

## iv. Biodiversity and its conservation...

**iv. Biodiversity and its conservation, Levels of biological diversity, biogeography zones of India, biodiversity patterns and global biodiversity hotspots, India as a mega-biodiversity nation**

## Biodiversity and Its Conservation

### Concept and Importance of Biodiversity

#### 1. Definition

- **Biodiversity** refers to the **variety and variability** of life on Earth, including the diversity within species (genetic), between species, and of ecosystems.
- Integral to **ecosystem functioning**, **ecosystem services** (pollination, soil fertility, water purification), and **resilience** to environmental changes (climate shifts, invasive species).

#### 2. Value of Biodiversity

- **Ecological Services:** Nutrient cycling, carbon sequestration, hydrological balance, pest control.
- **Economic:** Agriculture (crop varieties, pollinators), pharmaceuticals (natural compounds), tourism (ecotourism).
- **Cultural/Ethical:** Intrinsic value, cultural identity, and heritage in many human communities.

#### 3. Conservation Objectives

- **Prevent species extinction** and maintain genetic diversity.
- **Preserve ecosystem integrity** to sustain long-term productivity and resilience.
- Balancing **human development needs** with **sustainable resource use**.

### Threats to Biodiversity

#### 1. Habitat Loss and Fragmentation

- Agricultural expansion, urbanization, deforestation.
- Leads to reduction in species ranges, isolation of populations, edge effects.

#### 2. Overexploitation

- Unsustainable harvesting of wildlife (logging, poaching, fisheries).
- Results in population declines or local extinctions (e.g., large mammals, medicinal plants).

#### 3. Invasive Alien Species

- Non-native species can outcompete or prey upon indigenous species, altering community dynamics.
- E.g., *Lantana camara*, *Eichhornia crassipes* (water hyacinth) in India.

#### 4. Pollution

- Industrial discharges, agrochemicals (pesticides, fertilizers), plastic waste degrade habitats, poison species.
- Bioaccumulation in food webs has cascading impacts.

#### 5. Climate Change

- Alters temperature/precipitation regimes, pushing species beyond tolerance limits, changing phenology, triggering range shifts.

## Levels of Biological Diversity

Biodiversity can be examined at multiple hierarchical levels:

#### 1. Genetic Diversity

- Variations in genes within individuals, populations, or species.
- Ensures adaptive potential to environmental changes or disease pressures.
- E.g., different landraces of rice (*Oryza sativa*) or wheat reflect genetic diversity shaped by geography and farming practices.

#### 2. Species Diversity

- Variety of species within a community or region.
- Typically assessed via **species richness** (number of species) and **species evenness** (relative abundance distribution).

- **Alpha diversity** (within a specific habitat), **Beta diversity** (between habitats), **Gamma diversity** (across a landscape).
- 3. **Ecosystem Diversity**
  - Range of distinct ecosystems (forests, grasslands, wetlands, coral reefs) and their ecological processes.
  - Contributes to regional and global stability, nutrient cycles, and climate moderation.
- 4. **Landscape Diversity** (sometimes included)
  - Variation in topography, habitat mosaics, and ecosystem patches over broader spatial scales.
  - Shapes corridors, ecological connectivity, and large-scale processes (e.g., migration routes).

## Biogeography Zones of India

India's complex **topography**, **climate** variation, and **geological history** have fostered high biodiversity, reflected in distinct **biogeographic zones**:

1. **Trans-Himalaya**
  - Extends across Ladakh plateau, cold desert landscapes.
  - Sparse vegetation, adapted to extreme cold and aridity. Key fauna: snow leopard, Tibetan antelope.
2. **Himalaya**
  - Ranges from subtropical foothills to alpine meadows and perpetually snow-covered peaks.
  - Diverse forest types (temperate broadleaf, conifers), high endemism.
  - Vital water catchment for major rivers (Ganges, Brahmaputra).
3. **Desert (Thar)**
  - Hot, semi-arid region in Rajasthan and Gujarat.
  - Xerophytic vegetation (cacti, shrubs), adapted to low rainfall. Fauna includes desert fox, Indian gazelle.
4. **Semi-Arid**
  - Transition zones between desert and more humid areas, e.g., parts of Deccan plateau.
  - Thorn forests, grasslands; moderate rainfall, seasonal climate extremes.
5. **Western Ghats**
  - Mountain chain along the southwestern coast.
  - Tropical moist forests, high endemism (frogs, flowering plants). Declared a global biodiversity hotspot.
6. **Deccan Peninsula**
  - Central India's plateau with broadleaf dry forests, savannas.
  - Distinct seasonal rainfall patterns (monsoonal). Iconic megafauna (tiger, elephant in some areas).
7. **Gangetic Plain**
  - Alluvial plains of North India.
  - Highly fertile soils, intensive agriculture, wetlands, floodplain ecosystems. Threats from population pressure.
8. **Coasts**
  - Stretches along Bay of Bengal and Arabian Sea. Mangroves (Sundarbans in the east), beaches, estuaries. High fish diversity, important for migratory birds.
9. **Northeast India**
  - Part of Indo-Burma biodiversity hotspot, heavily forested hills, shifting cultivation areas.
  - Rich tribal ethnobotanical knowledge, extremely high species richness.
10. **Islands (Andaman & Nicobar, Lakshadweep)**
  - Tropical rainforests, coral reefs, marine biodiversity. High endemism due to isolation.

## Biodiversity Patterns and Global Biodiversity Hotspots

### Biodiversity Gradients

1. **Latitudinal Gradient**
  - Species richness increases from poles to equator (tropical areas harbor greatest species counts).
  - High solar energy input, longer growing seasons, and stable climates over evolutionary timescales.
2. **Altitude Gradient**
  - Species diversity often declines with increasing elevation, though mid-altitude peaks can occur (the "mid-domain effect").



- Environmental complexity can allow niche differentiation in mountainous regions.

### 3. **Peninsular Effects**

- Regions like the southern Indian peninsula can show distinct endemism due to historical isolation, climatic differences.

## **Global Biodiversity Hotspots**

### 1. **Concept by Myers et al.**

- Regions that harbor exceptionally high levels of endemism and face severe habitat loss.
- Original definition required  $\geq 1,500$  endemic vascular plants and  $\geq 70\%$  original habitat lost.

### 2. **Examples**

- **Tropical Andes, Sundaland, Madagascar, Mediterranean Basin, Eastern Himalayas**, etc.
- **Western Ghats** and **Eastern Himalayas** recognized as key Indian hotspots.

### 3. **Conservation Priorities**

- These hotspots represent small areas with disproportionate amounts of global biodiversity, thus targeting them is cost-effective for species conservation.
- Challenges: balancing local communities' livelihoods and biodiversity protection.

## **India as a Mega-Biodiversity Nation**

### **Rationale for Mega-Diversity Status**

#### 1. **High Species Richness**

- India hosts  $\sim 8\%$  of the world's recorded species across  $< 2.5\%$  of Earth's land area.
- Over 48,000 species of plants,  $\sim 97,000$  species of animals documented; endemism notable in reptiles, amphibians, flowering plants.

#### 2. **Varied Climate and Topography**

- From alpine Himalayan ecosystems to tropical rainforests, mangroves, deserts, coral reefs.
- This heterogeneity fosters ecological niches supporting thousands of endemic taxa.

#### 3. **Ancient Geographic History**

- Gondwanaland separation, collisions with Eurasia shaped unique evolutionary lineages (Western Ghats, Himalayas).
- Cultural traditions and agro-biodiversity (e.g., 50,000 rice cultivars historically) reflect millennia of domestic innovation.

### **Conservation Efforts in India**

#### 1. **Protected Areas**

- Network of National Parks, Wildlife Sanctuaries, Tiger Reserves, Biosphere Reserves.
- Project Tiger (1973), Project Elephant, and upcoming species-specific programs. Yet habitat corridors remain threatened.

#### 2. **Legal Framework**

- **Wildlife (Protection) Act** (1972), **Forest (Conservation) Act** (1980), **Biological Diversity Act** (2002).
- Emphasis on **community reserves**, **eco-sensitive zones**, joint forest management.

#### 3. **Challenges**

- High human population density leads to **human-wildlife conflicts**, encroachment, resource extraction.
- **Fragmented habitats** hamper gene flow, intensify extinction risks for wide-ranging species (tigers, elephants).
- Balancing economic development with environmental sustainability remains a policy dilemma.

#### 4. **Success Stories**

- **Tiger population** stabilization in some reserves; **Kaziranga** for rhinos, successful reforestation in certain community-led initiatives.
- Non-governmental involvement (WWF-India, BNHS, community-based conservancies) fosters grassroots engagement.



## Concluding Remarks

**Biodiversity** underpins ecosystems' resilience, productivity, and capacity to support human societies. At multiple levels—**genetic, species, and ecosystem**—the richness of life reveals complex spatial patterns, from latitudinal gradients to localized biodiversity hotspots.

**India's biogeographic zones**, ranging from trans-Himalayan cold deserts to tropical coastal mangroves, collectively harbor a dazzling array of flora and fauna, elevating the subcontinent to **mega-biodiversity** status. However, pressures from **habitat loss, overexploitation, invasive species**, and **climate change** demand robust conservation strategies that combine **scientific rigor** with **community-based management** and **policy reforms**.

In this context, protecting biodiversity hot spots such as the **Western Ghats** and **Northeast Himalayas** remains central to preserving India's unique natural heritage, ensuring the continued provision of essential ecosystem services, and fulfilling ethical stewardship of the planet's life-support systems for future generations.