

## CH-1 Basics of Indian Physiography

### TOPICS TO BE COVERED

#### I. The Indian Geological History

1. Pre-cambrian Rocks
  - A. Archaean System
  - B. Dharwar System
  - C. Cuddapah System
  - D. Vindhyan System
2. Dravidian Rocks
3. Aryan Rocks
  - A. Gondwana System
  - B. Jurassic System
  - C. Deccan Trap
  - D. Tertiary System
  - E. Quarternary System

#### II. Geography of India

1. Geographical facts about India
2. Indian Standard Meridian
3. India, Tropical or Temperate Country?
4. UN Convention on laws of seas
5. India and Its Neighbours

#### III. The Northern and Northeastern Mountains

1. Formation of Himalayas
2. Characteristic Features
3. Division of Himalayas
  - A. Lateral Division
    - a. The Greater Himalayan range, which includes:
      - ❖ The Great Himalayas (Himadri)
      - ❖ The Trans-Himalayan range
    - b. Lesser or Middle Himalayas (The Himachal Range)
    - c. Outer or Sub-Himalayas (The Siwalik Range)
  - B. Longitudinal Division
    - a. Punjab Himalayas
    - b. Kumaon Himalayas
    - c. Nepal Himalayas
    - d. Assam Himalayas

#### IV. Eastern Himal

1. The North-Eastern Hills and Mountains (Purvanchal)



# Dr Lakshmaiah IAS Study Circle



20B, Opp: HDFC Bank, Main Road, Old Rajinder Nagar

New Delhi-110060 Ph No: +91 9773731858

2. Extension of Purvanchal to A&N Islands
3. Key Difference between Western and Eastern Himalayas

## V. Important Passes in India

1. Passes of J&K
2. Passes of Himachal Pradesh
3. Passes of Uttarakhand
4. Passes of Sikkim
5. Passes of Arunachal Pradesh

## VI. Glaciers and Snowline in Himalayas

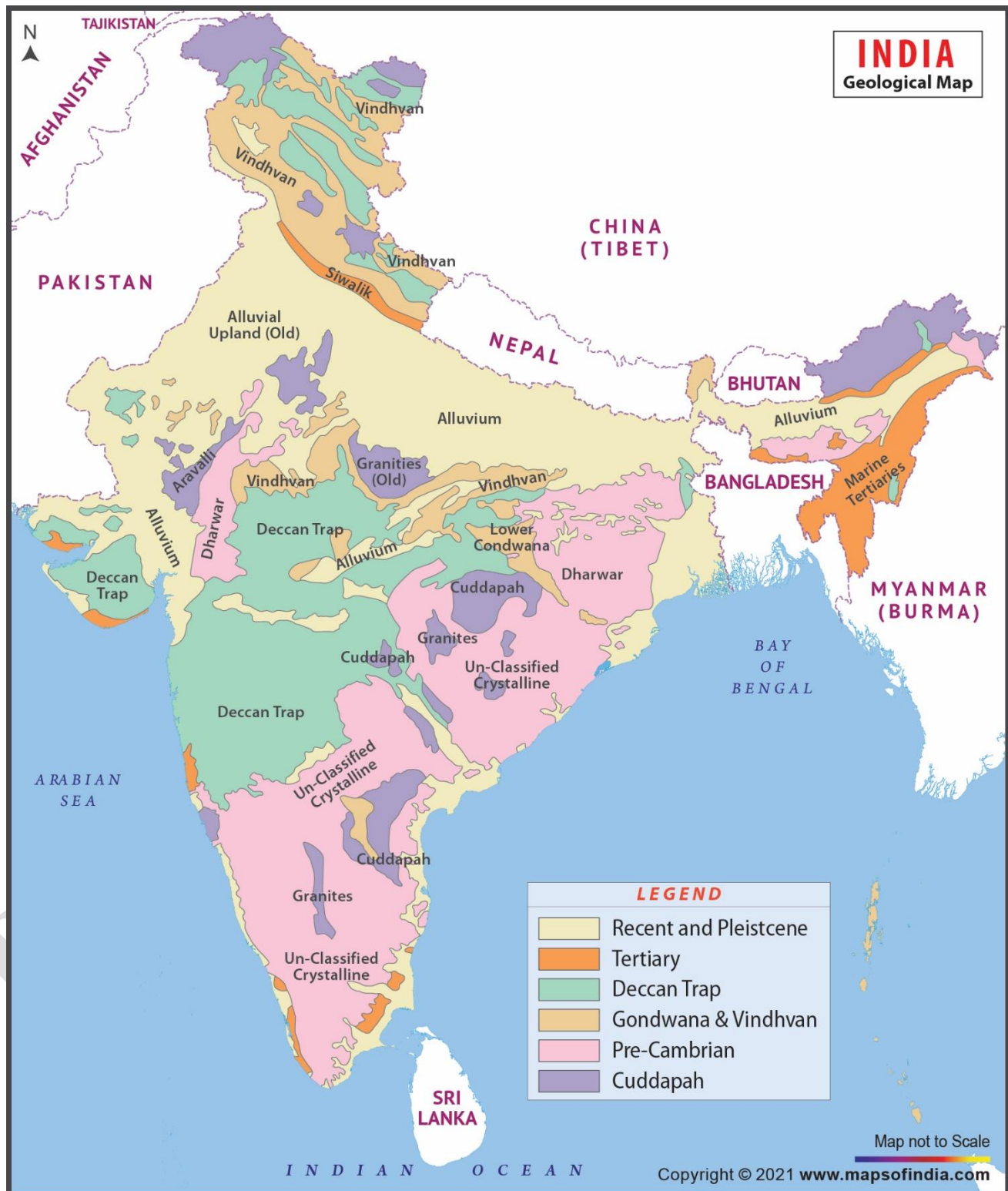
## VII. Important Valleys in the Himalayas

## VIII. Himalayas- Source of Fresh Water/Rivers

## IX. Significance of Himalayas for India

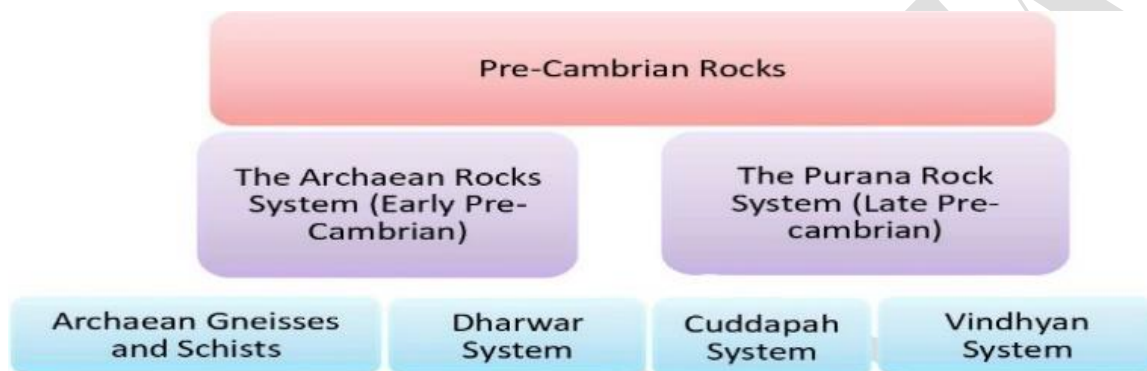
## THE INDIAN GEOLOGICAL HISTORY

Based on this complex and varied geological history, the *Geological Survey of India* has classified rock systems of the country into 4 major divisions:



	The Indian Classification	Corresponding period on the earth's Geological timescale:
1	Archaean	Early Precambrian Eon
2	Purana	Late Precambrian (or Proterozoic Eon)
3	Dravidian	600-400 mya (largely coinciding with the Palaeozoic era)
4	Aryan	400 mya - present

Classification of the Indian rock systems by the Geological Survey of India



## Rocks of the Archaean System

- These are the oldest and primary rocks formed by the condensation of hot-molten earth.
- There are no presence of fossils in them
- Their original form has been destroyed due to the excessive metamorphosis.
- Igneous Rocks --> Metamorphosis --> Gneiss
- The Bundelkhand gneiss is the oldest on
- The Archaean rocks cover about 66% of the peninsular India and also found in roots of the mountain peaks all along the Greater Himalayas
- The rocks of this system are found in Karnataka, Tamil Nadu, Andhra Pradesh, Madhya Pradesh, Orissa, Chotanagpur plateau in Jharkhand and the southern-eastern part of Rajasthan.

## Rocks of Dharwar System

- The erosion and sedimentation of the rocks of the Archaean system resulted in formation of Dharwar System Rocks.
- No fossil is found here (no origin of species during their formation).
- These are the oldest sedimentary rocks.
- The oldest fold mountain of the world, Aravali mountain range, has been made with these rocks.
- These rocks system are economically very important. All prominent metallic minerals (gold, iron, manganese, etc.) are found in these rocks.
- The rocks of the Dharwar system are found mainly in the southern Deccan region from Karnataka to the Kaveri valley, districts of Dharwar, Bellary, Shimoga, Sasar mountain range in Jabalpur and Nagpur and the Champaner mountain range in Gujarat
- In north India, the rocks of this system are present in the Himalayan ranges of Ladakh, Zaskar, Garhwal and Kumaon, and the long range of Assam plateau.



## Rocks of Cuddapah System

- The erosion and sedimentation of the rocks of the Archaean system resulted in formation of Cuddapah System Rocks.
- These are also sedimentary rocks famous for sandstone, limestone, and marble, asbestos.
- The name of these rocks is derived from the district of Cuddapah in Andhra Pradesh.
- These rocks are found in Karnataka, Madhya Pradesh, Jharkhand, Meghalaya and Rajasthan.
- Metallic content in the Cuddapah rock ores is low and at places uneconomical for extraction.

## Rocks of the Vindhyan System

- These rocks are formed after the Cuddapah rocks by the silt deposition of river valleys and shallow oceans. Hence, these rocks are also sedimentary rocks.
- The evidences of micro-organisms fossils are found in these rocks.
- These rocks are famous for house-building. The Red Fort, the Sanchi Stupa, the Jama Masjid etc. are built with the red sandstone of this structure. Besides, china clay, dolomite, limestone, etc. are also found in this structure.
- Vindhyan rocks are buried under the Deccan lava in some of the tract.
- The diamond mines of Panna in Madhya Pradesh and Golconda in Karnataka are found in this structure.
- These rocks are found in the Malwa plateau, the Semari range in the Son valley, Bundelkhand etc.

## DRAVIDIAN ROCKS

### The Dravidian Rock system (Cambrian to middle carboniferous)

- These rocks are found in continuous sequence in the Himalayas.
- They contain fossils in abundance.
- Coal formation started in the Carboniferous age.
  - Carboniferous in geology means coal-bearing.
  - Most of the coal found in India does not belong to the Carboniferous period.
  - High-quality coal of Great Lakes Region in USA, U.K., and Ruhr region (of Germany) is Carboniferous coal.
- These formations do not occur in the peninsular plateau as it was above the sea level at that time.

## ARYAN ROCKS

### The Aryan Rock system (Upper Carboniferous to

The  
Gondwana  
System

Jurassic  
System

Deccan  
Trap

Tertiary  
System

Pleistocene  
and recent  
formations  
(The  
quaternary  
period)

## Rocks of Gondwana System

- The word Gondwana is derived from the Gond region of Madhya Pradesh.
- 98% of coal in India is found in this structure.
  - Gondwana coal is much younger than the Carboniferous coal hence possess less carbon content.
- The formation of these rocks occurred between the Carboniferous and Jurassic periods.
- Several cracks were formed in the peninsular India during the Carboniferous period. This led to the formation of basin-shaped depressions because of the sinking of land among these cracks.
  - Coal was formed as a result of burying down of the vegetation of that period.
  - This coal is now found mainly in the river valleys of the Damodar, the Son, the Mahanadi, the Godavari, and the Wardha etc.

## Jurassic System:

- The marine transgression in the latter part of the Jurassic gave rise to thick series of shallow water deposits in Rajasthan and in Kutch.
- Coral limestone, sandstone, conglomerates and shales occur in Kutch.
- Another transgression on the east coast of the Peninsula is found between Guntur and Rajahmundry.

## The Deccan Trap

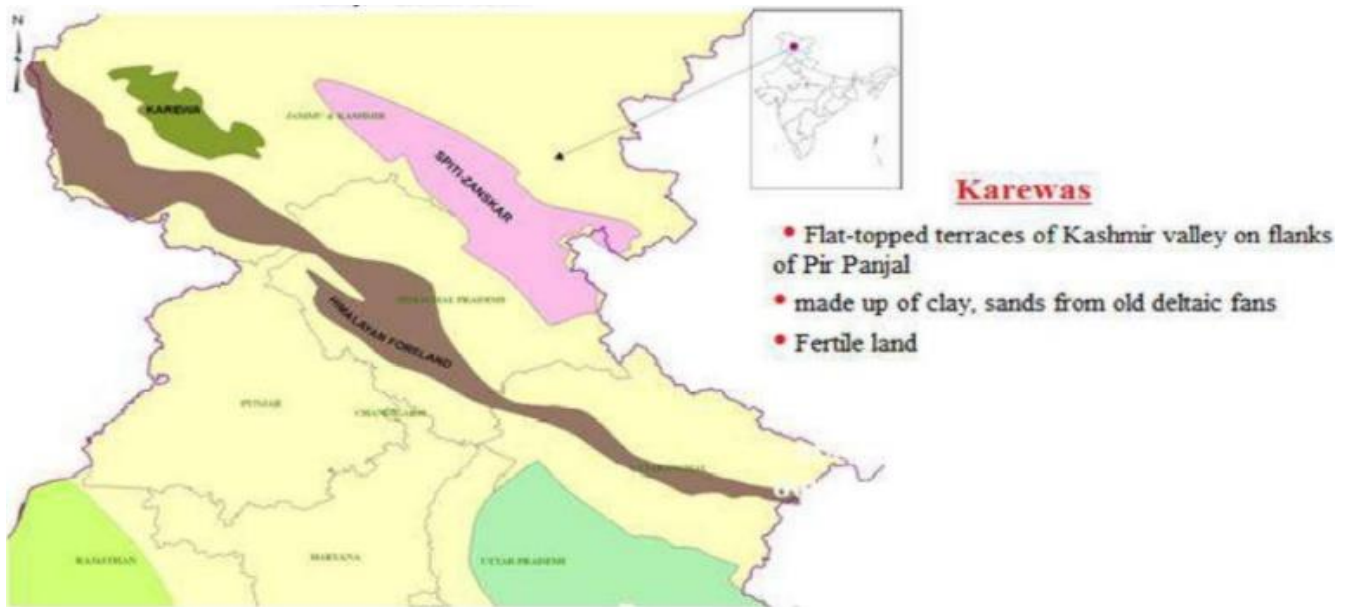
- In the last period (Cretaceous period) of the Mesozoic era, the volcanic action in the peninsular India began resulted in the formation of Deccan trap.
- This structure is made up of basalt and dolerite rocks.
- The volcanic rocks possess some thin fossiliferous sedimentary layers between the lava flows. This indicates the non-continuous flow of lava. The volcanic activity led to two great events
  1. Breakup of the Gondwanaland masses.
  2. Uplift of the Himalayas out of the Tethys Sea.
- These rocks are very hard and the weathering of these rocks for a long time resulted in the formation of the black cotton soil known as 'regur'.
- This structure is found in the most parts of Maharashtra and some parts of Gujarat, Madhya Pradesh and Tamil Nadu.

## Rocks of the Tertiary System

- The Tertiary epoch has been divided chronologically into four parts
  1. Eocene
  2. Oligocene
  3. Miocene
  4. Pliocene
- This period is the most significant in India's geological history due to the development of Himalayas during this period.
- The Himalayan mountain range has developed as discussed below:
  1. The Great Himalayas were formed during the **Oligocene period**.
  2. The Lesser Himalayas were formed during the **Miocene period**.
  3. Shiwaliks were formed during the **Pliocene and Upper Pliocene periods**.
- Mineral oil in Assam, Rajasthan and Gujarat is found in the structures of the Eocene and Oligocene period.

## Rocks of the Quarternary System

- These rocks are found in the plains of the Ganga and the Indus.
- The Quarternary epoch is divided chronologically into 2 parts



1. Pleistocene periods
  - Old alluvial soil known as 'bangar' was formed during the Upper and Middle Pleistocene periods.
  - The Kashmir valley was a lake in the beginning but the continuous deposition of soil gave rise to the present form (valley) which is known as '*kareva*'.
  - Deposition of the Pleistocene period is also found in the Thar Desert.
2. Holocene periods
  - The formation of the alluvial soil known as 'khadar' started at the end of the Pleistocene period and it is still going on in the present Holocene period.
  - The 'Rann of Kachchh' was previously a part of the ocean was filled by the sedimentary deposits during the Pleistocene and Holocene period.

## GEOGRAPHY OF INDIA

India is the 7th largest country in the world separated from the rest of Asia by the Himalayas. The mainland of India, extends from Kashmir in the north to Kanyakumari in the south and Arunachal Pradesh in the east to Gujarat in the west.

### Map-key:

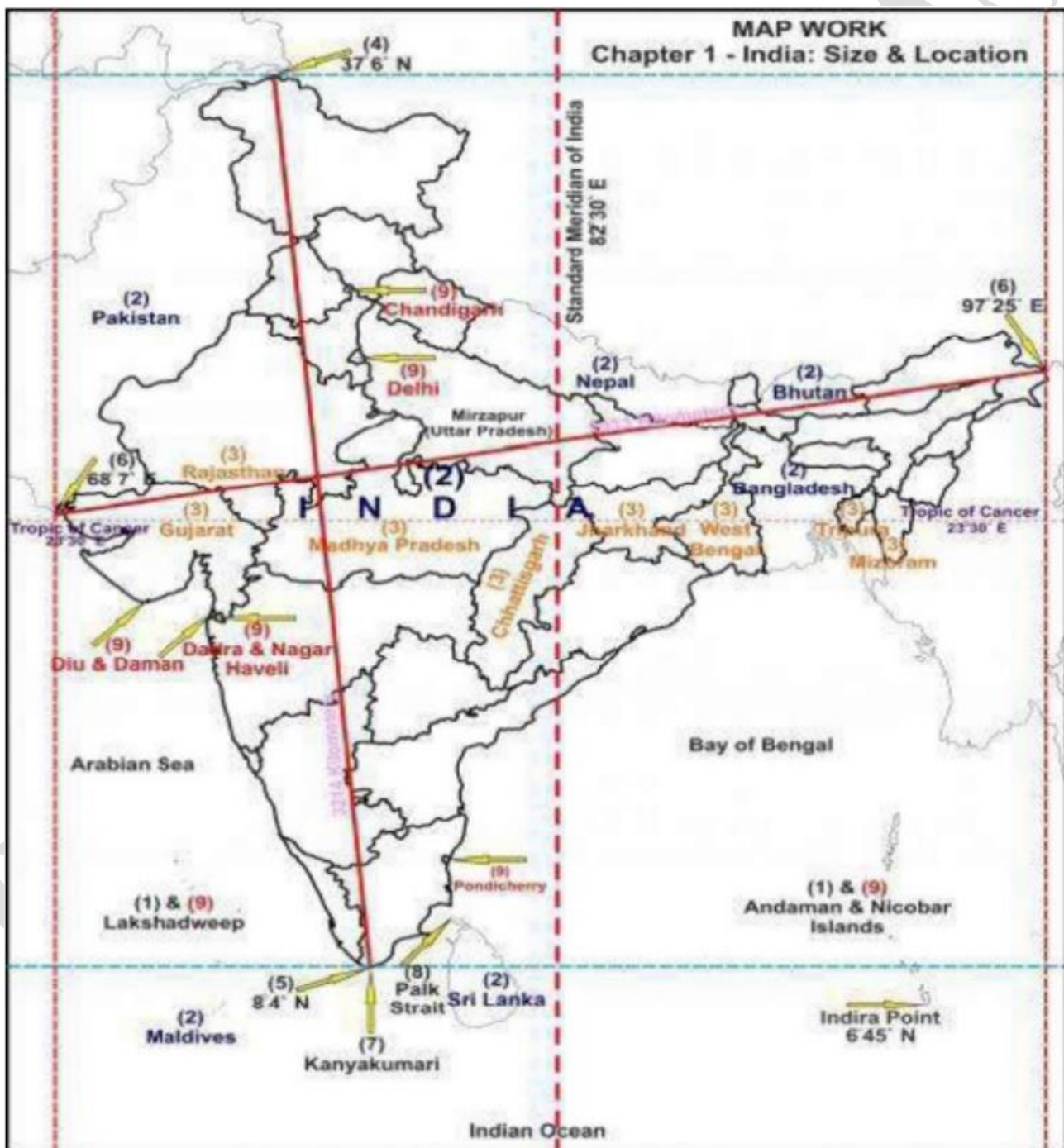
1. The island groups of India lying in the Arabian Sea and the Bay of Bengal.
2. The countries constituting Indian Subcontinent.
3. The states through which the Tropic of Cancer passes.
4. The northernmost latitude in degrees (Indira Col in Jammu and Kashmir).
5. The southernmost latitude of the **Indian mainland** in degrees (Kanyakumari in Tamil Nadu). Note that the southernmost point of **India** is the Indira Point which is the southernmost point of Great Nicobar



Island of the Andaman and Nicobar archipelago. The Indira Point was previously known as the Pygmalion Point or the Parson Point.

6. The eastern and the westernmost longitudes in degrees.
7. The place situated on the three seas.
8. The strait separating Sri Lanka and India.
9. The Union Territories of India.

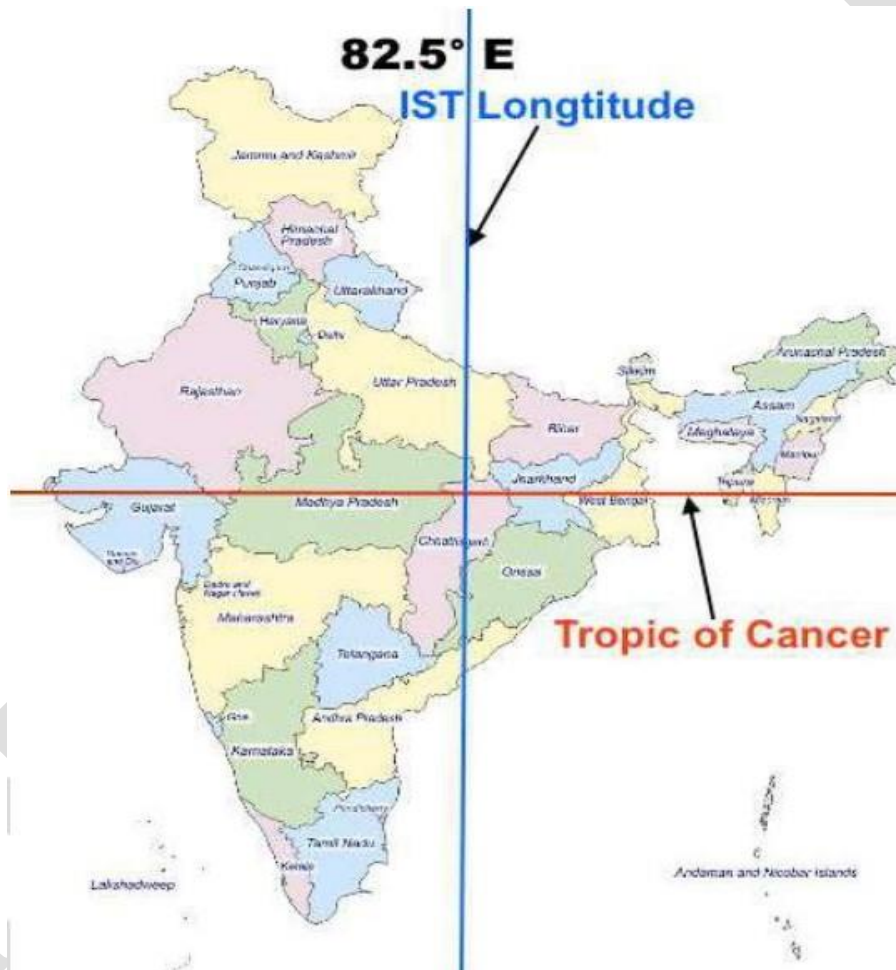
## India: Longitudinal and Latitudinal features





## Geographical facts about India

- Area of India is 3.28 million square km
- India accounts for about 2.4 percent of the total geographical area of the world
- The coastline of India stretches along the Bay of Bengal in the east and the Arabian Sea in the west
- There is a time difference of two hours between Gujarat and Arunachal Pradesh. ( $1^\circ = 4$  minute)
- The maximum length of the mainland from north to south is about 3214 km
- The maximum length of the mainland from east to west is about 2933 km.
- India's total length of coastline is 6,100 km of its mainland and after including Andaman and Nicobar, and Lakshadweep islands, it is about 7,516 km.
- India's territorial limit further extends towards the sea up to 12 nautical miles (i.e. about 21.9 km) from the coast.



## Indian Standard Meridian

- **82°30' E Meridian** crossing through the **Mirzapur** city of Uttar Pradesh is taken as India's Standard Meridian.
- Indian Standard Time is ahead of Greenwich Mean Time (also known as GMT or  $0^\circ$  or Prime Meridian) by 5 hours and 30 minutes.
- Tropic of cancer ( $23^\circ 30' N$ ) passes through Gujarat, Rajasthan, Madhya Pradesh, Chhattisgarh, Jharkhand, West Bengal, Tripura, and Mizoram.

## Longitudinal and Latitudinal Extent

East-West Extent (~30°)	68° 7' East to 97° 25' East longitude
South-North Extent of mainland India (Including POK) (~29°)	8° 4' North to 37° 6' North latitude
South-North Extent of India (Including POK and the Andaman and Nicobar Islands) (~31°)	6° 45' North to 37° 6' North latitude

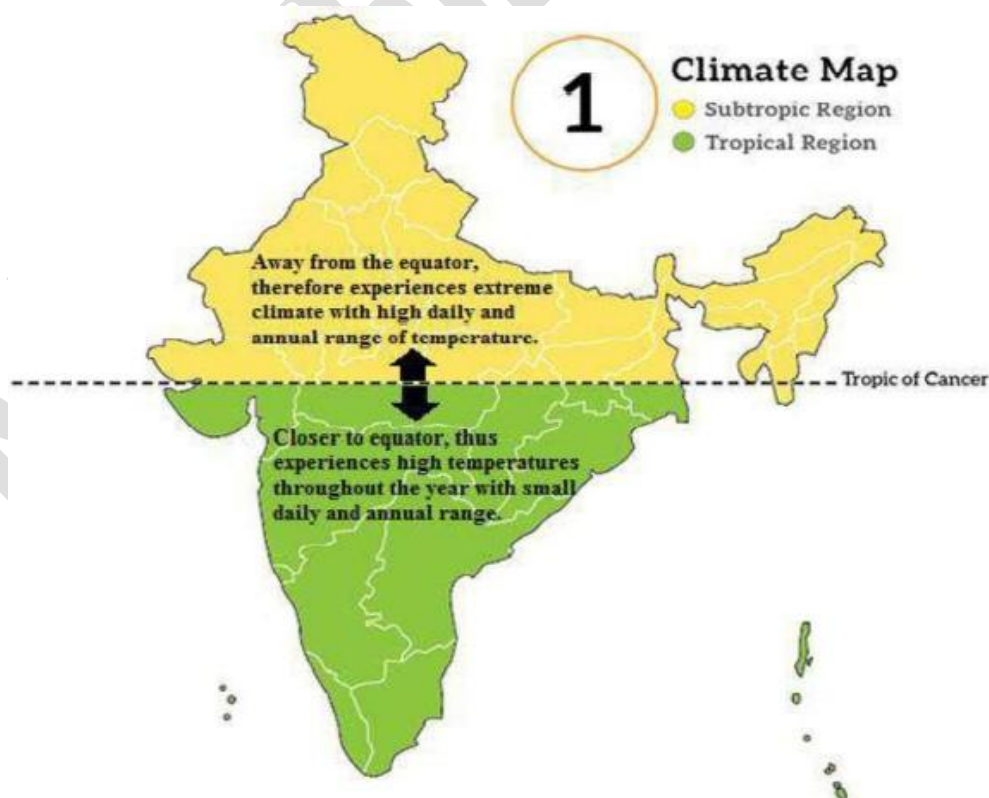
- The Tropic of Cancer passes through the middle of the country dividing it into two latitudinal halves
- The area to the north of Tropic of Cancer is near twice the area which lies to the south of it
- South of 22° north latitude, the country tapers off over 800 km into the Indian Ocean as a peninsula.
- This location is responsible for large variations in landforms, climate, soil types and natural vegetation in the country.

## India, Tropical or Temperate Country?

Half of the country to the south of the Tropic of Cancer is situated in the Tropical or Torrid zone and the other half lying north of the Tropic of Cancer falls in the Subtropical zone.

- The country is separated from the rest of Asia by the Himalayas
- The tropical monsoons dominate its climate
- Himalayas blocks the cold temperate air masses

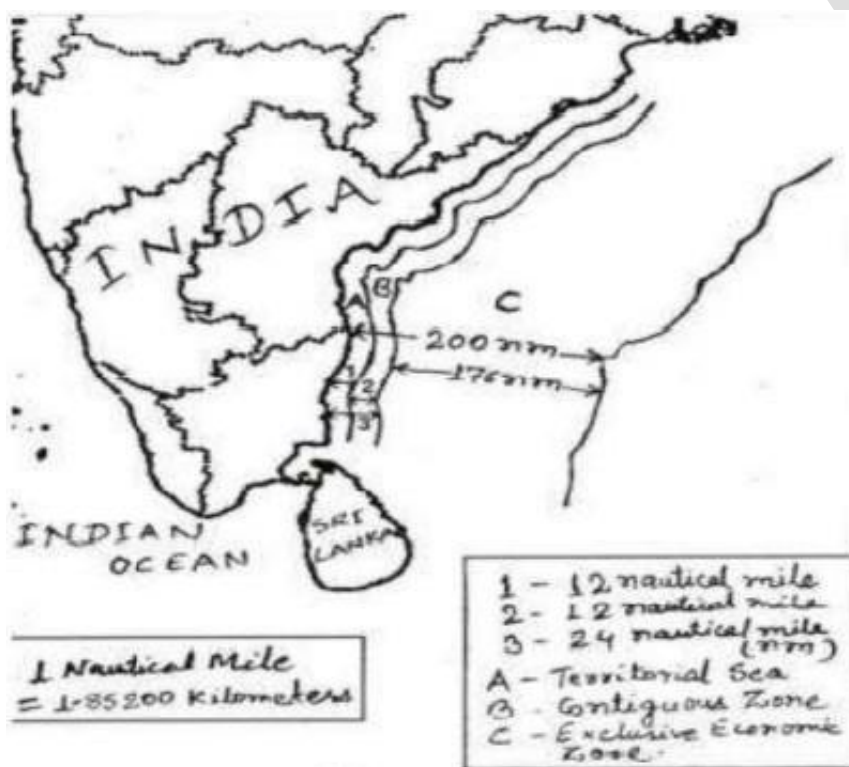
Thus, It is **primarily** because of the Himalayas that India is a predominantly tropical country.



## UN Convention on laws of seas

- United Nations Convention on the Law of the Sea (UNCLOS) is also known as *Law of the Sea treaty*.
- It is considered as the "*constitution of the oceans*".
- The latest UNCLOS is UNCLOS III. It covers all the vital issues regarding the maritime boundaries.
  - Decides deep sea mining, environment protection, maritime boundary, and dispute settlement.

## UNCLOS sections the oceans

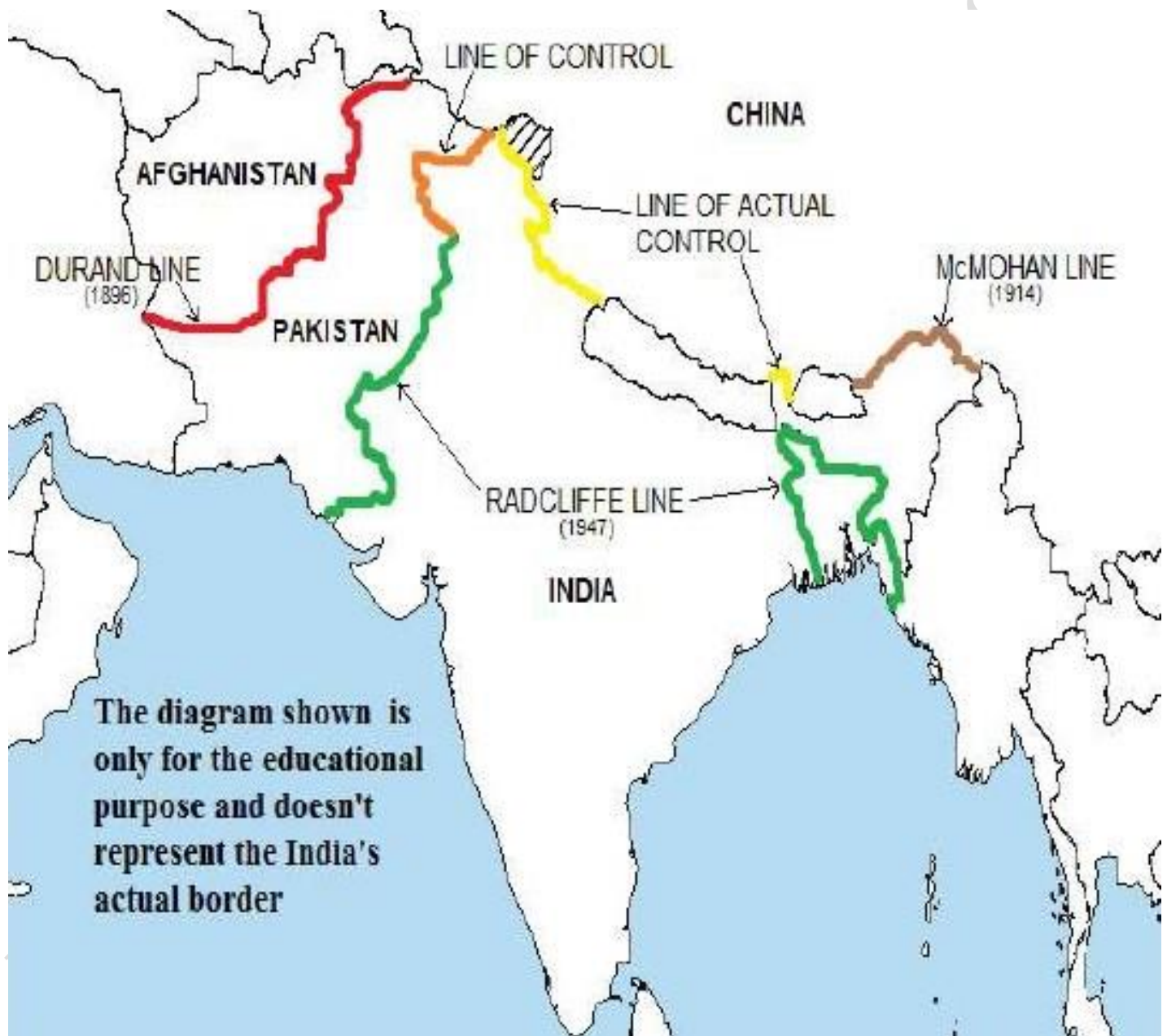


1. Territorial waters
    - 12 Nautical Miles from the baseline.
    - Countries are free to set laws and use its resources.
    - Foreign vessels are not given all rights to passage through except "Innocent Passage".
      1. Passing through the waters which are not prejudicial to peace and security.
      2. Nations have right to suspend the innocent passage.
    - Submarine while passing through other country's territorial waters has to navigate on the surface and show their flags.
  2. Contiguous Zone
    - Area 12 Nautical Miles beyond the Territorial waters (i.e. 24 Nautical Miles from the baseline limit).
    - Country can enforce laws only in 4 areas viz. pollution, taxation, customs, and immigration.
  3. Exclusive Economic Zones (EEZs)
    - Area from the edge of the territorial sea out to 200 nautical miles from the baseline.
    - Country has sole exploitation rights over all-natural resources.
- The most important reason to introduce EEZ was to halt the clashes over the fishing rights and oil rights.
  - Foreign vessels have freedom of navigation and over flight, subject to the regulation of the coastal states.
  - Foreign states are allowed to lay submarine pipes and cables.



## India and Its Neighbours

- India has **15106.7 Km of land border** running through **17 States**.
- India is bounded by young fold mountains (the Great Himalaya) in the North and North-East.
- Throughout the history, India's connections with other parts of the world has been heavily influenced by waterways and also the mountain passes.



- India shares its international boundaries with Afghanistan and Pakistan in the North-West; China, Tibet (China), Nepal, and Bhutan in the North and NorthEast; and Myanmar and Bangladesh in the East.
- India's **longest border is with Bangladesh** while the shortest border is with Afghanistan.
- Sri Lanka and Maldives are two island countries located in the Indian Ocean which are our neighbours
- Sri Lanka is departed from India by the Gulf of Munnar and Palk Strait





Neighbour	Length of Border (in Km)	Bordering States
Bangladesh	4096	West Bengal, Assam, Meghalaya, Tripura, Mizoram
China	3488	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh
Pakistan	3322	Jammu & Kashmir, Punjab, Rajasthan, Gujarat
Nepal	1751	Uttarakhand, Uttar Pradesh, Bihar, West Bengal, Sikkim
Myanmar	1643	Arunachal Pradesh, Nagaland, Manipur, Mizoram
Bhutan	699	Sikkim, West Bengal, Assam, Arunachal Pradesh
Afghanistan	106	Jammu & Kashmir (at Wakhan Corridor in PoK)

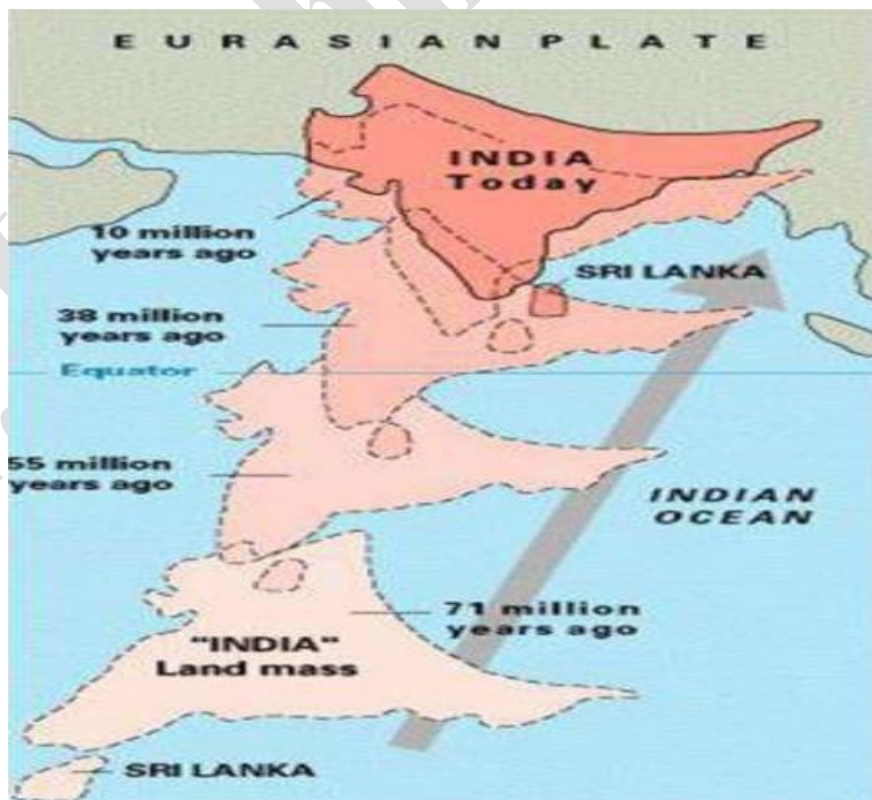
## THE NORTHERN AND NORTHEASTERN MOUNTAINS

The Himalayas, geologically young and structurally fold mountains stretch over the northern borders of India. These mountain ranges run in a west-east direction from the Indus to the Brahmaputra. The Himalayas represent the loftiest and one of the most rugged mountain barriers of the world. They form an arc, which covers a distance

of about 2,400 Km. Their width varies from 400 Km in Kashmir to 150 Km in Arunachal Pradesh. The altitudinal variations are greater in the eastern half than those in the western half. The Himalaya consists of three parallel ranges in its longitudinal extent. A number of valleys lie between these ranges. The northern most range is known as the Great or Inner Himalayas or the 'Himadri'. It is the most continuous range consisting of the loftiest peaks with an average height of 6,000 metres. It contains all the prominent Himalayan peaks.

## FORMATION OF HIMALAYAS

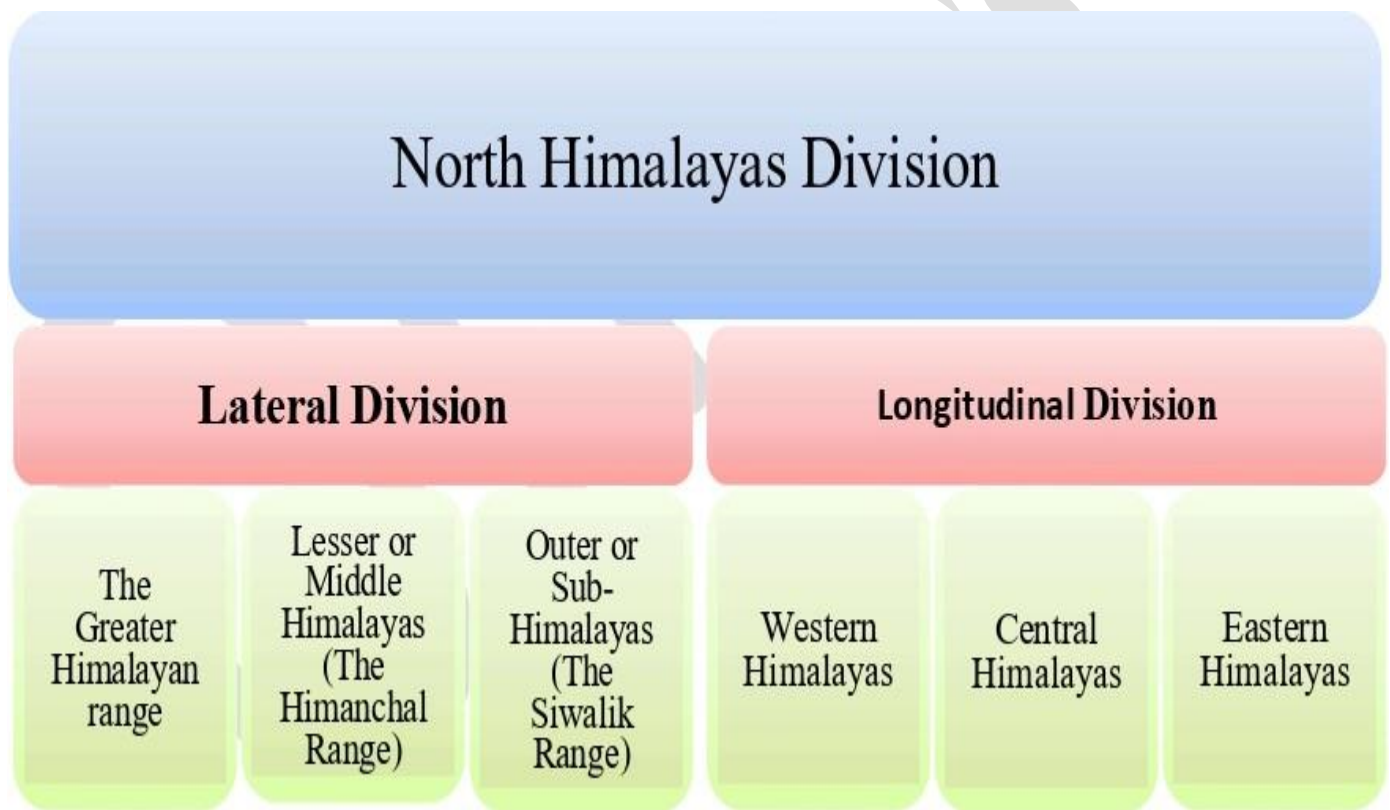
- 225 million years ago (Ma) India was a large island situated off the Australian coast and separated from Asia by the Tethys Ocean.
- The supercontinent Pangea began to break up 200 Ma and India started a northward drift towards Asia.
- 80 Ma India was 6,400 km south of the Asian continent but moving towards it at a rate of between 9 and 16 cm per year.
- At this time **Tethys Ocean** floor would have been **subducting** northwards beneath Asia and the plate margin would have been a Convergent oceaniccontinental one just like the Andes today.
- From about 50-40 Ma the rate of northward drift of the Indian continental plate slowed to around 4-6 cm per year.
- This slowdown is interpreted to mark the beginning of the collision between the Eurasian and Indian continental plates, the closing of the former Tethys Ocean, and the **initiation of Himalayan uplift**.
- The Eurasian plate was partly crumpled and buckled up above the Indian plate but due to their low density/high buoyancy neither continental plate could be subducted.
- This caused the continental crust to thicken due to folding and faulting by compressional forces pushing up the Himalaya and the Tibetan Plateau.
- The Himalayas are still rising by more than 1 cm per year as India continues to move northwards into Asia, which explains the occurrence of shallow focus earthquakes in the region today.



## CHARACTERISTIC FEATURES

- The Himalayas form ***an arcuate curve*** convex to the south.
- This curved shape of the Himalayas is created due to the maximum push offered at the two ends on the Indian peninsula during its northward drift.
- In the north-west, it was done by Aravalis and in the Northeast by the Assam ranges. ***Syntaxial Bends of the Himalayas***
- Himalayas extend in the east-west direction from the Indus gorge in the west to the Brahmaputra gorge in the east and take sharp southward bends at these gorges. These bends are called syntaxial bends of the Himalayas.
- The western syntaxial bend occurs near the ***Nanga Parbat***.
- The eastern syntaxial bend occurs near the **Namche Barwa**

## DIVISION OF HIMALAYAS

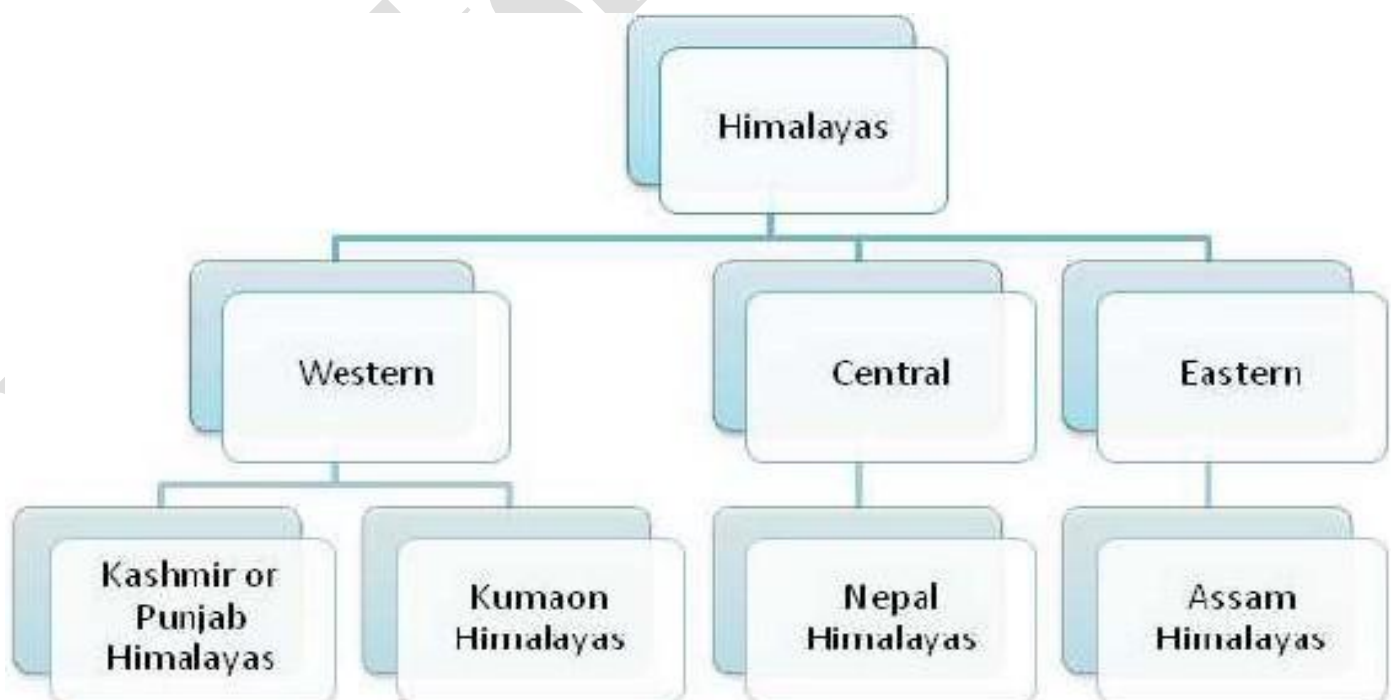


- Himalaya Mountain Range can be categorized into western, central and eastern Himalayas.
- Sometimes one more classification is added by including Tibetan Himalayas which include the southern edge of Tibetan Plateau.
- Western Himalayas include the area of Jammu & Kashmir, Pir Panjal, Ladakh and Baltistan, and Gilit region.
- The central Himalayas extends from Jammu & Kashmir to Sikkim and includes the area of Himachal, Garhwal, Punjab, and Nepal.
- The Eastern Himalayas extend from Sikkim to Assam and include the part of the range running in Bhutan, Arunachal Pradesh and Assam.



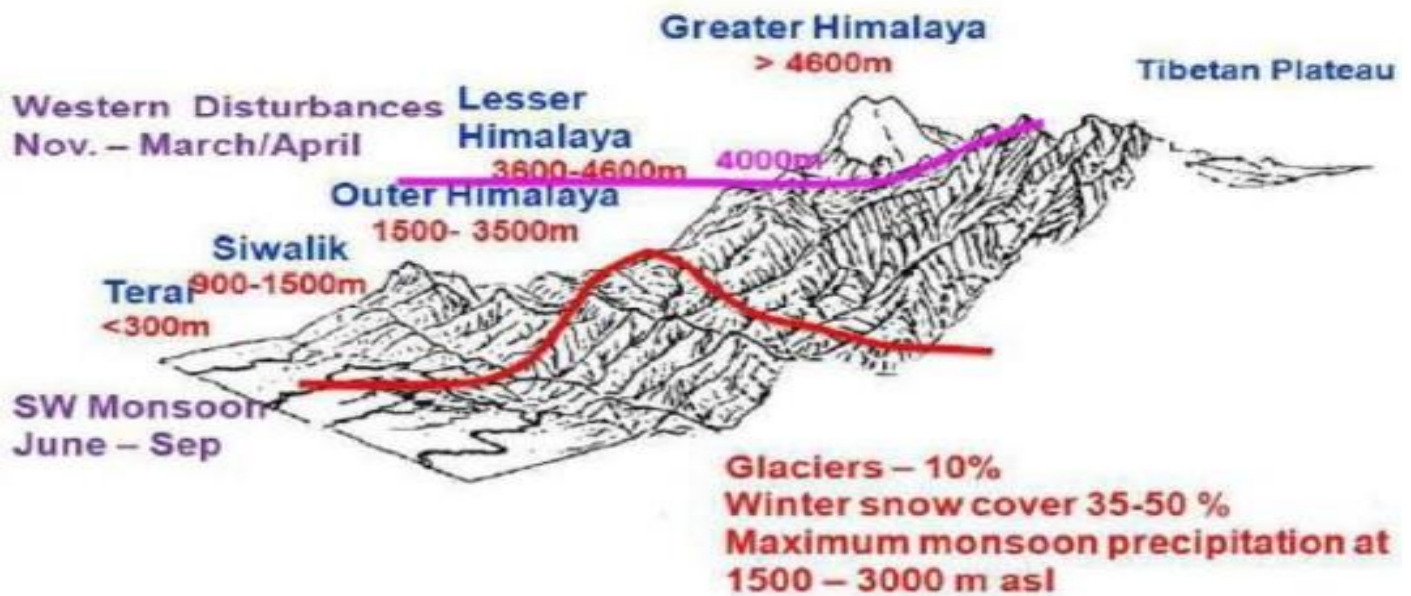


- The Himalaya Mountain Range can also be classified on the basis of height and they are as follow
  1. The Greater Himalayan range, which includes:
    - The Great Himalayas (Himadri)
    - The Trans-Himalayan range
  2. Lesser or Middle Himalayas (The Himanchal Range)
    - Outer or Sub-Himalayas (The Siwalik Range)





## The Himalayan System



### *Himalayan Mountain Complex: Cross-sectional view from South to North*

- The Himalayas are wider in the west than in the east.

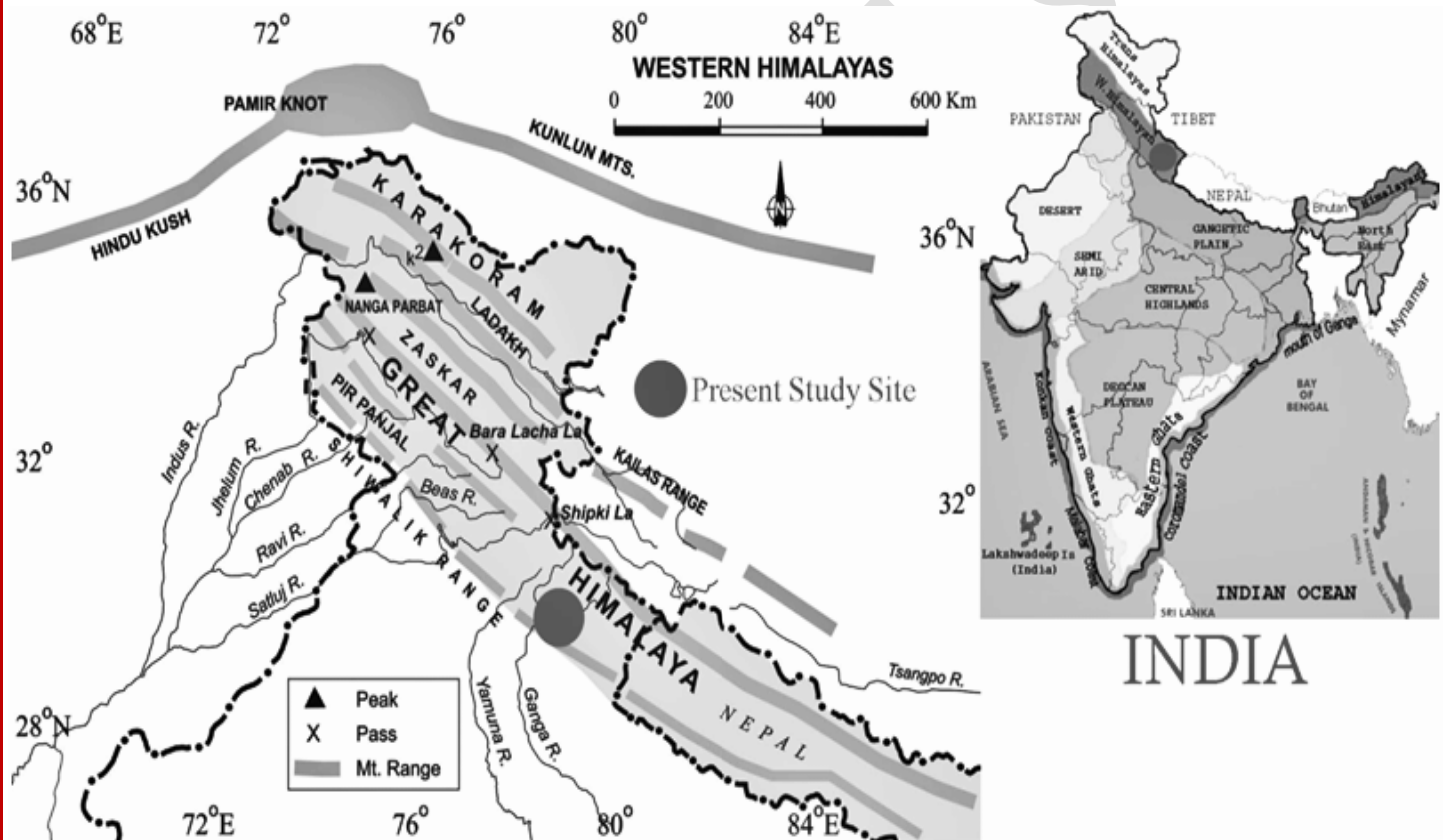


- The width varies from 400 km in Kashmir to 150 km in Arunachal Pradesh.
- The main reason behind this difference is that the compressive force was more in the east than in the west.
  - That is why high mountain peaks like Mount Everest and Kanchenjunga are present in the Eastern Himalayas.
- The ranges are separated by deep valleys creating a highly dissected topography.
- The southern slopes of the Himalayas facing India are steeper and those facing the Tibetan side are generally gentler.

- It contains some of the largest glaciers in the world and count goes as high as 15000 glaciers including **Gangotri** and **Yamunotri** glaciers.
- Rivers originating from Himalaya Mountain are perennial and they have water for almost every part of the year.
- Almost one-fifth of the world population depends on water from the Himalayan system.
- Himalayas Basin is drained by nearly 19 rivers and they can be grouped into three major river systems of Ganges, Indus, and Brahmaputra.
- Apart from rivers, the Himalayan range has a large number of freshwater lakes.
- Some important lakes include Tilicho, Pangong Tso, and Yamdrok Tso Lake.

## THE GREATER HIMALAYAN RANGE

### The Trans-Himalayan range (Tibetan Himalaya)



Most of the part of this Himalayan range lies in the Tibet and hence also called *Tibetan Himalaya*. This range lies in immediate north of Himadri with main ranges of

#### 1. Zaskar

1. It separate from the great Himalayan Range near 80° E longitudes and runs parallel to it.
2. The Nanga Parbat (8126 mt) is the culmination of Zaskar range in north-west but the adjoining Deosai Mountain may also be included in it.
3. Ladakh range is in the north of the Zaskar range which runs parallel to it.

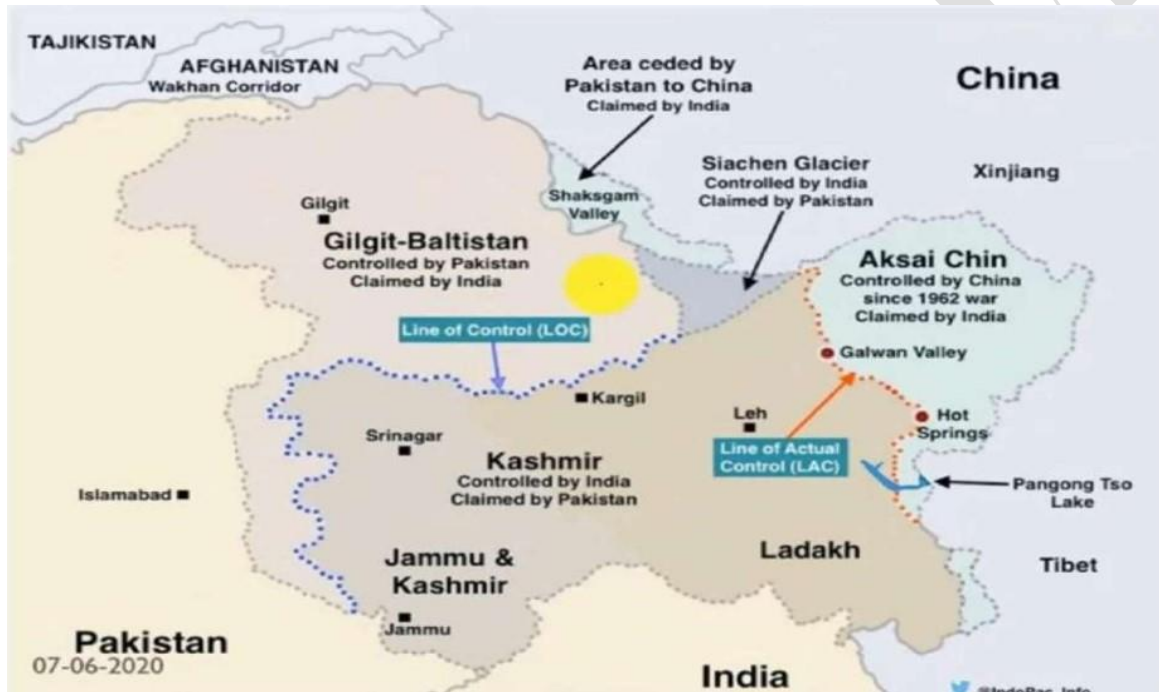


## 2. Karakoram (northmost range)

1. It is also known as Krishnagiri which is situated in the northern most range of the Trans-Himalayan ranges.
2. Home of 3rd largest glacier in the world and greater glacier outside the polar regions.
3. It forms Frontier which China and Afghanistan.
4. K2 ( Godwin Austen) is the second highest peak in the world and **highest in the Indian Territory** lies here.

## 3. Ladakh

1. It lies to the north of the Leh,
2. It merges with the Kailash range in Tibet.



## 4. Kailash

### ROAD TO SALVATION

> 250 pilgrims will take Nathula route to Kailash-Mansarovar from June to August

> Pilgrim covers journey by air and road, treks for only 2.5 days instead of 12 days



#### KNOW KAILASH

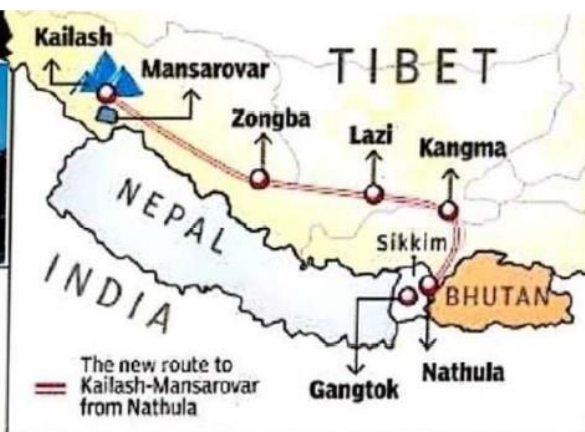
> Mount Kailash is a peak in Kailash range that forms part of Trans-Himalaya in Tibet  
> It is near the source of Indus, Sutlej, Yarlong Tsangpo (Brahmaputra) and Karnali rivers  
> Considered sacred by

Hindus, Buddhists, Jains, and followers of Bon religion

> Hindus consider Mount Kailash the abode of Lord Shiva

> Buddhists believe Lord Buddha was conceived there

> Jains believe Ashtapada.



the mount next to Kailash, is where the first Tirthankara, Rishabhadeva, attained moksha

> Bon religion, predating Buddhism in Tibet, believes Kailash-Mansarovar region is the seat of all spiritual power

## Pamir Knot

- It is a unique geographical feature in the Pamir Mountains.
- It refers to the convergence of some of the world's major mountain ranges, including the Tian Shan, Karakoram, Kunlun Shan, Hundukush and Pamir Systems.
- While a number of countries claim to be home to the Pamir knot, it is actually centred in the Gorno-Badakh-Shan autonomous region of eastern Tajikistan.

## The Great Himalayas (Himadri)

Some Highest Peaks of the Himalayas

Peak	Country	Height in metres
Mt. Everest	Nepal	8848
Kanchenjunga	India	8598
Makalu	Nepal	8481
Dhaulagiri	Nepal	8172
Nanga Parbat	India	8126
Annapurna	Nepal	8078
Nanda Devi	India	7817
Kamet	India	7756
Namcha Barwa	India	7756
Gurla Mandhata	Nepal	7728

- The highest and the northern most range of the Himalayas.
- The most continuous range consisting of the loftiest peaks with an average height of 6,000 metres
- It contains all the prominent Himalayan peaks.
- Terminate abruptly at the syntaxial bend.
- The folds of Great Himalayas are asymmetrical in nature. The core of this part of Himalayas is composed of granite.
- The peaks are perennially covered with snow due to the lofty heights (Hence Himadri).
- Almost all the prominent Himalayan peaks lie in this range like Mt Everest, Kanchenjunga, etc.
- Famous glaciers like the Gangotri and the Yamunotri lie here.
- Forests type → Needle leaved coniferous

## LESSER OR MIDDLE HIMALAYAS (THE HIMANCHAL RANGE)

- This range lies between the Shiwalik in the south and the Greater Himalayas in the north.
- Most rugged mountain system ranges mainly composed of highly compressed and altered rocks.
- The altitude varies between 3,700 and 4,500 metres and the average width is of 50 Km.
- It mainly consists of metamorphosed rocks.
- Gentle slopes of the eastern part of this range are covered with dense forests.
- The south facing slopes of this range are very steep and generally devoid of any vegetation.
- The north facing gentle slope of this range are covered by dense vegetation.



- Local names = Pir Panjal in Jammu and Kashmir; Dhauladhar in Himachal Pradesh.
- Most of the hill towns or resort towns are located in Himachal range for example Shimla, Mussoorie, Nainital, Darjeeling etc.
- All great valleys like Kashmir valley, Kangra valley, Kullu valley are present here.
- Forests type → Broad leaved evergreen



## OUTER OR SUB-HIMALAYAS (THE SIWALIK RANGE)

- The southernmost and outer most range of Himalayas which lies between the great plains and the Lesser Himalayas.
- It is also known as Manak Parbat in ancient times.
- They extend over a width of 10-50 Km and have an altitude varying between 900 and 1100 metres.
- These ranges are composed of unconsolidated sediments brought down by rivers from the main Himalayan ranges located farther north.
- These valleys are covered with thick gravel and alluvium.
- They are almost unbroken chain of low heels except for a gap of 80-90 km which is occupied by the valley of the Teesta river and Raidak river.
- Most of the Dun & Duars are located in this range
- Forests type → Deciduous type forests

### Duns

Duns are longitudinal valleys formed as a result of folding when Eurasian plate and Indian plate collided. They are formed between Lesser Himalayas and Shiwaliks. These valleys are deposited with coarse alluvium brought down by Himalayan rivers. These are known as Dun in the west and Duara in the East. Dehra Dun, Kotlic Dun and Patli Dun are some of the well-known Duns.

### Chhos

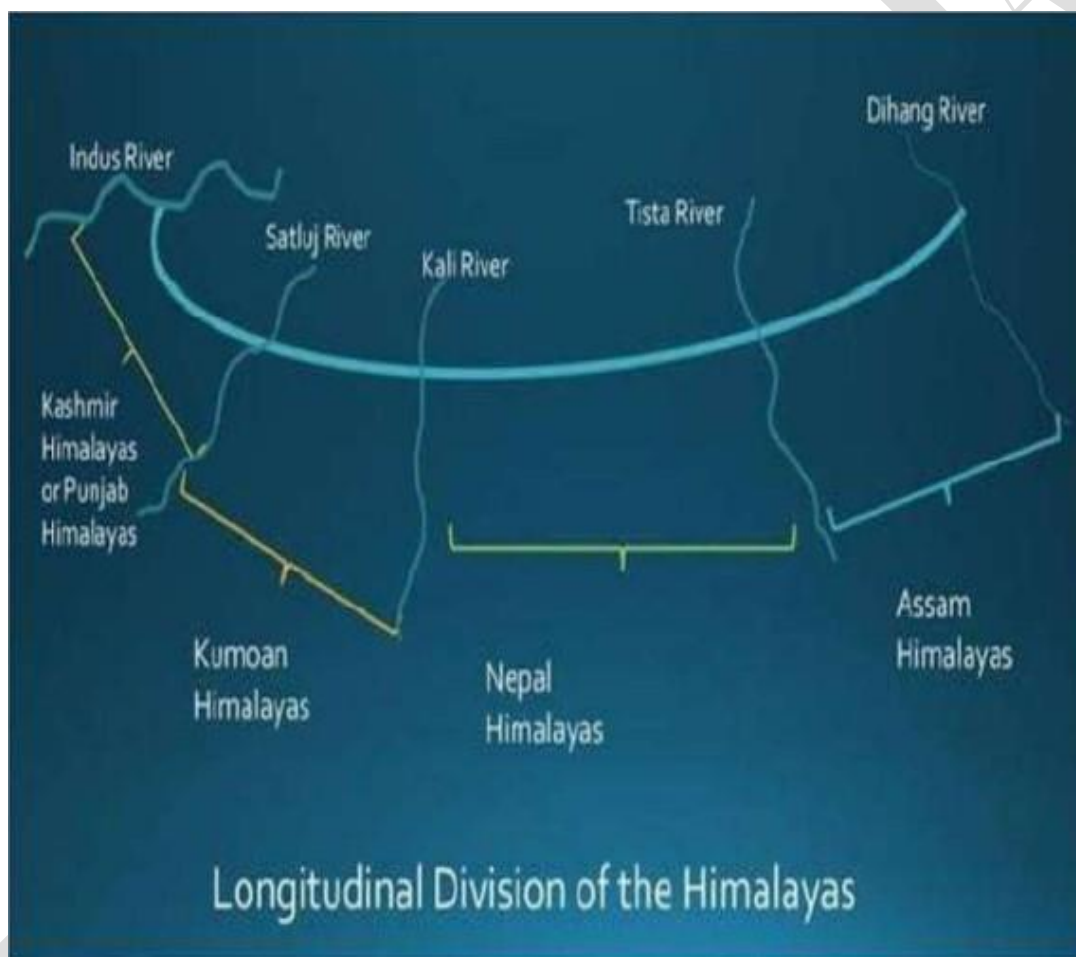
The eastern part of Shiwalik range up to Nepal is covered with thick forests whereas forest cover becomes thin in the west. The southern slopes of Shiwalik range in Punjab and Himachal Pradesh are almost devoid of forest

cover and directed by seasonal streams. Such areas are locally referred to as Chhos, typical manifestation seen in Hoshiarpur district of Punjab.

<i>Name of Shiwaliks</i>	<i>Region</i>
Jammu Region	Jammu Hills
Dafla, Miri, Abor and Mishmi Hills	Arunachal Pradesh
The Dhang Range, Dundwa Range	Uttarakhand
Churia Ghat Hills	Nepal

## LONGITUDINAL DIVISION

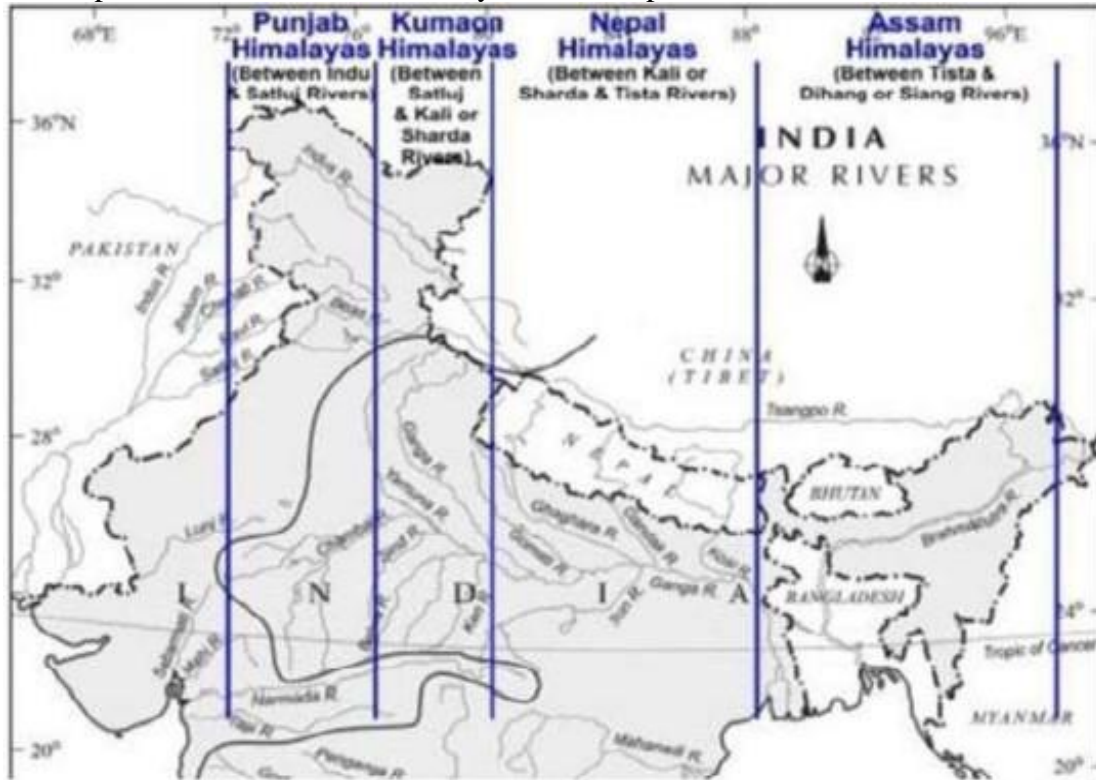
The Himalayas have also been divided on the basis of regions from west to east demarcated by river valley



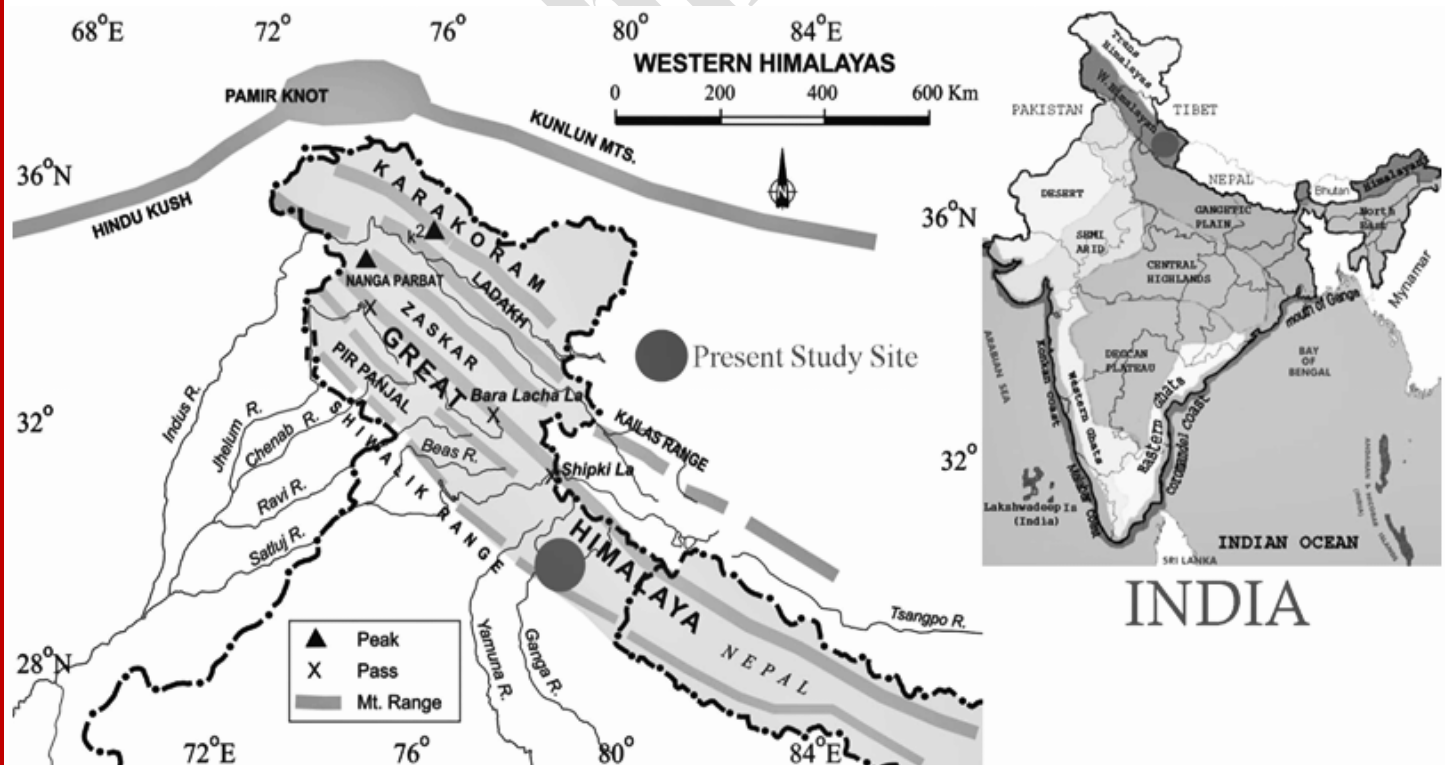
## PUNJAB HIMALAYAS

- The Himalayan region between the Indus and the Satluj rivers (560 km long). All the major rivers of the Indus river system flow through Punjab Himalayas.
- A large portion of Punjab Himalayas is in Jammu and Kashmir and Himachal Pradesh. Hence, they are also called the Kashmir and Himachal Himalaya.
- **Major ranges:** Karakoram, Ladakh, Pir Panjal, Zaskar and Dhaola Dhar
- The general elevation falls westwards.
- The Kashmir Himalayas are also famous for Karewa formations which are useful for the cultivation of **Zafran**, a local variety of saffron.

- Important glaciers of South Asia such as the *Boltaro and Siachen* are also found in this region.
- The Ladakh plateau and the Kashmir valley are two important areas of the Kashmir Himalayan region.



## KUMAON HIMALAYAS

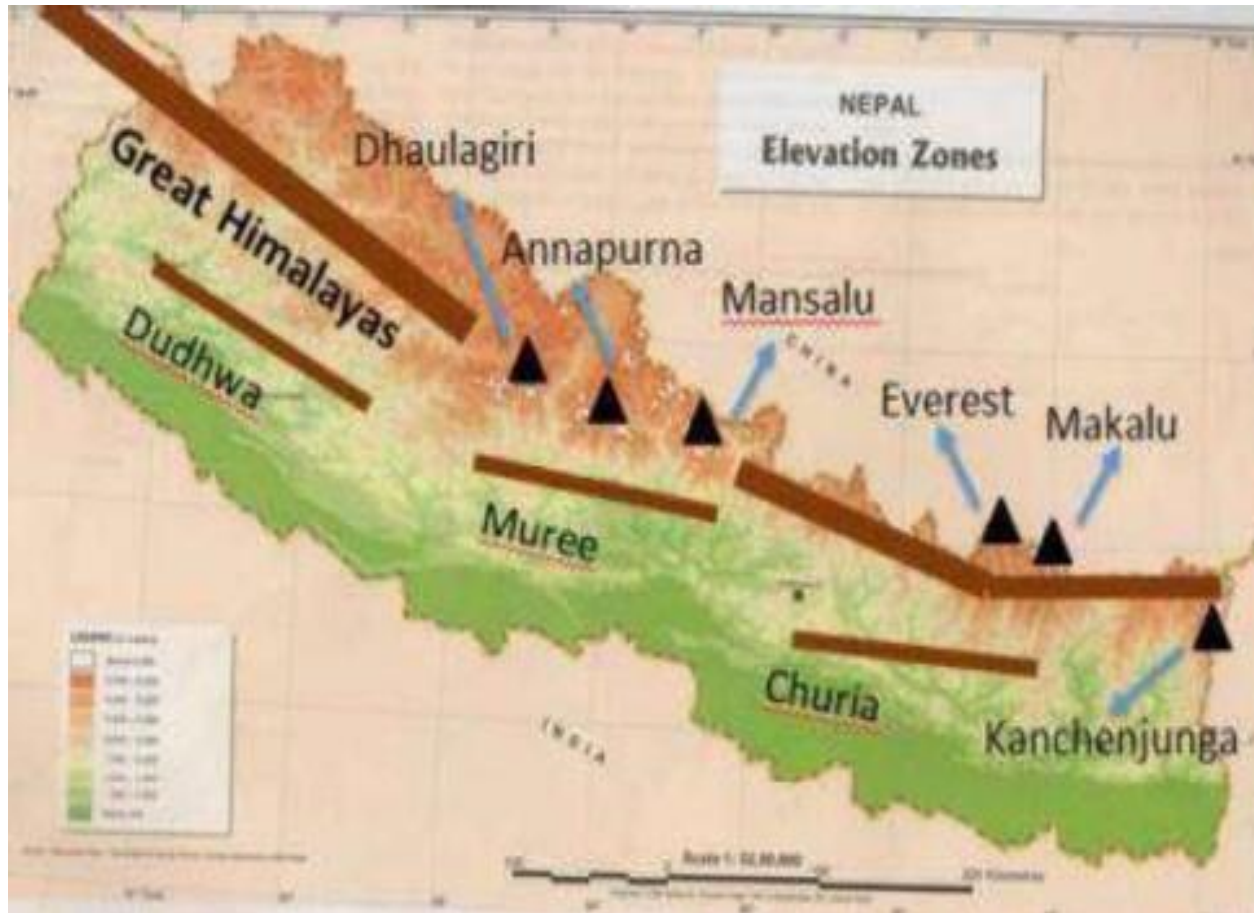




- The Kumaon Himalayas lie in Uttarakhand and extend from the Satluj to the Kali river.
- The Lesser Himalayas in Kumaon Himalaya is represented by the Mussoorie and Nag Tiba ranges
- Two distinct features of this region from the point of view of physiography are the 'Shiwalik' and 'Dun' formations.
- The Shiwalik in this region runs south of the Mussoorie range between the Ganga and the Yamuna rivers.
- The region is also known to have five famous Prayags (river confluences).



## NEPAL HIMALAYAS

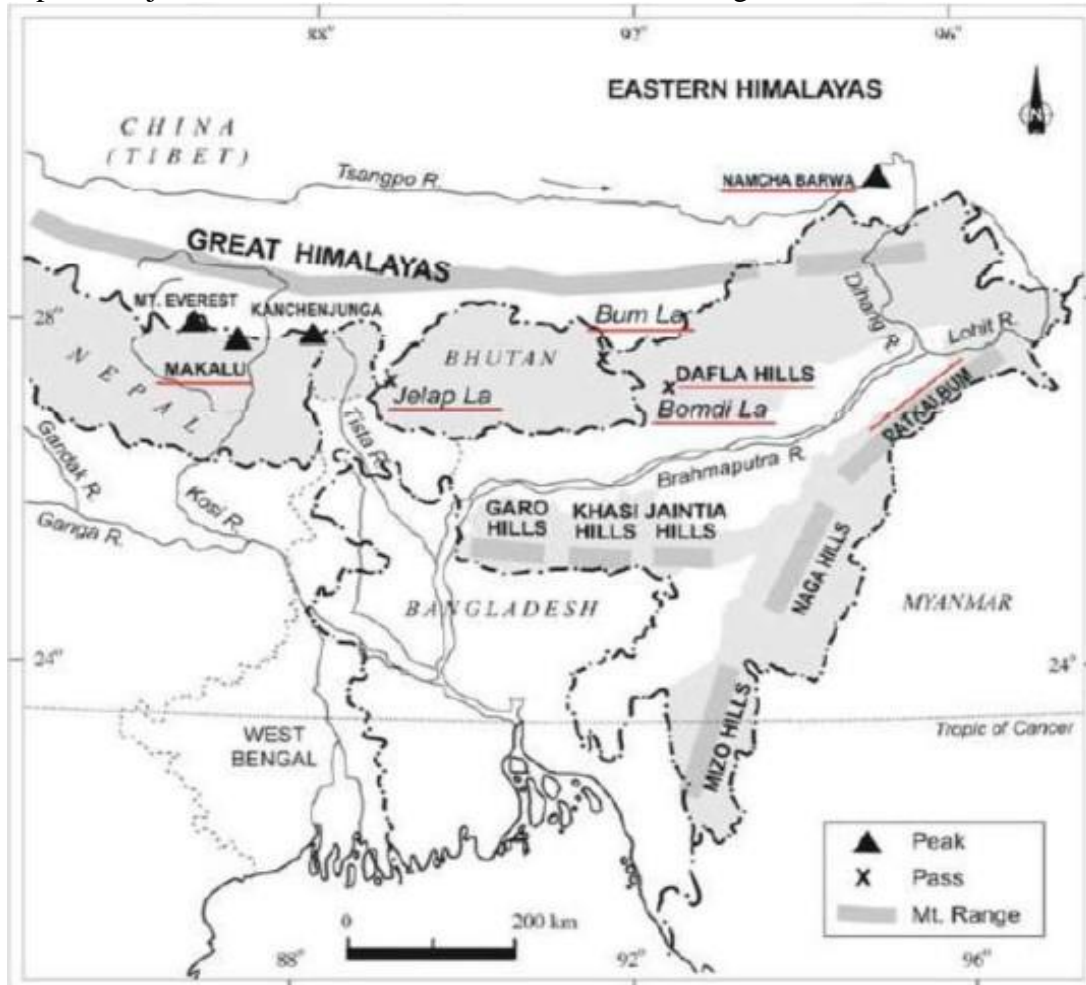


- The Great Himalaya range attains maximum height in this portion.
- Lies between river Kali in the west and river Teesta in the east.
- Famous peaks Mt. Everest, Kanchenjunga, Makalu, Annapurna, Gosainthan and Dhaulagiri, are located here
- The Lesser Himalaya is known as **Mahabharat Lekh** in this region.
- The range is crossed by rivers like Ghaghara, Gandak, Kosi, etc.
- In between the Great and the Lesser Himalayas, there are Kathmandu and Pokhara lacustrine valleys.

## ASSAM HIMALAYAS

- This part of the Himalayas lies between the Tista river in the west and the Brahmaputra river in the east and stretches for a distance of about 720 km.
- It is a region of High mountain peaks like Kanchenjunga, and deep valleys.
- The southern slopes are very steep, but the northern slopes are gentle.
- British introduced Tea plantations in this region
- Famous for 'Duar formations' e.g Bengal 'Duars'
- Himalayas are narrower in this region and Lesser Himalayas lie close to Great Himalayas.
- The Assam Himalayas show a marked dominance of fluvial erosion due to heavy rainfall.

- Jelep la pass- tri-junction of India- China-Bhutan lies in this region



## EASTERN HIMALAYAS

### The North-Eastern Hills and Mountains (Purvanchal)

- The Himalayas take a sudden southward turn after the Dihang gorge and the hill ranges running in a more or less north-south direction along India's border with Myanmar are collectively known as the Purvanchal
- Purvanchal hills are known by various local names such as Patkai Bum, Naga Hills, Kohima hills, Manipur hills, Mizo hills (previously known as the Lushai hills), Tripura hills and Barail range
- These hills run through the northeastern states of India
- These hills differ in scale and relief but stem from the Himalayan orogeny.
- They are mostly composed of sandstones (i.e. Sedimentary rocks)
- These hills are covered with dense forests.
- Their elevation decreases from north to south. Although comparatively low, these hill ranges are rather forbidding because of the rough terrain, dense forests and swift streams.

### These hills are composed of:

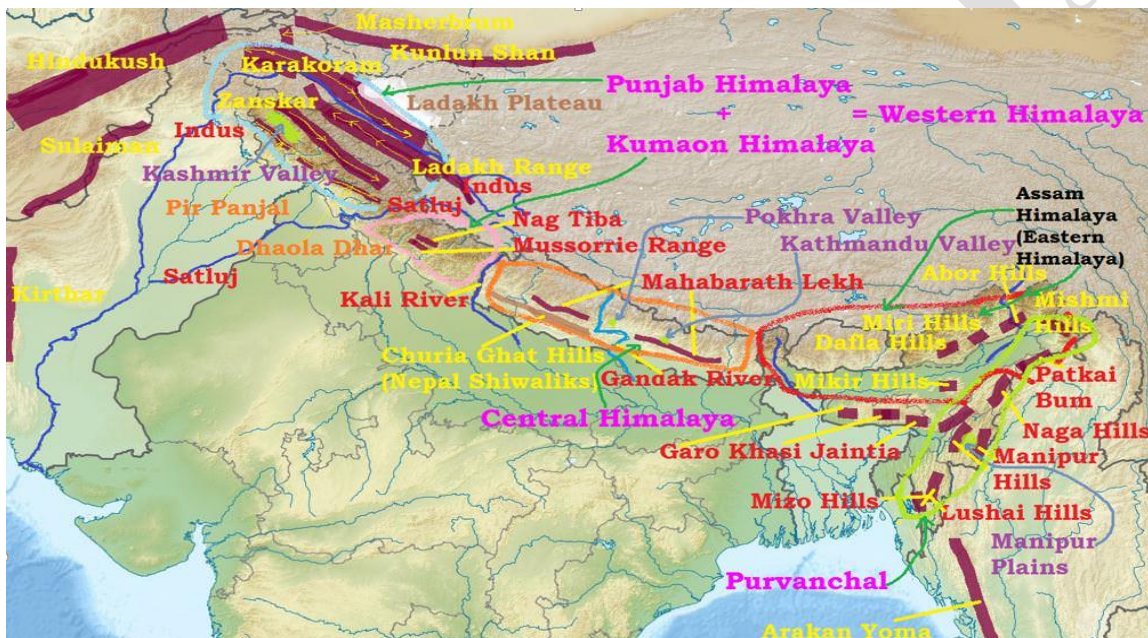
- Patkai Bum – Border between Arunachal Pradesh and Myanmar
- Naga Hills



- Manipuri Hills – Border between Manipur and Myanmar
- Mizo Hills
- Patkai Bum and Naga Hills form the watershed between India and Myanmar

## Extension of Purvanchal to A&N Islands

- The extension of the Purvanchal Himalaya continues southwards up to Andaman and Nicobar Islands through the Myanmar range (Arakan Yoma) and even up to the Indonesian archipelago.
- They are mostly composed of sandstones (i.e. Sedimentary rocks)
- These hills are covered with dense forests.
- Their elevation decreases from north to south. Although comparatively low, these hill ranges are rather forbidding because of the rough terrain, dense forests and swift streams.



## Key Difference between Western and Eastern Himalayas

### Western Himalayas

1. Extends till west of River Kali (around 80°E Longitude).
2. Height of the mountains from the plains in this part rises in a number of stages. The high mountain ranges are at a long distance from the plains
3. Amount of rainfall here is less and is 1/4th of that of Eastern Himalayas.
4. The dominant vegetation in the western Himalayas is Coniferous forests and alpine vegetations. The Natural vegetation reflects the impact of lower rainfall.
5. The altitude of the Western Himalayas is higher than the Eastern Himalayas
6. Snowline is Lower than Eastern Himalayas
7. Western Himalayas receive more precipitation from northwest in the winters
8. Less biodiversity in comparison to eastern Himalayas

### Eastern Himalayas

1. This is considered to be ranging from east of the Singalila ranges in Sikkim (88°E Longitudes) to eastern boundaries of Himalayas.
2. This part rises abruptly from the plains, thus peaks are not faraway from the plains (Example: Kanchenjunga)
3. This region receives 4 times more rainfall than western Himalayas. Due to high rainfalls, it is covered with dense forests.
4. Snowline is Higher than Western Himalayas
5. Eastern Himalayas receive more precipitation from south-eastern monsoon in the summers.
6. Much ahead from western Himalayas in terms of Biodiversity and is one of the Biodiversity hotspots

## IMPORTANT PASSES IN INDIA

A mountain pass is a navigable route through a mountain range or over a ridge. Since many of the world's mountain ranges have presented formidable barriers to travel, passes have played a key role in trade, war, and both human and animal migration throughout Earth's history.

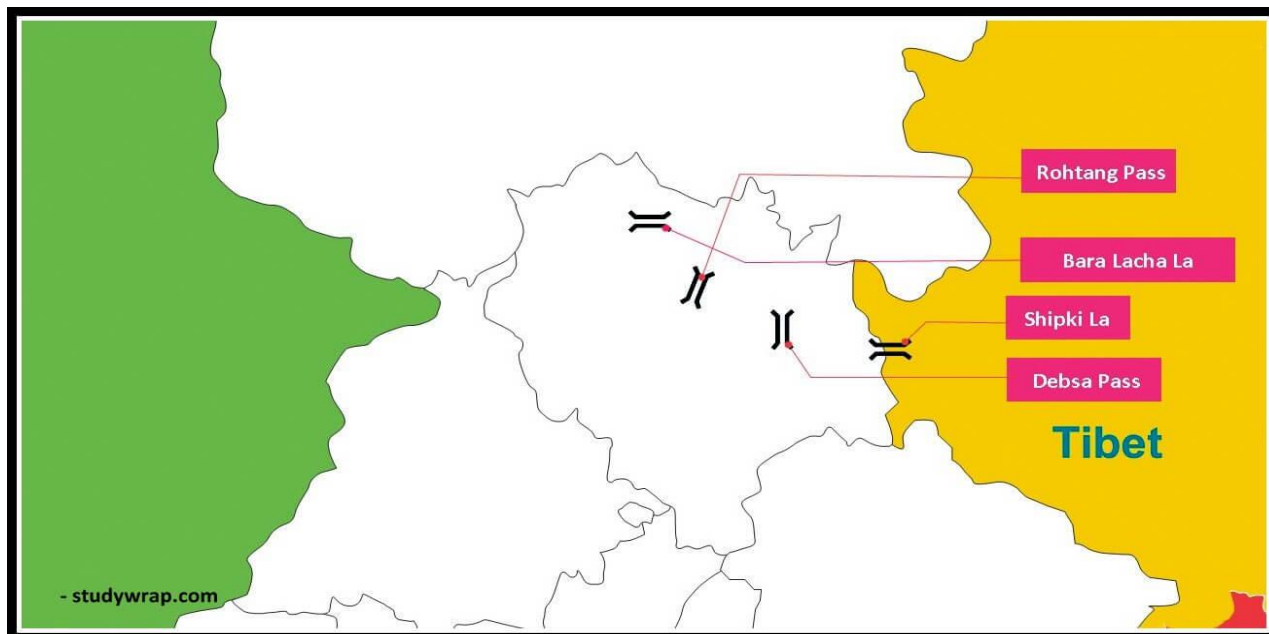
### Passes of J&K



Jammu and Kashmir		
Name	Significance (connects)	Comments
<b>Mintaka Pass</b>	Kashmir and China	<b>Trijunction of India-China and Afghanistan border</b>
<b>Parpik Pass</b>	Kashmir and China	• East of Mintaka pass on the Indo-China border
<b>Khunjerab Pass</b>	Kashmir and China	• Indo-China border
<b>Aghil Pass</b>	Ladakh with the Xinjiang Province (China)	• 5000 m above sea level. • north of K2 Peak (the highest peak in India)
<b>Banihal Pass</b>	Jammu and Srinagar	<ul style="list-style-type: none"> <li>• 2832 m</li> <li>• across the <b>Pir-Panjal Range</b></li> <li>• remains snow covered during the winter season</li> </ul>
		<ul style="list-style-type: none"> <li>• The road from Jammu to Srinagar transversed Banihal Pass until 1956 when Jawahar Tunnel was constructed under the pass.</li> <li>• The road now passes through the tunnel, and the Banihal Pass is no longer used for road transport.</li> <li>• Another 11 km long tunnel provides a <b>railway link between Banihal and Kazigund</b>. It was thrown open to railway transport in 2013.</li> </ul>



## Passes of Himachal Pradesh

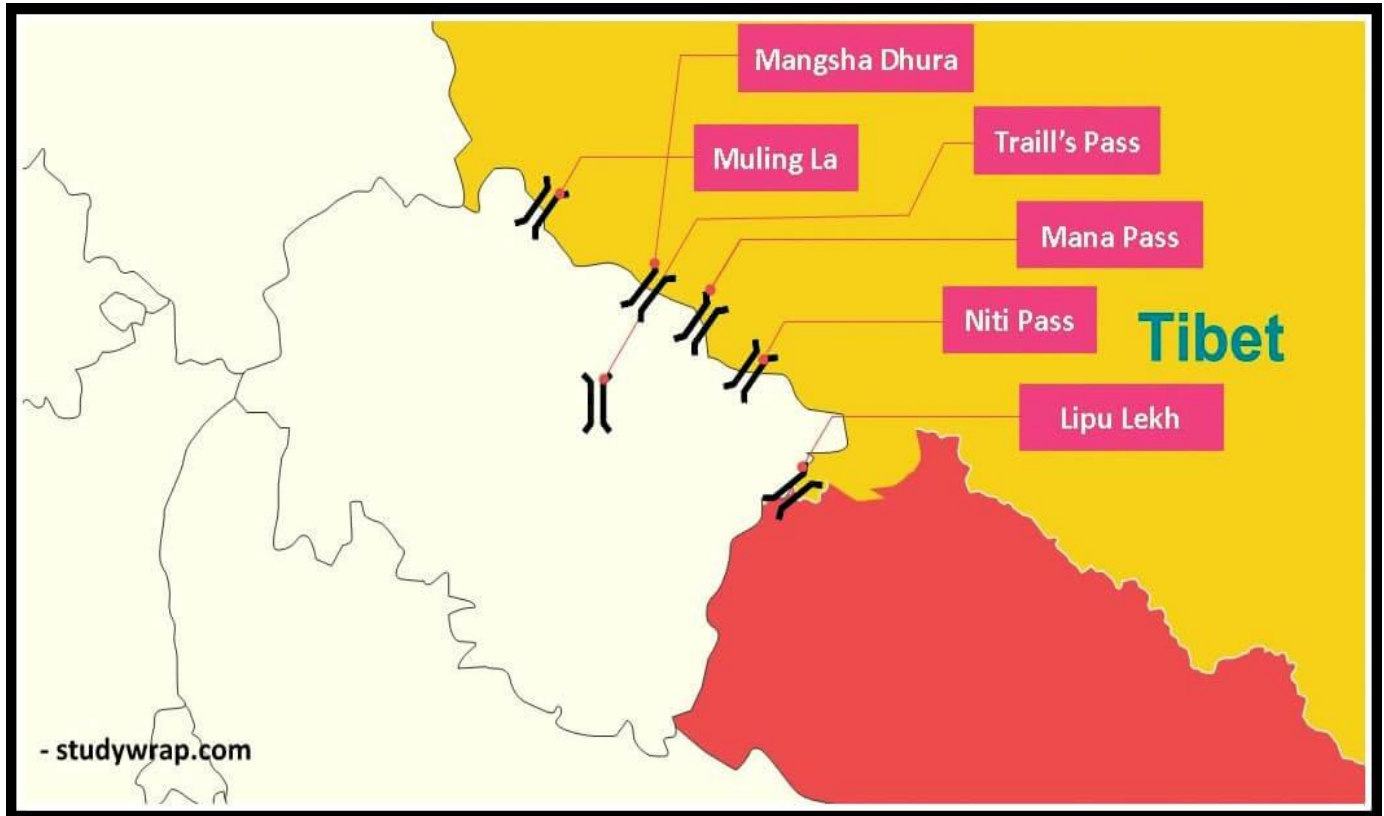


### Himachal Pradesh

<b>Bara Lacha La</b>	Himachal Pradesh and Jammu and Kashmir	<ul style="list-style-type: none"> <li>Elevation: 4,890 m</li> <li>National highway connecting Mandi in Himachal Pradesh with Leh in Jammu and Kashmir passes through this pass.</li> <li>Being situated at high altitude, it remains snow covered in winter and is not used as a transport route.</li> </ul>
<b>Debsa Pass</b>	link between Kullu and Spiti districts	<ul style="list-style-type: none"> <li>elevation of 5270 m above sea level</li> <li>It offers a much easier and shorter alternative route to traditional Pin-Parbati Pass route between Kullu and Spiti</li> </ul>
<b>Rohtang Pass</b>	road link between Kullu, Lahul and Spiti Valleys	<ul style="list-style-type: none"> <li>Elevation: 3979 m</li> <li>Border Road Organisation (BRO) is responsible for constructing and maintaining roads in this area.</li> <li><b>Rohtang pass is a great tourist attraction</b>, and traffic jams are very common because this route is widely used by the military, public and private vehicles.</li> </ul>
<b>Shipki La</b>	Himachal Pradesh and Ti-	<ul style="list-style-type: none"> <li>Elevation: 6000 m</li> </ul>

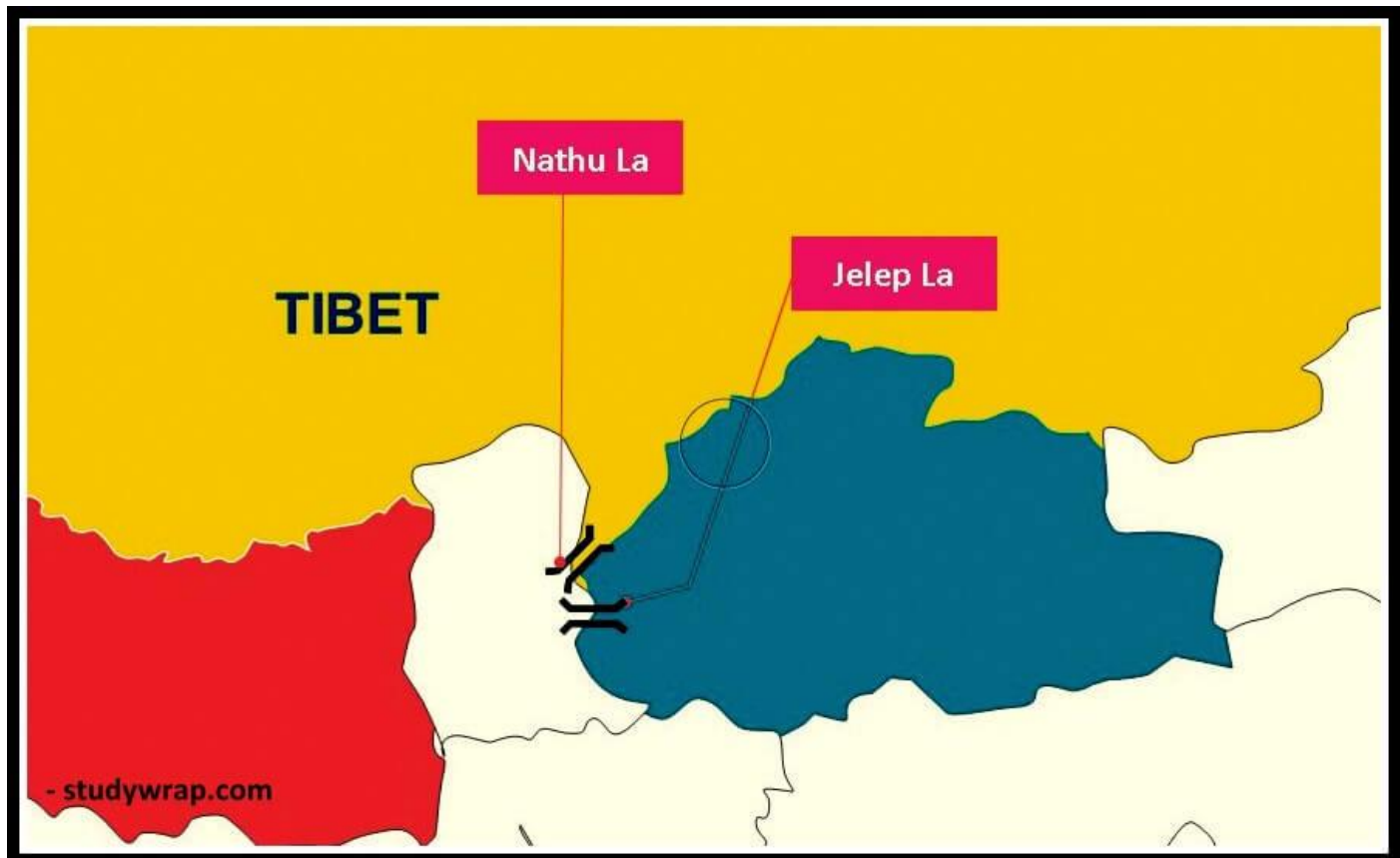


## Passes of Uttarakhand



Uttarakhand		
<b>Lipu Lekh</b>	trijunction of Uttarakhand (India), Tibet (China) and Nepal borders	<ul style="list-style-type: none"> <li>• <b>Kailash-Mansarovar pilgrims use this pass.</b></li> </ul>
<b>Mana Pass</b>	Uttarakhand with Tibet	<ul style="list-style-type: none"> <li>• elevation of 5610</li> <li>• Situated a little north of Badhrinath</li> <li>• Remains closed in the winter season (Nov - Apr)</li> </ul>
<b>Mangsha Dhura</b>	Uttarakhand with Tibet	<ul style="list-style-type: none"> <li>• <b>It is used by pilgrims going to Kailash-Mansarowar</b></li> </ul>
<b>Niti Pass</b>	Uttarakhand with Tibet	<ul style="list-style-type: none"> <li>• Remains closed in the winter season (Nov - Apr)</li> </ul>
<b>Muling La</b>	Uttarakhand and Tibet	<ul style="list-style-type: none"> <li>• situated in the north of Gangotri at an elevation of 5669 m in the Great Himalayas</li> </ul>

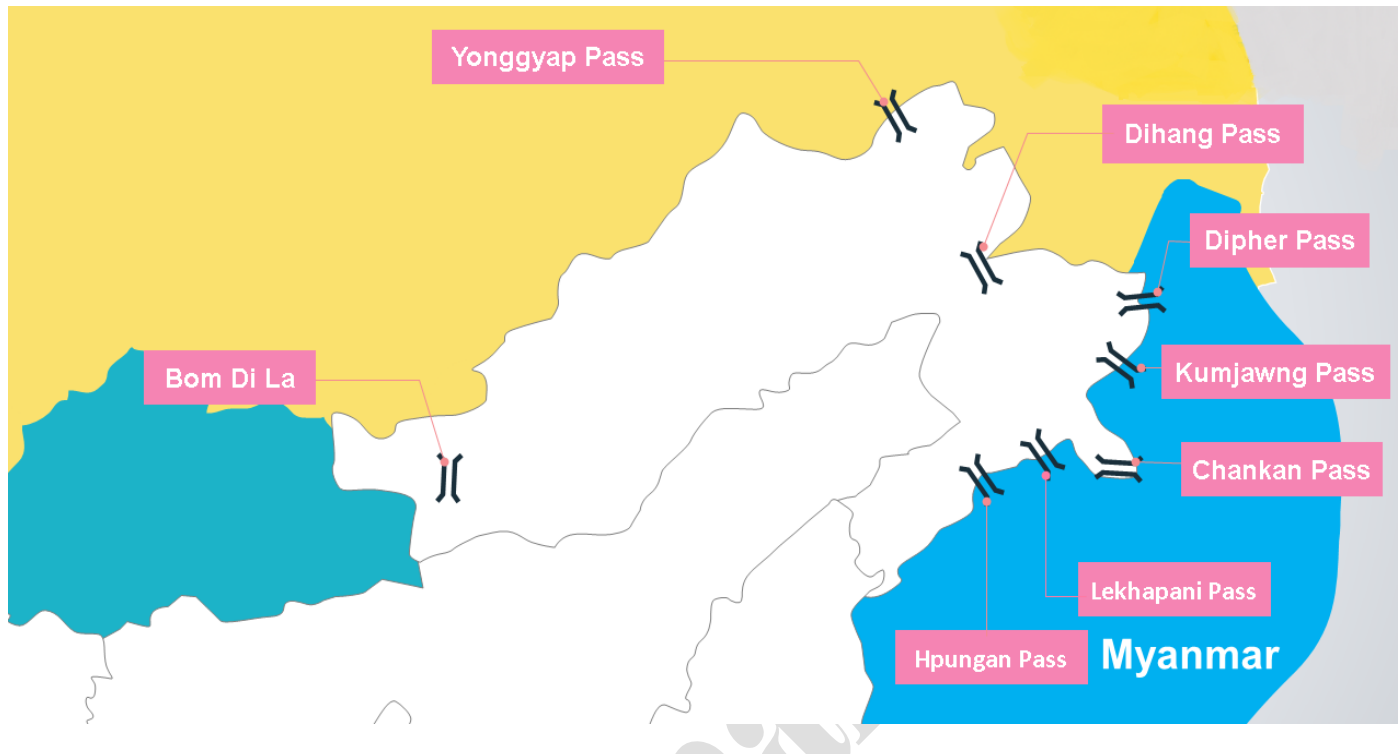
## Passes of Sikkim



### Sikkim

<b>Nathu La</b>	Sikkim with Tibet	<ul style="list-style-type: none"> <li>altitude of 4310 m</li> <li>it forms part of an offshoot of the <b>ancient Silk Route</b></li> <li>an important trade route between India and China</li> <li>It was closed after the Chinese aggression on India in 1962 but was reopened in 2006 as the governments of the two countries decided to enhance their trade through land routes</li> </ul>
<b>Jelep La</b>	Sikkim-Bhutan border	<ul style="list-style-type: none"> <li>altitude of 4538 m</li> <li>passes through Chumbi Valley</li> <li>an important link between Sikkim and Lhasa</li> </ul>

## Passes of Arunachal Pradesh



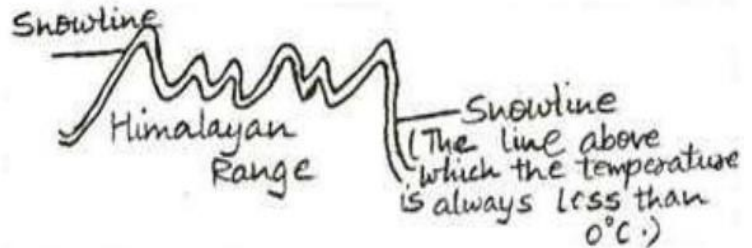
### Arunachal Pradesh

<b>Bom Di La</b>	Arunachal Pradesh with Bhutan	<ul style="list-style-type: none"> <li>altitude of 4331 m</li> <li>Situated at an altitude of 4331 m near the eastern boundary of Bhutan in the Greater Himalayas, this pass connects Arunachal Pradesh with Lhasa (Tibet)</li> </ul>
<b>Dihang Pass</b>	Arunachal Pradesh and Myanmar.	<ul style="list-style-type: none"> <li>elevation of more than 4000 m it provides passage</li> </ul>
<b>Yonggyap Pass</b>	Arunachal Pradesh with Tibet	
<b>Dipher Pass</b> (Diphu pass)	trijunction of India, China and Myanmar	<ul style="list-style-type: none"> <li>easy access between Arunachal Pradesh and Mandalay in Myanmar.</li> <li>It is an important land trade route between India and Myanmar and remains open throughout the year.</li> </ul>



## GLACIERS AND SNOWLINE IN HIMALAYAS

The **SNOWLINE** on a mountain is the *boundary beyond which there is permanent snow*. It is about 3,500 metres above sea level. The snow line's location depends on conditions such as elevation, latitude, proximity to the sea, climate, wind direction, exposure, and the steepness of the slope. In India, it occurs at 4,250 metres above sea level while in Europe it may begin at about 3,500 metres. Further North, at the poles, the snow line starts at sea level.



Higher Snowline in the Western Himalayas than that in the Eastern Himalayas

- The snowline in the Western Himalaya is at a lower altitude than in the Eastern Himalaya.
  - For example, while the glaciers of the Kanchenjunga in the Sikkim portion hardly move below 4000m, and those of Kumaon and Lahul to 3600m, the glaciers of the Kashmir Himalayas may descend to 2500m above the sea level.
  - It is because of the increase in latitude from 28°N in Kanchenjunga to 36°N in the Karakoram (Lower latitude → warmer temperatures → higher snowline).
  - Also, the Eastern Himalayas rise abruptly from the plains without the intervention of High ranges.
  - Though the total precipitation is much less in the western Himalayas, it all takes place in the form of snow.
- In the Great Himalayan ranges, the snowline is at a lower elevation on the southern slopes than on the northern slopes. This is because the southern slopes are steeper and receive more precipitation as compared to the northern slopes.

### Glaciers:

The main glaciers are found in the Great Himalayas and the Trans-Himalayan ranges (Karakoram, Ladakh and Zaskar). The Lesser Himalayas have small glaciers, though traces of large glaciers are found in the Pir Panjal and Dhauladhar ranges.

Location	Important Glaciers
Karakoram	Siachin, Hispara, Baltora
Kashmir	Rimo, Punma, Rupal
Uttarakhand	Gangotri, Milam, Pindari
Sikkim	Zemu (Largest glacier in Eastern Himalayas)

## IMPORTANT VALLEYS IN THE HIMALAYAS

1. Valley of Kashmir and the Karewas,
2. Kangra and Kulu valley in Himachal Pradesh;
3. Dun valley (Doon valley, Dehradun valley); the Bhagirathi valley (near Gangotri) and the Mandakini valley (near Kedarnath) in Uttarakhand
4. Kathmandu valley in Nepal.

## HIMALAYAS- SOURCE OF FRESHWATER/RIVERS

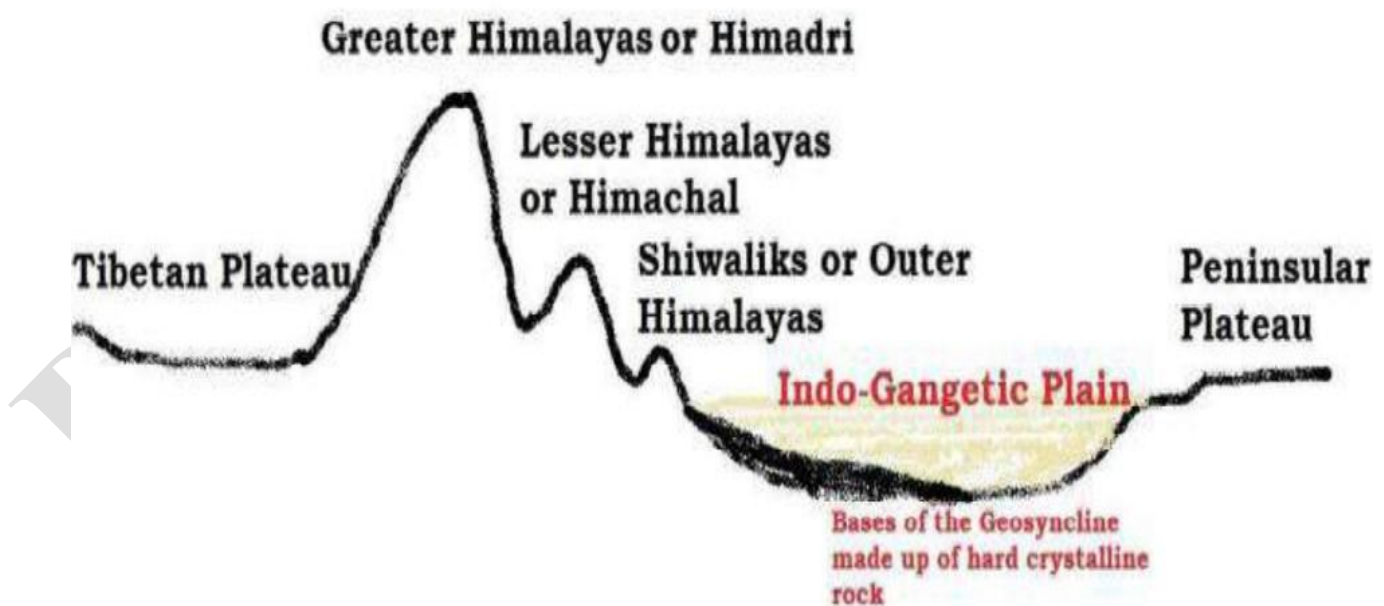
- The Himalaya Mountain range is the source of some of the largest rivers in India as well as in the world.
- It is also the largest source of fresh water on earth after the Polar Regions.
- After Antarctica and Arctic, it has the third-largest deposit of ice and snow on earth.
- It contains some of the largest glaciers in the world and count goes as high as 15000 glaciers including **Gangotri** and **Yamunotri** glaciers.
- Rivers originating from Himalaya Mountain are perennial and they have water for almost every part of the year.
- Almost one-fifth of the world population depends on water from the Himalayan system.
- Himalayas Basin is drained by nearly 19 rivers and they can be grouped into three major river systems of Ganges, Indus, and Brahmaputra.
- Apart from rivers, the Himalayan range has a large number of freshwater lakes.
- Some important lakes include Tilicho, Pangong Tso, and Yamdrok Tso Lake.

## SIGNIFICANCE OF HIMALAYAS FOR INDIA

<b>Climatic significance</b>	<ul style="list-style-type: none"> <li>• The altitude of the Himalayas, their sprawl and extension intercept the summer monsoon.</li> <li>• They also prevent the cold Siberian air masses from entering into India.</li> </ul>
<b>Agricultural significance</b>	<ul style="list-style-type: none"> <li>• The swift flowing rivers from the Himalayas bring an enormous amount of silt (alluvium) which continually enrich the plains to form India's most fertile agricultural grounds known as Northern plains.</li> </ul>
<b>Strategic significance</b>	<ul style="list-style-type: none"> <li>• Himalayas are a natural defence barrier for Indian Subcontinent from ages.</li> </ul>
<b>Economic significance</b>	<ul style="list-style-type: none"> <li>• Huge hydro-electric power potential of Himalayan rivers.</li> <li>• Himalayas host rich coniferous and evergreen forests which provide fuelwood and a large variety of timber for industries.</li> <li>• They host a wide variety of Himalayan Herbs &amp; Medicinal plants too.</li> </ul>
<b>Tourism Significance</b>	<ul style="list-style-type: none"> <li>• Comprises of major natural views and hill stations.</li> <li>• Srinagar, Dalhousie, Dharamshala, Chamba, Shimla, Kulu, Manali, Mussoorie, Nainital, Ranikhet, Almora, Darjeeling, Mirik, Gangtok, etc. are important tourist centres in the Himalayas. They host many Hindu and Buddhist shrines too.</li> </ul>
<b>Environmentl Significance</b>	<ul style="list-style-type: none"> <li>• Comprises of Large ecological biodiversity and one of the four hotspot zone in India.</li> </ul>

## CH-2 THE NORTHERN PLAINS

The great Northern Plains of India are an aggradation surface of extraordinary degree formed after the Himalayas. They are relatively of recent origin and are accepted to have formed by the filling up of a depression resulting from the elevation of the Himalayas, by deposition of silt brought by swift-flowing Himalayan rivers, started in Himalayas.



*Elevation of the major physiographic divisions of India*



The vast plain region of North India lies to the south of the Shivaliks, separated by the Himalayan Frontal Fault (HFF). The peninsular plateau region forms the southern boundary. On the eastern side, the plains are bordered by the Purvanchal hills. Northern plains are the youngest physiographic feature of India.

## DEVELOPMENT OF NORTHERN PLAINS

The formation of the Indo-Gangetic plain is firmly identified with the the formation of Himalayas.

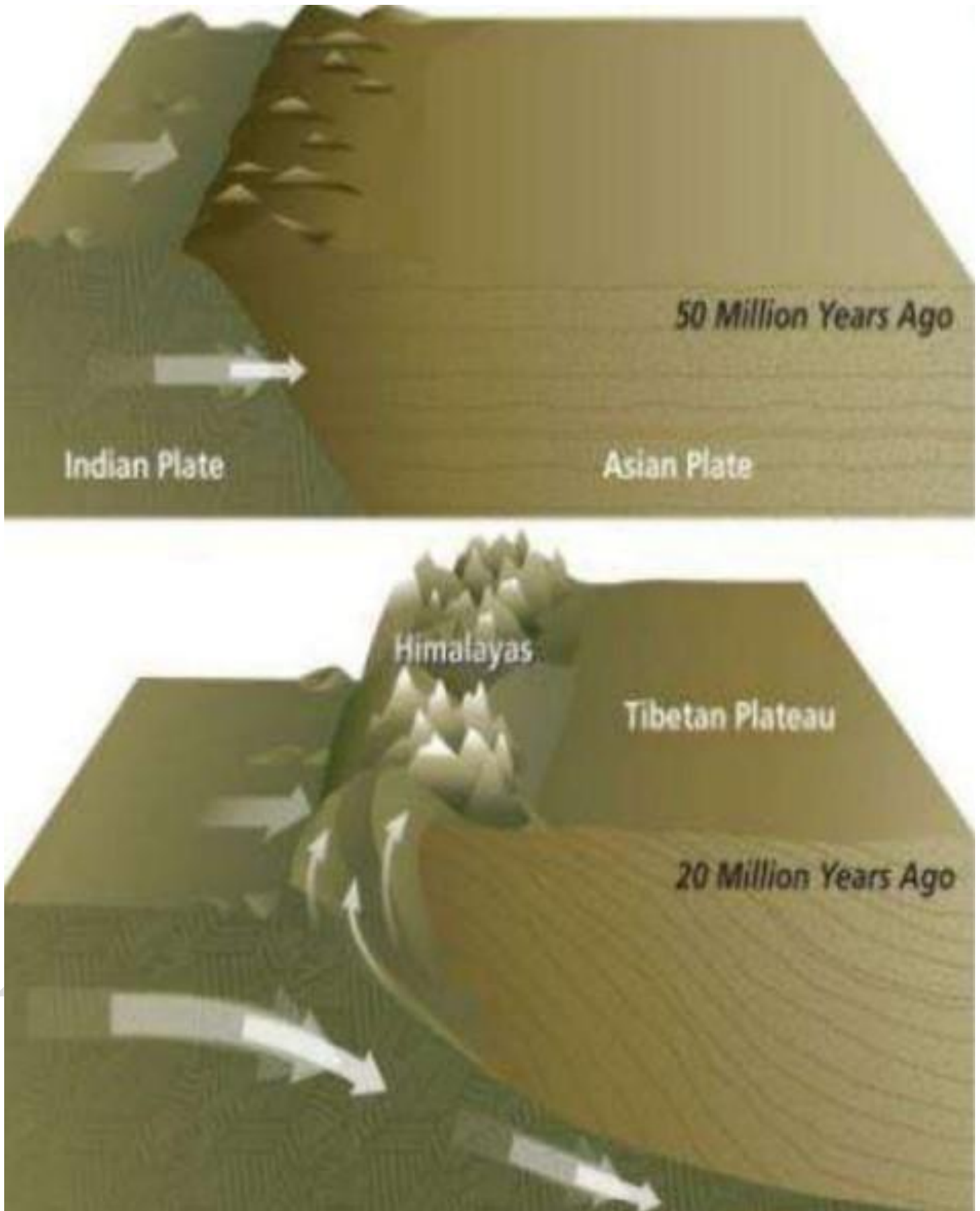
- Due to the uplift of the Himalayas in the Tethys Sea, the northern part of the Indian Peninsula got subsided and formed an enormous basin.
- That basin was loaded up with sediments from the rivers which originated from the mountains in the north and from the peninsula in the south.
- During recent times (since a few million years), depositional work of three major rivers viz., the Indus, the Ganga and the Brahmaputra have become transcendent.
- Consequently, this plain is also known as Indo- Gangetic-Brahmaputra Plain.

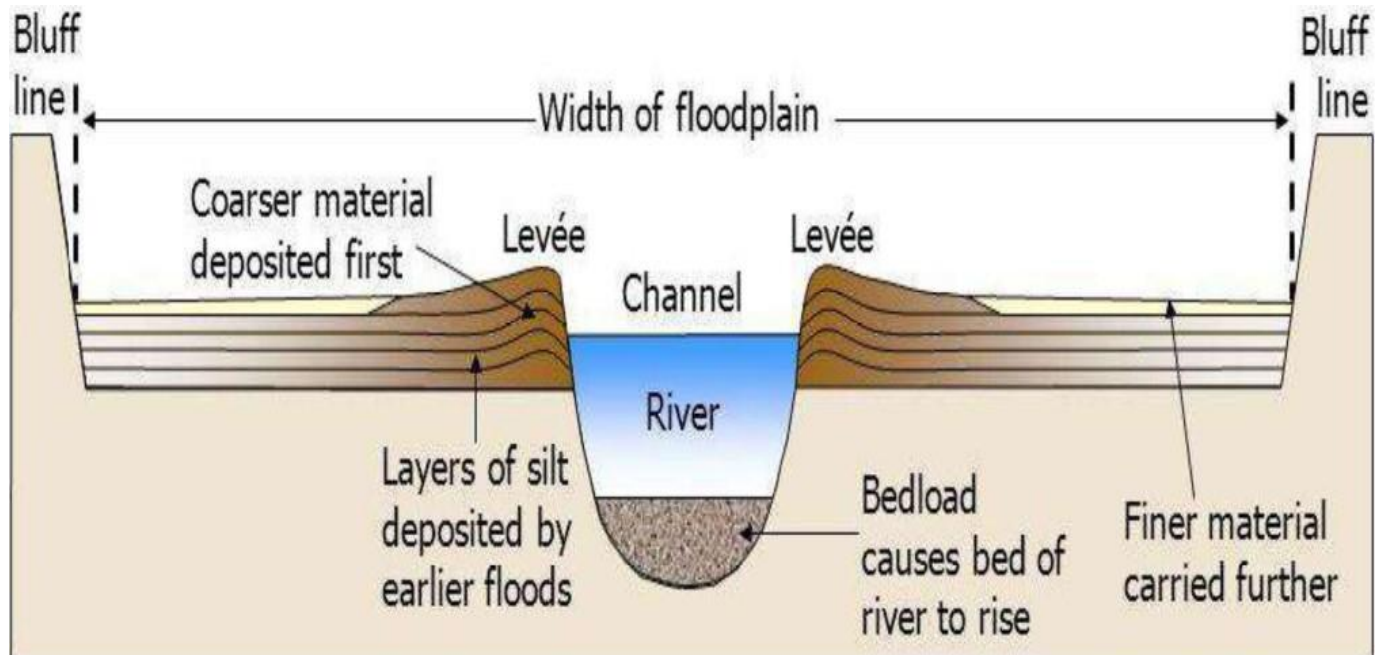
## HIGHLIGHTS OF NORTHERN PLAINS:

- The northern plain of India is shaped by three river systems, i.e. the Indus, the Ganga and the Brahmaputra; alongside their tributaries.
- Northern Plains are the biggest alluvial tract of the world.
- It extends for around 3,200 km from the mouth of the Indus to the mouth of the Ganga.
- The average width of these plains shifts in the range of 150 and 300 km. In general, the width of the northern plains increments from east to west (90-100km in Assam to about 500km in Punjab).
- The northern boundary is well marked by the Shiwaliks and the southern boundary is a wavy spotadic line along the northern edge of Peninsular India
- The western fringe is set apart by Sulaiman and Kirthar ranges.
- The thickness of the alluvium deposits also varies from place to place. The maximum depth of the alluvium up to the basement rocks is about 6,100 m



*Elevation of the major physiographic divisions of India*





- Extreme horizontality of this tedious plain is its main feature
- Its normal elevation is about 200 m above mean sea level, most noteworthy height being 291 m above mean ocean level close to Ambala (This elevation shapes the drainage divide or watershed between Indus River system and Ganga river system).
- The dreariness of the physical landscape is broken by the river bluffs, levees etc.
  - **Floodplain** – That part of a river valley, contiguous to the channel, over which a stream flows in times of a flood.
  - **Levee** – A raised bank flanking the channel of the river and remaining above the level of the flood plain.
  - **Bluff** – A river cut cliff or steep slant on the outside of a meander. A line of bluffs often denotes the edge of a previous floodplain.

## PHYSIOGRAPHIC DIVISION OF NORTHERN PLAIN

The Great North Indian plain is divided into following subdivisions on the basis of relief features:

1. The Bhabar Plains
2. The Tarai Tract
3. The Bhangar
4. The Khadar
5. Delta Plains

### Bhabar

The Bhabar plains lie to the south of Shiwalik from Jammu to Assam

- It is a narrow, permeable, northernmost stretch of Indo-Gangetic plain
- It is around 8-16 km wide running in an east-west direction along the lower regions (alluvial fans) of the Shiwaliks
- They show a striking continuity from the Indus to the Teesta
- Rivers descending from the Himalayas deposit their load along the lower regions in the form of alluvial fans



- These alluvial fans (often pebbly soils) have combined to develop the bhabar belt
- The streams vanish once they come to the bhabar region in light of this porosity
- Subsequently, the region is set apart by dry river courses except in the rainy season
- The Bhabar belt is nearly limited in the east and broad in the west

The area is not appropriate for farming due to its porous nature and presence of pebble studded rocks; only enormous trees with huge roots flourish in this belt.

## Terai



- Terai is an ill-drained, moist (damp) and thickly forested narrow tract to the south of Bhabar running parallel to it
- The Terai is around 15-30 km in width
- The underground streams of the Bhabar belt reappear in this belt.
- The Terai is more set apart in the eastern part than in the west on the grounds that the eastern parts get comparatively higher measure of precipitation
- The terai soils are silty and rich in nitrogen and organic matter but are inadequate in phosphate
- Nowadays the Terai tract in Haryana, Punjab, Uttarakhand, and Uttar Pradesh has been cleared for cultivation because it is rich in humus and organic matter.
- It is good for the cultivation of Wheat, rice, maize, sugarcane etc.

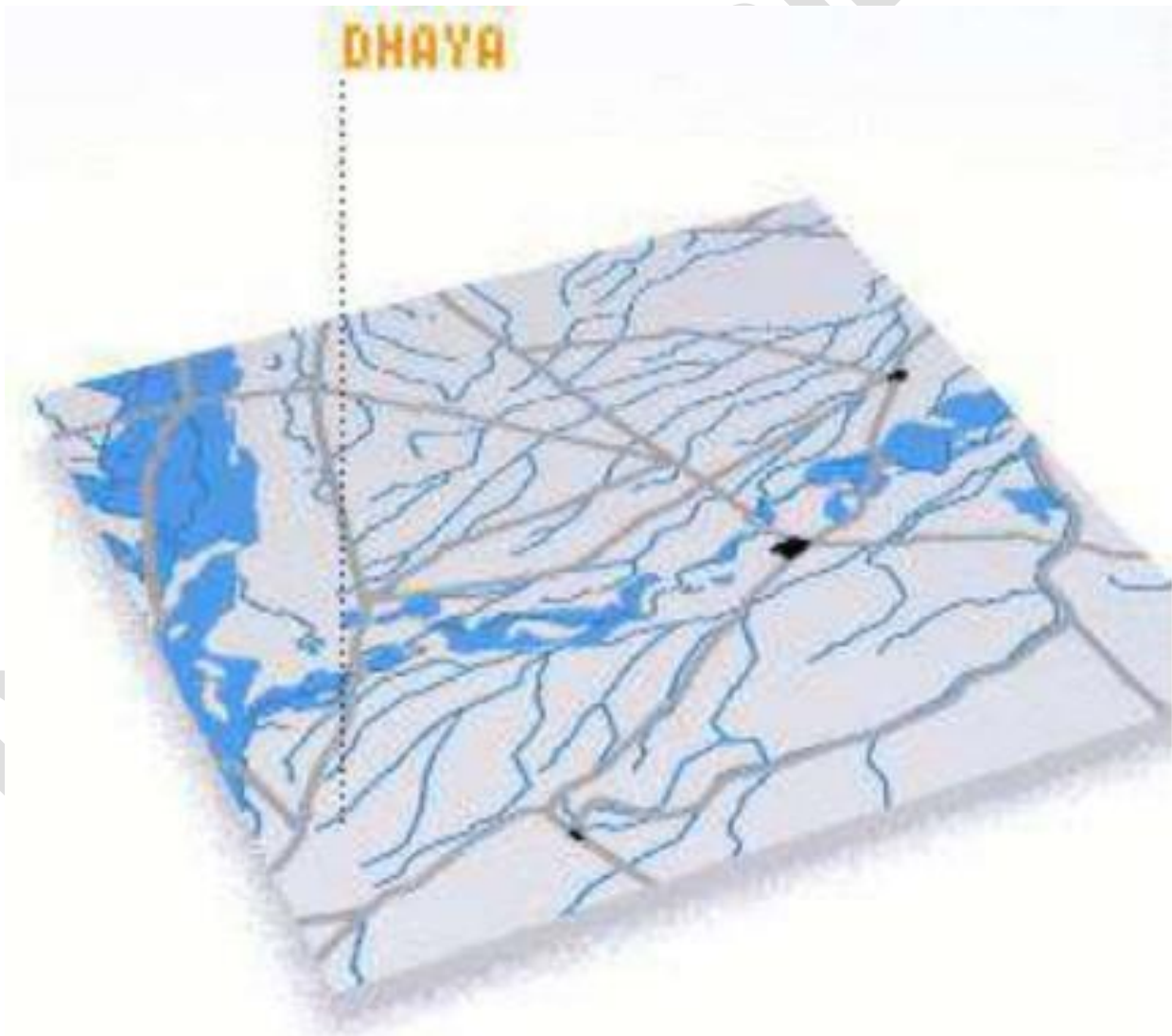
## Bhangar

- The Bhangar is the older alluvium along the river beds forming terraces higher than the floodplain

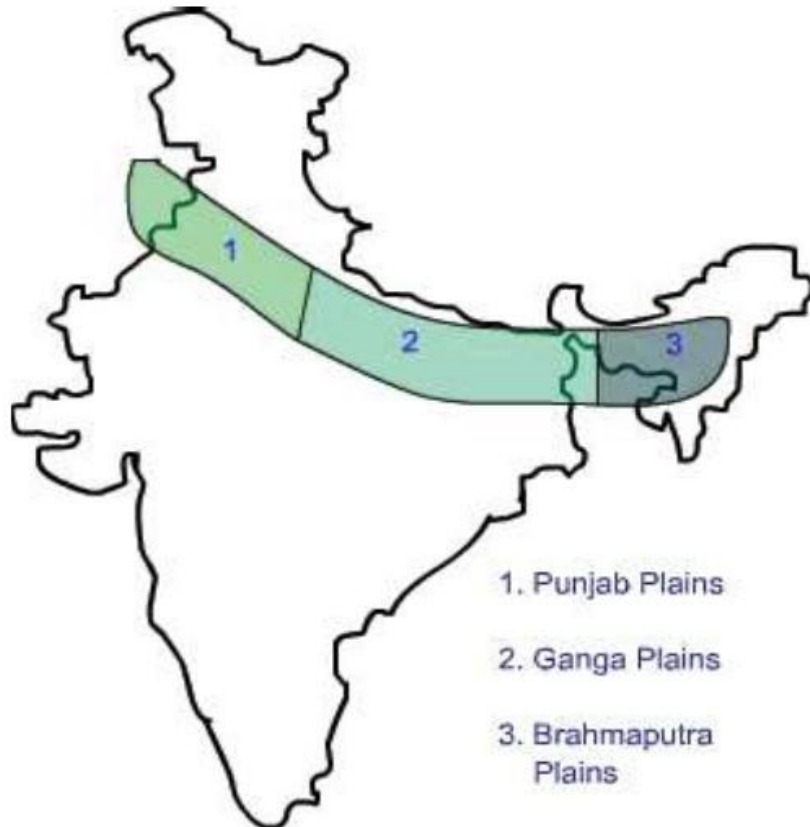
- The terraces are regularly impregnated with calcareous solidifications (beds of lime nodules) known as 'Kankar'
- In moderately drier zones, the Bhangar also exhibits small tracts of saline and alkaline efflorescence known as 'Reh', 'Kallar' or 'Bhur'. Reh areas have spread in recent times with increase in irrigation (capillary action brings salts to the surface).
- 'The Barind fields' in the deltaic area of Bengal and the 'bhur formations' in the middle Ganga and Yamuna doab are regional variations of Bhangar.
- Bhangar contains fossils of creatures like rhinoceros, hippopotamus, elephants and so forth.
- The soil is of an increasingly clayey sythesis and is generally dark coloured.

## Khadar

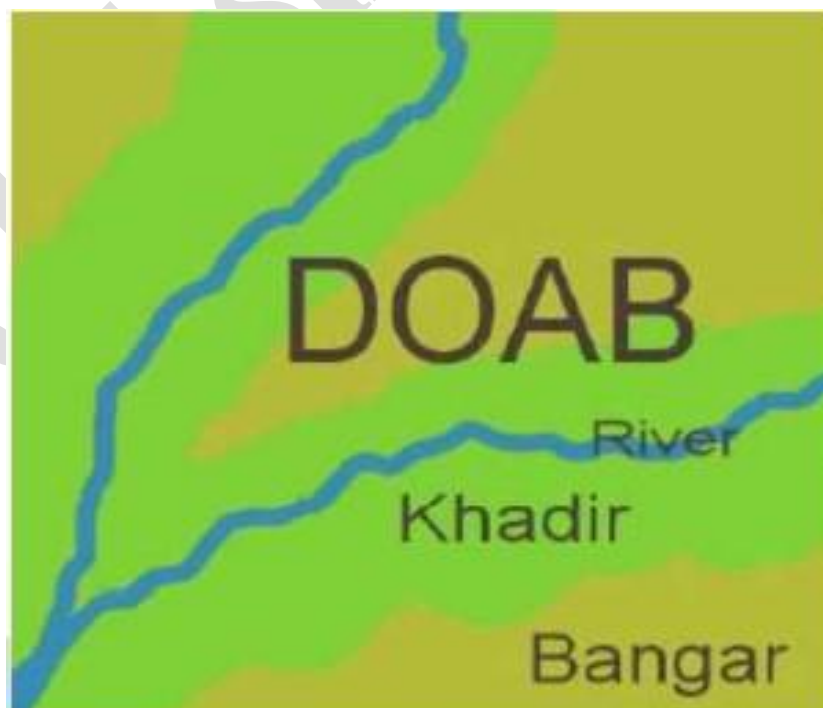
- The Khadar is made out of newer alluvium and forms the floodplains along the river banks.
- A new layer of alluvium is deposited by river flood every year
- This makes them the most fertile soils of Ganges Plains
- They are sandy clays and loams, drier and more leached and less calcareous.
- In Punjab, the Khadar rich flood plains are locally known as 'Betlands 'or 'Bets'.



- The rivers in Punjab-Haryana plains have broad flood plains of Khadar flanked by bluffs, locally known as Dhayas. These bluffs are as high as 3 metres.



## Punjab Plains





Punjab Plains are large alluvial plain in northwestern India. It has an area of about 38,300 square miles (99,200 square km) and covers the states of Punjab and Haryana and the union territory of Delhi, except for the Shahdara zone. It is bounded by the Siwalik (Shiwalik) Range to the north, the Yamuna River to the east, the arid zone of Rajasthan state to the south, and the Ravi and Sutlej rivers to the northwest and southwest, respectively.

- This plain is shaped by five significant rivers of the Indus system
- The plain is primarily comprised up of 'doabs' — the land between two rivers.
- The depositional process by the rivers has joined these doabs giving a homogenous appearance
- Punjab actually implies "(The Land of) Five Waters" alluding to the accompanying rivers: Jhelum, Chenab, Ravi, Sutlej, and Beas
- The average elevation of the plain is around 250 m above mean ocean level
- The eastern boundary of Punjab Haryana plain is set apart by subsurface Delhi-Aravali ridge
- To the south of the Satluj river, there is Malwa plain of Punjab
- The geologic origin of the plain is Paleogene and Neogene (i.e., between about 65 and 2.6 million years ago)—except in the extreme south—its surface having been built up by the silting action of meandering streams.
- The plain is slightly undulating, sloping from 2,140 feet (650 metres) in the northeast to 700 feet (200 metres) in the southeast. The Ravi, Beas, Sutlej, and Yamuna are perennial rivers.
- Subtropical thorn forests grow in the southeast, and subtropical dry deciduous forests are found in the sub montane region in the north.
- Agriculture is the mainstay of the region's economy, and most of the plain is farmed; cereals, cotton, sugarcane, and oilseeds are grown. Most of the region is crisscrossed by irrigation canals
- Large-scale industries centred in Delhi, Amritsar, Ludhiana, Jalandhar, and Chandigarh produce a variety of goods, including textiles, bicycle parts, machine tools, agricultural implements, sporting goods, rosin, turpentine, and varnish.

## Ganga Plains

- This is the biggest unit of the Great Plain of India extending from Delhi to Kolkata (about 3.75 lakh sq km)
- The Ganga along with its enormous number of tributaries follow a dendritic drainage pattern in this plain. Originating in the Himalayas these streams bring large quantities of alluvium from the mountains and deposited it here to fabricate this broad plain
- The peninsular rivers such as Chambal, Betwa, Ken, Son, etc. joining the Ganga river system have also contributed to the development of this plain
- Rivers flow sluggishly in the lower areas of Ganges because of which the area is set apart by local prominences such as levees, bluffs, oxbow lakes, marshes, ravines, etc
- Almost all the rivers keep on shifting their courses making this region prone to frequent floods
- The Kosi river is extremely infamous in this regard. It has long been called the 'Sorrow of Bihar'
- The northern states, Haryana, Delhi, UP, Bihar, part of Jharkhand and West Bengal in the east lie in the Ganga plains.
- The Ganga-Brahmaputra delta: the biggest delta in the world. A Large part of the coastal delta is secured by tidal forests called Sunderbans.
- Sunderbans, the largest mangrove swamp on the planet gets its name from the Sundari tree which grows well in marshland. It is home to the Royal Tiger and crocodiles.



Regional divisions of Ganga plains:

- Rohilkhand plains
- Avadh Plains
- Mithila Plain
- Magadh Plain.

## Brahmaputra Plain

- This is also called as the Brahmaputra valley or Assam Valley or Assam Plain as the vast majority of the Brahmaputra valley is situated in Assam
- Its western boundary is formed by the Indo-Bangladesh border as well as the boundary of the lower Ganga Plain. Its eastern boundary is formed by Purvanchal hills
- It is an aggradational plain developed up by the depositional work of the Brahmaputra and its tributaries.
- The endless tributaries of the Brahmaputra river originating from the north form various alluvial fans
- Therefore, the tributaries branch out in numerous channels giving birth to river meandering leading to the formation of bill and ox-bow lakes
- There are huge marshy tracts in this region. The alluvial fans shaped by the coarse alluvial debris have led to the formation of terai or semi-terai conditions. Majuli Riverine Island in Brahmaputra is the largest riverine island in the world
- Majuli has been nominated by ministry of culture for UNESCO's world heritage site status for couple of times but it missed the tag again in 2020

**Significance of Northern Plains** This one-fourth of the land of the nation has half of the Indian population

- Fertile alluvial soils, flat surface, slow-moving perennial rivers and ideal atmosphere encourage the extraordinary agrarian movement.
- The sedimentary rocks of plains have petroleum and natural gas deposits.
- The rivers here have very gentle gradients which make them navigable over long distances.
- The extensive utilisation of irrigation has made Punjab, Haryana and western part of Uttar Pradesh the granary of India (Prairies are known as the granaries of the world)
- The whole plain except the Thar Desert has a close network of roads and railways which has prompted enormous scope industrialisation and urbanization.
- Cultural tourism: There are many religious places along the banks of the holy rivers like the Ganga and the Yamuna which are extremely dear to Hindus, Buddhists and Jains. e.g : Haridwar, Varanasi, Allahabad, Gaya, Amritsar.

## Indian Islands

**There are** Total 247 islands in India out of which 204 islands are in Bay of Bengal and 43 in the Arabian Sea. Also a few coral islands in the Gulf of Mannar too.

The major island groups of India are :

- Andaman and Nicobar Archipelago in Bay of Bengal
- Lakshadweep islands in the Arabian Sea.



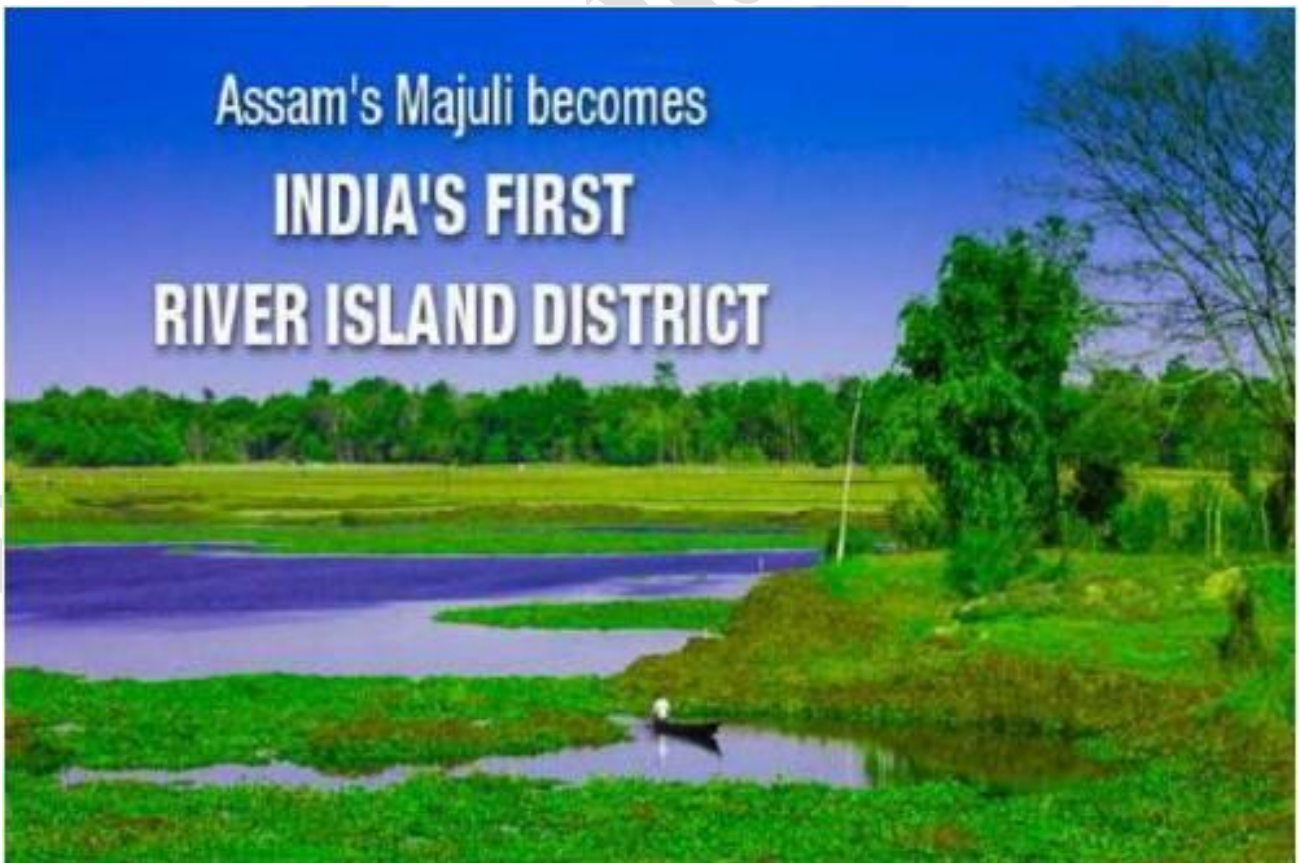
Andaman and Nicobar Islands in Bay of Bengal consist of hard volcanic rocks while Lakshadweep islands are formed by corals. The middle Andaman and Nicobar Islands are the largest islands of India.

The southern – most point of India is in Nicobar Island, known as Indira Point. Which was formally called Pigmalion Point, it is submerged now, after 2004 Tsunami.





Assam's Majuli becomes  
**INDIA'S FIRST  
RIVER ISLAND DISTRICT**



## ANDAMAN AND NICOBAR ISLANDS

Andaman and Nicobar Islands were formed because of the crash between Indian Plate and Burma Minor Plate (part of Eurasian Plate) (Similar to the formation of Himalayas). They are the southward extension of Arakan Yoma range (Myanmar).

- This archipelago is made out of 265 big and small islands (203 Andaman islands + 62 Nicobar Islands)
- The Andaman and Nicobar Islands reach out from 6° 45' N to 13° 45' N and from 92° 10' E to 94° 15' E for a distance of around 590 km
- The Andaman Islands are separated into three main islands, i.e. *North, Middle and South*
- **Duncan passage** isolates Little Andaman from South Andaman]



Andaman and Nicobar Islands

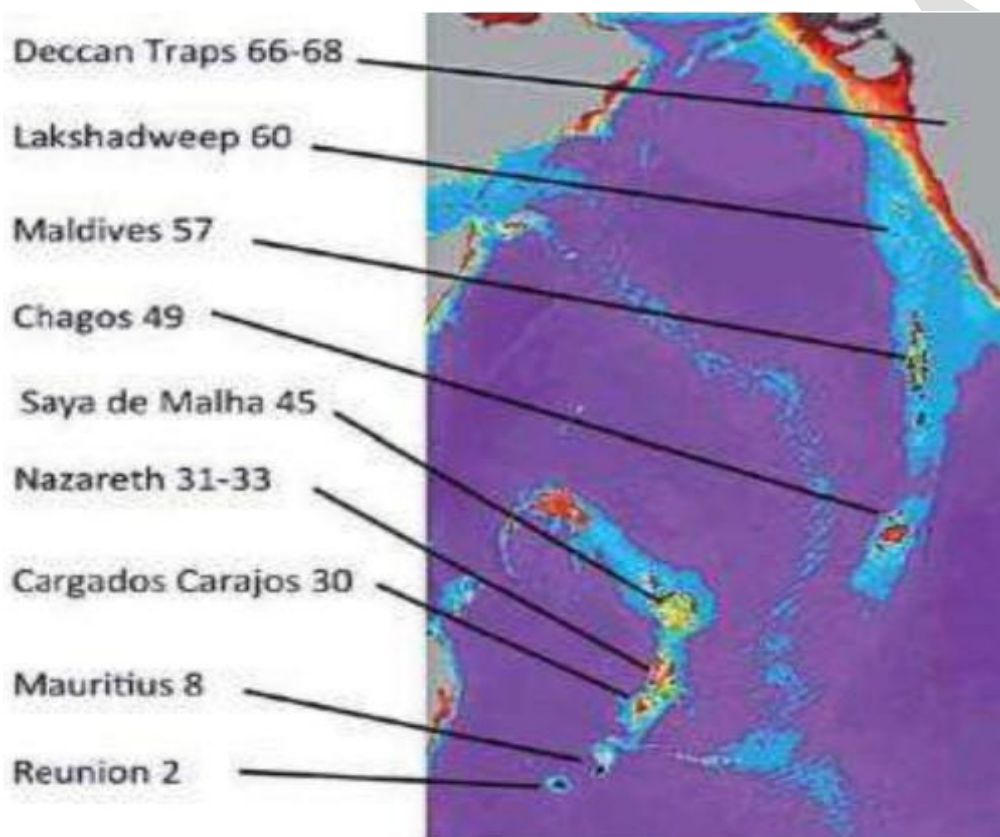
- The Great Andaman group of islands in the north is separated by the **Ten Degree Channel** from the Nicobar group in the south
- Port Blair, the capital of Andaman Nicobar Islands, lies in the South Andaman
- Among the Nicobar Islands, the **Great Nicobar** is the **biggest** and is only 147 km away from the Sumatra island of Indonesia.
- Great Nicobar is the southernmost island
- The Car Nicobar is the northernmost island
- Greater part of these islands are made of tertiary sandstone, limestone and shale resting on basic and ultrabasic volcanoes (Similar to the Himalayas)



- The Barren Island (the only active volcano in India) and Narcondam Islands (an extinct or dormant volcano), north of Port Blair, are volcanic islands
- A portion of the islands are bordered with coral reefs.. Many of them are covered with thick forests. Most of the islands are mountainous
- **Saddle peak** (737 m) in North Andaman is the **highest** peak.

## LAKSHADWEEP ISLANDS

Lakshadweep Islands are **coral islands**. These islands are a part Reunion Hotspot volcanic chain

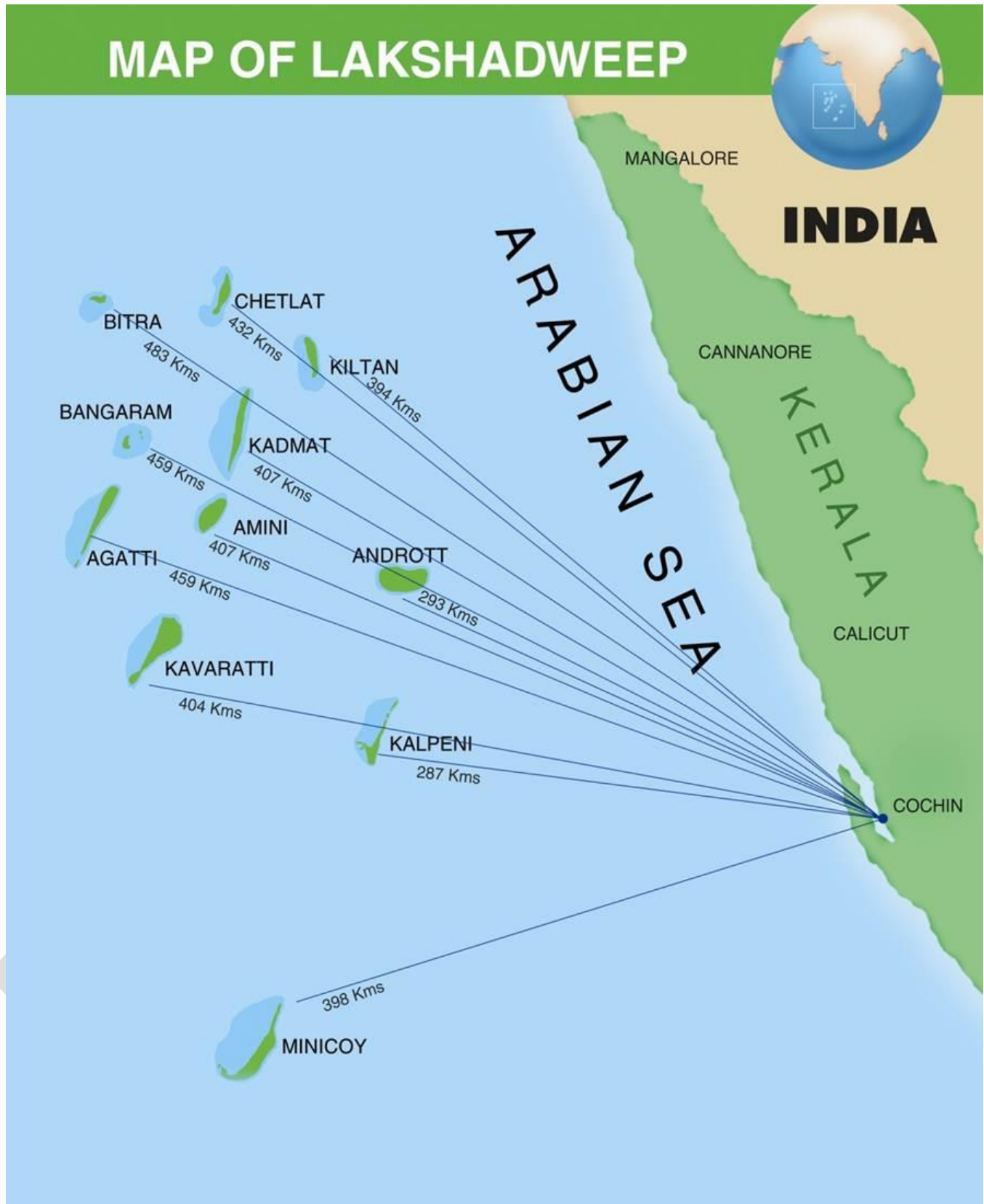


- In the Arabian Sea, there are three categories of islands.
  - **Amindivi Islands** (consisting of six main islands of Amini, Keltan, Chetlat, Kadmat, Bitra and Perumul Par).
  - **Laccadive Islands** (consisting of five major islands of Androth, Kalpeni, Kavaratti, Pitti and Suheli Par)
  - **Minicoy.**
- At present these islands are collectively known as Lakshadweep
- The Lakshadweep Islands are a group of 25 small islands
- They are widely scattered about 200-500 km southwest of the Kerala coast
- Amindivi Islands are the northernmost while the Minicoy island is the southernmost
- All are little islands of coral inception (coral depositions on atolls) and are encircled by bordering reefs.
- **Andrott** (4.9 sq km) is the **biggest Island**. Minicoy (4.5 sq km) is the second biggest
- The vast majority of the islands have low height and do not rise more than five meters above sea level (extremely vulnerable to sea level rise)

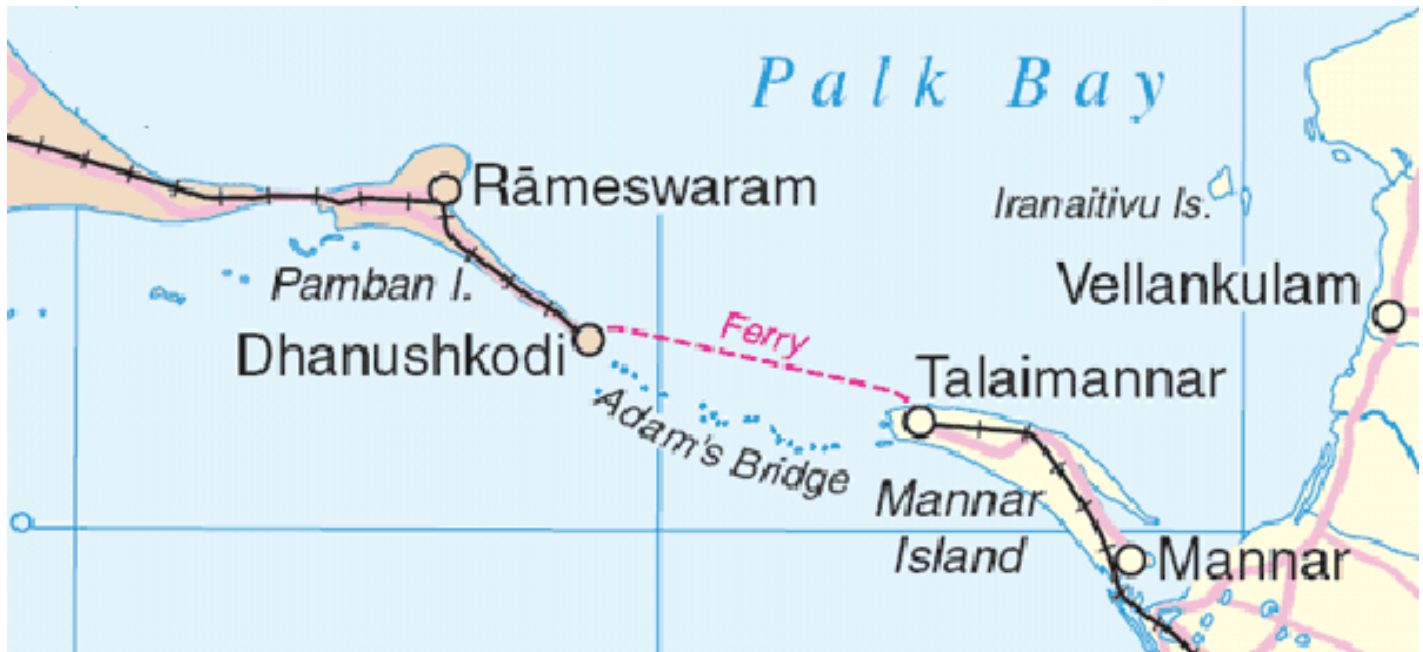




- Their topography is flat and relief features such as hills, streams, valleys, etc. are missing



## OTHER ISLANDS



Other than these two groups there are islands in Indo- Gangetic Delta (they are more a part of the delta than islands) and between India and Sri Lanka (Remnants of Rama Setu or Adams Bridge; formed due to submergence).

### Some other Important islands :

1. **Majuli:** in Assam. It is:
  - The world's largest freshwater (Brahmaputra river) island.
  - India's first island district
2. **Salsette:** India's most populous island. Mumbai city is located on this island.
3. **Sriharikota:** A barrier island. On this island is located the satellite launching station of ISRO.
4. **Aliabet:** India's first off-shore oil well site (Gujarat); about 45 km from Bhavnagar, it is in the Gulf of Khambat.
5. **New Moore Island:** in the Ganga delta. It is also known as Purbasha island. It is an island in the Sunderban deltaic region and it was a bone of contention between India and Bangladesh. In 2010, it was reported to have been completely submerged by the rising sea water due to Global warming.
6. **Pamban Island:** lies between India and Sri Lanka.
7. **Abdul Kalam Island:** The Wheeler Island near the Odisha coast was renamed as Abdul Kalam island in 2015. It is a missile launching station in the Bay of Bengal. The first successful land-to land test of the Prithvi Missile was conducted from the mainland and it landed on the then uninhabited 'Wheeler Island' on November 30, 1993.

## The Indian Desert

The Indian desert is also known as the Thar Desert or the Great Indian Desert.

## LOCATION AND EXTENT

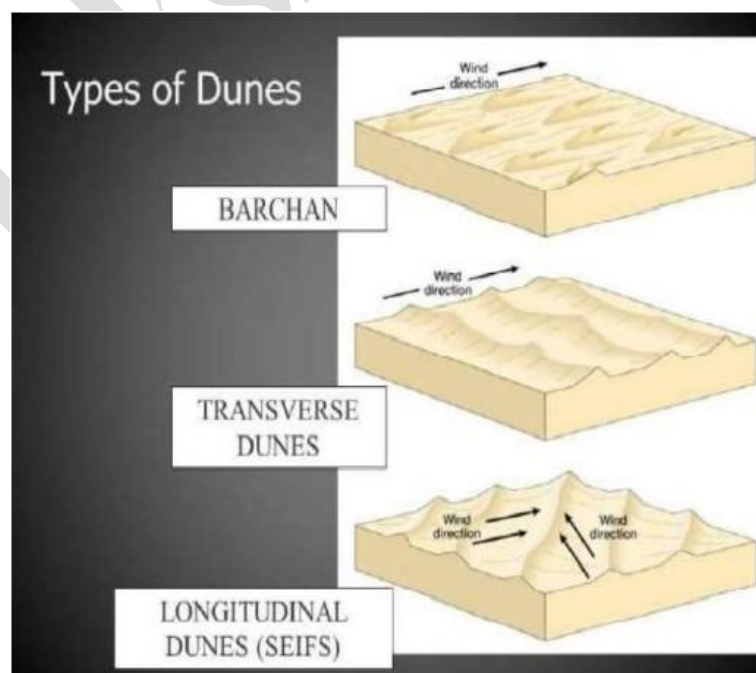
- Location – To the north-west of the Aravali hills.

- It covers Western Rajasthan and extends to the adjacent parts of Pakistan



## Geological History

- During the mesozoic era, this region was under the sea. This can be
- corroborated by the evidence available at wood fossils park at Aakal and
- marine deposits around Brahmsar, near Jaisalmer
- The presence of dry beds of rivers (eg Saraswati) shows that the region was once fertile.
- Geologically, the desert area is a part of peninsular plateau region but on the surface it seems like an aggradational plain





## Features of Indian Desert

- The desert is called the **Marusthali** (dead land) as this region has
- an arid climate with low vegetation spread. The Eastern part of the desert is rocky, while its western part is covered by shifting sand dunes.
- **Bagar**: Bagar alludes to the semi-desert zone which is west of Aravallis. Bagar has a thin layer of sand. It is drained by Luni in the south while the northern area has a number of salt lakes.
- The Rajasthan Bagar are has various short seasonal streams which start from the Aravallis. These streams support agriculture in some fertile patches called **Rohi**.
- Even the most significant river '**Luni**' is a seasonal stream. The Luni begins in the Pushkar valley of the Aravalli Range, close to Ajmer and flows towards the southwest into the Rann of Kutch.
- The region north of Luni is known as the **Thali or sandy plain**.
- There are few streams which vanish after flowing for some distance and present a typical instance of inland drainage by joining a lake or **playa e.g. the Sambhar Lake**.
- The lakes and the playas have brackish water which is the fundamental source of getting salt.

## Well pronounced desert land features:

- **Sand dunes**: It is a land of undulating topography dotted with **longitudinal dunes**, **transverse dunes** and **barchans**. (Barchan – A crescent-shaped sand dune, the horns of which point away from the direction of the dominant wind; Longitudinal dune – A sand dune with its crest running parallel to the direction of prevailing wind)
- Mushroom rocks
- Shifting dunes (locally called Dhrians)
- Oasis (mostly in its southern part)

## CH-3 PENINSULA

### TOPICS TO BE COVERED

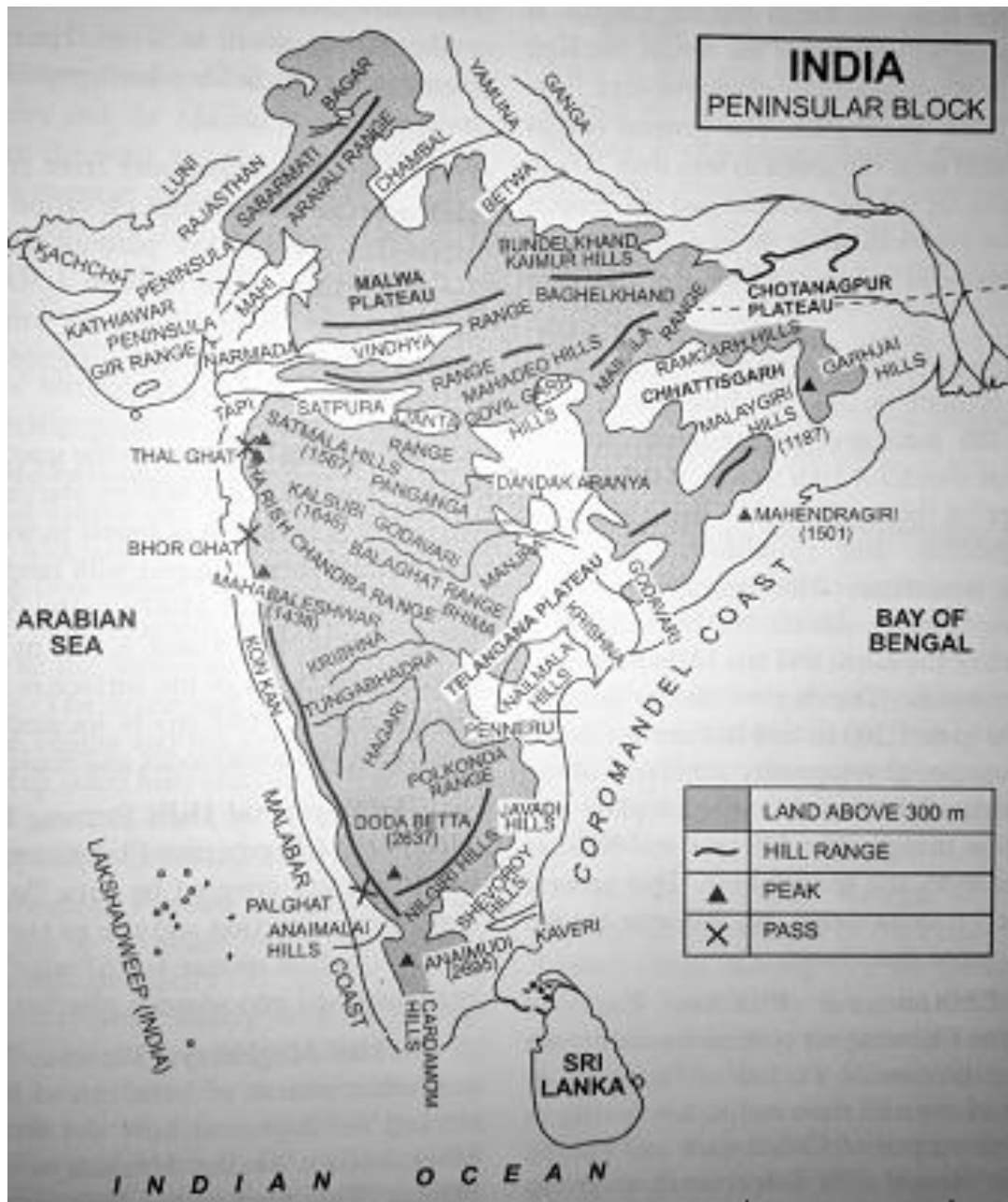
#### Peninsular India

1. Features
2. Hill Ranges
  - Aravali Range
  - Vindhyan Range
  - Satpura Range
  - Western Ghats (or The Sahyadris)
    - The Northern Section
    - The Middle Section
    - The Southern Section
  - Eastern Ghats
3. Plateau
  - Marwar Plateau or Mewar Plateau
  - Central Highland
  - Bundelkhand Upland
  - Malwa Plateau
  - Baghelkhand
  - Chotanagpur Plateau (CNP)
  - Meghalaya or Shillong Plateau
  - Kathiawar Plateau
  - Deccan Plateau
    - Maharashtra Plateau
    - Karnataka Plateau
    - Telangana plateau
  - Chhattisgarh Plain

#### Coastline and Coastal Plains

1. Western Coastal Plains of India
2. Eastern Coastal Plains of India

- The Peninsular Plateau is a one of the oldest and the most stable landmass of India composed mostly of the Archaean gneisses and schists.
- Roughly triangular in shape and lie in the south of the great plain of North India. Apex of the triangular plateau is at Kanniyakumari.
- It is bordered on all sides by the hill ranges:
  - North-west (extension of Aravalis) = Delhi ridge
  - East = Rajmahal hills
  - West = Gir range
  - South = Cardamom hills (constitute the outer extent of the peninsular plateau)
  - Outlier = Shillong and Karbi-Anglong plateau



- Peninsular Plateau consist of several smaller plateaus, hill ranges interspersed with river basins and valleys
- It covers a total area of about 16 lakh square kilometre (India as a whole is 32 lakh sq km).
- The average height of the plateau is 600-900 meter above sea level (varies from region to region).
- Most of the peninsular rivers flow from west to east indicating the general elevation of the plateau is from the west to the east.
  - Narmada-Tapti are the exceptions which flow from east to west in a rift (rift is caused by divergent boundary).
- Ever since the dawn of geological history, Peninsula has been a land area and has never been submerged beneath the sea except in a few places where marine transgressions have been made and that too locally and temporarily.



## THE GARO-RAJMAHAL GAP

- The Garo-Rajmahal is a physiographic gap in the outcrop continuity of Satpura strike due to alluvial cover between Garo and Rajmahal hills.
- It is believed that a huge fault was created between the Rajmahal hills and the Meghalaya plateau due to the force exerted by the northeastward movement of the Indian plate at the time of the Himalayan origin.
- Later, this depression got filled up by the deposition activity of the numerous rivers leaving Meghalaya plateau separated from the main Peninsular Block.

## GEOLOGICAL HISTORY AND FEATURES

In its otherwise stable history, the peninsula has seen a few changes like:

1. Gondwana Coal Formation.
2. Narmada-Tapi rift valley formation.
3. Basalt Lava eruption on Deccan plateau
  - a. The Indian Plate passed over a geologic hotspot, the Réunion hotspot, during its journey northward after breaking off from the rest of Gondwana which caused extensive melting underneath the Indian Craton. The melting broke through the surface of the craton in a massive flood basalt event known as the Deccan Traps.
  - b. The region has black cotton soil formed due to the weathering of lava material.

## HILL RANGES

- Most of the hills in the peninsular region are of the **residual hills** (relict type).
  - They are the remnants of the hills and horsts (uplifted block) formed many million years ago.
- These hill ranges and various river valleys separate plateaus of the Peninsular region from one another.

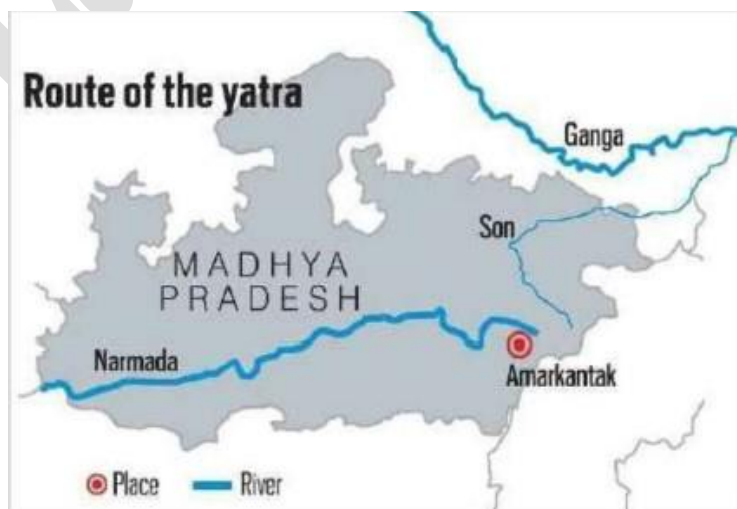


## ARAVALI RANGE

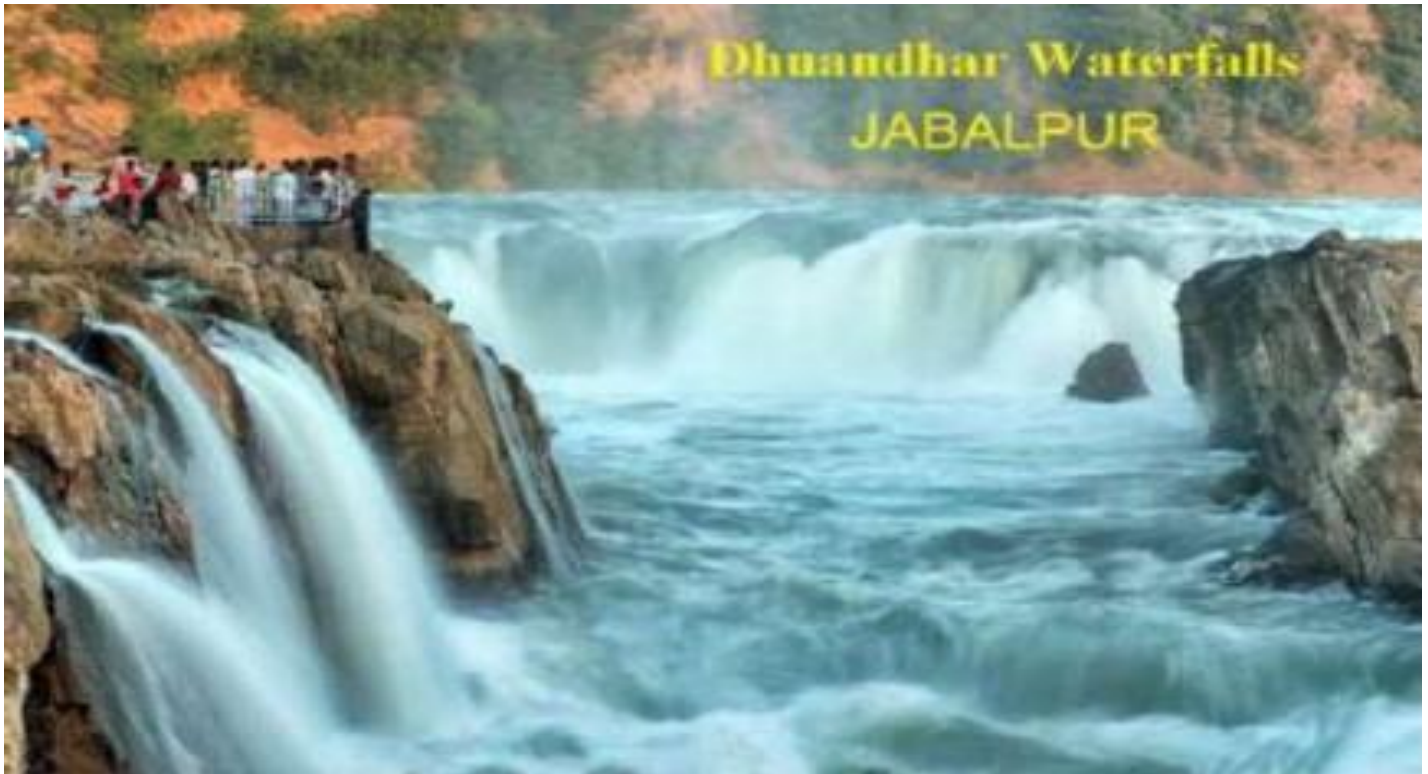
- It is residual mountain range aligned in north-east to south-west direction.
- The length of the Aravalis is 1100 km which extends from Delhi to Ahmedabad.
- They are one of the oldest fold mountains of the world and the oldest in India.
  - After its formation in Archaean Era (several 100 million years ago), its summits had glaciers and were probably higher than the present day Himalayas.
- They continue up to Haridwar buried under the alluvium of Ganga Plains.
- The range is noticeable in Rajasthan (continuous range south of Ajmer where it rises to 900 m) but becomes less distinct in Haryana and Delhi (characterized by a chain of discontinuous ridges beyond Ajmer).
- Only a few peaks reach an elevation of above 1000m. These include
- Its highest peak is Guru Shikhar. It is on the 'Abu hills. Mt. Abu is a famous hill station. The famous religious place for the Jains is situated on Mt Abu.
- Rivers Banas, Luni, Sabarmati are originates from Aravallis.
  - Banas is a tributary of Chambal.
  - Luni is an ephemeral river which terminates in the Rann of Kutch.
- It contains several passes that cut through them, especially between Udaipur and Ajmer like Piplighat, Dewair, Desuri etc.
- It contains several lakes such as Lake Sambhar (largest inland saline water body in India), Lake Dhebar (south of Aravallis), Lake Jaisamand (in the Jaisamand wildlife sanctuary) etc.

## SATPURA RANGE

- Satpura hills are tectonic mountains formed as a result of folding and structural uplift (Horst landform).
- With peaks more than 4,000 feet (1,200 metres) high, the Satpura Range includes the Mahadeo Hills to the north, the Maikala Range to the east, and the Rajpipla Hills to the west.
- The Satpura range is a block mountain which has the valley of the Narmada river on its northern side and that of the Tapi on the western side.
- It stretches for a distance of about 900 km.
- Dhupgarh (1,350 m) on Mahadev Hills (near Pachmarhi) is the highest peak of the Satpura range.
- Amarkantak (1,127 m) is another important peak, highest of the Maikal hills, from where two prominent rivers, the Narmada and the Son originate.



- It is noteworthy that three rivers do originate from the three sides of the Maikal hills but only two rivers, the Narmada and the Son originate from Amarkantak and not the Mahanadi.
- Due to the presence of Gondwana rocks, these hills are rich in bauxite.



- The rivers in the Satpura range make several waterfalls. The 'Dhuandhar' waterfall on the Narmada is important one. There are marble rocks found here.

## VINDHYAN RANGE

- This range is a group of the Vindhyachal, the Bhandar, the Kaimur and Parasnath hills.
  - These are non-tectonic mountains formed not only because of plate collision but also by downward faulting of the Narmada Rift Valley (NRV) to their south.
  - It runs more or less parallel to the Narmada Valley in an east-west direction from Bharuch in Gujarat to Sasaram in Bihar for a distance of over 1,200 km.
  - The general elevation of the Vindhyan Range is in between of 300 to 650 meters.
  - Most parts of the Vindhyan Range are comprised of horizontally bedded sedimentary rocks of ancient age.
  - They locally named as Panna, Kaimur, Rewa etc.
- This range acts as a divide between the Ganga system and the river systems of south India.

## WESTERN GHATS (OR THE SAHYADRIS)

- The Western Ghat mountain range is India's second largest mountain range after the Himalayas which forms the western edge of the Deccan tableland.
- They extend between the Tapi river valley in north and the Kanyakumari in south for a distance of 1,600 km.



- The Western Ghats present a stepped topography facing the Arabian Sea coast due to the horizontally bedded lavas.
- The Western Ghats abruptly from the west coast plains to an altitude of 1km from the mean sea level.
- From the Deccan plateau, they have a gentle slope towards their eastern edge and don't appear to be a tall range of hills.
- Quite different landscape presented by the Nilgiris, Anamalai, etc. in the south of Malabar due to the difference in geological structure.

## The Northern Section

- This section of the Western Ghats is located in Maharashtra and also known as the Sahyadris.
- The average height of Sahyadris is about 1200 meter above the mean sea level.
- Sahyadris are made of volcanic igneous rocks (Deccan lavas or Deccan Traps). Hence they are geologically younger than the rocks in the other sections of the Western Ghats.
- Godavari (Nasik), Bhima (Bhimashankar), And Krishna (Mahabaleshwar) is the main river of this section.
- Some of the prominent peaks of the Sahyadris are - Kalasubai peak (the tallest peak of the Sahyadris), Salher peak, Harischandragarh peak etc.
- Sahyadris give rise to more number of large rivers in comparison of other section of the Ghats forming the most important watershed of south India.
- Some of the important passes of this section are
  - Thal Ghat—It links Nasik to Mumbai. (the route leading from Kolkata to Mumbai passes through Nasik).
  - Bhor Ghat—It links Mumbai to Pune.

## The Middle Section

- This section runs through the States of Karnataka and Goa and terminates in the Nilgiris, where it joins the Eastern Ghats.
- Nilgiris are block mountains standing between the two faults, hence can be considered as Horst landforms. They are made of igneous and metamorphic rocks like the granite and gneiss.
- They have dense forests and a number of short streams originate from them. This resulted in a headward erosion of these hills and created gaps in the ranges.
- Their average height is around 1200 meters and some of the prominent peaks such as the Vavulmala, Kudremukh, Pushpagiri etc.
- Bababudan hills of Karnataka are a part of this section are famous for the coffee plantations. Bhadra, one of the originating streams of River Tungabhadra, coming from these hills.
  - Tungabhadra and Kaveri river (Brahmagiri) is the main river of this section.

## The Southern Section

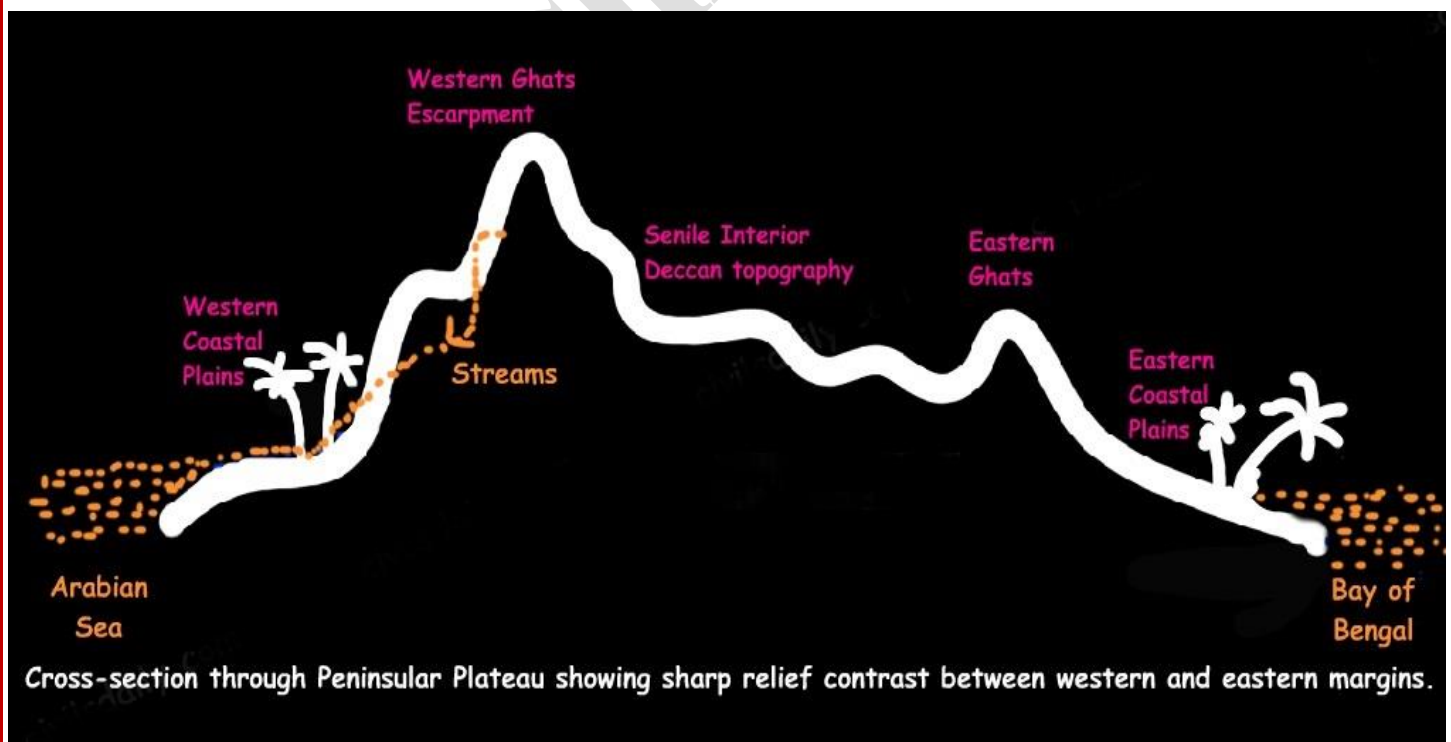
- This section comprising the Annamalai and Cardamom hill ranges.
- Palghat gap is the largest gap in the Western Ghats (about 24 km wide) which separates the Nilgiris from the Annamalai hills.
  - It is through this gap that moist-bearing clouds of the south-west monsoon can penetrate some distance inland, bringing rain to Mysore region.
- Anaimudi peak is the highest point of peninsular India lying in the Annamalai hills.
- Palani hills are a part of the Annamalai range are made of Dharwar igneous rocks.
  - Kodaikanal hill station lies in the Palani hills.

- Periyar river originates close to the Annamalai hills and flows into the Arabian Sea.
- Cardamom hills are in the south of Annamalai hills separated by the Shenkottai pass. These hills are famous for Cardamom cultivation and also known as Ealaimalai
  - Varushnad hills are a part of the Cardamom hills from where River Vaigai originates.
- The southernmost section of the Western Ghats is Agasthyamalai hills situated in Kerala and Tamil Nadu. The southernmost peak of peninsular India is Agasthamalai peak.

## EASTERN GHATS

- Eastern Ghats run almost parallel to the eastern coast of India leaving broad plains between their base and the coast.
- It has been eroded than the Western Ghats. Therefore, it is of less height than that.
- They are mainly comprising of Dharwar igneous and metamorphic rocks.
- It is a chain of highly broken and detached hills starting from the Mahanadi in Odisha to the Vagai in Tamil Nadu.
- These hills lack structural and physiographic continuity and treated as independent units.
- The Eastern Ghats exhibit true mountain character only in the northern part between the Mahanadi and the Godavari.
- This range is almost absent in between of Madugula Konda range and Nallamala hills. This region is made up of the Godavari-Krishna delta.
- Some prominent hills
  - Andhra Pradesh = Velikonda hills, Palakonda hills, and the Seshachalam
  - Tamil Nadu = Javadi hills and Shevaroy hills
- Eastern Ghats merge with the Western Ghats at the Nilgiris.

## GADGIL REPORT AND KASTURIRANGAN REPORT ON WESTERN GHATS



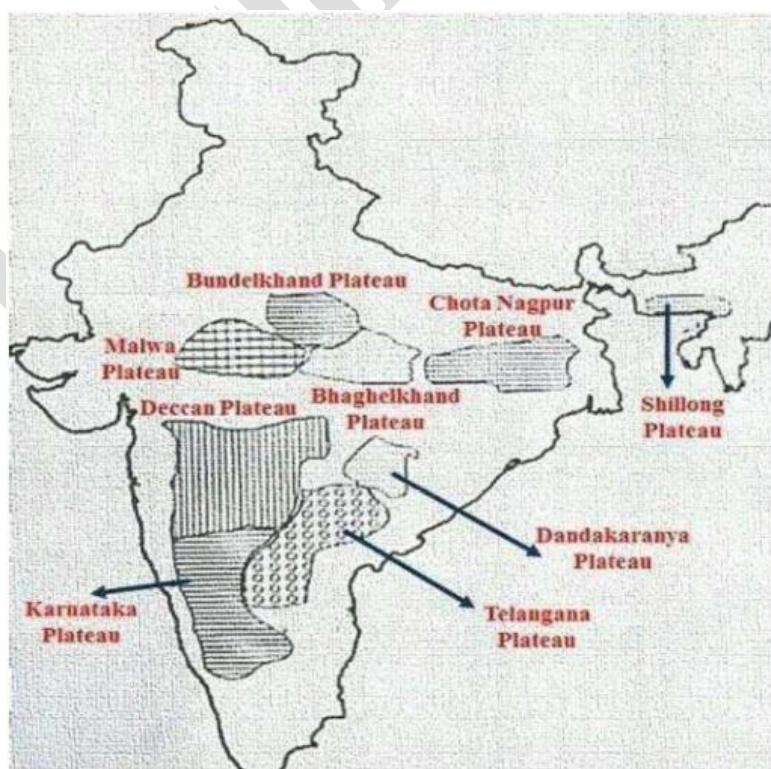


## WHAT IS AN ECO-SENSITIVE ZONE?

Eco-sensitive zones, or ESZs, act as "shock absorbers" to protected areas by regulating and managing the activities around such areas. According to guidelines of the Union ministry of environment and forests, the basic aim is to regulate certain activities around national parks and wildlife sanctuaries to minimise negative impacts of human activities.

S. No.	Features	Western Ghats	Eastern Ghats
1.	Height	Their height is 900 to 1,600 meters. The highest peak of this region is from Anaimudi with a height of 2,659 km.	The Eastern Ghats are lower in height than the Western Ghats. It ranges from 600 to 900 meters. Mahendragiri 1501 m is the highest peak in Eastern Ghats.
2.	Slope	They have steep slope as height increases from North to South.	They have a gentle-slope.
3.	Continuity	They are continuous and can be crossed through passes only.	They are irregular and discontinuous and dissected by the rivers.
4.	Rivers	They lie parallel to Western Coast and are source for some rivers.	They stretch from Mahanadi valley to Nilgiris in South. The rivers flow through easily.
5.	Vegetation	Western Ghats have tropical evergreen forests. They are evergreen to deciduous forests.	Eastern Ghats have scrub vegetation due to over-grazing and deforestation.

## PLATEAU





## MARWAR PLATEAU OR MEWAR PLATEAU

- It is the plateau in eastern Rajasthan. (Marwar plain lie in the west of Aravalis whereas Marwar plateau lie in the east).
- The height is in between 250-500 meters above sea level and it slopes down eastwards.
- It contains sandstone, shales and limestones of the Vindhyan period.
- A rolling plain carved by Banas river.

‘Rolling plains’ are not completely flat. There are slight rises and fall in the land form. Example = Prairies of USA

## CENTRAL HIGHLAND

- Also known as Madhya Bharat Pathar or Madhya Bharat Plateau.
- It lie in the east of Marwar or Mewar Upland.
- It is a rolling plateau with sandstone containing rounded hills.
- Thick forests grow here.
- Ravines or badlands of the Chambal river found in the north.

## BUNDELKHAND UPLAND

- Yamuna river to the north, Malwa Plateau to the south, Vindhyan Scarplands to the east and south-east and Madhya Bharat Pathar to the west.
- It is the old dissected (divided by a number of deep valleys) upland of the ‘Bundelkhand gneiss’ made up of granite and gneiss rocks.
- The height of the plateau is in the range of 300-600 meters.
- It has a drainage system into the Bay of Bengal.
- It unfit for cultivation as the flowing rivers in the region have converted it into an undulating (wave like surface) area due to the erosional work.
- Streams like Betwa, Dhasan and Ken flow through the plateau.

## MALWA PLATEAU

- The Malwa Plateau roughly forms a triangle based on the Vindhyan Hills, bounded by the Aravali Range from the west and Madhya Bharat Pathar from the north and Bundelkhand from the east.
- This plateau has two systems of drainage
  - Towards the Arabian sea (Narmada, Tapi and Mahi)
  - Towards the Bay of Bengal (Chambal and Betwa by joining the Yamuna)
- The average elevation of the plateau is 500 meter with a gently sloping towards the north.
- Geologically, it's among India's most diverse landmasses comprises with Dharwar rocks, Vindhyan rocks, Gondwana rocks, and Volcanic Basalt.
- It is made-up of extensive lava flow and is covered with black soils.
- This is a rolling plateau and dissected by rivers.
- It has semi-arid to arid type of climate where temporary streams emerges on short spells of rainfall. These streams remove the topsoil due to the absence of dense vegetation, giving rise to narrow valley type of structures known as Gullies.
  - The gullies deepen eventually and form Ravines.

- Ravine-Gully erosion turns the landform into a Badland, not suitable for agriculture. Chambal's drainage basin is abundant with such Badland topography

## BAGHELKHAND

- It is situated east of Maikala range and is made of limestones and sandstones on the west and granite in the east.
- The plateau contains Dharwar and Gondwana rocks.
- The central part of the plateau acts as a water divide between the Son drainage system in the north and the Mahanadi river system in the south.
  - Rihand Dam and Govind Vallabh Pant Sagar reservoir (largest manmade lake in India) build on Son river.
- The plateau has a general elevation of 150 meters to 1200 meters and has uneven relief
- The main elements of Physiography are scarps of the Vindhyan sandstones between the Ganga plain and the Narmada -son trough.
- Bhaner and Kaimur are located close to the axis.
- The general horizontality of the strata shows that this area has not undergone any major disturbance.

## CHOTANAGPUR PLATEAU (CNP)

- It's a continental plateau with an average elevation of the plateau is 700 meter above sea level.
- It is spread in Jharkhand , northern part of Chattisgarh and Purulia district of West Bengal and parts of Odisha.
- Damodar rift valley (DRV) is the most prominent structure of this plateau which possess Gondwana rocks making it one of the richest coal deposits of India viz., the Damodar Valley Coal Fields.
- The region comprised of alternate soft and hard rock strata which resulted in the differential weathering and form topography known as the Patland (erosion of the soft rock strata, leaving the hard rock strata).
  - At places it is interrupted by monadnocks (an isolated hill or ridge of erosion-resistant rock rising above a peneplain).
- Intense weathering and erosion has converted the CNP region into a laterite soil region.
- The plateau is possess numerous rivers and streams in different directions making a radial drainage pattern.
  - The Son river flows in the north-west of the plateau and joins the Ganga.
  - Rivers like the Damodar, the Subarnrekha, the North Koel, the South Koel and the Barkar have developed extensive drainage basins.
- Hazaribagh plateau lies in the north of the Damodar river with an average elevation of 600 meter above mean sea level. This plateau has isolated hills and looks like a peneplain due to large scale erosion.
- The Ranchi Plateau to the south of the Damodar Valley rises to about 600 meter above mean sea level. The plateau is highly dissected. Most of the surface is rolling where the city of Ranchi (661 meter) is located
- The Ranchi plateau gradually slopes down towards south-east into the hilly and undulating region of Singhbhum (earlier Singhbhum district or what is now Kolhan division). To the north it is separated from the Hazaribagh plateau by the Damodar trough. Western part of the plateau has maximum height and is called patland.
- The rivers coming from over the Ranchi plateau form waterfalls when they descend through the precipitous escarpments of the plateau and enter the area of significantly lower height.
  - The North Karo River has formed a 17-metre (56 ft) high Pheruaghaugh Falls at the southern margin of Ranchi plateau. Such falls are called scarp falls.

- Hundru Falls (75 m) on Subarnarekha River near Ranchi, Dassam Falls (39.62 m) on Kanchi River, east of Ranchi, Sadni Falls (60 m) on Sankh River (Ranchi plateau) are examples of scarp falls.
- **Singhbhum area** broadly covers Kolhan division of Jharkhand. The Singhbhum area is rich in metallic minerals.
- The Rajmahal Hills forming the north-eastern edge of the CNP are mostly made of basalt and are covered by basaltic lava flows.
- Chota Nagpur plateau is a store house of minerals like mica, bauxite, copper, limestone, iron ore and coal. The Damodar valley is rich in coal and it is considered as the prime centre of coking coal in the country.

## MEGHALAYA OR SHILLONG PLATEAU

- The peninsular plateau extends further east beyond the Rajmahal hills to form Meghalaya or the Shillong plateau.
- An extension of the peninsular plateau is also visible in the northeast, locally known as the Meghalaya or the Shillong plateau, Karbi-Anglong Plateau and North Cachar Hills.
- It is separated by a fault from the Chotanagpur Plateau and its western boundary more or less coincides with the Bangladesh border.
- Three prominent hill ranges from the west to the east are the Garo, the Khasi and the Jaintia Hills.
- This Plateau is largely formed by Dharwarian (Archean) quartzites, shales and schists with granite intrusions. These rock formations contain rich deposits of valuable minerals like coal, limestone, uranium and sillimanite, Kaolin and granite etc.
- Its average height is about 1500 meters above the mean sea level.
- Brahmaputra's basin is to the north of the plateau. River Surma enters the plateau from Assam and joins the river Meghna in Bangladesh.
- Shillong is the highest point of the Plateau. It is a high plateau with Garo, Khasi and Jaintia Hills. These hills run in the east-west direction with several peaks. Among them Shillong Peak (1,916 m) and Nokrek Peak (1,515 m) are important.
- Cherrapunji and Mawsynram are the wettest places in India and are a part of the plateau located in the Khasi hills.

## KATHIAWAR PLATEAU

- Located in the Kathiawar region of Gujarat having many pipe-like volcanic openings which gave rise to many hill ranges such as the Girnar range, Junagarh range, Pavagarh range etc.
- Lake Nalsarovar (a bird sanctuary) forms the Northeast boundary of the plateau.
- To the north of Kathiwar plateau, Little Rann is situated.
- It has some volcanic rocks in the form of Mandav hills and Balda hills.
- Mt. Girnar = Highest point of Kathiawar plateau

## DECCAN PLATEAU

- This is the largest unit of Peninsular Plateau of India covering an area of about five lakh sq km.
- It is triangular in shape and is bordered by
  - the Satpura and the Vindhya in the north-west
  - the Mahadev and the Maikal in the north
  - the Western Ghats in the west
  - the Eastern Ghats in the east



- Its average elevation is 600 m.
  - It rises upto 1000 meter in the south but dips to 500 meter in the north.
- Its general slope is from west to east which is indicated by the flow of its major rivers like the Mahanadi, Godavari, the Krishna and the Cauvery. These rivers have further subdivided this plateau into a number smaller plateaus described as under:
  - The Maharashtra Plateau – it has typical deccan trap topography underlain by basaltic rock, the regur.
  - The Karnataka Plateau (also known as Mysore plateau) – divided into western hilly country region of 'Malnad' and plain 'Maidan'
  - Telangana Plateau

## Maharashtra Plateau

- The Maharashtra Plateau lies in Maharashtra forming the northern part of the Deccan Plateau.
- Much of the region made-up of basaltic rocks of lava origin. The horizontal lava sheets have led to the formation of typical Deccan Trap topography.
- The area looks like a rolling plain due to action of exogenetic forces.
- The broad and shallow valleys of the Godavari, the Bhima and the Krishna are flanked by the flat topped steep sided hills and ridges like Ajanta, the Balaghat and the Harishchandra range.
- The entire area is covered by black cotton soil also known as regur

## Karnataka Plateau

- The Karnataka Plateau also known as mysore plateau lies to the south of Maharashtra plateau.
- The area looks like a rolling plateau with an average height of 600-900 meters.
- It is highly dissected by numerous rivers rising from the Western Ghats. It contains the heads of the Tungabhadra and the Cauvery rivers.
- The general trend of the hills is either parallel to the Western Ghats or across it.
- The highest peak is at Mulangiri in Baba Budan Hills of Chikmagalur district.
  - Baba Budan Hills are famous for ironore mining and coffee production.
- The plateau is divided into western hilly country region of 'Malnad' and plain 'Maidan'.
- The plateau tapers between the Western Ghats and the Eastern Ghats in the south and merges with the Nilgiri hills there.

## Telangana plateau

- It is made up of Dharwar rocks.
  - The plateau is rich in mineral resources because of the Dharwar rock strata.
  - Gondwana rocks (famous for its coal fields) are also found in the Godavari valley.
- The region is drained by three river systems, the Krishna, the Godavari, and the Penneru.
  - This plateau is divided in two part by Godavari river.
- The entire plateau is divided into two major physiographic regions, namely the Ghats and the Peneplains(a vast featureless, undulating plain which the last stage of deposition process).
- The plateau receives good rainfall (average of 100mm/year) similar to the CNP.
- The northern part is lower than its southern Counterpart

## DANDAKARANYA PLATEAU

- Towards the northeast of the Deccan plateau is a thickly forested area known as the Dandakaranya plateau.

- It covers the states of Chhattisgarh, Jharkhand, the eastern edge of Maharashtra and the northern tip of Andhra Pradesh.

## CHHATTISGARH PLAIN

- A saucer shaped basin lies between the Maikala Range and the Odisha hills laid with nearly horizontal beds of limestone and shales.
- It drained by the upper Mahanadi.
- The range of general elevation of the plain is from 250 meter in the east to 330 meter in the west.

## Significance

- This is the oldest and the most stable part of the Indian Subcontinent.
- It is rich in both metallic and non-metallic mineral resources. It has huge reserves of iron, manganese, copper, bauxite, mica, chromium, limestone, etc.
- More than 98% of the Gondwana coal deposits of India are found in the plateau region.
- The north-western part of the plateau is covered by fertile black lava soil useful for growing cotton and sugar cane.
- Some lowlands are suitable for growing rice and a variety of tropical fruits.
- The highlands are covered with thick valuable forests.
- The rivers originating from the Western Ghats provide suitable sites for the generation of hydroelectricity. The peninsular plateau has a number of hill stations such as Udagamandalam (Ooty), Kodaikanal, Pachmarhi, Mahabaleshwar, Khandala, Matheron, etc.

The Himalayan Region	The Peninsular Plateau
Having a comparatively recent origin, it is made up of young fold mountains.	It is the oldest landmass of the Indian subcontinent; was part of the Gondwana land.
Consists of the loftiest mountains and deep valleys.	Consists of broad and shallow valleys, and rounded hills.
Formed due to the collision of the Indo-Australian and Eurasian plates.	Formed due to the breaking and drifting of the Gondwana land.
Composed of sedimentary rocks.	Composed of igneous and metamorphic rocks.
From the point of view of geology, this region forms an unstable zone.	This region forms a stable zone.
Major rivers like – the Indus, the Ganges and the Brahmaputra originate from the Himalayas.	Major rivers like – the Narmada and the Tapi, Godavari, Krishna and Kaveri originate from these hills.
Important hill stations like – Shimla, Mussoorie, Darjeeling, Nainital, etc. are found on the Himalayas.	Important hill stations like - Khandala, Panchgani, Ooty, Kodaikanal, etc. are found on the Peninsular Plateau.

## COASTLINE AND COASTAL PLAINS

We have already read that India has a long coastline. On the basis of the location and active geomorphological processes, it can be broadly divided into two: (i) the western coastal plains; (ii) the eastern coastal plains.

Western Coastal Plains	Eastern Coastal Plains
Between western ghat and Arabian sea.	Between Eastern ghat and Bay of Bengal.

<b>They extend from Kachchh to Kanyakumari.</b>	They extend from Sunderbans to Kanyakumari.
<b>They are parallel to the Western Ghats.</b>	They are parallel to the Eastern Ghats.
<b>They are further divided into coastal plains of Kachchh, Konkan, Kanara and Malabar.</b>	They are further divided into coastal plains of Utkal, Andhra and Coromandel.
<b>They are narrower and elongated.</b>	They are broader than the western coast.
<b>These are submerged coastal plains.</b>	These are emergent coastal plains.
<b>This coastal plain receives heavy rainfall</b>	This coastal plain receives comparatively less rainfall
<b>The rivers flowing through western coastal plains do not form any delta.</b>	There are well-developed deltas formed by the rivers flowing through the eastern coastal plains.
<b>Coarse grained infertile soil hence less developed agriculture.</b>	Fine, fertile alluvial soil hence fairly developed agriculture.
<b>Important natural ports are located on the western coast- Kandla, Jawaharlal Nehru Port Trust, Marmagaon, Mangalore, Cochin.</b>	Here less number of ports and harbours are there.

## WESTERN COASTAL PLAINS OF INDIA





- The western coast strip extends from the Gulf of Cambay (Gulf of Khambhat) to Cape Comorin (Kanniyakumari).
- Starting from north to south, it is divided into
  1. Kachchh and Kathiawar coast
  2. Konkan coast
  3. Karnataka/Kanada coast
  4. Kerala/Malabar coast
- It is made up of alluvium deposited by the short streams originating in the Western Ghats.
- It is dotted with a large number of **coves** (a very small bay), **creeks** (a narrow, sheltered waterway such as an inlet in a shoreline or channel in a marsh) and a few **estuaries**. (Marine Landforms).
  - The estuaries of the Narmada and the Tapi are the major ones.
- The Kerala coast (Malabar Coast) consist of some lakes, lagoons, and backwaters (**Vembanad Lake** is the largest).

## Coastlines of Emergence and Submergence

- Coastline of submergence is formed either by an lowering of the land or by the uplift of the sea level. Coastline of emergence is an exact opposite case.
- The east coast of India is a coast of emergence.
- The west coast of India is both emergent and submergent.
  - The northern portion of the coast is submerged as a result of faulting.
  - The southern portion (Kerala coast) is an example of an emergent coast
- Coastline of emergence
  - Coromandal coast (Tamil Nadu)
  - Malabar coast (Kerala Coast)
- Coastline of submergence
  - Konkan coast (Maharashtra and Goa Coast)

## Kutch and Kathiawar region

- Kutch and Kathiawar are treated as an integral part of the Western Coastal Plains (because they are now leveled down) **in spite** they are an extension of Peninsular plateau (because there are tertiary rocks in the Kutch area and Kathiawar is made of the Deccan Lava).
- The Kutch Peninsula was an island surrounded by seas and lagoons later filled by sediment brought by the Indus River. It is turned into an arid and semi-arid landscape due to lack of rains in recent times.
- Great Rann is a salt-soaked plain in the north of Kutch. Its southern continuation is known as the Little Rann.
- The Kathiawar Peninsula lies To the south of the Kachchh, the Kathiawar Peninsula lies.
  - Highland of Mandav Hills is at the central part from where small streams radiate in all directions (Radial Drainage).
  - Mt. Girnar (1,117 m) is the highest point and is of volcanic origin.
  - In the southern part of the Kathiawar peninsula, the Gir Range is located. It possess high density forests and is famous as a place of residence for the Gir lion.

## Gujarat Plain

- The Gujarat Plain lies in the east of Kachchh and Kathiawar and slopes in the direction of west and south west.

- It is formed by the rivers Narmada, Tapi, Mahi and Sabarmati. The plain includes the southern part of Gujarat and the coastal areas of the Gulf of Khambhat.
- The eastern part of this plain is fertile but the major part near the coast is covered by wind-blown loess (heaps of sand).

## Konkan Plain

- The Konkan Plain is in the south of the Gujarat plain and extends from Daman to Goa.
- The Konkan coast is characterised by subduction and erosional features including cliffs, shoals, reefs and islands in the Arabian Sea.
- The Thane creek around Mumbai is an important embayment (a recess in a coastline forming a bay) which provides an excellent natural harbour

## Karnataka Coastal Plain

- Goa to Mangalore.
- Kanara coast extends between Marmagaon and Mangalore.
- The Kanara coast is narrow and indented.
- The region is rich in iron deposits.
- At some places, the streams originating in the Western Ghats descend along steep slopes and make waterfalls.
- The Sharavati makes an impressive waterfall known as Gersoppa (Jog) Falls of 271-meter height while descending over such a steep slope.
- Marine topography is quite marked on the coast

The highest waterfall on earth is Venezuela's Angel falls (979 meter) followed by South Africa's Tugela Falls (948 m) in Drakensberg.

## Kerala Plain

- The Kerala Plain or Malabar Plain is the coast extends between Mangalore to Kanyakumari.
- The coastal plains are low lying plain and relatively broad.
- The lakes, lagoons, backwaters, spits, etc. are the significant characteristic of the Malabar coast.
  - The Malabar coast has got certain distinguishing features in the form of 'Kayals' (backwaters), which are the shallow lagoons or inlets of the sea, lying parallel to the coastline.
    - These used for fishing, inland navigation and also due to its special attraction for tourists. Every year the famous Nehru Trophy Vallamkali (boat race) is held in Punnamada Kayal in Kerala.
    - The largest among these is the Vembanad Lake

## EASTERN COASTAL PLAINS OF INDIA

- It is found between the Eastern Ghats and the Bay of Bengal.
- It extends from the Ganga delta to Kanniyakumari.
- It is marked by well-developed deltas of rivers like the Mahanadi, the Godavari, the Krishna and the Cauvery.
- Chilka lake and the Pulicat lake (lagoon) are the important geographical features of east coast.

- The Eastern coastal plains are broader than the western coastal plains and are an example of emergent coastal plain.
- The continental shelf here extends up to 500 km into the sea making difficult to develop good natural harbours and ports in these regions

## Regional Names of The East Coast of India

- Starting from north to south, it is divided into
  1. Utkal coast
  2. Andhra coast
  3. Tamil Nadu coast
- This plain is called the Northern Circars between the Mahanadi and the Krishna rivers and Carnatic between the Krishna and the Cauvery rivers

Parts of Andhra coast and Tamil Nadu coast together are known as Payan or Coramandal Coast.

## Utkal Plain

- The Utkal Plain comprises coastal areas of Odisha including the Mahanadi delta.
- Chilka Lake is the most prominent physiographic feature of this plain.
  - It is the biggest lake in the country

## Andhra Plain

- It is found in the south of the Utkal Plain and extends upto Pulicat Lake.
  - Pulicat lake has been barred by a long sand spit known as Sriharikota Island (ISRO launch facility).
- Rivers Godavari and Krishna forms delta. The two deltas have merged with each other resulting a single physiographic unit.
- This part of the plain has a straight coast and lacks good harbours with the exception of Vishakhapatnam and Machilipatnam.

## Tamilnadu Plain

1. The Tamil Nadu Plain stretches from Pulicat lake to Kanniyakumari along the coast of Tamil Nadu.
2. Its average width is 100 km.
3. The most important feature of this plain is the Cauvery delta where the plain is 130 km wide.
4. The Cauvery delta is known as granary of South India because of the fertile soil and large-scale irrigation facilities.

## SIGNIFICANCE OF INDIAN COASTLINES

1. The coastal plains in India are mostly covered by fertile soils.
  - Rice is the major crop that is cultivated in these regions.
2. The ports along the Indian coastlines helps in carrying out the trade activities.
3. The sedimentary rocks of these coastal plains are said to contain large deposits of mineral oil which can be used as a source of marine economy.
4. Fishing has become an important occupation of the people living in coastal areas.
5. Rich in coastal and marine ecosystems like mangroves, coral reefs, estuaries and lagoons serving as great tourism potential.

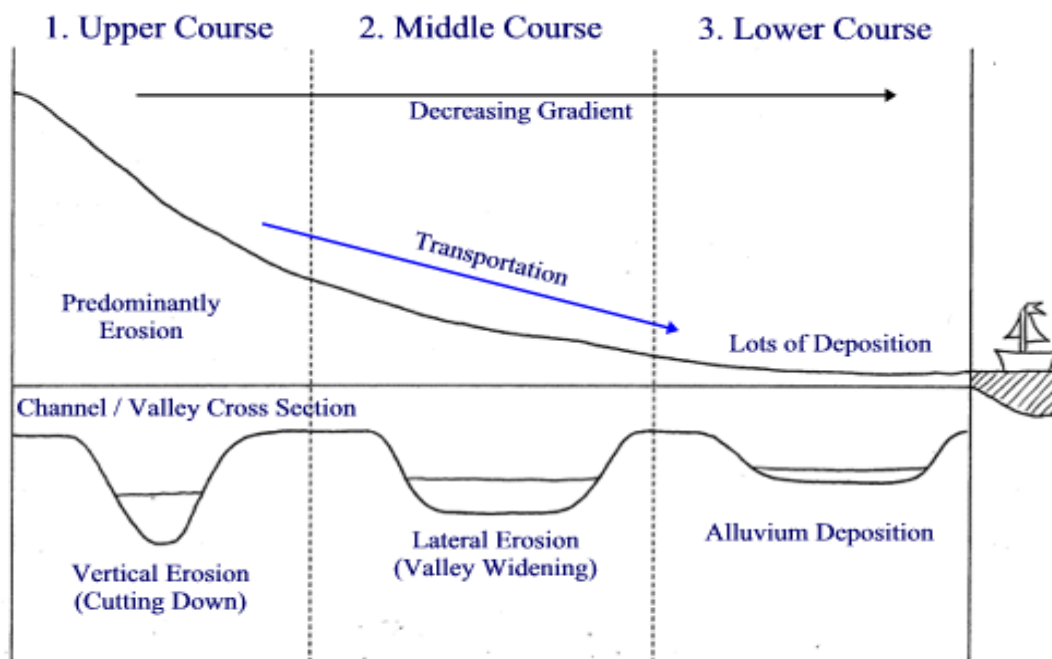


6. Indian coastlines enjoy a favourable climate with no extreme temperature which is ideal for human development

## Delta and Estuary

A river has 3 stages of channel development

- Deltas are like alluvial fans (i.e. a depositional feature) but develop at a different location .
- Unlike in alluvial fans, the deposits making up deltas are very well sorted with clear stratification.
  - The coarsest materials settle out first and the finer fractions like silts and clays are carried out into the sea.



- Deltas are **found at the mouth of large rivers** - for example, the Ganges delta.
  - The load carried by the rivers is dumped and spread into the sea.
- As the delta grows, the river distributaries continue to increase in length and delta continues to build up into the sea.

Delta	Estuary
1. The triangular deposits made by the rivers at their mouth form Delta.	1. The sharp edged mouth of rivers, devoid of any deposits is known as Estuary.
2. Deltas are formed in the regions of low tides and coastal plains.	2. Regions of high tides and rift valleys witness Estuaries.
3. Deltas are fertile lands.	3. Estuary does not have fertile lands.
4. Ganga and Brahmaputra, Krishna, Kaveri and Mahanadi form delta.	4. Narmada and Tapi rivers form Estuaries.

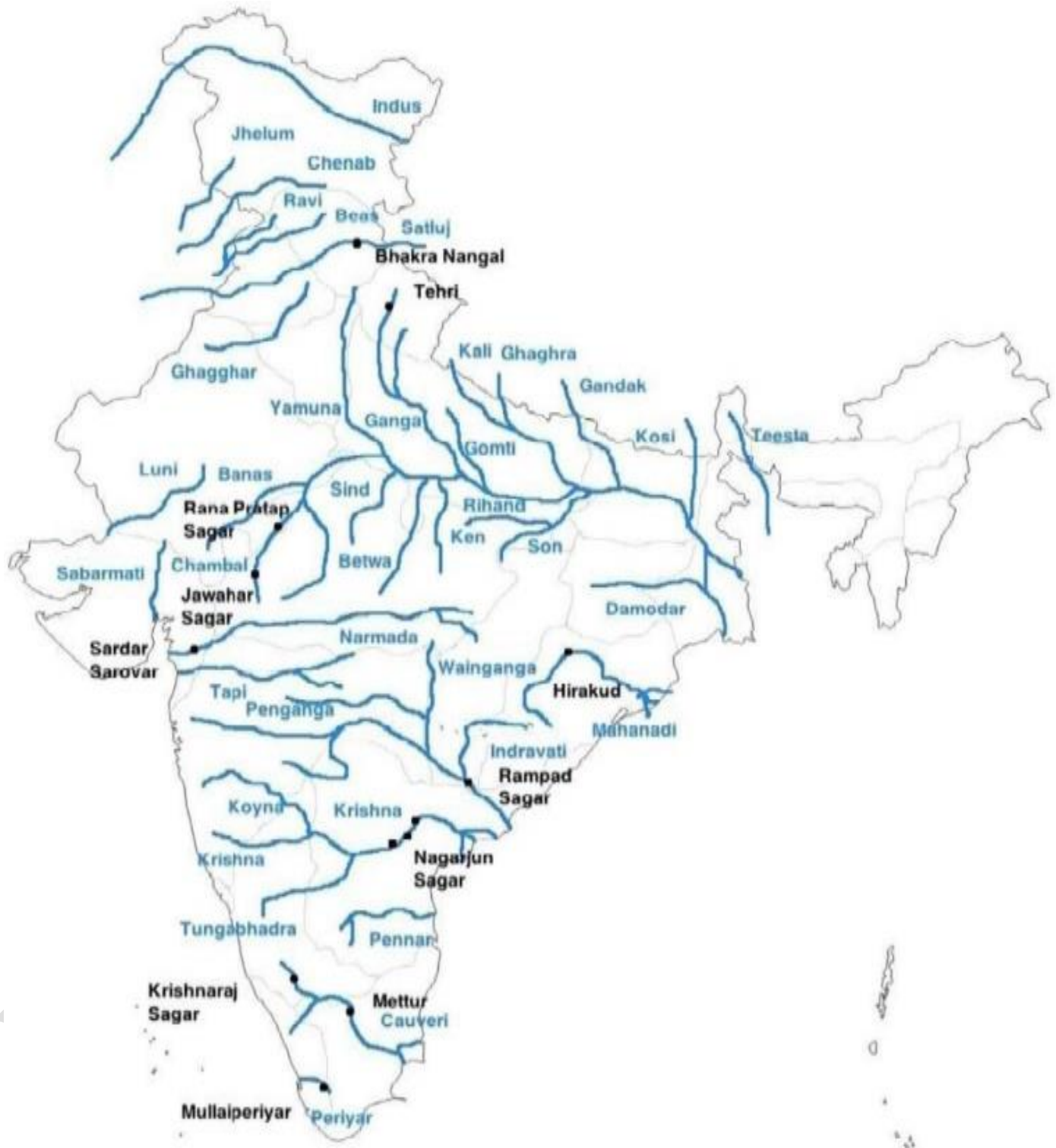
## MAJOR PORTS OF INDIA

- There are 13 major and 185 minor seaports located in the 5,600 km long coast line of the mainland of the country.
- The major ports are controlled by the Central Government while the medium and minor ports are included in the concurrent list of the constitution and are managed and administered by the respective states

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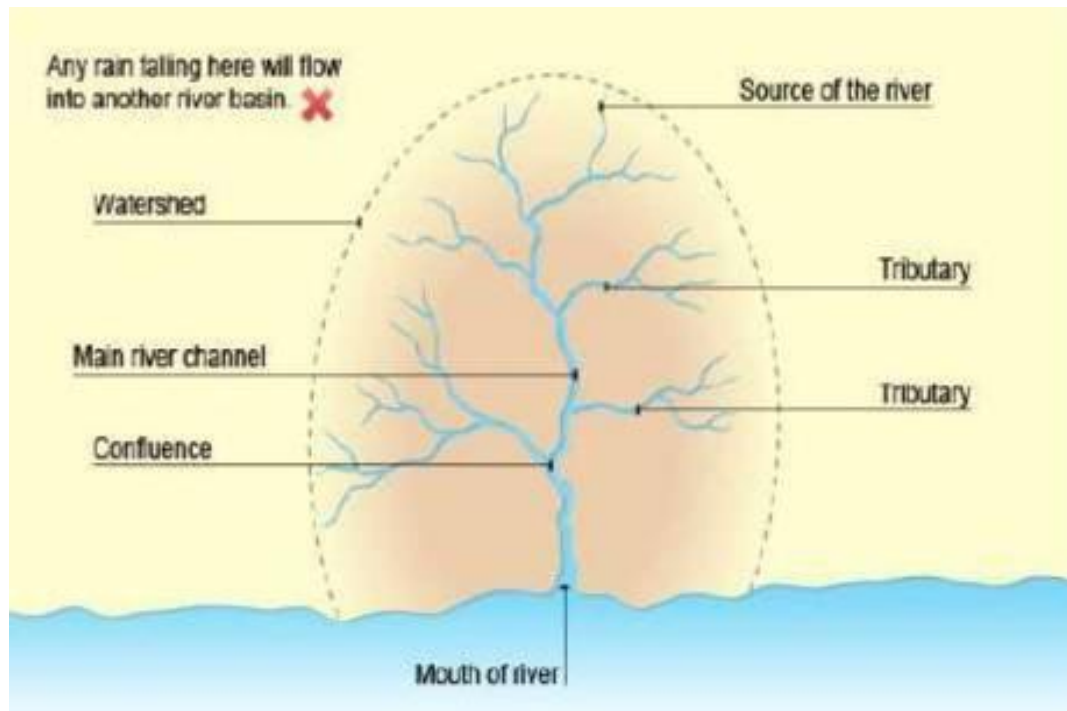


## CH-4 DRAINAGE SYSTEMS OF INDIA



Indian drainage system consists of a large number of small and big rivers. It is the outcome of the evolutionary process of the three major physiographic units i.e Great Himalayas, Peninsular Plateau, Western Ghats; and the nature and characteristics of precipitation





## BASIC TERMS

**Drainage system:** The flow of water through well-defined channels is known as drainage and the network of such channels is known as a drainage system.

**Source of a river:** The beginning or start of a river.

**Confluence:** The point at which two rivers or streams join.

**Distributary:** The small river that branches out from the main river and then never meets again. It thus decreases the river's water volume. Distributaries are commonly found on deltas but are also important in the formation of alluvial fans and cones.

**Tributary:** A stream or smaller river which joins a larger stream or river and thus increases its water volume.

**Mouth:** The point where the river comes to the end, usually when entering a sea.

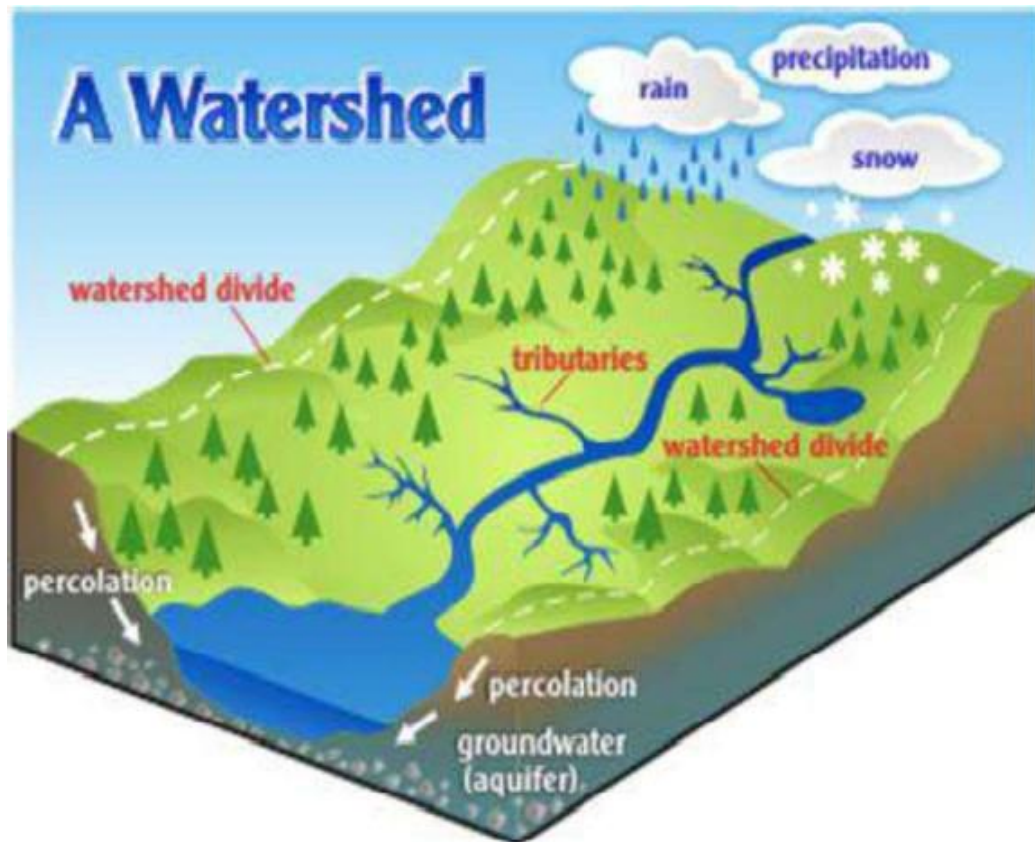
**Catchment area:** It refers to all the area of land over which rain falls and is caught to serve a river basin.

**River Profile:** It refers to the cross-section of a river from its source to mouth representing the height of the river at various points. The peninsular rivers have almost reached their base levels of erosion.

**Discharge:** The volume of water flowing in a river measured over time. It is measured either in cusecs (cubic feet per second) or cumecs (cubic metres per second).

**River regime:** It refers to the seasonal fluctuation in respect of volume of water in the river.

**Watershed:** The boundary line separating one drainage basin from the other is called as the watershed area



## DRAINAGE PATTERN

A geometric arrangement of streams in a region is known as a drainage pattern. The factors controlling the pattern of drainage in a region include:

Topography: The arrangement of the natural and artificial physical features of an area.

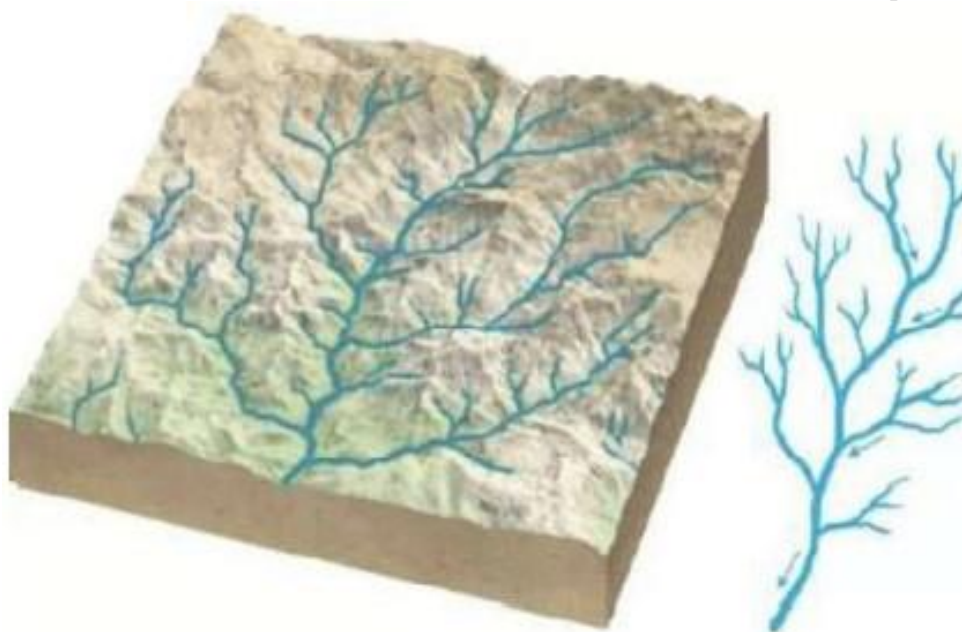
Structure (Geology)	Present climate and palaeo- climates	Tectonic history	Human beings as a geomorphic agent and Anthropocene
Lithology or type of rocks	Tropical, temperate or polar environments	Changes in the general elevation of land and resultant eustatic changes	Detention of water and sediments
Characteristics of rocks	Internal(geothermal) and external(solar)	Slope gradients and morphometry	Interlinking of the drainage basins

- **Slope:** The direction of the river Flow is generally guided by the direction of the slope since the flow of the water is controlled by gravitational force. There are rivers whose flow is exclusively determined by the direction of the slope.
- **Structural control:** At certain stages in the course of the river , The arrangement of rock layers may influence the direction that river takes. The river may change its direction due to the direction of the strike of an exposed rock layer despite the general direction of the flow.
- **Nature of rocks:** As the river erode its channel, the nature of the bedrock becomes significance in determining how deep the river channel will become. If the river encounter a very resistant rock outcrop in its path, it may have to change its direction to circumvent it despite the nature of the slope.

- Tectonic activities: Tectonic movements influence the shape of rivers, fluvial processes, forms and deposits. Tectonic traces are visible along all the rivers
- Geological history of that region

## Types of drainage patterns found in India:

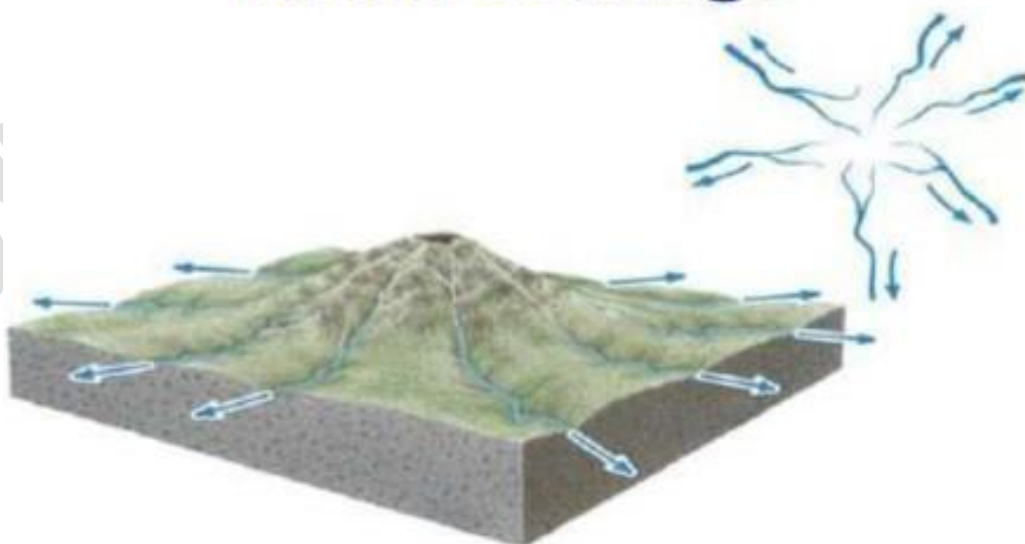
**Dendritic:** A drainage pattern which looks like tree branches with lots of twigs is known as a Dendritic drainage pattern. For example, the rivers of the northern plain.



*Dendritic Pattern*

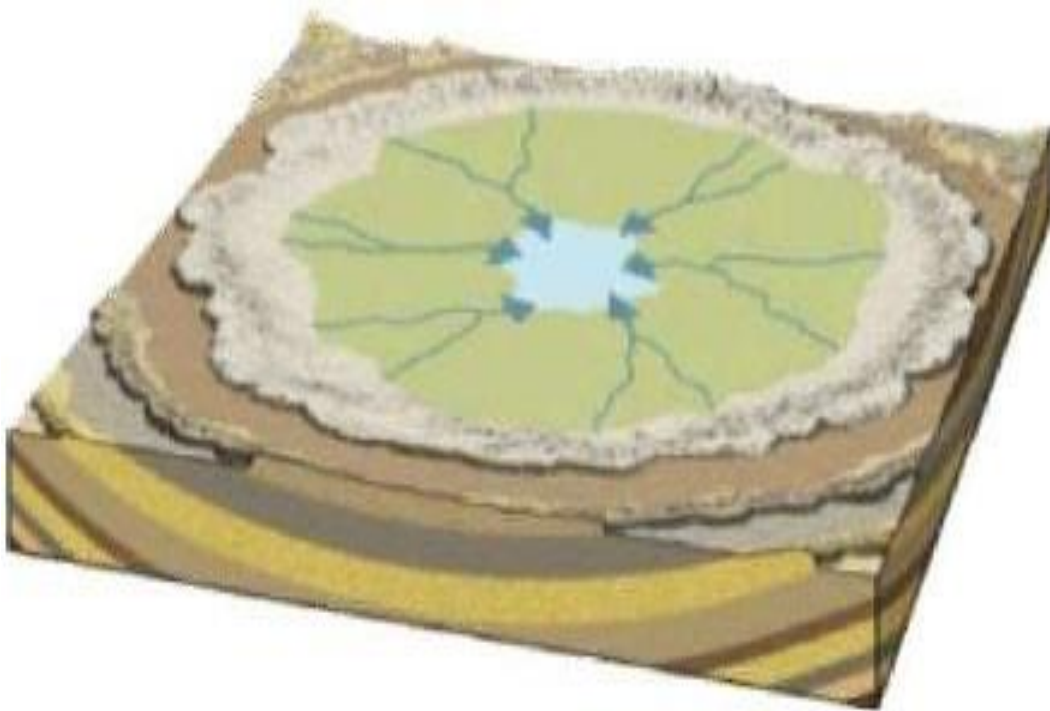
**Radial:** Radial drainage patterns form when rivers originate from a hill and flow in all directions. For example, the rivers originate from the Amarkantak

## Radial Drainage





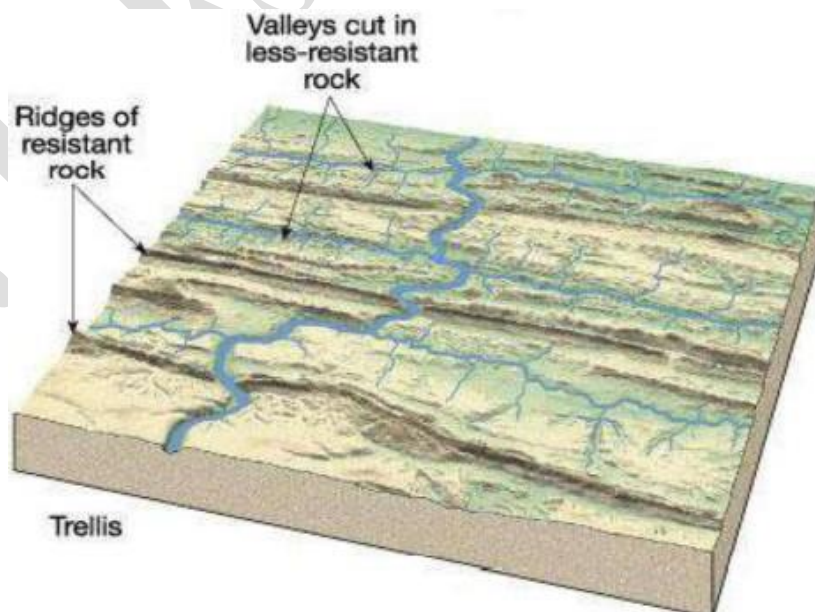
**Centripetal:** Centripetal drainage pattern is formed when rivers discharge their waters from all directions into a lake or a depression.



*Centripetal Drainage*

For example, Loktak lake in Manipur.

**Trellis:** Trellis drainage pattern is formed when the primary tributaries of main rivers flow parallel to each other and secondary tributaries join them at right angles. For example, rivers in the upper part of the Himalayan region and The old folded mountains of the Singhbhum (Chotanagpur Plateau) i.e Damodar River system



*Trellis Drainage*

**Rectangular:** In rectangular drainage, both the main stream and its tributaries show right-angled bends. A rectangular drainage pattern develops on strongly joined rocky terrain. For example: streams found in the Vindhya Mountains of India.

## RECTANGULAR



### Types of Drainage Patterns

Based on the shape and formation of river patterns, there are different drainage patterns.

#### A) Discordant Drainage

A pattern of drainage that does not correlate to the topology [surface relief features] and geology [geological features] of the area.

Discordant drainage patterns are classified into two main types:

- **Antecedent Drainage:** The river has stayed more or less in its original position as slow uplift of the region has taken place. The Indus, Satluj, Ganga, Sarju (Kali), Arun (a tributary of Kosi), Tista and Brahmaputra are some of the important antecedent rivers, originating from beyond the Greater Himalayas.
- **Superimposed Drainage:** It is formed when a stream with a course originally established on a cover of rock now removed by erosion, so that the stream or drainage system is independent of the newly exposed rocks and structures. The Damodar, the Subarnarekha, the Chambal, the Banas are some good examples of superimposed drainage.

## B) Concordant Drainage

The pattern of drainage which arises from and closely follows the trends of the underlying strata is called concordant drainage.

Consequent Streams: Streams are guided by the slope of the land.

Subsequent Streams: Streams follow slope and are aligned to the consequent streams.

Obsequent streams: streams run opposite to the general dip of the land  
Resequent Streams: A resequent stream flows in the same direction as that of the initial consequent stream, but which develops in response to a new base level formed due to inversion of relief.

Indian River Systems		
River System	Total length	Length in India
Indus River System	3180 km	1114 km
Brahmaputra River System	2900 km	916 km
Ganga River System	2510 km	2510 km
Yamuna river System	1376 km	1376 km
Narmada River System	1312 km	1312 km
Tapi River System	724 km	724 km
Godavari River System	1465 km	1465 km
Krishna River System	1400 km	1400 km
Cauvery River System	805 km	805 km
Mahanadi River System	851 km	851 km

## Major River Systems of India

### Classification of Indian Drainage System

#### 1. On the basis of discharge of water:

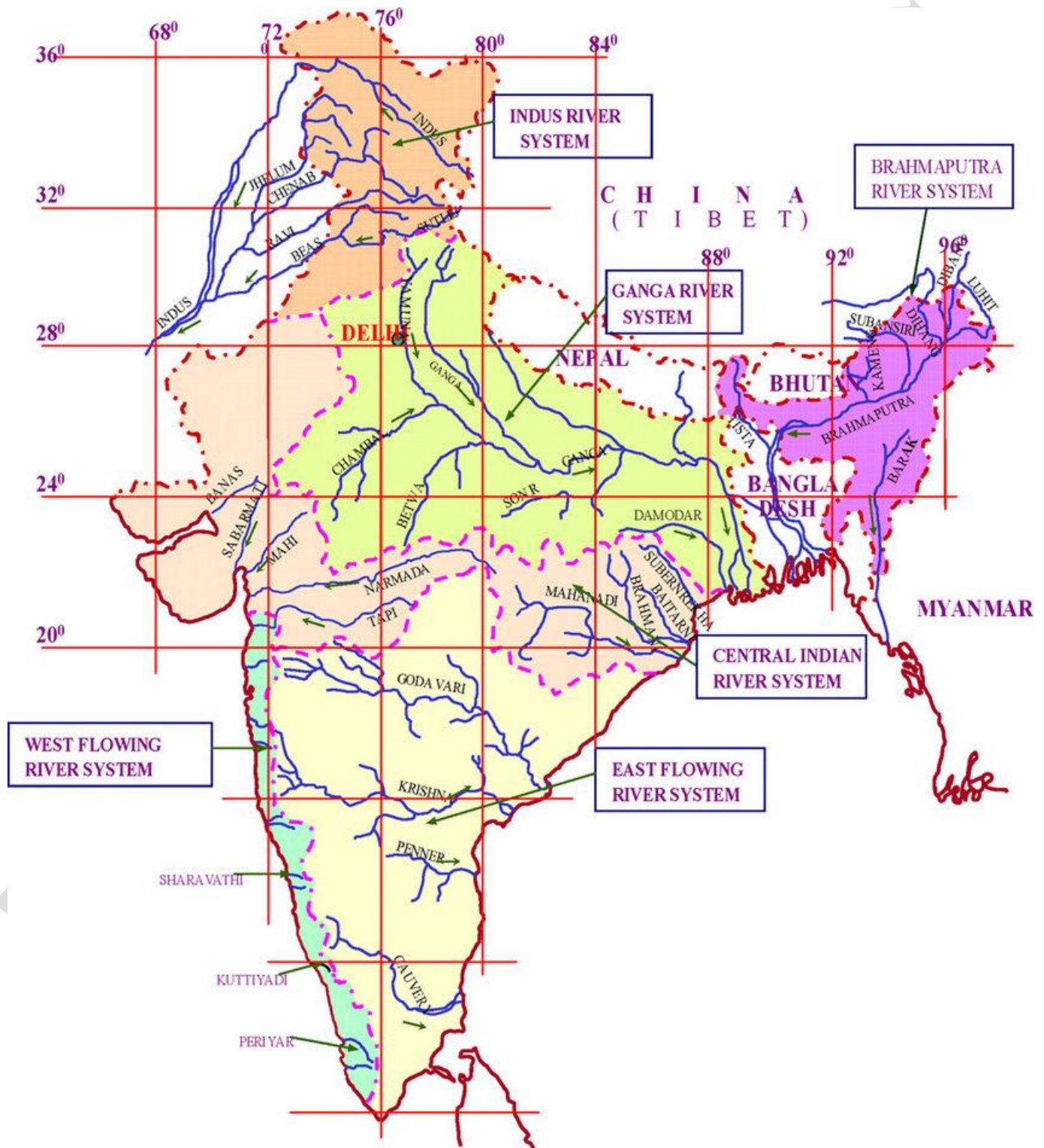
- Arabian Sea drainage
- Bay of Bengal drainage

The Bay of Bengal drainage	The Arabian Sea drainage
Rivers that drain into the Bay of Bengal	Rivers that drain into the Arabian sea
East flowing rivers	West flowing rivers
~ 77 per cent of the drainage area of the country is oriented towards the Bay of Bengal	~ 23 per cent of the drainage area of the country is oriented towards the Arabian sea
The Ganga, the Brahmaputra, the Mahanadi, the Godavari, the Krishna, the Cauvery, the Penneru, the Penneyar, the Vaigai, etc.	The Indus, the Narmada, the Tapti, the Sabarmati, the Mahi and the large number of swift flowing western coast rivers descending from the Sahyadris.



The drainage systems flowing into the Arabian Sea and the Bay of Bengal are separated by a water divide extending approximately along the Western Ghats, Aravallis and Yamuna Sutlej divide

About 90 per cent of the water drains into the Bay of Bengal; the rest is drained into the Arabian Sea or forms inland drainage.



## 2. On the basis of the mode of origin, nature and characteristics:

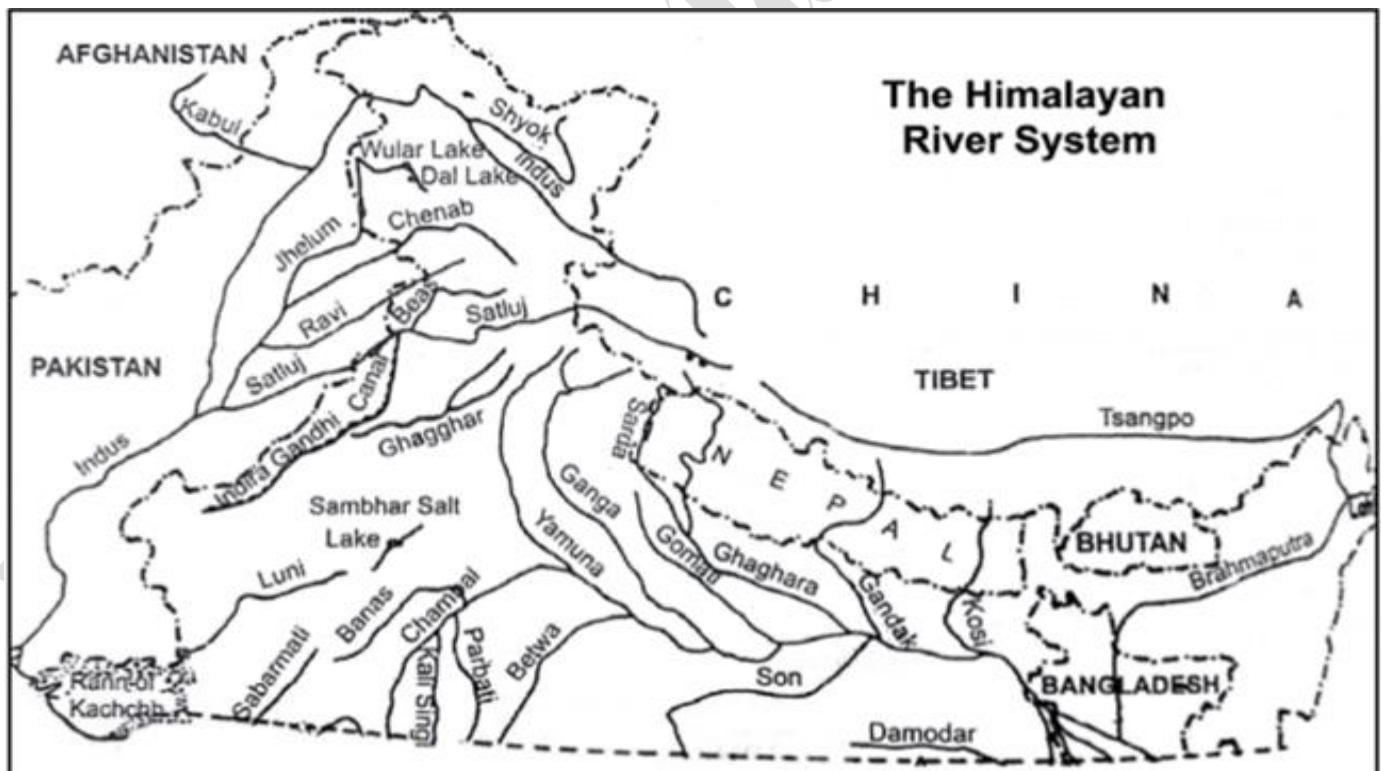
- The Himalayan drainage
- The Peninsular drainage.
- Himalayan Drainage is much younger than Peninsular Drainage
- There is no clear-cut line of demarcation between these two drainage systems, as many of the peninsular rivers like the Chambal, Betwa, Sind, Ken and Son are tributaries of Himalayan rivers.

## Himalayan Drainage System

It consists of the rivers originating in the Himalayan and trans-Himalayan region. It further consists of three river systems namely:

- the Ganga,
- the Indus, and
- the Brahmaputra river systems
- Since these are fed both by the melting of snow and precipitation, rivers of this system are perennial.
- The various geographical features made by the Himalayan rivers are:
- In upper reaches (Youthful stage): Gorges, V-shaped valleys, rapids, waterfalls, truncated spurs etc.
- In plain areas or middle part (Mature stage): While entering the plains, they form depositional features like flat valleys, ox-bow lakes, flood plains, braided channels, and deltas near the river mouth. Over the plains, they display a strong meandering tendency and shift their courses frequently.

## Evolution of the Himalayan Drainage System



- The major Himalayan Rivers existed even before the formation of the Himalayas, i.e. before the collision of Indian Plate with the Eurasian plate.
- They were flowing into the Tethys Sea. These rivers had their source in the now Tibetan region



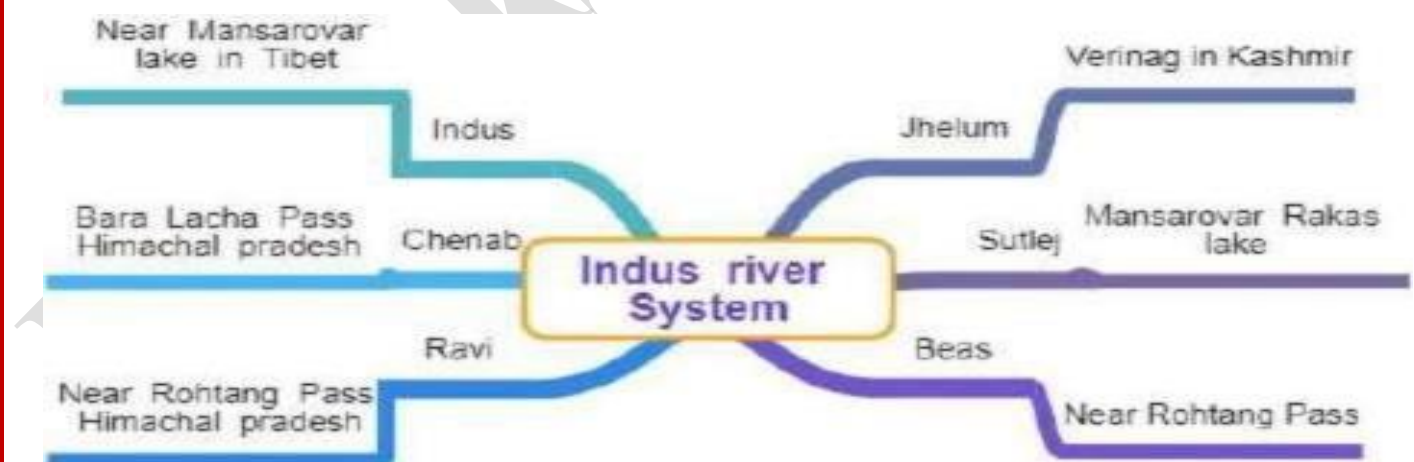
- The deep gorges of the Indus, the Sutlej, the Brahmaputra etc. indicate that these rivers are older than the Himalayas
- They continued to flow throughout the building phase of the Himalayas; their banks were rising steeply while the beds went lower and lower due to vertical erosion (Vertical downcutting was significant and was occurring at a rate faster than the rising of Himalayas), thus cutting deep gorges
- Thus, many of the Himalayan Rivers are typical examples of antecedent drainage.

## Indus River System

This river system includes the Indus and its tributaries like Jhelum, Chenab, Rabi, Beas, Sutlej (The Panchnad) etc. It is one of the largest river basins of the world. A little over one-third of the Indus basin is located in India; in the states of Jammu & Kashmir, Himachal Pradesh and Punjab. The rest of the portion is in Pakistan.

- The Indus, which is also known as the **Sindhu**, is the westernmost of the Himalayan Rivers in India.
- The Indus originates from a glacier near **Bokhar Chu** in the Tibetan region at an altitude of 4,164 m in the *Kailash* Mountain range.
- After entering J&K, it flows between the Ladakh and the Zaskar Ranges
- It is joined by the Zaskar River at Leh
- The Indus drains the largest number of glaciers of Himalayas, Ladakh, Zaskar, and Kailash.
- It is 3600 km long and one of the largest rivers of the world.
- In Tibet, the Indus is known as **Singi Khamban** or the Lion's mouth.
- The Indus enters into Pakistan near *Chillar* in the Dardistan region.
- Major tributaries of Indus are the *Shyok*, the *Gilgit*, the *Zaskar*, the *Hunza*, the *Nubra*, the *Shigar*, the *Fasting*, and the *Dras* in the upper part.
- In the lower part, the *Satluj*, the *Beas*, the *Ravi*, the *Chenab*, and the *Jhelum* are the major tributaries of the *Indus*.
- Finally, the *Indus* discharges into the *Arabian* Sea near Karachi in Pakistan.

## Tributaries of Indus and their source of origin



## Jhelum River

- The Jhelum rises from a spring at Verinag situated at the foot of the Pir Panjal in the south-eastern part of the valley of Kashmir.



- It flows through Srinagar and the Wular lake before entering Pakistan through a deep narrow gorge. It joins the Chenab near Jhang in Pakistan.
- Dams: Mangla Dam, Uri Dam, Kishanganga Hydroelectric Plant

## Chenab River

- The Chenab is the largest tributary of the Indus. It is formed by two streams, the Chandra and the Bhaga, which join at Tandi near Keylong in Himachal Pradesh.
- Hence, it is also known as Chandrabhaga. The river flows for 1,180 km before entering into Pakistan.
- Dams: Salal Dam, Pakal Dul Dam, Ratle Hydroelectric Plant, Dul Hasti Hydroelectric Plant

## Ravi River

- The Ravi is another important tributary of the Indus. It rises west of the Rohtang pass in the Kullu hills of Himachal Pradesh and flows through the Chamba valley of the state.
- Before entering Pakistan and joining the Chenab near Sarai Sidhu, it drains the area lying between the southeastern part of the Pir Panjal and the Dhauladhar ranges.
- Dams: Ranjit Sagar Dam, Chamara Dam

## Beas River

- The Beas is another important tributary of the Indus, originating from the Beas Kund near the Rohtang Pass at an elevation of 4,000 m above the mean sea level.
- The river flows through the Kullu valley and forms gorges at Kati and Largi in the Dhauladhar range.
- It enters the Punjab plains where it meets the Satluj near Harike.
- Dams: Pong Dam, Pandoh Dam

## Sutlej River

- The Sutlej originates in the Rakas lake near Mansarovar at an altitude of 4,555 m in Tibet where it is known as Langchen Khambab.
- It flows almost parallel to the Indus for about 400 km before entering India and comes out of a gorge at Rupar.
- It passes through the Shipki La on the Himalayan ranges and enters the Punjab plains. It is an antecedent river.
- It is a very important tributary as it feeds the canal system of the Bhakra Nangal project

## Indus water treaty

- India and Pakistan share the waters of the Indus river system according to the Indus Water Treaty signed between the two countries on 19th September 1960.
- A **Permanent Indus Commission** was set up by the United Nations for resolving any disputes that may arise in water sharing, with a mechanism for arbitration to resolve conflicts amicably.
- According to this treaty, India can utilise only 20 percent of its total discharge of water.
- Under the treaty signed between India and Pakistan in 1960, all the waters of three rivers, namely Ravi, Sutlej and Beas ( Eastern Rivers) were allocated to India for exclusive use.
- While, the waters of Western rivers - Indus, Jhelum, and Chenab were allocated to Pakistan except for specified domestic, non-consumptive and agricultural use permitted to India as provided in the Treaty.
- India has also been given the right to generate hydroelectricity through run of the river (RoR) projects on the Western Rivers which, subject to specific criteria for design and operation is unrestricted

## Current Developments

To utilize the waters of the Eastern rivers which have been allocated to India for exclusive use, India has constructed following dams:

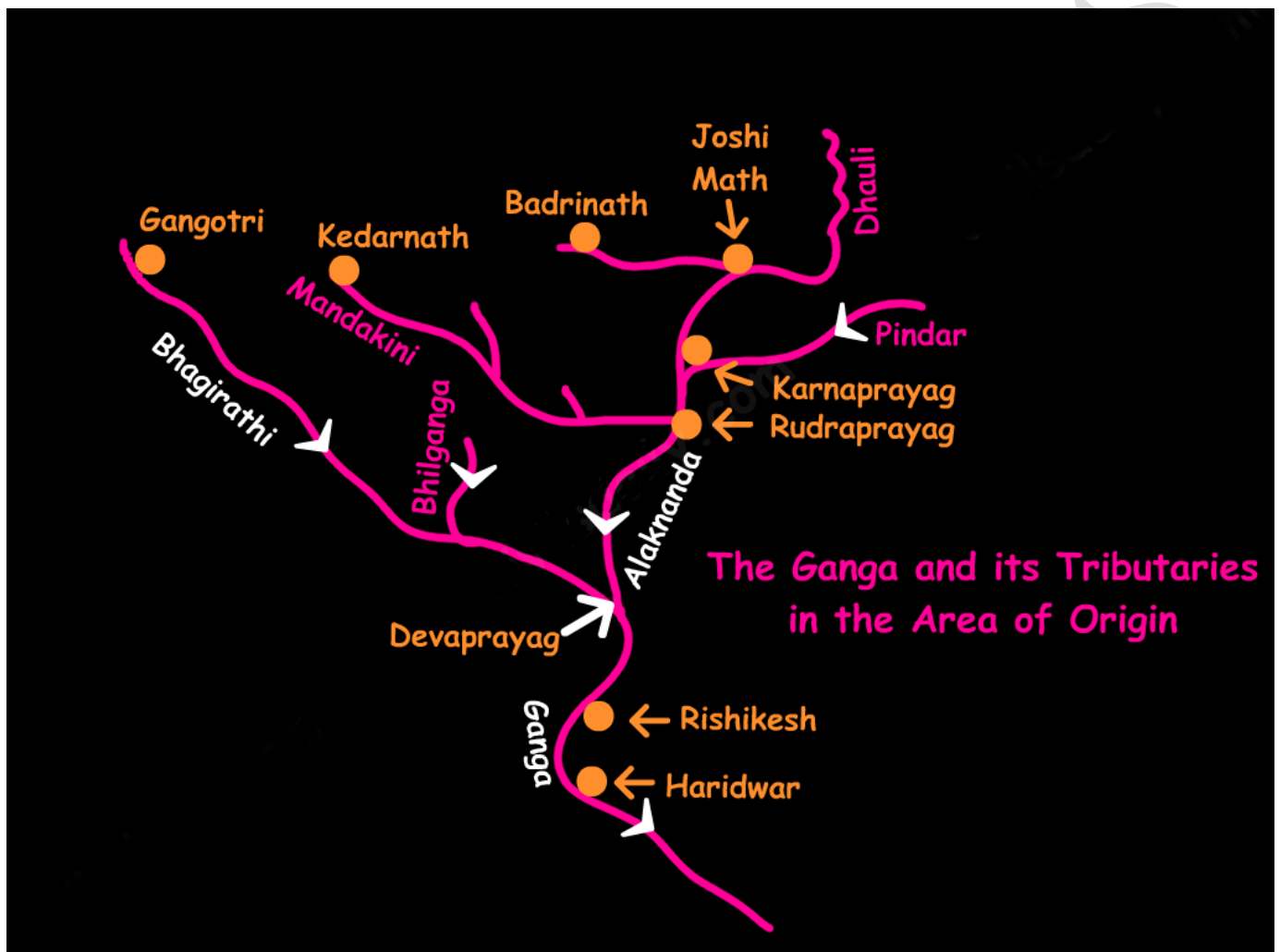
- Bhakra Dam on Satluj,
- Pong and Pandoh Dam on Beas and
- Thein (Ranjit Sagar) on Ravi.
- In 2016, Pakistan had approached the World Bank raising concerns of India's Kishenganga and Ratle hydroelectric power projects being constructed in Jammu & Kashmir.
- India then requested for neutral experts to inspect the plants, saying that the points raised by Pakistan were technical ones and do not require a court of arbitration.
- The World Bank permitted India to proceed with the projects after talks were concluded between both the countries on the technicalities of the treaty

## Ganga River System



- The Ganga river system is the largest in India and has a number of perennial and non-perennial rivers originating in the Himalayas in the north and the Peninsula in the south, respectively.
- The Ganga is the most important river of India both from the point of view of its basin and cultural significance.
- Ganga **basin** covers 11 **states** viz., Uttarakhand, U.P., M.P., Rajasthan, Haryana, Himachal Pradesh, Chhattisgarh, Jharkhand, Bihar, West Bengal and Delhi.

- It rises in the Gangotri glacier near Gaumukh (3,900 m) in the Uttarkashi district of Uttarakhand. Here, it is known as Bhagirathi.
- It cuts through the Central and the Lesser Himalayas in narrow gorges.
- At Devprayag, the Bhagirathi meets the Alaknanda; hereafter, it is known as the Ganga. The Ganga enters the plains at Haridwar.
- It is joined by the Yamuna at Prayagraj (Allahabad).



- The river has a length of 2,525 km. The Ganga basin covers about 8.6 lakh sq. km area in India alone

Place	Confluence
Devprayag	Bhagirathi + Alaknanda
Rudraprayag	Mandakini + Alaknanda
Karnaprayag	Pindar + Alaknanda
Vishnuprayag	Dhauliganga + Alaknanda



- Important Dams: **Tehri Dam** constructed on Bhagirathi River, tributary of the Ganges, **Farakka Barrage** close to the point where the main flow of the river enters Bangladesh.
- A large number of cities have been built on the Gangetic Plain. Among the most notable are Saharanpur, Meerut, Agra, Aligarh Kanpur, Bareilly, Lucknow, Allahabad, Varanasi (Benares or Kashi; the holy city of the Hindus), Patna, Bhagalpur, Murshidabad, Kolkata, Howrah and Dhaka
- In Bangladesh, later it is known as the Padma. Padma river is later on known as Meghna when it meets Jamuna (Brahmaputra river), which along with Hoogly river makes the world's largest Delta is known as Sunderban while emptying into Bay of Bengal located both in West Bengal of India and Bangladesh.

## Important left bank tributaries of the Ganga

- Ramganga
- Gomati
- Ghaghara
- Ganda
- Kosi
- Mahananda

## Important right bank tributaries of the Ganga

- Son
- Yamuna

## Tributaries of Ganga and their source of origin



## Alaknanda River

- The Alaknanda has its source in the Satopanth glacier above Badrinath.
- The Alaknanda consists of the Dhauli and the Vishnu Ganga which meet at Joshimath or Vishnu Prayag.
- The other tributaries of Alaknanda such as the Pindar join it at KarnaPrayag while Mandakini or Kali Ganga meets it at RudraPrayag

## Ramganga River

- The Ramganga is comparatively a small river rising in the Garhwal hills near Gairsain.
- It changes its course to the southwest direction after crossing the Shiwalik and enters into the plains of Uttar Pradesh near Najibabad.

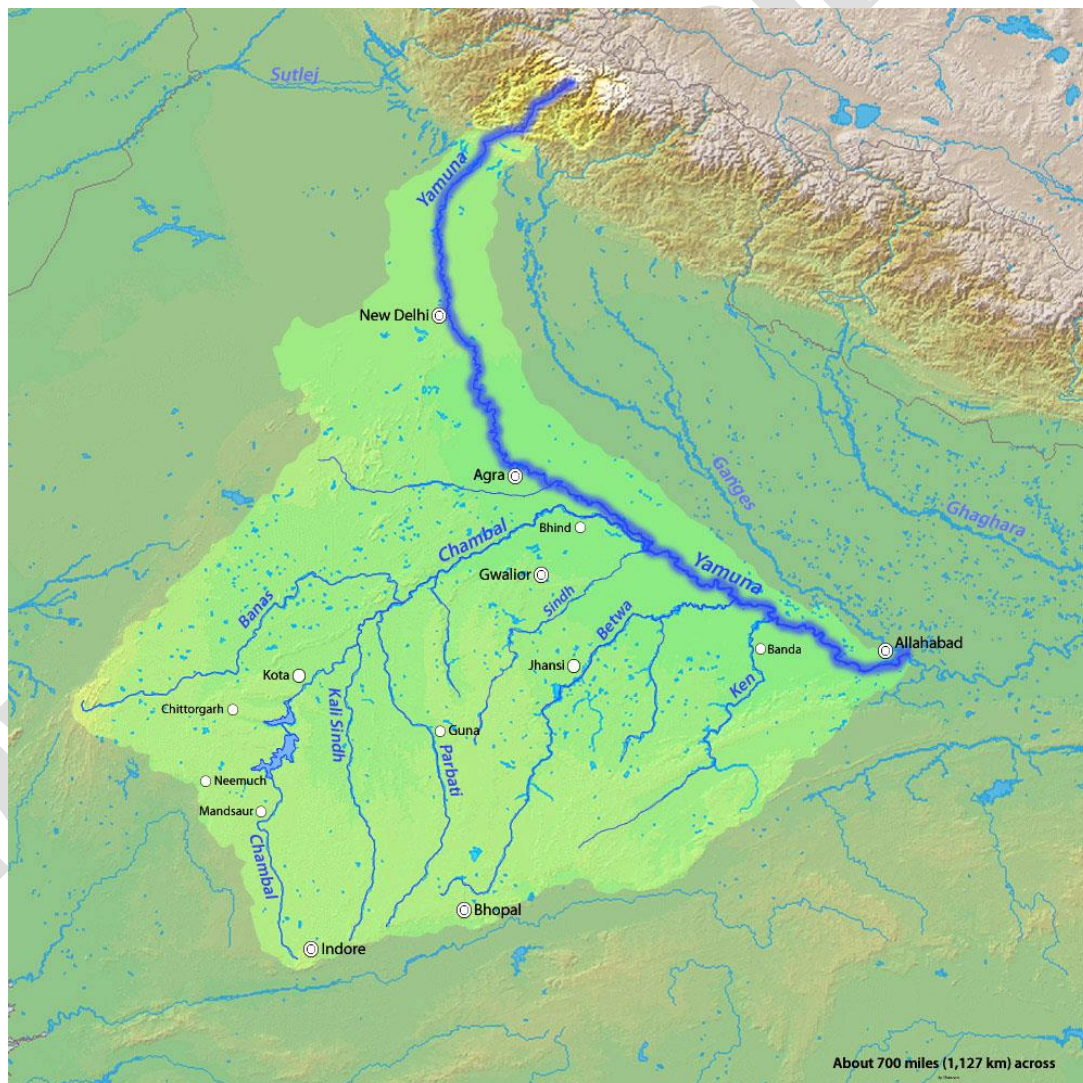
- Finally, it joins the Ganga near Kannauj

## Gomti River

- Originates from Gomat Taal / Fulhaar jheel – Pilibhit
- It joins the Ganga at Ghazipur in Uttar Pradesh before flowing through the cities of Lucknow and Jaunpur.

## Yamuna River

- Yamuna, the westernmost and the longest tributary of the Ganga, has its source in the Yamunotri glacier on the western slopes of Bandarpunch range (6,316 km).
- It joins the Ganga at Prayag (Allahabad). It is joined by the Chambal, the Sind, the Betwa and the Ken on its right bank which originates from the Peninsular plateau while the Hindan, the Rind, the Sengar, the Varuna, etc. join it on its left bank.
- Much of its water feeds the western and eastern Yamuna and the Agra canals for irrigation purposes.
- Lakhwar-Vyasi Dam project** on Yamuna River includes under-construction **Lakhwar Dam** and Power Station, **Vyasi Dam**, Hathiari Power Station and Katapathar Barrage, near the **Lakhwar** town in Kalsi block of Dehradun district of Uttarakhand in India



## Tributaries of Yamuna

Non – Peninsular Tributaries	Peninsular Tributaries
<ol style="list-style-type: none"> <li>1. Rishiganga</li> <li>2. Uma</li> <li>3. Hanuman Ganga</li> <li>4. Tons</li> <li>5. Hindon</li> </ol>	<p>Most of the Peninsular rivers flow into the Yamuna between Agra and Allahabad.</p> <ol style="list-style-type: none"> <li>1. Chambal</li> <li>2. Sind</li> <li>3. Betwa</li> <li>4. Ken.</li> </ol>

## Chambal River

- The Chambal rises near Mhow in the Malwa plateau of Madhya Pradesh and flows northwards through a gorge upwards of Kota in Rajasthan, where the Gandhisagar dam has been constructed
- From Kota, it traverses down to Bundi, Sawai Madhopur and Dholpur, and finally joins the Yamuna. The Chambal is famous for its badland topography called the Chambal ravines

## Dams on the Chambal

- The Gandhi Sagar dam is the first of the four dams built on the Chambal River, located on the RajasthanMadhya Pradesh border.
- The Rana Pratap Sagar dam is located downstream of Gandhi Sagar dam.
- The Jawahar Sagar Dam is located downstream of Rana Pratap Sagar dam.
- The Kota Barrage is the fourth in the series located upstream of Kota City in Rajasthan.

## Banas

- The Banas is a tributary of the Chambal.
- It originates in the southern part of the Aravalli Range.
- It joins the Chambal on Rajasthan – Madhya Pradesh border near Sawai Madhopur

## Sind

- The Sind originates in Vidisha Plateau of Madhya Pradesh.
- It flows for a distance of 415 km before it joins the Yamuna.

## Betwa

- The Betwa rises in Bhopal district (Vindhyan Range) and joins the Yamuna near Hamirpur.
- The Dhasan is its important tributary

## Ken

The Ken river rising from the Barner Range of Madhya Pradesh joins the Yamuna near Chila.

## Gandak River

- The Gandak comprises two streams, namely Kali Gandaki and Trishul Ganga.
- It rises in the Nepal Himalayas between the Dhaulagiri and Mount Everest and drains the central part of Nepal.
- It enters the Ganga plain in Champaran district of Bihar and joins the Ganga at Sonpur near Patna.



## Ghaghra River

- The Ghagra originates in the glaciers of Mapchachungo.
- After collecting the waters of its tributaries – Tila, Seti and Beri, it comes out of the mountain, cutting a deep gorge at Chisapani.
- The river Sarda (Kali or Kali Ganga) joins it in the plain before it finally meets the Ganga at Chhapra

## Sharda River

- The Sarda or Saryu river rises in the Milam glacier in the Nepal Himalayas where it is known as the Goriganga.
- Along the Indo-Nepal border, it is called Kali or Chauk, where it joins the Ghaghara

## Kosi River

- The Kosi is an antecedent river with its source to the north of Mount Everest in Tibet, where its mainstream Arun rises.
- After crossing the Central Himalayas in Nepal, it is joined by the Son Kosi from the West and the Tamur Kosi from the east.
- It forms Sapta Kosi after uniting with the River Arun. River Kosi, also known as the 'sorrow of Bihar', has been notorious for frequently changing its course.
- The Kosi brings the huge quantity of sediments from its upper reaches and deposits it in the plains. The course gets blocked, and consequently, the river changes its course

## Mahananda River

- The Mahananda is another important tributary of the Ganga rising in the Darjeeling hills
- It joins the Ganga as its last left bank tributary in West Bengal

## Son River

- The Son is its major right bank tributary. The Son is a large south bank tributary of the Ganga, originating in the Amarkantak plateau.
- After forming a series of waterfalls at the edge of the Rohtas plateau, it reaches Arrah, west of Patna, to join the Ganga

## Damodar River

- The Damodar occupies the eastern margins of the Chotanagpur Plateau where it flows through a rift valley and finally joins the Hugli.
- The Barakar is its main tributary.
- Once known as the 'sorrow of Bengal', the Damodar has been now tamed by the Damodar Valley Corporation (DVC), a multipurpose project.

## Brahmaputra River System

Region	Name
Tibet	Tsangpo (meaning 'The Purifier')
China	Yarlung Zangbo, Jianguin
Assam Valley	Dihang or Siang, South of Sadiya: Brahmaputra
Bangladesh	Jamuna River
	Padma River: Combined Waters of Ganga and Brahmaputra
	Meghana: From the confluence of Padma and Meghna

The Brahmaputra River System (3848 km) is one of the longest rivers of the world. It is known as the Yarlung Tsangpo River in Tibet; Brahmaputra, Lohit, Siang, and Dihang in India, and the Jamuna in Bangladesh.

- The Brahmaputra, one of the largest rivers of the world, has its origin in the Chemayungdung glacier of the Kailash range near the Mansarovar lake.
- From here, it traverses eastward longitudinally for a distance of nearly 1,200 km in a dry and flat region of southern Tibet, where it is known as the Tsangpo, which means 'the purifier.'



- It emerges as a turbulent and dynamic river after carving out a deep gorge in the Central Himalayas near Namcha Barwa (7,755 m), enters into India taking a 'great bend'.
- The Tsangpo river emerges from the foothills under the name of Siang or Dihang. It enters India west of Sadiya town in Arunachal Pradesh.



- Flowing southwest, it receives its main leftbank tributaries, viz., Dibang or Sikang and Lohit; thereafter, it is known as the Brahmaputra.
- The Brahmaputra receives numerous tributaries in its 750 km long journey through the Assam valley.
- Its major left bank tributaries are the Burhi Dihing and Dhansari whereas the important right bank tributaries are the Subansiri, Kameng, Manas and Sankosh.
- The Subansiri which has its origin in Tibet is an antecedent river.
- The Brahmaputra enters into Bangladesh near Dhubri and flows southward.
- In Bangladesh, the Tista joins it on its right bank from where the river is known as the Jamuna.
- It finally merges with the river Padma, which falls in the Bay of Bengal.
- The Brahmaputra is well-known for floods, channel shifting and bank erosion.
- This is due to the fact that most of its tributaries are large, and bring a large number of sediments owing to heavy rainfall in its catchment area.

## Tributaries of Brahmaputra

The important tributaries of River Brahmaputra are:

- **Left bank tributaries:** Dhansiri, Kapili, Barak
- **Right bank tributaries:** Subansiri, Jia Bhoraali, Manas, Sankosh, Tista & Raidak
- **Dhansiri:** Rises from Naga Hills.
- **Sankosh:** It's the main river of Bhutan, meets Brahmaputra at Dhubri, Assam.
- **Manas:** Rises from Tibet and joins Brahmaputra on its right bank.
- **Subansiri:** It flows in between the Mikir hills & Abor hills and later joins Brahmaputra on its right bank.
- **Teesta:** Rises from Kanchan-junga, fed by the tributaries like Rangit & Rangpo, it joins the Brahmaputra river in Bangladesh.
- **Barak:** Rises in Maniour. It enters Bangladesh as River Surma which falls into River Padma at Chandpur.

## Peninsular Drainage System

- The Peninsular drainage system is older than the Himalayan one.
- This is evident from the broad, largely-graded shallow valleys, and the maturity of the rivers.
- The Western Ghats running close to the western coast act as the water divide between the major Peninsular Rivers, discharging their water in the Bay of Bengal and as small rivulets joining the Arabian Sea.
- Most of the major Peninsular rivers except Narmada and Tapi flow from west to east.
- The Chambal, the Sind, the Betwa, the Ken, the Son, originating in the northern part of the Peninsula belong to the Ganga river system.

## The Evolution of Peninsular Drainage System

Three major geological events in the distant past have shaped the present drainage systems of Peninsular India:

- I. Subsidence of the western flank of the Peninsula leading to its submergence below the sea during the early tertiary period. Generally, it has disturbed the symmetrical plan of the river on either side of the original watershed.
- II. The upheaval of the Himalayas when the northern flank of the peninsular block was subjected to subsidence and the consequent trough faulting. The Narmada and The Tapi flow in through faults and fill the original cracks with their detritus materials. Hence, there is a lack of alluvial and deltaic deposits in these rivers.



III. Slight tilting of the Peninsular block from northwest to the southeastern direction gave orientation to the entire drainage system towards the Bay of Bengal during the same period.

## Rivers of the peninsular India

The peninsular river system are categorised into the following sections:

### East flowing rivers

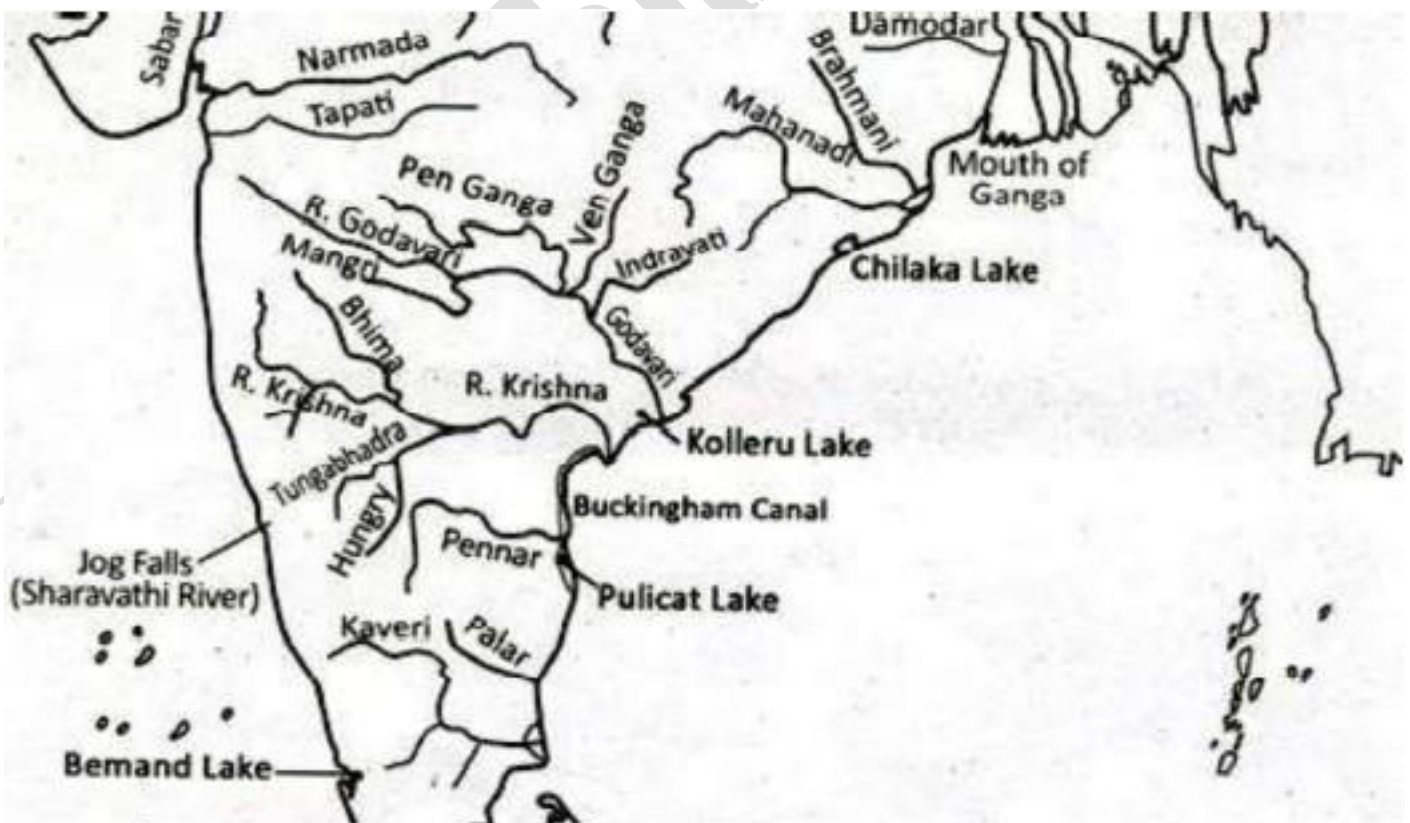
- Mahanadi, Subarnarekha, Godavari, Krishna, Cauvery are major Rivers of Peninsular India.
- While Godavari, Krishna, Cauvery originate from the Western Ghats, While Subarnarekha emerges from Ranchi plateau.
- They drain into the Bay of Bengal. All except Subarnarekha form Delta.

### West flowing rivers

Narmada, Tapi, Sabarmati, Mahi Rivers are major west flowing rivers which empty into the Arabian Sea and form estuaries.

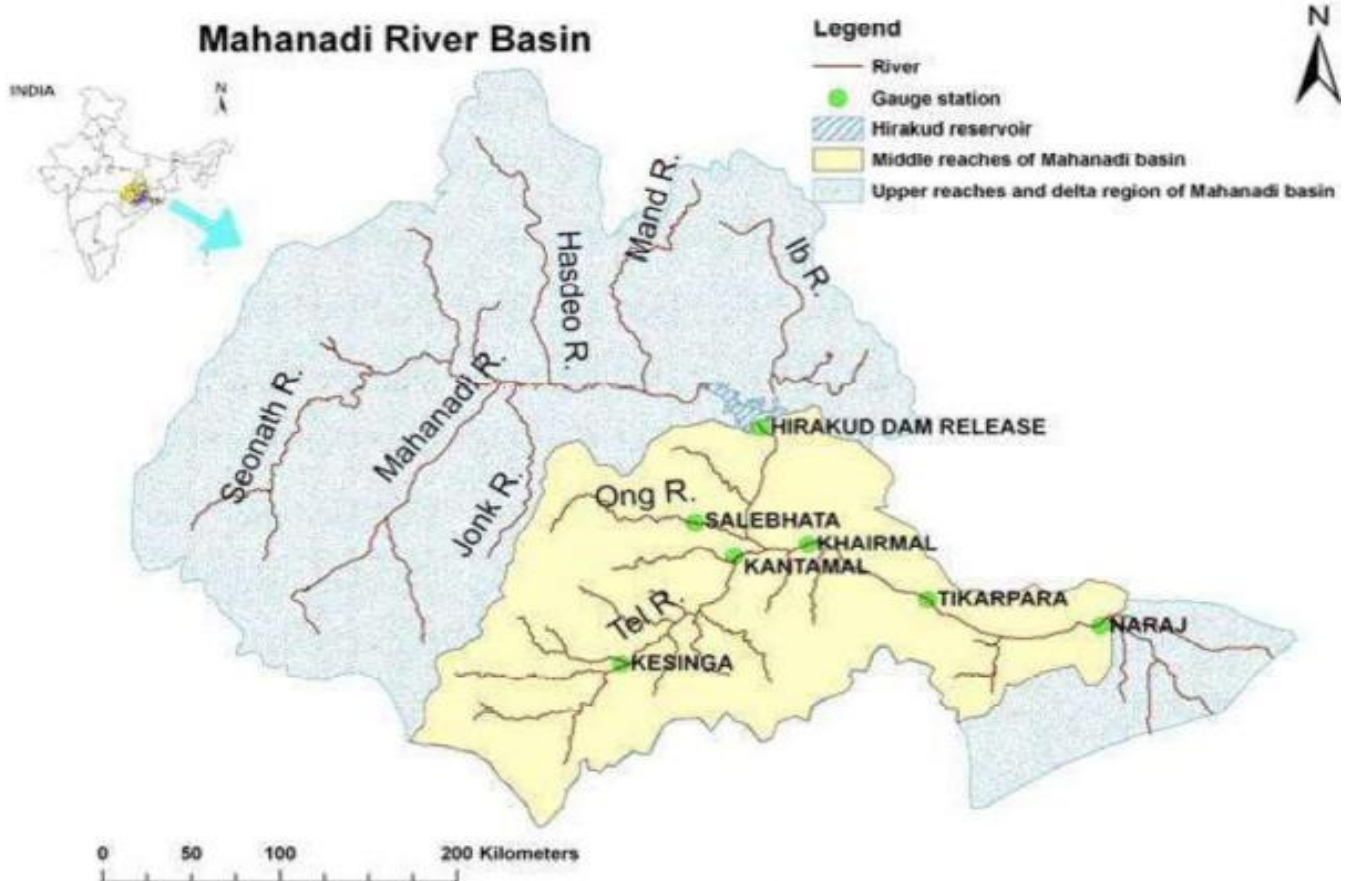
### West flowing rivers of Sahyadris:

- Although these west flowing rivers of Sahyadri form only about 3% of the areal extent of basins of India, they contain about 18% of the country's water resources.
- About six hundred small streams originate from the Western Ghats and flow westwards to fall into the Arabian Sea.
- The western slopes of the Western Ghats receive heavy rainfall from the south-west monsoons and are able to feed such a large number of streams
- The Jog or Gersoppa Falls (289 m) made by the Sharavathi river is the most famous waterfall of India



## Peninsular River System

### Mahanadi River



- The Mahanadi basin extends over states of Chhattisgarh and Odisha and comparatively smaller portions of Jharkhand, Maharashtra and Madhya Pradesh, draining an area of 1.4 lakh Sq.km
- Its upper course lies in the saucer-shaped basin called the Chhattisgarh Plain
- It is bounded by the Central India hills on the north, by the Eastern Ghats on the south and east and by the Maikal range on the west
- The Mahanadi (Great River) has its source in the northern foothills of Dandakaranya in Raipur District of Chhattisgarh at an elevation of 442 m
- The Mahanadi is one of the major rivers of the peninsular rivers, in water potential and floodproducing capacity, it ranks second to the Godavari
- Other small streams draining directly into the Chilka Lake also forms the part of the Mahanadi basin
- At Sambalpur, the Hirakud Dam (one of the largest dams in India) on the river has formed a humanmade lake 35 miles (55 km) long
- It enters the Odisha plains near Cuttack and enters the Bay of Bengal at False Point by several channels
- Puri, at one of its mouths, is a famous pilgrimage site.
- Brahmani River is NOT a tributary of Mahanadi. It's a seasonal river that flows in Odisha. Together with the rivers Mahanadi and Baitarani, it forms a large delta before entering into the Bay of Bengal at Dhamra



River	Source	Length	Major tributaries	The sea to which it merges
Mahanadi	Dandkaranya, Chhattisgarh	857 km	Left bank- Brahmini, Baitarni, Ib, Hasdo Right Bank- Jonk, Tel, Onk.	Bay of Bengal
Godavari	Western Ghats (Nasik district of Maharashtra)	1465 km	Left Bank- Sewand, Dudna, Purna, Pranhita, Sileru, Penganga, Venganga, Vardha, Indravati. Right Bank- Manjra	Bay of Bengal
Krishna	Western Ghats (a spring to the north of Mahabaleshwar in Maharashtra)	1400 km	Bhima, Tungabhadra, Musi, Don, Palleru, Muneru, Koyana.	Bay of Bengal
Cauveri	Western Ghats (Brahmagiri hills in Coorg district of Karnataka)	800 km	Kabani, Amaravati	Bay of Bengal
Narmada	Maikala ranges (Chhattisgarh)	1312 km	Hiran, Bajan	Arabian Sea
Tapti	Multai plateau (Betul district of Madhya Pradesh)	724 km	Anar, Girna	Arabian Sea

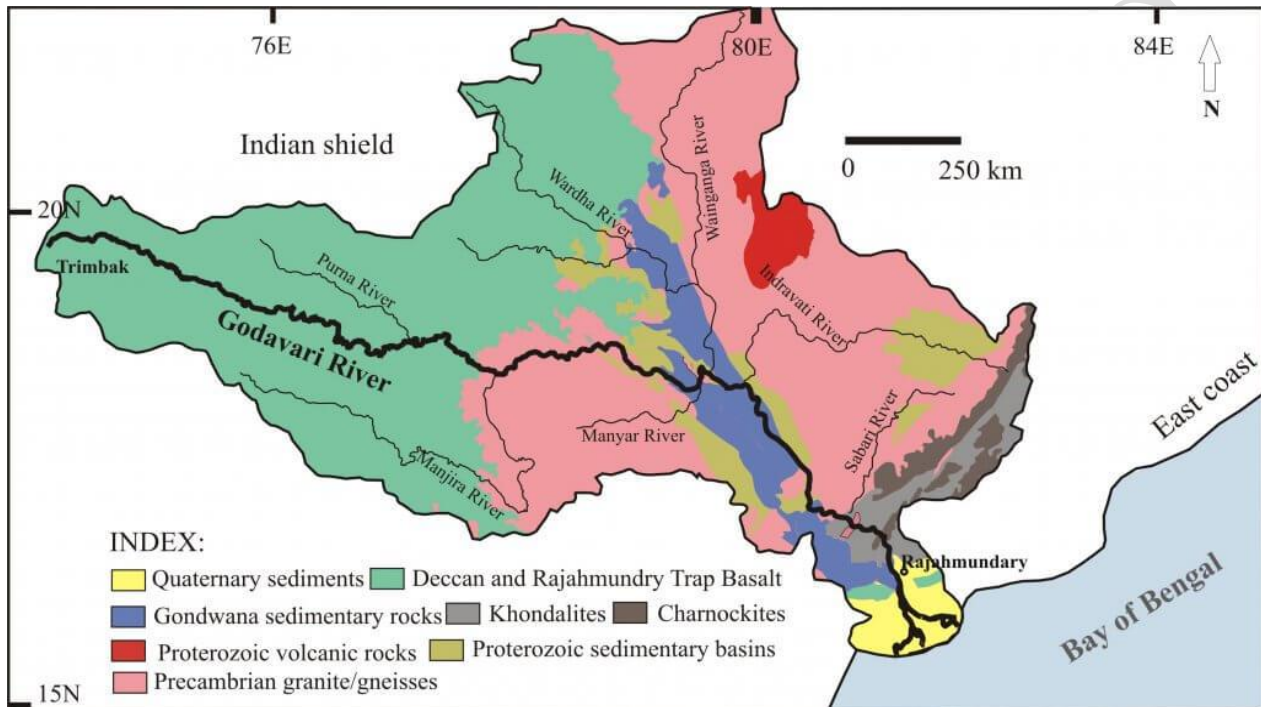
- Turtle rookery The mouth of this river delta serves as a nesting ground for olive ridley sea turtles
- The major tributaries of Mahanadi are Seonath, Jonk, Hasdo, Mand, Ib, Ong, Tel etc.
- **Seonath River:** The Seonath River is the longest tributary of Mahanadi. It rises in an undulating region with numerous small groups of hills at Kotgal and flows 383 kilometers to join Mahanadi at its left bank at Khargand.
- **Jonk River:** Jonk River originates from the Khariar Hills of Kalahandi district of Odisha at an elevation of 762 meters. It flows 196 kilometers to join the Mahanadi on its right at Sheorinarayan.
- **Hasdo River:** It rises in the Sarguja district of Chhattisgarh and traverses 333 kilometers to meet Mahanadi at Mahuadih.
- **Mand River:** Mand River originates at an elevation of 686 meters in Sarguja district of Odisha and flows 241 kilometers to meet Mahanadi at Chandarpur.
- **Ib River :** Ib originates in Pandrapat of the Raigarh district of Chhattisgarh and flows 251 kilometers to fall into Hirakud Dam. It is a rainfed river.
- **Ong River:** It rises at an elevation of 457 meters on a hill in the northern outskirts of hills located on the course of Jonk River and flows 204 kilometers to meet Mahandi at Sonepur.
- **Tel River:** Tel river originates in plain in the Koraput of Odisha. It traverses 296 kilometers to meet Mahanadi at Sonepur.

## Godavari River

- The Godavari is the largest peninsular river system. It is also called the **Dakshin Ganga**.
- It rises in the Nasik district of Maharashtra and discharges its water into the Bay of Bengal.
- Godavari tributaries run through the states of Maharashtra, Madhya Pradesh, Chhattisgarh, Odisha and Andhra Pradesh.
- It is 1,465 km long with a catchment area spreading over 3.13 lakh sq km 49 per cent of this, lies in Maharashtra, 20 per cent in Madhya Pradesh and Chhattisgarh, and the rest in Andhra Pradesh.

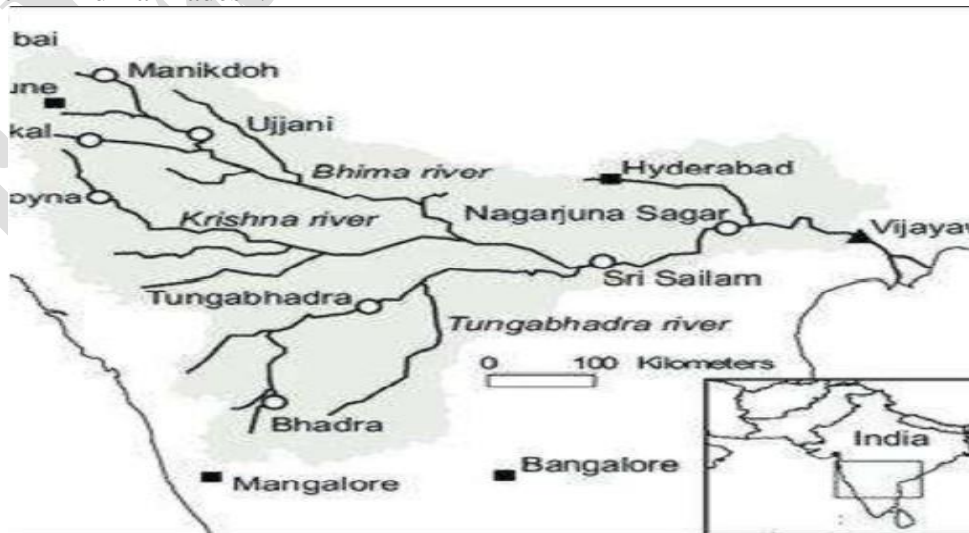


- The Penganga, the Indravati, the Pranhita, and the Manjra are its principal tributaries.
- The Godavari is subjected to heavy floods in its lower reaches to the south of Polavaram, where it forms a picturesque gorge.
- It is navigable only in the deltaic stretch. The river after Rajamundry splits into several branches forming a large delta



## Krishna River

- The Krishna is the second-largest east-flowing Peninsular River which rises near Mahabaleshwar in Sahyadri. Its total length is 1,401 km.
- The Koyna, the Tungabhadra and the Bhima are its major tributaries.
- Of the total catchment area of the Krishna, 27 per cent lies in Maharashtra, 44 per cent in Karnataka and 29 per cent in Andhra Pradesh.



## Krishna River Basin

### Kaveri River

- The Kaveri rises in Brahmagiri hills of Kodagu district in Karnataka.
- Its length is 800 km and it drains an area of 81,155 sq. km.
- Since the upper catchment area receives rainfall during the southwest monsoon season (summer) and the lower part during the northeast monsoon season (winter), the river carries water throughout the year with comparatively less fluctuation than the other peninsular rivers.



- About 3 percent of the Kaveri basin falls in Kerala, 41 per cent in Karnataka and 56 per cent in Tamil Nadu.
- Its important tributaries are the Kabini, the Bhavani and the Amravati

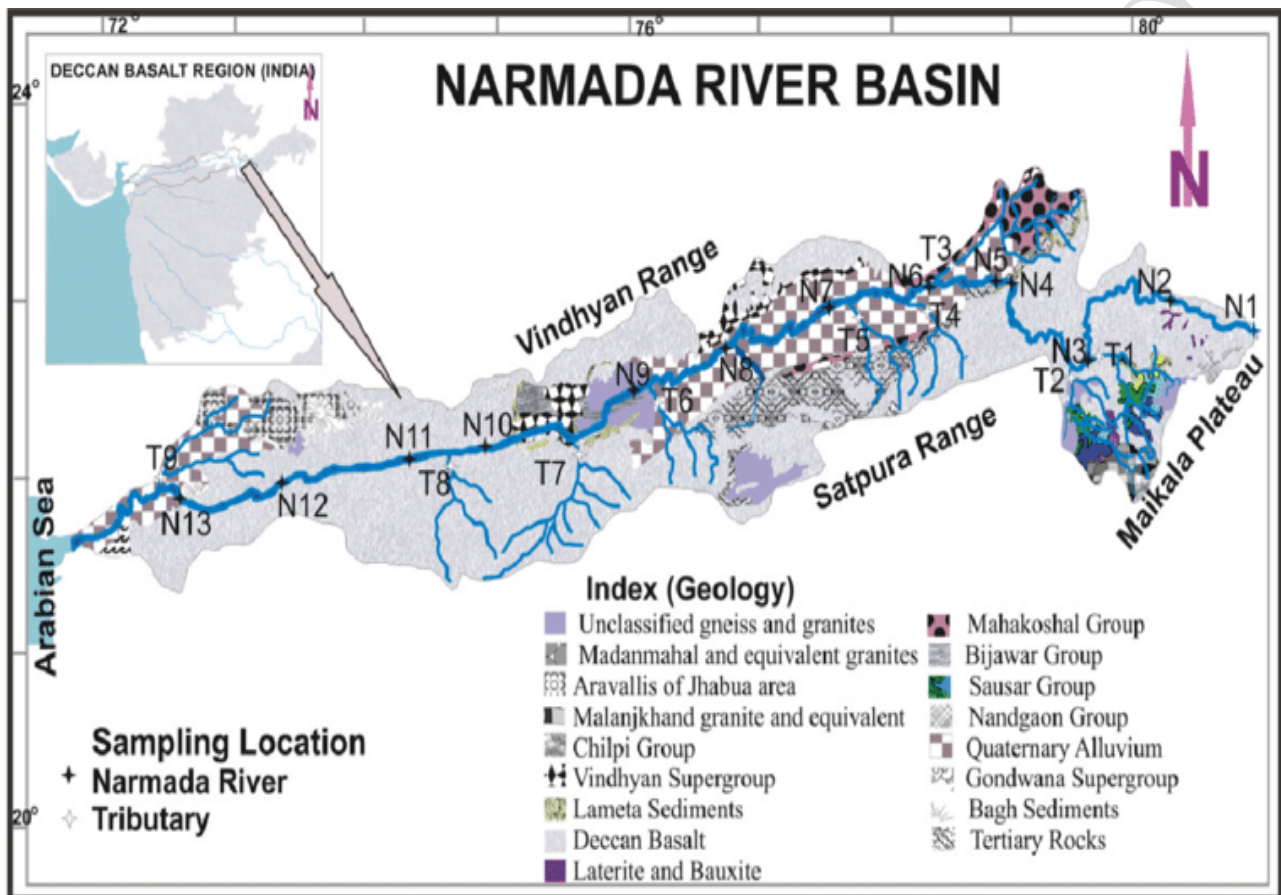
### Smaller east flowing rivers

- Subarnarekha
  - Baitarani
  - Brahmani
  - Vamsadhara
  - Pennar
  - Palar
  - Vaigai



## Narmada River

- The Narmada originates on the western flank of the Amarkantak plateau at a height of about 1,057 m.
- While flowing in a rift valley between the Satpura in the south and the Vindhya range in the north, it forms a picturesque gorge in marble rocks and Dhuandhar waterfall near Jabalpur.

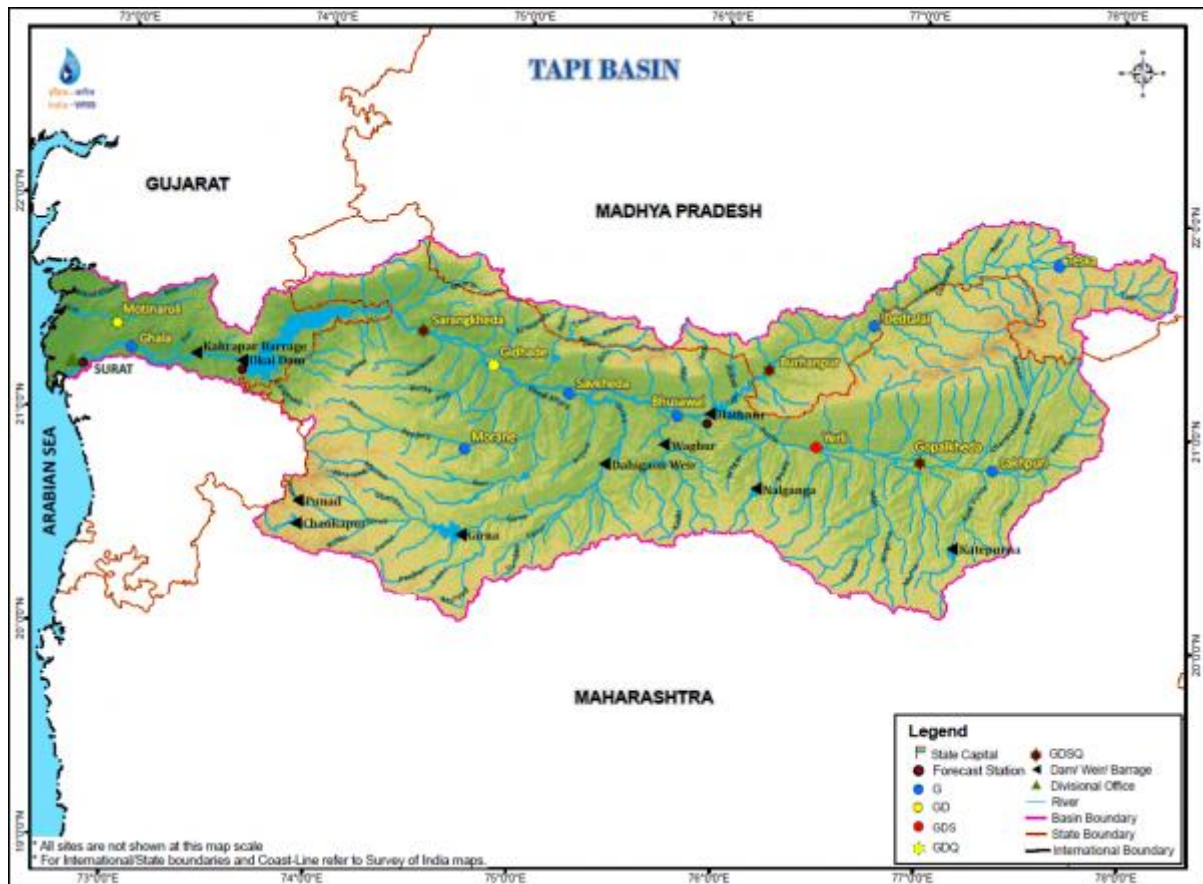


- After flowing a distance of about 1,312 km, it meets the Arabian Sea south of Bharuch, forming a broad 27 km long estuary. Its catchment area is about 98,796 sq. km.
- The Sardar Sarovar Project along with other dams has been constructed on this river under Narmada Multipurpose project

## Tapi River

- The Tapi is an important westward flowing river. It originates from Multai in the Betul district of Madhya Pradesh.
- Just like the Narmada, it flows in a rift valley south of Satpura range. It is 724 km long and drains an area of 65,145 sq. km.
- Nearly 79 per cent of its basin is in Maharashtra, 15 per cent in Madhya Pradesh and the remaining 6 per cent in Gujarat.
- Sabarmati and Mahi are the two famous rivers of Gujarat. They emerge from the Aravali range and flow into the Gulf of Khambhat into the Arabian Sea.





## Key Differences between Himalayan & Peninsular River System

Characteristics	Himalayan River	Peninsular River
Place of origin	Himalayan mountains (covered with glaciers).	Peninsular plateau and central highland.
Nature of flow	Perennial; receive water from glacier and rainfall.	Seasonal; dependent on monsoon rainfall.
Type of drainage	Antecedent and consequent leading to dendritic pattern in plains.	Super imposed, rejuvenated resulting in trellis, radial, and rectangular patterns.
Nature of river	Long course, flowing through the rugged mountains experiencing head ward erosion and river capturing; In plains, meandering and shifting off course.	Smaller, fixed course with welladjusted valleys.
Catchment area	Very large basin.	Relatively smaller basin.
Age of the river	Young and youthful, active and deepening in the valleys	Old rivers with graded profile, and have almost reached their base levels.

## Lakes

- A large water body which is surrounded by land is called a lake.
- Most of the lakes are permanent, while some contain water only during the rainy season.
- Lakes are formed by the action of glaciers and ice sheets, by wind, river action and by human activities

## Types of Lakes

**Ox-bow Lake:** A lake formed when a meandering river is cut off from the mainstream. The shape of this lake resembles an ox-bow



**Lagoon:** When the lake is formed by spits and bars in coastal areas, it is called a lagoon. Chilika lake, Pulicat lake, Kolleru lake, etc. are examples of lagoon.





**Glacial Lake:** A lake formed by melting of glacier is called a glacial lake. Most of the lakes in the Himalayan region are glacial lakes. Wular lake (Jammu & Kashmir) is the largest freshwater lake in India. It was formed by tectonic activity.



**Man Made Lakes:** These lakes are created by human activities. Gobind Sagar is a man-made reservoir situated in Bilaspur District, Himachal Pradesh.





## Benefits of a Lake

1. A lake helps in preventing flood by regulating the flow of river.
2. During dry seasons, a lake helps to maintain an even flow of the river.
3. Lakes can also be used for generating hydel power.
4. Tourism development.
5. Maintain aquatic ecosystem.

## River Pollution

- The growing domestic, municipal, industrial and agricultural demand for water from rivers naturally affects the quality of water.
- As a result, more and more water is being drained out of the rivers reducing their volume.
- On the other hand, a heavy load of untreated sewage and industrial effluents are emptied into the rivers.
- This affects not only the quality of water but also the self-cleansing capacity of the river.

## National River Conservation Plan (NRCP)

- The National River Conservation Directorate (NRCD) in the Ministry of Environment, Forests and Climate Change is implementing the Centrally Sponsored Schemes of National River Conservation Plan (NRCP) for conservation of rivers, lakes and wetlands in the country.
- The objective of the River Action Plans is to improve water quality of rivers through implementation of pollution abatement schemes in identified polluted stretches of rivers.
- NPCA aims at conserving aquatic ecosystems (lakes and wetlands) through implementation of sustainable conservation plans, and governed with application of uniform policy and guidelines.

## Namami Gange Programme

- **Namami Gange Programme** is an **Integrated Conservation Mission**, approved as a 'Flagship Programme' by the Union Government in **June 2014** to accomplish the twin objectives of effective abatement of pollution and conservation and rejuvenation of National River Ganga.
- It is being operated under the Department of Water Resources, River Development and Ganga Rejuvenation, **Ministry of Jal Shakti**.
- The program is being implemented by the **National Mission for Clean Ganga (NMCG)**, and its state counterpart organizations i.e., State Program Management Groups (SPMGs).
- NMCG is the implementation wing of **National Ganga Council** (set in 2016; which replaced the National Ganga River Basin Authority (NRGBA)).
- It has a **Rs. 20,000-crore, centrally-funded**, nonlapsable corpus and consists of nearly 288 projects.
- **The main pillars of the programme are:**
  - Sewerage Treatment Infrastructure & Industrial Effluent Monitoring,
  - River-Front Development & River-Surface Cleaning,
  - Bio-Diversity & Afforestation,
  - Public Awareness

## Other Initiatives Taken

- **Ganga Action Plan:** It was the first River Action Plan that was taken up by the Ministry of Environment, Forest and Climate Change in 1985, to improve the water quality by the interception, diversion, and treatment of domestic sewage.



# Dr Lakshmaiah IAS Study Circle

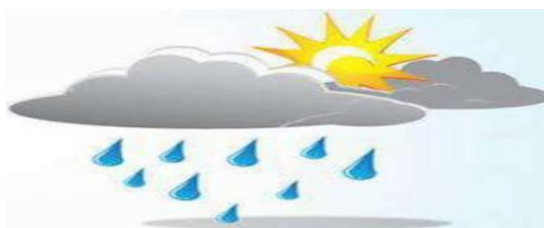


20B, Opp: HDFC Bank, Main Road, Old Rajinder Nagar

New Delhi-110060 Ph No: +91 9773731858

- **The National River Conservation Plan** is an extension to the Ganga Action Plan. It aims at cleaning the Ganga river under Ganga Action Plan phase-2.
- **National River Ganga Basin Authority (NRGBA):** It was formed by the Government of India in the year 2009 under Section-3 of the Environment Protection Act, 1986.
  - It declared the Ganga as the 'National River' of India.
- **Clean Ganga Fund:** In 2014, it was formed for cleaning up of the Ganga, setting up of waste treatment plants, and conservation of biotic diversity of the river.
- **Bhuvan-Ganga Web App:** It ensures involvement of the public in monitoring of pollution entering into the river Ganga.
- **Ban on Waste Disposal:** In 2017, the **National Green Tribunal** banned the disposal of any waste in the Ganga

## CH-5 INDIAN WEATHER- SEASON



- Climate is an **important element of the physical environment** of mankind. It is the **aggregate of atmospheric conditions** involving heat, moisture and air movement.
- In a developing country like **India climatic characteristics have a dominant role in affecting the economic pattern**, way of life, mode of living, food preferences, costumes and even the behavioural responses of the people.
- In India despite a lot of scientific and technological developments our **dependence on monsoon rainfall for carrying out successful agricultural activities**, has not been minimized.
- The climate of India belongs to the **‘tropical monsoon type’** indicating the impact of its location in tropical belt and the monsoon winds.
- Although a sizeable part of the country lying north of the Tropic of Cancer falls in the northern temperate zone but the **shutting effects of the Himalayas** and the **existence of the Indian Ocean in the south** have played significant role in giving India a distinctive climatic characteristics. **Note** - NCERT mentions 50 years but according to WMO it is 30 years.

Weather is the **momentary state of the atmosphere** while climate refers to the average of the weather conditions over a longer period of time. **Weather changes quickly**, may be within a day or week but climate changes imperceptible and may be **noted after 50 years or even more**.

Climate	Weather
Climate is the weather of a place averaged over a period of time, <b>often 30 years</b> .	It is the mix of events that happen <b>each day</b> in our atmosphere (One atmosphere on the Earth but different weathers at different locations).
Describes what the weather is like over a long period of time in a specific area.	Refers to short-term changes in the atmosphere.
Climatology	Meteorology

### Salient Features of Indian Climate

- Reversal of winds** – The Indian climate is characterized by the **complete reversal of wind system** with the change of season in a year. During the winter season winds generally blow **from north-east to south-west** in the direction of trade winds. These winds are dry, devoid of moisture and are characterized by low temperature and high pressure conditions over the country. During summer season complete reversal in the direction of the winds is observed and these blow primarily **from south-west to north-east**.
- Formation of Alternatively High and Low pressure areas over the land** – There is a change in the atmosphere pressure conditions with the change of season. During winter season due to low temperature conditions high pressure areas is formed over the northern part of the country. On the other hand the



intense heating of the land during summer season leads to the formation of a thermally induced low pressure cell over the north-western part of the country. These pressure areas control the direction and intensity of wind.

- **Seasonal and variable rainfall** – In India **over 80 per cent** of annual rainfall is obtained in the latter part of the summer whose duration ranges **from 1-5 months** in different parts of the country. Since the rainfall is in the form of heavy downpour, it creates problems of floods and soil erosion. Sometimes there is continuous rain for many days a sometimes there is a long spell of dry period. Similarly, there is a spatial variation in the general distribution of rainfall. **Cherrapunji** has received in a single day an amount equal to 10 years of rainfall at Jaisalmer, Rajasthan.

Indian climate is so **varied and complex** that it denotes **climatic extremes and climatic varieties**. While it provides enough heat to grow crops and carry on agricultural activities all over the country it also helps in the cultivation of a number of crops belonging to tropical, temperate as well as frigid areas.

- **Plurality of seasons** – the Indian climate is characterized by **constantly changing weather conditions**. There are three main seasons but on broader consideration their number goes to six a year (winter, fall of winter, spring, summer, rainy and autumn).
- **Unity of Indian Climate** – the Himalayas and the associated mountain ranges extend to the north of India from east to west. These tall mountain ranges prevent the cold northerly winds of Central Asia from entering into India. Therefore, even the parts of India extending north of the Tropic of Cancer experience a tropical climate. These ranges force the monsoon winds to cause rainfall over India and the entire country comes under the influence of the monsoon winds. In this manner the climate in the entire country becomes monsoon type.
- **Diversity of Indian Climate** – In spite of the unity of Indian climate, it is characterized by regional differences and variations. For example, while in the summer the mercury **occasionally touches 55°C** in the western Rajasthan, it **drops down to as low as minus 45°C** in winter around Leh. These differences are visible in terms of winds, temperature, rainfall, humidity and aridity etc. These are caused by differences in the location, altitude, distance from the sea, distance from mountains and general relief conditions at different places.
- **Characterized by natural calamities** – Due to its peculiar weather conditions especially rainfall the Indian climate is characterized by natural calamities like floods, droughts, famines and even epidemics.

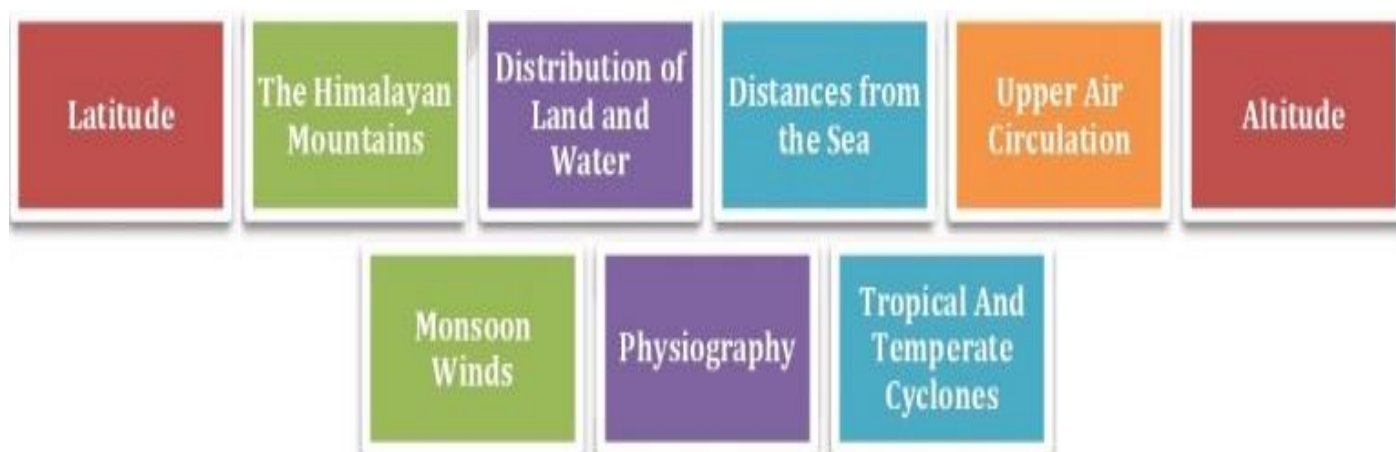
## Factors Influencing the Indian Climate:

India's climate is controlled by a number of factors which can be broadly divided into two groups –





## 1. Factors Related to Location and Relief:



- **Latitude** – The mainland of India extends **between 8°N to 37°N**. Areas south of the Tropic of Cancer are in tropics and hence receive high solar insolation. The summer temperatures are extreme and winters temperatures are moderate in most of the regions. Northern parts on other hand lie in warm temperate zone and receive comparatively less solar insolation. Summers are hot in north India & winters are very cold because of **continentality** and arrival of western disturbances. **Coastal regions see moderate climatic conditions** irrespective of latitudinal position.
- **The Himalayan Mountains** – the lofty Himalayas in the north along with its extensions act as an effective **climatic divide between central Asia and Indian subcontinent**. The cold and chilly winds that originate near the Arctic Circle are obstructed by the Himalayas and **give a distinctive taste to climate of India**.
- **Distribution of Land and Water** – India is **flanked by the Indian Ocean on three sides** in the south and **girdled by a high and continuous mountain-wall** in the north. As compared to the landmass, water heats up or cools down slowly. This differential heating of land and sea creates different air pressure zones in different seasons in and around the Indian subcontinent.
- **Oceans Currents** - Marine areas are influenced by the warm or cold ocean currents. Ocean currents like the **Gulf Stream or the North Atlantic Drift** warm the coastal districts of Western Europe keeping their ports ice-free. Ports located in the same latitude but washed by cold currents, such as the **cold Labrador Current off north-east Canada**, are frozen for several months. Cold currents also lower the summer temperature, particularly when they are carried landwards by on-shore winds.
- **Local winds** - If winds are warm i.e. they have been blown from a hot area, they will raise temperatures. If winds have been blown from cold areas, they will lower temperatures. Local winds like **Fohn, Chinook, Sirocco and Mistral** also produce marked changes in temperature.
- **Distances from the Sea (Continentality)** – With a long coastline, large coastal areas have an equable climate. Areas in the interior of India are far away from the moderating influence of the sea. Such areas have extremes of climate. That is why, the people of the Konkan coast have hardly any idea of extremes of temperature and the seasonal rhythm of weather. On the other hand, the seasonal contrasts in weather at places in the interior of the country such as Kanpur and Amritsar affect the entire sphere of life.
- **Altitude** – Temperature decreases with height. Due to thin air, places in the mountains are cooler than places on the plains. For example, Agra and Darjeeling are located on the same latitude, but temperature of January in Agra is 16°C whereas it is only 4°C in Darjeeling.
- **Physiography** - The Arabian Sea branch of SW monsoon strikes almost perpendicular at Western Ghats and causes heavy rainfall on western slopes. On contrary, vast areas of Maharashtra, Karnataka,

Telangana, Andhra Pradesh and Tamil Nadu lie in rain-shadow or leeward side of the Western Ghats and receive scanty rainfall. Monsoons winds flowing in Rajasthan and Gujarat blow almost parallel to Aravalis & are not obstructed by any orographic barrier and hence these regions receive no rainfall. Very heavy rainfall in plateau of Meghalaya is due to funnelling effect followed by orographic upliftment. This makes the places of **Mawsynram** and **Cherrapunji** amongst the wettest places on earth with mean annual rainfall over 1100 cm.

**Funnelling Effect:** When clouds are channelled into a narrow region between mountains and hence the cloud density increases.

- **Monsoon Winds** - The complete reversal of the monsoon winds brings about a sudden change in the seasons. Most of the rainfall over the Indian subcontinent is due to these winds.
- **Upper Air Circulation** - Southern branch of Subtropical Jetstream is responsible for bringing western disturbances from the Mediterranean region into the Indian sub-continent. The formation of Tropical Easterly Jetstream helps in the sudden onset of south west monsoons.
- **Tropical And Temperate Cyclones** - Majority of tropical cyclones are originated in the Bay of Bengal and influence the coastal weather. Remnants of temperate cyclones arrive as western disturbances and influence the weather in north India.

## 2. Factors Related to Air Pressure and Wind:

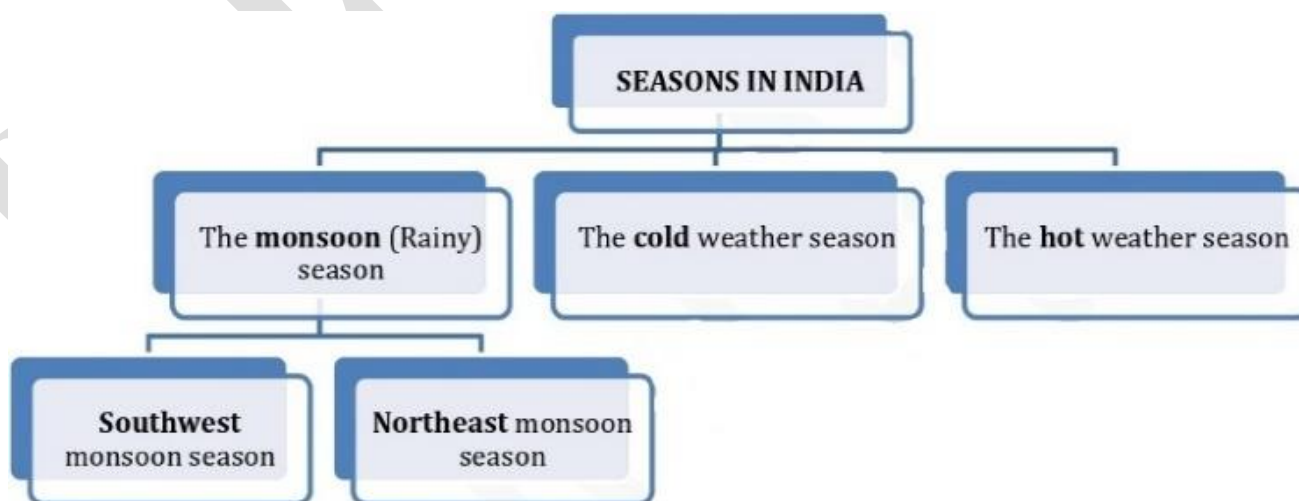
Air pressure and wind system is different at different altitude which affects the local climates of India. Consider the following factors:

- Distribution of pressure and surface winds.
- Upper air circulation and the movement of different air masses and the jet stream.
- Rainfall caused by the westerly disturbances in winter and the tropical depressions in south-west monsoon season.

**Q.** What characteristics can be assigned to monsoon climate that succeeds in feeding more than 50 percent of the world population residing in Monsoon Asia? **GS 1, Mains 2017**

## SEASONS IN INDIA

- The meteorologists recognise the following four seasons:





## INDIAN MONSOONS

- The term monsoon has been derived from the Arabic word '**mausim**' meaning '**season**'.
- Monsoons are **seasonal winds (secondary winds)** which **reverse their direction** with the change of season.
- Monsoons are **peculiar to Indian Subcontinent, South East Asia, parts of Central Western Africa** etc. They are more pronounced in the Indian Subcontinent compared to any other region.
- India receives **south-west monsoon** winds (from south west to north east) during June – September and **north-east monsoon** winds (from north east to south west) during October to December.
- South-west monsoons are formed due to **intense low pressure system** formed over the Tibetan plateau.
- **North-east monsoons are associated with high pressure cells** over Tibetan and Siberian plateaus.
- South-west monsoons **bring intense rainfall to most of the regions in India** and **north-east monsoons bring rainfall to mainly south- eastern coast of India** (Southern Andhra Pradesh coast and Tamil Nadu coast).

Monsoons are especially **prominent within the tropics on the eastern sides of the great landmass**, but in Asia, it occurs outside the tropics in China, Korea and Japan.

## Important features of Indian Monsoons:

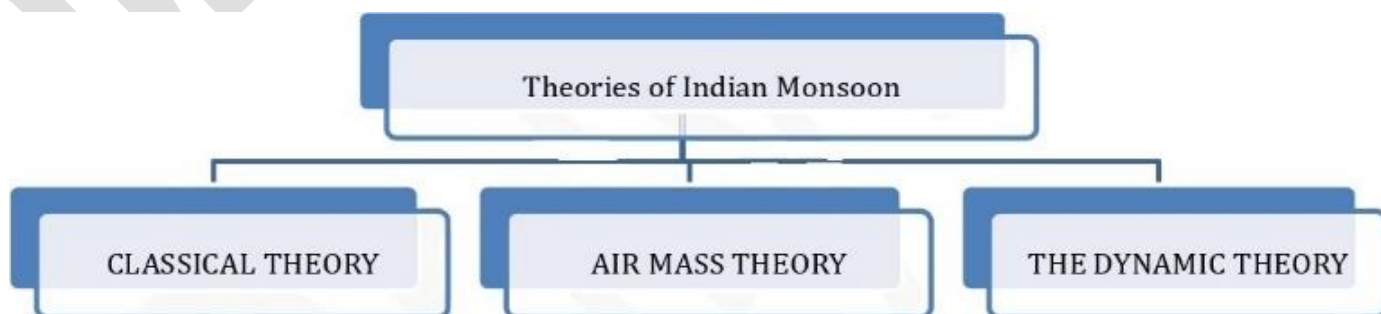
### Factors Influencing Monsoons:

- Intense heating of Tibetan plateau during summer months and formation of high pressure cells over Tibetan plateau and Siberian Plateau in winter.
- Shifting of Inter Tropical Convergence Zone (ITCZ) with the apparent movement of sun.
- Permanent high pressure cell in the South Indian Ocean (east to north-east of Madagascar in summer).
- Jet streams, particularly Subtropical Jetstream, Somali Jetstream and Tropical Easterly Jetstream.
- Indian Ocean Dipole.
- El Nino and La Nino.

Monsoon is a **complex meteorological phenomenon**. Experts of meteorology have developed a number of concepts about the origin of the monsoon. Some of the important concepts about the origin of monsoon have been given as under.

## MECHANISM OF INDIAN MONSOON

- The mechanism behind the onset of Indian Monsoon is a complex process which is not yet completely understood.
- Different theories have been put forward to explain this complex phenomenon.



## 1. CLASSICAL THEORY

- The **first scientific study of the monsoon winds was done by Arab traders.**
- In 10th century, **Al Masudi**, an Arab explorer, gave an account of the reversal of ocean currents and the monsoon winds over the north Indian Ocean.
- In 17th century, **Sir Edmund Halley** explained the monsoon as resulting from thermal contrasts between continents and oceans due to their differential heating.

<b>SUMMER MONSOON:</b>	<ul style="list-style-type: none"> <li>• In summer the sun's apparent path is vertically over Tropic of Cancer resulting in high temperature and low pressure in Central Asia.</li> <li>• The pressure is sufficiently high over Arabian Sea and Bay of Bengal. Hence winds flow from ocean towards landmass in summer.</li> <li>• This moisture laden air brings heavy rainfall to the Indian subcontinent.</li> </ul>
<b>WINTER MONSOON:</b>	<ul style="list-style-type: none"> <li>• In winter the sun's apparent path is vertically over the Tropic of Capricorn.</li> <li>• North western part of India grows colder than Arabian Sea and Bay of Bengal and the flow of the monsoon is reversed.</li> </ul>
<b>DRAWBACKS OF THE THEORY</b>	<ul style="list-style-type: none"> <li>• Monsoons do not develop equally everywhere on earth and the thermal concept of Halley fails to explain the intricacies of the monsoons such as the sudden burst of monsoons, occasional delays in onset of monsoons etc.</li> </ul>

## 2. AIR MASS THEORY

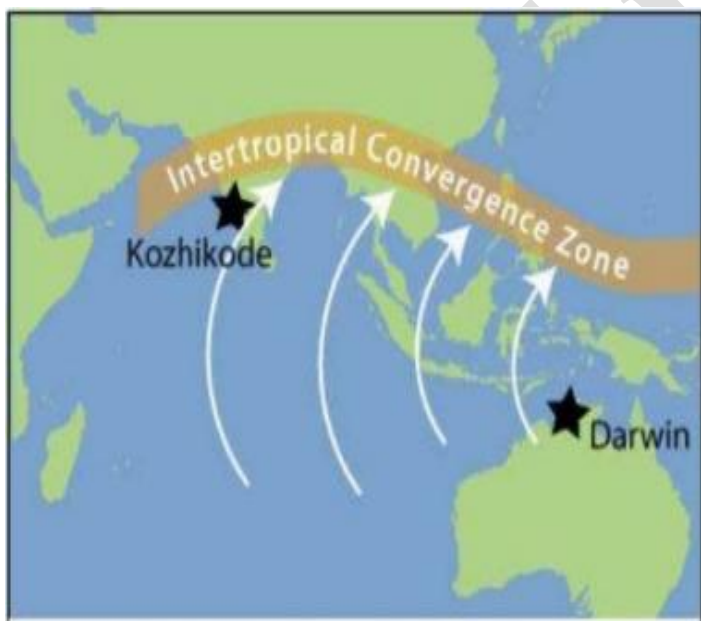


Figure – South West Monsoon Winds

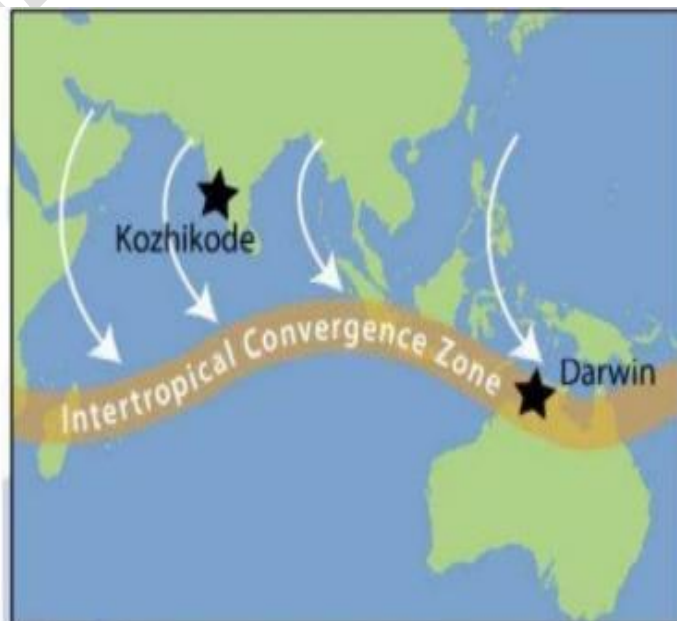


Figure - North-East Monsoon Winds

- This theory is **based on the migration of ITCZ** because of seasonal movement of sun across the tropics. According to this theory, monsoon is simply a modification of the trade winds.

- In summers, the ITCZ shifts to  $20^{\circ}$  -  $25^{\circ}$  N latitude and is located in Indo-Gangetic Plain. The ITCZ in this position is often called the “Monsoon Trough”.
- During April and May when the sun shines vertically over the Tropic of Cancer, the large landmass in the north of Indian ocean gets intensely heated. This causes the formation of an intense low pressure in the north western part of the subcontinent. These conditions help in the northward shift in the position of the ITCZ.
- Southeast trade winds of southern hemisphere cross the equator and start blowing towards northeast direction under the influence of Coriolis force.
- These displaced trade winds are called south- west monsoons when they blow over the Indian sub-continent.

In winter season, sun shines vertically over Tropic of Capricorn & the ITCZ shifts south of equator. The trade winds in northern hemisphere blow in their normal north- easterly direction, resulting in North-East Monsoons.

### Inter Tropical Convergence Zone (ITCZ)

The Inter Tropical Convergence Zone (ITCZ) is a **low pressure zone located at the equator where trade winds converge**, and so, it is a zone where **air tends to ascend**. In July, the ITCZ is located around  $20^{\circ}$ N- $25^{\circ}$ N latitudes (over the Gangetic plain), sometimes called the **monsoon trough**. This monsoon trough encourages the development of thermal low over north and northwest India. Due to the shift of ITCZ, the trade winds of the southern hemisphere cross the equator between  $40^{\circ}$  and  $60^{\circ}$ E longitudes and start blowing from southwest to northeast due to the Coriolis force. It becomes southwest monsoon. In winter, the ITCZ moves southward, and so the reversal of winds from northeast to south and southwest, takes place. They are called **northeast monsoons**.

### 3. THE DYNAMIC THEORY

- It is the **latest theory regarding the origin of monsoons & has earned worldwide acceptance**.
- This theory incorporates various factors into the mechanism of monsoons and explains their influence on the Indian monsoons.
- This theory is named so because **it treats monsoons as a dynamic system**, frequency, intensity and regularity of which is determined by a combination of factors like:
  - Differential heating of land and sea.
  - Shifting of ITCZ.
  - Heating of Tibet plateau.
  - Role of Jet streams (Subtropical Jet, Somali Jet and Tropical Easterly Jet).
  - Indian Ocean Dipole
  - El Niño and La Niña.

### Role Of Subtropical Jetstream

- Sub-Tropical Jetstream (STJ) plays a significant role in both hindering the monsoon winds as well as in quick onset of monsoons. (Polar Jet has no influence on Indian monsoons)

### Seasonal Migration Of Sub-Tropical Jet Stream (STJ)

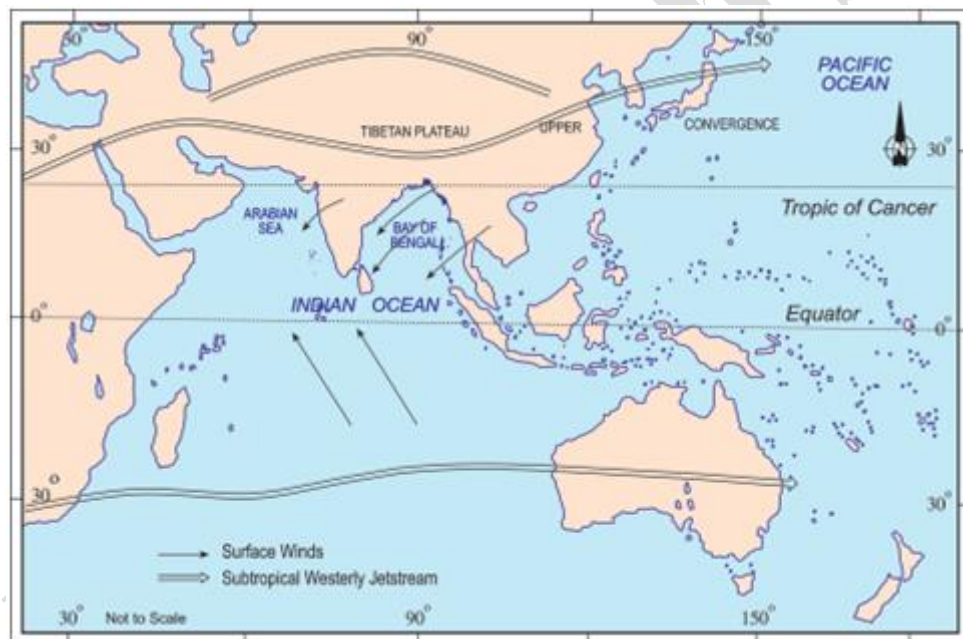
- The jet streams are stronger in winters with more areal extent and they shrink in the summers leading to meandering.



- In northern winters, STJ flows along south of Himalayas but in summers, it shrinks and shifts northwards & flows along the northern edge of Himalayas /Tibetan Plateau.
- The sudden periodic movement of STJ explains the sudden onset & withdrawal of monsoons.

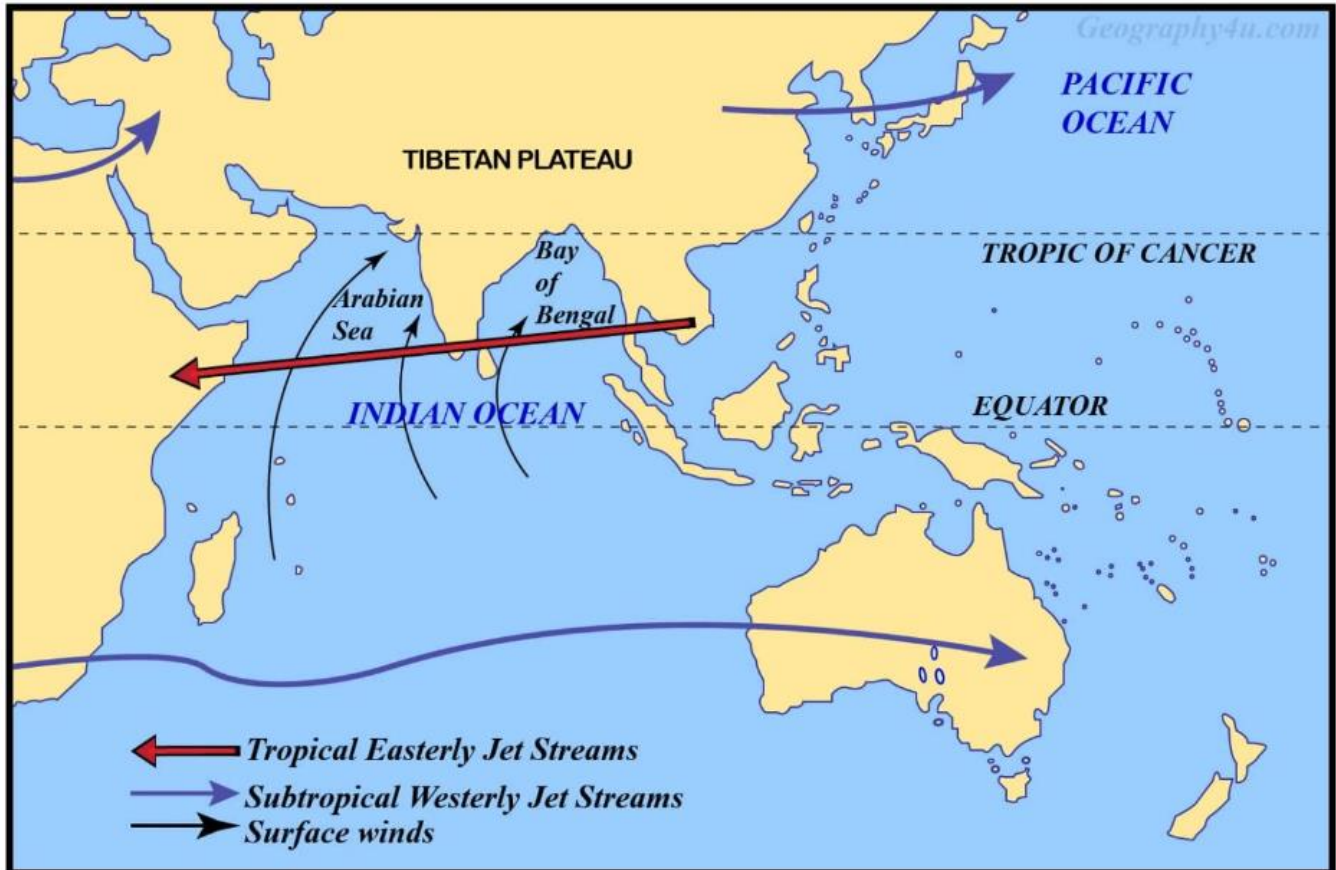
## JET STREAM IN WINTER

- Westerly STJ stream blows at a **very high- speed** during winter **over the sub-tropical zone**. However, this jet stream is bifurcated by the high-altitude Himalayan ranges and Tibetan Plateau into two:
  1. The **northern branch** of this jet stream blows along the northern edge of the Tibetan Plateau.
  2. The **southern branch** blows to the south of the Himalayan ranges along  $25^{\circ}$  N latitude.
- This Southern branch of jet stream **exercises a significant influence** on the winter weather conditions in India. It is responsible for steering of the **Western Disturbances** from the Mediterranean Sea into North-West India.
- This **southern branch creates a high-pressure region over north India** with diverging winds.
- This **reinforces the north east trade winds** blowing as north east monsoon winds.



## JET STREAM IN SUMMER

- With the beginning of summer, **the southern branch of STJ begins to weaken**. The ITCZ also pushes northwards, further weakening the southern branch of STJ.
- By the end of May, the southern jet breaks and is diverted to the north of Tibet and there is **sudden burst** of monsoons.
- By the middle of July, the Inter Tropical Convergence Zone (ITCZ) shifts northwards, roughly parallel to the Himalayas **between  $20^{\circ}$  N and  $25^{\circ}$  N**.
- By this time, the westerly jet stream withdraws from the Indian region.
- In fact, **meteorologists have found an interrelationship between the northward shift of the equatorial trough (ITCZ) and the withdrawal of the westerly jet stream** from over the North Indian Plain. It is generally believed that there is a cause and effect relationship between the two.



## Atmospheric Conditions over the Indian Subcontinent in the Month of June

- The **Tropical Easterly Jet (TEJ)** emerges over peninsular India with the northward migration of STJ. This is partly the result of thermally induced low-pressure over Tibetan Plateau in summer, resulting in anti-cyclonic divergence in upper atmosphere.
- The easterly winds in upper atmosphere are associated with westerly winds in lower atmosphere. These westerly winds blow as south-west monsoon winds over Indian subcontinent.

### Western Disturbances

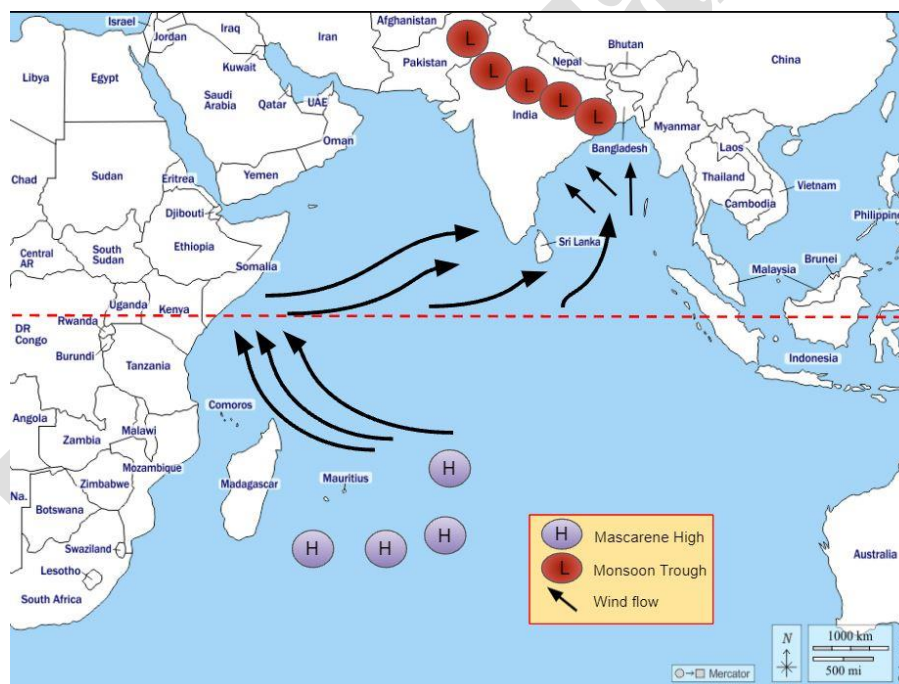
- These depressions are residual frontal cyclones. The southern branch of the jet stream is responsible for steering of these western depressions (Western Disturbances) from the Mediterranean Sea. These depressions pick up moisture from the Caspian Sea and the Black Sea while travelling east.
- On an average, 4 to 6 cyclonic waves reach north-western India between October and April each year.
- The arrival of these temperate storms causes precipitation leading to an abrupt decrease in air temperature over North- West India.





- Winter rain in north-western plains, occasional heavy snowfall in hilly regions and cold waves in the whole of northern plains are caused by these disturbances.
- The occasional winter rains are beneficial for standing rabi crops (wheat, barley, mustard etc).

## ROLE OF HIMALAYAS AND TIBETAN PLATEAU



- Due to its **protruded height** it receives **2-3°C more insolation** than the neighbouring areas.
- The plateau affects the atmosphere in two ways: as a mechanical barrier and as a high- level heat source.
- In winters, the plateau acts as a **mechanical barrier** and **bifurcates** the STJ into two parts.
- Winter Tibetan Plateau also **cools rapidly** and produces a **high pressure cell**, which strengthens N-E monsoons.
- In summers, Tibet gets heated & is **2°C to 3°C warmer than the adjoining regions**. Thus, it generates an area of rising air (low pressure) in lower atmosphere. During its ascent the air spreads outwards in upper troposphere (high pressure or divergence).



- This is responsible for **emergence of Tropical Easterly Jet (TEJ) in upper atmosphere over peninsular India**, which has its correspondence in Southwest monsoon winds at surface.
- The southwest monsoon winds are also a result of the gradual sinking (subsidence) of the air diverged over Tibetan Plateau over the equatorial part of the Indian Ocean (Mascarene High).
- It finally approaches the west coast of India as a return current from a south-westerly direction (South-West Monsoon).

## ROLE OF SOMALI JET

- Along with Tropical Easterly Jet, Somali Jet is another **temporary jet stream**.
- In summers, the Somali Jet is observed to flow from Mauritius, passing over Kenya, Somalia and Sahel, before reaching the coast of Kenya at about 3° S.
- It **strengthens high pressure near Madagascar** and also helps to drive S-W monsoons towards India at a greater pace and intensity.

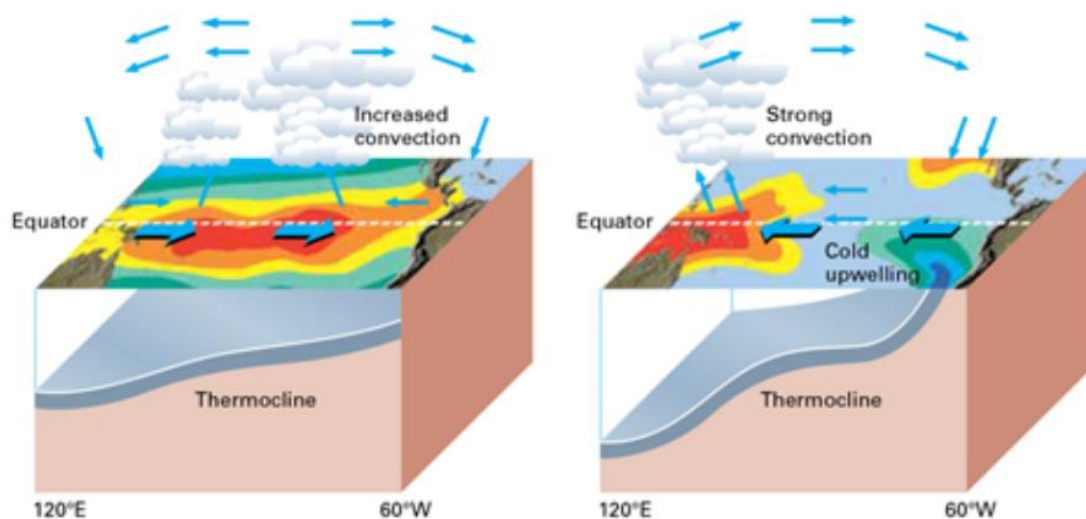
## ROLE OF INDIAN OCEAN DIPOLE (IOD)

- Indian Ocean Dipole is a **sea surface temperature anomaly** that occurs **occasionally in Northern or Equatorial Indian Ocean Region (IOR)**.
- A **positive IOD** is when western Indian Ocean near African Coast is much warmer than normal. This is good for Indian Monsoons as more evaporation occurs in warm waters & SW monsoonal winds blowing over the region before striking India are able to carry more moisture.
- In the **negative dipole year**, reverse happens making Indonesia much warmer and rainier. This inhibits the intensity of Indian Monsoons.

## ROLE OF EL-NIÑO AND La-NIÑA

### EL Nino vs La Nina

#### El Niño/La Niña Background



El Niño  
Typical circulation pattern El Nino and La Nina

- Occurrence of El Nino in the Pacific Ocean adversely effects the Indian monsoons.
- La Nina supports a stronger monsoon in Indian subcontinent.

## NATURE OF INDIAN MONSOON:

Systematic studies of the causes of rainfall in the South Asian region help to understand the important aspects of monsoons such as:

The onset of the monsoon

Rain-bearing systems (e.g. tropical cyclones) and the relationship between their frequency and distribution of monsoon rainfall.

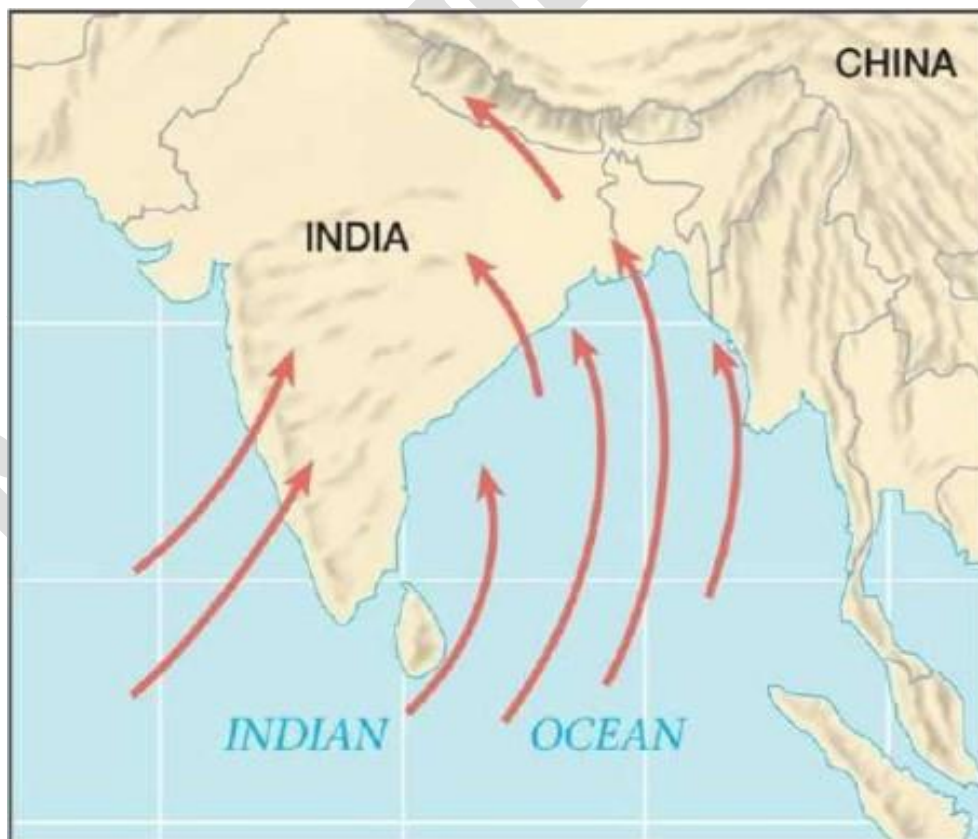
Break in the monsoon

<b>Quick Onset</b>	<ul style="list-style-type: none"> <li>• The northward shift of the ITCZ and withdrawal of the westerly jet stream from its position over the north Indian plains, lead to quick arrival of monsoon winds soon after.</li> <li>• The southwest monsoon sets in over the Kerala coast by 1st June and moves swiftly to reach Mumbai and Kolkata between 10th and 13th June. By mid- July, southwest monsoon engulfs the entire subcontinent.</li> </ul>
<b>Rain-Bearing Systems And Rainfall Distribution</b>	<ul style="list-style-type: none"> <li>• <b>There are primarily two rain-bearing systems in India.</b> <ol style="list-style-type: none"> <li>1. First originate in the Bay of Bengal causing rainfall over the plains of north India.</li> <li>2. Second is the Arabian Sea current of the southwest monsoon which brings rain to the west coast of India.</li> </ol> </li> <li>• Their paths over India are mainly determined by the position of ITCZ which is generally termed as the monsoon trough.</li> <li>• As the axis of the monsoon trough oscillates, there are fluctuations in the track and direction of these depressions, and the intensity and the amount of rainfall vary from year to year.</li> <li>• The rain which comes in spells, displays a declining trend from west to east over the west coast, and from the southeast towards the northwest over the North</li> <li>• Indian Plain and the northern part of the Peninsula.</li> </ul>

	<ul style="list-style-type: none"> <li>• Much of the rainfall along the Western Ghats is orographic as the moist air is obstructed and forced to rise along the Ghats.</li> <li>• <b>The intensity of rainfall over the west coast of India is, however, related to two factors:</b> <ol style="list-style-type: none"> <li>1. The offshore meteorological conditions.</li> <li>2. The position of the equatorial jet stream along the eastern coast of Africa.</li> </ol> </li> </ul>
<b>Break In Monsoon</b>	<ul style="list-style-type: none"> <li>• During the south-west monsoon period after having rains for a few days, if rain fails to occur for one or more weeks, it is known as break in the monsoon.</li> <li>• These dry spells are quite common during the rainy season. These breaks in the different regions are due to different reasons: <ol style="list-style-type: none"> <li>1. In northern India rains are likely to fail if the rain-bearing storms are not very frequent along the monsoon trough or the ITCZ over this region.</li> <li>2. Over the west coast the dry spells are associated with days when winds blow parallel to the coast.</li> </ol> </li> </ul>

## SOUTH WEST MONSOON (RAINY SEASON)

- From June to mid-September.
- Most of the rainfall occurs in this season but monsoons are often delayed.
- There are large scale spatial variations in the distribution of rainfall.





<b>TEMPERATURE</b>	<ul style="list-style-type: none"> <li>• With the onset of monsoons, temperature falls drastically, and humidity levels rise.</li> <li>• The temperature rises in September with the cease of south-west monsoons.</li> <li>• There is rise in temperature whenever there is break in the monsoons. Diurnal range of temp is small due to clouds and rains.</li> </ul>
<b>PRESSURE AND WINDS</b>	<ul style="list-style-type: none"> <li>• Low pressure conditions prevail over northwest India due to high temperature.</li> <li>• ITCZ (monsoon trough) lies along the Ganga plain. There are frequent changes in its location depending upon the weather conditions.</li> <li>• The atmospheric pressure increases steadily southwards.</li> <li>• Over peninsular region, winds blow in a southwest to northeast direction from Arabian Sea and Bay of Bengal. Their direction undergoes a change in Indo-Gangetic plain where they move from east to west.</li> </ul>

## SUMMER

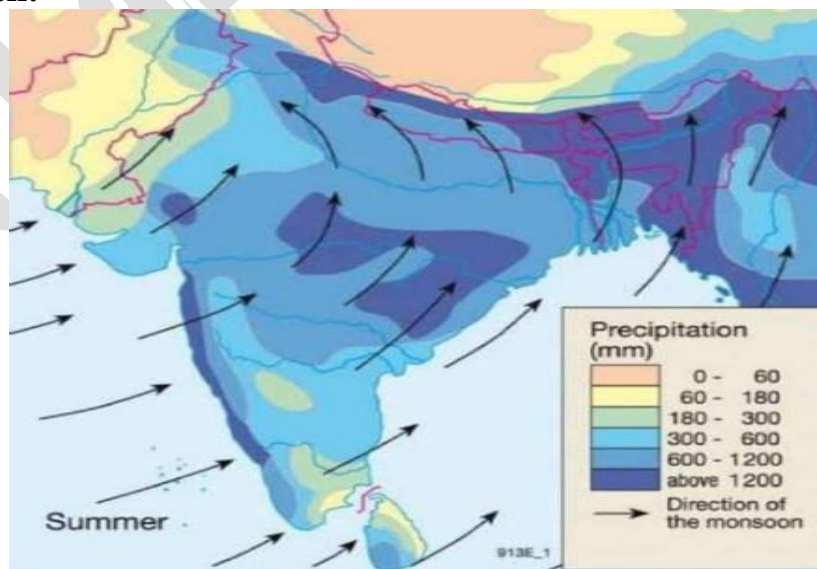
- South west monsoon winds consist of two branches:

### Branches of South West Monsoon

1. Arabian Sea Branch

2. Bay Of Bengal Branch

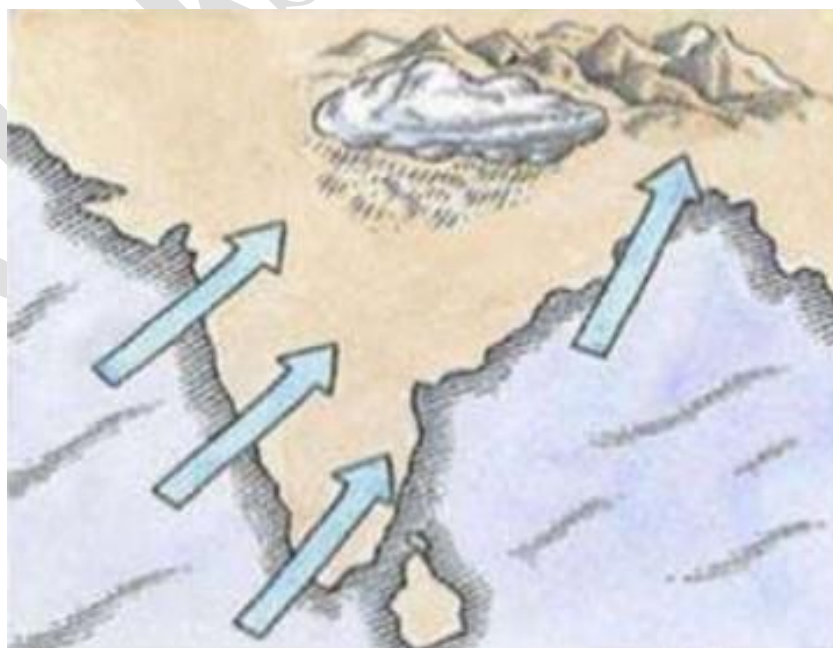
### Arabian Sea Branch:



<b>First Branch:</b>	It is obstructed by the Western Ghats causing heavy rainfall. The windward side of the Sahyadris and Western Coastal Plain receive very heavy rainfall ranging between 250 cm and 400 cm. Little rainfall is caused east of Western Ghats making a rain shadow region.
<b>Second Branch:</b>	It enters the river valleys of Narmada and Tapi and cause rainfall in central India. Thereafter, they enter the Ganga plains and mingle with the Bay of Bengal branch
<b>Third Branch:</b>	It enters from coast of Gujarat. It causes little to scanty rainfall in Gujarat plains and along Aravallis. In Punjab and Haryana, it too joins the Bay of Bengal branch. These two branches, reinforced by each other, cause rains in the western Himalayas.

## Bay of Bengal Branch

- It gathers moisture from Bay of Bengal and **strikes Myanmar** and south east Bangladesh. This branch is then deflected towards India by **Arakan Yoma and Poorvanchal Hills**.
- This, branch thus enters North east India and West Bengal from south and south east direction.
- This branch splits into two after impacting Himalayas.
  - First Branch** moves westwards along the Ganga Plains, covering the whole of India.
  - Second Branch** moves up from Brahmaputra Valley and Poorvanchal Hills. It causes heavy rainfall in North East India.
- The **advance of the monsoon is much faster** in the Bay of Bengal than in the Arabian Sea.
- The **two branches merge with each other mostly around Delhi** to form a single current. Both the branches reach Delhi more or less at the same time.
- The combined current gradually extends to west Uttar Pradesh, Haryana, Punjab, Rajasthan and finally to Himachal Pradesh and Kashmir.
- By the end of June, the monsoon is usually established over most parts of the country.
- Arabian Sea branch of the monsoon is much powerful than the Bay of Bengal branch for reasons:**
  - The Arabian Sea is larger than the Bay of Bengal.
  - Entire Arabian Sea current advances towards India, whereas only a part of the Bay of Bengal current enters India, the remainder proceeding to Myanmar, Thailand and Malaysia.

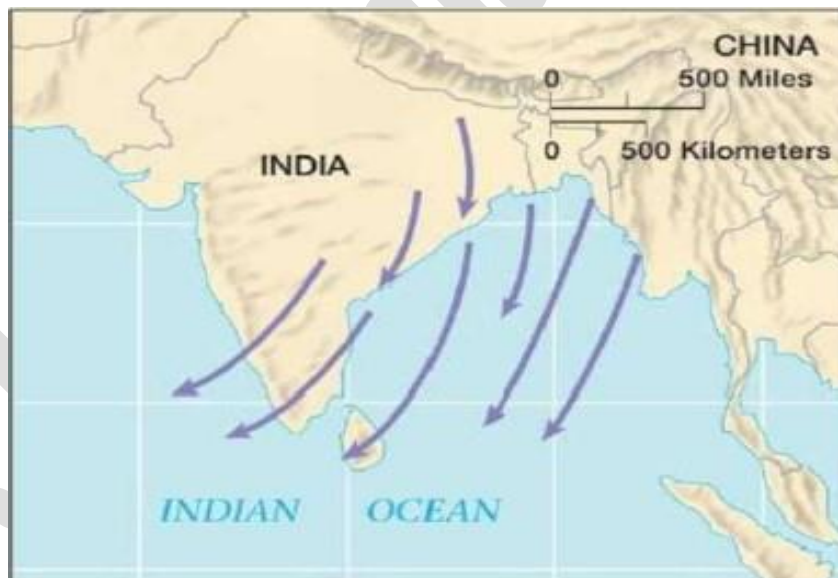


## PRECIPITATION

- **Three fourths of the total annual rainfall** is received during this season.
- Normal date of onset of SW monsoon over Kerala i.e. the first place of entry in the mainland of India is 1st June.
- The monsoons advance quickly accompanied with a lot of thunder, lightning and heavy downpour. This sudden onset of rain is termed as monsoon burst.
- **The Tamil Nadu coast remains relatively dry during the south-west monsoon period because:**
  1. Rain shadow effect of the Arabian Sea current.
  2. Bay of Bengal current flows parallel to the coast.
- During **July and August**, there are certain periods when the monsoons become weak & rainfall practically ceases over the country outside the Himalayan belt and southeast peninsula. This is known as break in the monsoon.

## NORTH EAST MONSOON (RETREATING MONSOON SEASON)

- Starts with the beginning of the withdrawal of southwest monsoon (middle of September – November).
- The monsoons withdraw from the extreme north-west end of the country in September, from the peninsula by October and from the extreme south-eastern tip by December.
- In Punjab, SW monsoons reach in the first week of July and withdraw in the second week of September. SW monsoons reach Coromandel coast in first week of June and withdraw from there only in the middle of December.
- Unlike the sudden burst of the advancing monsoons, the withdrawal is rather gradual and takes about three months.



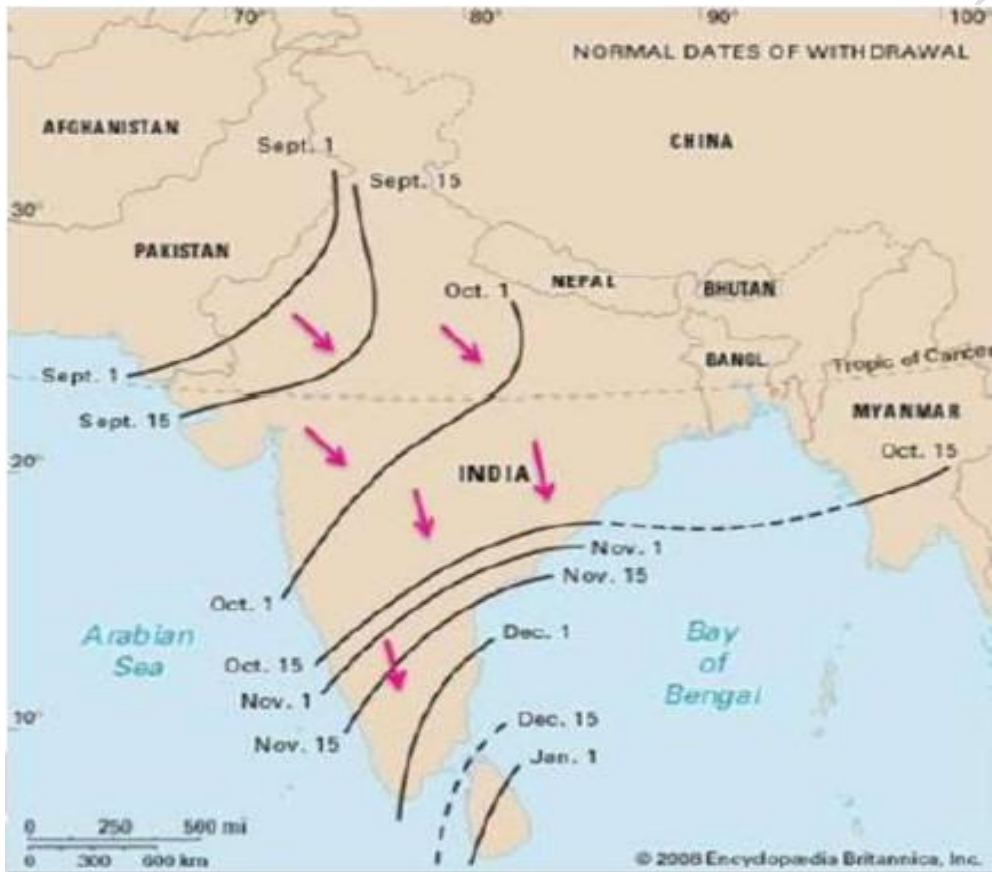
## TEMPERATURE

- The retreating southwest monsoon season is marked by clear skies and rise in temperature. The land is still moist.
- Owing to the conditions of high temperature and humidity, the weather becomes rather oppressive. This is commonly known as the 'October heat'.
- In the second half of October, temperature starts falling steeply in northern India.
- The diurnal range of temperature increases due to lack of cloud cover.



## PRESSURE AND WINDS

- As the monsoons retreat, the monsoon trough weakens and gradually shifts southward. Consequently, the pressure gradient is low.
- Unlike south-west monsoon, the onset of NE monsoon is not clearly defined.
- The direction of winds over large parts of the country is influenced by the local pressure conditions.



## TROPICAL CYCLONES

- In this season, most severe and devastating tropical cyclones originate in the Indian seas, especially in the Bay of Bengal.
- The **highest frequency of the cyclones is in the month of October and the first half of November.**
- More cyclones originate in Bay of Bengal than in Arabian Sea.
- The area's most vulnerable to these storms include the coastal belts of Tamil Nadu, Andhra Pradesh, Odisha and West Bengal.
- In north-west India the western disturbances produce clouding and light rainfall in the otherwise fine weather.

## PRECIPITATION

- The humidity and cloud cover are reduced with the retreat of the south-west monsoons and most parts of the country remain without much rainfall.
- **October-November is the main rainy season in Tamil Nadu and adjoining areas of Andhra Pradesh to the south of the Krishna delta as well as a secondary rainy period for Kerala.**

- The retreating monsoons absorb moisture while passing over the Bay of Bengal and cause this rainfall.

### Understanding of the Monsoon

Attempts have been made to understand the nature and mechanism of the monsoon on the basis of data collected on land, oceans and in the upper atmosphere. The intensity of southwest monsoon winds of southern oscillation can be measured, among others, by measuring the difference in pressure between **Tahiti** (roughly 20°S and 140°W) in French Polynesia in East Pacific and **port Darwin** (12°30'S and 131°E) in northern Australia. Indian Meteorological Department (IMD) can forecast the possible behaviour of monsoons on the basis of **16 indicators**.

## FEATURES OF MONSOONAL RAINFALL

- Monsoonal rainfall is **largely governed by relief or topography**. For instance, the windward side of the Western Ghats register a rainfall of over 250 cm. Again, the heavy rainfall in the north-eastern states can be attributed to their hill ranges and the Eastern Himalayas.
- The monsoon rainfall has **a declining trend with increasing distance from the sea**. Kolkata receives 119 cm during the southwest monsoon period, Patna - 105 cm, Prayagraj - 76 cm and Delhi - 56 cm.
- The monsoon rains **occur in wet spells of few days duration at a time**. The wet spells are interspersed with rainless interval known as '**breaks**'. These breaks in rainfall are related to the **cyclonic depressions** mainly formed at the head of the Bay of Bengal, and their crossing into the mainland. Besides the frequency and intensity of these depressions, the passage followed by them determines the spatial distribution of rainfall.
- The summer rainfall comes in a heavy downpour leading to considerable run off and soil erosion.
- Monsoons **play a pivotal role in the agrarian economy of India** because over three-fourths of the total rain in the country is received during the southwest monsoon season
- Its **spatial distribution is also uneven** which ranges from 12 cm to more than 250 cm.
- The beginning of the rains sometimes is **considerably delayed** over the whole or a part of the country.
- The rains sometimes end considerably earlier than usual, causing great damage to standing crops and making the sowing of winter crops difficult.

## MONSOON AND THE ECONOMIC LIFE IN INDIA

- Monsoon is that **axis around which revolves the entire agricultural cycle of India**.
- It is because **about 49 per cent people of India depend on agriculture** for their livelihood and agriculture itself is based on southwest monsoon.
- Except Himalayas all the parts of the country have temperature above the threshold level to grow the crops or plants throughout the year.
- **Regional variations** in monsoon climate help in growing various types of crops.
- **Variability of rainfall** brings droughts or floods every year in some parts of the country.
- **Agricultural prosperity of India** depends very much on timely and adequately distributed rainfall. If it fails, agriculture is adversely affected particularly in those regions where means of irrigation are not developed.
- **Sudden monsoon burst** creates problem of soil erosion over large areas in India.
- **Winter rainfall by temperate cyclones** in north India is highly beneficial for rabi crops.
- **Regional climatic variation** in India is reflected in the vast variety of food, clothes and house types.

**Q.** How far do you agree that the behaviour of Indian monsoon has been changing due to humanizing landscapes? Discuss. **GS 1, Mains 2015**

## WINTER SEASON (COLD WEATHER)

- This season is **distinct in areas north of the Tropic of Cancer**. It falls from November to March. December and January are the coldest month.
- Clear sky, pleasant weather, low temperature, low humidity, high range of temperature, cool and slow north-east trade winds.
- The diurnal range of temperature, especially in interior parts of the country, is very high.

## TEMPERATURE

- The **isotherm of 20°C runs roughly parallel to the Tropic of Cancer**.
- To the south of this isotherm, the temperatures are above 20 °C. Thus, there is **no distinct winter season in south India**.
- To the **north** mean temperatures are **below 21 °C** and the winter weather is distinct.
- The mean minimum temperature is **about 5° C** in north-west India and **10 °C** in the Gangetic plains.
- The night temperature may be quite low, sometimes going below freezing point in Punjab and Rajasthan.
- **There are three main reasons for the excessive cold in north India during this season:**
  - States like Punjab, Haryana and Rajasthan being far away from the moderating influence of sea experience continental climate.
  - The snowfall in the nearby Himalayan ranges creates cold wave situation.
  - Around February, the cold winds coming from the Caspian Sea and Turkmenistan bring cold wave along with frost and fog over the north western parts of India (western disturbances).
- There is **hardly any seasonal change in the distribution pattern of the temperature in coastal areas** because of moderating influence of the sea and the proximity to equator.
- For example, the mean maximum temperature for January at Thiruvananthapuram is as high as 31°C, and for June, it is 29.5°C.

## SURFACE PRESSURE AND WINDS

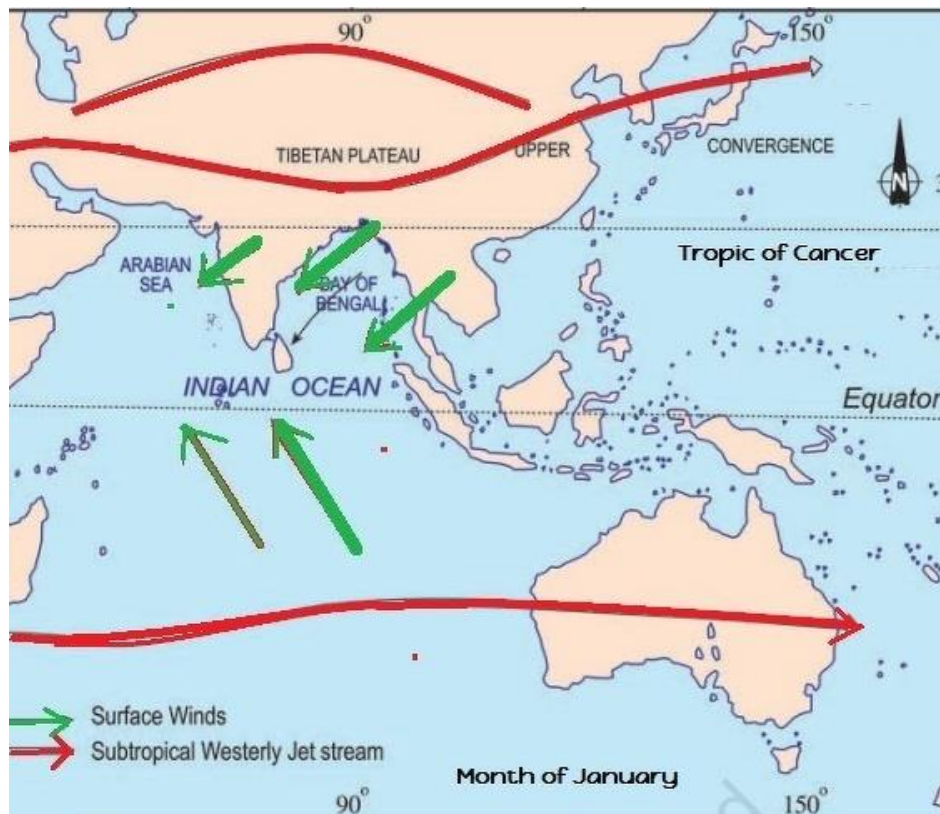
- In winter months, the weather conditions over India are generally influenced by the distribution of pressure in Central and Western Asia.
- High air pressure prevails over large parts of north-west India and Central Asia due to low temperatures.
- This high pressure centre in the region lying to the north of the Himalayas and Indian plains gives rise to the flow of air at the low level from the north towards the Indian ocean.
- The surface winds blowing out of the high pressure centre over Central Asia reach India in the form of a dry continental air mass.
- These continental winds come in contact with trade winds over north-western India. The position of this contact zone is not, however, stable.
- Occasionally, it may shift its position as far east as the middle Ganga valley with the result that the whole of the northwestern and northern India up to the middle Ganga valley comes under the influence of dry north-western winds.
- Pressure is comparatively lower in south India.

## JET STREAMS AND UPPER AIR CIRCULATION

- All of Western and Central Asia remains under the influence of westerly winds along the altitude of 9-13 km from west to east.
- These winds blow across the Asian continent at latitudes north of the Himalayas roughly parallel to the Tibetan highlands. These are known as jet streams.



- Tibetan highlands act as a barrier in the path of these jet streams. As a result, jet streams get bifurcated.
- One of its branches blows to the north of the Tibetan highlands, while the southern branch blows in an eastward direction, south of the Himalayas.
- It has its mean position at  $25^{\circ}\text{N}$  in February at 200-300 mb level.



## WESTERN DISTURBANCES

These are shallow cyclonic depressions originating over the east Mediterranean Sea and travelling eastwards across West Asia, Iran, and Pakistan before they reach the north-western parts of India.



- On their way, the moisture content gets augmented from the Caspian Sea in the north and the Persian Gulf in the south.
- They are brought into India by the westerly jet stream. An increase in the prevailing night temperature generally indicates an advance in the arrival of these cyclones disturbances. They intensify over Rajasthan, Punjab, and Haryana.
- They move eastwards across the sub - Himalayan belt up to Arunachal Pradesh.
- These depressions pick up They cause light rain in the Indus-Ganga plains and snowfall in the Himalayan belt.
- After the passage of the disturbance widespread fog and cold waves are experienced.

## TROPICAL CYCLONES

Season of least tropical cyclone activity due to low sea surface temperature and exit of ITCZ farthest south.

## PRECIPITATION

Most parts of India do not have rainfall in the winter season. However, there are some exceptions to it:

Retreating Monsoon	During October and November, northeast monsoon while crossing over the Bay of Bengal, picks up moisture and causes torrential rainfall over the Tamil Nadu coast, southern Andhra Pradesh, southeast Karnataka and southeast Kerala.
Western Disturbances	<ul style="list-style-type: none"> <li>• Western disturbances also cause a little rainfall in north India.</li> <li>• The amount of rainfall gradually decreases from the north and north-west to east.</li> <li>• It is highly beneficial for rabi crops.</li> <li>• The precipitation is in the form of snowfall in the lower Himalayas. It is this snow that sustains the flow of water in the Himalayan rivers during the summer months.</li> <li>• These depressions can also persist up to and cause little precipitation in Central India and Eastern Himalayas.</li> </ul>

## SUMMER SEASON (HOT WEATHER)

- April, May and June are the months of summer in north India.
- High temperature and low humidity are the chief characteristics.

## TEMPERATURE

- Temperatures increase because of sun's northward movement. The southern parts of the country are distinctly warmer in March and April whereas, by June, north India has higher temperatures.
- This is because of the moderating influence of water bodies and northward movement of the sun. The highest temperatures are recorded just before the onset of the southwest monsoons. The diurnal range of temperature is also very high. It may be as high as 18°C in some parts. The maximum summer temperatures are comparatively lower in the costal and southern peninsular regions due to moderating effect of the sea.
- In peninsular India, temperature does not decrease from north to south rather it increases from the coast to the interior.



- The temperatures along the west coast are comparatively lower than those prevailing on the east coast due to the prevailing westerly winds.
- Due to altitude, the temperatures in the hills of Western Ghats remain below 25°C.
- Northern and central parts of India experience heat waves in this season.

Heat Wave: When abnormally high temperature is experienced by regions. Temperature increase of the order of 6° to 7°C above normal is termed as 'moderate' and 8°C and more as 'severe' heat wave.

## PRESSURE AND WINDS

- The atmospheric pressure is low all over the country due to high temperature.
- By the middle of July, the Inter Tropical Convergence Zone (ITCZ) shifts northwards, roughly parallel to the Himalayas between 20° N and 25° N.
- By this time, the westerly jet stream withdraws from the Indian region.
- The ITCZ being a zone of low pressure, attracts inflow of winds from different directions.
- The maritime tropical airmass (mT) from the southern hemisphere, after crossing the equator, rushes to the low pressure area in the general south-westerly direction. It is this moist air current which is popularly known as the southwest monsoon.



**Mean Temperature (April)**



**Pressure, Prevailing Winds and Cyclones (April)**

## LOO

- Extremely hot and dry winds which originate over Iranian, Baloch and Thar deserts.
- In May and June, high temperature in northwest India builds steep pressure gradient which draws these winds to the north Indian plains.



## AANDHIS

- Strong dust storms originate in northern plains from Rajasthan to Bihar because of low pressure and strong convective currents.
- Dust storms in the evening are very common during May in Punjab, Haryana, Eastern Rajasthan and Uttar Pradesh. These temporary storms bring a welcome respite from the oppressing heat since they bring with them light rains and a pleasant cool breeze.
- They reduce the visibility to a few metres.

## CONVECTIONAL THUNDERSTORMS

- Low pressure also draws in moist winds and strong convectional movements lead to thunderstorms in different part of the country.

## Some Famous Local Storms of Hot Weather Season

Mango Shower	Towards the end of summer, there are pre-monsoon showers which are a common phenomenon in Kerala, Andhra Pradesh and coastal areas of Karnataka. Locally, they are known as mango showers since they help in the early ripening of mangoes.
Blossom Shower	With this shower, coffee flowers blossom in Kerala and nearby areas.
Nor Westers	These are dreaded evening thunderstorms in West Bengal, Jharkhand, Odisha, Bengal and Assam. Their notorious nature can be understood from the local nomenclature of 'Kalbaisakhi', a calamity of the month of Baisakh. These showers are useful for tea, jute and rice cultivation. In Assam, these storms are known as Tea Showers and Barodoli Chheerha. They cause heavy damage to standing crops, trees, buildings, livestock and even lead to loss of human lives.
Loo	Hot, dry and oppressing winds blowing in the Northern plains from Punjab to Bihar with higher intensity between Delhi and Patna.

## JET STREAMS AND UPPER AIR CIRCULATION

- An easterly jet stream flows over the southern part of the Peninsula in June, and has a maximum speed of 90 km per hour.
- In August, it is confined to 15°N latitude, and in September up to 22°N latitudes. The easterlies normally do not extend to the north of 30°N latitude in the upper atmosphere.

## TROPICAL CYCLONES

- Their frequency increases (more in Bay of Bengal than in Arabian Sea).

- Most of the storms of this season initially move west or north-west, but later they recurve northeast and strike Bangladesh and the Arakan Coast of Myanmar.
- Indian coasts are rarely hit by these cyclones.

## PRECIPITATION

- Very little rainfall.
- Convictional thunderstorms bring some rainfall to the north eastern and southern parts of the country.
- The easterly jet stream steers the tropical depressions into India. These depressions play a significant role in the distribution of monsoon rainfall over the Indian subcontinent.

## TRADITIONAL INDIAN SEASONS

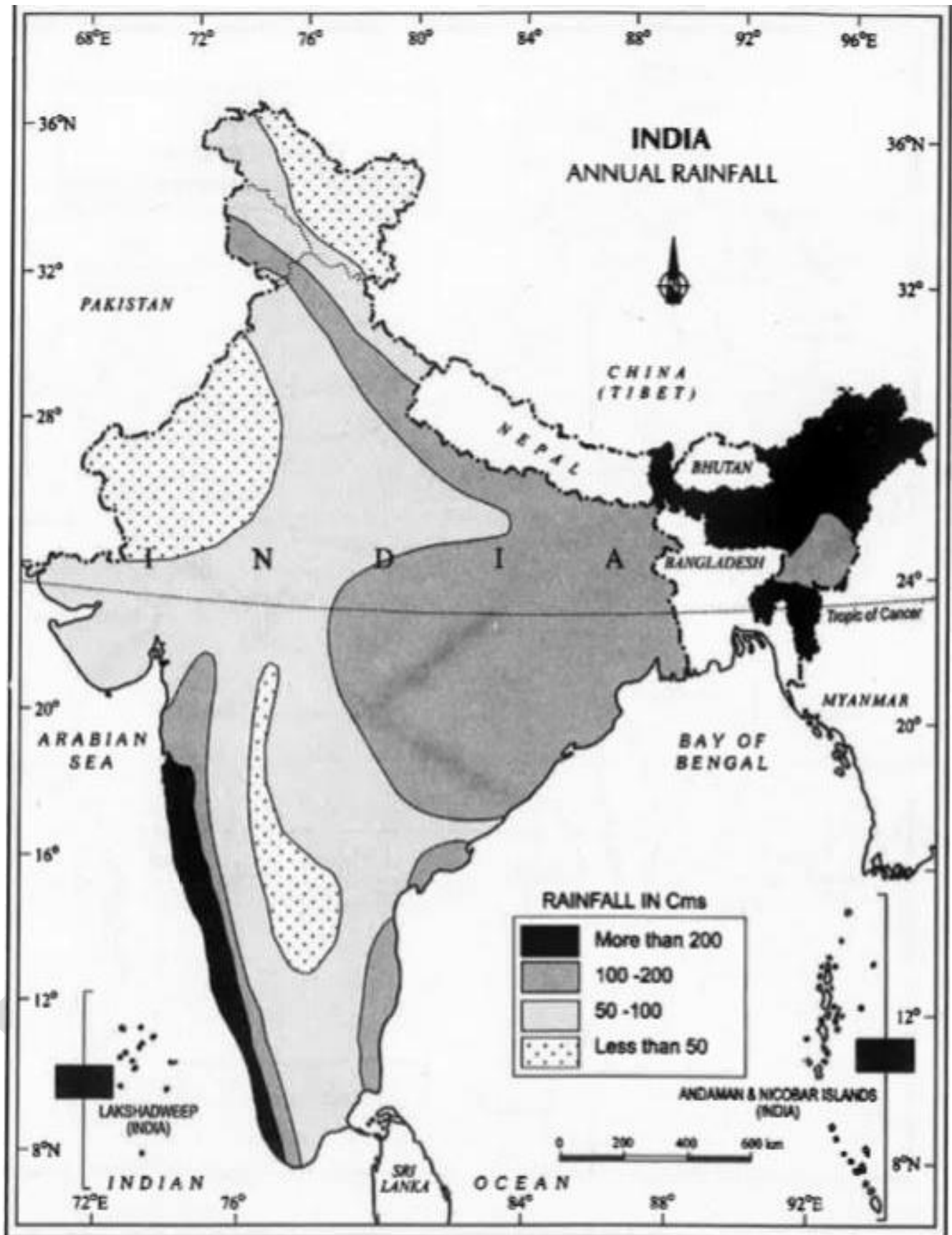
In the Indian tradition, a year is divided into six two-monthly seasons. This cycle of seasons, which the common people in north and central India follow is based on their practical experience and age-old perception of weather phenomena. However, this system does not match with the seasons of south India where there is little variation in the seasons.

Season	Months according to Indian Calendar	Months according to English Calendar
Vasanta	Chaitra-Vaisakha	March-April
Grishma	Jyaistha-Asadha	May-June
Varsha	Sravana-Bhadra	July-August
Sharada	Asvina-Kartika	September-October
Hemanta	Margashirsa-Pausa	November-December
Shishira	Magha-Phalguna	January-February

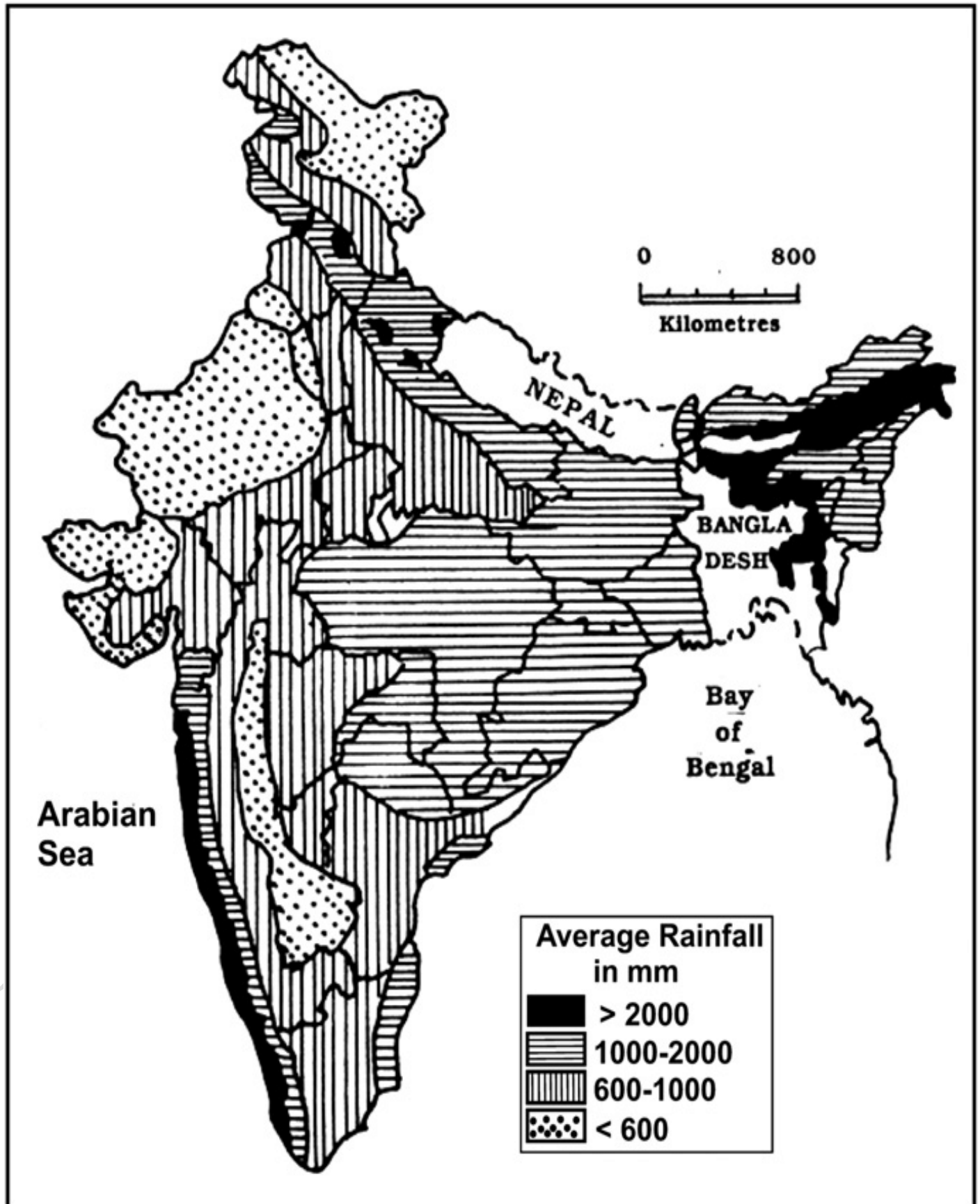
## Distribution Of Annual Rainfall

The average annual rainfall in India is about 125 cm, but it has great spatial variations. A glance on this map indicates that the distribution of rainfall in India is uneven. On the basis of the distribution of rainfall, India can be divided into the following four regions as shown below in table.

Category	Rainfall in cms	Regions
Heavy Rainfall	More than 200	Western coast, western ghats, sub-Himalayan region of northeast, Garo, Khasi and Jaintia hills of Meghalaya. In some parts, rain exceeds 1000 cm.
Moderate rainfall	Between 100 to 200	100 cm isohyet extends from Gujarat to south up to Kanyakumari parallel to western ghats. Northern Andhra Pradesh, eastern part of Maharashtra, Madhya Pradesh, Odisha, some parts of Jammu and Kashmir.
Low rainfall	Between 60 to 100	Most parts of Tamil Nadu, Karnataka, Andhra Pradesh, eastern Rajasthan, south- western Uttar Pradesh.
Inadequate rainfall	Less than 60	Punjab, Haryana, north- western Rajasthan, Kachchh, Kathiawar







## VARIABILITY OF RAINFALL

- A characteristic feature of rainfall in India is its variability. Variability of rainfall refers to variations in rainfall from the average amount. The variability of rainfall is computed with the help of the following formula:

$$C.V. = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100$$

- The values of coefficient of variation show the change from the mean values of rainfall.
- The actual rainfall in some places deviates from 20-50 per cent. The values of coefficient of variation show variability of rainfall in India.
- A variability of less than 25 per cent exists on the western coasts, Western Ghats, north-eastern Peninsula, eastern plains of the Ganga, north-eastern India, Uttarakhand and Himachal Pradesh and south-western part of Jammu and Kashmir. These areas have an annual rainfall of over 100 cm.
- A variability of over 50 per cent exists in the western part of Rajasthan, northern part of Jammu and Kashmir and interior parts of the Deccan plateau. These areas have an annual rainfall of less than 50 cm.
- Rest of India have a variability of 25-50 per cent and these areas receive an annual rainfall between 50 - 100 cm.

## UPSC Previous Years' Mains Questions on Climate:

- List the significant local storms of the hot-weather season in the country and bring out their socio-economic impact. (UPSC 2010/12 Marks)
- Bring out the significance of the various activities of the Indian Meteorological Department. (UPSC 2009/15 Marks)
- Write about Nor westers in 20 words. (UPSC 2008/15 Marks)
- The winter rains in North India are largely related to Jet Streams and Western Disturbances. Bring out the relationship. (UPSC 2008/15 Marks)
- Write note on winter rains in India. (UPSC 2006/2 Marks)
- Discuss the distribution of winds and rainfall over India in the summer monsoon season. (UPSC 2002/10 Marks)
- Explain the causes of the Indian Monsoon. (UPSC 2001/10 Marks)
- Write short note on Mango Showers. (UPSC 2000/2 Marks)
- Discuss the origin of Monsoon in India. (UPSC 1997/15 Marks)
- What is 'intensity of rainfall'? Discuss its importance to Indian farmers. (UPSC 1995/15 Marks)
- Which part of India receives more rainfall from the north-east monsoon than from the south-west monsoon? Explain why it is so? (UPSC 1994/15 Marks)
- What is the basis of Monsoon forecasts now prepared by the Indian Meteorological Department, which have been reasonably correct for the last three successive years? (UPSC 1991/20 Marks)
- How far is it justifiable to state that the financial budget of this country is a gamble, against the Indian monsoon? To what extent have developmental measures solved the problem? (UPSC 1986/20 Marks)
- Why is India undertaking expeditions to Antarctica? Describe the influence of Antarctica and Antarctic Ocean on the climate of India and on the nutrient and energy supply to Indian Ocean.



# Dr Lakshmaiah IAS Study Circle



20B, Opp: HDFC Bank, Main Road, Old Rajinder Nagar

New Delhi-110060 Ph No: +91 9773731858

15. "Monsoon is known to be an energy released by the sea." Explain. How does this energy benefit the entire economic system of our country? In what ways could this country prepare itself to fight the vagaries of the monsoons? (UPSC 1982/30 Marks)
16. Unlike most other parts of the country, why is the Tamil Nadu coast wettest in November-December and not in July- August? (UPSC 1980/3 Marks)
17. Mention the agro-climatic regions of India starting the basis of classification. (UPSC 2000/10 Marks)



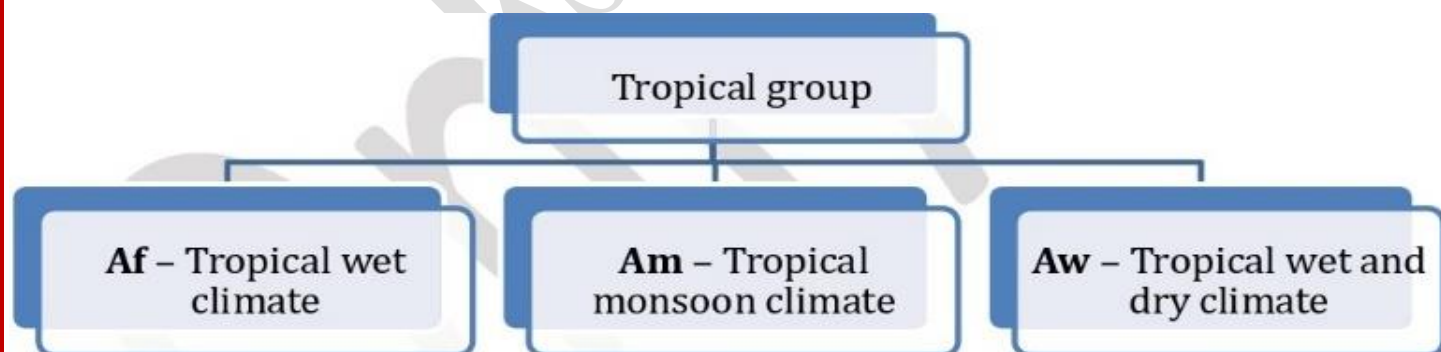
## CH-6 CLIMATIC REGIONS OF INDIA

### Introduction:

- A climatic region is that area which possesses a broad uniformity (homogeneous climatic condition) of climatic conditions caused by the combined effects of climatic elements – temperature, pressure, winds, humidity and precipitation. To study the variations of climate in various parts, India is divided into a large number of climatic regions of small size.
- India is often referred to as a country with tropical monsoon type of climate. However, the large latitudinal extent, the presence of Himalayas in the north, the India Ocean in the south have resulted in great variations in the distribution of temperature and precipitation in the India. The climate of north is different from that of south and so is the climate of east from that of the west.
- Temperature and rainfall are two important elements which are considered to be decisive in all the schemes of climatic classification. There are different schemes of classification of climate
- The whole of India has a monsoon type of climate. But the combination of elements of the weather, however, reveal many regional variations. These variations represent the subtypes of the monsoon climate.

### TROPICAL – HUMID CLIMATE

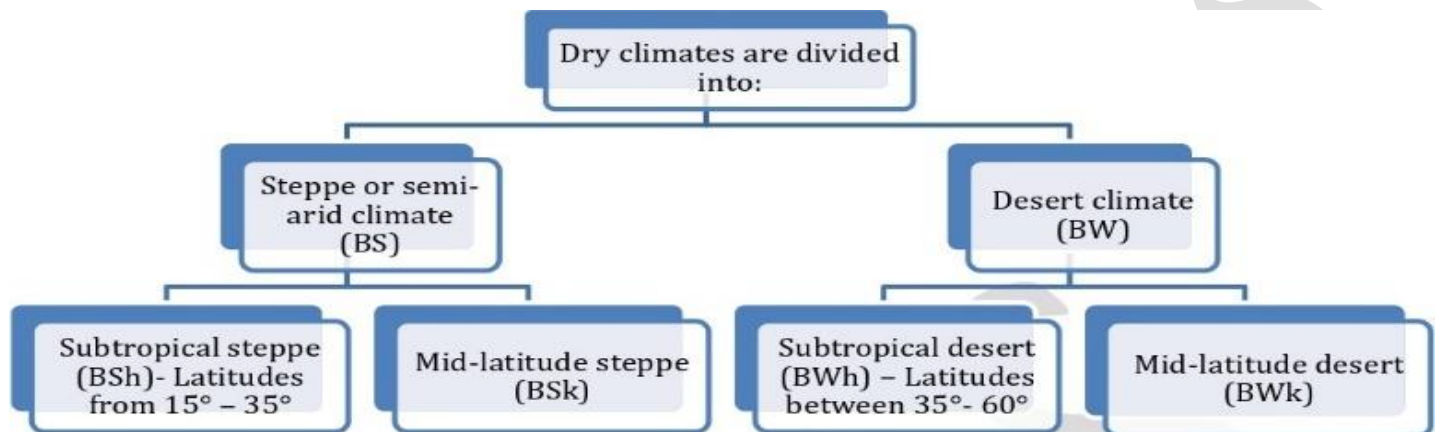
- The tropical climate is also known as rainforest climate or the equatorial climate. This type of climate has similar weather conditions throughout the year. The region is also a high energy region as it receives maximum insolation from the sun which explains its rich flora and fauna.
- Regions, where the tropical climate is found, are dominated by equatorial rainforests or the evergreen rainforests. They are broad-leaf forests which are a type of evergreen forests found on lowlands.
- Tropical humid climates exist between Tropic of Cancer and Tropic of Capricorn.
- Inter-Tropical Convergence Zone makes the climate hot and humid.
- The annual range of temperature in this region is very low whereas the annual rainfall is high.
- The tropical group is divided into three types. They are:



### DRY CLIMATE

- The Group-B Climates of Koppen's Climate Classification are Dry Climates
- These arid and semiarid climates cover about a quarter of the land surface of the Earth
- This region lies between 50° North and 50° South.
- But these regions are predominantly seen in the 15–30° latitude belts in northern and southern hemispheres.

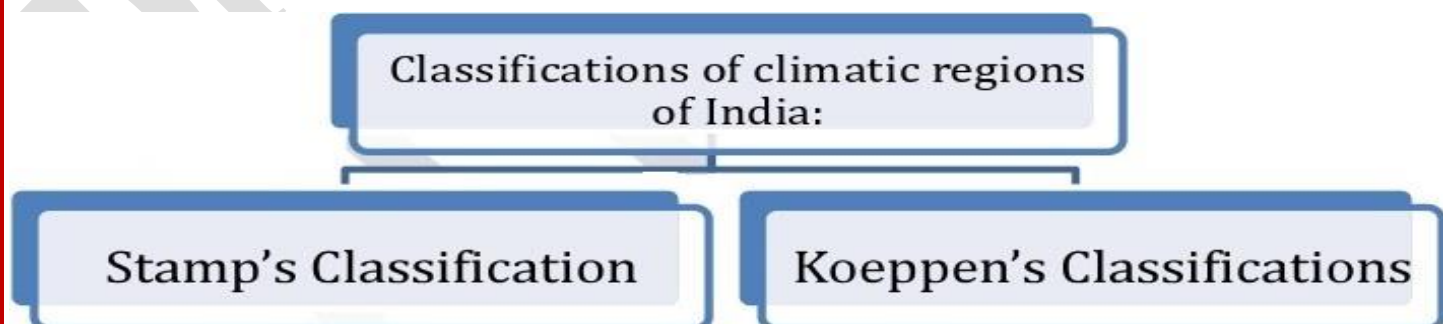
- These regions have intense solar radiation and clear skies.
- These regions experiences:
  - Low precipitation
  - Great variability in precipitation from year to year
  - Low relative humidity
  - High evaporation rates



## SUB - TROPICAL HUMID CLIMATE

- Subtropical steppe (BSh) and subtropical desert (BWh) have common temperature and precipitation characteristics.
- The maximum temperature in this region in summer is very high.
- The annual and diurnal ranges of temperature are also high.
- The highest temperature of 58°C was recorded at Libya in 1922 at Al Aziziyah.
- This region is positioned in the transition zone between dry climates and humid.
- Subtropical steppe region receives slightly more rainfall than the subtropical desert which is sufficient enough for the growth of meagre grasslands.
- The rainfall in both the climates is highly variable.
- Rain occurs in short intense thundershowers in deserts and is futile in building soil moisture.
- The inconsistency in the rainfall distresses the life in the steppe much more than in the desert, more frequently causing famine.
- Fog is common in coastal deserts neighbouring cold currents.

There are two important classifications of climatic regions of India:



## STAMP'S CLASSIFICATION

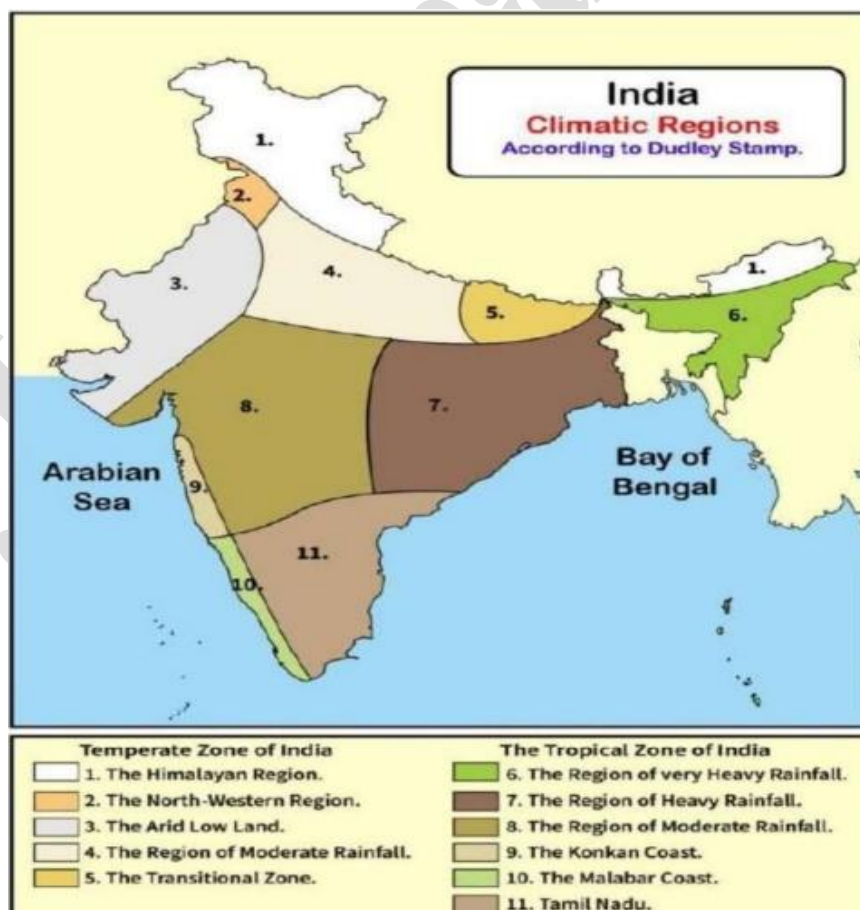
- Stamp used 18°C isotherm of mean monthly temperature for January to divide the country into two broad climatic regions, viz., temperate or continental zone in the north and tropical zone in the south.
- These two major regions are further divided into 11 regions based on variations in temperature and rainfall.

### Temperate or Continental India

Region	Avg. Temperature	Annual Rainfall
Himalayan Region	W: 4 - 7°C S: 13 - 18°C	Over 200 cm in east. Very less in the west.
North- western Region	W: 16°C S: 24°C	Below 200 cm.
Arid lowland	W: 16 - 24°C S: 48°C	Below 40 cm.
Moderate rainfall region	W: 15-18°C S: 33-35°C	40 cm to 80 cm
Transition zone	W: 15 - 19°C S: 30 - 35°C	100 cm to 150 cm

### Tropical India

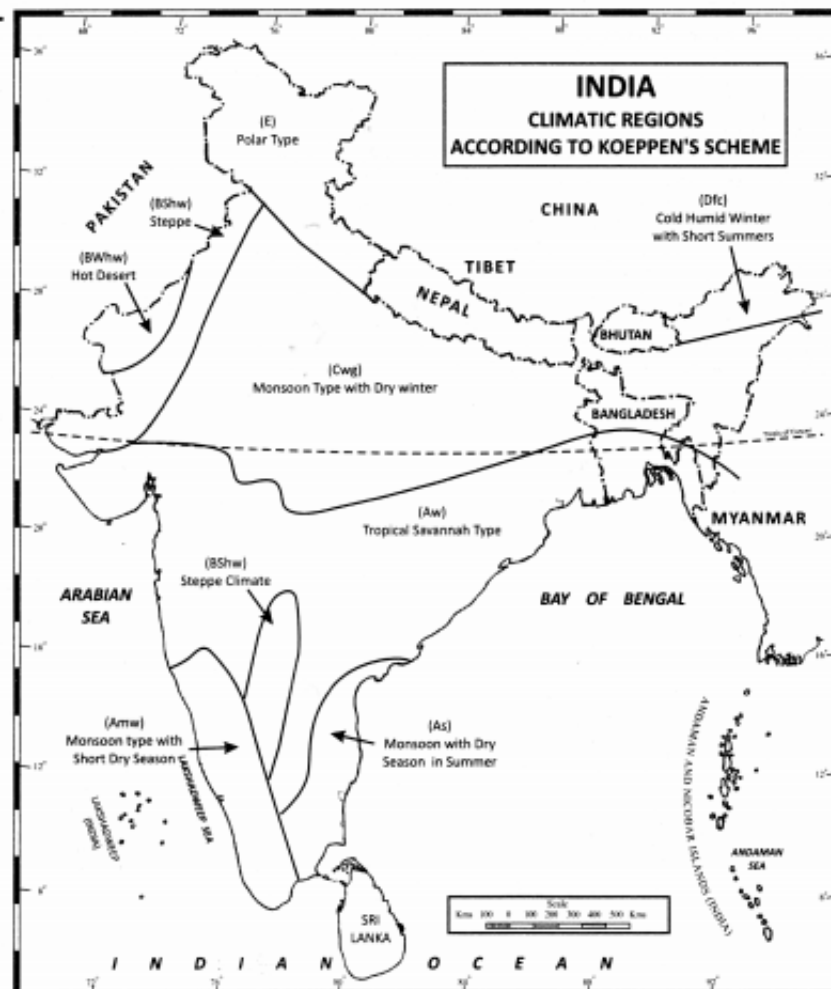
Very heavy rainfall region	W: 18°C S: 32 - 35°C	Over 200 cm.
Heavy rainfall region	W: 18 - 24°C S: 29 - 35°C	100 - 200 cm.
Moderate rainfall region	W: 18 - 24°C S: around 32°C	50 - 100 cm.
Konkan coast	Annual: 24 - 27°C	Over 200 cm.
Malabar coast	Annual: 24 - 27°C	Over 250 cm.
Tamil Nadu	Annual: 24 - 27°C	100 - 150 cm





## KOEPPEN'S CLASSIFICATION

- Koeppen divided India into 9 climatic regions based on annual distribution on temperature and precipitation.
- Koeppen recognized five major climatic groups, four of them are based on temperature and one on precipitation:
  - A - tropical with no winter and mean monthly temperature throughout the year is over  $18^{\circ}\text{C}$ .
  - B - dry climates; If dryness is less, it is semiarid (S); if it is more, the climate is arid (W).
  - C - Warm temperate climates, where mean temperature of the coldest month is between  $18^{\circ}\text{C}$  and minus  $3^{\circ}\text{C}$ .
  - D - Cool temperate climates, where mean temperature of the warmest month is over  $10^{\circ}\text{C}$ , and mean temperature of the coldest month is under minus  $3^{\circ}$ .
  - E - avg. temp. for all months below  $10^{\circ}\text{C}$ .
- The seasons of dryness are indicated by the small letters: f, m, w, and s.
  - f: no dry season.
  - m: monsoon climate.
  - w: winter dry season.
  - s: summer dry season





Climate Type	Region	Annual rainfall
Amw: Monsoon type with short dry winter season.	Western coastal region.	Over 300 cm.
As: Monsoon type with dry summers.	Coromandel Coast.	75 – 100 cm.
Aw: Tropical Savannah.	Most of the peninsular plateau except for coasts.	75 cm.
BShw: Semi-arid steppe.	Rain shadow areas of Western Ghats, Rajasthan and parts of Haryana & Gujarat.	12 – 25 cm.
BWhw: Hot desert type.	Most of western Rajasthan.	< 12 cm.
Cwg: Monsoon type with dry winters	Ganga plain, east Rajasthan, Assam.	100 - 200 cm
Dfc: Cold, humid winters with short summers.	Sikkim, Arunachal Pradesh and parts of Assam.	~ 200 cm.
Et: Tundra type.	Areas of Uttarakhand.	Snowfall
E: Polar type.	Higher areas of Himalayas (max. temp. < 10°C).	Snowfall

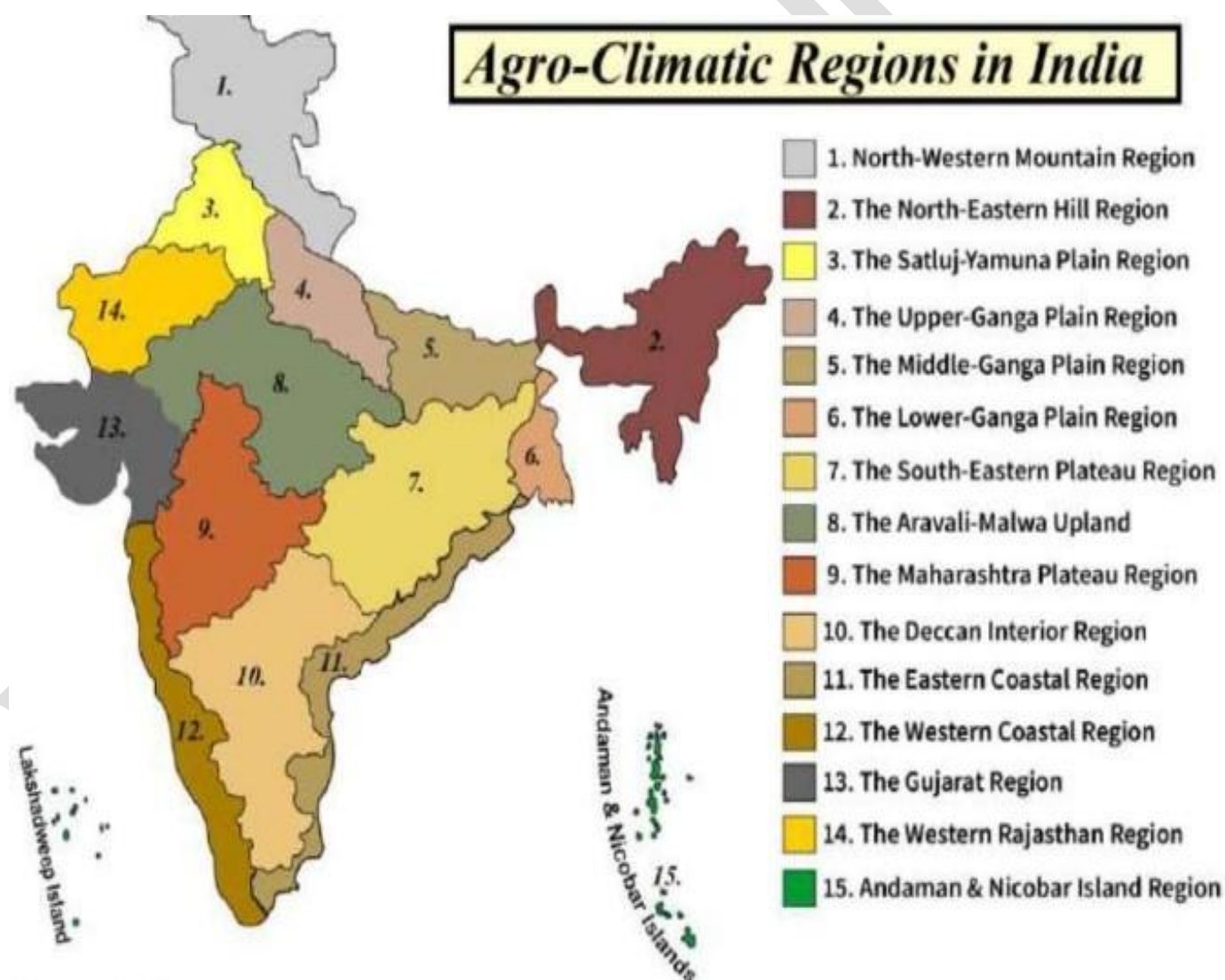
## Agro Climatic Zones Of India

- The agro-climatic classification is nothing but an extension of the climate classification keeping in view the suitability to agriculture.
- Generally, the climate types may be distinguished on the rainfall, temperature and as these two characteristics are influenced by altitude, the climate can also be classified on the basis of above three parameters.
- National commission on agriculture (1971) classified the country into 127 agro-climatic zones. The planning commission, as a result of mid-term appraisal of planning targets of VII plan (1985 - 90) divided the country into 15 broad agro - climatic zones based on physiographic and climate.
- The emphasis was given on the development of resources and their optimum utilization in a suitable manner with in the frame work of resource constraints and potentials of each region.

1	Western Himalayan Region	Ladakh, Kashmir, Punjab, Jammu etc. brown soils & silty loam, steep slopes.
2	Eastern Himalayan Region	Arunachal Pradesh, Sikkim and Darjeeling. Manipur etc. High rainfall and high forest covers heavy soil erosion, Floods.
3	Lower Gangatic plants Regions	West Bengal Soils mostly alluvial & are prone to floods.
4	Middle Gangatic plans Region	Bihar, Uttar Pradesh, High rainfall 39% irrigation, cropping intensity 142%.
5	Upper Gangatic Plains Region	North region of U.P. (32 dists) irrigated by canal & tube wells good ground water.
6	Trans Gangatic plains Region	Punjab Haryana Union territory of Delhi, Highest sown area irrigated high.
7	Eastern Plateaus & Hills Region	Chota Nagpur, Garhjat hills, M.P, W. Banghelkhand plateau, Orissa, soils Shallow to medium sloppy, undulating Irrigation tank & tube wells.



8	Central Plateau & hills Region	M. Pradesh
9	Western Plateau & hills Region	Sahyadri, M.S. M.P. Rainfall 904 mm Sown area 65% forest 11% irrigation 12.4%
10	Southern Plateau & Hills Region	T. Nadu, Andhra Pradesh, Karnataka, Typically semi and zone, Dry land Farming 81% Cropping Intensity 11%
11	East coast plains & hills Region	Tamil Nadu, Andhra Pradesh Orissa, Soils, alluvial, coastal sand, Irrigation
12	West coast plains & Hills Region	Saurashtra, Maharashtra, Goa, Karnataka, T. Nadu, Variety of cropping Pattern, rainfall & soil types.
13	Gujarat plains & Hills Region	Gujarat (19 districts) Low rainfall arid zone. Irrigation 32% well and tube wells.
14	Western Dry Region	Rajasthan (9 districts) Hot. Sandy desert rainfall erratic, high evaporation. Scanty vegetation, famine draughts.
15	The Island Region	Eastern Andaman, Nicobar, Western Lakshadweep. Typical equatorial, rainfall 3000 mm (9 months) forest zone undulating.





## CH-7 SOILS OF INDIA

Soil is the uppermost thin layer on the earth's crust comprising rock particles mixed with organic matter. The soil is one of the important components of the sustainability of an ecosystem because it is the vitally important natural medium for the growth of vegetation and thus it supports the lives on earth. Geologically, Indian soils can broadly be divided into soils of peninsular India and soils of extra-peninsular India.

- The soils of Peninsular India are formed by the decomposition of rocks in situ, i.e. directly from the underlying rocks.
- Soils of Peninsular India are transported and re-deposited to a limited extent and are known as sedentary soils.
- The soils of the Extra-Peninsula are formed due to the depositional work of rivers and wind. They are very deep. They are often referred to as transported or azonal soils.

### Major Factors that influence soil formation

The major factors that determine soils' characteristics are parent material, climate, relief, vegetation, time, and some other life-forms.

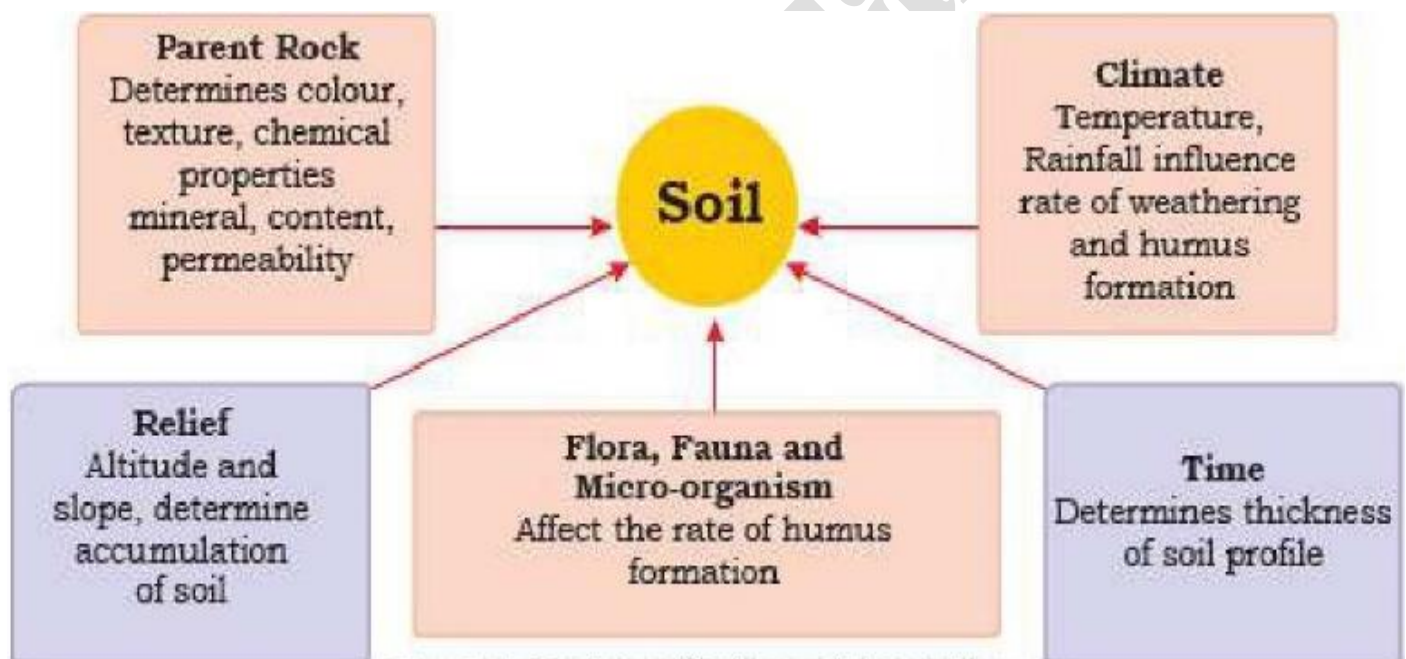


Fig. 2.4: Factors affecting soil formation

### Parent Material

It is deposited by streams or derived from in-situ weathering. In this stage, soil acquires numerous properties like the mineral composition, the shade, the particle size and the chemical elements.

For example

- Black soil got its colour from lava rock
- The peninsular soils mirror the parent rock
- Sandy soils are derived from sandstone.

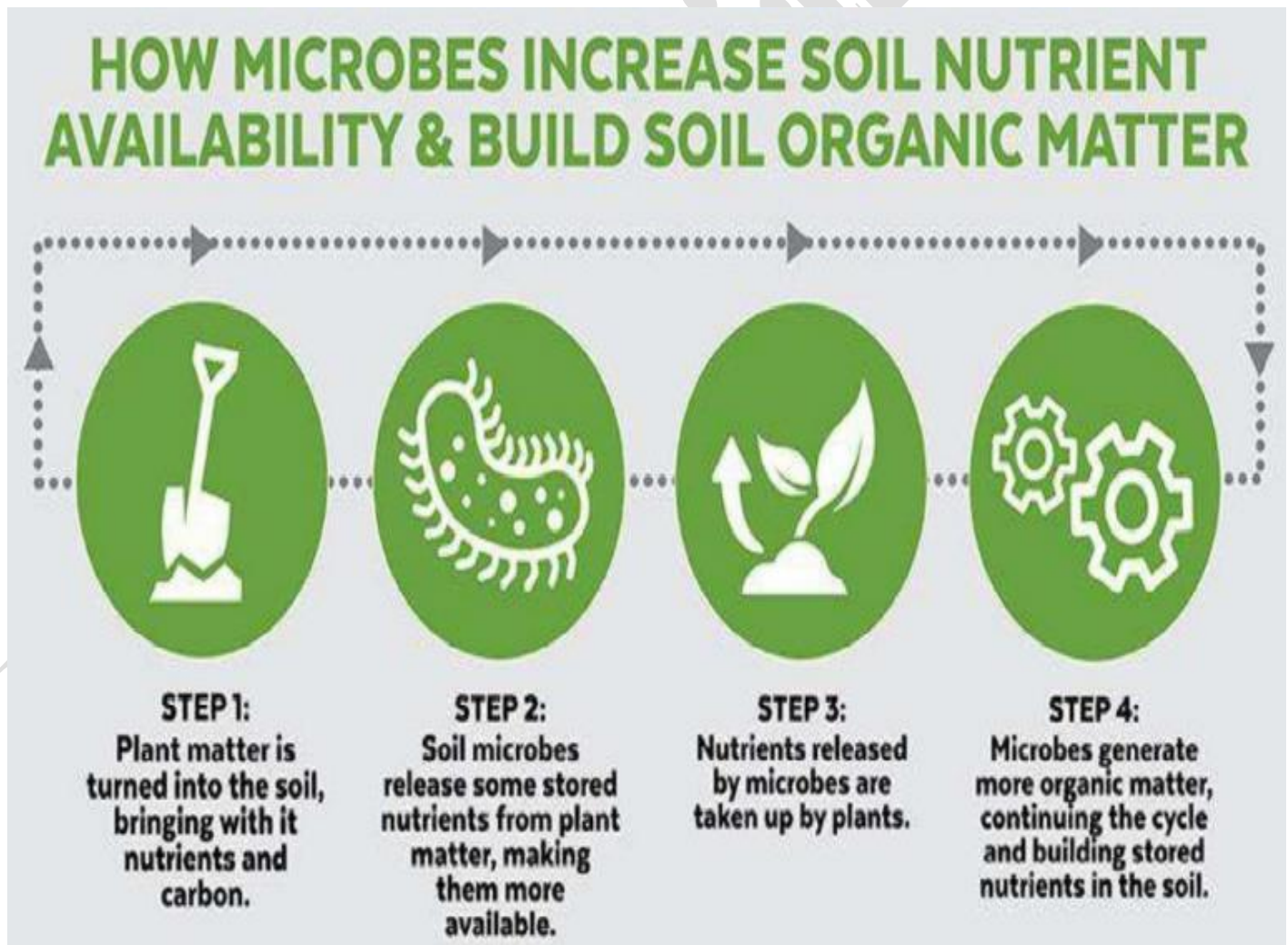
## Climate

It is one of the significant components in the formation of soil since it influences the pace of weathering of the parent rock.

- Role of precipitation: The variability in the precipitation alters the composition of the soil. For Example- Areas with little precipitation with high rate of evaporation prompted the accumulation of salts in the soil. The soils underlying tropical rain forests tend to be nutrient-poor due to concentrated intensive leaching because of heavy rains.
- Role of temperature: It also plays a significant role since variances in temperature causes contracting and expanding, frost action and general weathering in soils.

## Biotic Factors (Flora, Fauna and Microorganisms)

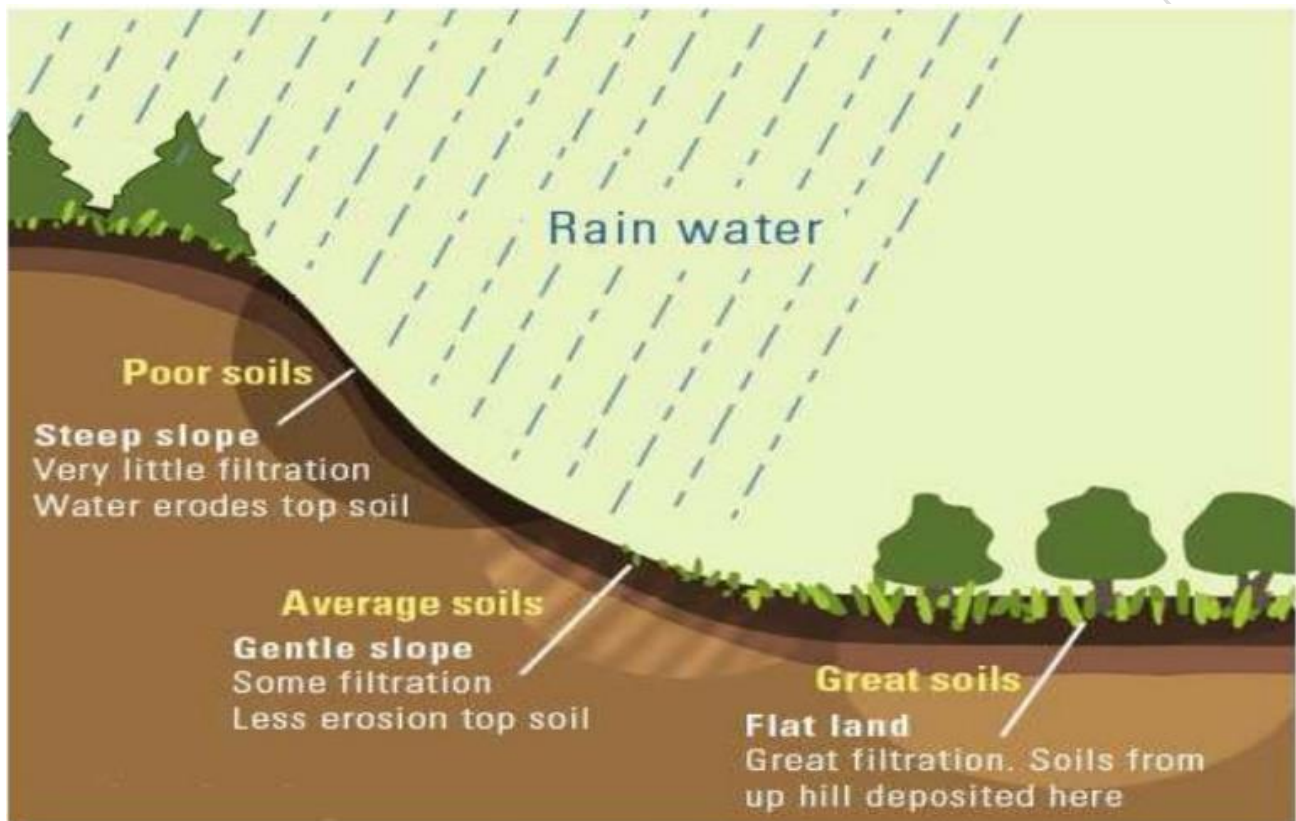
Biotic elements In conjunction with atmosphere, alters parent material to produce soil. For Example- Leguminous plants (such as beans, peas, and groundnuts) have nitrogen-fixing microscopic organisms. These plants take the nitrate ions directly from these nitrogen-fixing bacteria. It improves the fertility of soil by fixing atmospheric nitrogen to ammonia or ammonium.





## Topography

Topography redistributes the water arriving at the soil surface. Spillover from uplands creates wetter conditions on the lowlands, in some cases saline swamps or organic soils. In this way, as a redistributor of the climate features, topography influences soil forms, soil distribution and the kind of vegetation at the site.



## Time

Soils can take numerous years to shape. Younger soils have some qualities from their parent material, however as they age, the expansion of organic matter, exposure to moisture and other ecological factors may change its features. With time, they settle and are covered further beneath the surface, taking time to transform. In the end, they may change from one soil type to another.

The soils of India on the basis of their formation are separated in the following two broad categories:

- Residual Soil → Which form at the place of their source for ex. Black soils
- Transported Soil → Which are moved from place of their source for ex. Alluvial soils

## Soil Profile (Soil Horizon)

The soil profile is a vertical section of the soil that delineates all of its horizons. It extends from the soil surface to the parent rock material. The soil profile is comprised of layers, running parallel to the surface, called *Soil Horizons*. These layers are distinguished by their physical and chemical properties.



Soil Horizon is arranged into three categories – Horizon A, Horizon B, and Horizon C; collectively known as Soil Profile (i.e. the arrangement of soil layers). Aside these three, there are also the O, E and R horizons.

**O Horizon** - The top, *organic layer of soil*, made up generally of leaf litter and humus (decomposed organic matter)

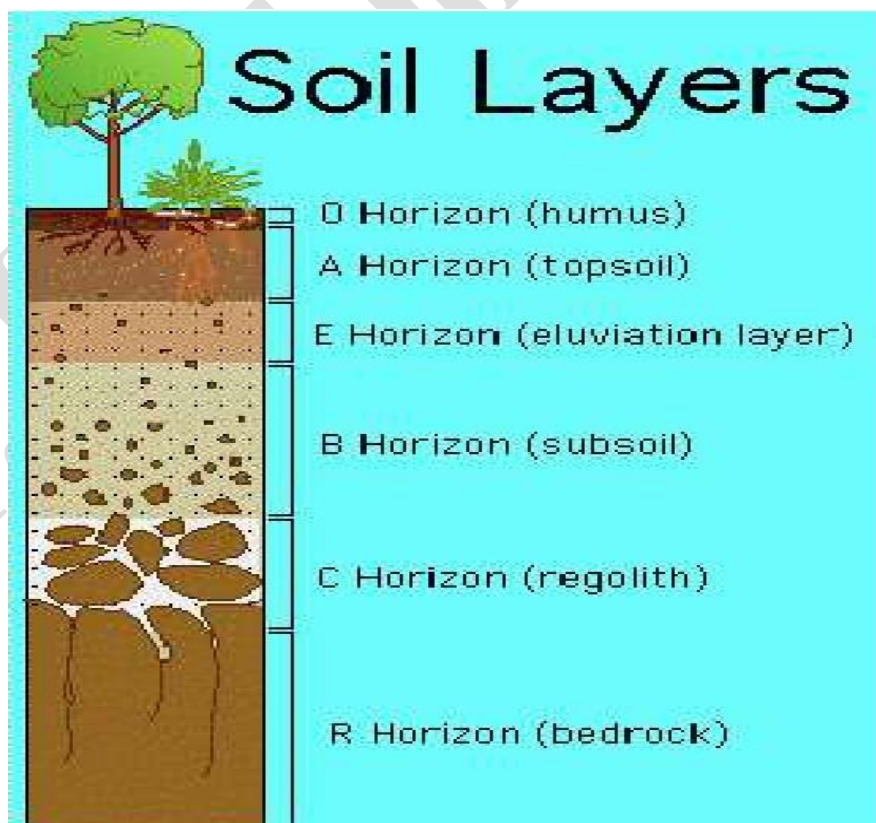
**A Horizon** - The layer is called *topsoil*; it is found beneath the O horizon and above the E horizon. Seeds develop and plant roots grow in this dark-colored layer. It is comprised of humus (decomposed organic matter) blended with mineral particles

**E Horizon** - This *eluviation* (leaching) layer is light in color; this layer is underneath the A Horizon and above the B Horizon. It is made up mostly of sand and silt, having lost the majority of its minerals and clay as water drips through the soil (during the process of eluviation)

**B Horizon** - Also called the *subsoil* - this layer is underneath the E Horizon and above the C Horizon. It contains clay and mineral deposits (like iron, aluminium oxides, and calcium carbonate) that it gets from layers above it when mineralized water drips from the layers above

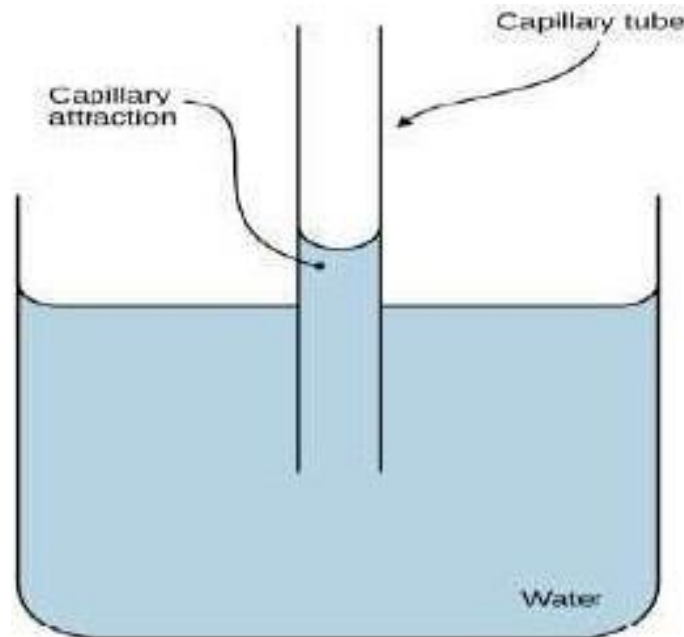
**C Horizon** - Also called *regolith*: the layer underneath the B Horizon and above the R Horizon. It comprises of slightly broken-up bedrock. Plant roots do not enter into this layer; almost no organic material is found in this layer

**R Horizon** - The *unweathered rock* (bedrock) layer that is underneath all the other layers.



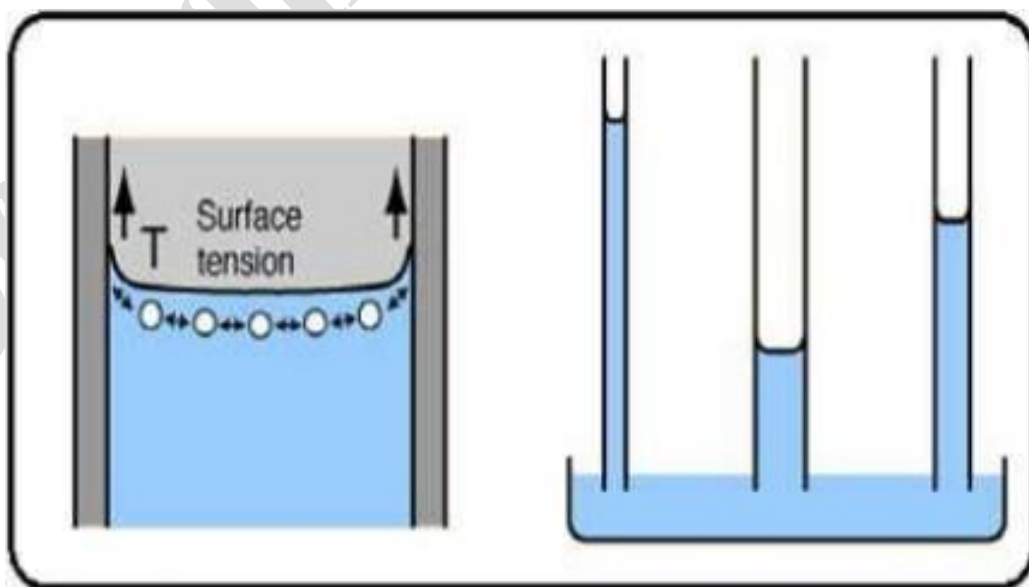
## Capillary Action

- Capillary action is the capacity of a fluid to flow in restricted spaces without the help of, and in opposition to, external forces like gravity
- The power behind capillary action is surface tension.



## Surface tension

- Surface tension is the elastic tendency of fluids (a membrane-like surface) that causes them to procure the least surface area possible
- Surface tension causes bugs (e.g. water striders), generally denser than water, to float and step on the water surface
- Surface tension offers the necessary buoyant force (buoyancy) required for an article to float in water (Ships float due to difference in density as well as surface tension).



## Soil Salinisation

The salinity of soil refers to the amount of salts in the soil and it can be estimated by measuring the electrical conductivity (EC) of an extracted soil solution.

*Salinization* is the increase of salt concentration in topsoil and is, in most cases, caused by dissolved salts in the water supply.

## Factors affecting Soil Salinity

- **Irrigation water quality** – The total amount of dissolved salts in the irrigation water, and their composition, influence the soil salinity. Therefore, various parameters, such as source water EC and its minerals content should be tested.
- **Fertilizers applied** – The type and amount of fertilizers applied to soil, affect its salinity. Some fertilizers contain high levels of potentially harmful salts, such as potassium chloride or ammonium sulphate. Overuse and misuse of fertilizers leads to salinity buildup, and should be avoided.
- **Irrigation regimen and type of irrigation system** – The higher the water quantity applied, the closer soil salinity is to irrigation water salts concentration. When the soil dries, the concentration of salts in the soil solution is increased.

Soil Salinity Class	Conductivity of the Saturation Extract (dS/m)	Effect on Crop Plants
Non saline	0 - 2	Salinity effects negligible
Slightly saline	2 - 4	Yields of sensitive crops may be restricted
Moderately saline	4 - 8	Yields of many crops are restricted
Strongly saline	8 - 16	Only tolerant crops yield satisfactorily
Very strongly saline	> 16	Only a few very tolerant crops yield satisfactorily

## Effect of Salinisation

- Salinity affects plant growth in several ways, directly and indirectly:
  - Decreased water uptake
  - Ion-specific toxicity
  - Interference with uptake of essential nutrients.
- Decreases soil fertility
- Excess soil salinity causes poor and spotty stands of crops, uneven and stunted growth and poor yields
- Difficulties in Housing & road construction

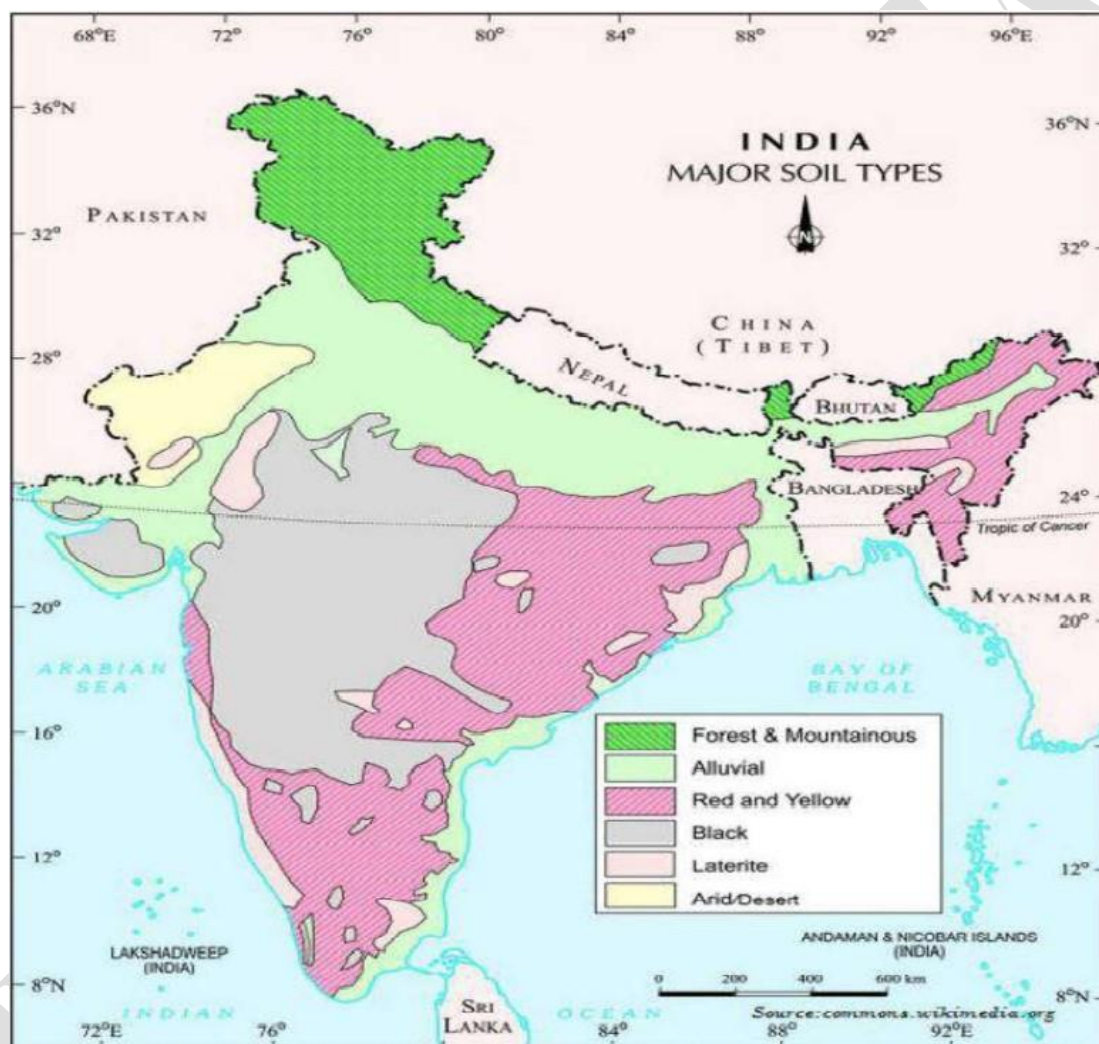
## Control Measures

- **Drainage of Excessive water:** Drainage is the primary method of controlling soil salinity. The system should permit a small fraction of the irrigation water (about 10 to 20 percent, the drainage or leaching fraction) to be drained and discharged out of the irrigation project.
- **Lining of Canals:** Seepage from canals may cause rising groundwater levels, resulting in soil salinity and waterlogging. Inhibiting infiltration in soil-lined canals can be effectively accomplished by lining them with concrete or membranes of rubber, plastic, or bitumen.



- Increased Irrigation frequency: More frequent irrigations, by keeping the soil at a higher soil moisture content prevent the concentration of salts in the soil solution and tend to minimize the adverse effects of salts in the soil
- Treating the soil with lime and gypsum: To reduce the exchangeable sodium content add calcium in a soluble form such as gypsum
- Flushing the salts by flooding the fields: Washing away the surface accumulated salts by flushing water over the surface is sometimes used to desalinize soils having surface salt crusts.

## Major Soil Groups of India



India has varied relief features, landforms, climatic domains and vegetation types. These have added to the development of different types of soils in India.

- The soils of Peninsular India are formed by the deterioration of rocks in-situ. Thus, they are called as sedentary soils
- The soils of the Indo-Gangetic- Brahmaputra plains are formed due to the depositional work of rivers and wind. They are very deep. They are often referred to as transported soils.

## Classification of Soils

1. In ancient times, soils used to be characterized into two primary groups:
  - Urvara (fertile)
  - Usara (sterile)
2. Based on their inherent characteristics and external features including texture, color, slope of land, and moisture content in the soil

Based on *texture*, primary soil types were identified as sandy, clayey, silty and loam, etc.

- **Sandy Soil:** It consists of small particles of weathered rock. Sandy soils are one of the poorest types of soil for growing plants because it has very low nutrients and poor water holding capacity, which makes it hard for the plant's roots to absorb water. This type of soil is very good for the drainage system.
- **Silt Soil:** Silt is known to have much smaller particles compared to the sandy soil and is made up of rock and other mineral particles which are smaller than sand and larger than clay. It is the smooth and quite fine quality of the soil that holds water better than sand. Silt is easily transported by moving currents, and it is mainly found near the river, lake, and other water bodies.
- **Clay Soil:** Clay is the smallest particle amongst the other two types of soil. The particles in this soil are tightly packed together with each other with very little or no airspace. This soil has very good water storage qualities and makes it hard for moisture and air to penetrate into it. It is very sticky to the touch when wet, but smooth when dried. Clay is the densest and heaviest type of soil which does not drain well or provide space for plant roots to flourish.
- **Loamy Soil:** Loam is the fourth type of soil. It is a combination of sand, silt, and clay such that the beneficial properties from each is included. For instance, it has the ability to retain moisture and nutrients; hence, it is more suitable for farming. This soil is also referred to as an agricultural soil as it includes an equilibrium of all three types of soil materials being sandy, clay, and silt, and it also happens to have humus.

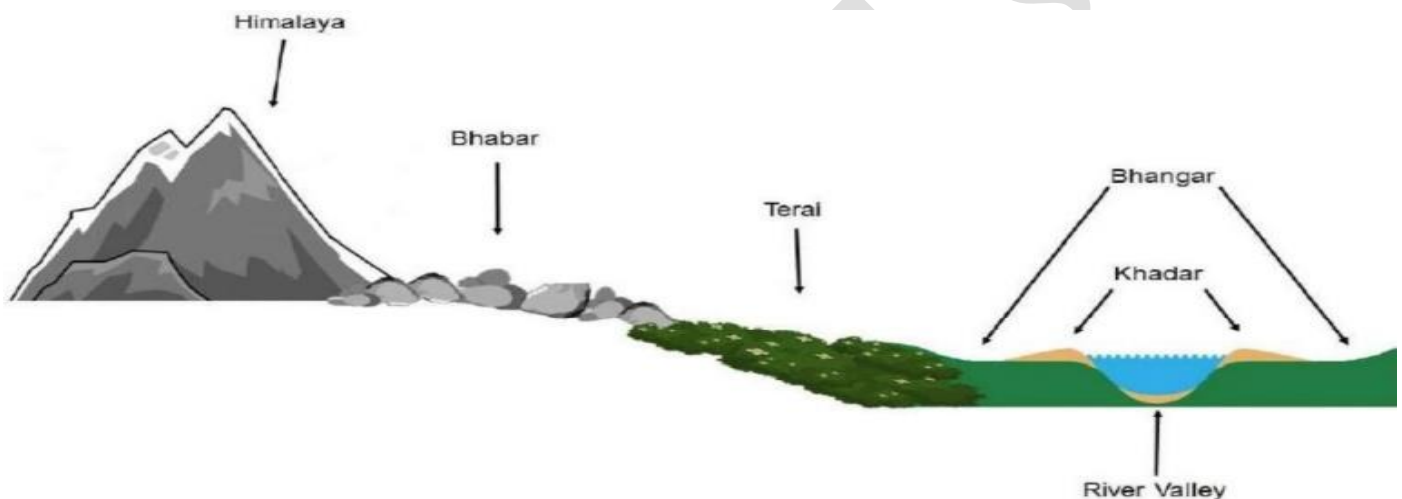
On the basis of *colour*, they were red, yellow, black, etc.

3. Based on beginning, colour, composition and location, the soils of India have been arranged into:
  - Alluvial soils
  - Black soils
  - Red and Yellow soils
  - Laterite soils
  - Saline soils
  - Forest soils
  - Arid soils
  - Peaty soils

## Alluvial Soil

- Alluvial soils are formed fundamentally because of silt deposited by Indo-Gangetic-Brahmaputra rivers
- Alluvial soils are widespread in the northern plains and the river valleys of Punjab, Haryana, Uttarakhand, UP, Bihar and West Bengal. Through a restricted passage in Rajasthan, they stretch out into the plains of Gujarat. In the Peninsular region, they are found in deltas of the east coast and in the river valleys.
- In coastal regions some alluvial deposits are formed due to wave action
- They are the biggest soil group covering about 40% of the total area of India

- Biggest Tract → Satluj Ganga Plains
- They also occur in deltas of the Mahanadi, the Godavari, the Krishna and the Cauvery, where they are called deltaic alluvium (coastal alluvium).
- Profoundly fertile Riverine soils → Transported type
- Less association with Parent material
- Wealthy in Potash yet inadequate in Nitrogen & Humus content
- Good for both rabi and kharif crops like Wheat, rice, maize, sugarcane, pulses, oilseeds, fruits and vegetables, leguminous crops.
- In deltaic region, they are ideal for jute cultivation
- The alluvial soil can be further divided into the Khadar and the Bhangar
- Khadar → Deposited by flood annually (Fresh silt) → non-porous, clayey and loamy
- Bhangar → Above flood level; well drained & drier → coarse in nature, contain kankar (lime nodules), pebbles, gravels
- In some areas, these soils are covered with unproductive wind-borne soil called Loess.



- They are immature and have weak profiles due to their recent origin.
- Most of the soil is Sandy and clayey soils are not uncommon.
- Pebbly and gravelly soils are rare. Kankar (calcareous concretions) beds are present in some regions along the river terraces.
- The soil is porous because of its loamy (equal proportion of sand and clay) nature.
- Porosity and texture provide good drainage and other conditions favorable for agriculture.
- These soils are constantly replenished by the recurrent floods.
- The proportion of Iron oxide and lime vary within a wide range.

## Black Soil

- Black soils are mineral soils which have a black surface horizon, enriched with organic carbon
- A typical black soil is highly argillaceous [Geology (of rocks or sediment) consisting of or containing clay] with a large clay factor, 62 per cent or more.
- The parent material for most of the black soil are the volcanic rocks that were formed in the Deccan Plateau (Deccan and the Rajmahal trap).



- In Tamil Nadu, gneisses and schists form the parent material. The former are sufficiently deep while the later are generally shallow.
- These are the region of high temperature and low rainfall. It is, therefore, a soil group typical to the dry and hot regions of the Peninsula
- Otherwise called black cotton soil or Regur soil
- The black colour is due to the presence of a small proportion of titaniferous magnetite or iron and black constituents of the parent rock.
- Wealthy in lime and iron, magnesia and alumina; likewise contains Potash
- In general, black soils of uplands are of low fertility while those in the valleys are very fertile.
- These soils swell and get sticky when wet and grow deep wide cracks when dry. This aids in self-aeration, which prompts to absorption of nitrogen from atmosphere. In this way, there happens a kind of 'self-ploughing'.
- This aeration and oxidation to profound levels contributes to maintenance of fertility of these soils. This continued fertility is ideal in the area of low precipitation for cotton cultivation even without irrigation.
- Various tints of the black colour such as deep black, medium black, shallow black, a mixture of red and black may be found in this group of soils.
- Residual type of Soil
- Inadequate in organic content, phosphorus, nitrogen
- Exceptionally clayey and impermeable → Highly moisture retentive
- Farrowed in dry season as on evaporation cracks develop for better seed penetration
- These soils are highly productive and appropriate to the cultivation of cotton, pulses, millets, linseed, tobacco, sugarcane, vegetables and citrus fruits.
- Regions → Maharashtra, Gujrat, Madhya Pradesh, Andhra Pradesh, Parts of Tamil Nadu
- Forms 15.6 % of the total land region of the country

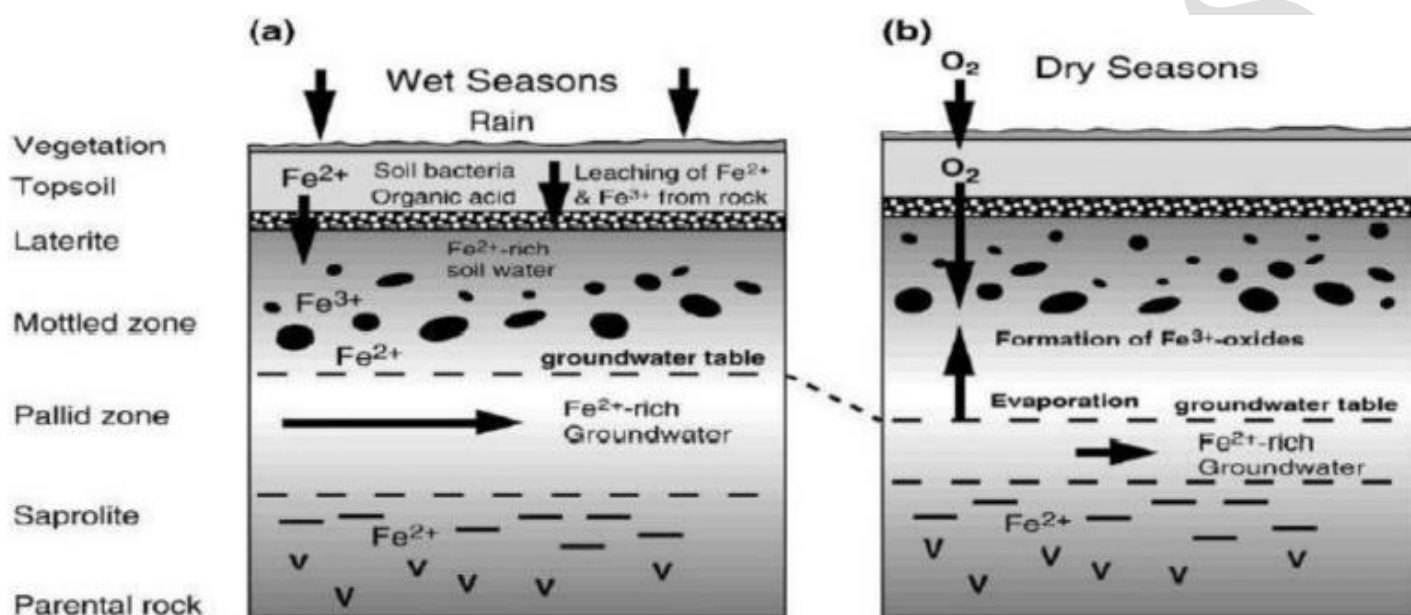
## Red Soil

- Shaped by weathering of Igneous (crystalline) & metamorphic rocks
- Less fertile than Alluvial & Black soils
- Lacks water retentive capacity
- When limestone, granites, gneisses and quartzites are eroded the clay enclosed within the rocks remains intact with other forms of non-soluble materials.
- In oxidizing conditions, rust or iron oxide develops in the clay, when the soil is present above the water table giving the soil a characteristic red colour.
- The colour is more due to the wide diffusion rather than high percentage of iron oxide content.
- These are shaped under well-drained conditions.
- These soils for the most part occur in the areas of low precipitation.
- Looks Yellow in Hydrated form
- Extraordinary leaching is a menace in these soil areas.
- These soils are airy and need irrigation for farming.
- Transported kind of soil
- Inadequate in nitrogen, lime, magnesia, humus and phosphate
- Wealthy in potash and become fertile with the proper use of fertilizers and irrigation
- Are permeable, aerated & friable in nature
- Regions: Periphery areas of Deccan Plateau viz. Chhotanagpur plateau, Telangana, Nilgiris, Karnataka, Andhra Pradesh; and almost whole of Tamil Nadu

- Suitable for the cultivation of millets, pulses, Linseed, tobacco etc.
- Red soils along with its minor groups form the largest soil group of India.

## Laterite Soil

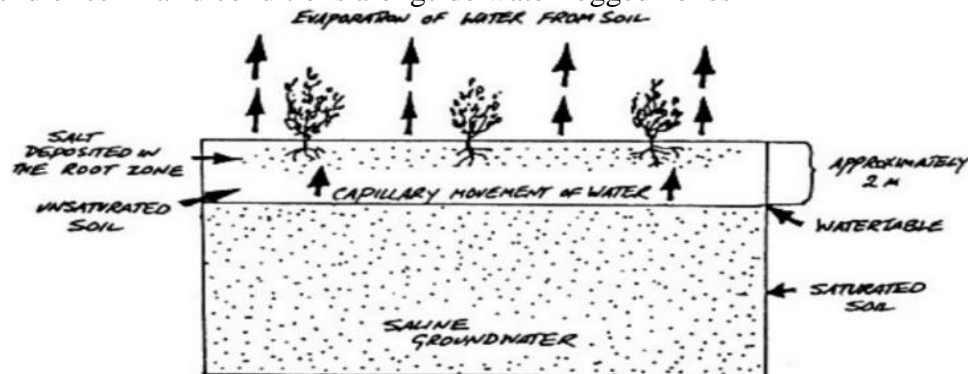
- Formed under state of high temperature and heavy precipitation with interchange wet and dry periods. They are mostly the end products of weathering.



- The lateritic soils are especially found on high flat erosion surfaces in areas of high (>200cm) and seasonal precipitation.
- These soils are acidic in character due to leaching. Use of composts and fertilisers is required for making these soils fertile for cultivation.
- These soils represent the final product of decomposition and are generally low in fertility.
- Humus substance of soil is quickly removed by microbes which flourish well in high temperature
- Formed by leaching away of siliceous matter
- They solidify significantly on losing moisture.
- Laterite soils are red in colour because of little clay and more gravel of red sand-stones.
- With rain, Lime & Silica filters away, leaving insoluble Iron & Aluminium compounds → Desilication
- Residual type of soils, formed by leaching in zones of heavy rain
- Mainly found in Highland or Plateaus with substantial precipitation
- Not useful for farming except for plantation crops like Tea, Rubber, Coffee & Cashews
- Utilized as building material & in making bricks
- Are of Coarse surface with delicate & friable nature
- Poor in Lime, Nitrogen, Magnesium & Humus content; Rich in Iron & Alumin
- Sometimes, the phosphate content may be high as iron phosphate.
- In wetter places, there may be higher content of humus.
- Regions → Meghalaya, Karnataka, Kerala, Tamil Nadu, hilly regions of Assam, Rajmahal hills and Chhotanagpur plateau
- Forms 3.2 % of the total land region of the country

## Saline / Alkaline Soil

- Found in arid or semi-arid conditions alongside water logged zones



- Highly saline because of dry atmosphere, poor drainage & high evaporation
- Infertile & does not bolster vegetative development
- They are also known as Usara soils. Different local names for saline soils are Reh, Kallar, and Chopan, Rakar, Thur, Karl etc
- Found in Bihar, Rajasthan, UP., Punjab, Haryana, Maharashtra
- Salinity also Caused because of excessive irrigation in dry conditions which advances capillary action
- In the Rann of Kutch, the Southwest Monsoon brings salt particles and stores there as a crust.
- These soils are also formed when saline water spreads on the land at the time of elevated tide in coastal areas. Also, seawater intrusions in the deltas advance the occurrence of saline soils.
- Salinization also happens on account of over-irrigation (canal irrigation/groundwater use) and in areas of high water table (as in the coastal areas of Maharashtra and Tamil Nadu). Salinity from irrigation can happen over time wherever irrigation occurs. This is on the grounds that practically all water (even natural precipitation) contains some dissolved salts. When the plants use the water, the salts are abandoned in the soil and eventually begin to accumulate.
- Also, excessive irrigation with dry climatic conditions advances capillary action, which results in the deposition of salt on the top layer of the soil.
- Texture ranges from sandy to loamy.
- Because of capillary action, the salts are sucked up in solution to the surface and structure white encrustations on the Surface





## Arid Soil

- The Arid soils consist of Aeolian sand (90 to 95 per cent) and clay (5 to 10 per cent)
- Found in areas with precipitation < 50 cm
- Sandy, permeable, coarse & rich in salts
- Generally saline due to high evaporation
- They are normally poor in organic matter.
- Some Arid soils are alkaline with changing level of soluble salts like calcium carbonate.
- Calcium content increases downwards and the subsoil has multiple times more calcium.
- The phosphate content of these soils is as high as in normal alluvial soils.
- Nitrogen is initially low but some of it is accessible in the form of nitrates.
- Covered with thick brown mantle which represses soil development
- Started from the mechanical breaking down of the ground rock or by deposition by wind
- Plants are widely spaced.
- Chemical weathering is limited.
- Lower horizons of the soil are occupied by 'kankar' layers because of the increasing calcium content downwards. The 'Kankar' layer formation in the bottom horizons restricts the infiltration of water, and as such when irrigation is made available, the soil moisture is readily available for a sustainable plant growth.
- Low precipitation and high temperature are reasons for the formation of this soil
- Found mainly in South Western Haryana & Punjab and Western Rajasthan
- Actually fertile, water being the only limiting factor
- Cereals grown are Jowar, Bajra, Ragi & Oil seeds → Drought resistance crops
- Forms 3.9 % of the total land region of the country

## Mountain Soils

- Soils that are found in the mountains and that belong to almost all the soil types known on earth. The distribution of mountain soils is subject mainly to a vertical (elevation) zonation; the soils change with ascent into the mountains depending on changes in climatic conditions
- These soils have less developed soil profile and mainly found in the valleys and hill slopes of Himalayas.
- In the snow-bound regions of the Himalayas, mountain soils are acidic with low humus content. This is on the grounds that humus is rarer at more elevated levels. Additionally, these soils are exposed to denudation due to landslides and snowfall.
- The soils found in the lower valleys are fertile and rich in organic content.
- Inclined to soil erosion; top soil getting washed away because of the steep slopes of the mountains after an overwhelming precipitation
- Include peat, meadow and forest hill soils
- Wealthy in humus but deficient in potash, phosphorous and lime
- Generally loamy & silty on valley side and coarser in upper inclines
- Valuable for Tea, coffee, spices and tropical fruits
- Regions: Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Assam, Sikkim, Arunachal Pradesh

## Peaty / Organic Soil

- These are marshy soils and are an after-effect of water logging and anaerobic conditions (which prompts partial disintegration of organic matter).
- Found in high precipitation + high humid areas

- Found in Kottayam and Alappuzha districts of Kerala where it is called kari
- Also occur in the coastal areas of Odisha and Tamil Nadu, Sunderbans of West Bengal, in Bihar and Almora district of Uttarakhand.
- Rich in Humus & organic content
- These soils are commonly acidic in nature. But at numerous places, they are alkaline also.
- These are commonly submerged during the rainy season and utilised for the cultivation of rice.

## Soil Erosion

Washing away of topmost fertile layer of the soil by the action of wind or water is known as soil erosion

### Common causes of soil erosion

- Over-grazing
- Deforestation
- Action of wind, water, glacier, etc.
- Topography viz. steep slopes & heavy rainfall
- Faulty methods of agriculture, over – irrigation, shifting agriculture etc.
- Other anthropogenic factors viz. mining, industrial activities etc.

### Effects of Soil Erosion

- Loss of fertile top soil
- Lowering of the underground water table and decreasing soil moisture
- Drying of vegetation and extension of arid lands
- Increase in the frequency of droughts and floods
- Silting of river and canal beds
- Recurrence of landslides

### Zones of Soil Erosion in India

Major Regions	Causes of Erosion
Arid regions of Rajasthan and South Punjab	Wind action
Nilgiris hills of South India	Steep slopes, heavy rainfall and faulty methods of cultivation.
Siwalik Ranges of the Himalaya	Destruction of vegetation and deposition of debris.
North Eastern Region.	Heavy rains, floods and widespread bank cutting.
River banks of arid regions	Transformed into ravines.

## Measures to Conserve Soil

### Terrace Farming

- On uneven slants, terraces go about as bunds and prevent the soil from being washed away



- Cultivating is done on a one of a kind step like structure and the power of water running off is eased back down

### Contour ploughing

- Land ought to never be ploughed up & down as it increases erosion
- Ploughing along contours on a slant forestalls soil being washed away by water or by surface run off



- Contours act like bunds and hence prevents soil erosion by permitting water to gradually penetrate the soil



## Contour barriers / Contour trenching

- Contourstrips catch downslope flowing water and soil particles
- A few 2 feet by one-foot trenches are formed across the slants at appropriate intervals
- Tree seedlings are to be planted above the Channel.
- These hindrances slow down the water movement and decrease its erosive force
- They additionally filter out and trap a considerable lot of the suspended soil particles, shielding them from being washed out of the field



## Afforestation

- Planting of trees along the edges of the fields, the waste land and on steep inclines to prevent soil erosion
- Additionally, to upgrade the capacity of the soil to retain water

## Shelter Belts

- A line of trees or bushes planted to ensure an area, particularly a field of crops, from fierce weather
- Farmers plant trees in few columns to check wind erosion
- Also known as wind breaks

## Cover crops / Crop rotations

- Cover crops such as legumes, white turnip, radishes and other species are pivoted with cash crops to cover the soil year-round
- Go about as green compost that recharges nitrogen and other basic supplements
- Also help smother weeds & increase soil fertility

## No-till farming

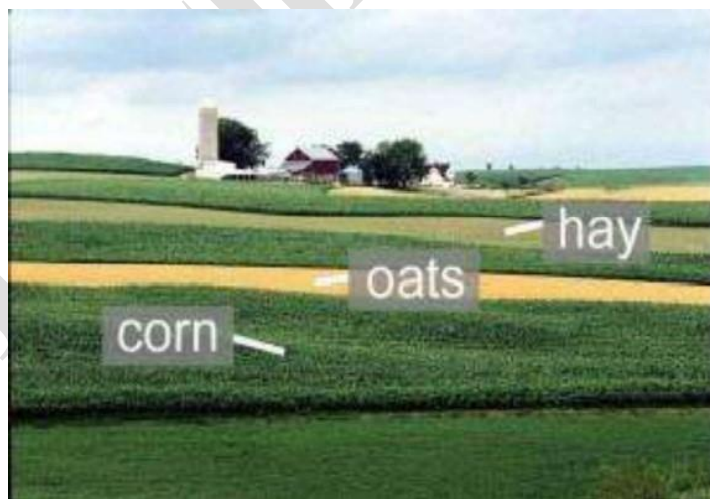
- Also called zero tillage or direct penetrating
- A method of growing crops or pasture from year to year without upsetting the soil through tillage
- Increases the measure of water that invades into the Soil



- Also builds organic matter retention and cycling of supplements in the soil
- keeps soils tied down in place rather than having uncovered ground exposed to wind and water

## Strip Cropping

- Crops are grown in alternate strips of land to check the effect of the wind
- It is utilised when an incline is excessively steep or when there is no alternative technique of preventing soil erosion.
- Contour strip cropping → Cultivation of soil ensuring crops in strips alternating with erosion permitting crops. The strips ought to be across the slope.
- Field strip cropping → Plants are cultivated in parallel strips across the slopes



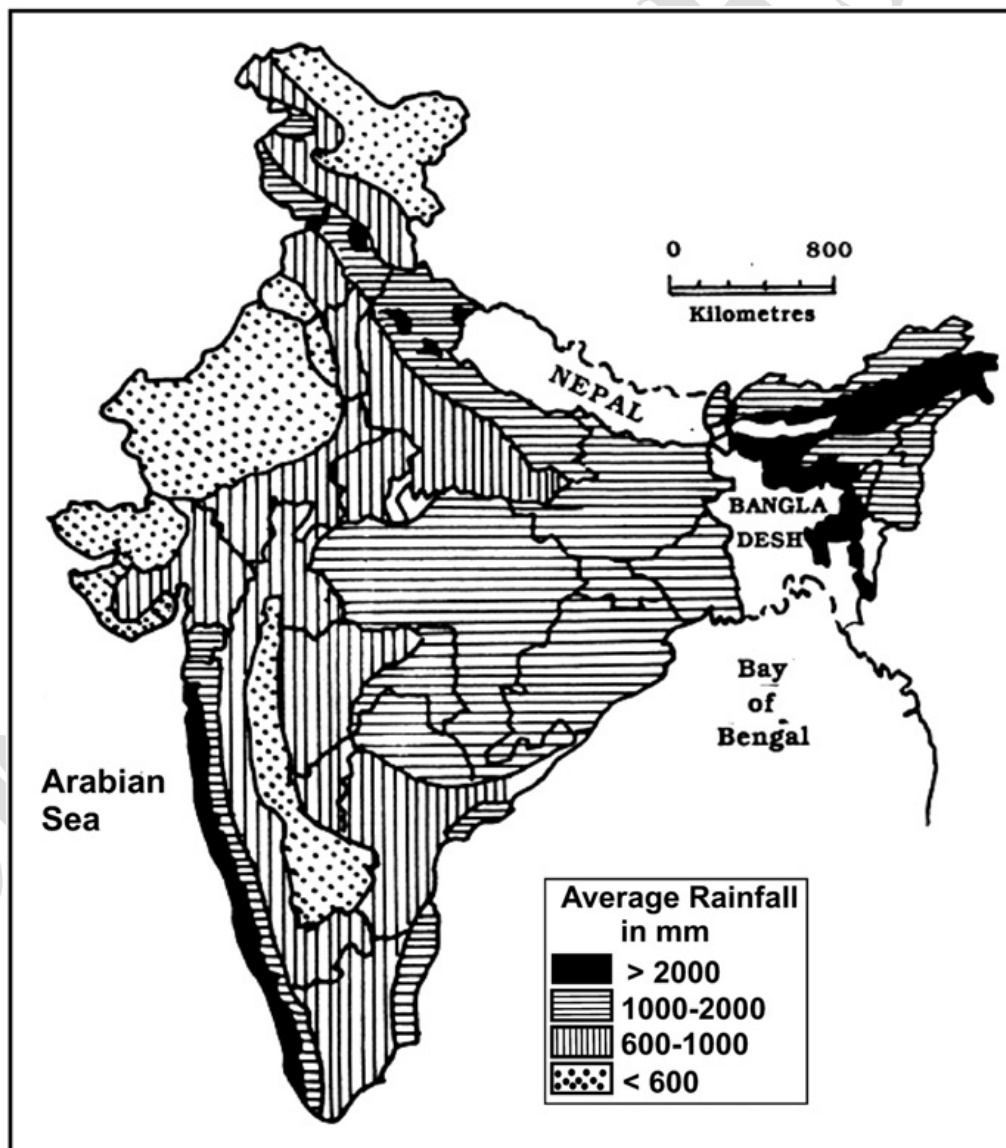
## Mulching

- Mulches are materials put over the soil surface to keep up moisture and improve soil conditions
- A defensive layer of a material that is spread on top of the soil
- Mulches can either be natural, such as grass clippings, straw, bark chips, and similar materials
- Or inorganic, such as stones, brick chips, and plastic

## CH-8 VEGETATION

Our country India is one of the 12 mega bio-diversity countries of the world. With about 47000 plant species, India occupies tenth place in the world and fourth in Asia in plant diversity. There are about 15000 flowering plants in India, which account for 6% in the world's total number of flowering plants. The country has many non-flowering plants, such as ferns, algae and fungi. India also has approximately 90000 species of animals, as well as, a rich variety of fish in its fresh and marine waters. Natural vegetation refers to a plant community, which has grown naturally without human aid and has been left undisturbed by humans for a long time. This is termed as a virgin vegetation. Thus, cultivated crops and fruits, orchards form part of vegetation but not natural vegetation. The term flora is used to denote plants of a particular region or period. Similarly, the species of animals are referred to as fauna. This huge diversity in flora and fauna kingdom is due to the following factors.

### DISTRIBUTION OF RAINFALL

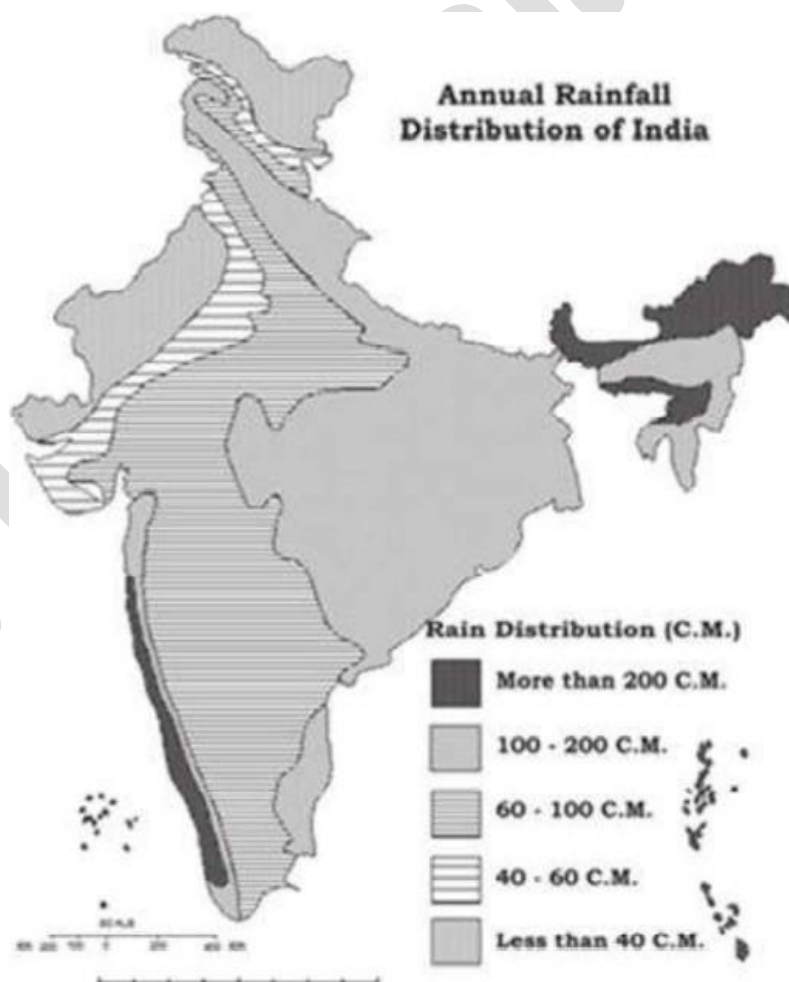




The rainfall in India is seasonal, uncertain and unevenly distributed. Most of the rain comes during the South-West Monsoon period. Rainfall may be too much or too little. There are also long dry periods in between. On the basis of the quantity of rainfall, we can divide India into five major rainfall regions.

1. Very low rainfall region (Less than 40 cms per year). It is found in Karakoram ranges, northern Kashmir and western parts of Kachchh and Rajasthan (Thar desert).
2. Low rainfall region (40 cms to 60 cms. per year). It is found in Zaskar range, parts of Punjab and Haryana, Central Rajasthan, Western Gujarat and the rainshadow areas of the Western Ghats.
3. Moderate rainfall (60 cms. to 100 cms. per year). It is found over a greater part of India, excluding the areas of low rainfall and heavy rainfall. Most of the rain is from the South-West Monsoon winds.
4. Heavy rainfall region (100 cms. to 200 cms. per year). It is found in four separate areas, including a narrow belt of the western coast, eastern coastal belt, the foothills of the Himalayas and a part of north-east India.
5. Very heavy rainfall region (over 200 cms. per year). It is found on the western side of the Western Ghats, the foothills of Himalayas, Meghalaya plateau (Shillong plateau) and Andaman and Nicobar Islands. Mawsynram in Meghalaya plateau has recorded 1141 cms. of rainfall per year and it is the place which gets the heaviest rainfall in India/world.

## Rainfall Variability



A characteristic feature of rainfall in India is its variability. The variability of rainfall is computed with the help of the following formula:

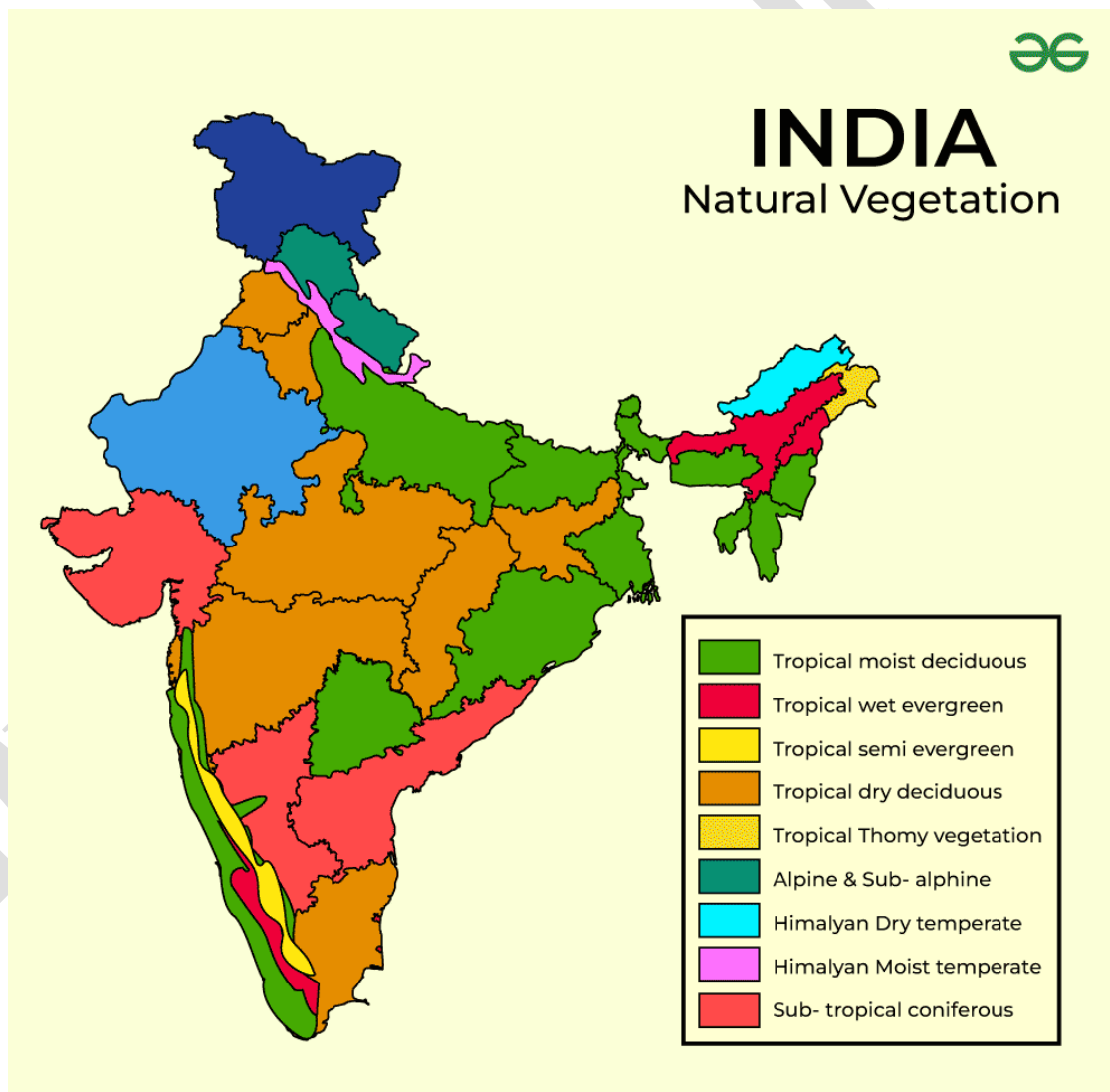
$$C. V. = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100$$

Where C. V. is the coefficient of variation

- The values of coefficient of variation show the change from the mean values of rainfall. The actual rainfall in some place's deviates from 20-50%.
- A variability of less than 25% exists on the western coasts, Western Ghats, northeastern Peninsula, eastern plains of the Ganga, northeastern India, Uttarakhand and Himachal Pradesh and southwestern part of Jammu and Kashmir. These areas have an annual rainfall of over 100 cm.
- A variability of over 50% exists in the western part of Rajasthan, northern part of Jammu and Kashmir and interior parts of the Deccan plateau. These areas have an annual rainfall of less than 50 cm.
- Rest of India have a variability of 25-50% and these areas receive an annual rainfall between 50 - 100 cm.

## Precipitation

- Areas of heavy rainfall have more dense vegetation as compared to other areas of less rainfall.



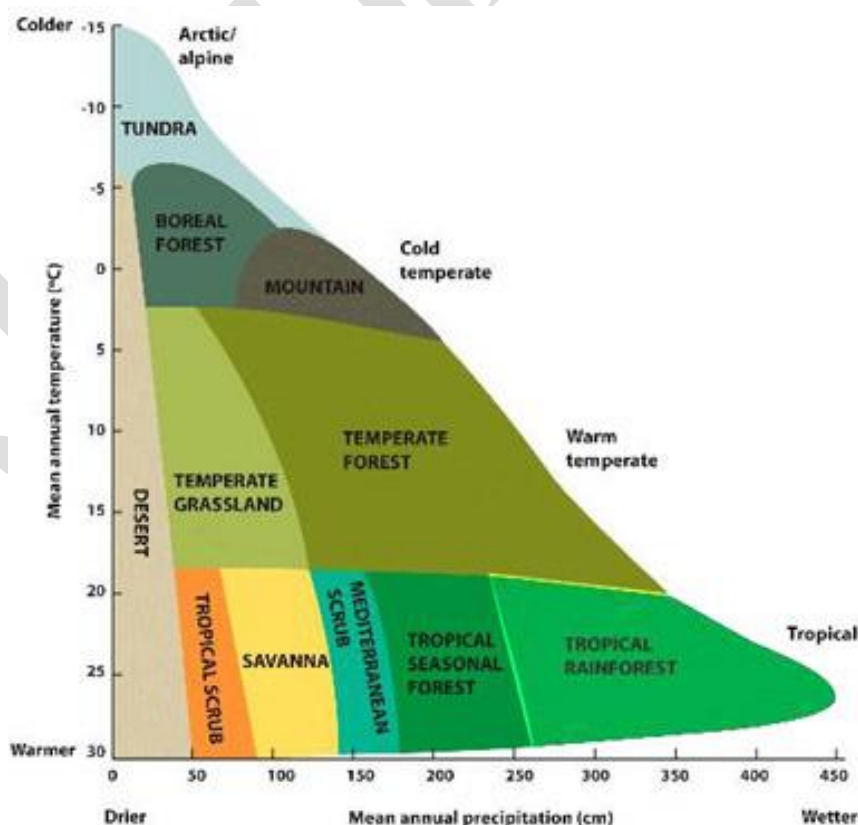
## Temperature and Humidity

- Temperature and humidity are the major factors which determine the character and extent of vegetation.
- For example, an area with high temperature and high humidity supports evergreen forest, while an area with high temperature and low humidity supports thorny bushes (desert).

See the following diagram to understand the combined effect of temperature and annual precipitation on the vegetation type of an area:

**Temperature Characteristics of the Vegetation Zones**

Vegetation Zones	Mean annual Average Temp. (In degree C)	Mean Temp. in January (In degree C)	Remarks
Tropical	Above 24°C	Above 18°	No Frost
Subtropical	17°C to 24°C	10°C to 18°C	Frost is rare
Temperate	7°C to 17° C	-1°C to (-10) °C	Frost some snow
Alpine	Below 7°C	Below -1°C	Snow



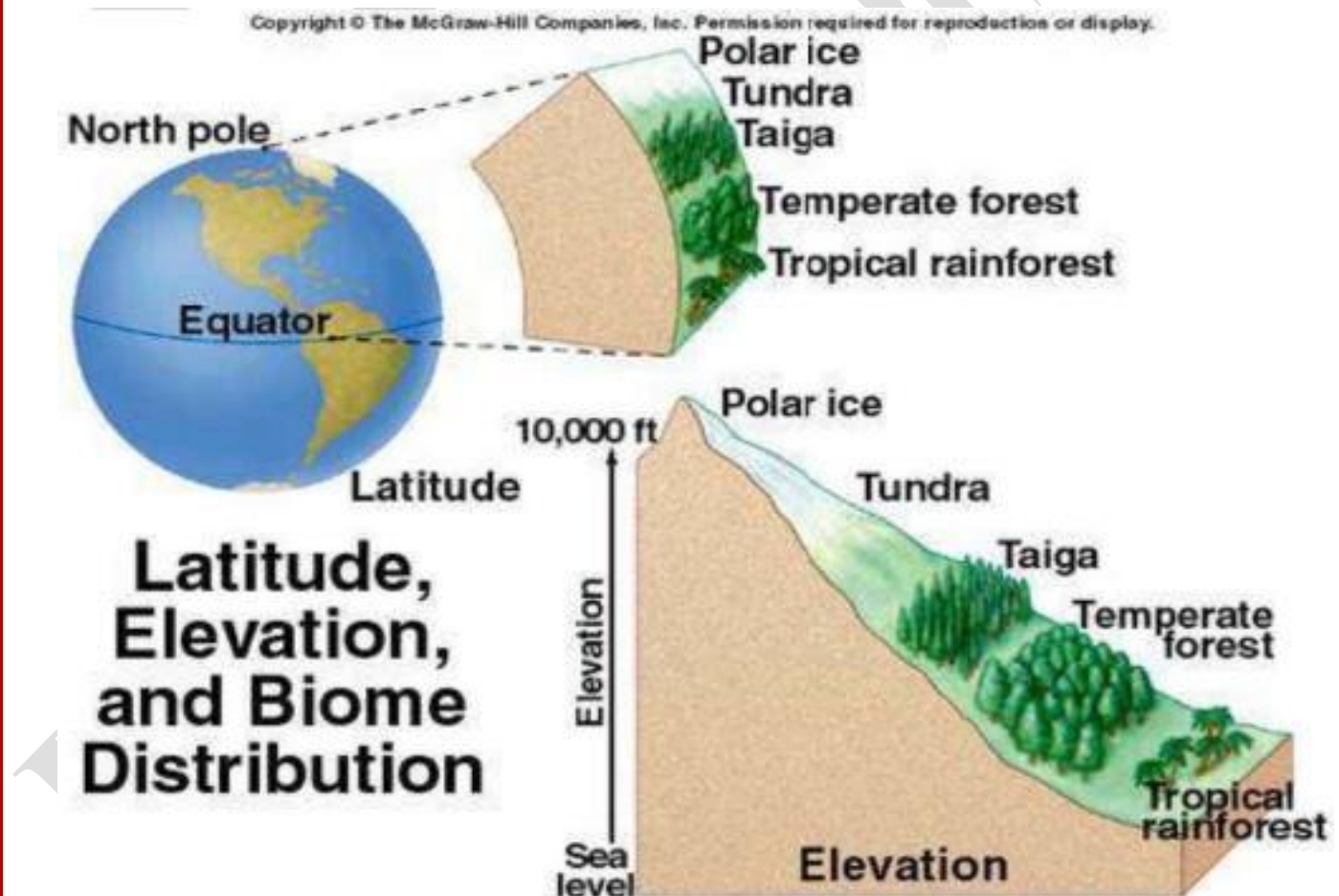


## Sunlight

- The duration of light or day length variation at different places is caused because of the differences in latitude, altitude, season and duration of the day.
- Due to longer duration of sunlight, trees grow faster in summer.

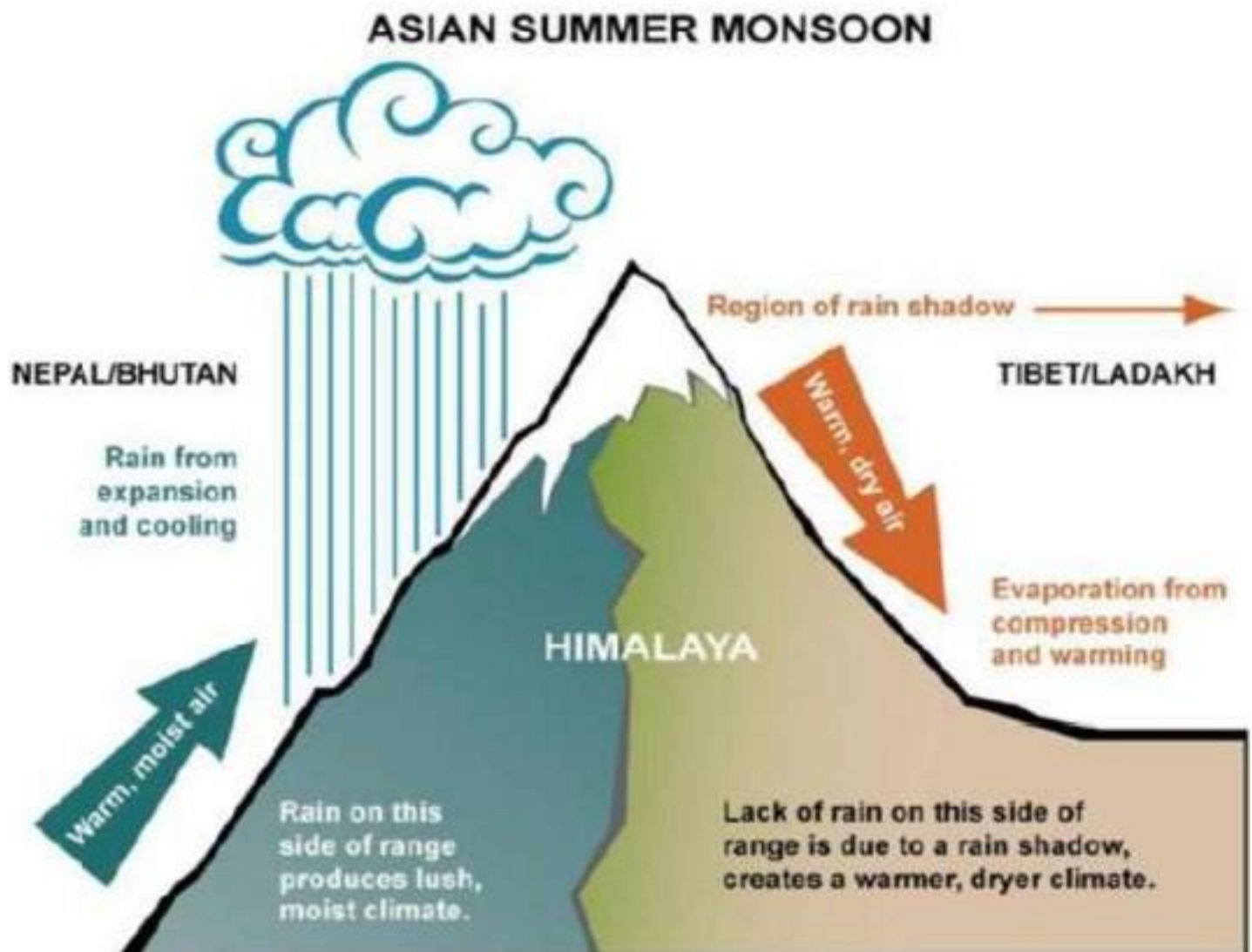
## Altitude

- Latitude, or how far one is from the equator, greatly affects the climate and weather of an area. If you live close to the equator, the climate will be warmer, while moving north or south from the equator brings a cooler climate. Altitude, or how high one is above sea level, has a similar effect—the higher the elevation, the colder the climate.
- Vegetation is partially determined by altitude. More specifically, vegetation is determined primarily by temperature and precipitation and altitude is going to have effects on both temperature and precipitation.
- As altitude increases, temperature decreases. This is going to change the structure and composition of our biome. For example, in the image below, as we increase in elevation or altitude, we see that there is different vegetation and eventually less and less vegetation.



- Precipitation and altitude is a bit more complex. Higher elevations typically receive snow instead of rain because the temperature is lower. Mountains can trap moisture on one side, leading to an increase in precipitation in this area but lower amounts of precipitation on the opposite of the mountain. See the image below for more explanation.

- Thus, altitude is going to affect both temperature and precipitation which will affect the composition of biome.
- It was Alexander Von Humboldt who first recognised the relationship between vegetation and altitude.



## Land

- The natural vegetation is affected directly and indirectly by the nature of land.
- For example, the type of vegetation in the mountainous regions is different than that in the plateau and plain areas.
- The fertile land is generally used for agriculture, while the undulating and rough terrains are the region of grassland and woodlands that give shelter to a variety of wildlife.

## Soil

- Different types of soils help in creating different types of vegetation.
- The sandy soils of the desert support cactus and thorny bushes whereas wet, marshy, deltaic soils support mangroves and deltaic vegetation.
- The hill slopes with some depth of soil have conical trees.



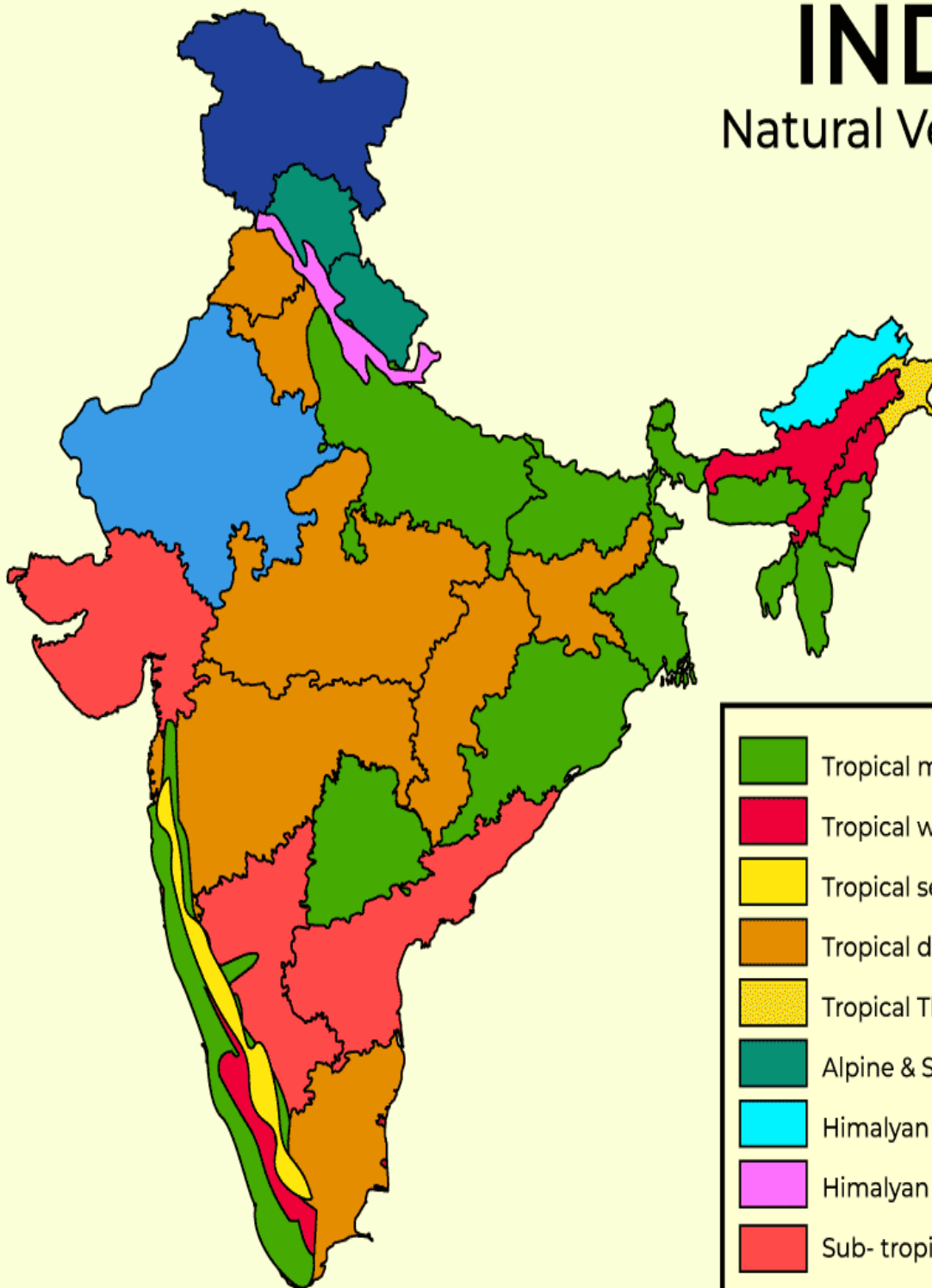


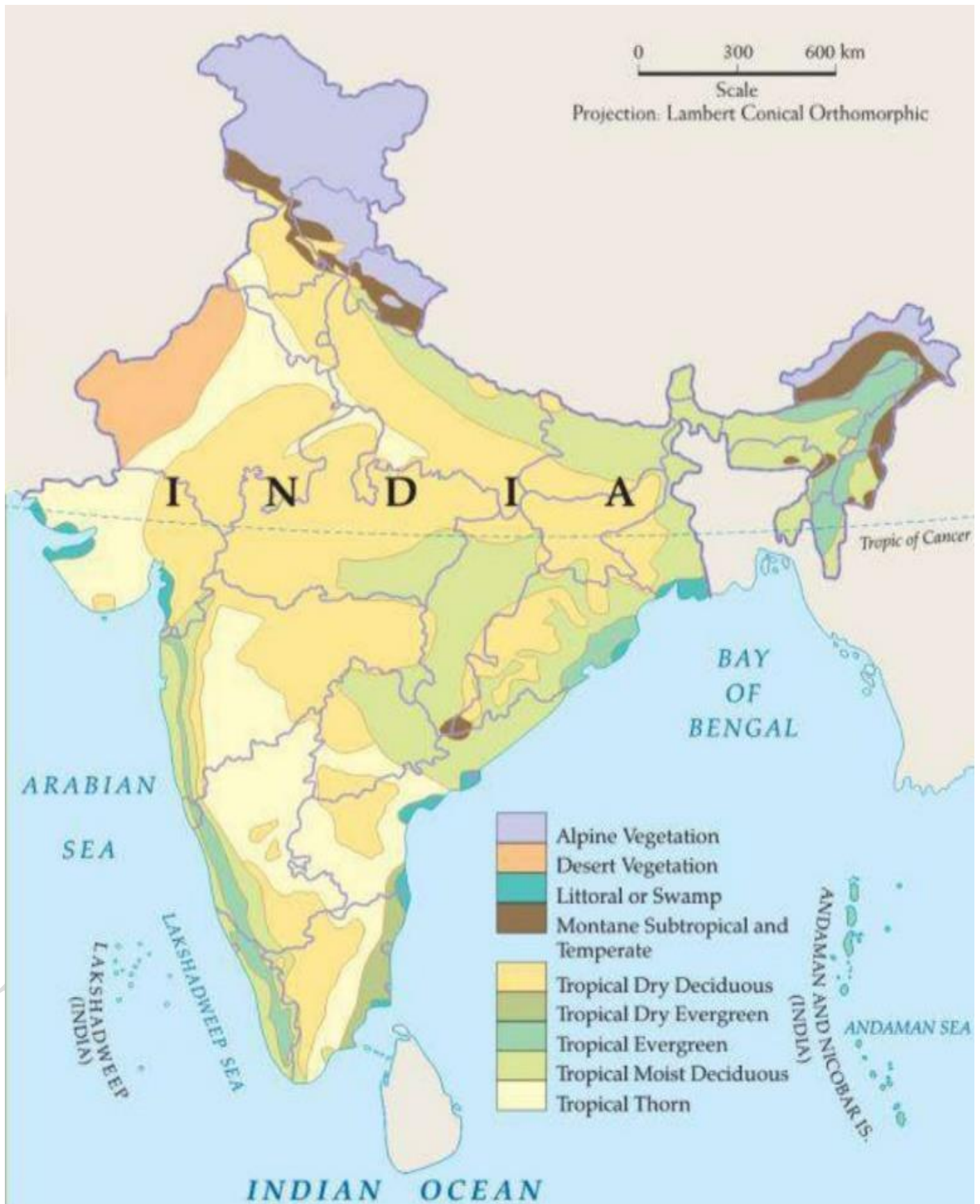




## INDIA

### Natural Vegetation





## TYPES OF VEGETATION IN INDIA

### Moist Tropical Forests

- Tropical Wet Evergreen
- Tropical Semi-Evergreen
- Tropical Moist Deciduous
- Littoral and Swamp

### Dry Tropical Forests

- Tropical Dry Evergreen
- Tropical Dry Deciduous
- Tropical Thorn

### Montane Sub-Tropical Forests

- Sub-tropical broad-leaved hill
- Sub-tropical moist hill (pine)
- Sub-tropical dry evergreen

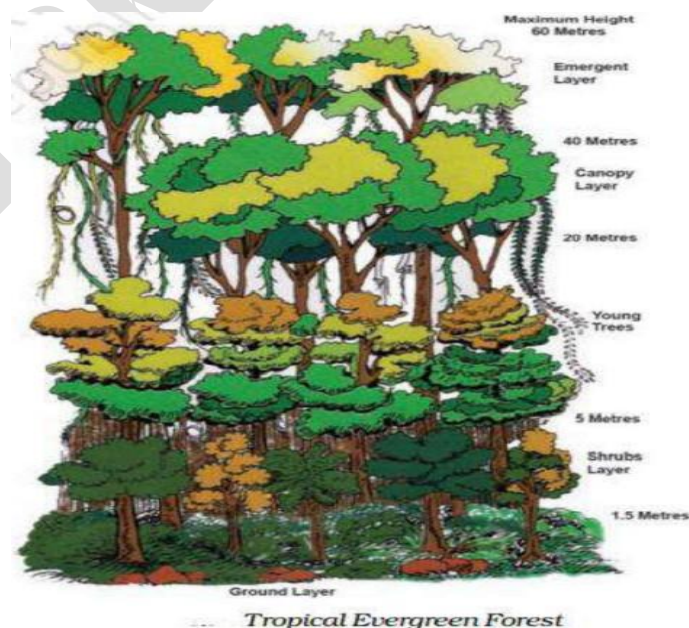
### Montane Temperate Forests

- Montane Wet Temperate
- Himalayan Moist Temperate
- Himalayan Dry Temperate

### Alpine Forests

## MOIST TROPICAL FORESTS

## TROPICAL WET EVERGREEN FORESTS OR RAIN FORESTS





## Distribution

- Western side of the Western Ghats (500 to 1370 metres above sea level).
- Some regions in the Purvanchal hills.
- In the Andaman and Nicobar Islands.

## Climatic Conditions

- Annual precipitation exceeds 250 cm with a short dry season.
- The annual temperature is between 25°-27°C.
- The average annual humidity exceeds 77%.

## Characteristics

- The trees of these forests do not shed their leaves together due to high heat and high humidity.
- Plants are *Mesophytic* and are adopted to neither too dry nor too wet type climate.
- *Lofty*: The trees have lofty height often reaching to 45-60 metres.
- The tropical rain forest appears like a thick canopy of foliage from the air. It only breaks when it is crossed by large rivers or cleared for cultivation.
  - The sun light rarely reaches the ground due to thick canopy causing less undergrowth. The undergrowth is formed mainly of bamboo, ferns, climbers, orchids, etc.
- All plants struggle upwards (most epiphytes) for sunlight resulting in a peculiar layer arrangement. The entire morphology looks like a green carpet when viewed from above.



## Timber

- The timber of these forests is durable fine-grained Hardwood.
- It has high commercial value but difficult to exploit because of high density and lack of transportation facilities.
- The important species of these forests are mahogany, mesua, white cedar, jamun, canes, bamboo etc.

## TROPICAL SEMI-EVERGREEN FORESTS

- They are transitional forests lying in between tropical wet evergreen forests and tropical deciduous forests.
- *They are comparatively drier areas in comparison to tropical wet evergreen forests.*

### Climatic Conditions

- Annual rainfall is in between 200-250 cm.
- Mean annual temperature fluctuates between 24°C to 27°C.
- The relative humidity is about 75%.
- The dry season is long in comparison to tropical evergreen forests.

### Distribution

- Western coast
- Assam
- Lower slopes of the Eastern Himalayas
- Odisha and Andamans.

### Characteristics

- The semi-evergreen forests are less dense and are more gregarious (living in flocks or colonies) than the wet evergreen forests.
- These forests possess many species.
- Trees usually have buttressed trunks with abundant epiphytes.



- The important species are: -
  - Rosewood, mesua, laurel, thorny bamboo in Western Ghats
  - White cedar, mango, Indian chestnut, champa, etc. in Himalayan region.

### Timber

- Hardwood just like in tropical evergreen forests except that these forests are less dense with more pure stands (timber industry here is better than in evergreen forests).

## TROPICAL MOIST DECIDUOUS FORESTS Distribution

- It is found along the Western Ghats surrounding the belt of evergreen forests.
- Belt running along the Western Ghats surrounding the belt of evergreen forests.
- A strip along the Shiwalik range including terai and bhabar region.
- Regions of Manipur and Mizoram.
- Hills of eastern Madhya Pradesh and Chhattisgarh, Chota Nagpur Plateau, most of Odisha, parts of West Bengal, and Andaman and Nicobar Islands.

## Climatic Conditions

- Annual rainfall is in between 100 to 200 cm.
- Mean annual temperature is about 27°C
- The average annual relative humidity is in between 60-75%.
- Spring (season between summer and winter) and summer are dry.

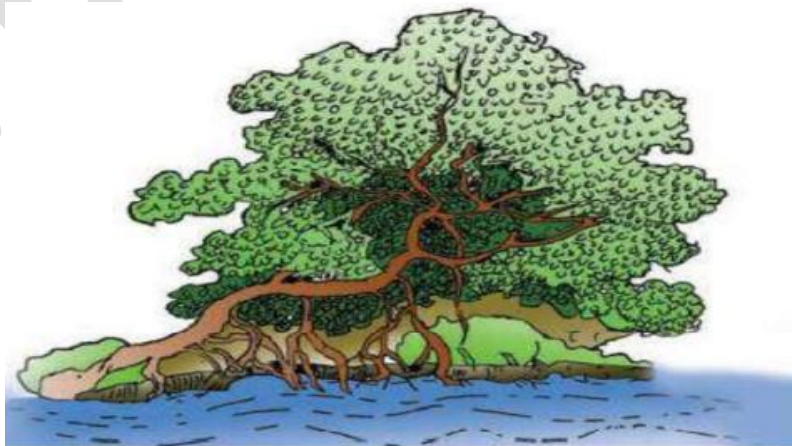
## Characteristics

- The trees drop their leaves during the spring and early summer because of the insufficient moisture in the atmosphere.
  - The general appearance is bare in extreme summers (April-May).
- Tropical moist deciduous forests present irregular top storey (25 to 60 m), heavily buttressed trees, and undergrowth.
- These forests cover much larger area than the evergreen forests but major tracts under these forests have been cleared for cultivation.

## Timber

- The main species found in these forests are teak (valuable timber), sal, laurel, rosewood, amla, jamun, bamboo, etc.
- Due to the high degree of gregarious (more pure stands) trees, it is comparatively easy to exploit these forests.

## Littoral and Swamp Vegetation (Mangrove Vegetation / Tidal Forests)



Mangrove Forests



- mangrove vegetation found in the tidal deltas of Ganga, Mahanadi, Godavari and Krishna rivers.
- These areas have rainfall of more than 200cm.
- Important Tree Species are Sundari, Agar, Bhendi, Keora, Nipa.
- Turtles, crocodiles, gharials, and snakes are also found in these forests. Royal Bengal Tiger is the famous animal in these forests.
- Characteristic Features:
  - The trees are mainly evergreen.
  - Typically, they produce tangled webs of arching roots that are exposed during low tides.
  - This vegetation is an adaptation to two conditions:
    - High water salinity
    - Flooded at regular intervals
  - Prominent among these adaptations are the presence of stilt roots, buttress, pneumatophores etc.
    - Stilt roots (also called prop roots) are the outgrowth of the trunk, branches or already existing stilt roots in the mangrove. As soon as stilt roots reach the ground, the tip of the stilt root develops an underground root system connecting the stilt root into the ground and then developing further stilt.



- Buttress Roots – Competition over nutrients is almost as intense as competition for light. The excessive rainfall rapidly dissolves nutrients in the soil, making it relatively infertile except at the top layers. For this reason, rainforest tree roots grow outward to cover a wider area, rather than downward to lower levels. This makes rainforest trees somewhat unstable, since they don't have very strong anchors in the ground. Some trees compensate for this by growing natural buttresses. These buttresses are basically tree trunks that extend out from the side of the tree and down to the ground, giving the tree additional support.
- Pneumatophores are specialized aerial roots stemming from a subterranean root system, which enable plants to utilize air in waterlogged soil habitats. These have pores which enable the trees to breathe when other roots are submerged under water during high tide.
- Mangrove shrubs act as “green shields” buffering the coastline against sea erosion and the potential devastating impacts of cyclones and tsunamis.



## DRY TROPICAL FORESTS

## TROPICAL DRY EVERGREEN FORESTS

### Distribution

- Along the coasts of Tamil Nadu.
- These forests are found in the areas of relatively high temperature and small rainfall available only during summers.

### Climatic Conditions

- Annual precipitation of about 100 cm
  - mostly from the north-east monsoon winds in October–December.
- Mean annual temperature is about 28°C.
- The mean humidity is about 75%.

### Characteristics

- *Short statured trees up to the height of 12 meter with complete canopy.*
- Dense distribution of mixed small evergreen and deciduous Trees of 10 to 15 meter height.
- Bamboos and grasses are not conspicuous absent.
- The important species are neem, jamun, tamarind, etc.
- Most of the land under these forests has been cleared for agriculture or casuarina plantations.



## TROPICAL DRY DECIDUOUS FORESTS



### Distribution

- They occur in an irregular wide strip running from the foot of the Himalayas to Kanyakumari except in Rajasthan, Western Ghats and West Bengal.

### Climatic Conditions

- Annual rainfall is 100-150 cm.
- These forests are found in areas having temperatures of 25-32°C and annual rainfall of 75-125 cm along with a dry season of about six months.

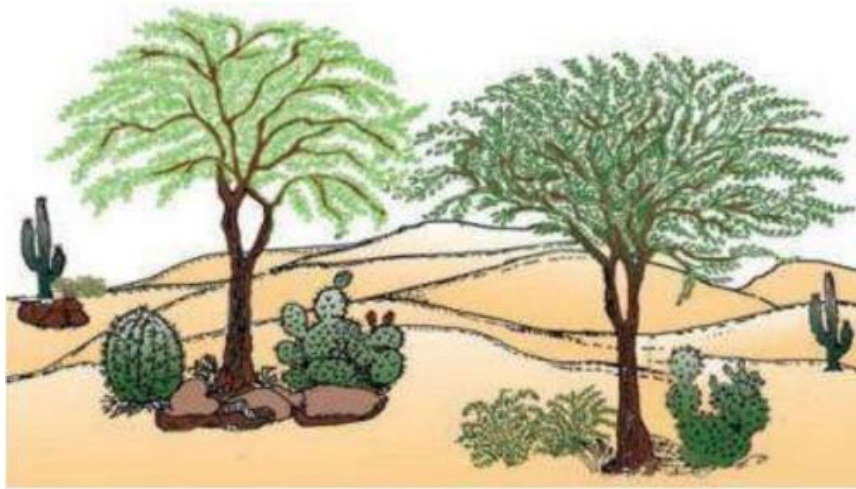
### Characteristics

- These forests shed their leaves in the dry season like the moist deciduous forests.
  - The major difference is that they can grow in areas of comparatively less rainfall.
- They are transitional types with moist deciduous on the wetter side and thorn forests on the drier side.
- Chief characteristic feature of the forests is the open canopy of small (10-15 m high) trees and abundance of shrubs.
- The forests include a mixture of a few deciduous trees species rising up to a height of 20 metres.
- Enough light penetration to the ground permits the undergrowth.
- The important species are Teak, Sal, Laurel, Palas, Khair, Tendu, Amaltas, Bel, Axlewood etc
- Large tracts of this forest have been cleared for agricultural purposes.
- These forests have suffered from overgrazing, fire, etc.

### TROPICAL THORN FORESTS Distribution

- These forests are distributed in western Rajasthan, Madhya Pradesh, south-western Punjab, western Haryana, Kachchh and neighbouring parts of Saurashtra.
  - Here they degenerate into desert type in the Thar desert.
- Such forests also grow on the leeward side of the Western Ghats covering large areas of Karnataka, Telangana, Andhra Pradesh, Maharashtra, and Tamil Nadu.





*Thorn Forests and Scrubs*

## Climatic Conditions

- These forests are found in the areas of high temperature of 27-30°C and very low annual rainfall of 20-60 cm with long periods of dryness (Humidity is less than 50%).

## Characteristics

- Scattered distribution of small (8-10 in high) mostly thorny trees with shrubs being more common than trees.
- The plants in these forests develop leaves only during the brief rainy season when grasses and herbs also become abundant and remain leafless for most of the year.
- Acacias and Euphorbias are very prominent.
- The Indian wild date is common. Some grasses also grow in the rainy season.

## MONTANE SUB-TROPICAL

## SUB-TROPICAL BROAD-LEAVED HILL

## FORESTS

### Climatic conditions

- Mean annual rainfall is in between 75 cm to 125 cm.
- Average annual temperature is in between 18°-21°C.
- Humidity is 80%.

### Distribution

- These forests occur in relatively moist areas at lower altitudes (varying from 1000 to 2000 m) on mountain ranges.
- They are majorly found in eastern Himalayas of West Bengal and Assam, hills of Khasi, Mahabaleshwar and Nilgiri.

## Characteristics

- Chief characteristic feature of the forests is dense growth of climbers and epiphytic fern and orchids.
  - Epiphytes are the plants that grow nonparasitically on a tree or other plant.
- Commonly found species are evergreen oaks, chestnuts, ash, beech, sals and pines.
- Dominant tree in the forests of the north are Quercus, Schima and Castanopsis with some temperate species.

## SUBTROPICAL MOIST PINE FORESTS

### Distribution

- These forests occur at middle altitudes between the range of 1500-2000 meters in the Himalayas.
- They are distributed in western Himalayas from Kashmir to Uttar Pradesh.
- In eastern Himalayas, the forests occur in the hilly regions of Arunachal Pradesh, Manipur, Naga Hills and Khasi Hills.

### Timber



- Chir or Chil is the most dominant tree which forms pure stands.
- It provides valuable timber for boxes, furniture, and buildings and also used in resin and turpentine production.

## SUB-TROPICAL DRY EVERGREEN FORESTS

### Distribution

- These forests occur in areas basing quite low temperature and rainfall.
- The forests are distributed in the lower altitudes of eastern and western Himalayas, the Bhabar and the Shiwaliks regions up to about 1000 metres above sea level.

## Climatic Conditions

- Annual rainfall is in between 50-100 cm (15 to 25 cm in December-March).
- The summers are sufficiently hot and winters are very cold.

## Characteristics

- Low scrub forest with small evergreen stunted trees and shrubs.
- Olive, acacia modesta and pistacia are the most predominant species.
- Chief characteristic feature of the forests is the presence of thorny xerophytes and small –leaved evergreen plants.

## MONTANE TEMPERATE

### HIMALAYAN DRY TEMPERATE FORESTS

## Climatic Conditions

- These forests are present in the very low rainfall regions of Himalayas.
- Precipitation is below 100 cm and occurs mostly in the snow form.

## Characteristics

- Coniferous forests with xerophytic shrubs.
- Important Species are Chilgoza, Deodar, oak, ash, olive, etc.

## Distribution

- Such forests are found in the inner dry ranges of the Himalayas where south-west monsoon is very feeble like Ladakh, Lahul, Chamba, Kinnaur, Garhwal and Sikkim.

### HIMALAYAN MOIST TEMPERATE FORESTS

## Climatic Conditions

- These areas have annual rainfall above 100 cm but relatively less than the areas of wet temperate forests.

## Distribution

- These forests are found at the altitude of 1700-3500 meters in eastern and western Himalayas.
- Cover the entire length of this mountain range in Kashmir, Himachal Pradesh, Uttarakhand, Darjeeling and Sikkim.

## Characteristics

- Mainly composed of coniferous species.
- Species occur in mostly pure strands.
- Trees are 30 to 50 m high.
- Pines, cedars, silver firs, spruce, etc. are the most important trees.



- They are high but open forest having shrubby undergrowth like rhododendrons, oaks, and some bamboo.

## Timber

- The wood from the region is used in construction, timber and railway sleepers.

## MONTANE WET TEMPERATE FORESTS

### Climatic Conditions

- Mean annual rainfall is in between about 150 cm to 300 cm.
- Mean annual temperature is in between about 11°C to 14°C.
- Average relative humidity is over 80%.

### Distribution

- These forests are present at heights of 1800-3000 meter in the cooler and humid mountains.
- Distributed in
  - Eastern Himalayas from eastern Nepal to Assam.
  - Western Himalayas from Kashmir to western Nepal.
  - Higher hills of Tamil Nadu and Kerala.

### Characteristics

- Since rainfall is high as well as temperature is moderate in summer and cool in winter, the rate of evaporation is not high. So trees do not shed their leaves annually, at least not at the same time.
- These are closed evergreen forests with large circumference Trunks.
- Branches are clothed with mosses, ferns, and other epiphytes.
- The trees rarely reach to the height of more than 6 metres.
- In south India, these forests are termed Shola forests and mostly have 15-20 m high broad-leaved trees with dense leaf canopy, abundant epiphytic flora and rich herbaceous undergrowth.
- Oak, Poplar, Elm, Laurel, Maple, Birch, Alder, Magnolia, etc. are important species.

## ALPINE VEGETATION

- They are found above 2700 meter of altitude in the eastern Himalayas and above 3000 meter in the western Himalayas.
- It is a dense scrubby forest of Birch, Rhododendron, Juniper, Pine, and Silver Fir

### Characteristic Features

- These forests can be divided into:
  1. sub-alpine
  2. moist alpine scrub
  3. dry alpine scrub
- The alpine forests extend upwards up to the snowline and give way to alpine grasslands through shrubs and scrub.
- These areas are characterised with short dwarf conifers and lush green nutritious grasses during the summer season.



# Dr Lakshmaiah IAS Study Circle



20B, Opp: HDFC Bank, Main Road, Old Rajinder Nagar

New Delhi-110060 Ph No: +91 9773731858

## Bugyals

Bugyals are high altitude alpine grasslands or meadows with flat or sloped topography of the terrain found in Uttarakhand (at an elevation between 3400m and 4000m) and referred to as 'nature's own gardens'. The surface of these bugyals is covered with natural green grass and

seasonal flowers. They are used by tribal herdsmen to graze their cattle. During the winter season the alpine meadows remain snow-covered. During summer months, the Bugyals present a riot of beautiful flowers and grass.

Bugyals have a very fragile ecosystem. Some examples of Bugyals:

- Auli (near Joshimath) – A premier skii range is located here.
- Gorso
- Kwani Bugyal
- Bedni
- Panwali and Kush Kalyan
- Dayara
- Munsiyari Bugyal