M.Sc 2nd Semester

ENV C21

Topic: Biodiversity

Dr. Santanu Chowdhury

BIODIVERSITY

Biodiversity or biological diversity simply means the variety of life. The more formal definition is **''the variety and variability among all groups of living organisms and the ecological complexes of which they are a part''** this includes diversity within species, between species and ecosystems."

Article 2 of the **CBD** defines "Biological diversity 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 part; this includes biological diversity within species and ecosystems".

According to Edward Wilson "Biodiversity is the combined diversity at all the levels of biological organization."

Biodiversity is basically the variety within and among life forms on a site, ecosystem, or landscape. Biodiversity is defined and measured as an attribute that has two components — **richness** and **evenness**.

Richness : The number of groups of genetically or functionally related individuals. In most vegetation surveys, richness is expressed as the number of species and is usually called **species richness**.

Evenness : Proportions of species or functional groups present on a site. The more equal species are in proportion to each other the greater the evenness of the site. A site with low evenness indicates that a few species dominate the site.

- *Since there are published records of all the species discovered and named, we know how many species in all have been recorded so far, but it is not easy to answer the question of how many species there are on earth. According to the IUCN (2004), the total number of plant and animal species described so far is slightly more than 1.5 million, but we have no clear idea of how many species are yet to be discovered and described. Some extreme estimates range from 20 to 50 million, but a more conservative and scientifically sound estimate made by **Robert May** places the global species diversity at about 7 million.*

- *Although India has only 2.4 per cent of the world's land area, its share of the global species diversity is an impressive 8.1 per cent. That is what makes our country one of the 12 mega diversity countries of the world. Nearly 45,000 species of plants and twice as many of animals have been recorded from India. If we accept Robert May's global estimates, only 22 per cent of the total species have been recorded so far. Applying this proportion to India's diversity figures, we estimate that there are probably more than 1,00,000 plant species and more than 3,00, 000 animal species yet to be discovered and described.*

Diversity can be used to describe variation in several forms:

- Genetic diversity
- Species diversity
- Ecosystem diversity

Genetic diversity - Genes are the basic units of hereditary information transmitted from one generation to other. A single species might show high diversity at the genetic level over its distributional range. The genetic variation shown by the medicinal plant Rauwolfia vomitoria growing in different Himalayan ranges might be in terms of the potency and concentration of the active chemical (reserpine) that the plant produces. India has more than 50,000 genetically different strains of rice, and 1,000 varieties of mango Genetic diversity revolves around the components of the genetic material that makes up organisms and the variations in the genetic construct between individuals of a certain population and between populations.

Species diversity - This is the variability found within the population of a species. The richness of species in an ecosystem is called species diversity. The total number of living species is in the range of 10-50 million. But till now only about 1.5 million species have been actually described and given scientific names. For example, the Western Ghats have a greater amphibian species diversity than the Eastern Ghats.

Ecosystem diversity - An ecosystem develops its own characteristic community of living organisms depending upon the availability of abiotic resources, environmental conditions and other factors. This diversity has developed over millions of years of evolution and is of great value that must be kept intact. At the ecosystem level, India, for instance, with its deserts, rain forests, mangroves, coral reefs, wetlands, estuaries, and alpine meadows has a greater ecosystem diversity than a Scandinavian country like Norway.

Alpha, Beta, and Gamma Diversity

Biodiversity is a measure that combines richness and evenness across species. It is often measured because high biodiversity is perceived a synonymous with ecosystem health. In general diverse communities are believed to have increased stability, increased productivity, and resistance to invasion and other disturbances.

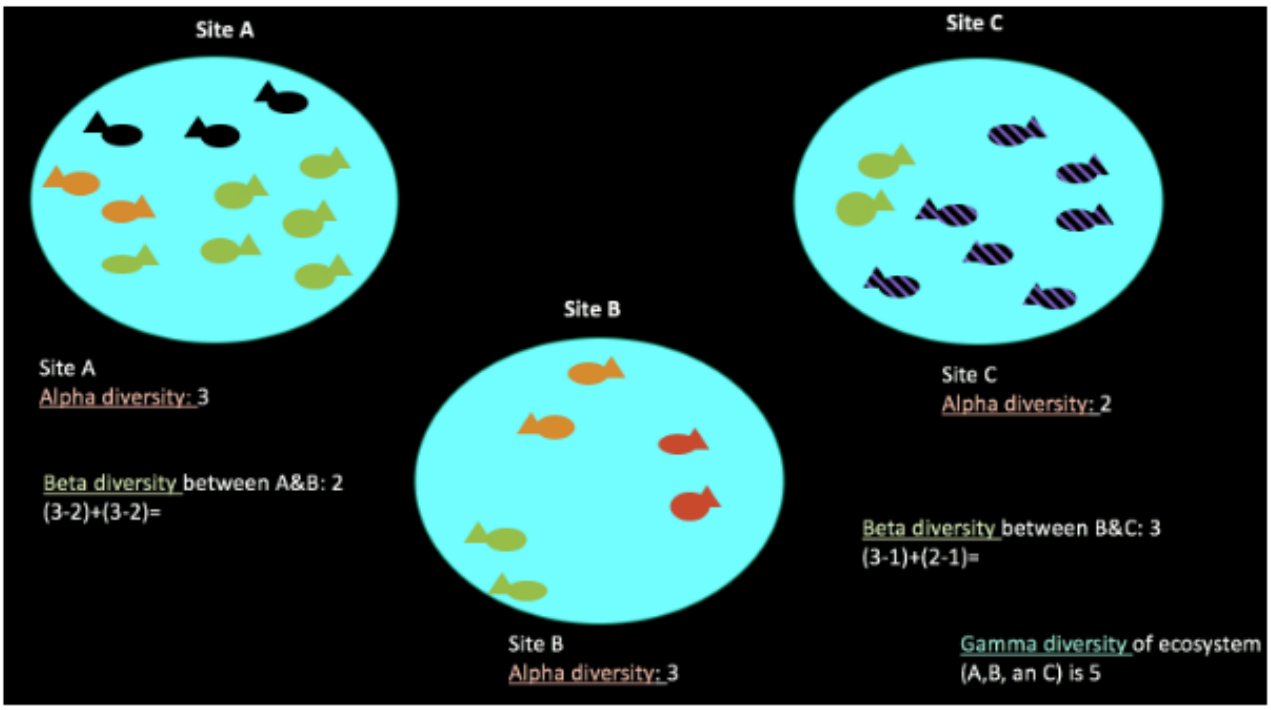
Whittaker (1972) described three terms for measuring biodiversity over spatial scales: alpha, beta, and gamma diversity.

- **Alpha diversity** refers to the diversity within a particular area or ecosystem, and is usually expressed by the number of species (i.e., **species richness**) in that ecosystem.

- **Beta diversity** is a comparison of diversity between ecosystems, usually measured as the amount of species change between the ecosystems.This is the diversity of species between two habitats or regions. It is calculated by the following equation:

(Number species in habitat 1- Number of species habitat 2&1 have in common) + (Number of sp in habitat 2- Number of species habitat1&2 have in common)

- **Gamma diversity** is a measure of the overall diversity for the different ecosystems within a region. it is also called "geographic-scale species diversity"according to Hunter (2002)



- *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 and its conservation are now vital environmental issues of international concern as more and more people around the world begin to realise the critical importance of biodiversity for our survival and well- being on this planet.*

Values of Biodiversity

The multiple uses of biodiversity value have been classified by **McNeely** et al in as follows:

- *Consumptive use value*
- *Productive use value*
- *Social value*
- *Ethical value*
- *Aesthetic value*
- *Option values*
- *Ecosystem service value*

➢ *Direct values:*

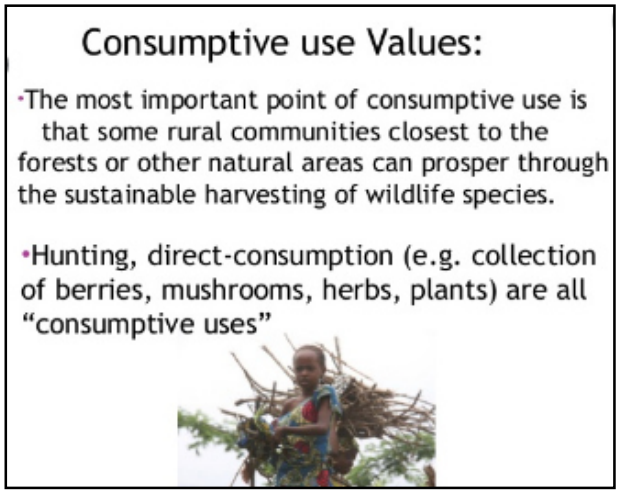
Consumptive use value

These are direct use values where the biodiversity product can be harvested and consumed directly e.g. fuel, food, drugs, fibre etc.

Food: A large number of plants are consumed by human beings as food. About 90% of present day crops have been domesticated from wild tropical plants.

Drugs and medicines:75% of the world's population depends upon plants or plant extracts for medicines Penicillin-Penicillium Quinine-Bark of cinchona Vinblastin and Vincristine-Catharanthus

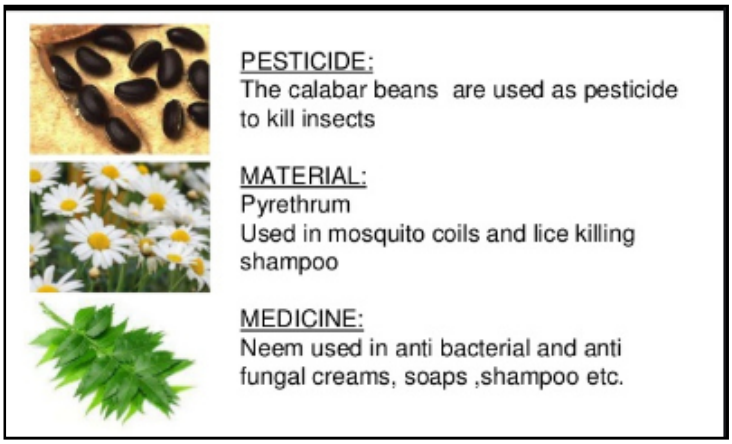
Fuel: Forests have been used since ages for fuel wood. Fossil fuels are also products of fossilized biodiversity



Productive use value

These are commercially usable values where the product is marketed and sold

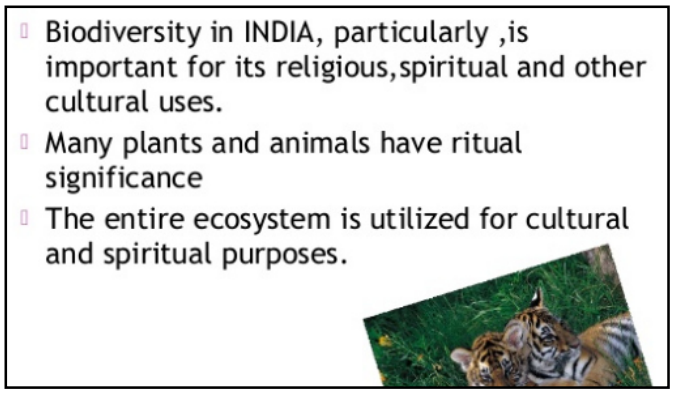
- It may be lumber, wild gene resources
- Animal products like tusks of elephants, musk from musk deer, wool from sheep
- Despite international ban on trade in products from endangered species, smuggled hide, fur, tusks worth millions of dollars are being sold.



- ***Indirect values:***

Social value

- Values associated with the social life, customs, religion and psycho-spiritual aspects of people
- Many of the plants are considered holy and sacred in our country (Tulsi, Peepal, Mango)
- Many animals like cow, snake, bull, peacock also have significant place in our psycho-spiritual arena and thus hold special social importance



Ethical value

- Ethical values is also sometimes known as existence value.
- It involves ethical issues like "all life must be preserved" and the concept of "Live and let live"
- The ethical value means we may or may not use a species, but we feel the existence of the species is necessary

Aesthetic value

- Great aesthetic value is attached to biodiversity
- Stretches of barren lands with no signs of visible life is not a pleasant sight
- Eco-tourism is based on the aesthetic value of biodiversity
- Ecotourism is estimated to generate about 12 billion dollars of revenue annually

Option values

- These include the potentials of biodiversity that are presently unknown and need to be explored
- For eg, there is a possibility that we may have potential cure for AIDS or cancer existing within the depths of marine ecosystem, or tropical ecosystem

Ecosystem service value

It refers to the services provided by ecosystem like

1) Prevention of soil erosion
2) Prevention of floods
3) Maintenance of soil fertility
4) Cycling of nutrients and water
5) Fixation of nitrogen
6) Role as carbon sinks

- *Different categories of biodiversity value clearly indicate that ecosystem, species and genetic diversity have enormous potential and a decline in biodiversity will lead to huge economic, ecological and socio-cultural losses.*

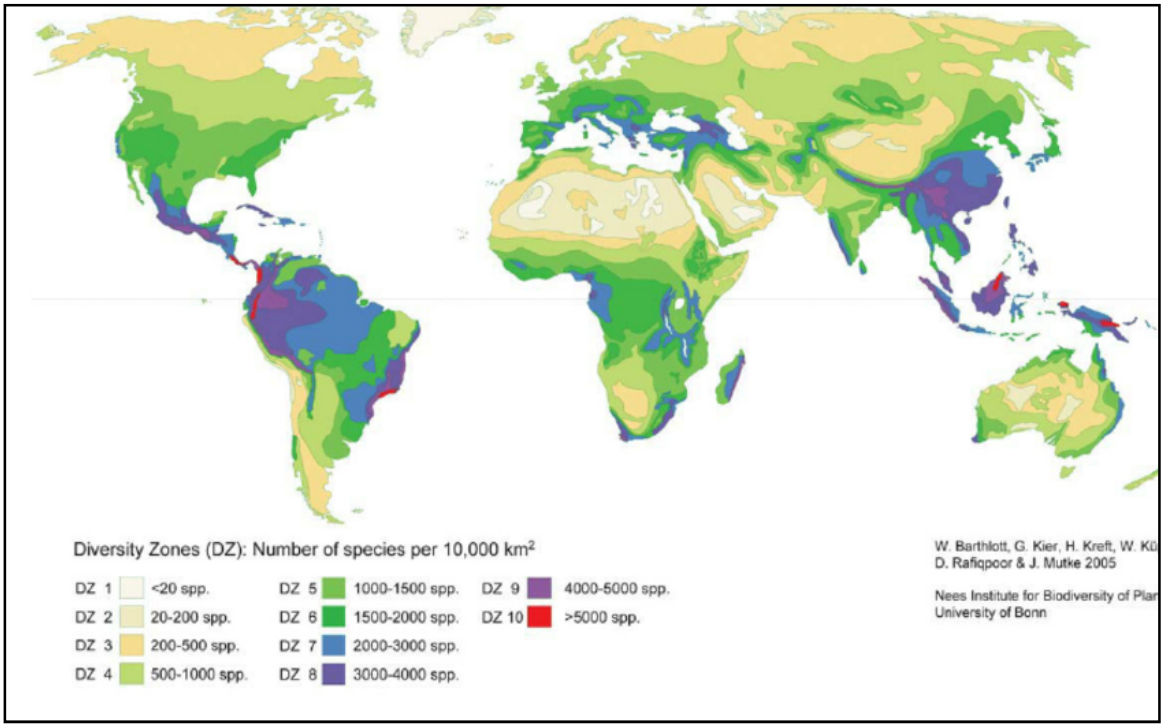
Global pattern of Biodiversity

Biodiversity, the variety of life, is distributed heterogeneously across the Earth. Some areas teem with biological variation (for example, some moist tropical forests and coral reefs), others are virtually devoid of life (for example, some deserts and polar regions), and most fall somewhere in between. This includes patterns in hotspots and coldspots (highs and lows) of diversity (including comparisons between biological realms and between biogeographical regions), variation with spatial scale (for example, species–area relationships and relationships between local and regional richness) and along gradients across space or environmental conditions (for example, latitude, longitude, altitude, depth, peninsulas, bays, isolation, productivity/energy and aridity). Although several different levels of organization (genes to ecosystems) of biological variation can be distinguished, most analyses of spatial variation concern biodiversity as measured by the number of species observed or estimated to occur in an area (species richness). This results from widespread recognition of the significance of the species as a biological unit, and from the practical issues of the ease and magnitude of data acquisition. Consideration of spatial variation in other measures of biodiversity, particularly those concerning the difference between entities rather than simply their numbers, has been remarkably sparse (with the possible exception of patterns in body size and morphology). Thus, although much attention has been paid to latitudinal variation in species richness, little is known about variation in the diversity of genes, individuals or populations along latitudinal gradients. The growth of interest in broad-scale spatial variation in biodiversity has been particularly striking with regard to four areas of enquiry: latitudinal gradients in species richness, species–energy relationships, relationships between local and regional richness, and taxonomic covariance in species richness

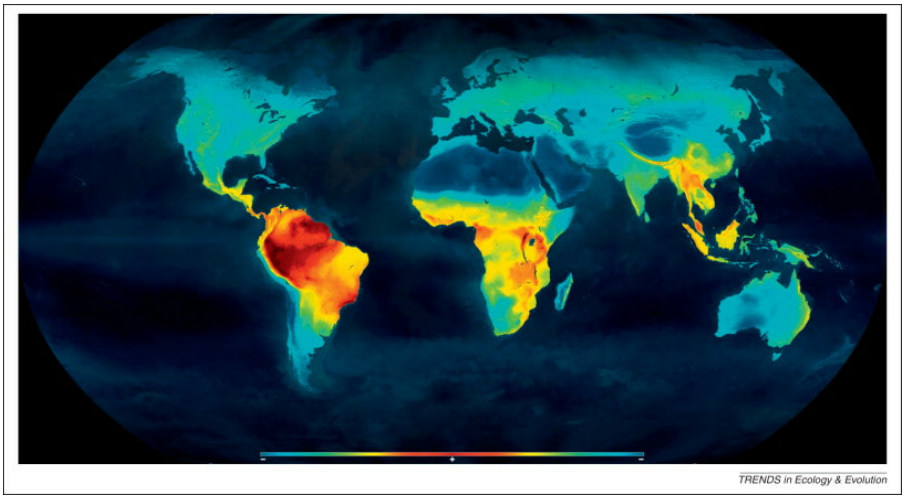
Latitudinal gradients in species richness

High proportions of terrestrial and freshwater species occur in the tropics. Moving from high to low latitudes the average species richness within a sampling area of a given size increases, as has been documented for a wide spectrum of taxonomic groups. It is interesting to note that this change is not monotonic, but sometimes it happens an abrupt decline in species richness while moving from the equator to the poles. It has been

showed for many different species. However, it does not apply to all mammal species and world regions. In marine mammals, for example, the peak of diversity seem to happens at higher latitudes. Many reasons have been proposed to explain this gradient. In the tropics, high primary productivity, climatic stability, and habitat heterogeneity are some of the main factors that are cited as the responsible for the creation and maintenance of this pattern. The high diversity, which promotes interespecific interactions seems to be also strengthen the latidudinal gradient by promoting species coexistence.



Latitudinal gradient of vascular plant species (Mutke et al. 2010).



An example of the modern-day latitudinal biodiversity gradient. Distribution of extant terrestrial vertebrate species showing the high concentration of diversity in equatorial regions (closer to the red end of the colour spectrum), declining polewards (closer to the blue end of the colour spectrum) to form the modern-day latitudinal biodiversity gradient. (Mannion et al. 2014)

Biogeographical classification of India

India has different types of climate and topography in different parts of the country and these variations have induces enormous variability in flora and fauna. India has a rich heritage of biological diversity and occupies the tenth position among the plant rich nations of the world. Based on the biodiversity, climate, topography India has been classified into 10 biogeographic zones

- Trans-Himalayan Region
- Himalayan Zone
- Indian Desert Zone
- Semi Arid Region
- Western Ghats
- Deccan Plateau
- Gangetic Plain
- North East Region
- Coastal Region
- Andaman and Nicobar Islands

- ***Trans-Himalayan Region***

It constitutes 5.6 per cent of the total geographical area, includes the high altitude, cold and arid mountain areas of Ladakh, Jammu & Kashmir, North Sikkim, Lahaul and Spiti areas of Himachal Pradesh. This zone has sparse alpine steppe vegetation that harbours several endemic species and is a favourable habitat for the *biggest populations of wild sheep and goat in the world* and other rare fauna that *includes* ***Snow Leopard*** *and the migratory Blacknecked Crane (Grus nigricollis).* The cold dry desert of this zone represents an extremely fragile ecosystem.

- ***Himalayan Zone***

It constitutes 6.4 per cent of the total geographical area includes some of the highest peaks in the world. The Himalayan zone makes India one of the richest areas in terms of habitats and species.

The alpine and sub-alpine forests, grassy meadows and moist mixed deciduous forests provide diverse habitat for endangered species of bovids such as Bharal (*Pseudois nayaur*), Ibex (*Capra ibex*), Markhor (*Capra falconeri*), Himalayan Tahr (*Hemitragus jemlabicus*), and Takin (*Budoreas taxicolor*). Other rare and endangered species restricted to this zone include Hangul (*Cervus eldi eldi*) and Musk Deer (*Moschus moschiferus*).

- ***Indian Desert Zone***

Indian Desert Zone, constituting 6.6 per cent of the total geographical area, includes the Thar and the Kutch deserts and has large expanses of grassland that supports several

endangered species of mammals such as Wolf (*Canis lupus*), Caracal (*Felis caracal*), Desert Cat (*Felis libyca*) and birds of conservation interest viz., Houbara Bustard (*Chamydotis undulate*) and the Great Indian Bustard (*Ardeotis nigriceps*).

- ***Semi Arid Region***

Semi-arid Region, constituting 16.6 per cent of the total geographical area, is a transition zone between the desert and the dense forests of Western Ghats.
Peninsular India has two large regions, which are climatically semi-arid. *This semi-arid region also has several artificial and natural lakes and marshy lands.*
The *dominant grass and palatable shrub layer in this zone supports the highest wildlife biomass*. The cervid species of **Sambar** (*Cervus unicolor*) and **Chital** (*Axis axis*) are restricted to the better wooded hills and moister valley areas respectively. The Lion (*Leo persica*), an endangered carnivore species (restricted to a small area in Gujarat), Caracal (Felis caracal),Jackal (Canis aureus) and Wolf (Canis lupus) are some of the endangered species that are characteristic of this region.

- ***Western Ghats***

Constitutes 4.0 per cent of the total geographical area. It is one of the major tropical evergreen forest regions in India and represents one of the two biodiversity 'hot spots'. Western Ghats are home to viable populations of most of the vertebrate species found in peninsular India, besides an endemic faunal element of its own.
Significant species endemic to this region include **Nilgiri Langur** *(Presbytis jobni),* **Lion Tailed Macaque** *(Macaca silenus),* **Grizzled Giant Squirrel** *(Ratufa macroura),* **Malabar Civet** *(Viverricula megaspila),* **Nilgiri Tahr** *(Hemitragus bylocrius)* **and Malabar Grey Hornbill** *(Ocycerous griseus).* The Travancore Tortoise *(Indotestudo forstem)* and Cane turtle *(Heosemys silvatica)* are two endangered taxa restricted to a small area in central Western Ghats.

- ***Deccan Plateau***

Deccan Plateu is India's largest biogeographic region making 42 per cent of the total geographical area. It's a semi-arid region that falls in the rain shadow area of the Western Ghats. This bio-geographic zone of peninsular India is by far the most extensive zone, covering India's finest forests, particularly in the States of Madhya Pradesh, Maharashtra and Odisha.
Majority of the forests are deciduous in nature but there are regions of greater biological diversity in the hill ranges. The zone comprising of deciduous forests, thorn forests and degraded scrubland support diverse wildlife species.
Species found in this region are **Chital** *(Axis axis),* **Sambar** *(Cervus unicolor),* **Nilgai** *(Boselapbus tragocamelus)* **and Chousingha** *(Tetracerus quadricornis)*, **Barking deer** (Muntiacus muntjak) and Gaur (Antilope cervicapra), Elephant (Elephas maximus) in Bihar-Orissa and Karnataka-Tamil Nadu belts, Wild Buffalo (Bubalus bubalis) in a small area at the junction of Orissa, Madhya Pradesh and

Maharashtra and the hard ground Swamp Deer (Cervus duvauceli), now restricted to a single locality in Madhya Pradesh.

- ***Gangetic Plain***

Gangetoc plain constitutes around 10.8 per cent of the total geographical area. The Gangetic plain is topographically homogenous for hundreds of kilometers. The characterstic fauna of this region include Rhino (Rhinoceros unicornis), Elephant (Elephas maximus), Buffalo (Bubalus bubalis), Swamp Deer (Cervus duvauceli), Hog-Deer (Axis porcinus) and Hispid Hare (Carprolagus bispidus).

- ***North East Region***

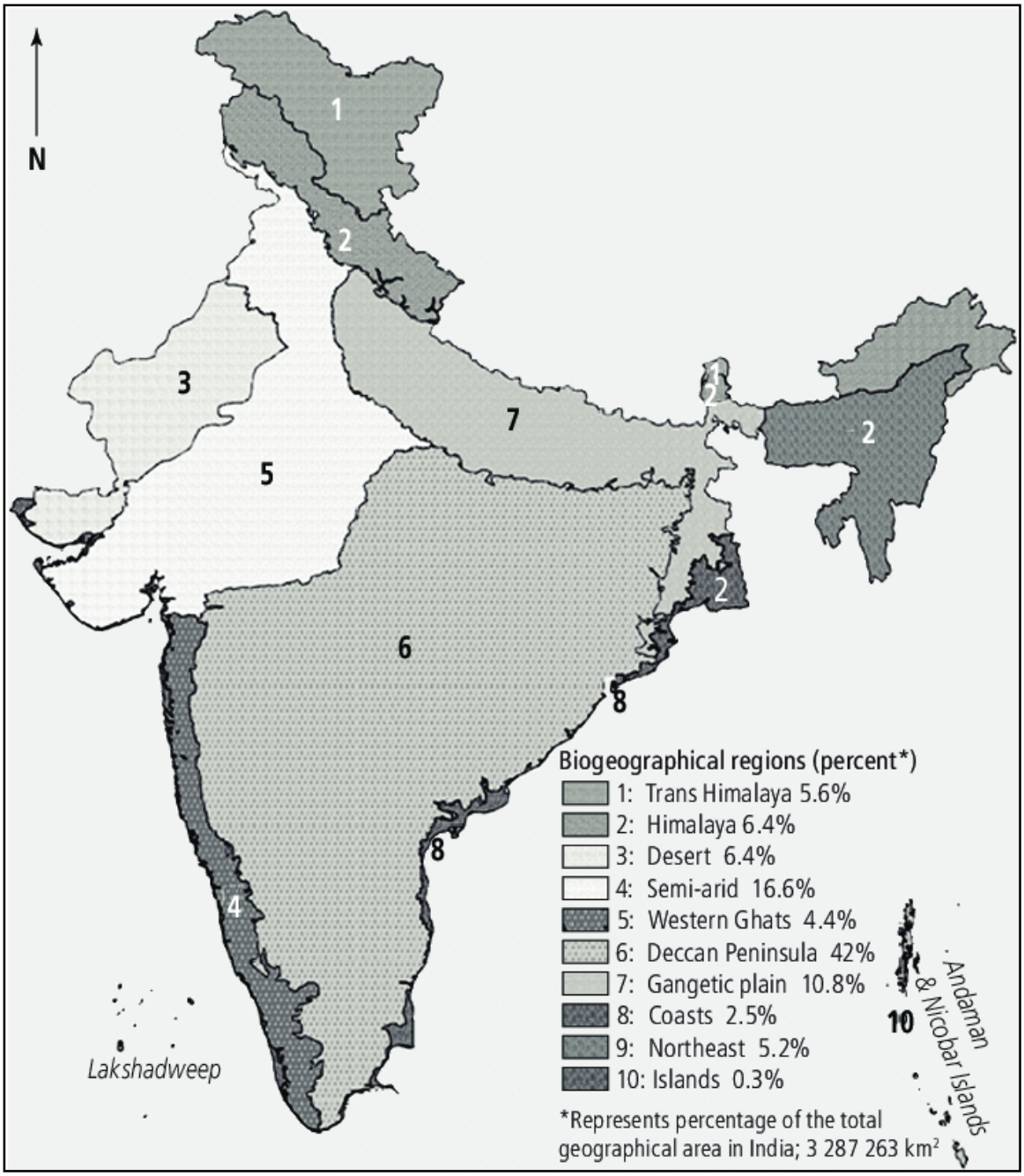
North East Region constitutes 5.2 per cent of the total geographical area. This region represents the transition zone between the Indian, Indo-Malayan and Indo-Chinese bio-geographical regions as well as being a meeting point of the Himalayan mountains and peninsular India. The North-East is thus the biogeographical 'gateway' for much of India's fauna and flora and also a biodiversity hotspot (Eastern Himalaya). Many of the species contributing to this biological diversity are either restricted to the region itself, or to the smaller localized areas of the Khasi Hills.

- ***Coastal Region***

Coastal region constitutes 2.5 per cent of the total geographical area with sandy beaches, mangroves, mud flats, coral reefs and marine angiosperm pastures make them the wealth and health zones of India. The coastline from Gujarat to Sunderbans is estimated to be 5,423 km long. Atotal of 25 islets constitute the Lakshadweep, which are of coral origin, and have a typical reef lagoon system, rich in biodiversity. However, the densely populated Lakshadweep islands virtually have no natural vegetation.

- ***Andaman and Nicobar Islands***

This constitutes 0.3 per cent of the total geographical area are one of the three tropical moist evergreen forests zones in India. *The islands house an array of flora and fauna not found elsewhere.* These islands are centres of high endemism and contain some of India's finest evergreen forests and support a wide diversity of corals. In India, *endemic island biodiversity is found only in the Andaman and Nicobar Islands.* Some of the endemic fauna of Andaman & Nicobar islands include *Narcondam hornbill*, South Andaman krait etc.


N
1
2
3
4
5
6
7
8
9
10
Lakshadweep
Andaman & Nicobar Islands
Biogeographical regions (percent*)
1: Trans Himalaya 5.6%
2: Himalaya 6.4%
3: Desert 6.4%
4: Semi-arid 16.6%
5: Western Ghats 4.4%
6: Deccan Peninsula 42%
7: Gangetic plain 10.8%
8: Coasts 2.5%
9: Northeast 5.2%
10: Islands 0.3%
*Represents percentage of the total geographical area in India; 3 287 263 km²

Biodiversity Hotspots

Biodiversity hotspots are defined as regions "where exceptional concentrations of endemic species are undergoing an exceptional loss of habitat". The concept of biodiversity hotspots was developed by the **Norman Myers in 1988** when he identified that the tropical forest losing its plants species as well as habitat. IUCN prepares '**Red Data Book'**. There are **34 areas around the world** which are qualified as **Biodiversity hotspots**. These hotspots represent only 2.3% of the total Earth's land surface. These hotspots are important because Biodiversity underpins all life on Earth. Without species, there would be no air to breathe, no food to eat, no water to drink. There would be no human society at all. And as the places on Earth, where the most biodiversity is under the most threat, hotspots are critical to human survival.

There are currently 35 recognized biodiversity hotspots. These are Earth's most biologically rich—yet threatened—terrestrial regions.

To qualify as a biodiversity hotspot, an area must meet two strict criteria:

- ✓ *Contain at least 1,500 species of vascular plants found nowhere else on Earth (known as "endemic" species).*
- ✓ *Have lost at least 70 percent of its primary native vegetation.*

Many of the biodiversity hotspots exceed the two criteria. For example, both the Sundaland Hotspot in Southeast Asia and the Tropical Andes Hotspot in South America have about 15,000 endemic plant species. The loss of vegetation in some hotspots has reached a startling 95 percent.

Among 35 hot spots of the world, some have relatively more endemism and are more threatened. To address this, 8 have been declared hottest hot spots. These are:

- **Madagascar**
- **Philippines**
- **Sunderland**
- **Brazil's Atlantic**
- **Caribbean**
- **Indo Burma**
- **Western Ghat & Srilanka**
- **Eastern arc coastal forest of Tanzania/Kenya**

World's 35 Biodiversity Hotspots

I. Africa

1. **Cape Floristic Region**
2. **Coastal Forests of Eastern Africa**
3. **Eastern Afromontane**
4. **Guinean Forests of West Africa**
5. **Horn of Africa**
6. **Madagascar and the Indian Ocean Islands**
7. **Maputaland-Pondoland-Albany**
8. **Succulent Karoo**

II. Asia-Pacific

9. **East Melanesian Islands**
10. **Himalaya**
11. **Indo-Burma**
12. **Japan**
13. **Mountains of Southwest China**
14. **New Caledonia**
15. **New Zealand**
16. **Philippines**
17. Polynesia-Micronesia
18. Southwest Australia
19. Forests of Eastern Australia (new)
20. Sundaland
21. Wallacea
22. Western Ghats and Sri Lanka

III. Europe and Central Asia

23. **Caucasus**
24. **Irano-Anatolian**
25. **Mediterranean Basin**
26. **Mountains of Central Asia**

IV. North and Central America

27. **California Floristic Province**
28. **Caribbean Islands**
29. Madrean Pine-Oak Woodlands
30. **Mesoamerica**

V. South America

31. **Atlantic Forest**
32. **Cerrado**
33. **Chilean Winter Rainfall-Valdivian Forests**
34. Tumbes-Chocó-Magdalena
35. **Tropical Andes**

Among the 35 hot spots of the world, **4 are found in India**. These areas of the country are exceptionally rich in flowering plants, reptiles, amphibians, butterflies and some species of mammals.

➢ *The Western Ghats and Sri Lanka*

- These regions have a moist deciduous forest and rainforest. The region shows high species diversity as well as high levels of endemism.
- Nearly 77% of the amphibians and 62% of the reptile species found here are found nowhere else.
- Sri Lanka, which lies to the south of India, is also a country rich in species diversity.
- It has been connected with India through several past glaciation events by a land bridge of almost 140 km wide.

➢ *The Eastern Himalayas*

- The Eastern Himalayas is the region encompassing Bhutan, North Eastern India, and southern, central, and eastern Nepal. The region is geologically young and shows high altitudinal variation.
- The Eastern Himalayan hotspot has nearly 163 globally threatened species including the One-horned Rhinoceros (Rhinoceros unicornis), the Wild Asian Water buffalo (Bubalus bubalis (Arnee)) and in all 45 mammals, 50 birds, 17 reptiles, 12 amphibians, 3 invertebrate and 36 plant species.
- Mammals like the Golden langur, The Himalayan tahr, the pygmy hog, Langurs, Asiatic wild dogs, sloth bears, Gaurs, Muntjac, Sambar, Snow leopard, Black bear, Blue sheep, Takin, the Gangetic dolphin, wild water buffalo, swamp deer call the Himalayan ranged their home.
- The only endemic genus in the hotspot is the Namadapha flying squirrel which is critically endangered and is described only from a single specimen from Namdapha National Park.

➢ *Indo-Burma Region*

- It is spread out from Eastern Bangladesh to Malaysia and includes North-Eastern India south of Brahmaputra river, Myanmar, the southern part of China's Yunnan province, Lao People's Democratic Republic, Cambodia, Vietnam and Thailand.
- The Indo-Burma region is spread over 2 million sq. km of tropical Asia. Since this hotspot is spread over such a large area and across several major landforms, there is a wide diversity of climate and habitat patterns in this region.

- This region is home to several primate species such as monkeys, langurs and gibbons with populations numbering only in the hundreds. Many of the species, especially some freshwater turtle species, are endemic.

➢ *Sunderland*

- Sunderland is a region in South-East Asia that covers the western part of the Indo-Malayan archipelago. It includes Thailand, Malaysia, Singapore, Brunei and Indonesia.
- India is represented by the Nicobar Islands. The United Nations declared the islands a World Biosphere Reserve in 2013.
- The islands have a rich terrestrial and marine ecosystem that includes mangroves, coral reefs and seagrass beds.
- The marine biodiversity includes several species such as whales, dolphins, dugong, turtles, crocodiles, fishes, prawns, lobsters, corals and seashells.