Biodiversity (TEEB)
 - Launched by Germany and the European Commission
 - International initiative to draw attention to the global economic benefits of biodiversity.
 - TEEB India Initiative
 - Being implemented under the Indo-German Biodiversity Programme.
 - It focusses on
 - Forests
 - Inland waters
 - Coastal and Marine mangroves

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- Ecological footprint
 - The measure of human demand on the earth's ecosystem.
 - Carbon footprint – Amount of carbon being emitted
 - The carbon footprint is 54% of the ecological footprint.
 - Global Footprint Network (GFN)
 - Earth Overshoot Report – The day we bust our ecological footprint.

Global Climate Finance Architecture

- Strategic Climate Fund
 - WB
 - Adaptation and Mitigation
 - Since 2008
- Forest Investment Programme
 - WB
 - Area of focus – mitigation – REDD+
 - It is a targeted programme of the Strategic Climate Fund.
- BioCarbon Fund
 - WB
 - Adaptation and Mitigation
 - Since 2004
 - BioCarbon Fund Initiative for Sustainable Forest Landscapes - Support countries to reduce emissions
- Clean Technology Fund
 - WB
 - India is a member
 - Mitigation
- Forest Carbon Partnership Facility
 - WB
 - Mitigation – REDD+
 - It consists of a Readiness Fund and Carbon Fund.
 - To assist developing countries to manage REDD+
- Special Climate Change Fund (Under UNFCCC)
 - Established in 2001
 - To address the specific needs of developing countries.
 - Supports technology transfer.
- Strategic Priority on Adaptation
 - Global Environment Facility
 - Adaptation
- Least Developed Countries Fund
 - Administered by GEF
 - Adaptation
 - Since 2002
 - Preparation and implementation of NAPA's (National Adaptation programs of Actions)

CLIMATE CHANGE

- Global Climate Change Alliance
 - Administered by the European Commission.
 - Adaptation and Mitigation
 - Since 2008
 - To fight climate change.
- Greenhouse Gas Protocol
 - It establishes comprehensive global standardized frameworks to measure and manage greenhouse gas emissions from private and public sector operations.
 - It is a partnership between
 - World Resource Institute (NGO – 1982, based in India)
 - World Business Council for Sustainable Development.

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Biodiversity

- It is the variety of life on Earth. It includes all organisms, species and populations, the genetic variations and the complex assemblage of communities and ecosystems.
- Levels of Biodiversity
 - Genetic Diversity – Variation in genes within a particular species
 - Species Diversity – Variety of living organisms on earth
 - One species population/Total number of organisms
 - 0 = Infinite diversity
 - 1 = Only one species present
 - Ecosystem Diversity – Different types of habitats
- Measurement of Biodiversity
 - Species Richness – Measure of the number of species
 - Alpha diversity – Diversity within a particular ecosystem
 - Beta diversity – Comparison of diversity of species between ecosystems
 - Gamma diversity – Comparison of overall diversity between ecosystems
 - Species Evenness – Measures the proportion of species at a given site.
 - Low evenness indicates few species dominate
- Modes of Conservation
 - Ex-Situ – Conserving biodiversity outside the areas where they naturally occur
 - Zoological Parks
 - Botanical Gardens
 - In-Situ – Conserving the animals and plants in their natural habitats
 - National Parks
 - Sanctuaries
 - Biosphere Reserves
 - Reserved Forests
 - Protected Forests
- Red Data Book
 - Published by IUCN
 - Pink Pages – Critically endangered species
 - Green Pages – Species that were formally endangered.
- IUCN Classification of Conservation Purity
 - Extinct – The last individual has died.
 - Extinct in the wild – Only known to survive in captivity
 - Critically Endangered
 - Reduction in population >90% over the last 10 years
 - Population size < 50
 - The probability of extinction in wild is at least 50% in the coming 10 years
 - Endangered
 - Reduction in population – 70% in last 10 years
 - The population size of fewer than 250 individuals
 - The probability of extinction in wild – at least 20% within 20 years
 - Vulnerable
 - Reduction in population - >50% over the last 10 years
 - The population size of fewer than 10,000 individuals
 - The probability of extinction in wild is at least 10% within 100 years.

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Indian Biodiversity

- Mega-diverse country
 - Mega-diverse countries are all the countries on our planet that house a large number of endemic species.
 - The World Conservation Monitoring Centre (WCMC) of the United Nations Environment Program has identified a total of 17 mega-diverse countries.
- The conjunction of two bio-geographical realms
 - Palearctic realm
 - Indo-Malayan realm
- Biodiversity Hotspots
 - Coined by Norman Myers
 - Conservation International (Non-Profit Organization) – protect these incredible places.
 - Around the world, 36 areas qualify as hotspots.
 - To qualify as a biodiversity hotspot, a region must meet two strict criteria:
 - It must have at least 1,500 vascular plants as endemics
 - It must have 30% or less of its original natural vegetation. In other words, it must be threatened.
 - Conservation International is an investor in the Critical Ecosystem Partnership Fund.
 - CEPF is an alliance of leading conservation donors that provides grants to nonprofit and private-sector organizations that are working to protect biodiversity hotspots and improve human well-being.
- FAUNA
 - Vertebrates
 - Backbones and spinal cords
 - Fishes – Cold-blooded, lay eggs, use gills and not lungs, etc.
 - Amphibians – Cold-blooded, webbed feet, breathe with lungs, lay eggs, etc.
 - Reptiles – Cold-blooded, dry skin, etc.
 - Aves – warm-blooded, lay eggs
 - Mammals – warm-blooded, etc.
 - Egg-laying monotremes – Echidna, Platypus, etc.
 - Marsupials
 - Placentals.
 - Invertebrates
 - More than 98% of animal species are invertebrates.
 - Don't have an internal skeleton made up of bones.
 - Annelids – Divided into segments, well-developed internal organs, don't have any limbs – earthworms, leeches, etc.
 - Molluscs – Hard outside shell – snail, oyster, octopus
 - Echinoderms – Marine animals that live in oceans have arms that radiate from the centre of the body – sea stars, sea urchins, etc.
 - Protozoa – single-celled animals, the smallest of all the animals, they breathe and reproduce – amoebas, flagellates
 - Arthropods – Have limbs with joints, and also have an exoskeleton
 - Crustaceans – Hard external shell – crab, lobster

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- Insects – consist of three body parts – beetle, butterfly, moth, dragonfly, etc.
- Arachnids – Do not have antennae – spiders, scorpions, ticks and mites.
- Floral Diversity
 - India has 11% of the world's known floral diversity
 - Algae – Green non-differentiated plants that possess chlorophyll – manufacture their own food.
 - Fungi – Absence of chlorophyll – moulds and mushrooms – highest diversity is in the Western Ghats followed by Eastern Himalayas (Both saprophytes and parasites)
 - Bacteria – Non-chlorophyllous microorganisms, soil-borne (Both saprophytes and parasites)
 - Lichens –
 - The symbiotic relationship between algae and fungi
 - Algae manufacture food and fungus keeps the algae moist by absorbing water.
 - They are not found in groundwater.
 - Bryophytes – small stems and simple leaves but true roots are absent, grows in moist places – liverworts and mosses, the second largest group of green plants in India.
 - Pteridophytes – Well-differentiated plant bodies – consist of root, stem and leaves
 - Gymnosperms – Naked seeded plants and naturally there is no fruit
 - Angiosperms – close-seeded plants
- Floral Endemism Order
 - Peninsular India (Western Ghats and Eastern Ghats)
 - Eastern Himalayas
 - North Western Himalayas
 - Andaman and Nicobar Islands.

Wildlife Protection Act (1972)

- Constitutional Provisions related to Wildlife
 - 42nd Amendment Act, 1976 - Forests and Protection of Wild Animals and Birds was transferred from State to Concurrent List.
 - Article 51 A (g) - Fundamental duty of every citizen is to protect and improve the natural environment including forests and Wildlife.
 - Article 48 A in the Directive Principles of State Policy – The state shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country.
- The Act was enacted for the protection of plants and animal species.
- It extends to the whole of India.

Protection of Wildlife Species

Schedules of the Act as per the recent Wildlife Protection (Amendment) Act 2022

- Initially, there were 6 schedules
- Now there are 4 schedules
 - Schedule I - Animal species that will enjoy the highest level of protection

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- Schedule II - Animal species that will be subject to a lesser degree of protection
- Schedule III - Protected Plant species
 - Their cultivation is restricted and requires prior permission from the Chief Wildlife Warden.
 - Their collection, extraction and trade are prohibited.
- Schedule IV - Specimens listed in the Appendices under CITES (scheduled specimens)
- A wild animal listed under these schedules can be hunted/ killed only after getting permission from the Chief Wildlife Warden (CWLW) of the state if:
 - It becomes dangerous to human life or to property (including standing crops on any land).
 - It is disabled or suffering from a disease that is beyond recovery.
- It provides for captive breeding programmes for endangered species.

Appointment of Authorities

- The Central Government appoints the Director of Wildlife Preservation and assistant directors and other officers subordinate to the Director.
- The State Governments appoint a Chief Wildlife Warden (CWLW) who heads the Wildlife Wing of the department and exercises complete administrative control over Protected Areas (PAs) within a state.
- The Wildlife Protection (Amendment) Act 2022 entrusts the Chief Wildlife Warden to control, manage and maintain all sanctuaries in a state.
- The state governments are also entitled to appoint Wildlife Wardens in each district.

Institutional Bodies Created

- National Board for Wildlife (NBWL)
 - The central government of India shall constitute the National Board for Wildlife (NBWL).
 - It serves as an apex body for the review of all wildlife-related matters and for the approval of projects in and around national parks and sanctuaries.
 - The NBWL is chaired by the Prime Minister
 - The Minister of Environment, Forest and Climate Change is the Vice-Chairperson of the board.
 - The board is 'advisory' in nature and can only advise the Government policy-making for the conservation of wildlife.
- Standing Committee of NBWL:
 - The NBWL constitutes a Standing Committee for the purpose of approving all the projects falling within protected wildlife areas or within 10 km of them.
 - The committee is chaired by the Minister of Environment, Forest and Climate Change.
- State Board for Wildlife (SBWL):
 - The state governments are responsible for the constitution of the state board of wildlife.
 - The Chief Minister of the state/UT is the chairperson of the board.
 - The board advises the state government in:
 - The selection and management of areas to be declared as protected areas.

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- The formulation of the policy for the protection and conservation of the wild life
 - Any matter relating to the amendment of any Schedule.
- Central Zoo Authority:
 - The act provides for the constitution of Central Zoo Authority consisting of a total 10 members including the Chairperson and a Member-Secretary.
 - The Environment Minister is the chairperson.
 - The authority provides recognition to zoos and is also tasked with regulating the zoos across the country.
 - It lays down guidelines and prescribes rules under which animals may be transferred among zoos nationally and internationally.
- National Tiger Conservation Authority (NTCA):
 - Following the recommendations of the Tiger Task Force, the National Tiger Conservation Authority (NTCA) was constituted in 2005 for strengthening tiger conservation.
 - The Union Environment Minister is the Chairperson of NTCA and the State Environment Minister is the Vice-Chairperson.
 - The Central Government on the recommendations of NTCA declares an area as a Tiger Reserve.
 - More than 50 wildlife sanctuaries in India have been designated as Tiger Reserves and are protected areas under the Wildlife Protection Act, of 1972.
- Wildlife Crime Control Bureau (WCCB):
 - The act provided for the constitution of the Wildlife Crime Control Bureau (WCCB) to combat organized wildlife crime in the country.
 - The Bureau has its headquarters in New Delhi.
 - It is mandated to:
 - Collect and collate intelligence related to organized wildlife crime activities and disseminate the same to the State to apprehend the criminals.
 - Establish a centralized wildlife crime data bank.
 - Assist State Governments to ensure success in prosecutions related to wildlife crimes.
 - Advise the Government of India on issues relating to wildlife crimes having national and international ramifications, relevant policies and laws.
 - Creation of Protected Areas

Creation of Protected Areas

- Wildlife Sanctuaries
 - Sanctuaries are naturally occurring areas that are meant to protect endangered species from hunting, poaching and predation.
 - The goal of wildlife sanctuaries is usually to provide safe havens where animals can receive the best possible care that the sanctuaries can provide.
 - Wildlife sanctuaries are where wild animals are bred and protected for the rest of their lives until they die naturally.
 - There is no trading of animals in wildlife sanctuaries, and they are not used in animal experiments.
 - Both the Central and State governments can declare Wildlife Sanctuaries.
 - In wildlife sanctuaries, only very limited human activity is permitted.

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- Animal hunting and poaching are strictly prohibited, and trees and plants may not be cut down for agriculture or any other purpose.
- Wildlife sanctuaries have been designated as Category IV protected areas by the International Union for Conservation of Nature (IUCN).
- Wildlife sanctuaries have fewer restrictions than national parks.
- A wildlife sanctuary does not require official permission to visit.
- Wildlife sanctuaries have no defined boundaries
- In wildlife sanctuaries, human activities are permitted to some extent.
- National Parks
 - National parks are areas that aim to protect the natural environment.
 - In a national park, the landscapes and their flora and fauna are present in their natural state.
 - National parks not only conserve wildlife, but they also provide enjoyment of the ecological and scenic heritage
 - National parks have been classified as Category II protected areas by the International Union for Conservation of Nature (IUCN).
 - National parks can be declared both by the Central Government and State governments.
 - No alteration of the boundaries of a national park shall be made except on a resolution passed by the State Legislature.
 - The boundaries can be altered only with prior consultation and approval with the National Board of Wildlife.
 - National parks are heavily restricted areas that are only accessible to a select group of people.
 - To visit a national park, you must first obtain official permission from the appropriate authorities.
 - National parks have clearly defined boundaries.
 - In national parks, human activities are strictly prohibited by the authorities.
- Tiger Reserves
 - The State Government shall, on the recommendation of the Tiger Conservation Authority, notify an area as a tiger reserve.
 - The limit of the Tiger Reserve may not be changed without the National Board for Wild Life's approval and the National Tiger Conservation Authority's suggestion.
 - Unless it is in the public interest and with the consent of the National Board for Wild Life and the National Tiger Conservation Authority, no State Government may de-notify a tiger reserve.
 - Critical tiger habitats (CTH) are designated under the Wild Life Protection Act (WLPA), which is also known as the core of tiger reserves.
 - There are 53 Tiger Reserves in India which are governed by Project Tiger under the jurisdiction of the National Tiger Conservation Authority.
 - Guru Ghasi Das National Park and Tamor Pingla Wildlife Sanctuary have joined together to create Guru Ghasi Das Tiger Reserve as the 53rd one.
 - Tiger Population
 - MP>Karnataka>Uttarakhand
 - In North East – Assam
 - Highest Tiger Density
 - Jim Corbett>Nagarhole>Bandipur Tiger Reserve
 - Pench Tiger Reserve – Straddle across two states – MP and Maharashtra

BIODIVERSITY

- With 2,967 tigers, India, four years in advance, has achieved the target set in the 2010 St Petersburg Declaration of doubling the tiger population by 2022.
- There are currently 13 tiger range countries - India, Bangladesh, Bhutan, Cambodia, China, Indonesia, Lao PDR, Malaysia, Myanmar, Nepal, Russia, Thailand and Vietnam.
- Out of 53 tiger reserves in the country, three reserves - Mizoram's Dampa reserve, Bengal's Buxa reserve and Jharkhand's Palamau reserve - have no tigers left.
- The "M-STrIPES" has been designed to address this void. It is a platform where modern technology is used to assist effective patrolling, assess ecological status and mitigate human-wildlife conflict in and around tiger reserves.
- Conservation Reserves
 - Conservation reserve includes the reserve and restricted land occupied by the government to protect wild animals.
 - Both Central and State governments can declare land as conservation reserves.
 - They typically act as buffer zones to connectors and migration corridors between established national parks, wildlife sanctuaries and reserved and protected forests of India.
- Community Reserves
 - It can be defined as privately owned land either by an individual or the entire community which includes wildlife resources.
 - They typically act as buffer zones to connectors and migration corridors between established national parks, wildlife sanctuaries and reserved and protected forests of India.

Other provisions of the Amendment Act 2022

- It implements the provisions of the CITES.
- The central government can designate a Management Authority, which grants export or import permits for the trade of specimens.
- Central Government can regulate or prohibit the import, trade, possession or proliferation of invasive alien species.
- The central government may also notify a conservation reserve (typically act as buffer zones to or connectors and migration corridors between established national parks, and wildlife sanctuaries)
- States can declare areas adjacent to National parks and Sanctuaries as Conservation Reserve, for protecting flora and fauna, and their habitat.
- Registration certificate for live specimens of scheduled animals: People possessing live specimens of scheduled animals must obtain a registration certificate from the Management Authority.
- Voluntary surrender of captive animals: The Act provides for any person to voluntarily surrender any captive animals, without any compensation and consequent authority over the animal.
- Exception for 'live elephant': The Act allows for Commercial Trade in Live Elephants. The Act, therefore, allows for commercial trade in elephants.
 - This is contrary to the previous act (Wildlife (Protection) Act, 1972) which specifically prohibits trade in Wild Animals including captive and wild elephants.

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Environment Protection Act 1986

- The Environment (Protection) Act (EPA) was enacted in 1986 with the objective of providing the protection and improvement of the environment.
- It empowers the Central Government to establish authorities charged with the mandate of preventing environmental pollution in all its forms and tackling specific environmental problems that are peculiar to different parts of the country.
- The Central government is also empowered to:
 - Plan and execute a nationwide programme for the prevention, control and abatement of environmental pollution.
 - Lay down standards for the quality of the environment in its various aspects.
 - Lay down standards for the emission or discharge of environmental pollutants from various sources.
 - The restriction of areas in which any industries, operations or processes or class of industries, operations or processes shall/ shall not be carried out subject to certain safeguards.
- Ecologically sensitive areas
 - Eco-sensitive zones are areas notified by the MoEFCC around Protected Areas, National Parks and Wildlife Sanctuaries.
 - The purpose of declaring ESZs is to create some kind of “shock absorbers” in the protected areas by regulating and managing the activities around such areas.
 - Declared under EPA.

Biological Diversity Act, 2002

- Enacted for the conservation of biological diversity and fair, equitable sharing of the monetary benefits from the commercial use of biological resources and traditional knowledge.
- The main intent of this legislation is to protect India’s rich biodiversity and associated knowledge against their use by foreign individuals.
- It seeks to check biopiracy, and protect biological diversity and local growers through a three-tier structure of central and state boards and local committees.
- The Act provides for the setting up of a National Biodiversity Authority (NBA), State Biodiversity Boards (SBBs) and Biodiversity Management Committees (BMCs) in local bodies.
- The NBA will enjoy the power of a civil court.
- Powers and Functions of National Biodiversity Authority (NBA).
 - Regulate activities and by regulations issue guidelines for access to biological resources and for fair and equitable benefit sharing.
 - Grant approval for undertaking any activity.
 - Advise the Central Government on matters relating to the conservation of biodiversity, sustainable use of its components and equitable sharing of benefits arising out of the utilization of biological resources.
 - Advise the State Governments in the selection of areas of biodiversity importance to be notified as heritage sites and measures for the management of such heritage sites.
 - Perform such other functions as may be necessary to carry out the provisions of this Act.

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- On behalf of the Central Government, take any measures necessary to oppose the grant of intellectual property rights in any country outside India on any biological resource obtained from India or knowledge associated with such biological resource which is derived from India.
- Powers and Functions of State Biodiversity Authority
 - The SBBs are established by the State Governments in accordance with Section 22 of the Act.
 - All the members of the SBB are appointed by the respective State Governments.
 - Advise the State Government, subject to any guidelines issued by the Central Government, on matters relating to the conservation, sustainable use or sharing of equitable benefits.
 - Regulate by granting approvals or otherwise requests for commercial utilization or bio-survey and bio-utilization of any biological resource by people.
 - This power of the State Biodiversity Boards which is applicable only on Indian citizens or organizations.
 - There are no State Biodiversity Boards constituted for Union territories.
- Biodiversity Management Committees (BMCs)
 - According to Section 41 of the Act, every local body shall constitute the BMC within its area for the purpose of promoting conservation, sustainable use and documentation of biological diversity including.
 - The main function of the BMC is to prepare the People's Biodiversity Register in consultation with the local people.
 - The register shall contain comprehensive information on the availability and knowledge of local biological resources, their medicinal or any other use or any other.
- The Biodiversity Act provides for payment of a prescribed fee to the Biodiversity Management Committees established at the Municipal or Panchayat level under "Access and Benefit Sharing" by companies who are using biological resources or use traditionally available knowledge.
- Any grievances relating to the determination of benefit sharing or order of the National Biodiversity Authority or a State Biodiversity Board under this Act shall be taken to the National Green Tribunal (NGT).

Convention on Biological Diversity (CBD)

- Legally binding convention
- Main goals
 - Conservation of biodiversity
 - Sustainable use of the components of biodiversity
 - Sharing the benefits arising from the commercial and other utilization of genetic resources in a fair and equitable way.
- Cartagena Protocol
 - To protect human health and the environment from the possible adverse effects of the products of modern technology.
 - Recognizes twin aspects
 - Access to transfer of technologies
 - Appropriate procedures to enhance the safety of biotechnologies.
 - It establishes procedures for regulating the import and export of LMOs (Living modified organism) from one country to another.

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- Advance Informed Agreement – A country intending to export an LMO for intentional release in the environment must notify the party of import in writing.
- Nagoya-Kuala Lumpur Supplementary Protocol
 - It is in liability and redress.
 - It specifies response measures to be taken in the event of damage to biodiversity resulting from LMOs.
 - India has ratified it.
 - Entered into force in 2018.
- Nagoya Protocol
 - It is on Access to genetic resources and fair and equitable sharing of benefits arising from their utilization.
 - Establishes clear rules and procedures for Prior Informed Consent and mutually agreed terms.
 - It addresses traditional knowledge associated with genetic resources.
- The Biodiversity targets
 - Strategic Plan for Biodiversity
 - At Nagoya, 2010 – Aichi biodiversity targets were adopted for 2011–2020.
- 15th Conference of Parties (COP15) to the UN Convention on Biological Diversity “Kunming–Montreal Global Biodiversity Framework” (GBF) was adopted.
 - The framework has 23 targets that the world needs to achieve by 2030.
 - The countries will monitor and report every five years or less on a large set of indicators related to progress.
 - The Global Environment Facility has been requested to establish a Special Trust Fund to support the implementation of the Global Biodiversity Framework (“GBF Fund”).
 - Key targets
 - 30x30 Deal:
 - Restore 30% of degraded ecosystems globally (on land and sea) by 2030
 - Conserve and manage 30% of areas (terrestrial, inland water, and coastal and marine) by 2030.
 - Stop the extinction of known species, and by 2050 reduce tenfold the extinction risk and rate of all species (including unknown)
 - Reduce risk from pesticides by at least 50% by 2030.
 - Money for nature:
 - Signatories aim to ensure \$200 billion per year is channelled to conservation initiatives, from public and private sources.
 - Pollution and pesticides:
 - One of the deal’s more controversial targets sought to reduce the use of pesticides by up to two-thirds.
 - Harmful subsidies:
 - Countries committed to identifying subsidies that deplete biodiversity by 2025, and then eliminating, phase out or reforming them.

Ramsar Convention

- Legally binding
- Adopted in 1971

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- Only global environmental treaty that deals with a particular ecosystem.
- It is not affiliated to United Nations.
- Montreux Record
 - Register of wetland sites where changes in ecological character have occurred.
 - Keoladeo
 - Loktak
- India not a founding member.
- Five global NGOs have been associated with the treaty
 - Birdlife International
 - IUCN
 - International Water Management Institute (IWMI)
 - Wetland Internationals
 - World Wide Fund for Nature (WWF)

CITES

- Legally binding.
- India is a member.
- The inter-governmental agreement that entered into 1975 and became the only treaty that international trade in plants and animals does not threaten their survival in the wild.
- It does not take the place of national laws.
- Administered by UNEP.
- Appendices
 - Appendix I – Species threatened with extinction and provides greatest level of protection.
 - Appendix II – Currently not threatened but may become without trade controls. So, it should be regulated.
 - Appendix III – Species for which a range country has asked other parties to help in controlling international trade.
- Held every three years.
- CoP 19 Panama City – 2022
- India submitted three proposals to CITES COP19 for stricter protection of its native species
 - The Jeypore Indian gecko
 - The red-crowned roofed turtle
 - Leith's softshell turtle.
- India hosted CoP (3rd) in 1981.
- India's proposal for transferring Leith's Softshell Turtle (*Nilssononia leithi*) and red-crowned roofed turtle (*Batagur Kachua*) from Appendix II to Appendix I has been adopted.
- India's proposal to add a gecko (*Cyrtodactylus jeyporensis*) to Appendix II which would imply that international trade will require permits, has also been adopted.
- The Jeypore Indian gecko is endangered. The wild reptile species are found in the Eastern Ghats and are known to be present in four locations including southern Odisha and northern Andhra Pradesh.
- *Nilssononia* has been categorized as critically endangered by the IUCN. It is a large fresh-water, soft-shelled turtle which is endemic to peninsular India and inhabits rivers and reservoirs.
- In CITES COP17 held in Johannesburg, South Africa in 2016, all species of Genus *Dalbergia* were included in Appendix II.

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- Two songbirds from South and Southeast Asia – the White Rumped Shama (found from Southern India to Indonesia) were added to Appendix II and the straw-headed bulbul was moved from Appendix II to Appendix I.

TRAFFIC: The Wildlife Trade Monitoring Network

- WWF + IUCN
- World's largest wildlife trade monitoring network of both plants and animals.

Convention on the Conservation of Migratory Species (CMS – Bonn Convention)

- It aims to conserve terrestrial, aquatic and avian migratory species throughout their range.
- 1979
- The intergovernmental treaty concluded under UNEP
- Only global convention specializing in the conservation of migratory species, their habitats and migration routes.
- Appendices
 - Appendix I – Threatened with extinction
 - Appendix II – Species that would significantly benefit from international cooperation.
- The agreements may range from legally binding to less formal instruments.
- India signed Raptor MoU
 - Conservation of Migratory Species of Prey in Africa and Eurasia.
 - Not legally binding.

Coalition against Wildlife Trafficking (CAWT)

- Aims to focus public and political attention and resources on ending the illegal trade in wildlife and wildlife products.
- Voluntary public-private participation.
- India is a partner.

The International Tropical Timber Organization (ITTO)

- Intergovernmental organization
- Under UNCTD
- Preserve tropical forest resources.
- India is a member.

United Nations Forum on Forests (UNFF)

- ECOSOC of the United Nations in 2000
- Management and sustainable development of all types of forests.

The Global Tiger Forum

- Intergovernmental organization to save five species of tigers in the wild distributed over 14 range countries.
- Formed in 1994
- Secretariat – New Delhi
- Meet once in three years.

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Global Tiger Initiative

- Launched in 2008
- It is led by 13 Tiger Range countries.
- St. Petersburg Declaration 2010 – Endorsed the implementation mechanism called the Global Tiger Recovery Programme.
 - The goal was to double wild tigers by 2022 (WWF is driving it forward).
- Bishkek Declaration – Global Snow Leopard and Ecosystem Protection Programme (GSLEP, 2013)

Stockholm Convention on PoP

- It is on elimination and restriction on the production and use of the Persistent Organic Pollutants
- Entered into force in 2004.
- PoPs are organic chemicals that are carbon-based.
 - Remain for a long period of time
 - Widely distributed throughout the environment.
 - Accumulate in fatty tissues.
 - Toxic to both humans and wildlife.
- Dirty Dozen – List of pesticides and industrial chemicals.
- Secretariat – UNEP.

Basel Convention

- For control of transboundary movements of Hazardous waste.
- It includes household waste.
- It has Prior Informed Consent
- 2019- Plastics have been included.
- Does not cover radioactive waste materials.

Rotterdam Convention

- Legally binding.
- International trade of certain hazardous chemicals in order to protect human health and the environment from potential harm

International Whaling Commission

- The intergovernmental body charged with the conservation of management of whales.
- Headquarter – UK
- India is a member.

Globally Important Agricultural Heritage Systems

- FAO
- Agricultural heritage sites of the world
- India
 - Kuttanad – Kerala – Below Sea level Farming System
 - Koraput – Odisha – High genetic repository
 - Pampore Karewas – Saffron heritage of Kashmir.
 - The Man and Biosphere (MAB)