Ch 13 · Biodiversity & Conservation

अध्याय 13 · जैव विविधता एवं संरक्षण

Class 12 Biology · NCERT based · English + हिंदी · ✍️ revision notes

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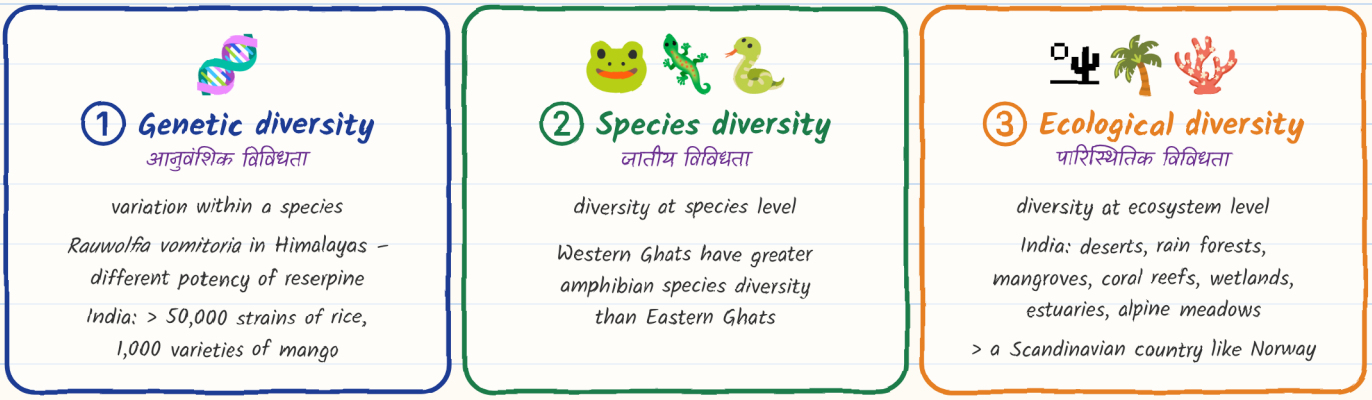
1. Biodiversity / जैव विविधता

- **Biodiversity** = the term popularised by socio-biologist Edward Wilson to describe the combined diversity at **all levels of biological organisation**.
- Life on earth is enormously diverse – not only in the number of species, but also at every level from macromolecules within cells to biomes.

3 levels of biodiversity · जैव विविधता के 3 स्तर



Infographic: Levels of biodiversity

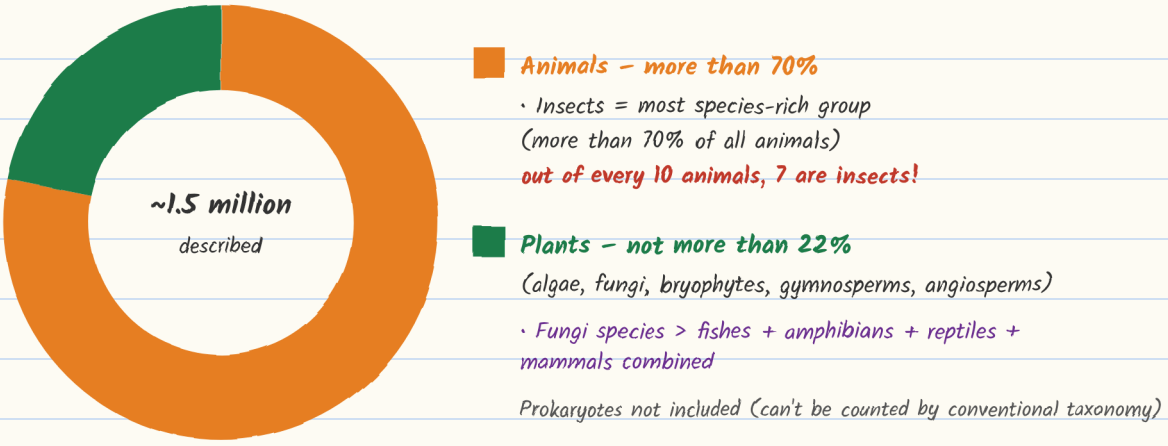
Level	Meaning	NCERT example
Genetic diversity	A single species might show high diversity at the genetic level over its distributional range	Medicinal plant *Rauwolfia vomitoria* growing in different Himalayan ranges shows genetic variation in terms of potency & concentration of active chemical **reserpine**. India has more than **50,000 genetically different strains of rice** & **1,000 varieties of mango**
Species diversity	Diversity at the species level	**Western Ghats** have a greater **amphibian** species diversity than the **Eastern Ghats**
Ecological diversity	Diversity at the ecosystem level	India, with its deserts, rain forests, mangroves, coral reefs, wetlands, estuaries & alpine meadows has greater ecosystem diversity than a Scandinavian country like **Norway**

📌 **Why care?** It has taken millions of years of evolution to accumulate this rich diversity in nature, but we could lose all that wealth in less than two centuries if the present rates of species losses continue. Biodiversity & its conservation are now vital environmental issues of international concern.

2. How Many Species are there on Earth & in India? / पृथ्वी व भारत में जातियाँ

- According to **IUCN (2004)**, the total number of plant & animal species **described** so far is slightly more than *1.5 million*.
- We have no clear idea of how many species are yet to be discovered & described. Estimates vary widely & many of them are only educated guesses.
- For many taxonomic groups, species inventories are more complete in temperate than in tropical countries. Biologists make a statistical comparison of the **temperate-tropical species richness** of an exhaustively studied group of insects & extrapolate this ratio to other groups of animals & plants to come up with a gross estimate.
- Such extreme estimates range from 20 to 50 million, but a more conservative & scientifically sound estimate made by *Robert May* places global species diversity at about *7 million*.

Global diversity of described species · जातियों का वैश्विक वितरण



Infographic: Proportionate number of species – animals vs plants (approx.)

- More than **70 per cent** of all species recorded are **animals**, while plants (including algae, fungi, bryophytes, gymnosperms & angiosperms) comprise no more than **22 per cent** of the total.
- Among animals, insects are the most species-rich taxonomic group, making up more than **70 per cent** of the total. That means, out of every 10 animals on this planet, **7 are insects**.
- Number of **fungi** species in the world is more than the combined total of species of fishes, amphibians, reptiles & mammals.
- Estimates do not give any figures for **prokaryotes** – biologists are not sure how many prokaryotic species there might be, because conventional taxonomic methods are not suitable for identifying microbial species & many species are simply not culturable under lab conditions. Their diversity alone might run into **millions**.

India's biodiversity भारत की जैव विविधता

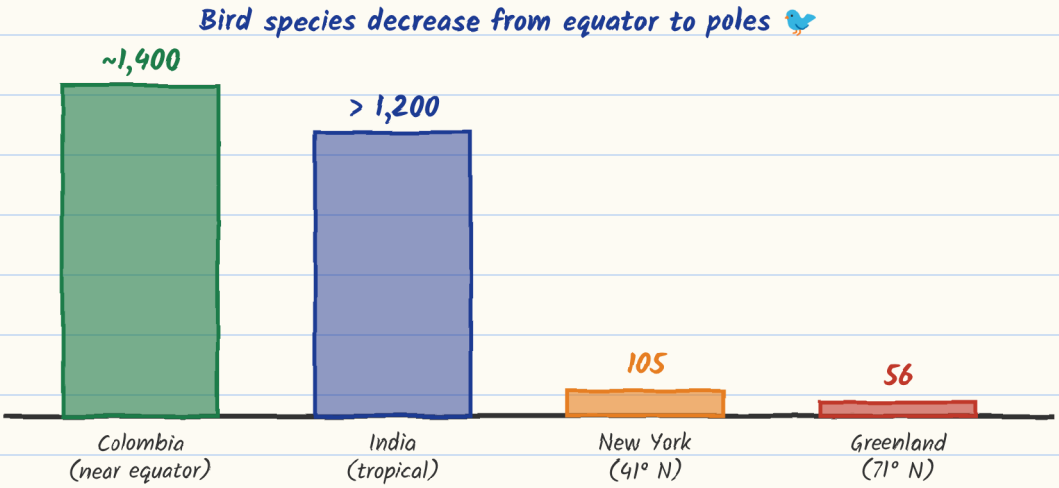
- India has only 2.4% of the world's land area, but its share of global species diversity is an impressive 8.1%.
- India is one of the 12 mega diversity countries of the world.
- Nearly **45,000 species of plants** & **twice as many of animals** have been recorded from India.
- Applying May's global estimates, only **22%** of the total species have been recorded so far. India may have more than **1,00,000 plant species** & more than **3,00,000 animal species** yet to be discovered & described.

📌 **Exam Tip:** Nature's biological library is burning even before we catalogued the titles of all the books stocked there. Majority of species might become extinct even before we discover them.

3. Patterns of Biodiversity / जैव विविधता के प्रतिरूप

(a) Latitudinal gradients अक्षांशीय प्रवणता

- Diversity of plants & animals is **not uniform** throughout the world; it shows a rather uneven distribution.
- In general, species diversity decreases as we move away from the equator towards the poles.
- **Tropics** (latitudinal range of **23.5° N to 23.5° S**) harbour more species than temperate or polar areas.



Infographic: Latitudinal gradient in bird species diversity (NCERT data)

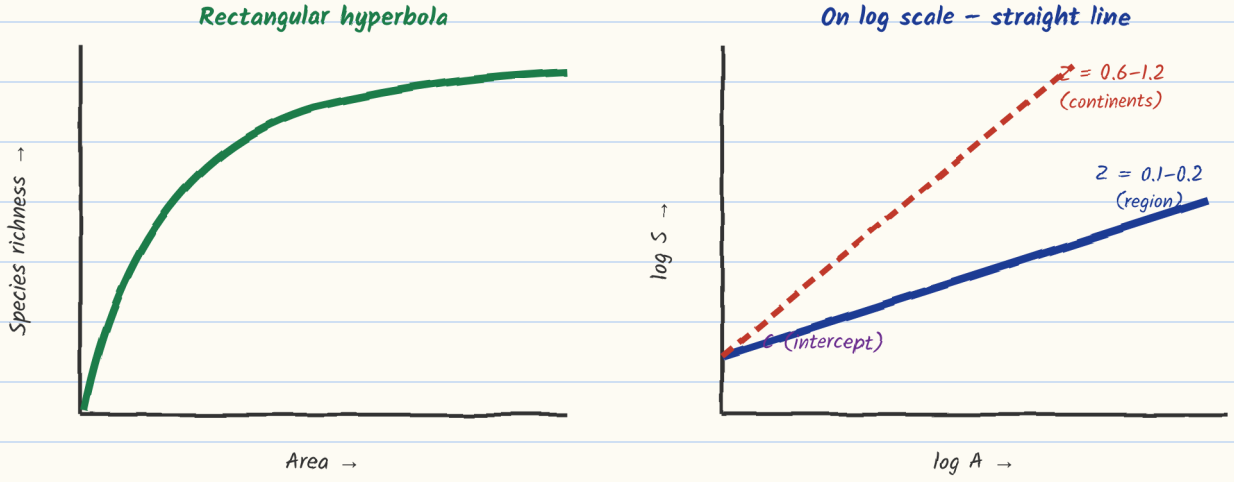
- **Colombia** located near the equator has nearly **1,400** species of birds while **New York at 41° N** has **105** species & **Greenland at 71° N** only **56** species. **India**, with much of its land area in the tropical latitudes, has more than **1,200** species of birds.
- A forest in a tropical region like **Ecuador** has up to **10 times** as many species of vascular plants as a forest of equal area in a temperate region like the Midwest of the USA.
- The largely tropical Amazonian rain forest in South America has the **greatest biodiversity on earth** – home to more than **40,000 species of plants, 3,000 of fishes, 1,300 of birds, 427 of mammals, 427 of amphibians, 378 of reptiles** & more than **1,25,000 invertebrates**.

Why are tropics richer in biodiversity? (उष्णकटिबंध में अधिक जैव विविधता क्यों?)

1. **Speciation is generally a function of time**, unlike temperate regions subjected to frequent **glaciations** in the past, tropical latitudes have remained relatively **undisturbed for millions of years** → long evolutionary time for species diversification.
2. Tropical environments, unlike temperate ones, are **less seasonal**, relatively more **constant & predictable** → promote **niche specialisation** → greater species diversity.
3. There is **more solar energy** available in the tropics → contributes to **higher productivity** → might contribute indirectly to greater diversity.

(b) Species-area relationships जाति-क्षेत्र संबंध

- During his pioneering & extensive explorations in the wilderness of South American jungles, the great German naturalist & geographer Alexander von Humboldt observed that within a region, **species richness increased with increasing explored area, but only up to a limit**.
- Relation between species richness & area for a wide variety of taxa (angiosperm plants, birds, bats, freshwater fishes) turns out to be a rectangular hyperbola.
- On a **logarithmic scale**, the relationship is a **straight line** described by the equation:



Infographic: Species-area relationship (Humboldt) · जाति-क्षेत्र संबंध

$$\log S = \log C + z \log A \quad (\text{or} \quad S = C A^z)$$

S = species richness; A = area; z = slope of the line (regression coefficient); C = Y-intercept

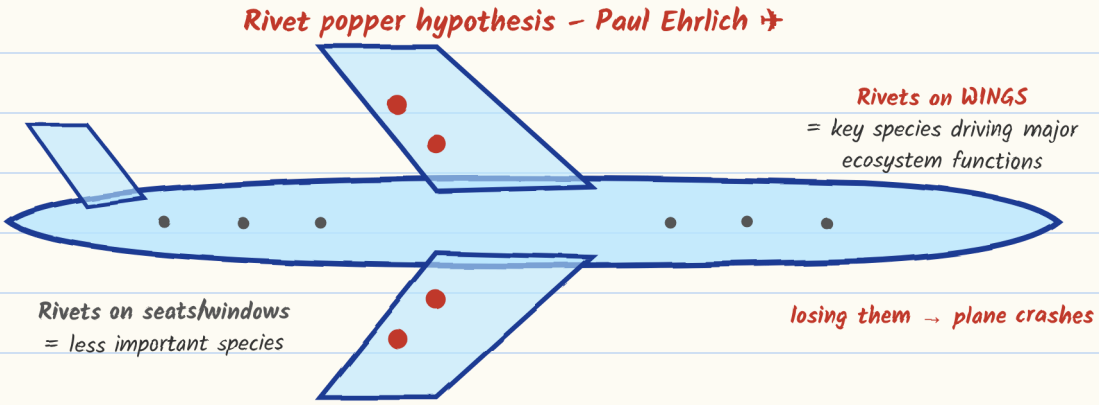
- Ecologists have discovered that the value of **z lies in the range of 0.1 to 0.2**, regardless of the taxonomic group or the region (whether it is the plants in Britain, birds in California or molluscs in New York state, slopes of regression line are amazingly similar).
- But, if you analyse species-area relationships among **very large areas like entire continents**, you will find that the slope of the line is **much steeper**, with **z values in the range of 0.6 to**

1.2.

- e.g. for frugivorous (fruit-eating) birds & mammals in the tropical forests of different continents, the slope is found to be **1.15**.
- A steeper slope (higher Z) means species richness increases faster as area increases.

4. Importance of Species Diversity to the Ecosystem / पारितंत्र के लिए जातीय विविधता का महत्व

- Does the number of species in a community really matter to the functioning of the ecosystem? Ecologists have not been able to give a definitive answer, but many believe that **communities with more species tend to be more stable** than those with less species.
- A stable community should not show too much variation in productivity from year to year; it must be either resistant or resilient to occasional disturbances (natural or man-made), & it must also be resistant to invasions by alien species.
- David Tilman's long-term ecosystem experiments using outdoor plots provide some tentative answers. He found that plots with **more species showed less year-to-year variation in total biomass**. He also showed that in his experiments, **increased diversity contributed to higher productivity**.



Infographic: Rivet popper hypothesis · रिवेट पॉपर परिकल्पना

- Stanford ecologist Paul Ehrlich proposed the 'rivet popper hypothesis':
  - In an airplane (ecosystem), all parts are joined together using thousands of rivets (species).
  - If every passenger travelling in it starts popping a rivet to take home (causing a species to become extinct), it may **not affect flight safety initially** (proper functioning of the ecosystem), but as more & more rivets are removed, the plane becomes **dangerously weak** over a period of time.
  - Furthermore, **which rivet is removed may also be critical**. Loss of rivets on the **wings** (key species that drive major ecosystem functions) is obviously a more serious threat to flight safety than loss of a few rivets on the seats or windows inside the plane.

5. Loss of Biodiversity / जैव विविधता की क्षति

- The colonisation of tropical Pacific Islands by humans is said to have led to the extinction of more than **2,000 species of native birds**.
- IUCN Red List (2004) documents the extinction of **784 species** (including **338 vertebrates, 359 invertebrates & 87 plants**) in the last **500 years**.
- Some examples of recent extinctions: dodo (Mauritius), quagga (Africa), thylacine (Australia), Steller's sea cow (Russia) & three subspecies (**Bali, Javan, Caspian**) of **tiger**.
- Last twenty years alone have witnessed the disappearance of **27 species**.
- Careful analysis of records shows that extinctions across taxa are not random; some groups like **amphibians** appear to be **more vulnerable** to extinction.
- Adding to the grim scenario of extinctions is the fact that more than **15,500 species** world-wide are facing the threat of extinction.

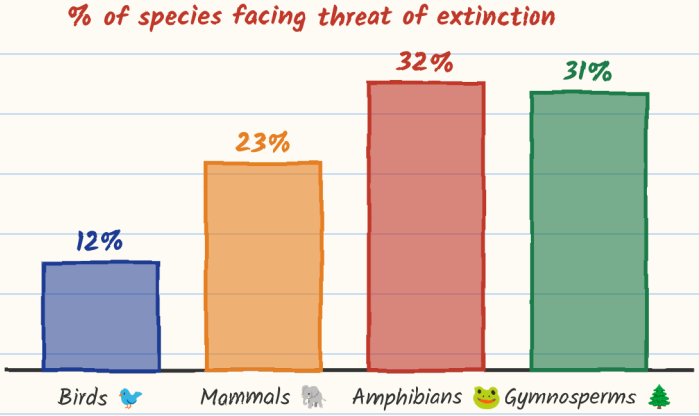


Fig: Threatened species by group (IUCN data in NCERT)

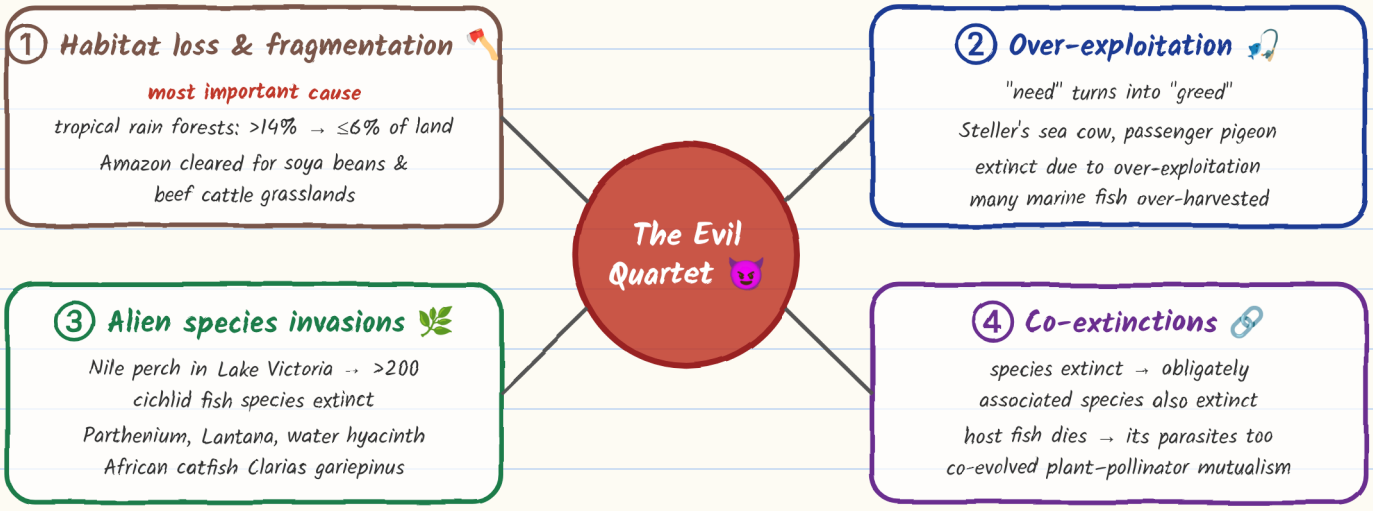
- Currently, **12%** of all bird species, **23%** of all mammal species, **32%** of all amphibian species & **31%** of all gymnosperm species in the world face the threat of extinction.
- From a study of the history of life on earth through fossil records, we learn that large-scale loss of species like the one we are currently witnessing has also happened earlier, even before humans appeared. During the long period (> 3 billion years) since the origin & diversification of life on earth, there were **five episodes of mass extinction** of species.
- 'Sixth Extinction' presently in progress is different from the previous episodes in that the current species extinction rates are estimated to be **100 to 1,000 times faster** than in the pre-human times, & our activities are responsible for the faster rates.
- Ecologists warn that if the present trends continue, nearly **half of all the species on earth might be wiped out within the next 100 years**.

Consequences of loss of biodiversity जैव विविधता क्षति के परिणाम

In general, loss of biodiversity in a region may lead to:

1. **Decline in plant production**.
2. **Lowered resistance** to environmental perturbations such as **drought**.
3. **Increased variability** in certain ecosystem processes such as plant productivity, water use, & pest & disease cycles.

Causes of biodiversity losses – 'The Evil Quartet' जैव विविधता क्षति के कारण – "दुष्ट चौकड़ी"



Infographic: The Evil Quartet – 4 major causes of biodiversity loss · दुष्ट चौकड़ी

Cause	Explanation & NCERT examples
① **Habitat loss & fragmentation** आवासीय क्षति व विखंडन	Most important cause driving animals & plants to extinction. Most dramatic examples in **tropical rain forests**. Once covering more than **14%** of the earth's land surface, these rain forests now cover **no more than 6%**. They are being destroyed fast. The Amazon rain forest (so huge that it is called the **'lungs of the planet'**) harbouring probably millions of species is being cut & cleared for cultivating **soya beans** or for conversion to grasslands for raising **beef cattle**. Besides total loss, degradation of many habitats by **pollution** also threatens survival. When large habitats are broken up into small fragments due to various human activities, **mammals & birds requiring large territories** & certain animals with **migratory habits** are badly affected → population declines.
② **Over-exploitation** अति-दोहन	Humans have always depended on nature for food & shelter, but when **'need' turns to 'greed'**, it leads to over-exploitation of natural resources. Many species extinctions in the last 500 years (Steller's sea cow, passenger pigeon) were due to over-exploitation by humans. Presently many marine fish populations around the world are **over-harvested**, endangering the continued existence of some commercially important species.
③ **Alien species invasions** विदेशी जातियों का आक्रमण	When alien species are introduced unintentionally or deliberately for whatever purpose, some of them turn **invasive**, & cause decline or extinction of indigenous species. · Nile perch introduced into **Lake Victoria** in East Africa led eventually to the extinction of an ecologically unique assemblage of more than **200 species of cichlid fish** in the lake. · Environmental damage caused & threat posed to our native species by invasive weed species like **carrot grass (Parthenium), Lantana & water hyacinth (Eicchornia)**. · Recent illegal introduction of the **African catfish *Clarias gariepinus*** for aquaculture purposes is posing a threat to the indigenous catfishes in our rivers.
④ **Co-extinctions** सह-विलुप्तता	When a species becomes extinct, the plant & animal species associated with it in an **obligatory way** also become extinct. · When a **host fish** species becomes extinct, its unique assemblage of **parasites** also meets the same fate. · Case of a **co-evolved plant-pollinator mutualism** where extinction of one invariably leads to the extinction of the other.

6. Why Should We Conserve Biodiversity? / जैव विविधता का संरक्षण क्यों?



Infographic: Three arguments for conserving biodiversity

(a) Narrowly utilitarian argument संकीर्ण रूप से उपयोगितावादी

- Humans derive countless **direct economic benefits** from nature – **food** (cereals, pulses, fruits), **firewood, fibre, construction material**, industrial products (**tannins, lubricants, dyes, resins, perfumes**) & products of **medicinal importance**.
- More than 25 per cent of the drugs currently sold in the market worldwide are derived from plants, & **25,000 species of plants** contribute to the traditional medicines used by native peoples around the world.
- Nobody knows how many more medicinally useful plants there are in tropical rain forests waiting to be explored.
- With increasing resources put into 'bioprospecting' (जैव पूर्वेक्षण) (exploring molecular, genetic & species-level diversity for products of economic importance), nations endowed with rich biodiversity can expect to reap enormous benefits.

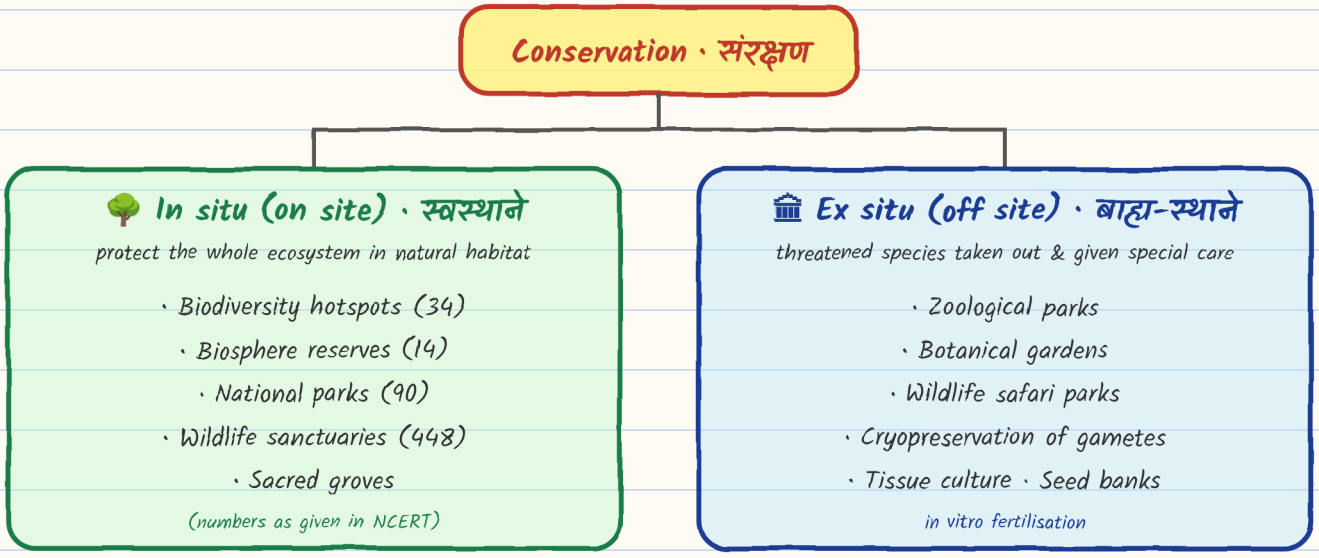
(b) Broadly utilitarian argument व्यापक रूप से उपयोगितावादी

- Biodiversity plays a major role in many **ecosystem services** that nature provides.
- The fast-dwindling Amazon forest is estimated to produce, through photosynthesis, 20 per cent of the total oxygen in the earth's atmosphere.
- **Pollination** (without which plants cannot give us fruits or seeds) – another service ecosystems provide through pollinators: **bees, bumblebees, birds & bats**.
- Other intangible benefits – **aesthetic pleasures** of walking through thick woods, watching spring flowers in full bloom or waking up to a **bulbul's song** in the morning.

(c) Ethical argument नैतिक तर्क

- We share this planet with millions of plant, animal & microbe species. We need to realise that every species has an intrinsic value, even if it may not be of any current economic value to us.
- We have a **moral duty** to care for their well-being & pass on our biological legacy in good order to future generations.

7. How do we Conserve Biodiversity? / जैव विविधता का संरक्षण कैसे?



Infographic: In situ vs ex situ conservation · स्वस्थाने व बाह्य-स्थाने संरक्षण

When we conserve & protect the whole ecosystem, its biodiversity at all levels is protected – e.g. we save the entire forest to save the tiger. This approach = in situ (on site) conservation. However, when there are situations where an animal or plant is endangered or threatened & needs urgent measures to save it from extinction, ex situ (off site) conservation is the desirable approach.

(a) In situ conservation स्वस्थाने संरक्षण

- Faced with the conflict between development & conservation, many nations find it unrealistic & economically not feasible to conserve all their biological wealth. Invariably, the number of species waiting to be saved from extinction far exceeds the conservation resources available.
- On a global basis, this problem has been addressed by eminent conservationists. They identified for maximum protection certain 'biodiversity hotspots' – regions with **very high levels of species richness** & **high degree of endemism** (that is, species confined to that region & not found anywhere else).
- Initially **25** biodiversity hotspots were identified, but subsequently **nine more** have been added to the list, bringing the total number of biodiversity hotspots in the world to 34.
- These hotspots are also regions of accelerated habitat loss.

Three hotspots covering India's rich biodiversity regions (भारत के जैव विविधता हॉटस्पॉट):

1. **Western Ghats & Sri Lanka**
2. **Indo-Burma**
3. **Himalaya**

Although all the biodiversity hotspots put together cover less than 2 per cent of the earth's land area, the number of species they collectively harbour is extremely high, & **strict protection of these hotspots could reduce the ongoing mass extinctions by almost 30 per cent**.

- In India, ecologically unique & biodiversity-rich regions are legally protected as **biosphere reserves, national parks & sanctuaries**.
- India now has 14 biosphere reserves, 90 national parks & 448 wildlife sanctuaries (as given in NCERT).
- India also has a history of religious & cultural traditions that emphasised protection of nature. In many cultures, tracts of forest were set aside, & all the trees & wildlife within were venerated & given total protection = sacred groves (पवित्र उपवन).

Sacred groves found in
Khasi & Jaintia Hills in **Meghalaya**
Aravalli Hills of **Rajasthan**
Western Ghat regions of **Karnataka & Maharashtra**
Sarguja, Chanda & Bastar areas of **Madhya Pradesh**

In **Meghalaya**, the sacred groves are the **last refuges** for a large number of rare & threatened plants.

(b) Ex situ conservation बाह्य-स्थाने संरक्षण

- Threatened animals & plants are taken out from their natural habitat & placed in special settings where they can be **protected & given special care**.
- **Zoological parks, botanical gardens & wildlife safari parks** serve this purpose. There are many animals that have become extinct in the wild but continue to be maintained in zoological parks.
- In recent years ex situ conservation has advanced beyond keeping threatened species. Now gametes of threatened species can be preserved in viable & fertile condition for long periods using cryopreservation techniques.
- Eggs can be **fertilised in vitro**, & plants can be propagated using **tissue culture** methods.
- Seeds of different genetic strains of commercially important plants can be kept for long periods in seed banks.

(c) International efforts अंतर्राष्ट्रीय प्रयास

Biodiversity knows no political boundaries; conservation of biodiversity is a ***collective responsibility of all nations.***

Event	Year & place	Outcome
The Earth Summit (Convention on Biodiversity)	**1992, Rio de Janeiro** (Brazil)	Called upon all nations to take appropriate measures for conservation of biodiversity & sustainable utilisation of its benefits
World Summit on Sustainable Development	**2002, Johannesburg** (South Africa)	**190 countries** pledged their commitment to achieve by **2010** a significant reduction in the current rate of biodiversity loss at global, regional & local levels

⚡ Quick Revision / त्वरित पुनरावृत्ति

Keyword	Remember
Biodiversity term popularised by	Edward Wilson
Rauwolfia vomitoria	Genetic diversity – reserpine
Described species (IUCN 2004)	~1.5 million
Robert May's estimate	~7 million
Insects	> 70% of animals; 7 out of 10 animals
India	2.4% land, 8.1% species, 12 mega diversity countries
Tropics	23.5° N to 23.5° S
Birds	Colombia 1400; India 1200+; New York 105; Greenland 56
Species-area	Humboldt; log S = log C + Z log A
Z values	0.1–0.2 (regions); 0.6–1.2 (continents); 1.15 (frugivores)
David Tilman	More species → less variation, higher productivity
Paul Ehrlich	Rivet popper hypothesis
IUCN Red List 2004	784 extinctions in 500 yrs (338 vertebrates, 359 invertebrates, 87 plants)
Recent extinctions	Dodo, quagga, thylacine, Steller's sea cow, 3 tiger subspecies
Sixth extinction	100–1000 times faster than pre-human times
Evil Quartet	Habitat loss, over-exploitation, alien species, co-extinction
Nile perch	Lake Victoria – >200 cichlid species extinct
Amazon	Lungs of the planet; 20% of earth's O_2
Hotspots	34 world; 3 in India; < 2% land; could cut extinctions ~30%
Earth Summit	Rio de Janeiro, 1992
WSSD	Johannesburg, 2002 – 190 countries, target 2010

⭐ Exam Corner / परीक्षा उपयोगी प्रश्न

1-Mark Questions 1M

Q1. Who popularised the term biodiversity? / जैव विविधता शब्द को किसने लोकप्रिय बनाया?

→ Edward Wilson.

Q2. Name the three biodiversity hotspots in India.

→ Western Ghats & Sri Lanka, Indo-Burma, Himalaya.

Q3. What does 'z' represent in the species-area equation?

→ Slope of the line (regression coefficient).

Q4. Name the most species-rich group of animals.

→ Insects.

Q5. Which is the most important cause of loss of biodiversity?

→ Habitat loss & fragmentation.

Q6. Why is the Amazon forest called "lungs of the planet"?

→ Produces ~20% of earth's oxygen through photosynthesis.

Q7. What is bioprospecting?

→ Exploring molecular, genetic & species-level diversity for products of economic importance.

Q8. Give an example of genetic diversity from NCERT.

→ Rauwolfia vomitoria (reserpine) / 50,000 rice strains / 1,000 mango varieties.

2/3-Mark Questions 2-3M

Q9. Explain the three levels of biodiversity with one example each.

→ Genetic (Rauwolfia), species (Western vs Eastern Ghats amphibians), ecological (India vs Norway).

Q10. Why are tropics richer in biodiversity than temperate regions? (Give 3 reasons)

→ Undisturbed for millions of years (no glaciations), less seasonal & predictable (niche specialisation), more solar energy (higher productivity).

Q11. Write the equation of species-area relationship and explain the terms. What are the z values for small regions & continents?

→ $\log S = \log C + z \log A$; $z = 0.1–0.2$ (regions), $0.6–1.2$ (continents).

Q12. Explain the rivet popper hypothesis.

→ Paul Ehrlich; plane = ecosystem, rivets = species; losing key species (wing rivets) more dangerous.

Q13. What are the consequences of loss of biodiversity?

→ Decline in plant production, lowered resistance to drought, increased variability in productivity, water use, pest & disease cycles.

Q14. How did the introduction of Nile perch affect Lake Victoria?

→ Extinction of more than 200 cichlid fish species (alien species invasion).

Q15. What is co-extinction? Give an example.

→ Obligatorily associated species die with the host; host fish & its parasites; plant-pollinator mutualism.

Q16. What are sacred groves? Name any two regions in India where they are found.

→ Forest tracts protected by religious tradition; Khasi & Jaintia hills (Meghalaya), Aravalli (Rajasthan), Western Ghats, Bastar.

5-Mark Questions SM ★★★

Q17. What is the 'Evil Quartet'? Explain each with examples.

→ Habitat loss & fragmentation (rain forests, Amazon), over-exploitation (Steller's sea cow, passenger pigeon), alien species (Nile perch, Parthenium, Lantana, water hyacinth, African catfish), co-extinctions.

Q18. Why should we conserve biodiversity? Explain the three arguments.

→ Narrowly utilitarian (food, medicines, bioprospecting), broadly utilitarian (ecosystem services, O_2, pollination, aesthetic), ethical (intrinsic value).

Q19. Differentiate between in situ and ex situ conservation with examples.

→ Hotspots, biosphere reserves, national parks, sanctuaries, sacred groves vs zoos, botanical gardens, safari parks, cryopreservation, tissue culture, seed banks.

Q20. Describe latitudinal gradients and species-area relationships as patterns of biodiversity.

→ Equator-to-pole decline (bird data, Amazon); Humboldt, rectangular hyperbola, log equation, Z values.

✏ **Diagrams to practise / अभ्यास हेतु चित्र:**

1. Species-area relationship graph (normal & log scale) ⭐
2. Pie chart of global biodiversity (proportionate species)

🎯 **Last-minute tips:** Learn NCERT numbers exactly – they are favourite MCQs (1.5 mn, 7 mn, 2.4%, 8.1%, 34 hotspots, 784 extinctions, 12/23/32/31%) · Evil Quartet trick: "**H-O-A-C**" – **H**abitat, **O**ver-exploitation, **A**lien, **C**o-extinction · Always pair a cause with its NCERT example · Remember Z ranges for regions vs continents.

~ All the best for your Board Exams! / बोर्ड परीक्षा के लिए शुभकामनाएँ! 🎉 ~