## iv. Biodiversity and its conservation...

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## **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).
- o 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

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

#### 2. Overexploitation

- Unsustainable harvesting of wildlife (logging, poaching, fisheries).
- o 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

- o 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.
- o 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).

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• 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.
- o 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

- o 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.
- o 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.
- o Thorn forests, grasslands; moderate rainfall, seasonal climate extremes.

## Western Ghats

- o Mountain chain along the southwestern coast.
- o Tropical moist forests, high endemism (frogs, flowering plants). Declared a global biodiversity hotspot.

#### 6. Deccan Peninsula

- o Central India's plateau with broadleaf dry forests, savannas.
- o Distinct seasonal rainfall patterns (monsoonal). Iconic megafauna (tiger, elephant in some areas).

## 7. Gangetic Plain

- Alluvial plains of North India.
- o 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

- o 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)

o 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").

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• 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 ≥1,500 endemic vascular plants and ≥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 ~8% of the world's recorded species across <2.5% of Earth's land area.
- Over 48,000 species of plants, ~97,000 species of animals documented; endemism notable in reptiles, amphibians, flowering plants.

## 2. Varied Climate and Topography

- o 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).
- $\circ \ \ \text{Balancing economic development with environmental sustainability remains a policy dilemma}.$

#### 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.

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## **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.

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