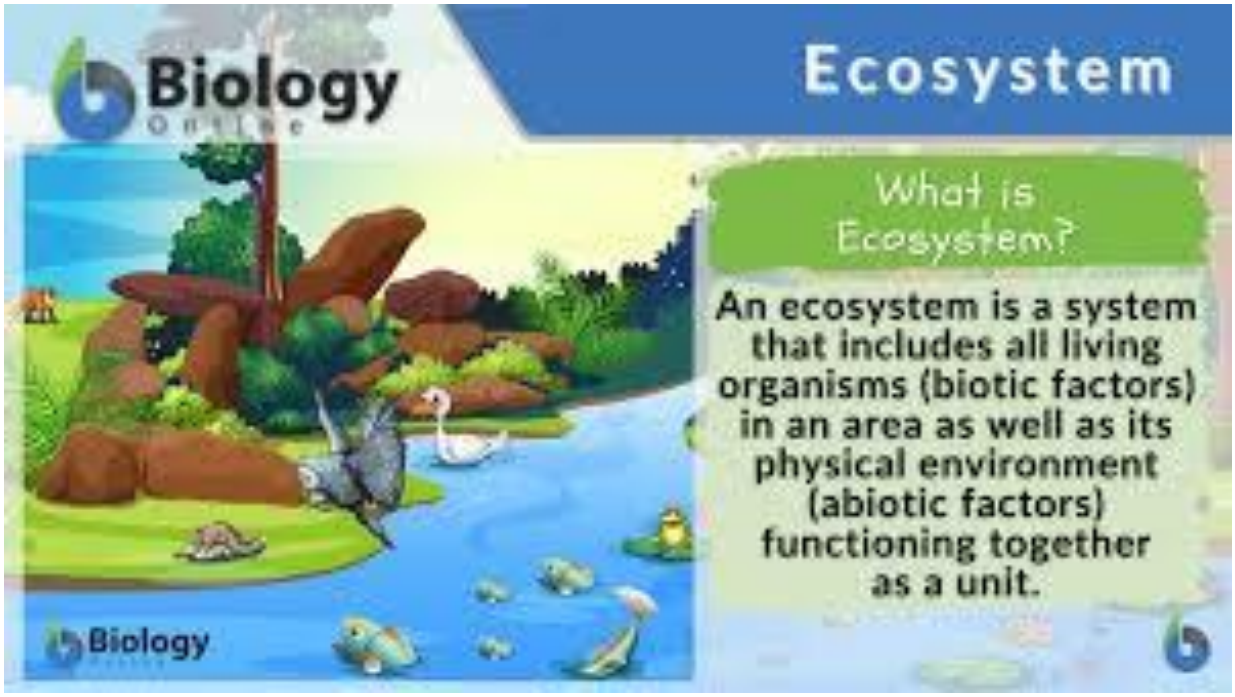
Unit III : Ecosystem and Biodiversity

(Weightage marks : **12**marks)

Unit- III Ecosystem and Biodiversity	3a. State the aspects and division of ecosystem. 3b. State the general characteristics and function of ecosystem. 3c. List levels of biodiversity. 3d. Enlist the endangered species. 3e. Describe value of biodiversity. 3f. Suggest methods for biodiversity conservation.	3.1 Ecosystem - Definition , Aspects of ecosystem, Division of ecosystem, General characteristics of ecosystem, Functions of ecosystem. 3.2 Biodiversity - Definitions, Levels, Value and loss of biodiversity. 3.3 Biodiversity assessment initiatives in India. 3.4 Threats and Hotspots of biodiversity. 3.5 Conservations of biodiversity - objects, various laws.



ECOSYSTEM

An ecosystem is a system formed by the interaction of living organisms (plants, animals, and microorganisms) with non-living components like soil, air, and water in a given area.

A.G. Tansley (1935) defined an ecosystem as the integration of all living and non-living elements of the environment, considering both the organisms and the physical factors that make up their surroundings.

Aspects of an Ecosystem

An ecosystem is a unit where living organisms and non-living components interact, exchanging materials and energy. It can be studied through two key aspects:

1. **Structural Aspect**
   Refers to the physical components of the ecosystem, including:
   - **Biotic factors**: Plants, animals, and microorganisms. (Environmental factors)
   - **Abiotic factors**: Soil, air, water, temperature, and sunlight.
2. **Functional Aspect**
   Focuses on the processes and interactions within the ecosystem, such as: Organisms
   - Energy flow
   - Nutrient cycling
   - Productivity
   - Decomposition

Structural Aspects

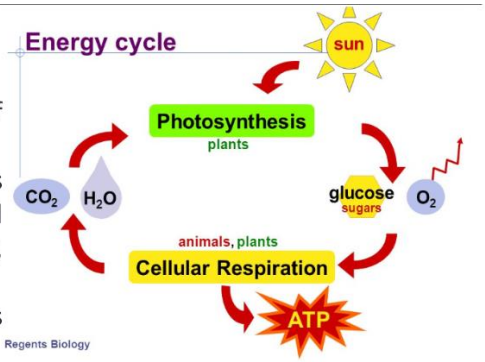
Components that make up the structural aspects of an ecosystem include :

1. Inorganic aspects - C, N, CO_2, H_2O.
2. Organic compounds - Protein, Carbohydrates, and Lipids - link abiotic to biotic aspects.
3. Climatic regimes - Temperature, Moisture, Light & Topography.
4. Producers - Plants.
5. Macro consumers - Phagotrophs - Large animals.
6. Micro consumers - Saprotrophs, absorbers - Fungi.

Functional aspects

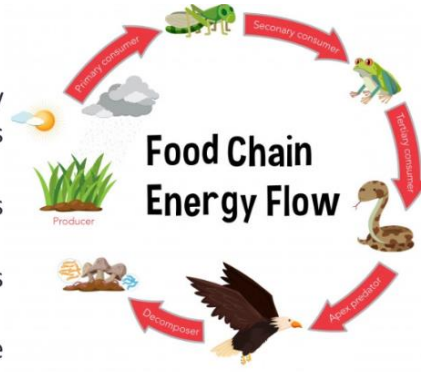
1. Energy cycles.
2. Food chains.
3. Diversity - Inter linkages between organisms.
4. Nutrient cycles - Biogeochemical cycles.
5. Evolution.

1) Energy cycles



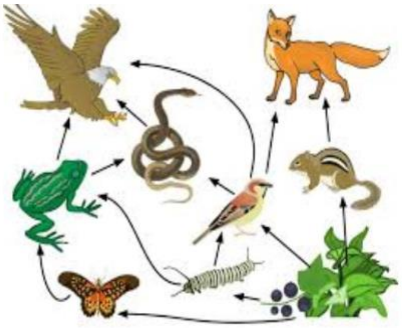
- The energy cycle is based on the flow of energy through the ecosystem.
- Energy from sunlight is converted by plants themselves into growing new plant material which includes leaves, flowers, fruit, branches, trunks and roots of plants.
- During photosynthesis carbon dioxide is taken up by plants and oxygen is released.
- Animals depend on this oxygen for their respiration.

2) Food chains



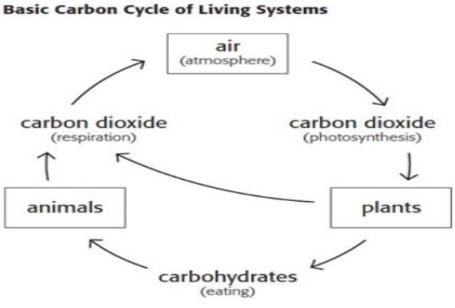
- Plants can grow by converting the sun's energy directly into their tissues, they are known as producers in the ecosystem.
- The plants are used by herbivorous animals as food, which gives them energy.
- The carnivores in turn depend on herbivorous animals on which they feed.
- Thus the different plant and animal species are linked to one another through **food chains**
- Each food chain has three or four links.

3) Diversity-
Inter linkages between organisms



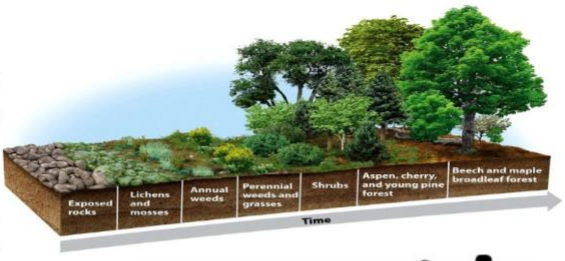
- The different plant and animal species are linked to one another through food chains.
- Each food chain has three or four links. However as each plant or animal can be linked to several other plants or animals through many different linkages.
- These inter-linked chains can be depicted as a complex **food web**.
- This is thus called the 'web of life' that shows that there are thousands of interrelationships in nature.

4) Nutrient cycles- (Biogeochemical cycles)

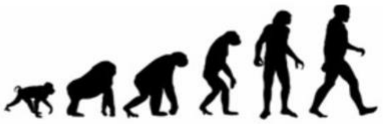


- Biogeochemical cycles are pathways of transport & transformation of nutrient
- These consists of Two types –
  Gaseous cycles e.g. Carbon cycle, Nitrogen cycle etc.
  Sedimentary cycle e.g phosphorus cycle, sulphur cycle etc.
- Carbon is released from ecosystem as carbon dioxide gas by the process of respiration.
- This CO2 gas is used by plants to prepare carbohydrates which is used by animals as food.
- Animals and plants again release CO2 through respiration.

5) Evolution -

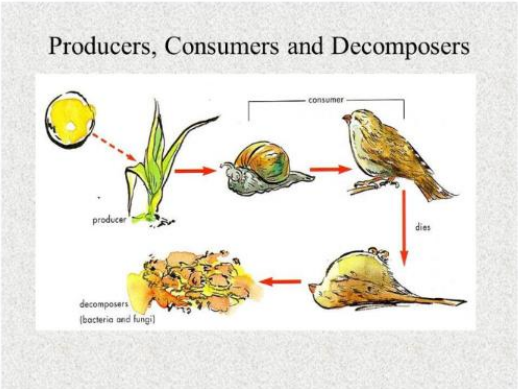


- Ecological succession is a process through which ecosystems tend to change over a period of time.
- If a forest is cleared, it is initially colonized by a certain group of species of plants and animals, which gradually change through an orderly process of community development.
- One can predict that an opened up area will gradually be converted into a grassland, a shrub land and finally a woodland & a forest
- Evolution of man from Monkeys is the result of ecological succession.



Division of Ecosystem

The ecosystem can be divided, from the energetic view point into three types of organisms: producers, consumers, and reducers. These can be explained as under:



Division of Ecosystem

(1) Producer

Photosynthetic algae, plants and bacteria are the producers of the ecosystem; all other organisms depend upon them directly or indirectly for food

(2) Consumers

Consumers are herbivorous, carnivorous, and omnivorous animals; they eat the organic matter produced by other organisms.

(3) Reducers

Reducers are heterotrophic organisms like animals; they are fungi and bacterial that decompose dead organic matter.

Division of ecosystem :

An ecosystem is a community made up of living organisms and nonliving components such as air, water, and mineral soil. Ecosystems can be studied in two different ways. The living (biotic) and non-living (abiotic) components interact through nutrient cycles and energy flows as shown in Fig. 3.1.4.

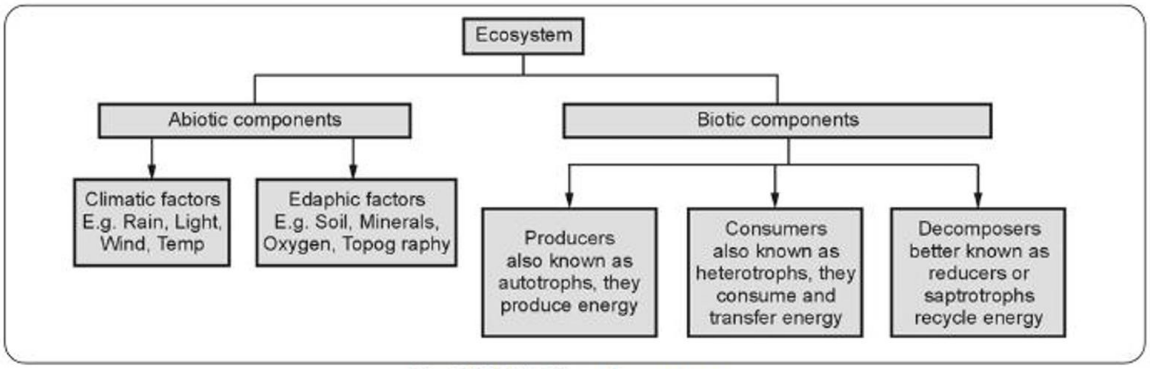
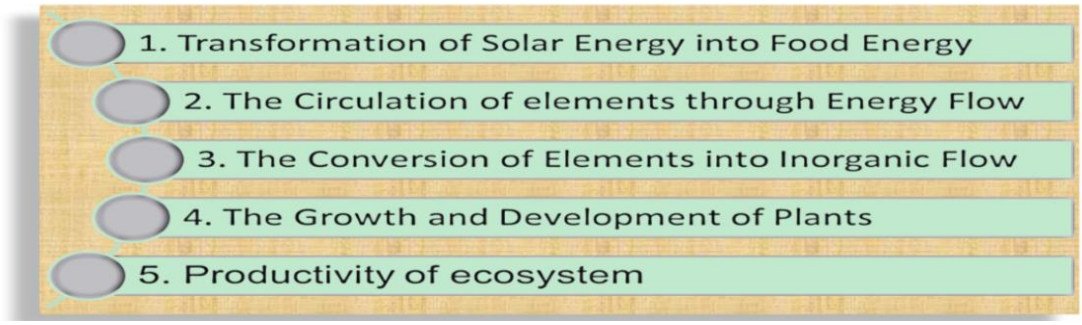


Fig. 3.1.4 Division of ecosystem

General Characteristics of Ecosystem :

1. The ecosystem is a major structural and functional unit of ecology.
2. The structure of an ecosystem is related to its species diversity; the more complex ecosystems have high species diversity.
3. The function of the ecosystem is related to energy flow and material cycling through and within the system.
4. The relative amount of energy needed to maintain an ecosystem depends on its structure. The more complex the structure, the lesser the energy it needs to maintain itself.
5. Ecosystems mature by passing from less complex to more complex states. Early stages of such succession have an excess of potential energy and a relatively high energy flow per unit biomass. Later (mature) stages have less energy accumulation and its flow through more diverse components.
6. Both the environment and the energy fixation in any given ecosystem are limited and cannot be exceeded without causing serious undesirable effects.
7. Alterations in the environments represent selective pressures upon the population to which it must adjust Organisms which are unable to adjust to the changed environment must needs vanish.
8. The ecosystem is an integrated unit or zone of variable size, comprising vegetation, fauna, microbes and the environment. Most ecosystems characteristically possess a well-defined soil, climate, flora and fauna (or communities) and have their own potential for adaptation, change and tolerance.
9. The functioning of any ecosystem involves a series of cycles, e.g., the water cycle and the cycles of various nutrients. These cycles are driven by energy flow, the energy being the solar energy Continuation of life demands a constant exchange and return of nutrients to and from (amongst) the different components of the ecosystem.

Functions of Eco-system



1. **Transformation of Solar Energy into Food Energy**: Conversion of sunlight into chemical energy via photosynthesis.
2. **Circulation of Elements through Energy Flow**: Movement of nutrients through food chains and ecosystems.
3. **Conversion of Elements into Inorganic Flow**: Recycling of organic matter into inorganic substances.
4. **Growth and Development of Plants**: Support for plant life and their development.
5. **Productivity of Ecosystem**: Overall production of biomass and energy.

3.2 Biodiversity - Definition, Levels, Value and Loss of Biodiversity

Biodiversity boosts ecosystem productivity where each species, no matter how small, all have an important role to play. For example, A larger number of plant species means a greater variety of crops. Greater species diversity ensures natural sustainability for all life forms.

Definition :

Biodiversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems.

Bio – Life: Diversity- Variety

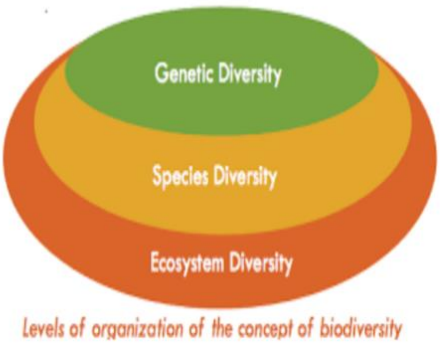
Biodiversity is the variety and variability among all group of living organisms and the ecosystem in which they occur

Definition:

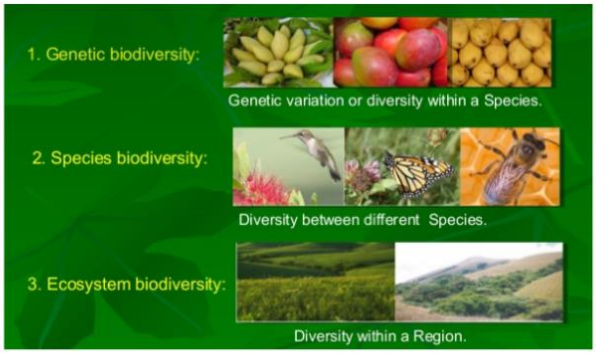
Biological diversity' or biodiversity is that part of nature which includes the differences in genes among the individuals of a species, the variety and richness of all the plant and animal species at different scales in space, locally, in a region, in the country and the world, and various types of ecosystems, both terrestrial and aquatic, within a defined area.

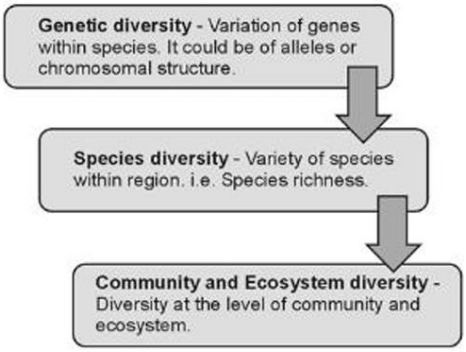
Levels of biodiversity :

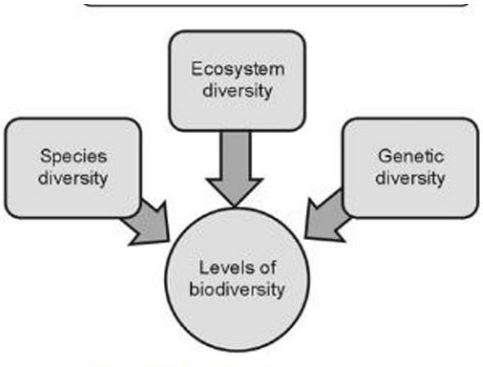
Biodiversity is generally described in terms of its 3 fundamental and hierarchically related levels of biological organisms. These are -



Levels of organization of the concept of biodiversity







1. **Genetic Diversity**
   Variation in genes within a species, including differences among individuals and populations.
   - *Example*: Varieties of rice, teak wood, or dog breeds.
   - Importance: Essential for healthy breeding and adaptability.
2. **Species Diversity**
   The variety of species within a habitat or ecosystem, ranging from microorganisms to large plants and animals.
   - *Examples*: Apple, mango, lion, tiger.
   - Observation: Natural tropical forests are richer in species than man-made plantations.
3. **Ecosystem Diversity**
   Variation in ecosystems, including the distinct habitats and interactions within them.
   - *Examples*: River ecosystem, forest ecosystem, desert ecosystem.
   - Observation: India has high ecosystem diversity.

Types of Diversity:

1. **Alpha Diversity (α)**
   Diversity within a single ecosystem, showing the variety of species in one area.
   - *Example*: In Ecosystem X, α = 4 (number of species).
2. **Beta Diversity (β)**
   Diversity between ecosystems, considering the differences in species between two habitats.
   - *Example*: Between Ecosystems X and Y, β = 6 (species unique to each ecosystem).
3. **Gamma Diversity (γ)**
   Overall diversity across multiple ecosystems within a region, including both unique and shared species.
   - *Example*: Across Ecosystems X, Y, and Z, γ = 13 (total species counted only once).

Values of Biodiversity

Biodiversity has immense value, categorized into **direct**, **indirect**, and **ethical** significance:

1. **Consumptive Value**
   Direct use of natural resources for survival or immediate use.
   - *Examples*: Food, fuelwood, medicinal plants, and water.
2. **Productive Use Value**
   Commercial value derived from biodiversity for economic benefit.
   - *Examples*: Timber, crops, fish, pharmaceuticals, and industrial raw materials.
3. **Social Value**
   Importance of biodiversity in maintaining cultural, religious, and social practices.
   - *Examples*: Sacred groves, cultural rituals, and traditional medicines.
4. **Ethical and Moral Values**
   Recognizing all living beings have the right to exist, emphasizing the moral responsibility to protect biodiversity.
   - *Examples*: Conservation of endangered species and protecting habitats.
5. **Aesthetic Value**
   The beauty and recreational value of biodiversity, contributing to mental well-being.
   - *Examples*: Scenic landscapes, national parks, and wildlife tourism.

Loss of Biodiversity

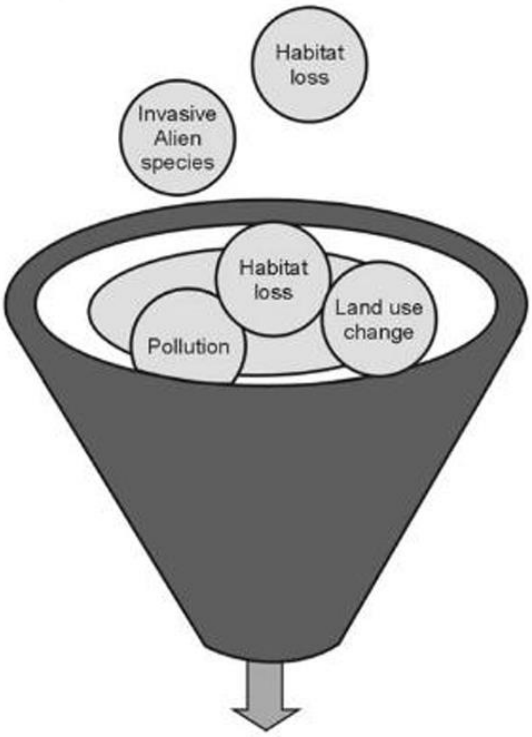


Figure 3.2.2 Loss of biodiversity

Biodiversity loss refers to the decline in the variety of life forms on Earth, including species, ecosystems, and genetic diversity.

Causes of Loss of Biodiversity

1. **Destruction of Habitat**
    - **Explanation**: The clearing of forests, wetlands, and other natural habitats for agriculture, urban development, and infrastructure.
    - **Impact**: Loss of living spaces for many species, leading to extinction.
2. **Hunting**
    - **Explanation**: Overhunting of animals for food, sport, or trade.
    - **Impact**: Depletion of species, particularly those with low reproductive rates.
3. **Exploitation of Selected Species**
    - **Explanation**: Overfishing, logging, and the trade of specific species for commercial use.
    - **Impact**: Depletion of valuable species and disruption of ecosystems.
4. **Habitat Fragmentation**
    - **Explanation**: The breaking up of large habitats into smaller, isolated patches due to human activities.
    - **Impact**: Limits gene flow, reduces biodiversity, and isolates populations.

5. **Pollution**
    - **Explanation**: Contamination of air, water, and soil by chemicals, plastics, and waste.
    - **Impact**: Toxic effects on plants, animals, and ecosystems, reducing biodiversity.
6. **Natural Calamities**
    - **Explanation**: Natural disasters such as wildfires, floods, earthquakes, and hurricanes.
    - **Impact**: Can cause immediate destruction of habitats and long-term changes in ecosystems.

Biodiversity Assessment Initiatives in India

India's Biodiversity

- **Mega-Diverse Country**:
    - India is one of 17 mega-diverse nations globally.
    - Occupies 2.4% of the world's land area but accounts for 7-8% of all recorded species.
    - Rich in species diversity:
        - **Mammals**: 8.58% of global species.
        - **Birds**: 13.66%.
        - **Reptiles**: 7.91%.
        - **Amphibians**: 4.66%.
        - **Fishes**: 11.72%.
        - **Plants**: 11.80%.
- **Challenges to Biodiversity**:
    - Rapid population growth, industrialization, and economic development increase pressure on biodiversity and ecosystems.

Importance of Conservation

- **Priority**: Biodiversity and ecosystem conservation are critical for India's economic, ecological, and social well-being.
- **Economic Valuation**: Assessing the value of ecosystem services aids in improving ecosystem management and conservation.

Conservation Initiatives for Ecosystems

1. **Forest Ecosystems**:
    - Forests cover large areas with high tree density and plant diversity.

- India is recognized for expanding forest cover through:
    - **Forest (Conservation) Act, 1980**.
    - **National Forest Policy, 1988**.
    - **Massive afforestation programs**.
    - **Joint Forest Management** encouraging community participation.
    - **Biosphere Reserves** to protect biodiversity.

2. **Inland Wetlands Ecosystems**:
    - Found at the interface of land and water, without direct sea connections.
    - Support diverse flora such as algae, mosses, ferns, and angiosperms (~1,200 plant species).
    - **National Wetlands Conservation Program (NWCP)** (since 1985-86):
        - Aims to prevent wetland degradation and promote their wise use for biodiversity and local communities.
3. **Coastal and Marine Ecosystems**:
    - Provide crucial services (e.g., food, water resources, sand, heavy minerals).
    - Host over 13,000 species and offer high biological productivity, supporting aquatic flora and fauna.
    - **Protection Efforts**:
        - 31 Coastal and Marine Protected Areas (CMPAs).
        - Species protection under the **Wildlife (Protection) Act, 1972**.

Threats to Biodiversity (The "Evil Quartet")

1. **Habitat loss and fragmentation**: Depleting tropical forests and habitats.
2. **Overexploitation**: Unsustainable resource use causing species extinction.
3. **Alien species invasions**: Introduced species threaten native biodiversity.
4. **Co-extinction**: Interdependence of species leading to mutual extinction.

Biodiversity Hotspots in India

1. **Western Ghats and Sri Lanka**: Rich in endemic species.
2. **Himalayas**: Habitat for tigers, rhinos, vultures, and elephants.
3. **Indo-Burma**: High endemism, particularly for freshwater turtles and bird diversity.

Endangered Species in India

- **Animals**: Bengal Tiger, Asiatic Lion, Snow Leopard, Red Panda, etc.
- **Birds**: Great Indian Bustard, Siberian Crane, Red-headed Vulture, etc.
- **Plants**: Red Sandalwood, Malabar Mahogany, etc.

Conservation of Biodiversity

1. **In-situ Conservation** (Natural habitats):
    - **Biosphere Reserves, National Parks, Wildlife Sanctuaries, Sacred Groves**.
2. **Ex-situ Conservation** (Outside habitats):
    - **Botanical Gardens, Zoological Parks, Seed Banks, Gene Banks.**

Legal Framework for Biodiversity Conservation

- **Indian Forest Act (1927)**, **Wildlife Protection Act (1972)**, **Forest Conservation Act (1980)**, and **Biological Diversity Act (2002)**.
- Biodiversity enshrined in **Articles 48(A)** and **51A(g)** of the Indian Constitution.

Global Initiatives

- **Earth Summit (1992)**: Focus on conservation and sustainable use of biodiversity.
- **World Summit (2002)**: Global pledge to reduce biodiversity loss.

Conservation of Biodiversity

1. **Objectives of Biodiversity Conservation**:
    - Preserve ecosystems, representative vegetation types, and extinction-prone species.
    - Manage forestry and wildlife under the Ministry of Environment and Forests.
2. **Laws Governing Biodiversity Conservation in India**:
    - **Key Acts**:
        - Madras Wild Elephant Preservation Act, 1873
        - Indian Fisheries Act, 1897
        - Wildlife (Protection) Act, 1972

        - Forest (Conservation) Act, 1980
        - Conservation of Forests and National Ecosystems Act, 1994
    - Evolution of laws highlights growing attention to biodiversity conservation.

Methods of Conservation

In-Situ Conservation (On-Site):

- Protecting species in their natural ecosystems.
- Examples:
    - **National Parks**: E.g., Corbett National Park, areas preserving wildlife and vegetation.
    - **Wildlife Sanctuaries**: Restricted areas for the protection of animal species.
    - **Biosphere Reserves**: Zones for ecological research and habitat preservation (core and buffer zones).

Ex-Situ Conservation (Off-Site):

- Protecting species outside their natural habitats.
- Techniques:
    - **Botanical Gardens**: Protect plant species for research and education.
    - **Zoological Parks**: Preserve animal species in controlled environments.
    - **Seed Banks**: Store seeds for future use.
    - **Gene Banks**: Preserve genetic material for research and reintroduction.

Special Conservation Projects

1. **Project Tiger**:
    - Launched in 1973 to reverse tiger population decline.
2. **Gir Lion Project**:
    - Conserves Asiatic lions in Gujarat's Gir Forest.
3. **Crocodile Breeding Project**:
    - Aims to protect gharials, muggers, and saltwater crocodiles.
4. **Himalayan Musk Deer Project**:
    - Addresses threats from poaching and habitat destruction.
5. **Project Elephant**:
    - Focuses on habitat restoration and reducing human-wildlife conflicts.

Distribution of Conservation Sites

1. **National Parks**:
    - First established in 1936 (e.g., Corbett National Park).
    - Total: 104 parks covering 40,501.13 sq. km (1.23% of India's geographical area).
2. **Wildlife Sanctuaries**:
    - Classified as IUCN Category IV protected areas.
    - Total: 543 sanctuaries covering 118,918 sq. km (2017 data).
3. **Biosphere Reserves**:
    - Total: 18 notified reserves.
4. **Conservation of biodiversity objects :**
    1. To maintain essential ecological processes and life supporting systems.
    2. To preserve the diversity of species.
    3. To make sustainable utilization of species and ecosystems.
    4. To conserve all the possible varieties (old or new) of food, forage and timber plants, live stock, agriculture animals and microbes
    5. To conserve all the economically important organisms in protected areas .
    6. To give priority to preserve unique ecosystems.
    7. To prevent poaching and hunting of wildlife .
    8. To create public awareness regarding biodiversity and its importance for the living organisms.
    9. To protect useful animals, plants and their wild relatives both in their natural habitat (in-situ) and in zoological botanical gardens (ex-situ)