GEOGRAPHY

Shorts Notes

For UPSC 2022

IAS NETWORK

TOPICS COVERED :

GEOGRAPHY

Indian geography.

- Location and the land Border.
- Physiography of India.
- Drainage system.
- Climate of India.
- Minerals and industries.
- Agriculture and soils.
- water resources
- Land use and agriculture.
- Major crops in India.
- Transport and communication.
- Power sector in India
- Demography of India.

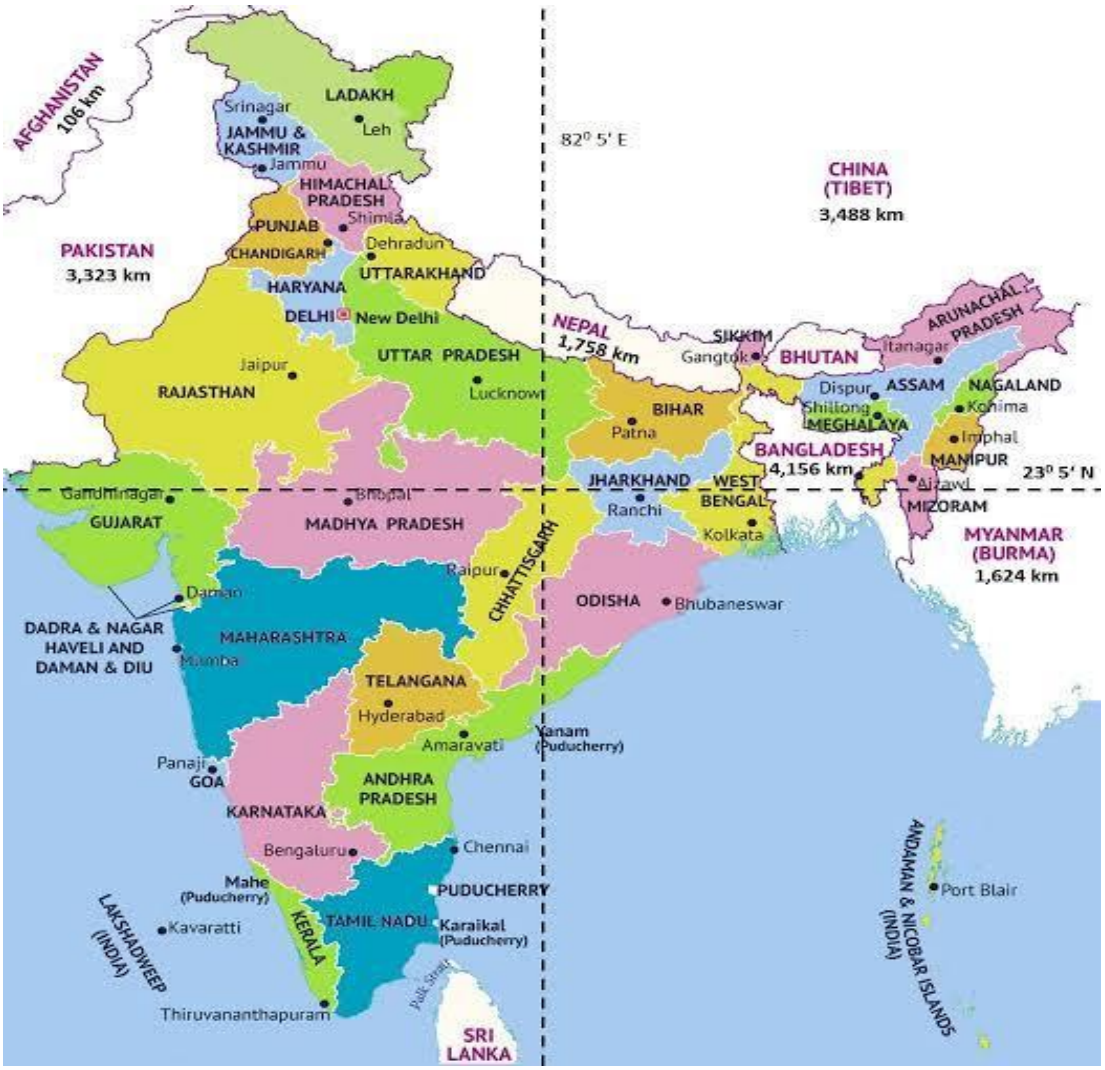
Physical geography.	
Geomorphology	• Origin of earth • Solar system. • Interior of earth. • Types and characteristics of rocks. • Theories of continent formation. • Volcanoes and earthquakes. • Landforms • Weathering and mass erosion.
Climatology	• Atmosphere and its structure. • Heat and temperature. • Pressure. • Winds. • Monsoon. • El Nino and la Nina. • Clouds and precipitation. • Cyclone and anticyclones
Oceanography	• Ocean bottom relief. • temperature distribution • Ocean density. • Salinity. • Ocean currents. • Tides wave and tsunami. • Coral reefs and atolls.

	• Maritime Zone
Biogeography	• Soils of the world. • Tribes of the world. • Local winds. • Settlement geography.

INDIAN GEOGRAPHY

LOCATION :

- Entirely located in the northern hemisphere , in Asia Continent.
- India is 7th Largest Country in world with 2.4% area of world.
- **Latitude** : 8°4'N and 37°6'N
- **Longitudes** : 68°7'E and 97°25'E
    - The latitudinal and longitudinal extent of the mainland is about 30°



About Boundary of India : (UPSC 2015, 2018 PRE)

- India has land boundary of about 15,200 km
    - The Northern most point – Indira Col (Ladakh UT)
    - Southern most point - Pygmalion Point or Indira Point is located at 6° 45′ N latitude.
    - Eastern most point – Kibithu In Arunachal Pradesh

  - Western Most point – Ghaur Moti (Gujrat)
- The total length of the coastline of the mainland, including Andaman and Nicobar and Lakshadweep, is 7,516.6 km.

About Time Zone :

- The 82°30' E is the standard meridian passing through Mirzapur(Uttar Pradesh) in the Standard time zone of India.
- This meridian passes through –
  - Uttar Pradesh
  - Madhya Pradesh
  - Chhattisgarh
  - Odisha
  - Andhra Pradesh
- From Gujarat to Arunachal Pradesh There is 2 hour time difference.

Tropic of Cancer :

- The Tropic of Cancer passes through eight states in India:
  - Gujarat (Jasdan), Rajasthan (Kalinjarh), MadhyaPradesh (Shajapur), Chhattisgarh (Sonha t), Jharkhand (Lohardaga), WestBengal (Krishnanagar), Tripura (Udaipur)and Mizoram (Champhai).

Coastline of India

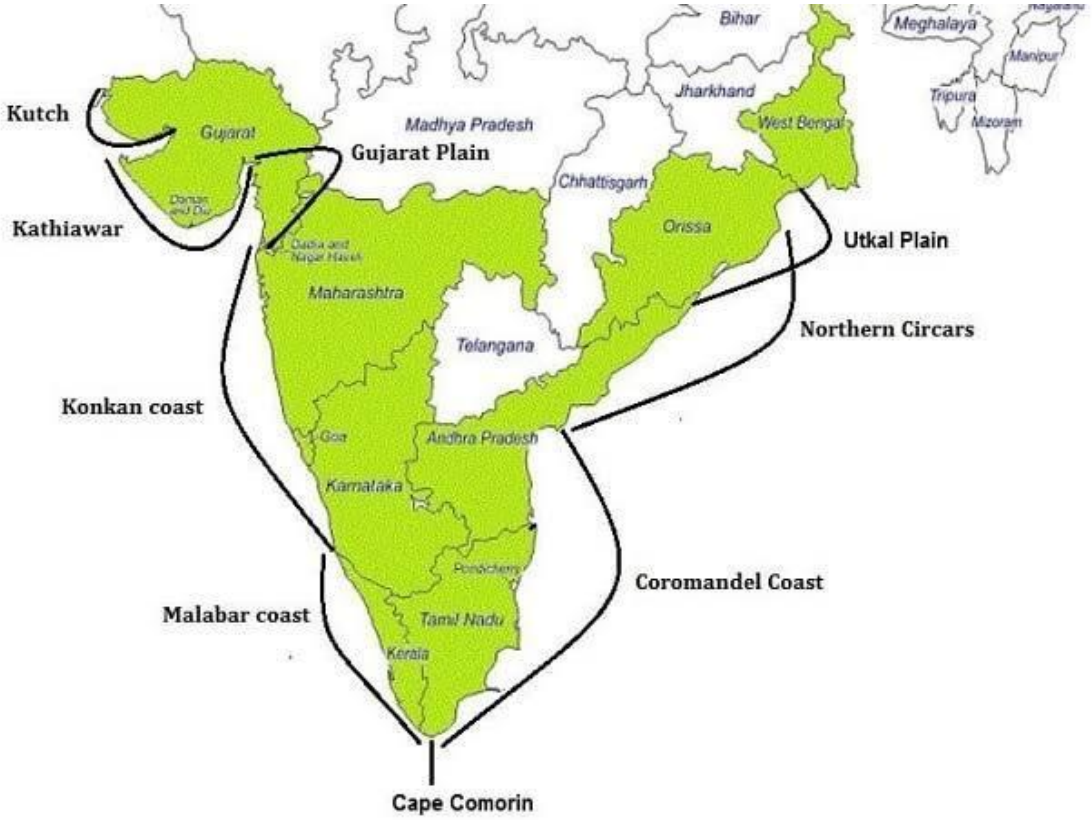
- Indian has sea on its three sides. The coastal plains in India are along the west and east of the country. Extending up to 7516.6 km, the coastal plains in India are of two types:
  - Eastern Coastal Plains of India
  - Western Coastal Plains of India

Eastern Coastal Plains of India :

- The east coast is stretch from – West Bengal, Odisha, Andhra Pradesh & Tamilnadu.
- Deltas of the rivers Mahanadi, Krishna, Godavari, and Cauvery are present in the eastern coastal plain.
- The deltas are very fertile and productive for agriculture. Therefore, the **delta of the River Krishna** is called the '**Granary of South India'.**
- The Eastern coast is again divided into **three categories**:
  - **Utkal coast**: Extending between the Chilika Lake and Kolleru Lake, they are much wider than the western coastal plains and undergo immense rainfall. Some of the crops that are cultivated here are rice, coconut, and banana.
  - **Andhra coast**: Extending between the Kolleru Lake and Pulicat Lake, the Andra coast forms a basin area for the Krishna and the Godavari rivers.
  - **Coromandel coast:** The Coromandel coast extends between Pulicat Lake and Kanyakumari in Tamil Nadu. This Indian coastline remains dry in summer and receives rainfall during the winter due to the north-east monsoons.

Western Coastal Plains of India (UPSC 2017 PRE)

- This passes through – Gujarat , Maharashtra , Goa, Karnataka, kerala.
- The western coastal plains stretch for 1500 km north to south and its width ranges from 10 to 25 km.
- The **West Continental Shelf** is at its **widest off the Bombay** coast.
- This place is rich in oil.
- Along the **Malabar Coast**, there are many beautiful lagoons that make the place a tourist destination.
- The western coast is narrower than the eastern coast.
- The western coast is further divided into **four categories**:
    - **<u>Kachchh and Kathiawar coast</u>**: Kachchh, formerly a gulf is formed by the deposition of silt by the Indus. The area of Kachchh is covered with shallow water during the monsoons and is divided into Great Rann in the north and Little Rann in the east. Whereas, Kathiawar is situated to the south of Kachchh.
    - **<u>Konkan coast:</u>** It extends between Daman in the north to Goa in the south. Rice and cashew are the two important crops of this region.
    - **<u>Kanada coast</u>**: It extends between Marmagaon and Mangalore and is rich in iron deposits.
    - **<u>Malabar coast:</u>** Extending between Mangalore to Kanyakumari, the Malabar coast is relatively broad. This region also consists of lagoons running parallel to the coast in southern Kerala.

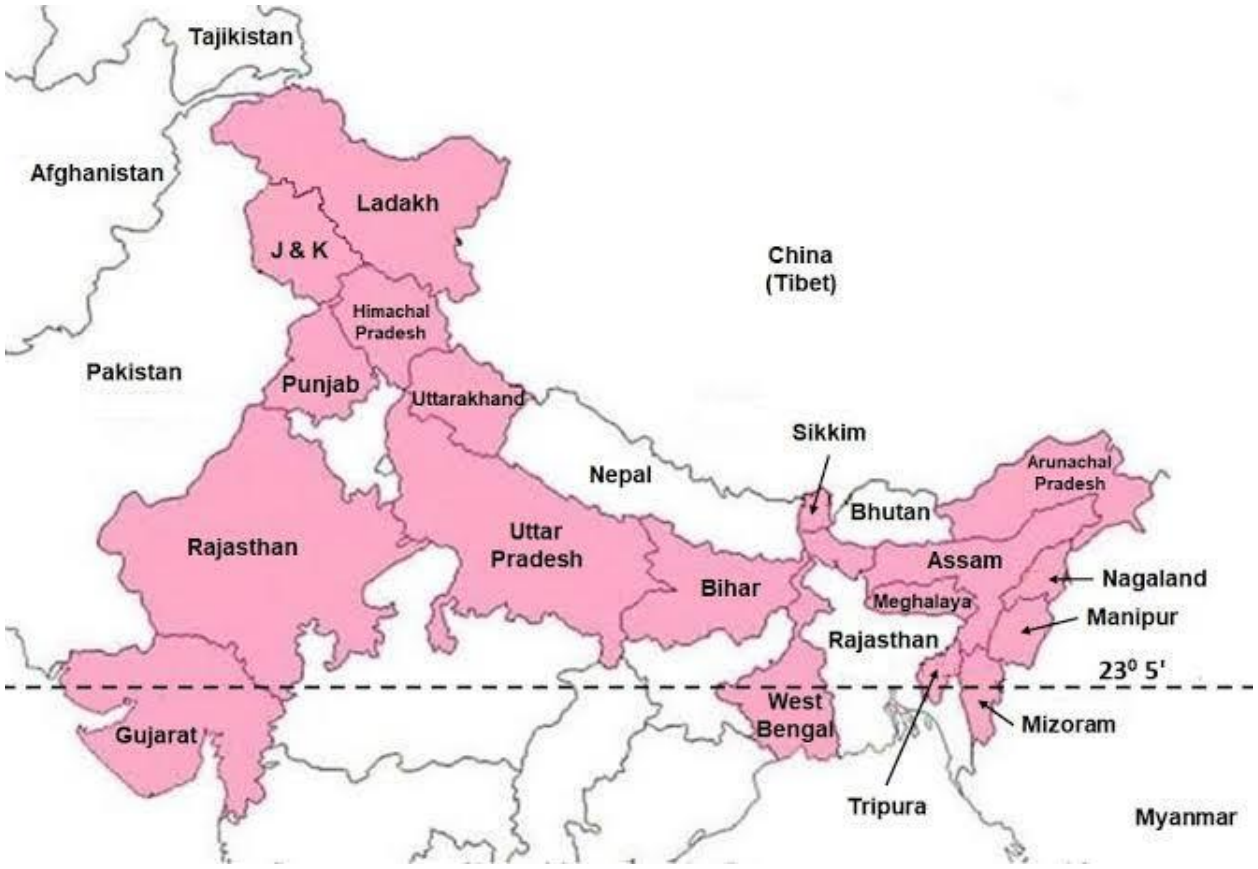


The States with Coastline : The states with coastline in ascending order is :

- Gujrat , Andhra Pradesh , Tamil Nadu, Maharashtra, Kerala, Odisha, Karnataka, West Bengal, Goa, Puducherry & Daman Diu

India's Land Border :

India has 15106.7 Km of land border running through 13 States and Union Territories (UTs). The states touching border of respective Countries as shown in Fig :



- India's Border with Countries –
  - Bangladesh – 4156
  - China – 3488
  - Pakistan – 3323
  - Nepal – 1758
  - Myanmar – 1674
  - Bhutan – 699
  - Afghanistan – 106

The India-Bangladesh Border

- India's 4,156 km long border with Bangladesh is the longest.
- This boundary has been determined under the Radcliffe Award which divided the erstwhile province of Bengal into two parts.

The Sino – India Border

- Five Indian states, namely Ladakh, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh touch the Indian boundary with China.
- The Sino-Indian border is generally divided into three sectors namely :
    1. The Western sector,
    2. the Middle sector,
    3. the Eastern sector.

The Western Sector (UPSC 2020 PRE)

- Only Ladakh Union territory touches the Sinkiang (Xinjiang) province of China.

- China claims the **Aksai Chin district, the Changmo valley, Pangong Tso and the Spongegar Tso** area of north-east Ladakh as well as a strip of about 5,000 sq km down the entire length of eastern Ladakh.
- China also claims a part of **Hunza-Gilgit area** in North ladakh (ceded to it in 1963 by Pakistan).
- The Johnson's line (proposed in 1865) shows Aksai Chin in erstwhile Jammu and Kashmir (now Ladakh) i.e. under India's control whereas McDonald Line (proposed in 1893) places it under China's control.
- India considers Johnson Line as a correct, rightful national border with China

The Middle Sector

- Two Indian states of Himachal Pradesh and Uttarakhand touch this border.

The Eastern Sector

- This boundary runs from the eastern limit of Bhutan to a point near **Diphu pass (Talu Pass) at the trijunction of India, Tibet, and Myanmar.**
- This line is usually referred to as the **Mc Mahon Line** after Sir Henry Mc Mahon, then foreign secretary of British India, who negotiated the boundary agreement between Great Britain and Tibet at Shimla accord in 1913-14.

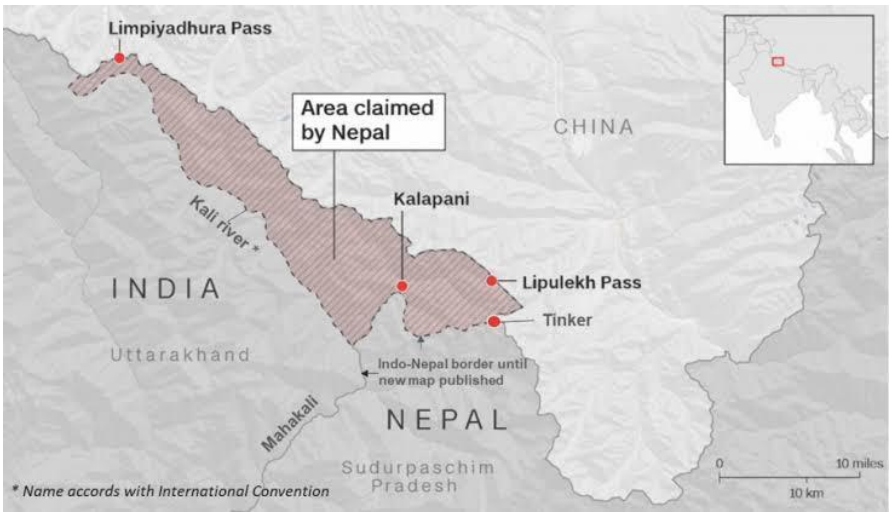
The India-Nepal Boundary

- Five states of India, namely Uttarakhand, Uttar Pradesh, Bihar, West Bengal, and Sikkim touch the Nepalese border with India.
- The border is a porous one with the unrestricted movement of goods and people between Indian and Nepal.

Disputed territories :

- **Kalapani :** Claimed by India as a part of the Pithoragarh district of Uttarakhand. It is **situated on the Kailash Mansarovar** route. The Kali River in the Kalapani region demarcates the border between India and Nepal.
    - The Treaty of Sugauli signed by the Kingdom of Nepal and British India (after the Anglo-Nepalese War) in 1816 located the Kali River as Nepal's western boundary with India.

- **Susta**: Susta area is one of the disputed territories between India (Uttar Pradesh) and Nepal. Susta is located on the bank of the Gandak river (called Narayani river in Nepal). The change of course by the Gandak river is the main reason for disputes in the Susta area.
    - According to the Sugauli Treaty signed between British East India Company and Nepal in 1816, the Gandak river is the international boundary and eastern part of the river belongs to India and western part of the river belongs to Nepal.
    - At the time the treaty was signed Susta village was situated west of the river. But, over the years, the Gandak river changed its course and Susta moved to the east side of the river, that is now on the Indian side of the river.



The India-Bhutan Boundary

- Quite a peaceful border and there is no boundary dispute between the two countries.

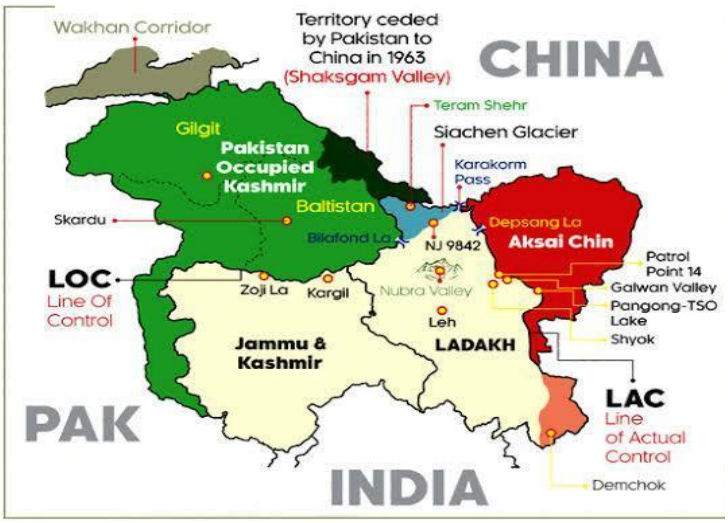
The Indo-Pakistan Boundary

- The Indo-Pakistan boundary is the result of the partition of the country in 1947 under the Radcliffe award of which Sir Cyril Radcliffe was the chairman.

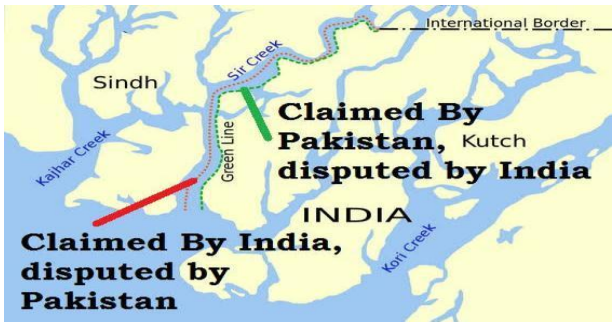
Disputed Territories (UPSC 2020 PRE)

- **Jammu and Kashmir, Pakistan-occupied Kashmir and Gilgit-Baltistan:** Pakistan is in the illegal and forcible occupation of approximately 78,000 sq. km of Indian Territory in Jammu and Kashmir. In addition, under the so-called Sino-Pakistan Boundary Agreement of 1963, Pakistan illegally ceded 5,180 sq. km in Pakistan Occupied Kashmir to China.
- **Siachen Glacier:** The Siachen Glacier is located in the eastern Karakoram in the Himalayas just east of the Actual Ground Position Line between India-Pakistan.
    - The entire Siachen Glacier, with all major passes, is currently under the administration of India since 1984 (Operation Meghdoot).
- **Saltoro Ridge**: The Saltoro Mountains mountain range is a subrange of the Karakoram Heights or of Saltoro Ridge. They are located in the heart of the Karakoram, on the southwest side of the Siachen Glacier.

- They are claimed as part of Jammu and Kashmir Union Territory by India and as part of Gilgit-Baltistan by Pakistan.
- In 1984, India assumed military control of the main peaks and passes of the range, with Pakistani forces into the glacial valleys just to the west.



- **Sir Creek**: It is a 96 km long strip of water disputed between India and Pakistan in the Rann of Kutch marshlands.
  - Pakistan claims the line to follow the eastern shore of the estuary while India claims a centreline (differing interpretations of paragraphs 9 and 10 of the Bombay Government Resolution of 1914 signed between the then Government of Sindh and Rao Maharaja of Kutch).
  - The International Boundary in the Sir Creek area and International Maritime Boundary line (IMBL) between India and Pakistan have not been demarcated.



India-Myanmar Boundary

- This boundary runs roughly along the watershed between the Brahmaputra and Ayeyarwady [Irrawaddy].

- It passes through thickly forested regions, with **Mizo Hills, Manipur, and Nagaland on the Indian side and Chin Hills, Naga Hills, and Kachin state on the Myanmar** side.

India-Sri Lanka Boundary

- India and Sri Lanka are separated from each other by a narrow and shallow sea called Palk Strait.
- **Dhanushkodi** on the Tamil Nadu coast in India is only 32 km away from **Talaimanar** in the Jaffna peninsula in Sri Lanka. These two points are joined by a group of islets forming Adam's Bridge.

- Though, by and large, peace has reigned where the Indo-Sri Lanka border issue is concerned, there were tensions over the question of who owned **Kachchatheevu** Island in the Palk Strait. It was given by India to Sri Lanka in 1974.

PHYSIOGRAPHY OF INDIA

'**Physiography'** of an area is the outcome of structure, process and the stage of development.

- Based on **macro variations**, India can be divided into the following physiographic divisions:
    1. The Northern and North-eastern Mountains
    2. The Northern Plain
    3. The Peninsular Plateau
    4. The Indian Desert
    5. The Coastal Plains
    6. The Islands.

North and North Eastern Himalaya: (UPSC PRE – 2017 , 2014)

Formation of Physical features of north and north-eastern Himalaya is a result of "Plate tectonics" According to Plate Tectonic theory earth is divided into several plateaus.

- The formation of Himalaya & north eastern mountain is due to **the convergence of two plates Eurasia** (North of Himalaya) and **Gondwana** (Indian subcontinents Australia, South Africa, South America).

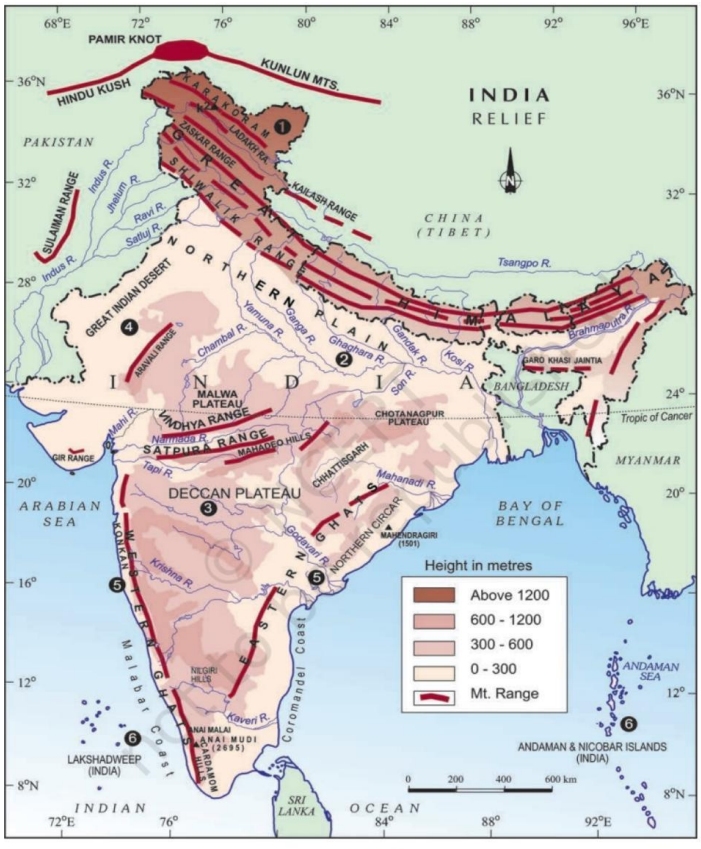
The Himalayan Mountains

The Himalayas, **geologically young and structurally folded** mountains, stretch over the northern borders of India in **west to east** direction from **Indus to Brahmaputra River.**

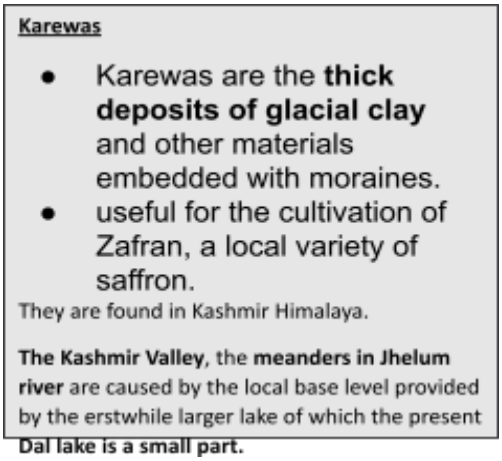
- The Himalayas represent the **loftiest** and one of the most **rugged mountain barriers** of the world.
- They form an arc, which covers a distance of about 2,400 Km. Their width varies from 400 Km in Kashmir to 150 Km in Arunachal Pradesh.
- The **altitudinal variations are greater in the eastern half** than those in the western half.

The Himalaya consists of **three parallel ranges** in its longitudinal extent :

- **Himadri :** The northernmost range is known as the Great or Inner Himalayas of 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, asymmetrical in nature.
    - The core of this part of Himalayas is composed of granite and perennially snowbound.
- **Lesser Himalaya :** The range lying to the south of the Himadri , mainly composed of highly compressed and altered rocks. The altitude varies between 3,700 and 4,500 metres and the average width is 50 Km.
    - **Pir Panjal Range :** The longest and the most important range, the **Dhaula Dhar** and the **Mahabharat** ranges are also prominent.
    - This range consists of the famous valley of Kashmir, the Kangra and Kullu Valley in HimachalPradesh.
- **Shiwaliks:** The outermost range of the Himalayas extend over a width of 10.50 Km and have an altitude varying between 900 and 1100 metres.
    - These ranges are composed of unconsolidated sediment brought down by rivers and valleys covered with thick gravel and alluvium.
    - The longitudinal valleys **lying between lesser Himalaya and the Shiwaliks** are known as **Duns**. DehraDun, Kotli Dun and Patli Dun are some of the well-known Duns.



Subdivision of Himalayas : On the basis of relief, alignment of ranges and other geomorphological features the Himalayas can be divided into the following subdivisions:



Longitudinal division

- Kashmir or North-western Himalayas
- Himachal and Uttaranchal Himalayas
- Darjeeling and Sikkim Himalayas
- Arunachal Himalayas
- Eastern Hills and Mountains

Kashmir or North-western Himalayas

- It comprises a series of ranges such as the Karakoram, Ladakh, Zaskar and Pir Panjal.
- The north-eastern part of Kashmir Himalaya between Grater Himalaya & Karakoram Range of the Kashmir Himalayas is a cold desert.
- **Kashmir valley & Dal Lake :** Between the Great Himalayas and the Pir Panjal range
- **Glaciers :** The Baltoro and Siachen
- **Important passes:** Zoji La on the Great Himalayas. Banihal on the Panjal, Photu La on the Zaskar and Khardung La on the Ladakh range.
- **Lakes :** The fresh lakes as Dal and Wular and salt water lakes such as Pangong Tso and Moriri
- **Other features :** Well-known for their scenic beauty and picturesque landscape. Some famous places of pilgrimage such as Vaishno Devi, Amarnath Cave, Charar -e-Sharif, etc.
- Dal Lake in Srinagar gets water from the Jhelum river.
- Jhelum in the valley of Kashmir is still in its **youth stag**e and yet forms meanders- a typical feature associated with the mature **stage in the evolution of fluvial landform.**
- The southernmost part of this region consists of longitudinal valleys known as ‘duns’. Jammu dun and Pathankot dun are important examples.

The Himachal and Uttaranchal Himalayas

- **Location** : In between , Ravi in the west and the Kali (a tributary of Ghagra) in the east.
  - Drained by two major river systems ,the Indus and the Ganga.
- **Unique features :** The northernmost part of the Himachal Himalayas is an extension of the Ladakh cold desert, which lies in the Spiti subdivision of district Lahaul and Spiti.
  - All the three ranges of Himalayas are prominent in this section.
  - The section of Lesser Himalayas, the altitude between 1,000-2,000 m especially attracted to the British colonial administration, and subsequently.
  - The some of the important hill stations such as Dharamshala, Mussoorie, Shimla Kaosani and the cantonment towns and health resorts such as Shimla, Mussoorie, Kasauli, Almora, Lansdowne and Ranikhet, etc. were developed in this region.
- **Duns :** These are the Plains in the Himalaya as the Chandigarh- Kalka dun, Nalagarh dun, DehraDun, Harike dun and the Kota dun, etc.
  - DehraDun is the largest of all the duns

- In the Great Himalayan range, Inhabited by Bhotia, nomadic groups migrate to '**Bugyals' (the summer grasslands in the higher reaches)** during summer months and return to the valleys during winters.
- The famous **'Valley of flowers'** is also situated in this region.
- The places of pilgrimage such as the Gangotri, Yamunotri, Kedarnath, Badrinath and Hemkund Sahib are also situated in this part.

The Darjeeling and Sikkim Himalayas

They are flanked by the Nepal Himalayas in the west and Bhutan Himalayas in the east.

- Relatively Small with fast- flowing rivers such as Tista, and a region of high mountain peaks like Kanchenjunga (Kanchan Giri), and deep valleys.
- **Lepchas :** The higher reaches inhabitants , while the southern part, particularly the Darjeeling Himalayas, has a mixed population of Nepalis, Bengalis and tribals from Central India.
- **Tea Plantation:** The moderate slope, thick soil cover with high organic content, well distributed rainfall throughout the year and mild winters, favoured the tea plantations in this region.
- Shiwaliks are absent here
- **Duar formation :** In place of Shiwaliks here, the 'duar formations' are important, which have also been used for the development of tea gardens.
- Sikkim and Darjeeling Himalayas are also known for their scenic beauty and rich flora and fauna, particularly various types of orchids.

The Arunachal Himalayas

These extend from the east of the Bhutan Himalayas upto the Diphu pass in the east in southwest to northeast direction.

- **Mountain peaks :** Of the region are Kangtu and Namcha Barwa, dissected by fast-flowing rivers from the north to the south, forming deep gorges.
    - Brahmaputra flows through a deep gorge after crossing Namcha Barwa.
    - Some of the important rivers are the Kameng, the Subansiri, the Dihang and the Lohit.
- **Ethnic Tribes :** Some of the prominent ones **from west to east** are the **Monpa, Daffla, Abor, Mishmi, Nishi and the Nagas**.
    - Most of these communities practice Jhumming.
- Due to **rugged topography**, the **inter-valley transportation linkages are nominal**. Hence, most of the interactions are **carried through the duar region along the Arunachal-Assam** border.

The Eastern Hills and Mountains

They are part of the Himalayan mountain system but have alignment from the north to the south direction.

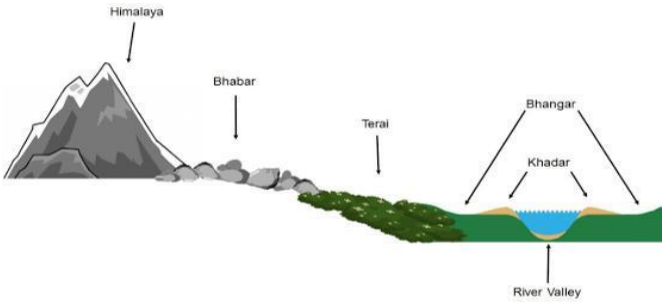
- **Local name :** PatkaiBum, Naga hills, the Manipur hills and in the south as Mizo or Lushai hills.
- Most of these ranges are separated from each other by numerous small rivers. **The Barak is an important river in Manipur and Mizoram.**
- The **physiography of Manipur** is unique by the presence of a large lake known as Loktak**' lake at the centre,** surrounded by mountains from all sides.

- **Mizoram** which is also known as the '**Molasses basin'** which is **made up of soft unconsolidated deposits.**
- Most of the rivers in **Nagaland form the tributary of the Brahmaputra**.
- While **two rivers of Mizoram and Manipur** are the **tributaries of Barak river**, which in turn is the **tributary of Meghna**
- The rivers in the eastern part of Manipur are the tributaries of **Chindwin**, which in turn is a **tributary of the Irrawaddy** of Myanmar.

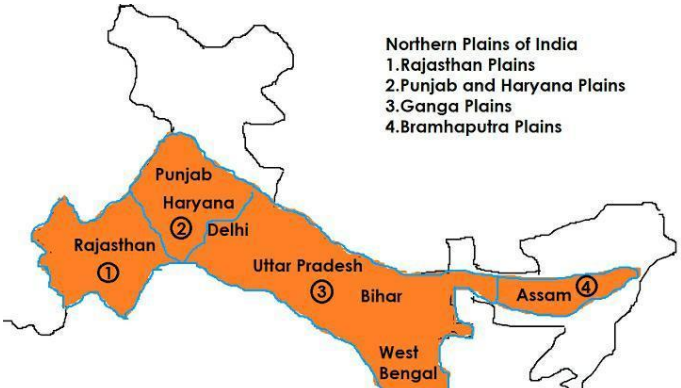
The Northern Plains

- **Formation :** By the **alluvial deposits** brought by the rivers- the Indus, the Ganga and the Brahmaputra.
- These plains extend from the east to the west. But it has a slope from west to East.
- From the north to the south, these can be divided into three major zones: **the Bhabar, the Tarai and the alluvial plains (** further divided into the Khadar and the Bhangar)

- **Bhabar** is a narrow belt ranging between 8-10 km parallel to the Shivalik foothills at the break-up of the slope.
    - Have the deposits of heavy materials of rocks and boulders, and at times, rivers disappear in this zone.
- **Terai Belt :** South of the Bhabar is the Terai belt, with an approximate width of 10-20 km where most of the streams and rivers re- emerge without having any properly demarcated channel, thereby creating marshy and swampy conditions known as the Tarai.
    - This has a luxurious growth of natural vegetation and houses a varied wildlife.
- **Alluvial Plains :** The south of Tarai is a belt consisting of old and new alluvial deposits known as the Bhangar and Khadar respectively.



    - **Characteristic features :** of the mature stage of fluvial erosional and depositional landforms such as **sand bars, meanders, oxbow lakes and braided channels.**
    - The Brahmaputra plains are known for their riverine islands and sandbars.
    - Most of these areas are subjected to periodic floods and shifting river courses forming braided streams.
    - **Deltas :** The mouths of these mighty rivers also form some of the largest deltas of the world, for example, the famous Sundarbans delta.



- The **states of Haryana and Delhi** form a **water divide** between the Indus and the Ganga river systems.
- As opposed to this, the Brahmaputra river flows from the **northeast to the southwest direction** before it takes an almost **90º southward turn at Dhubri** before it enters into Bangladesh.
- **Economic Benefits :** These river valley plains have a fertile alluvial soil cover which supports a variety of crops like wheat, rice, sugarcane and jute, and hence, supports a large population.

The Peninsular Plateau

Rising from the height of 150 m above the river plains up to an elevation of 600-900 m is the irregular triangle known as the peninsular plateau.

- **Extent of Plateau :** Delhi ridge in the **northwest**, (extension of Aravalis), the Rajmahal hills in the **east**, Gir range in the **west** and the Cardamom hills in the **south**
    - However, an extension of this is also seen in the northeast, in the form of the Shillong Karbi-Anglong plateau.
- **Patland plateau :** The peninsular India is made up of a series of patland plateaus such as the Hazaribagh plateau, the Palamu plateau, the Ranchi plateau, the Malwa plateau, the Coimbatore plateau and the Karnataka plateau, etc.
- The **general elevation** of the plateau is from the **west to the east,** and hence rivers flow in Such direction.
- Some of the important **physiographic features of this region are tors, block mountains, rift valleys, spurs, bare rocky structures**, series of hummocky hills and **wall-like quartzite dykes** offering natural sites for water storage.
- The western and north-western part of the plateau has an **empathic presence of black soil.**
- The Bhima fault had gone to recurrent seismic activities.
- The **north-western part of the plateau** has a complex relief of ravines and gorges. The **ravines of Chambal, Bhind and Morena** are some of the well- known examples.

On the basis of the prominent relief features, the peninsular plateau can be divided into three broad groups:

- The Deccan Plateau
- The Central Highlands
- The North-eastern Plateau.

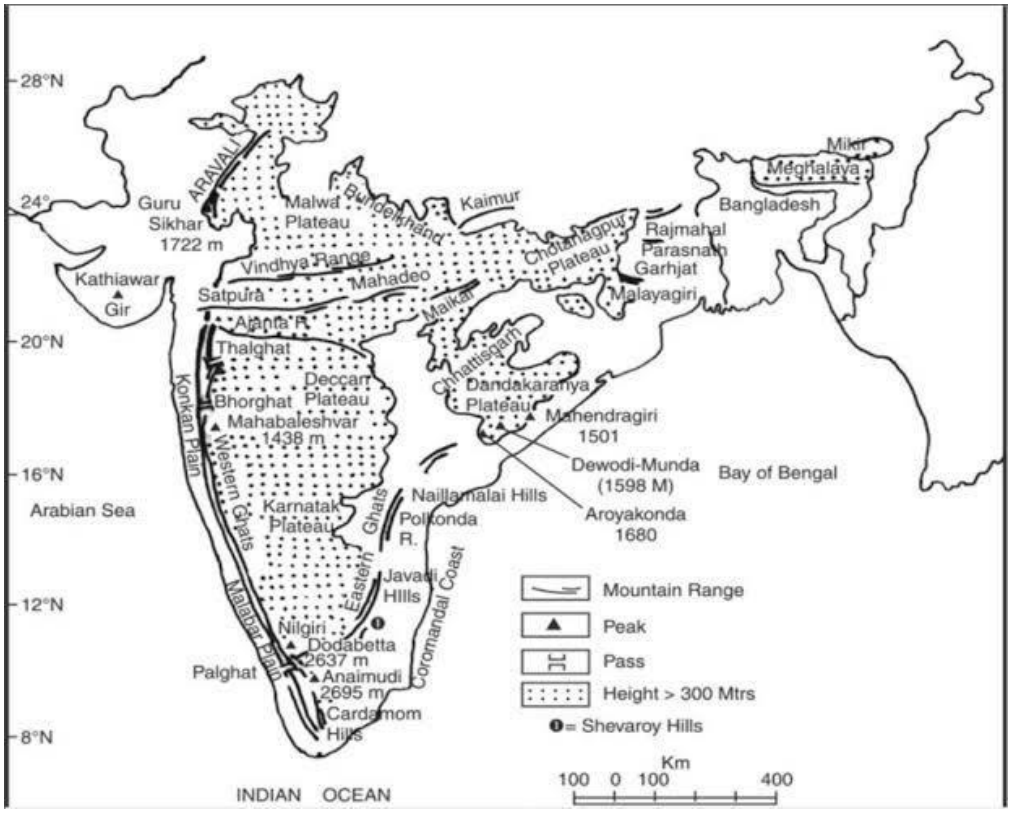
The Deccan Plateau (UPSC 2015, 2017, 2021)

- **Border :** Western Ghats in the west, Eastern Ghats in the east and the Satpura, Maikal range and Mahadeo hills in the north.
- **Western Ghats** are locally known by different names such as **Sahyadri in Maharashtra, Nilgiri hills in Karnataka and Tamil Nadu and Anaimalai hills and Cardamom hills in Kerala.**
    - Their average elevation is about 1,500 m with the height increasing from north to south.
    - **'Anamudi' (2,695 m),** the highest peak of Peninsular plateaus, is located on the Anaimalai hills of the Western Ghats followed by **Dodabetta (2,670 m) on the Nilgiri hills.**

  - Most of the Peninsular rivers have their origin in the Western Ghats.
- **Eastern Ghats** comprising the discontinuous and low hills are highly eroded by the rivers such as the Mahanadi, the Godavari, the Krishna, the Kaveri, etc.
  - Some of the important ranges include the **Javadi hills, the Palconda range, the Nallamala hills, the Mahendragiri hills,** etc.
- The Eastern and the Western Ghats meet each other at the Nilgiri hills.

The Central Highlands

- **Location :** Bounded to the west by the **Aravali range & Satpura range** , which is formed by a series of scarped plateaus in the south.
  - This forms the northernmost boundary of the Deccan plateau.
  - It is a classic example of the relict mountains which are highly denuded and form discontinuous ranges.
  - In the west , the Jaisalmer has been covered by the **longitudinal sand ridges and crescent-shaped sand dunes called barchans.**
  - This region has undergone metamorphic processes and has **metamorphic rocks such as marble, slate, gneiss, etc.**
- **Slope :** It slopes towards the **north and north-eastern** directions.
- **Rivers :** Most of the tributaries of the river Yamuna have their **origin in the Vindhyan and Kaimur ranges**.
  - **Banas** is the only significant tributary of the river **Chambal that originates from the Aravalli** in the west.
- An **eastern extension of the Central Highland** is **Rajmahal hills,** to the south of which lies a large reserve of mineral resources in the Chotanagpur plateau.



The North-eastern Plateau

- This has been separated **due to north-eastward movement** of the Indian plate at the time of the Himalayan origin, a huge fault was created between the Rajmahal hills and the Meghalaya plateau.
- Today, the **Meghalaya and Karbi Anglong plateau** stand detached from the main peninsular Block.
- The meghalaya plateau is further subdivided into three: (i) The Garo Hills; (ii) The Khasi Hills; (ii) The Jaintia Hills.
- An extension of this is also seen in the **Karbi Anglong hills of Assam**.
- The **Meghalaya plateau** is also **rich in mineral resources** like coal, iron ore, sillimanite, limestone and uranium.

This area receives maximum rainfall from the south west monsoon. As a result, the **Meghalaya plateau has a highly eroded surface**. Cherrapunji displays a bare rocky surface devoid of any permanent vegetation.

The Indian Desert

They are the extension of Peninsular plateau but due to extreme arid conditions, its surface features have been carved by physical weathering and wind actions

- **Location :** Northwest of the Aravali hills lies the Great Indian desert.
- It is a land of **undulating topography dotted with longitudinal dunes and barchans.**
- This region receives low rainfall below 150 mm per year; hence, it has an arid climate with low vegetation cover. Hence called Marusthali.
- It is believed that during the **Mesozoic era,** this region was under the sea.
    - This can be corroborated by the evidence available at the wood **fossils park at Aakal** and **marine deposits around Brahmsar, near Jaisalmer** (The approximate age of the wood fossils is estimated to be 180 million years).
- **Desert Land feature :** features present here are **mushroom rocks, shifting dunes and oases (mostly in its southern part).**
- On the **basis of the orientation**, the desert can be divided into two parts:
    - the northern part is sloping towards Sindh
    - south towards the Rann of Kachchh.
- **Rivers :** Most of the rivers in this region are **ephemeral**. The **Luni river flowing in the southern part of the desert** is of some significance.
    - There are some streams which disappear after flowing for some distance and present a typical case of inland drainage by joining a lake or playa.
    - The lakes and the playas have brackish water which is the main source of obtaining salt.

The Coastal Plains

On the basis of the location and active geomorphological processes, it can be divided into two:

- the western coastal plains
- The eastern coastal plains.

The western coastal plains

- They are an **example of a submerged coastal plain**.
- Because of this submergence it is a **narrow belt and provides natural conditions for the development of ports** and harbours. For example - **Kandla, Mazagaon, JLN port Navha Sheva, Marmagao. Mangalore, Cochin,** etc. are some of the important **natural ports** located along the west coast.
- The western coastal plains are **narrow in the middle and get broader towards north and south**.
- The rivers flowing through this **coastal plain do not form any delta.**
- The Malabar coast has certain distinguishing features in the form of '**Kayals' (backwaters),** which are 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 eastern coastal plain

- It is broader and is an example of an **emergent coast, having** well developed deltas here, formed by the rivers flowing eastward into the Bay of Bengal.
    - These include the deltas of the Mahanadi, the Godavari, the Krishna and the Kaveri.
- Because of its **emergent nature, it has fewer ports and harbours.**

The Islands

There are two major island groups in India- one in the Bay of Bengal and the other in the Arabian. The major island groups of India are Andaman and Nicobar Archipelago (A chain of islands similar in origin) in the Bay of Bengal and Lakshadweep islands in the Arabian Sea.

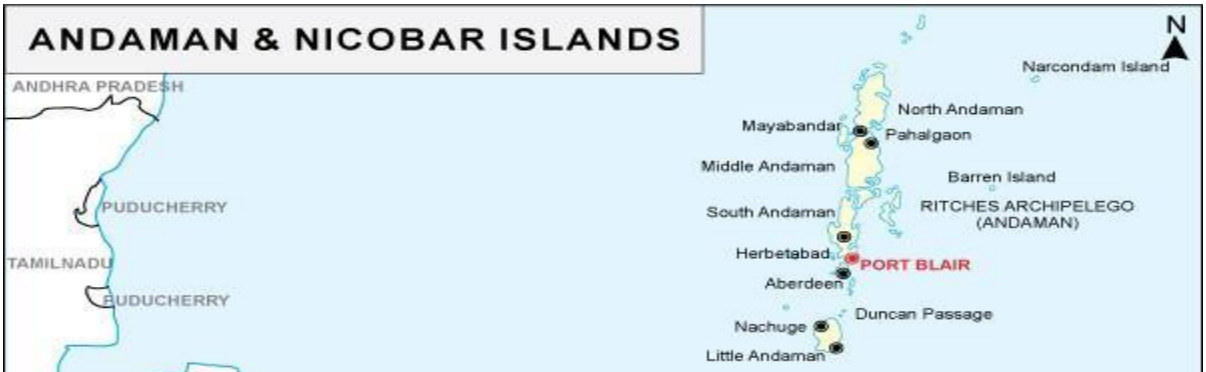
Some **important mountain peaks in Andaman and Nicobar islands** –

- Saddle peak (North Andaman- 738 m),
- Mount Diavolo (Middle Andaman- 515 m),
- Mount Koyob (South Andaman- 460 m)
- Mount Thuiller (Great Nicobar- 642 m).

Andaman & Nicobar Islands : (UPSC 2017 PRE)

Andaman and Nicobar Islands were formed due to collision between Indian Plate and Burma Minor Plate Similar to formation of Himalayas.

- They are **southward extension** of Arakan Yoma range while Arakan Yoma in itself is an extension of Purvanchal Hills.
- The Andaman islands are divided into three main islands i.e. North, Middle and South.
- **Duncan passage** separates **Little Andaman from South Andaman.**
- The **Great Andaman group** of islands in the north is separated by the **Ten Degree Channel from the Nicobar group** in the south .(UPSC 2014 PRE)
- **Port Blair,** the capital of Andaman Nicobar **Islands, lies in the South Andaman.**



- Among the **Nicobar islands, the Great Nicobar is the largest**. It is the **southernmost island and is very close to Sumatra** island of Indonesia. **The Car Nicobar is the northernmost.**
- Most of these **islands are made of tertiary sandstone**, **limestone** and **shale resting** on basic and ultrabasic volcanoes (Similar to Himalayas)
- **THE BARREN AND NARCONDAM ISLANDS**, north of Port Blair, are volcanic islands . These are the only active volcanoes in India. (UPSC 2018 pre)
- Some of the **islands are fringed with coral reefs.** Many of them are covered with thick forests. Most of the islands are mountainous.

Lakshadweep :

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

- In the Arabian Sea, there are three types of islands
    - **Amindivi Islands** (consisting of six main islands of Amini, Keltan, Chetlat, Kadmat, Bitra and Perumal Par).
    - **Laccadive Islands** (consisting of five major islands of Androth, Kalpeni, Kavaratti, Pitti and Suheli Par)
    - **Minicoy Island**.

At present these islands are collectively known as Lakshadweep.

- They are widely scattered about 200-500 km south-west of the Kerala coast.
- **Amindivi Islands** are the **northernmost** while the **Minicoy island is the southernmost.**
- All are **tiny islands of coral origin {Atoll} and are surrounded by fringing reefs.**
- The **largest and the most advanced is MINICOY island**. Most of the islands have low elevation and do not rise more than five metres above sea level .
- Their **topography is flat and relief features such as hills, streams, valleys, etc. are absent.**

DRAINAGE SYSTEM IN INDIA

A river drains the water collected from a specific area, which is called its ‘catchment area’.

- The flow of water through well-defined channels is known as ‘drainage’ and the network of such channels is called a ‘drainage system’.
- The boundary line separating one drainage basin from the other is known as the watershed.

The Indian drainage system may be divided on various bases.

- On the **basis of discharge of water** (orientations to the sea), it may be grouped into:
    - **The Arabian Sea drainage** :- 23 per cent comprising **the Indus, the Narmada, the Tapi, the Mahi and the Periyar** systems discharge their waters in the Arabian Sea.
    - **The Bay of Bengal drainage** :- Nearly 77 per cent of the drainage area consisting of **the Ganga, the Brahmaputra, the Mahanadi, Krishna,** etc. is oriented towards the Bay of Bengal
    - They are **separated from each other** through the **Delhi ridge, the Aravallis and the Sahyadris** .
- On the **basis of the size of the watershed,** the drainage basins of India are grouped into three categories:
    - **Major river basins with more than 20,000 sq. km. of catchment area -** It includes 14 drainage basins such as the Ganga, the Brahmaputra, the Krishna, the Tapi, the Narmada, the Mahi, the Pennar, the Sabarmati, the Barak, etc.
    - **Medium river basins with catchment area between 2,000- 20,000 sq. km** – This is incorporating 44 river basins such as the Kalindi, the Periyar, the Meghna, etc.
    - **Minor river basins with catchment area of less than 2,000 sq. km.** include a fairly good number of rivers flowing in the area of low rainfall.
- On the **basis of the mode of origin, nature and characteristics,** the Indian drainage may also be classified into :
    - The Himalayan drainage
    - The peninsular drainage.
    - Although it has the problem of including the **Chambal, the Betwa, the Son, etc. which are much older in age and origin** than other rivers that have their origin in the Himalayas, it is the most accepted basis of classification.

Drainage systems of India

It is the outcome of the evolutionary process of the three major physiographic units and the nature and characteristics of precipitation.

Important Drainage Patterns

- **Dendritic Pattern :** The drainage pattern resembling the branches of a tree is known as “dendritic” , the examples of which are the rivers of the northern plain.
- **Radial Pattern :** When the rivers originate from a hill and flow in all directions, the drainage pattern is known as ‘radial’. The rivers originating from the Amarkantak range present a good example of this.
- **Trellis Pattern :** When the primary tributaries of rivers flow parallel to each other and secondary tributaries join them at right angles, the pattern is known as ‘trellis’.
- **Centripetal Pattern :**When the rivers discharge their waters from all directions in a lake or depression, the pattern is known as ‘centripetal’.

The Himalayan Drainage System :

It mainly includes the Ganga, the Indus and the Brahmaputra rivers basins.

- They are perennial rivers fed by both – Melting of Glaciers & Precipitation.
- Major Characteristics of Himalayan River –
    - Pass through the **giant gorges** carved out by the **erosional activity**.
    - Also **form V-shaped valleys,** rapids and waterfalls in their mountainous course.
    - In plains, they form **depositional features** like **flat valleys, ox-bow, lakes, flood plains, braided channels,** and **deltas** near the river mouth.
    - Meandering in plains is the main display as for example - **River Kosi, also known as the 'sorrow of Bihar',** has been notorious for frequently changing its course.

Evolution of the Himalayan Drainage :

The geologists believe that a mighty river called Shiwalik or **Indo-Brahma traversed the entire longitudinal extent** of the Himalaya from **Assam to Punjab and onwards to Sind,** and finally discharge into the **Gulf of Sind near lower Punjab** during the **Miocene period** some 5-24 million years ago.

- It is opined that in due course of time Indo-Brahma river was dismembered into three main drainage systems:
    - **The Indus and its five tributaries** in the western part
    - **The Ganga and its Himalayan tributaries** in the central part
    - **The stretch of the Brahmaputra in Assam** and its Himalayan tributaries in the eastern part. The dismemberment was probably due to the
- **Pleistocene upheaval in the western Himalayan**, including the **uplift of the Potwar Plateau (Delhi Ridge)**, which acted as the water divide between the Indus and Ganga drainage systems.
- Likewise, the **down-thrusting of the Malda gap area between the Rajmahal hills and the Meghalaya plateau** during the **mid-Pleistocene period**, diverted the Ganga and the Brahmaputra systems to flow towards the Bay of Bengal.

The river Systems of the Himalayan Drainage :

The Indus system (UPSC 2021 PRE)

The Indus, also known as the Sindhu, is the westernmost of the Himalayan rivers in India.

- It originates from a **glacier near Bokhar Chu** in the Tibetan region in the Kailash Mountain range.
- In Tibet, it is known as '**Singi Khamban; or Lion's mouth**.
- After flowing in the **northwest direction between the Ladakh and Zanskar ranges, it passes through Ladakh and Baltistan**.
- It cuts across the ladakh range, forming a **spectacular gorge near Gilgit in Jammu and Kashmir.** It enters into Pakistan near Chillar in the Dardistan region.

- It finally **emerges out of the hills near Attock** where it receives the **Kabul river on its right bank**. The
- The right bank tributaries of **Indus after attock originate in the Sulaiman ranges.**
- The river flows southward and **receives Panjnad a little above Mithankot.**
- The Indus flows in India **only through the Leh district** in Ladakh UT.

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.
The 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.
The Ravi River :	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

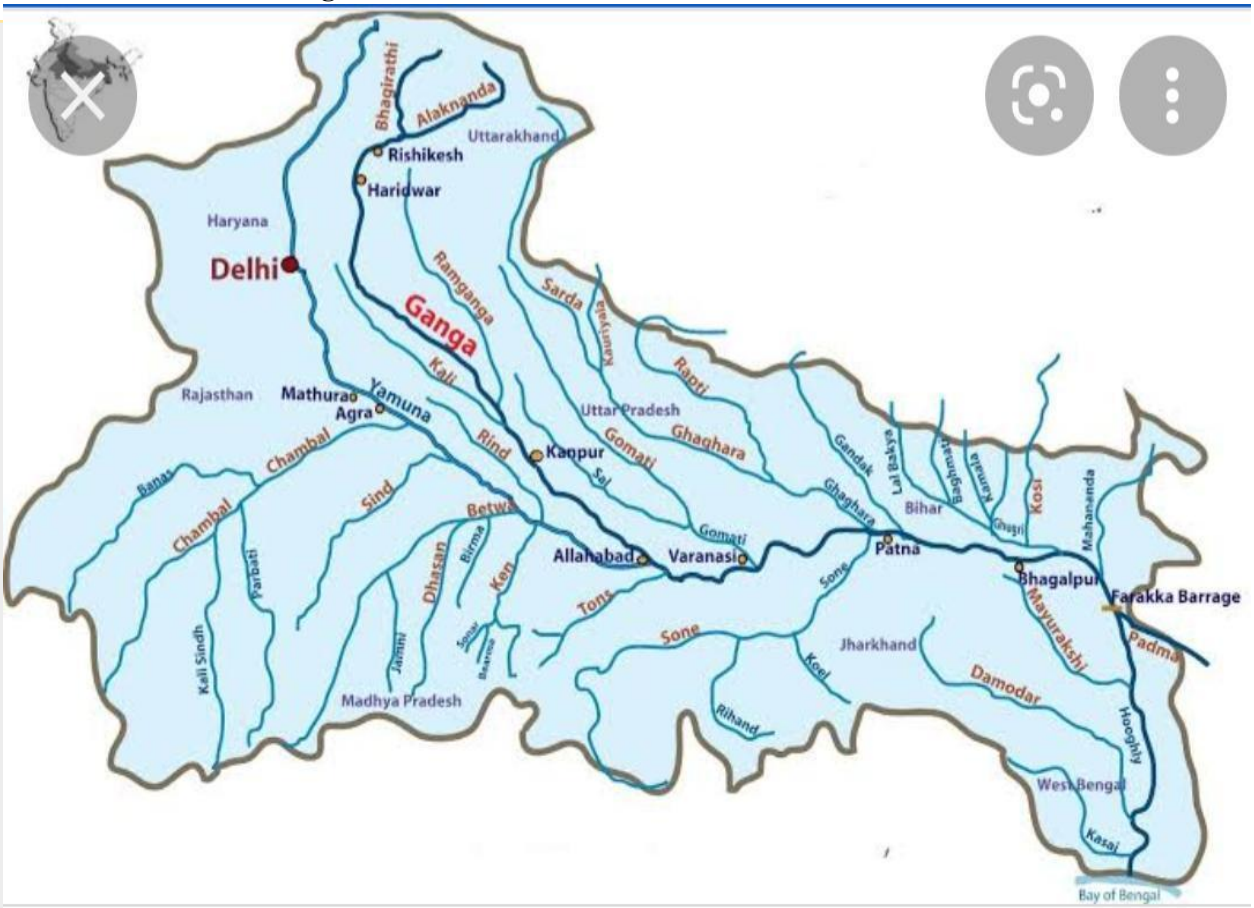
	• It drains the area lying between the **south-eastern part of the Pir Panjal and the Dhauladhar ranges.**
The Beas River :	The Beas originate from the **Beas Kund near the Rohtang Pass**. • The river flows **through the Kullu valley** and forms gorges at **Kati and Largi in the Dhauladhar range**. • It enters the Punjab plains where it **meets the Satluj near Harike.**
The Satluj River :	Satluj originates in the **Rakas lake near Mansarovar** 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 feeds the canal system of the **Bhakra Nangal project.**

The Ganga River System

The Ganga is the most important river of India both from the point of view of its basin and cultural significance.

- It rises in the Gangotri glacier near Gaumukh (3,900 m) in the Uttarkashi district of Uttarakhand.
- The river has a length of 2,525 km.
- It is shared by **Uttarakhand (110 km) and Uttar Pradesh (1,450 km), Bihar (445 km) and West Bengal (520 km).**
- The Ganga enters the plains at Haridwar.
- It flows first to the **south**, then to the **south-east and east before splitting** into **two distributaries, namely the Bhagirathi and the Hugli**.
- The river finally discharges itself into the Bay of Bengal near the Sagar Island.

Tributaries of River Ganga :



The Gandak River	**The Gandak comprises two streams, namely Kaligandak and Trishulganga.** ● 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.
The Ghaghara 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.
The Kosi River	**The Kosi is an antecedent river with its** source to the north of Mount Everest in Tibbet, **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.

The Ram Ganga River	**The Ramganga is a small river rising in the Garhwal hills near Gairsain.** ● It joins the Ganga near Kannauj.
The 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, a multipurpose project.
The Mahananda River	**The Mahananda rises in the Darjeeling hills.** ● It joins the Ganga as its last left bank tributary in West Bengal.
The Son River	**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 plateau, it reaches Arrah, west of Patna, to join the Ganga.

The Yamuna river :

The western most and the longest tributary of the Ganga, has its **source in the Yamunotri glacier** on the western slopes of the Bandarpunch range (6,316 km).

- This feeds the **western and eastern Yamuna and the Agra canals for irrigation purposes.**
- **Hindon river** is Yamuna's left bank tributary

The Chambal River :

The Chambal rises near Mhow in the Malwa plateau of Madhya Pradesh .

- Flowing 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.

The Saryu River :

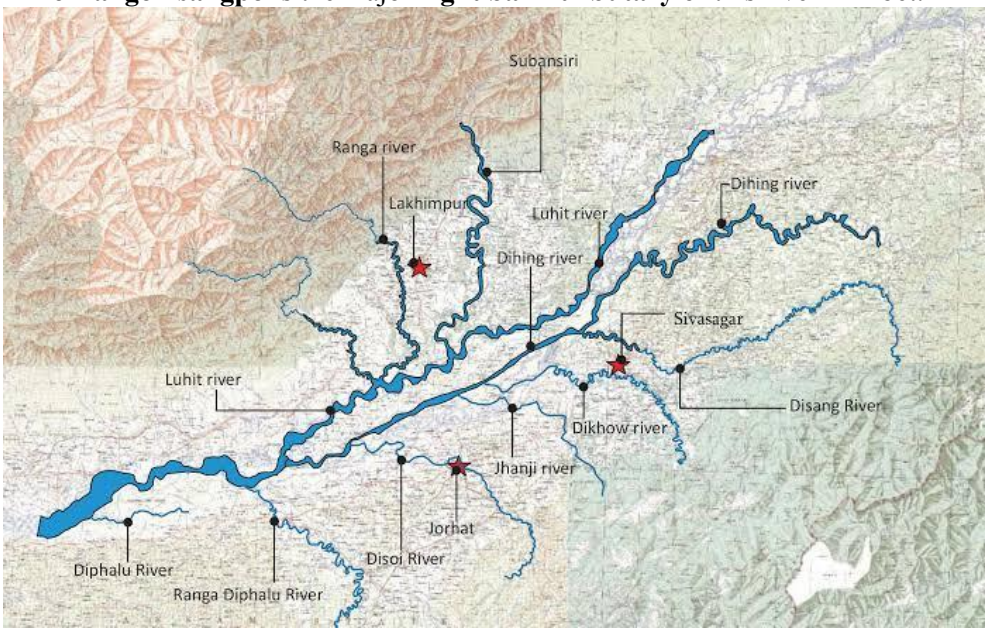
The Sarda or Saryu river rises in the Milan glacier in the Nepal Himalayas where it is known as the Goriganga.

- Along the Indo- Nepal border, it is called Kali or Chauk, where it joins the Ghaghara.

The Brahmaputra River System (UPSC 2014, 2016 PRE)

The Brahmaputra has its origin in the **Chemayungdung glacier of the Kailash range near the Mansarovar lake**.

- From here, it traverses **eastward longitudinally** in a dry and flat region of southern Tibet, where it is known as the **Tsangpo, which means 'the purifier**'.
- **The Rango Tsangpo** is the major **right bank tributary** of this river in Tibet.



- It **emerges as a turbulent and dynamic river** after carving out a deep gorge in the **Central Himalayas near Namcha Barwa** (7,755 m).
- The river emerges from the **foothills under the name of Siang or Dihang**. It enters India west of Sadiya town in Arunachal Pradesh.
- The Subansiri which has its **origin in Tibet**, is an **antecedent** river.
- 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.

<u>The peninsular drainage system</u>

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.

- 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 other major river systems of the peninsular drainage are- the **Mahanadi, the Godavari, the Krishna and the Kaveri.**

Characteristics of the Peninsular River :

Peninsular rivers are **characterized** by **fixed course, absence of meanders and no perennial flow of water**.

- The Narmada and the Tapi which flow through the rift valley are, however, exceptions. They meet in the Arabian sea.

<u>The Evolution of the Peninsular Drainage System</u>

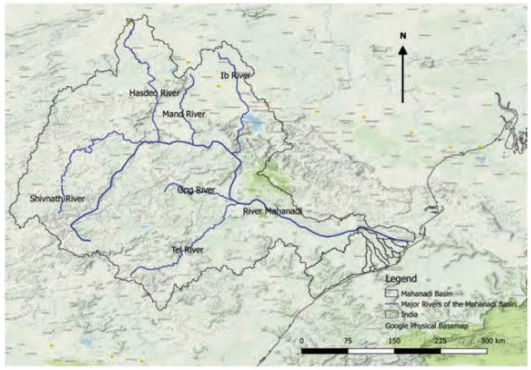
Three major geological events in the distant past have shaped the present drainage systems of peninsular India:

- **Subsidence and submergence of the western flank** of the peninsula during the early tertiary period has disturbed the symmetrical plan of the river on either side of the original watershed.
- **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** material.
- **Slight tilting of the peninsular block from northwest to the south-eastern direction** gave orientation to the entire drainage system towards the Bay of Bengal during the same period.

River systems of the peninsular drainage

A brief account of the major peninsular river systems is given below:

Map showing the tributaries of the Mahanadi river



The rivers flowing to Bay of Bengal :- (UPSC 2021 PRE)

The Mahanadi River :

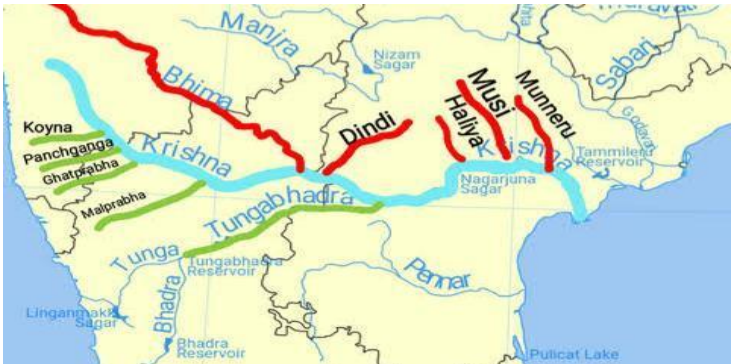
The Mahanadi rises near **Sihawa in Raipur district of Chhattisgarh** and runs **through Orissa** to discharge its water into the Bay of Bengal.

- Some navigation is carried on in the lower course of this river.

The Godavari River : (UPSC 2015 PRE)

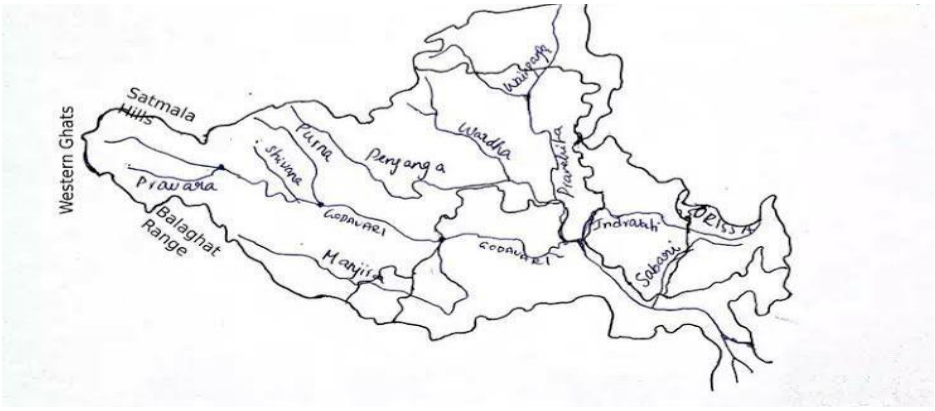
The Godavari is the **largest peninsular river** system. It is also called the **Dakshin Ganga.**

- It rises in the Nasik district of Maharashtra and discharges its water into the Bay of Bengal.
- 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 Rajahmundry splits into several branches** forming a large delta.



The Krishna River

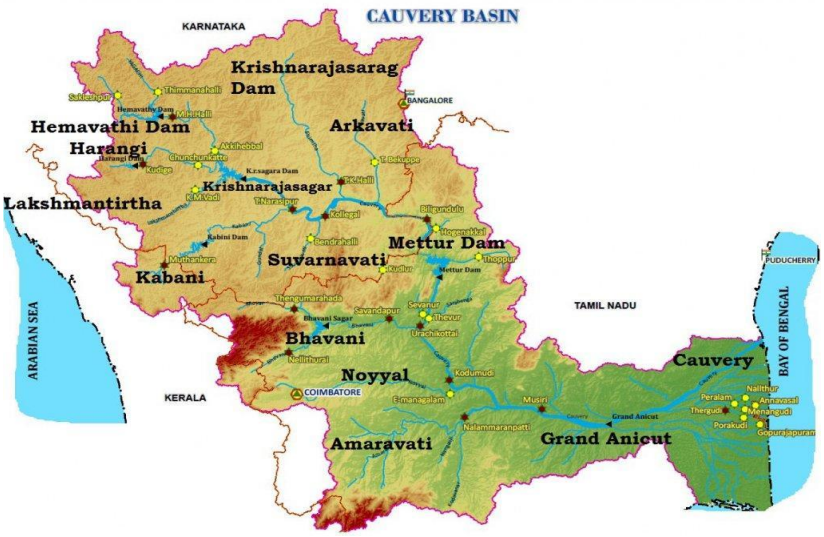
The Krishna is the second largest east-flowing peninsular river which **rises near Mahabaleshwar in Sahyadri**.



The Cauvery River :

Kaveri rises in the Brahmagiri hills 1,341m of Kodagu district in Karnataka.

- 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.

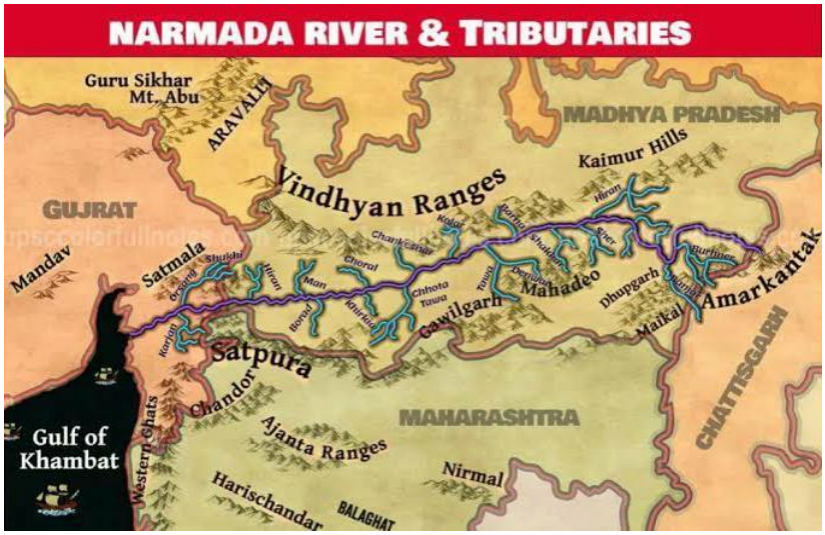


The Rivers flowing towards the West Coast of India :-

The Narmada River : (UPSC 2013 PRE)

The Narmada originates on the **western flank of the Amarkantak** plateau

- It Flows 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**.
- It meets the **Arabian sea south of Bharuch**, forming a broad 27 km long estuary.
- The Sardar Sarovar Project has been constructed on this river.



The Tapi River

The Tapi is the other important westward flowing river.

- It originates from **Multai in the Betul district of Madhya Pradesh**.

The Luni River :

Luni is the largest river system of Rajasthan, west of Aravali.

- It **originates near Pushka**r in two branches. i.e. the **Saraswati and the Sabarmati,** which join with each other at Govindgarh.
- From here, the river comes out of Aravali and is known as Luni.
- It flows towards the west **till Telwara and then takes a southwest direction to join the Rann of Kuchchh**. The entire river system is **ephemeral**.

Smaller Rivers flowing towards the West

Rivers in Gujarat :-

- The **Shetruniji** is one such river which rises near Dalkahwa in Amreli district.
- **The Bhadra originate** near Aniali village in Rajkot district.
- The **Dhadhar** rises near Ghantar village in Panchmahal district.
- **Sabarmati and Mahi** are the two famous rivers of Gujarat. **Mahi rivers crosses the Tropic Of Cancer twice.**

Rivers of Maharashtra & Karnataka :-

- The **Vaitarna rises** from the Trimbak hills in Nasik district.
- Kalinadi rises from Belgaum district and falls in the Karwar Bay.
- The source of the Bedti **river** lies in Hubli Dharwad and traverses a course of 161 km.
- The **Sharavati** is another important river in Karnataka flowing towards the west.
    - The Sharavati originates in Shimoga district of Karnataka

The rivers of Goa :-

- Mandovi
- Juari.

The rivers of Kerala :-

- **The Bharathapuzha** river is the longest river of Kerala, rising near Anamalai hills. It is also known as Ponnani.
- The **Periyar** is the second largest river of Kerala. Its catchment area is 5,243 sq. km.
- The **Pamba** river which falls in the **Vembanad lake** after traversing a course of 177 km.

CLIMATE OF INDIA

Climate refers to the sum total of weather conditions and variations over a large area for a long period of time (more than thirty years). **Weather** refers to the state of the atmosphere over an area at any point of time.

- The **elements of weather and climate** are the same, i.e. **temperature, atmospheric pressure, wind, humidity and precipitation.**

Factors determining the climate of India

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

- Factors related to location and relief,
- Factors related to air pressure and winds.

Factors related to Location and Relief

- **Latitude:** The northern part of India lies in the sub-tropical and temperate zone and the part lying south of the Tropic of Cancer falls in the tropical zone.
    - The tropical zone being nearer to the equator, experiences high temperatures throughout the year with a small daily and annual range.
    - Area north of the Tropic of Cancer being away from the equator, experiences extreme climate with high daily and annual range of temperature.
- **The Himalayan Mountains:** The towering mountain chain provides an invincible shield to protect the subcontinent from the cold northern winds.
    - The Himalayas also trap the monsoon winds, forcing them to shed their moisture within the subcontinent.
- **Distribution of Land and Water:** 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.
    - Difference in air pressure causes a reversal in the direction of monsoon winds.
- **Distance from the Sea:** 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.
- **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 the temperature of January in Agra is 16℃ whereas it is only 4℃ in Darjeeling.
- **Relief:** The physiography or relief of India also affects the temperature, air pressure, direction and speed of wind and the amount and distribution of rainfall.
    - **For example :** The windward sides of Western Ghats and Assam receive high rainfall during June-September whereas the southern plateau remains dry due to the leeward situation.

Factors Related to Air Pressure and Wind

To understand the climate of India we need to understand the mechanism of the following three factors:

- **Distribution of air pressure** and winds on the surface of the earth.
- **Upper air circulation is caused** by factors controlling global weather and the inflow of different air masses and jet streams.
- **Inflow of western cyclones** generally known as disturbances during the winter season and tropical depressions during the south-west monsoon period into India, creating weather conditions favourable to rainfall.

Mechanism of Weather in the Winter Season

- **Surface pressure and winds**: A high pressure centre in the north of the Himalayas during winter.
    - This will give rise to the flow of air at the low level from the north towards the Indian subcontinent, south of the mountain range.
    - 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 north-western and northern India up to the middle Ganga valley comes under the influence of dry north-western winds.
- **Jet Stream and Upper Air Circulation**: About 03 km above the surface of the earth, a different pattern of air circulation is observed. (UPSC 2020 PRE)
    - 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 a mean position at 25ºN in February at 200-300 mb level.
    - It is believed that this southern branch of the jet stream exercises an important influence on the winter weather in India.
- **Western Cyclonic Disturbance and Tropical Cyclones**: The western cyclonic disturbances blowing West to East in the Indian subcontinent during the winter months originate over the Mediterranean Sea and 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 cyclone disturbances.
    - Tropical cyclones originate over the Bay of Bengal and the Indian Ocean.
    - These tropical cyclones have very high wind velocity and heavy rainfall and hit the Tamil Nadu, Andhra Pradesh and Orissa coast.
    - Most of these cyclones are very destructive due to high wind velocity and torrential rain that accompanies it.
- **InterTropical 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 20ºN 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 south- ern hemisphere cross the equator between 40ºE and 60ºE longitudes and start blowing from southwest to northeast due to the Coriolis force.

- It becomes southwest monsoon. In winter, the ITCZ moves south- ward, and so the reversal of winds from northeast to south and southwest, takes place. They are called northeast monsoons.

Mechanism of Weather in the Summer Season

- **Surface Pressure and Winds**: As the summer sets in and the sun shifts northwards, the wind circulation over the subcontinent undergoes a complete reversal at both, the lower as well as the upper levels.
    - By the middle of July, the low pressure belt nearer the surface (termed as Inter Tropical Convergence Zone (ITCZ) shifts northwards, roughly parallel to the Himalayas between 20ºN and 25ºN.
    - By this time, the westerly jet stream withdrew from the Indian region.
    - The ITCZ being a zone of low pressure attracts an inflow of winds from different directions.
    - The maritime tropical air mass (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.
- **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 15ºN latitude, and in September up to 22ºN latitudes.
    - The easterlies normally do not extend to the north of 30ºN latitude in the upper atmosphere.

Easterly Jet Stream and Tropical Cyclones: The easterly jet stream steers tropical depressions into India.

- These depressions play a significant role in the distribution of monsoon rainfall over the Indian subcontinent.
- The tracks of these depressions are the areas of highest rainfall in India.
- The frequency at which these depressions visit India, their direction and intensity, all go a long way in determining the rainfall pattern during the southwest monsoon period.

The Nature of Indian Monsoon (UPSC 2014 PRE)

Systematic studies of the causes of rainfall in the South Asian region help to understand the causes and salient features of the monsoon, particularly some of its important aspects, 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.

Onset of the Monsoon

The Causes of the Monsoon Onset of Monsoon are as follows :

- Differential heating of Landmass (Extreme low pressure in North – Western India & High pressure in Reunion Island)
- Northward shifting of ITCZ

- Withdrawal of Westerly jets from its position in Northern plain & positioning of easterly jet at 15°N

This easterly jet stream is held responsible for the burst of the monsoon in India.

Rain-bearing Systems and Rainfall Distribution

First originates in the Bay of Bengal causing rainfall over the plains of north India. Second is the Arabian Sea current of the southwest monsoon which brings rain to the west coast of India.

- **Western Ghats :** Much of the rainfall along the Western Ghats is orographic as the moist air is obstructed and forced to rise along the Ghats.
- The intensity of rainfall over the west coast of India is, however, related to two factors:
    - The offshore meteorological conditions.
    - The position of the equatorial jet stream along the eastern coast of Africa.
- **Bay of Bengal :**The frequency of the tropical depressions originating from the Bay of Bengal varies from year to year.
    - Their paths over India are mainly determined by the **position of ITCZ** which is generally termed as the monsoon trough.
    - 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.

EI-Nino and the Indian Monsoon

EI-Nino is a complex weather system that appears once every three to seven years bringing drought, floods and other weather extremes to different parts of the world.

- The system involves oceanic and atmospheric phenomena with the appearance of warm currents off the coast of Peru in the Eastern Pacific and affects weather in many places including India.
- EI-Nino is merely an extension of the warm equatorial current which gets replaced temporarily by cold Peruvian current or Humboldt current.
- This current increases the temperature of water on the Peruvian coast by 10ºC. This results in:
    - The distortion of equatorial atmospheric circulation;
    - Irregularities in the evaporation of seawater;
    - Reduction in the amount of planktons which further reduces the number of fish in the sea.
- EI-Nino is used in India for forecasting long range monsoon rainfall. In 1990-91, there was a wild EI-Nino event and the onset of southwest monsoon was delayed over most parts of the country ranging from five to twelve days.

Break in the Monsoon

During the south-west monsoon period, after having rains for a few days, rain fails to occur for one or more weeks, it is known as break in the monsoon.

- These dry spells are quite common during the rainy season.
- These breaks in the different regions are due to different reasons:
    - 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.

- Over the west coast the dry spells are associated with days when winds blow parallel to the coast.

Some Famous Local Storms of Hot Weather Season

- **Mango Shower**: Towards the end of summer. There are pre-monsoon showers which are a common phenomena in **Kerala 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 **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 "**Bordoisila**".
- **Loo:** Hot, dry and oppressing winds blowing in the **Northern plains from Punjab to Bihar** with higher intensity between Delhi and Patna.

.**The Southwest Monsoon Season**

India is a Tropical sub tropical climate country. The word monsoon has its origin from the Arabic word "Mausim" which means – Change in the direction of air seasonally.

- The monsoon is an outcome of underwritten changes as :
    - Differential heating & Cooling of landmass
    - Transfer of ITCZ
    - Impact of Subtropical westerlies and Tropical easterlies
    - El- Nino & La – Nina
    - Equatorial Indian ocean oscillation (Equinox)

Process of South West monsoon formation :

- As a result of the rapid increase of temperature in May over the north-western plains, the low pressure conditions over there get further intensified.
- By early June, they are powerful enough to attract the trade winds of the Southern Hemisphere coming from the Indian Ocean.
- These southeast trade winds cross the equator and enter the Bay of Bengal and the Arabian Sea, only to be caught up in the air circulation over India.
- Passing over the equatorial warm currents, they bring with them moisture in abundance.
- After crossing the equator, they follow a south-westerly direction. That is why they are known as southwest monsoons.
- The rain in the southwest monsoon season begins rather abruptly. One result of the first rain is that it brings down the temperature substantially.
- This sudden onset of the moisture-laden winds associated with violent thunder and lightening, is often termed as the "break" or "burst" of the monsoons.
- As these winds approach the land, their south-westerly direction is modified by the relief and thermal low pressure over northwest India.
- The monsoon approaches the landmass in two branches:
    - The Arabian Sea branch
    - The Bay of Bengal branch.

Monsoon Winds of the Arabian Sea

The monsoon winds originating over the Arabian Sea further split into **three branches:**

- Its one branch is **obstructed by the Western Ghats**. These winds climb the slopes of the Western Ghats from 900-1200 m. Soon, they become cool, and as a result, the windward side of the Sahyadris and Western Coastal Plain receive very heavy rainfall ranging between 250 cm and 400 cm.
    - After crossing the Western Ghats, these winds descend and get heated up. This reduces humidity in the winds. As a result, these winds cause little rainfall east of the Western Ghats. This region of low rainfall is known as the rain-shadow area.
- Another branch of the Arabian sea monsoon **strikes the coast north of Mumbai.** Moving along the Narmada and Tapi river valleys, these winds cause rainfall in extensive areas of central India.
    - The Chotanagpur plateau receives 15 cm of rainfall from this part of the branch.
    - Thereafter, they enter the Ganga plains and mingle with the Bay of Bengal branch.
- A third branch of this monsoon **wind strikes the Saurashtra Peninsula and the Kachchh**. It then passes over west Rajasthan and along the Aravallis, causing only a scanty rainfall.
    - 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.

Monsoon Winds of the Bay of Bengal

The Bay of Bengal branch **strikes the coast of Myanmar and parts of southeast Bangladesh**.

- But the Arakan Hills deflects a big portion, therefore, enters West Bengal and Bangladesh from south and southeast instead of from the south-westerly direction.
- From here, this **branch splits into two under the influence of the Himalayas** and the thermal low is northwest India.
    - Its one branch moves **westward along the Ganga plains** reaching as far as the Punjab plains.
    - The other branch **moves up the Brahmaputra valley** in the north and the northeast, causing widespread rains. Its sub-branch strikes the Garo and Khasi hills of Meghalaya.
    - Mawsynram, located on the crest of Khasi hills, receives the highest average annual rainfall in the world.

Characteristics of Monsoonal Rainfall

- Rainfall received from the southwest monsoons is seasonal in character, which occurs between June and September.
- Monsoonal rainfall is largely governed by relief or topography.
- The monsoon rainfall has a declining trend with increasing distance from the sea.
- The monsoon rains occur in wet spells of a few days, duration at a time.
    - The wet spells are interspersed with rainless intervals known as ‘breaks’.
- The summer rainfall comes in a heavy downpour leading to considerable runoff and soil erosion.
- Its spatial distribution is also uneven, ranging from 12 cm to more than 250 cm.

Season of Retreating Monsoon

The months of October and November are known for Retreating Monsoon.

- The monsoon becomes weak as the low pressure trough of the Ganga plain starts moving southward in response to the southward march of the sun.

- The monsoon retreats from the western Rajasthan , the low pressure covers northern parts of the Bay of Bengal ,it moves over Karnataka and Tamil Nadu.
- By the middle of December, the centre of low pressure is completely removed from the Peninsula.
- 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, the mercury begins to fall rapidly, particularly in northern India.
- The weather in the retreating monsoon is dry in north India but it is associated with rain in the eastern part of the Peninsula.
- The widespread rain in this season is associated with the passage of cyclonic depressions which originate over the Andaman Sea and manage to cross the eastern coast of the southern Peninsula.
- These tropical cyclones are very destructive. The thickly populated deltas of the Godavari, Krishna and Kaveri are their preferred targets. Such cyclonic storms are less frequent in the Arabian Sea.

Distribution of Rainfall

The average annual rainfall in India is about 125 cm, but it has great spatial variations.

Areas of High Rainfall:

- The highest rainfall occurs along the west coast, on the Western Ghats, as well as in the sub-Himalayan areas in the northeast and the hills of Meghalaya. Here the rainfall exceeds 200 cm.
- In some parts of Khasi and Jaintia hills, the rainfall exceeds 1,000 cm.
- In the Brahmaputra valley and the adjoining hills. The rainfall is less than 200 cm.

Areas of Medium Rainfall:

- Rainfall between 100-200 cm is received in the southern parts of Gujarat, east Tamil Nadu, north-eastern Peninsula covering Orissa, Jharkhand, Bihar, eastern Madhya Pradesh, northern Ganga plain along the sub-Himalayas and the Cachar Valley and Manipur.

Areas of Low Rainfall:

- Western Uttar Pradesh, Delhi, Haryana. Punjab, Jammu and Kashmir, eastern Rajasthan, Gujarat and the Deccan Plateau receive rainfall between 50-100 cm.

Areas of Inadequate Rainfall:

- Parts of the Peninsula, especially in Andhra Pradesh, Karnataka and Maharashtra, Ladakh and most of western Rajasthan receive rainfall below 50 cm.
- Snowfall is restricted to the Himalayan region.

MINERALS & INDUSTRIES (UPSC 2013, 2014, 2015, 2020)

India is endowed with a rich variety of mineral resources due to its varied geological structure.

- Most of the valuable minerals are **products of pre-Palaeozoic** age mainly associated with metamorphic and igneous rocks of peninsular India.

- The vast alluvial plain tract of north India is devoid of minerals of economic use.

Mode of Occurrence of Minerals

- In **igneous and metamorphic rocks** minerals may occur in the cracks, crevices, faults or joints. The smaller occurrences are called veins and the larger are called lodes.
    - Major **metallic minerals like tin, copper, zinc and lead** etc. are obtained from veins and lodes.
- **In sedimentary rocks** a number of minerals occur in beds or layers.
    - They have been formed as a result of deposition, accumulation and concentration in horizontal strata.
    - **Coal and some forms of iron ore** have been concentrated as a result of long periods under great heat and pressure.
    - Another group of sedimentary minerals include gypsum Potash salt and sodium salt.
    - These are formed as a **result of evaporation especially in arid regions.**
- Another mode of formation involves the **decomposition of surface rocks**, and the removal of soluble constituents, leaving a residual mass of weathered material containing ores. **Bauxite** is formed this way.
- Certain minerals may occur as **alluvial deposits in the sands of valley floors and the base of hills.** These deposits are called '**placer deposits'** and generally contain minerals, which are not corroded by water.
    - Gold, silver, tin and platinum are the most important among such minerals.
- **The ocean waters** contain vast quantities of minerals, but most of these are too widely diffused to be of economic significance.
    - However, common salt, magnesium and bromine are largely derived from ocean waters.
    - The ocean beds, too, are rich in **manganese nodules**.

Rat Hole Mining : The tribal areas of the north-east India, minerals are owned by individuals or communities.

- In Meghalaya, there are large deposits of coal, iron ore, limestone and dolomite etc. Coal mining in Jowai and Cherapunjee is done by family members in the form of a long narrow tunnel, known as 'Rat hole' mining.

Distribution of Minerals in India

Most of the metallic minerals in India occur in the **peninsular plateau region in the old crystalline rocks.**

- Over 97 percent of **coal reserves occur** in the valleys of Damodar, Sone, Mahanadi and Godavari.
- **Petroleum reserves** are located in the sedimentary basins of Assam, Gujarat and Mumbai High i.e. off- shore region in the Arabian.
    - New reserves have been located in the Krishna-Godavari and Kaveri basins.
- Most of the major mineral resources occur to the east of a line linking Mangalore and Kanpur.

Minerals are generally concentrated in three broad belts in India. These belts are:

- **The North-Eastern Plateau Region :** This belt covers Chotanagpur (Jharkhand), Orissa Plateau, West Bengal and parts of Chhattisgarh.

- **The South-Western Plateau Region:** This belt extends over Karnataka, Goa and contiguous Tamil Nadu uplands and Kerala.
    - This belt is rich in ferrous metals and bauxite. It also contains high grade iron ore, manganese and limestone. This belt **packs in coal deposits except naively lignite.**
    - This belt does not have as diversified mineral deposits as the north-eastern belt. Kerala has deposits of monazite, thorium, and bauxite clay. Goa has iron ore deposits.
- **The North-Western Region:** This belt extends along Aravali in Rajasthan and part of Gujarat and minerals are associated with the Dharwar **system of rocks.**
    - Copper, zinc have been major minerals. Rajasthan is rich in building stones i.e. sandstone, granite, marble.
    - Gypsum and Fuller's earth deposits are also extensive. Dolomite and limestone provide raw materials for the cement industry.
    - Gujarat is known for its petroleum deposits. Gujarat and Rajasthan both have rich sources of salt.
- **The Himalayan belt** is another mineral belt where copper, lead, zinc, cobalt and tungsten are known to occur.
    - They occur in both the eastern and western parts. Assam valley has mineral oil deposits.
    - Oil resources are also found in off-shore-areas near Mumbai Coast (Mumbai High).

MINERALS & THEIR DEPOSITION :

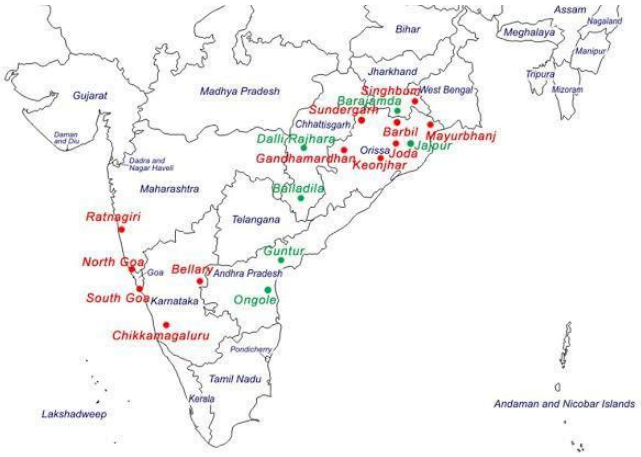
Ferrous Mineral:

Ferrous minerals such as iron ore, manganese, chromite, etc., provide a strong base for the development of metallurgical industries.

Iron Ore:

India has the largest reserves of iron ore in Asia, mainly hematite and magnetite.

- The iron ore mines occur in close proximity to the coal fields in the north- eastern plateau region of the country which adds to their advantage.
- About 95 per cent of total reserves of iron ore are located in the States of Orissa, Jharkhand, Chhattisgarh, Karnataka Goa, Andhra Pradesh and Tamil Nadu.



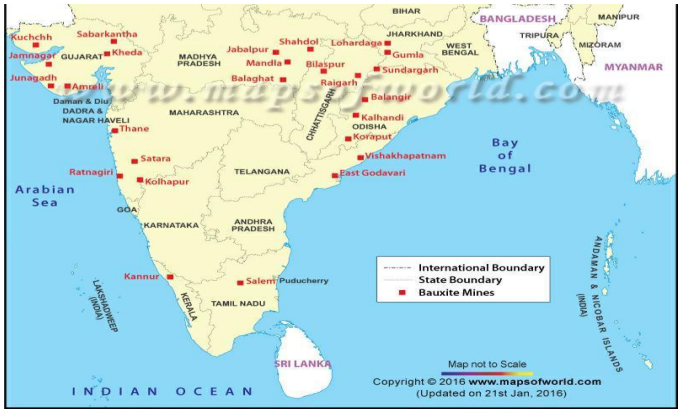
Manganese:

Manganese is an important raw material for smelting of iron ore and also used for manufacturing Ferro alloys.

- Manganese deposits are found in **almost all geological formations**; however, it is **mainly associated with the Dharwar system.**
- Orissa is the leading producer of Manganese.

Non-Ferrous Minerals: India is **poorly** with non-ferrous metallic minerals except bauxite.

Bauxite:



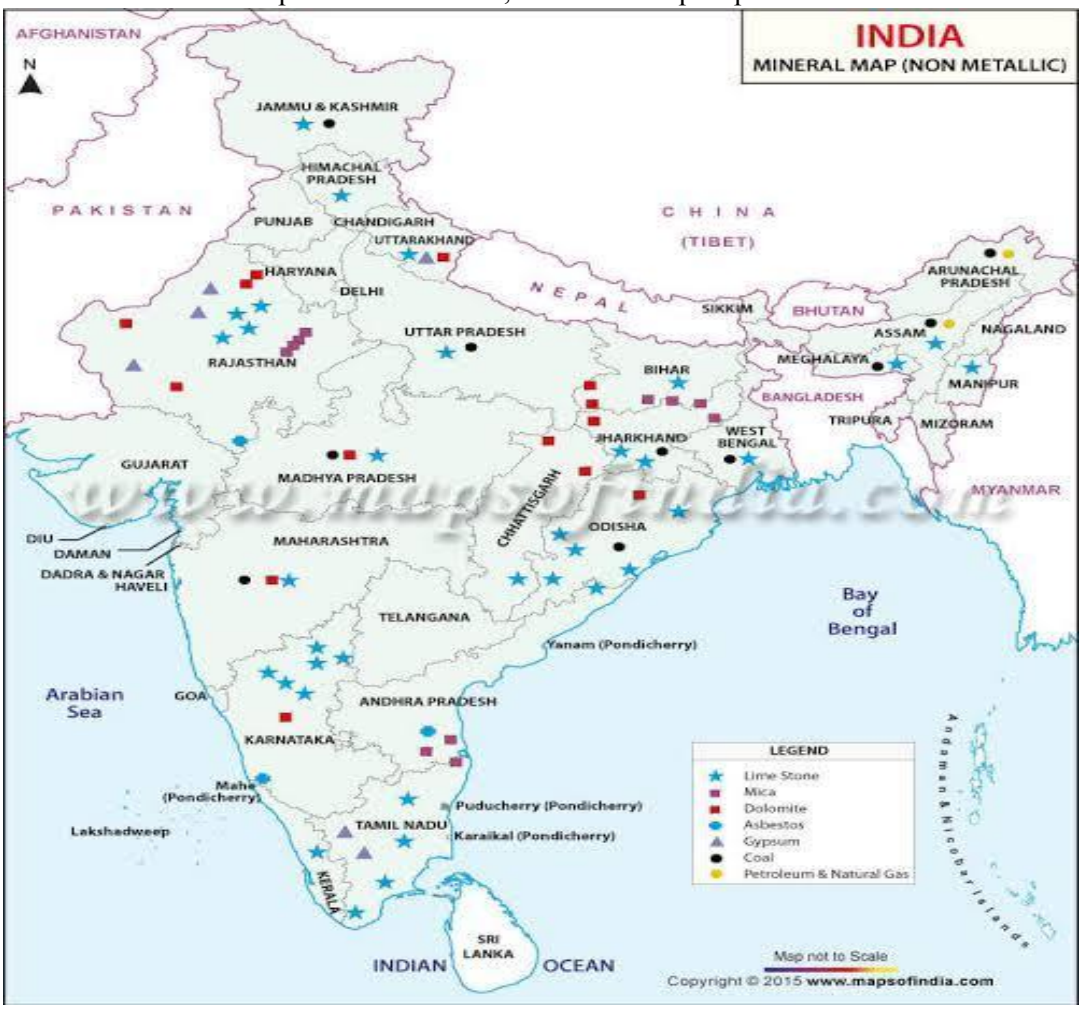
- Bauxite is the ore which is used in the manufacturing of aluminium.
- Bauxite is found **mainly in tertiary deposits** and is associated with **laterite** rocks and also in the coastal tracts of the country.

Copper:

- Copper is an indispensable metal in the electrical industry for making wires, electric motors, transformers and generators. It is allowable, Malleable and ductile.
- It is also mixed with gold to provide strength to jewellery.
- The **Copper deposits mainly** occur in Singhbhum district in Jharkhand, Balaghat district in Madhya Pradesh and Jhunjhunu and Alwar districts in Rajasthan.
- **Minor producers of Copper are Agnigundala** in Guntur District (Andhra Pradesh), Chitradurga and hasan districts (Karnataka) and South Arcot district (Tamil Nadu).

Non-metallic Minerals:

Among the nonmetallic minerals produced in India, mica is the most important one. The other minerals extracted for local consumption are limestone, dolomite and phosphate.



Mica: Mica is mainly used in the electrical and electronic industries. It can be split into very thin sheets which are tough and flexible.

Energy Resources:

Mineral fuels are essential for generation of power, required by agriculture, industry, transport and other sectors of the economy.

- Mineral fuels like coal, petroleum and natural gas (known as fossil fuels), and nuclear energy minerals, are the conventional sources of energy.
- These conventional sources are exhaustible resources.

Coal: Coal is a one of the important minerals which is mainly used in the generation of thermal power and smelting of iron ore.

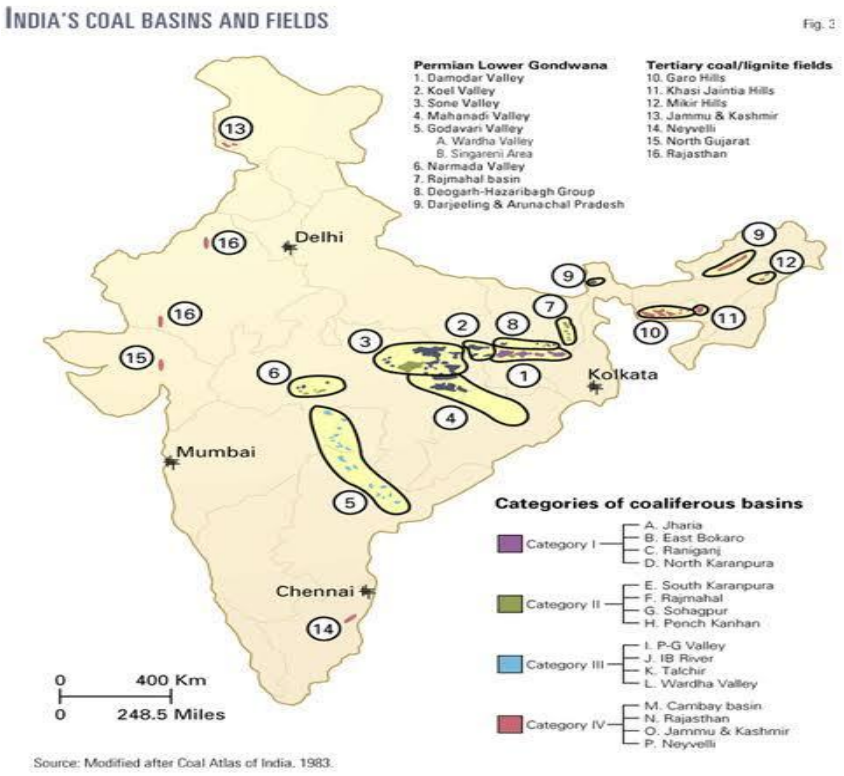
- Coal occurs in rock sequences mainly of two geological ages, namely **Gondwana and tertiary deposits. (UPSC PRE 2013)**

LIGNITE COAL	BITUMINOUS COAL	ANTHRACITE COAL
• It is a low grade brown coal, which is soft with high moisture content. • The principal lignite reserves are in Neyveli in Tamil Nadu and are used for generation of electricity.	• Coal that has been buried deep and subjected to increased temperatures is bituminous coal. It is the most popular coal in commercial use. • Metallurgical coal is high grade bituminous coal which has a special value for smelting iron in blast furnaces.	• Anthracite is the highest quality hard coal. About 80 per cent of the coal deposits in India is of bituminous type and is of non- coking grade.

The most important Gondwana coal fields of India are located in Damodar Valley.

Petroleum: Crude petroleum consists of hydrocarbons of liquid and gaseous states varying in chemical composition, colour and specific gravity.

- It is an essential source of energy for all internal combustion engines in automobiles, railways and aircraft.
- Its numerous by-products are processed in petrochemical industries such as fertilizer, synthetic fibre, medicines, Vaseline, lubricants, wax, soap and cosmetics.
- Most of the petroleum occurrences in India are associated with **anticlines and fault traps in the rock formations** of the tertiary age. In regions of folding, anticlines or domes, it occurs where oil is trapped in the crest of the up fold.
- The **oil bearing layer is a porous limestone or sandstone through which oil may flow**. The oil is prevented from rising or sinking by intervening non-porous layers.
- Petroleum is also found in fault traps between porous and non-porous rocks. Gas, being lighter, usually occurs above the oil.
- About 63 per cent of India's petroleum production is from Mumbai High, 18 per cent from Gujarat and 16 per cent from Assam.
- Crude petroleum occurs in **sedimentary rocks of the tertiary period**.



Natural Gas: The Gas Authority of India Limited was set up in 1984 as a public sector undertaking to transport and market natural gas.

- It is obtained along with oil in all the oil fields but exclusive reserves have been located along the **eastern coast as well as (Tamil Nadu, Orissa and Andhra Pradesh), Tripura, Rajasthan and off-shore wells in Gujarat and Maharashtra**.

Nuclear Energy Resources: Nuclear energy as a viable source in recent times.

- Important minerals used for the generation of nuclear energy are uranium and thorium.
- Uranium deposits **occur in the Dharwar rocks**.
- Geographically, uranium ores are known to occur in several locations along the Singbhum Copper belt.
- It is also found in Udaipur, Alwar and Jhunjhunu districts of Rajasthan, Durg district of Chhattisgarh, Bhandara district of Maharashtra and Kullu district of Himachal Pradesh.
- **Thorium** is mainly obtained from monazite and ilmenite in the beach sands along the coast of Kerala and Tamil Nadu.
- World's richest monazite deposits occur in Palakkad and Kollam districts of Kerala, near Visakhapatnam in Andhra Pradesh and Mahanadi river delta in Orissa.

Non-Conventional Energy Sources:

Sustainable energy resources are only renewable energy sources like solar, wind, hydro-geothermal and biomass.

- These energy sources are more equitably distributed and environmentally friendly.

Solar Energy: Sun rays tapped in photovoltaic cells can be converted into energy, known as solar energy.

- It is cost competitive, environmentally friendly and easy to construct.
- Solar energy is 7 per cent more effective than coal or oil based plants and 10 per cent more effective than nuclear plants.
- It is generally used more in appliances like heaters, crop dryers, cookers, etc.
- The **western part of India has greater potential** for the development of solar energy in Gujarat and Rajasthan.

Wind Energy: Wind energy is an absolutely pollution free, inexhaustible source of energy.

- The mechanism of energy conversion from blowing wind is simple. The kinetic energy of wind, through turbines is converted into electrical energy.
- In **Rajasthan, Gujarat, Maharashtra and Karnataka,** favourable conditions for wind energy exist.
- Wind power plant at **Lamba in Gujarat in Kachchh** is the largest in Asia. Another wind power plant is located at **Tuticorin in Tamil Nadu.**

Tidal and Wave Energy: Ocean currents are the store-house of infinite en

- The tidal waves are known to occur along the **west coast of India.**
- In India, the **Gulf of Kachchh provides** ideal conditions for utilizing tidal energy.
- A 900 mw tidal energy power plant is set up here by the National Hydropower Corporation.

Geothermal Energy: When the magma from the interior of earth, comes out on the surface, tremendous heat is released. This heat energy can successfully be tapped and converted to electrical energy.

- Apart from this, the hot water that gushes out through the **geyser** well is also used in the generation of thermal energy. It is popularly known as
- geysers have been used since the medieval period.
- The first successful (1890) attempt to tap the underground heat was made in the city of Boise, Idaho (U.S.A.), where a hot water pipe network was built to give heat to the surrounding buildings. This plant is still working.

Bio-energy: Bio-energy refers to energy derived from biological products which includes agricultural residues, municipal, industri

INDUSTRIAL DEVELOPMENT

The cotton textile Industry is one of our traditional industries. The sugar Industry is based on local raw materials which prospered even in the British period.

The industries can be classified as –

- **Weight losing industry –** The final produce is in less Quantity than input raw material are called Weight losing industry . For Example – Iron & Steel Industry , Sugar cane industry, Paper Industry , Cement Industry etc.
    - These Industries are mainly established in the Raw Material Area.
- **Footloose industry –** these industries can be established at any place like - cotton Industry
- **Weight gain Industry –** These are market based industries hence they are established near the Market . For Example – Bakery Industry

Footloose Industries –

Footloose industries can be located in a wide variety of places. They are not dependent on any specific raw material, weight losing, or otherwise. They produce in small quantities and also employ a small labour force. These are generally not polluting industries. The important factor in their location is accessibility by road network.

Classification of Industries

An industry can be classified on the basis of raw material, size and ownership –

Based on Raw Material

- Any material that we get from our natural surroundings to be used by the industry is called raw material. **Plant and animal-based products are used as raw materials in food processing, vegetable oil, cotton textile, dairy, and leather products, which are all examples of agro-based industries.**
- There is another type of industry that is based on the produce derived from forests. This is known as the **forest-based industry and is responsible for producing paper, pharmaceuticals, furniture, equipment, and buildings.**

Based in Ownership

- Industries are classified on the basis of ownership as well, i.e. **privately owned, cooperative, or state-owned.** A privately owned industry means it is owned by an individual or a group like the Tata group. State-owned or public sector means they are owned and operated by the government like Bharat Heavy Electricals Limited (BHEL).
- **A partnership between the state and an individual or a group is called the joint sector** like Maharashtra Scooters Limited, which is a partnership between the Government of Maharashtra and the Bajaj Group.
- The cooperative sector was formed to play a major role in the advancement of agriculture and related industries. In this sector, the state facilitates the producers, suppliers, and even workers to own the enterprise like the Amul Dairy.

Based on Size

- Industries are classified as large-scale or small-scale depending on the amount of capital invested, the number of people employed, and the volume of production.
- A small-scale industry needs a lesser amount of capital and technology inputs. A large scale industry has automated production, and is capital-and manpower-intensive and requires heavy investment in plant and machinery.

Factors responsible for location of Industries:

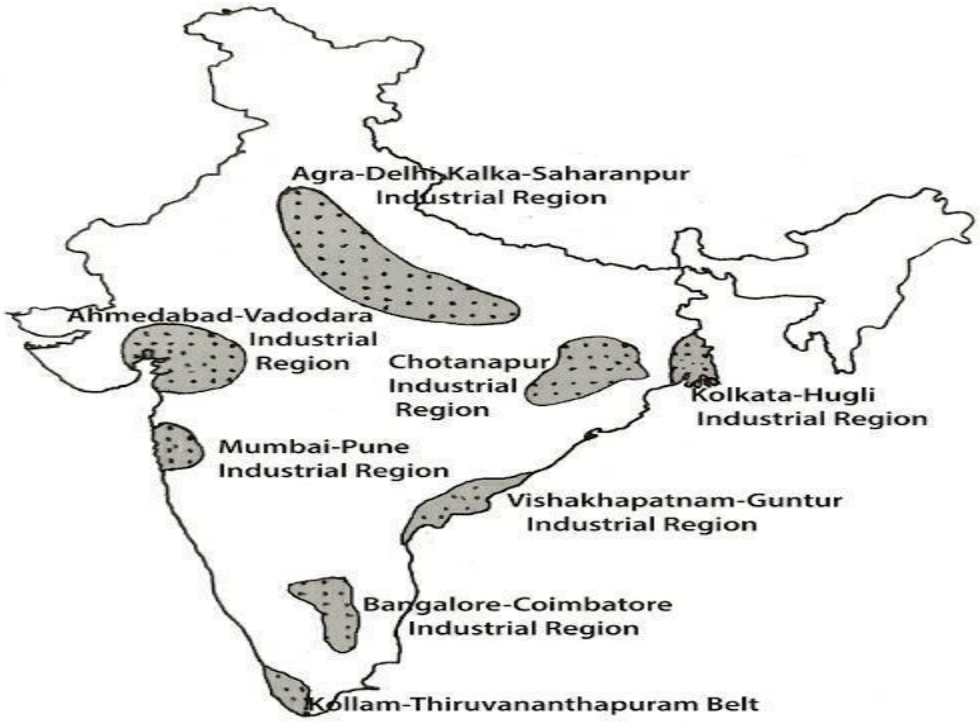
- Availability of Raw Material
- Power Resources
- Availability of water

- Labour
- Transportation
- Availability of Market
- Capital

Industrial Cycle :

The three steps involved in an industrial cycle are: Input, Processes and Output.

- The **first step is putting together the inputs, like raw material, labour, cost of land, transport, power, and other infrastructure.**
- The **second step is the process, which includes a wide range of activities that convert the raw material into finished goods** like ginning, spinning, weaving, dyeing, and printing.
- **The final step is the finished product or the output that we use.**



Primary Industry	• **Directly dependent on environments such as land, water, vegetation, building materials, and minerals.** • **Examples are hunting and gathering, pastoral activities, fishing, forestry, agriculture, and mining and quarrying.** • **Red-Collar job**

Secondary Industry	• **Transforming raw materials into valuable/useful products.** • Examples- manufacturing, processing, and construction (infrastructure) industries. • **Blue-Collar job**
Tertiary Industry	• It is the **sector/activity that provides services to end consumers and to the primary and secondary sectors** and is considered the most important sector in the chain. • Examples are- Transportation, health care, food service, retail sales, advertising, entertainment, tourism, banking, law, etc. are all examples of tertiary-level sectors. • **White-collar jobs.**
Quaternary Industry	• Although many **economic models divide the economy into only three sectors,** others divide it into four or even five sectors. **These final two sectors are closely linked with the services of the tertiary sector.** In these models, the quaternary sector of the economy consists of **intellectual activities often associated with technological innovation**. It is sometimes called the **knowledge economy.** • **Activities associated with this sector include government, culture, libraries, scientific research, education, and information technology.** These intellectual services and activities are what drives technological advancement, which can have a huge impact on short- and long-term economic growth.
Quinary Industry	• **This sector includes top executives or officials in such fields as government, science, universities, nonprofits, health care, culture, and the media.** It may **also include police and fire departments,** which are public services as opposed to for-profit enterprises. • Economists sometimes also include domestic activities (duties performed in the home by a family member or dependent) in the quinary sector. **Gold collar professions**

Minor Industrial Regions–

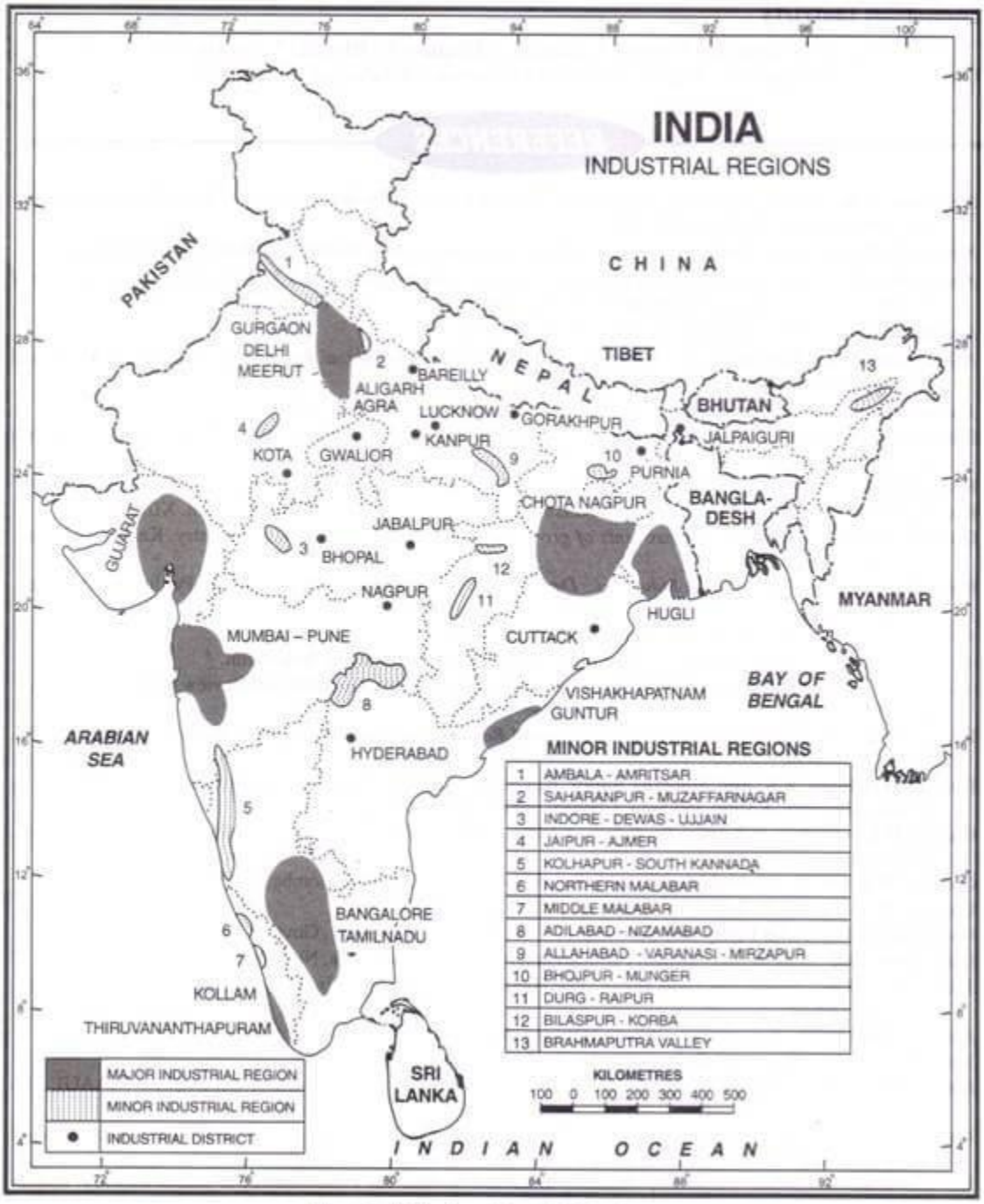
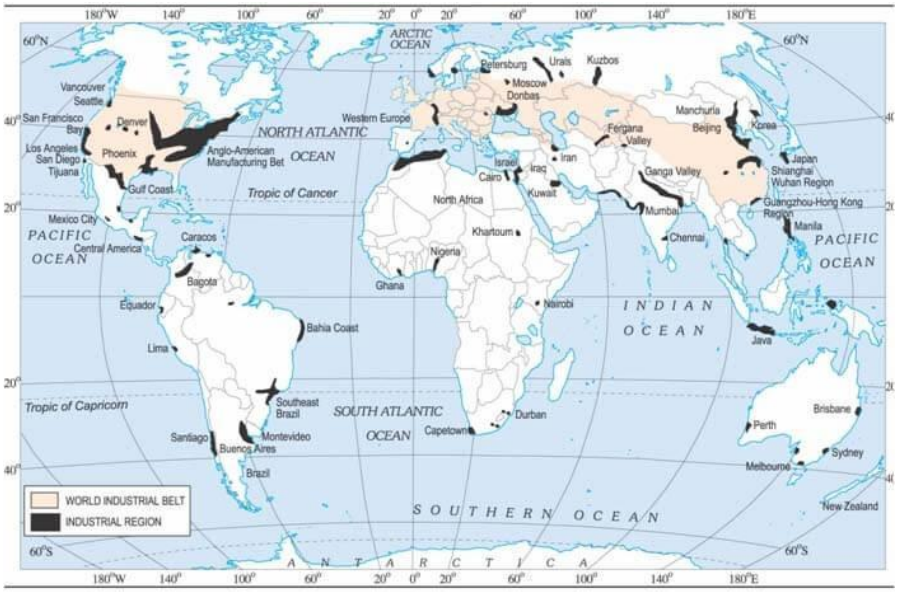


Fig. 27.18. India : Industrial Regions

World Industrial Regions –



Industrial Disasters

Industrial workers are sometimes required to work in a dangerous environment. Any lapse in the regular maintenance of technical equipment or i**rresponsible handling of a hazardous material may lead to accidents.** There are some risk reduction measures, which, if followed, can prevent large-scale disasters like:

- Industrial areas should be on the outskirts of a city or town or located far away from residential areas.
- People in the vicinity of the industrial area should be aware of the hazardous materials handled in these industries and their effects on humans in case of an accident.
- Improvement in the fire warning systems, firefighting systems, and pollution dispersion qualities, and limiting toxic storage capacity within these industries will reduce the risk of a large-scale disaster considerably.

Major Industries in India

Cement Industry

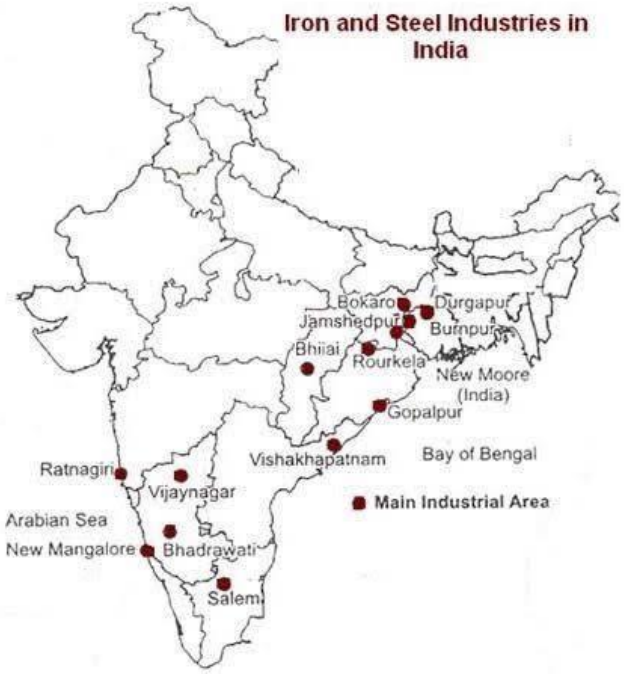
India is the second largest producer of cement in the world.

- As of July 2019, the production of cement stood at 28.08 million tonnes.
- The cement production capacity is estimated to touch 550 MT by 2020.
- Of the total capacity, 98 percent lies with the private sector and the rest with the public sector.
- Of the total 210 large cement plants in India, 77 are located in the states of Andhra Pradesh, Rajasthan, and Tamil Nadu.
- Cement production in India increased from 230.49 million tonnes in 2011-12 to 297.56 million tonnes in 2017-18.

Iron and Steel Industry (UPSC PRE 2015, 2020)

India was the world's second-largest steel producer in 2018 second to China. The growth in the Indian steel sector has been driven by the domestic availability of raw materials such as iron ore and cost-effective labour. Consequently, the steel sector has been a major contributor to India's manufacturing output.

- **India was the world's second-largest steel producer in 2018 second to China.** The growth in the Indian steel sector has been driven by the domestic availability of raw materials such as iron ore and cost-effective labour. Consequently, the steel sector has been a major contributor to India's manufacturing output.
- India's crude steel production in 2018 was at 106.5 MT, up by 4.9 percent from 101.5 MT in 2017.
- Indian steel industries are classified into three categories such as major producers, main producers, and secondary producers.
- The country is slated to surpass the USA to become the world's second-largest steel consumer in



2019. In India, as per Indian Steel Association (ISA), steel demand to grow by over 7 percent in both 2019-20 and 2020-21

- In FY19, India produced 131.57 million tonnes (MT) and 106.56 MT of gross finished steel and crude steel, respectively.
- Exports and imports of finished steel stood at 2.45 MT and 3.35 MT, respectively, in FY20P (up to August).
- The Government has launched the National Steel Policy 2017 that aims to increase the per capita steel consumption to 160 kgs by 2030-31.
- National Mineral Development Corporation is expected to invest US$ 1 billion in infrastructure in the next three years to boost iron production.
- As per Economic Survey 2018-19, steel production will touch 128.6 million tonnes by 2021.

Textiles Industry (UPSC PRE 2020)

India's textiles sector is **one of the oldest industries in the Indian economy** dating back several centuries.

India's overall textile exports during FY 2017-18 stood at US$ 39.2 billion in FY18 and is expected to increase to US$ 82.00 billion by 2021 from US$ 31.65 billion in FY19.

- The **Indian textiles industry, currently estimated at around US$ 150 billion, is expected to reach US$ 250 billion by 2019**.
- **India's textiles industry contributed seven percent of the industry output (in value terms) of India in 2017-18.**
- It contributed t**wo percent to the GDP of India and employs more than 45 million people in 2017-18.**
- The sector contributed 15 percent to the export earnings of India in 2017-18.
- The Indian government has come up with a number of export promotion policies for the textiles sector. It has also allowed 100 percent FDI in the Indian textiles sector under the automatic route.
- **India is the world's second-largest exporter of textiles and clothing.**

Gems & Jewellery Industry

India's gems & jewellery market size is expected to reach US$ 100 billion by 2025.

- The Gems and Jewellery sector play a significant role in the Indian economy, contributing around 7 percent of the country's GDP and 15 percent to India's total merchandise exports.
- It also employs over 4.64 million workers and is expected to employ 8.23 million by 2022.
- One of the fastest-growing sectors, it is extremely export oriented and labour intensive.
- The Indian government presently allows 100 percent Foreign Direct Investment (FDI) in the sector through the automatic route.
- India's gems and jewellery sector are one of the largest in the world contributing 29 percent to global jewellery consumption.
- India is the world's largest center for cut and polished diamonds in the world and exports 75 percent of the world's polished diamonds. Today, 14 out of 15 diamonds sold in the world are either polished or cut in India.

Oil refining

India imports crude oil from a number of West Asian countries. In order to refine crude oil, several oil refineries have been set up in different parts of the country. **The oldest refinery is Digboi in Assam.** Others are at Noonmati, Haldia, Bongaigaon, Barauni, Mathura, Visakhapatnam, Chennai, Cochin, Mumbai, and Koyali (Vadodara).

Sugar Industry (UPSC PRE 2020,2013)

The sugar industry is the second most important agro-based industry in the country.

- India is the largest producer of both sugarcane and cane sugar and contributes about 8 per cent of the total sugar production in the world.
- Besides, khandasari and gur or jaggery are also prepared from sugarcane.

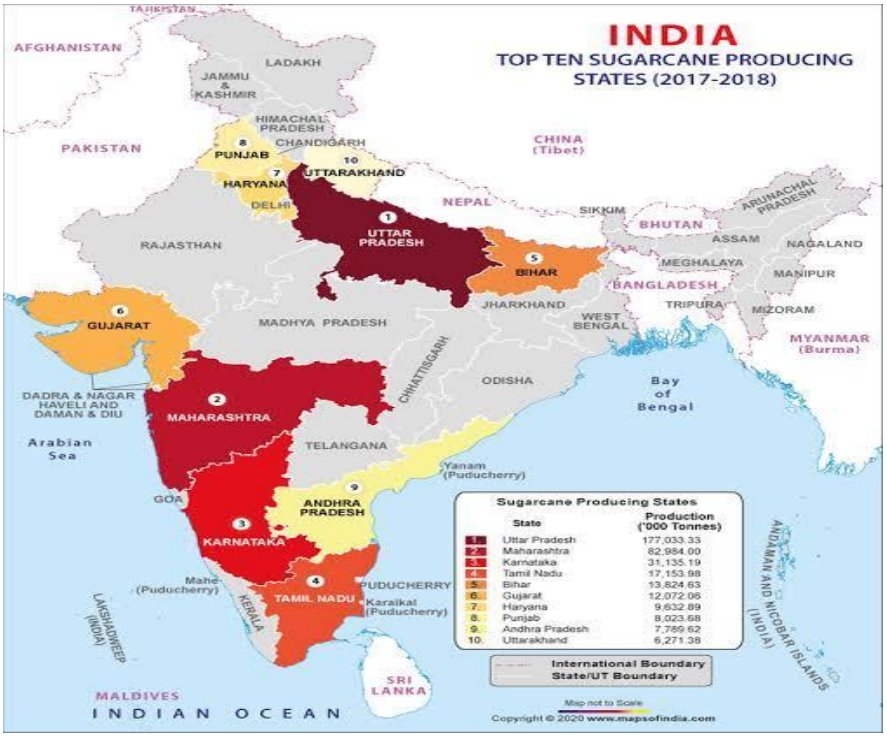
- Sugar industry is a seasonal industry because of the seasonality of raw materials.

Development of the industry on modern lines dates back to 1903, when a sugar mill was started in Bihar.

- Subsequently, sugar mills were started in other parts of Bihar and Uttar Pradesh.

Location of the Sugar Industry

Sugarcane is a **weight-losing** crop. The ratio of sugar to sugarcane varies between 9 to 12 per cent depending on its variety. Its sucrose content begins to dry during haulage after it has been harvested from the field.



<u>Petrochemical Industries</u>

This group of industries has been growing very fast in India. A variety of products come under this category of industries.

- Many items are derived from crude petroleum, which provide raw materials for many new industries; these are collectively known as petrochemical industries.
- This group of industries is divided into four sub- groups :
    - Polymers
    - Synthetic fibres
    - Elastomers
    - Surfactant intermediate.

<u>Location :</u>

- Mumbai is the hub of the petrochemical industries.

- Cracker units are also located in Auraiya (Uttar Pradesh), Jamnagar, Gandhinagar, and Hajira (Gujarat), Nagothane, Ratnagiri (Maharashtra), Haldia (West Bengal) and Visakhapatnam (Andhra Pradesh).

Govt organisation :

Three organizations are working in the petrochemical sector under the administrative control of the Department of Chemicals and Petrochemicals.

- **Indian Petrochemical Corporation Limited (IPCL**), a public sector undertaking. It is responsible for the manufacture and distribution of the various petrochemicals like polymers, chemicals, fibres and fibre intermediates.
- **Petrofils Cooperative Limited (PCL),** a joint venture of the Government of India and Weaver's Cooperative Societies. It produces polyester filament yarn and nylon chips at its two plants located at Vadodara and Naldhari in Gujarat.
- **Central Institute of Plastic Engineering and Technology (CIPET),** involved in imparting training in petrochemical industry.

Polymer : Polymers are made from ethylene and propylene.

- These materials are obtained in the process of refining crude oil.
- Polymers are used as raw materials in the plastic industry. Among polymers, polyethylene is a widely used thermoplastic.
- The production of plastic polymers started in India in the late fifties and the early sixties using other organic chemicals.
- The National Organic Chemicals Industries Limited (NOCIL), established in private sector.
- The industry also uses recycled plastics, which constitutes about 30 per cent of the total production.

Synthetic Fibre : Synthetic fibres are widely used in the manufacturing of fabrics because of their inherent strength, durability, wash ability, and resistance to shrinkage.

- Industries manufacturing nylon and polyester yarns are located at Kota, Pimpri, Mumbai, Modinagar, Pune, Ujjain, Nagpur and Udhna.
- Acrylic staple fibre is manufactured at Kota and Vadodara.

Information Technology (IT)

The **information technology** industry deals in the storage, processing, and distribution of information.

- Today, this industry has become global. This is due to a series of technological, political, and socio-economic events.
- The main factors guiding the location of these industries are resource availability, cost, and infrastructure.
- The major hubs of the IT industry are **Silicon Valley, California**, **and Bangalore, India.**

Cottage Industries (

A **cottage industry** is a small-scale, decentralized manufacturing business often operated out of a home rather than a purpose-built facility. **Cottage industries** are defined by the amount of investment required to start, as well as the number of people employed. hey often focus on the production of labor-intensive goods but face a significant disadvantage when competing with factory-based manufacturers that mass-produce goods.

Cottage Industries –

- Provide jobs to millions of people
- Check migration of rural people to urban areas
- Can be started with low investment
- Helps to earn additional income for rural people
- Use local raw material → Optimum utilization of national resources
- Earn a lot of foreign exchange for the country
- Generate seasonal as well as perennial employment for labour
- Play a significant role in our national economy.

Tea plantation Industry

Labour availability

- Weeding, manure, pruning and plucking → tedious job + need skill + patience
- Cheap female labour force is essential (same factor as sericulture)
- Since tea has to be grown in hill slopes, mechanization not possible
- Even while drying, rolling, fermentation, grading and packaging of tea, skilled manpower needed
- Therefore, tea plantation is done near areas with high population density

Raw material

- Tea leaves to tea, involves considerable weight loss
- Hence tea processing is done in the estate/plantation itself
- Further blending/repacking could be done at break of the bulk location
- For e.g. port cities like London
- **[Break of the bulk]** → Place where mode of transportation changes e.g. waterway to railways

Climate

- Frost damages the leaves hence tea is not grown beyond Northern China / Honshu
- Very long winter retards plant growth hence decreases yield

Topography

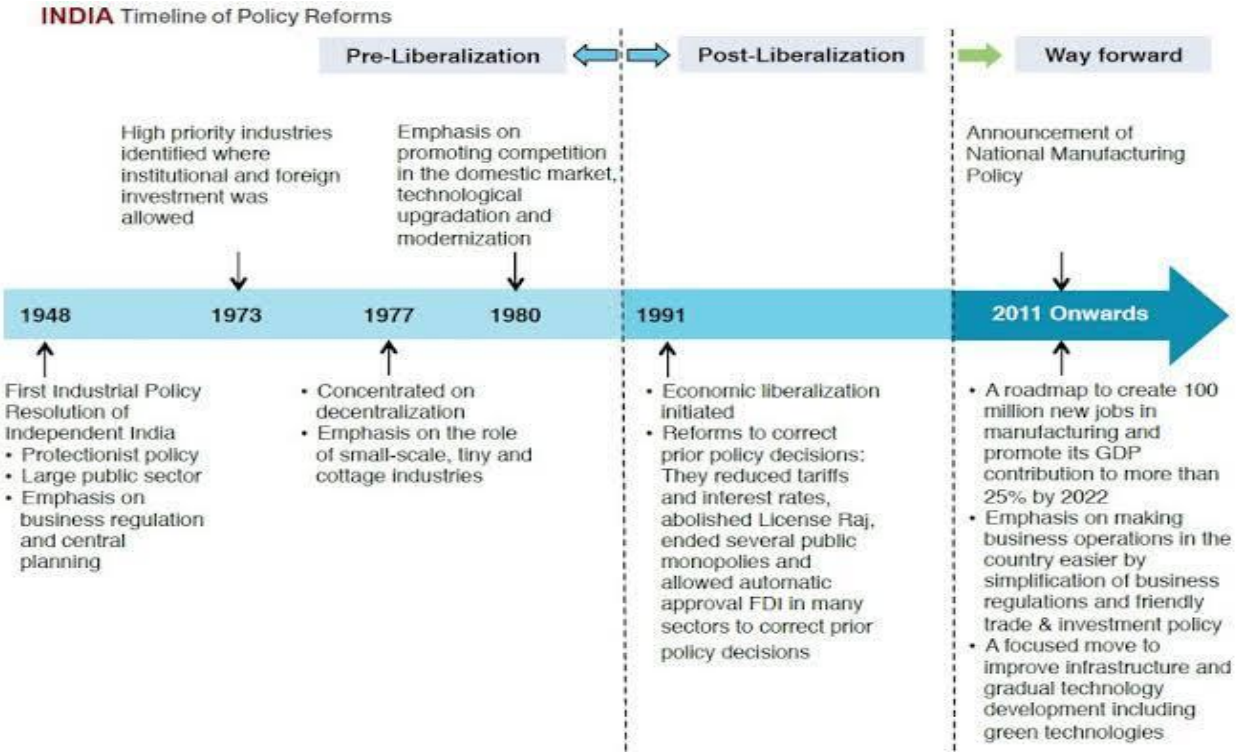
- Doesn’t like stagnant water
- Hence, has to be grown on highland or hill slopes
- for e.g. hills of Darjeeling, Jalpaiguri (West Bengal) & Nilgiri (Tamil Nadu)

Coffee Plantation → Karnataka + Kerala (India)

Region	**The Western Ghats + Nilgiri Hills region** **Suited for both Tea + coffee**
Soil	Red soil → best suited Hill areas of → No stagnant water
Temp	Coffee is grown on the Northern and Eastern slopes of the Ghat (Because coffee hates direct sunlight) Moderating effect of Lakshadweep sea Temp stays ~25 throughout the year
Transport	Via Kochi port
Market	Kochi port to (mostly) Italy Local demand in South India

Industrial Policy

- The new **Industrial Policy** was implemented in **1991**.
- The new industrial policy has three main dimensions − liberalization, privatization, and globalization.



- Within this new industrial policy, measures initiated are − abolition of industrial licensing; free entry to foreign technology; foreign investment policy; access to capital market; open trade; abolition of phased manufacturing program; and liberalized industrial location program.
- Globalization means integrating the economy of the country with the world economy.

AGRICULTURE & SOILS

SOILS (UPSC PRE 2021, 2018,2013)

Soil can be simply defined as a **mixture of small rock particles/debris and organic materials/ humus** which develop on the earth's surface and support the growth of plants.

- Soil is the topmost layer of the continental crust having weathered particles of rocks. The soils of India are the product of physical factors as well as human factors.
- Factors that influence soil formation–
    - Parent Material
    - Relief/Topography
    - Climate
    - Natural Vegetation & Biological factors
    - Time

Soil types in India (Types of Soil) - In India, the Indian Council of Agricultural Research (ICAR) has classified soils into 8 categories.

- Alluvial Soil
- Black Cotton Soil
- Red Soil
- Laterite Soil
- Mountainous or Forest Soils
- Arid or Desert Soil
- Saline and Alkaline Soil
- Peaty, and Marshy Soil/Bog Soil

The **ICAR has also classified the Indian soils** on the **basis of their nature and character** as per the **United States Department of Agriculture (USDA) Soil Taxonomy.**

ICAR has classified the soils of India into the following order as per the USDA soil taxonomy

Sl. No.	*Order*	*Area (in Thousand Hectares)*	*Percentage*
(i)	Inceptisols	130372.90	39.74
(ii)	Entisols	92131.71	28.08
(iii)	Alfisols	44448.68	13.55
(iv)	Vertisols	27960.00	8.52
(v)	Aridisols	14069.00	4.28
(vi)	Ultisols	8250.00	2.51
(vi)	Mollisols	1320.00	0.40
(viii)	Others	9503.10	2.92
Total			**100**

Source : Soils of India, National Bureau of Soil Survey and Land Use Planning, Publication Number 94

Alluvial Soils

- Alluvial soils are formed mainly due to **silt deposited by Indo-Gangetic-Brahmaputra rivers. In coastal regions, some alluvial deposits are formed due to wave action.**

- Rocks of the Himalayas form the parent material. Thus the parent material of these soils is of transported origin.
- They are the largest soil group covering about 15 lakh sq km or about **46 percent of the total area.**
- They **support more than 40% of India's population** by providing the most productive agricultural lands.

Characteristics of Alluvial Soils

- They are **immature and have weak profiles** due to their recent origin.
- Most of the soil is sandy and clayey soils are not uncommon.
- They **vary from loamy to sandy-loam in drier** regions and **clayey loam towards the delta.**
- 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.

Chemical properties of Alluvial Soils

- The proportion of **nitrogen is generally low.**
- The proportion of **Potash, phosphoric acid, and alkalis are adequate**
- The proportion of **Iron oxide and lime vary within a wide range.**

Distribution of Alluvial Soils in India

- They occur all along the **Indo-Gangetic-Brahmaputra plains except in few places where the top layer is covered by desert sand.**
- They also occur in deltas of the **Mahanadi, the Godavari, the Krishna, and the Cauvery, where they are called deltaic alluvium (coastal alluvium)**
- Some alluvial soils are found in the **Narmada, Tapi valleys, and Northern parts of Gujarat.**

Crops in Alluvial Soils

- They are mostly flat and regular soils and are best suited for agriculture.
- They are best suited to irrigation and respond well to the canal and well/tube-well irrigation.
- They yield splendid crops of rice, wheat, sugarcane, tobacco, cotton, jute, maize, oilseeds, vegetables, and fruits.

Geological divisions of alluvial soils

- Geologically, the alluvium of the Great plain of India is divided into newer or younger khadar and older bhangar soils.

Bhabar	**Tarai**	**Bhangar**

• The bhabar belt is about 8-16 km wide running along the Shivalik foothills. It is a porous, northernmost stretch of the Indo-Gangetic plain. • Rivers descending from the Himalayas deposit their load along the foothills in the form of **alluvial fans.** These alluvial fans (often pebbly soils) have merged together to build up the bhabar belt. • The porosity of bhabar is the most unique feature. The porosity is due to deposition of huge numbers of pebbles and rock debris across the alluvial fans. • The streams disappear once they reach the bhabar region because of this porosity. Therefore, the area is marked by **dry river courses** except in the rainy season. • **The area is not suitable for agriculture and only big trees with large roots thrive in this belt.**	• Terai is an **ill-drained, damp (marshy) and thickly forested narrow tract** (15-30 km wide) to the south of Bhabar running parallel to it. • The underground streams of the Bhabar belt re-emerge in this belt. It is a swampy lowland with silty soils. • The **terai soils are rich in nitrogen and organic matter** but are **deficient in phosphate.** • These soils are generally covered by tall grasses and forests but are suitable for a number of crops such as wheat, rice, sugarcane, jute, etc. • This **thickly forested region provides shelter to a variety of wildlife.**	• The Bhangar is the **older alluvium along the river beds** forming terraces higher than the floodplain (about 30 meters above the flood level). • It is of a more clayey composition and is generally dark-colored. • A few meters below the terrace of the bhangar are beds of lime nodules known as **"Kankar"**. **Khadar** • The Khadar is composed of **newer alluvium and forms the flood plains along the river banks.** • The banks are flooded almost every year and a new layer of alluvium is deposited with every flood. This makes them the most fertile soils of the Ganges. • They are sandy clays and loams, drier and leached, less calcareous and carbonaceous (less kankary). A new layer of alluvium is deposited by river floods almost every year.

<u>Alluvial regions with rainfall</u>

- **Above 100cm** – Suitable for paddy
- **B/w 50-100cm** – Suitable for wheat, sugarcane, tobacco, and cotton
- **Below 50cm**– Course grains (millets)

Black Soils (UPSC 2021 PRE)

- **Formation** –formed due to **weathering of these basaltic rocks** which **emerged during fissure eruption of the Cretaceous period.**
- 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.
- **Extent – 15 % of the area**
- **Black colour** is ordained by **titani-ferrous magnetic compounds** found in basalt.

Characteristics of Black Soils

- A typical black soil is highly argillaceous [Geology (of rocks or sediment) consisting of or containing clay] with a large clay factor, 62 percent or more.
- In general, **black soils of uplands are of low fertility while those in the valleys are very fertile.**
- The **black soil is highly retentive of moisture**. It swells greatly on accumulating moisture. Strenuous effort is required to work on such soil in rainy season as it gets very sticky.
- In summer, the moisture evaporates the soil shrinks and is seamed with broad and deep cracks. The lower layers can still retain moisture. The cracks permits oxygenation of the soil to sufficient depths and the soil has extraordinary fertility.
- **When dry**, it develops **cracks and has blocky structure**. (**Self Ploughing Capacity**)

Colour of Black Soils

- The black colour is due to the presence of a small proportion of **titaniferous magnetite or iron and black constituents of the parent rock.**
- In Tamil Nadu and parts of Andhra Pradesh, the black colour is derived from crystalline schists and basic gneisses.
- 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.

Chemical Composition of Black Soils

- 1**0 percent of alumina,**
- **9-10 percent of iron oxide,**
- 6-8 percent of lime and magnesium carbonates,
- Potash is variable (less than 0.5 percent) and
- **phosphates, nitrogen**, **and humus are low.**

Rich in iron and lime but deficient in humus, nitrogenous and phosphorous content.

Distribution of Black Soils

- It is found in the **Deccan lava plateau region of India.**
- Spread over **46 lakh sq km (16.6 percent of the total area) across Maharashtra, Madhya Pradesh, parts of Karnataka, Telangana, Andhra Pradesh, Gujarat, and Tamil Nadu.**

Crops in Black Soils

- These **soils are best suited for cotton crops. Hence these soils are called as regur and black cotton soils.**
- Other major crops grown on the black soils include wheat, jowar, linseed, virginia tobacco, castor, sunflower, and millets.
- **Rice and sugarcane are equally important where irrigation facilities are available.**
- Large varieties of vegetables and fruits are also successfully grown on the black soils.

- This soil has been used for growing a variety of crops for centuries without adding fertilizers and manures, with little or no evidence of exhaustion.

Red Soil

- **This soil developed on Archean granite** occupies the **second largest area of the country.**
- The **presence of ferric oxides makes the colour of soil red**, ferric oxides occurring as **thin coatings on the soil particles**.
- The **top layer of the soil is red** and the **horizon below is yellowish.**
- **Extent – 18.5 % of the area**
- **Texture:** Sandy to clay and loamy.
- This soil is **also known as the omnibus** group.

Characteristics of Red Soils

- Rainfall is highly variable. Thus, the soil has developed 3 subtypes
    - **Red & Yellow soil** – rainfall is 200cm – NE India – Nagaland, Mizoram, Manipur Hills, parts of Malabar coast, quick drainage is needed
    - **Red Sandy Soil** – Drier plateaus like Karnataka, TN, Telangana, Rayalseema – rainfall from 40-60cm
    - **RedAlluvial Soil** – Along river valleys – has good fertility
- Well drained soil and structure is sandy
- **Rich in iron and potash but deficient in other minerals.**

Chemical Composition of Red Soils

Generally, these soils are **deficient in phosphate, lime, magnesia, humus and nitrogen.**

Distribution of Red Soils

They are mainly found in the **Peninsula from Tamil Nadu in the south to Bundelkhand in the north and Raj Mahal in the east to Kathiawad in the west.**

Significance

- **Once irrigated and added with humus, it gives a high yield because the mineral base is rich.**
- It **supports rice, sugarcane, cotton cultivation**
- **Millets and pulses are grown in drier areas**
- **Kaveri and Vaigai basins are famous for red alluvium** and if irrigated well, are suitable for paddy
- Large regions of Karnataka and Kerala have developed Red soil regions for rubber and coffee plantation farming.

Laterite Soil (UPSC 2013 PRE)

- This soil has emerged in those regions where the following conditions are fulfilled
- There **must be laterite rock or structure** (Laterites are rich in iron and aluminium content)

- **Alternating dry and wet periods** are more suitable for the development of laterite soils.

Characteristics

- Brown in colour
- composed essentially of a mixture of hydrated oxides of aluminium and iron.
- Iron oxides are found in nodules form
- Its rich in iron and aluminium but poor in Nitrogen, Phosphorous, Potash, Lime, and Magnesia
- Its humus and water-retaining capacities are moderate
- Bacterial activities have been very high and heavy precipitation develops leaching of humus as a result humus content is moderate to low.

Distribution

- Regions of laterite soil in the country are :
    - It is found in patches in Western Ghats (Goa and Maharashtra).
    - In Belgam district of Karnataka and in laterite plateau of Kerala
    - In the state of Orissa, in the Eastern Ghats,
    - Amarkantak plateau region of MP-
    - Panchmahal district of Gujarat;
    - Santhal Pangana divisions of Jharkhand

Significance

- It is **famous for crops like groundnut, cashew nut, etc.**
- Laterite soil of Karnataka is given to coffee, rubber, and spices farming.

Forest Soil/ Mountain Soil

Formation – It is principally found on mountains with steeper slopes, high relief, shallow profiles.

Characteristics

- It is thin layered and the profiles and horizons are poorly developed
- Due to fast drainage, it has been vulnerable to soil erosion
- It is rich in organic content – humus content is also adequate but other nutrients are deficient
- It is a loamy soil when sand, silt, and clay are in mixed form

Distribution

- These are generally found over 900m altitude
- Himalayas, Himalayan foothills, mountain slopes of Western Ghats, Nilgiri, Annamalai, and Cardamom hills
- Significance – It is very helpful to those crops which need favourable air and water drainage which is provided by this soil by virtue of being on slopes
- Generally used for rubber plantation, bamboo plantation and also tea, coffee, and fruits farming
- Large area also given to shifting agriculture where the soil fertility deteriorates after 2-3 years

- Due to less scope of agriculture, silvi pastoral farming (forest+grasses) can be sustained.

Desert Soil (UPSC PRE 2018)

- **This soil is deposited by wind action** and mainly found in the **arid and semi-arid areas** like Rajasthan, West of the Aravallis, Northern Gujarat, Saurashtra, Kachchh, Western parts of Haryana, and southern part of Punjab.
- **It lacks moisture content**. **Humus content is less**, and **Nitrogen is originally low** but some of it is available in the form of **nitrates.**
- They are sandy with low organic matter. Living microorganisms are low in content
- It is rich in iron content. **Phosphorus content is nearly adequate**, **rich in lime and bases**.
- It has low soluble salts and moisture with very low retaining capacity.
- If irrigated, this soil gives a high agricultural return.
- These are suitable for less water-intensive crops like **Bajra**, **pulses, fodder, and guar.**

Distribution –western Rajasthan, Rann of Kachchh, in patches in south Haryana and south Punjab.

Saline and Alkaline Soil

- **Alkali soil contains a large content of NaCl**
- The soil is **infertile**
- These are also called Reh, Usar, Kallar, Rakar, Thur, and Chopan.
- These are mainly found in Rajasthan, Haryana, Punjab, Uttar Pradesh, Bihar, and Maharashtra.
- Sodium chloride and sodium sulphate are present in this soil. It is suitable for leguminous crops.
- **Formation and distribution** – It is both natural and anthropogenic
    - **Natural** – Includes dried up lakes of Rajasthan and Rann of Kachchh
    - **It has emerged in the Palaya basin** (a clay basin in the midst of the desert)
    - **Anthropogenic** –It is developed in **western UP and Punjab due to faulty agriculture.**
- **Characteristics** – Lack of moisture, humus, and living microorganisms, as a result, humus formation is almost absent

Peaty, and Marshy Soil/Bog Soil

This soil originates from the **areas where adequate drainage is not possible**. It is **rich in organic matter and has high salinity.** They are **deficient in potash and phosphate.**

- **Characteristics** – Dominance of clay and mud which make it heavy
    - **Rich in moisture content** but at the same time, greater content of salt and every day inundation by high tide has made it infertile soil
    - **No organic activity** due to excessive moisture content
- **Distribution** – It is characteristic of the **delta region of India**
    - Besides the delta region, it is also found in **Alleppey(Kerala)** (known as Karri along the backwaters or Kayals of Kerala) , **Almora (Uttaranchal)**
- **Significance** – Over **Bengal delta, it is suitable for jute and rice**, and over **Malabar, it is suitable for spices, rubber, big sized rice**
- It has to some extent been **favourable to the Mangrove forests of India**.

Characteristics of Indian Soils

- Most soils are **old and mature.** Soils of the peninsular plateau are much older than the soils of the great northern plain.
- Indian soils are **largely deficient in nitrogen, mineral salts, humus and other organic materials.**
- **Plains and valleys have thick layers of soils** while hilly and plateau areas depict thin soil cover.
- Some **soils like alluvial and black soils are fertile** while some other soils such as laterite, desert and alkaline soils lack fertility and do not yield good harvest.
- Indian soils have been **used for cultivation for hundreds of years and have lost much of their fertility.**

Problems of Indian Soils

- **Soil erosion** (Himalayan region, Chambal Ravines, etc.), deficiency in fertility (Red, lateritic, and other soils)
- **desertification** (around Thar desert, rain-shadow regions like parts of Karnataka, Telangana, etc.)
- **waterlogging** (Punjab-Haryana plain) salinity, and alkalinity (excessively irrigated regions of Punjab, Haryana, Karnataka, etc.)
- **wasteland overexploitation** of soils due to increase in population and rise in living standards and encroachment of agricultural land due to urban and transport development.

WATER RESOURCES (UPSC PRE 2021, 2019,2013)

Approximately, 71 per cent of the earth's surface is covered with it but fresh water constitutes only about 3 percent of the total water.

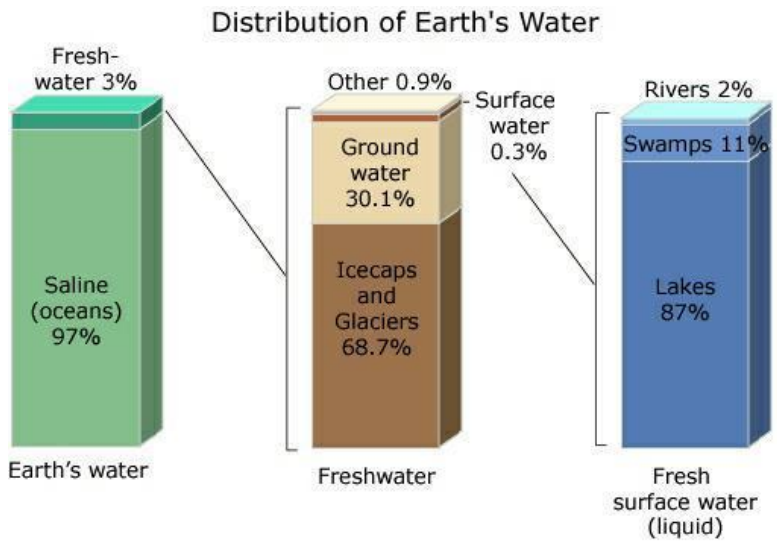
Water Resources of India

- India accounts for about 2.45 percent of the world's surface areas, 4 percent of the world's water resources and about 16 percent of the world's population.
- The total water available from precipitation in the country in a year is about 4,000 cubic km.
- Out of this only 60 per cent can be put to beneficial uses. Thus, the total utilizable water resource in the country is only 1,122 cubic km.

Surface Water Resources

There are four major sources of surface water. These are –

- Rivers
- Lakes
- Ponds
- Tanks

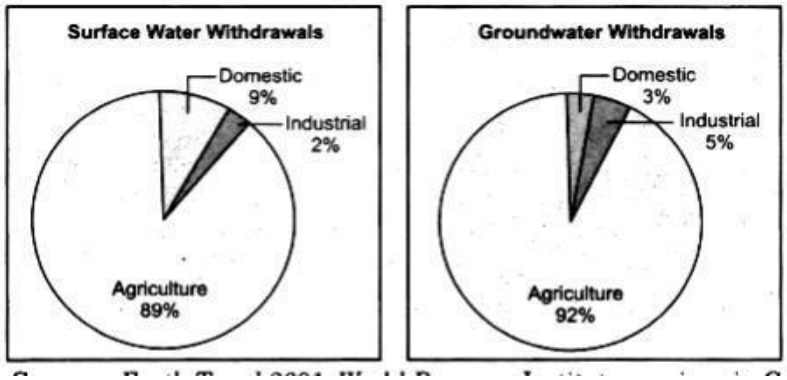


However, due to topographical, hydrological and other constraints, only about 690 cubic km (32 per cent) of the avail- able surface water can be utilized.

Groundwater Resources

The total replenish able groundwater resources in the country are about 432 km.

- The level of groundwater utilization is relatively high in the river basins lying in north-western region and parts of south India.



Status of Water Pollution

The Central Pollution Control Board (CPCB) in collaboration with State Pollution Control Boards has been monitoring water quality of national aquatic resources at 507 stations.

- The Yamuna river is the most polluted river in the country between Delhi and Etawah.
- Other severely polluted rivers are: the Sabarmati at Ahmedabad, the Gomti at Lucknow, the Kali, the Adyar, the Cooum (entire stretches), the Vaigai at Madurai and the Musi of Hyderabad and the Ganga at Kanpur and Varanasi.

- Groundwater pollution has **occurred due to high concentrations of heavy/toxic metals, fluoride and nitrates** at different parts of the country.

Prevention of Water pollution :

- **Proper implementation of legislations :** The legislative provisions such as the Water (Prevention and Control of Pollution) Act 1974, and Environment Protection Act 1986 have provisions for water pollution prevention but have not been implemented effectively.
- **The public awareness and action** can be very effective in reducing the pollutants from agricultural activities, domestic and industrial discharges.
- **Watershed management** – It basically refers to efficient management and conservation of surface and groundwater resources.

- **Rainwater Harvesting -** Rain water harvesting is a method to capture and store rainwater for various uses. It is also used to recharge groundwater aquifers.
    - It is a low cost and eco-friendly technique for preserving every drop of water by guiding the rain water to bore wells, pits and wells. Highlights of

India's National Water Policy, 2002

The National Water Policy 2002 stipulates water allocation priorities broadly in the following order:

- Drinking water; irrigation, hydro-power, navigation, industrial and other uses.
- The policy stipulates progressive new approaches to water management. Key features include:
    - Irrigation and multi-purpose projects should invariably include a drinking water component, wherever there is no alternative source of drinking water.
    - Providing drinking water to all human beings and animals should be the first priority.
    - Measures should be taken to limit and regulate the exploitation of groundwater.
    - Both surface and groundwater should be regularly monitored for quality. A phased programme should be

Watershed management – It basically refers to efficient management and conservation of surface and groundwater resources.

- It involves prevention of runoff and storage and recharge of groundwater through various methods like percolation tanks, recharge wells, etc.
- However, in broad sense watershed management includes conservation, regeneration and judicious use of all resources- natural (like land, water, plants and animals) and human with in a watershed.
- Watershed management aims at bringing about balance between natural resources on the one hand and society on the other.
- The success of watershed development largely depends upon community participation.
- The Central and State Governments have initiated many watershed development and management programmes in the country. Some of these are being implemented by

undertaken for improving water quality.
- The efficiency of utilization in all the diverse uses of water should be improved.
- Awareness of water as a scarce resource should be fostered.
- Conservation consciousness should be promoted through education, regulation, incentives and disincentives.

LAND USE AND AGRICULTURE

Land-use records maintained by the land revenue department. The land use categories add up to the reporting area, which is somewhat different from the geographical area.

- The Survey of India is responsible for measuring the geographical area of administrative units in India.
- The difference between the two concepts is that while the former changes somewhat depending on the estimates of the land revenue records, the latter does not change and stays fixed as per Survey of India measurements.
- The **land-use categories** as **maintained in the Land Revenue dept of Govt.** The categorisation is as follows –
    - **Forest**
    - **Land under settlement** - Land under settlements (rural and urban), infrastructure (roads, canals, etc.), industries, shops, etc. are included in this category.
    - **Barren and Wastelands**: The land which may be classified as a wasteland such as barren hilly terrains, desert lands, ravines, etc. normally cannot be brought under cultivation with the available technology.
    - **Area under Permanent pastures and Grazing Lands**: Most of this type land is owned by the village 'Panchayat' or the Government. Only a small proportion of this land is privately owned. The land owned by the village panchayat comes under 'Common Property Resources'.
    - **Area under Miscellaneous Tree Crops and Gove's (Not included is Net sown Area)**: The land under orchards and fruit trees are included in this category. Much of this land is privately owned.
    - **Culturable Waste-Land**: Any land which is left fallow (uncultivated) for more than five years is included in this category. It can be brought under cultivation after improving it through reclamation practices.
    - **Current Fallow:** This is the land which is left without cultivation for one or less than one agricultural year. Following is a cultural practice adopted for giving the land rest. The land recoups the lost fertility through natural processes.
    - **Fallow other than Current Fallow**: This is also a cultivable land which is left uncultivated for more than five years; it would be categorized as a culturable wasteland.
    - **Net Area Sown:** The physical extent of land on which crops are sown and harvested is known as net sown area.

Land-use Changes in India

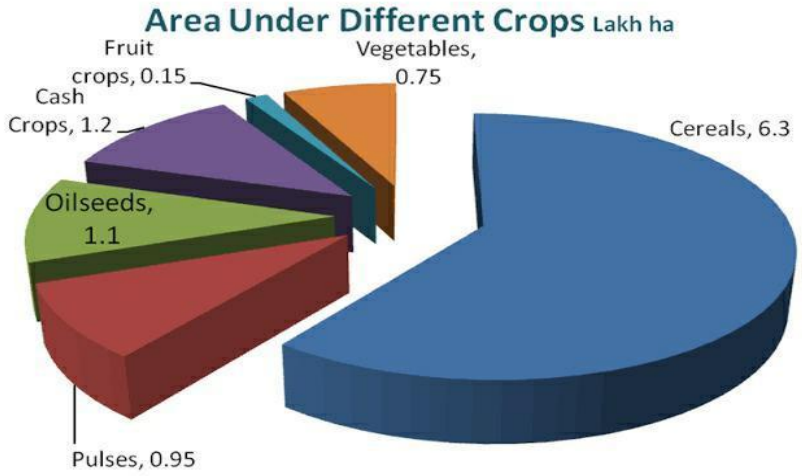
Land-use in a region, to a large extent, is influenced by the nature of economic activities carried out in the region.

- India has a varied land use pattern given the geographical diversity of the country. Land use pattern in India is as follows:
    - Net Sown Area is 46% of the total geographic area because of extensive availability of flat terrain in India.
    - About 22% of the country is under forest cover.
    - Barren and unCulturable waste land amounts to about 8.5%.
    - About 5.5% is under non-agricultural uses like houses, industries etc.
    - Rest of the area is under tree crops, grooves, permanent pastures and grazing lands etc.

Agricultural Land Use in India

Land resource is more crucial to the livelihood of the people depending on agriculture:

- Agriculture is a purely land based activity unlike secondary and tertiary activities. In other words, the contribution of land in agricultural output is more compared to its contribution in the outputs in the other sectors.
- Thus, lack of access to land is directly correlated with incidence of poverty in rural areas.



- There has been a greater decline of cultivated land, in spite of a corresponding decline of cultivable wasteland.

Cropping Seasons in India: (UPSC PRE 2013,2019,2020)

There are three distinct crop seasons in the northern and interior parts of country, namely kharif, rabi and zaid.

KHARIF CROPS	RABI CROPS	ZAID CROPS

Some important Kharif Crops are: • Bajra • Jowar • Maize (corn) • Millet • Rice (paddy and deepwater rice) • Soybean Tea & Coffee are the Kharif Crops	Some important crops are : • Barley • Gram • Rapeseeds • Mustard • Oats • Wheat • Bajra	Some important crops of Zaid : • Pumpkins • Cucumber • Bitter Gourd
The cropping season : In India starts in June and ends in October where monsoon crops are cultivated and harvested.	**Sowing & Harvesting Seasons** : The season where crops are sown in mid-November and harvested in April/May is called Rabi season.	**Sowing & Harvesting season** : Since the Zaid crops are also called summer crops, they are sown and harvested between March and June

Farming Techniques (UPSC PRE 2021, 2020, 2018)

Primitive Subsistence Farming : Primitive subsistence agriculture is practiced on small patches of land with the help of primitive tools like hoe, dao and digging sticks, and family/ community labour.

- This type of farming depends upon monsoon, natural fertility of the soil and suitability of other environment conditions to the crops grown.
- It is a 'slash and burn' agriculture. Farmers clear a patch of land and produce cereals and other food crops to sustain their family.

Different names of Jhummming Agriculture :

- 'Milpa' in Mexico and Central America, 'Conuco' in Venzuela, 'Roca' in Brazil, 'Masole' in Central Africa, 'Ladang' in Indonesia, 'Ray' in Vietnam.
- In India, this primitive form of cultivation is called 'Betwar' or 'Dahiya' in Madhya Pradesh, 'Podu' or 'Penda' in Andhra Pradesh, 'Pama Dabi' or 'Koman' or 'Bringa' in Orissa, 'Kumari' in Western Ghats, 'Valre' in South-Eastern Rajasthan, 'Khil' in the Himalayan belt, 'Kuruwa' in Jharkhand, and 'Jhumming' in the North-Eastern region.

Intensive Subsistence Farming : This type of farming is practiced in areas of high population pressure on land.

- It is labour intensive farming, where high doses of biochemical inputs and irrigation are used for obtaining higher production.
- Though the 'right of inheritance' leading to the division of land among successive generations has rendered land-holding size uneconomical, the farmers continue to take maximum output from the limited land in the absence of alternative source of livelihood.
- Thus, there is enormous pressure on agricultural land.

Commercial Farming : The main characteristic of this type of farming is the use of higher doses of modern inputs, e.g. high yielding variety (HYV) seeds, chemical fertilizers, insecticides and pesticides in order to obtain higher productivity.

- The degree of commercialization of agriculture varies from one region to another.
- In this type of farming, a single crop is grown on a large area. The plantation has an interface of agriculture and industry.
- Plantations cover large tracts of land, using capital intensive inputs, with the help of migrant labourers.
- All the produce is used as raw material in respective industries.

DRYLAND FARMING	Features of Dry-land Farming : ● 2/3 rd of India's cultivable area is dry-land. ● 60% of the Indian population live in the dry-land region. ● This region of Important crops like oilseeds, pulses, cotton, groundnut, and cereals. ● To reduce the regional disparity in the country. ● To reduce migration and the pressure on cities are becoming lesser. ● To feed the ever-growing population of the country, its necessary to bring more land into cultivation. Dry-lands are the only partial areas to be topped.	**Majority of the cultivation area in India is dry-land. This type of farming is cultivated where there is lack of water.** **Farmers mostly selected water crops.** **Annual rainfall is low and partial irrigation is available in dry-land farming.**
MIXED FARMING	**Features of Mixed Farming :** ● It can empower farmers. ● It may increase the productivity of agriculture. ● Mixed Farming improves soil fertility. ● Symbiotic to each other. ● It's labour intensive farming. ● This practice is followed in areas having high rainfall and good irrigation facilities.	Mixed Farming is growing crops along with livestock. They can be beneficial to each-others. This can be done in regions with high rainfall and good irrigation facilities.

CROP ROTATION	**Features of Crop Rotation :** • Leguminous crop is grown after the other crops. • legumes crops for nitrogen fixation of the soil. • Highly fertiliser intensive crops such as sugarcane or pulses are rotated with cereal crops. • Selection of crops depending on the soil conditions and water availability. • It will increase productivity of crops.	To systematic growing number of crops in rotating manner to boost fertility of the soil. The rotation of crops takes one year or more than one year.
TERRACE FARMING	**Features of Terrace Farming :** • Made terraces on hill slopes. • Mostly grown plantation crops. • Terrace Farming located at North-eastern regions. • Terrace Farming can prevent soil erosion.	This cultivation done at the hill and mountain are cut to form terraces. Flat land availability is limited on terraces made of small patches of level land. Soil is eroding due to physical features of the land (slopes) but terrace Farming reduces soil erosion.
NOMADIC HEARDING	**Features of Nomadic Herding :** • Mostly depending on animals rather than plants. • Mostly performed by tribal people. • This is done in extreme climatic regions.	People dependency on livestock and livestock dependency on natural pasture. It is the most primitive form practiced by tribals living in extreme climatic regions.
PLANTATION FARMING	**Features of Plantation Crops :** • It grows in the remotest part of the world but is connected with the international market. • Cheaper labour availability. • Value addition product. • Scientifically manage. • It use - specialized machine, pesticides, insecticides. • Supply of these products depends on the demand of the global market.	This type of farming is cultivated closer to the equator / tropical region. It requires a high temperature. It is tree or bush farming which was introduced in colonial times in the 19th century. The selected crops are tea, rubber, spice crops, coconut, tobacco, cocoa, coffee, lime, oranges, apples etc. Plantation farming is very useful for commercial purposes. These crops are more profitable

Advance Farming Techniques :

Sustainable Agriculture/Eco-Farming

The high use of modern farming techniques has led to the degradation of land and has led to various ecological problems like eutrophication, land degradation, etc., which has depleted the quality of land as a sustainable resource.

- Sustainable agriculture is a system of cultivation with the use of manures, Crop rotation, and minimal tillage.
- Sustainable agriculture also involves agroforestry (growing trees near the crops), multi-level cultivation (growing trees of different heights in sequence), and integrated animal husbandry (growing crops with animal rearing practices).
- The term sustainability denotes the characteristic of a process that can be maintained indefinitely. With the help of sustainable farm practices, the needs of the present generation can be met without compromising the needs of future generations.

Tillage

Tillage is an agricultural land preparation through mechanical agitation which includes digging, stirring, and overturning.

Zero Tillage farming/No-Till Farming (UPSC 2020)

Zero Tillage

Zero tillage is the process where the crop seed will be sown through drillers without prior land preparation and disturbing the soil where previous crop stubbles are present.

- Zero tillage not only reduces the cost of cultivation it also reduces the soil erosion, crop duration, and irrigation requirement, and weed effect which is better than tillage.

Zero tillage (ZT) also called No-Tillage or Nil Tillage.

- No-till farming decreases the amount of soil erosion tillage causes in certain soils, especially in sandy and dry soils on sloping terrain.
- No-till management results in fewer passes with equipment and the crop residue prevent evaporation of rainfall and increase water infiltration into the soil.

ADVANTAGES OF ZERO TILLAGE	DISADVANTAGE OF ZERO TILLAGE
• Reduction in the crop duration and thereby early cropping can be obtained to get higher yields. • Reduction in the cost of inputs for land preparation and therefore a saving of around 80%. • Residual moisture can be effectively utilized and the number of irrigations can be reduced. • Dry matter and organic matter get added to the soil.	• the initial cost of zero tillage equipment (the upfront costs can be high, but they should be recouped through higher crop yields and fuel and labor savings) • gullies can form in the fields (low-pressure tires and changing traffic patterns across the field can help prevent these) • increased use of herbicide • the learning curve for zero tillage farming

• Environmentally safe – Greenhouse effect will get reduced due to carbon sequestration. • No-tillage reduces the compaction of the soil and reduces the water loss by runoff and prevents soil erosion. • As the soil is intact and no disturbance is done, No-Till lands have more useful flora and fauna. • This practice has carbon-sequestration potential. Apart from reducing carbon emission, the no-tilling practice can also reduce nitrous oxide emissions by 40 to 70%.	

Zero budget natural farming (ZBNF) (UPSC PRE 2020)

Zero Budget Natural Farming, a type of farming that involves the elimination of chemical pesticides, sustaining agriculture with eco-friendly processes, and restoring soil fertility and organic matter.

- It is a unique chemical-free method that involves agro ecology. For the zero-net expenditure of manufacturing, yields are known as the term zero budget.
- ZBNF reduces farming expenses and promotes the use of natural fertilizers, biological pesticides, and local seeds.

Benefits of Zero Budget Natural Farming (ZBNF):

- As both a social and environmental program, it aims to ensure that farming – particularly smallholder farming – is economically viable by enhancing farm biodiversity and ecosystem services.
- It reduces farmers' costs by eliminating external inputs and using in-situ resources to rejuvenate soils, whilst simultaneously increasing incomes, and restoring ecosystem health through diverse, multi-layered cropping systems.
- Cow dung from local cows has proven to be a miraculous cure to revive the fertility and nutrient value of soil.
- Zero budget natural farming requires only 10 percent water and 10 percent electricity than what is required under chemical and organic farming.
- ZBNF may improve the potential of crops to adapt to and be produced for evolving climatic conditions.

Four wheels of ZBNF to be implemented in practically:

The "four wheels" of ZBNF are 'Jiwamrita', 'Bijamrita', 'Mulching' and 'Waaphasa', says Palekar, a Padma Shri awardee.

- **Jiwamrita** is a fermented mixture of cow dung and urine (of desi breeds), jaggery, pulses flour, water, and soil from the farm bund. This isn't a fertilizer, but just a source of some 500 crore micro-organisms that can convert all the necessary "non-available" nutrients into "available" form.
- **Bijamrita** is a mix of desi cow dung and urine, water, bund soil, and lime that is used as a seed treatment solution prior to sowing.
- **Mulching**, or covering the plants with a layer of dried straw or fallen leaves, is meant to conserve soil moisture and keep the temperature around the roots at 25-32 degrees Celsius, which allows the microorganisms to do their job.
- **Waaphasa**, or providing water to maintain the required moisture-air balance, also achieves the same objective.

	Zero Budget Natural Farming(ZBNF)	Organic Farming
	No external fertilizers are used in ZBNF.	Organic fertilizers such as compost, cow dung, and vermicompost are used in organic farming.
	There is no tilling and no mixing. It requires natural ecosystems.	It requires basic agro methods like tilling, plowing, mixing, etc.
	It is low-cost farming due to the local biodiversity.	It is expensive due to the need for bulk manures

Problems of Indian Agriculture: Yet, there are some problems which are common and range from physical constraints to institutional hindrances. A detailed discussion on these problems follows:

- **Dependence on Erratic Monsoon:** Irrigation covers about 33 per cent of the cultivated area in India. The crop production in the rest of the cultivated land directly depends on rainfall.
- **Low productivity**: The yield of the crops in the country is low in comparison to the international level. The vast rainfed areas of the country, particularly drylands which mostly grow coarse cereals, pulses and oilseeds, have very low yields.
- **Constraints of Financial Resources and Indebtedness:** The inputs of modern agriculture are very expensive. Crop failures and low returns from agriculture have forced them to fall in the trap of indebtedness.
- **Lack of Land Reforms**: After independence, land reforms were accorded priority, but these reforms were not implemented effectively due to lack of strong political will.
- **Small Farm Size and Fragmentation of Landholding:** There are a large number of marginal and small farmers in the country. More than 60 per cent of the ownership holdings have a size smaller than one (ha).
    - Furthermore, about 40 per cent of the farmers have an operational holding size smaller than hectare (ha). The average size of land holding is shrinking further under increasing population pressure.
- **Lack of Commercialization:** Most of the small and marginal farmers grow food grains, which are meant for their own family consumption.
    - Modernization and commercialization of agriculture have however, taken place in the irrigated areas. Vast Under-employment: In these areas, there is seasonal unemployment ranging from 4 to 8 months. Even in the cropping season work is not available throughout, as agricultural operations are not labour intensive.

- **Degradation of Cultivable Land:** One of the serious problems that arises out of faulty strategy of irrigation and agricultural development is degradation of land resources.

MAJOR CROPS & SPECIFICATION (UPSC PRE 2021, 2020)

Crops	Specifications
RICE	Temperature: Between 22-32°C with high humidity. Rainfall: Around 150-300 cm. Soil Type: Deep clayey and loamy soil. Top Rice Producing States: West Bengal > Punjab > Uttar Pradesh > Andhra Pradesh > Bihar. It is the staple food crop of majority of Indian people.
WHEAT	Temperature: Between 10-15°C (Sowing time) and 21-26°C (Ripening & Harvesting) with bright sunlight. Rainfall: Around 75-100 cm. Soil Type: Well-drained fertile loamy and clayey loamy (Ganga-Satluj plains and black soil region of the Deccan)
MILLETS	Temperature: Between 27-32°C Rainfall: Around 50-100 cm. Soil Type: Can be grown in inferior alluvial or loamy soil because they are less sensitive to soil deficiencies. Jowar- Rain-fed crop grown in the moist areas with less or no irrigation. Bajra- Sandy soils and shallow black soil. Ragi- Red, black, sandy, loamy and shallow black soils. (dry regions) Top Millets Producing States: Rajasthan > Karnataka > Maharashtra > Madhya Pradesh > Uttar Pradesh
MAIZE	Temperature: Between 21-27°C Rainfall: High rainfall. Soil Type: Old alluvial soil. Top Maize Producing States: Karnataka > Maharashtra > Madhya Pradesh > Tamil Nadu > Telangana India is the seventh largest producer worldwide. It is used both as food and fodder.
PULSES	Temperature: Between 20-27°C Rainfall: Around 25-60 cm. Soil Type: Sandy-loam soil. Top Pulses Producing States: Madhya Pradesh > Rajasthan > Maharashtra > Uttar Pradesh > Karnataka. India is the largest producer as well as the consumer of pulses in the world. These are the major source of protein in a vegetarian diet. Major pulses grown in India are tur (arhar), urad, moong, masur, peas and gram.

	Being leguminous crops, all these crops except arhar help in restoring soil fertility by fixing nitrogen from the air. Therefore, these are mostly grown in rotation with other crops.
SUGARCANE	Temperature: Between 21-27°C with hot and humid climate. Rainfall: Around 75-100 cm. Soil Type: Deep rich loamy soil. Top Sugarcane Producing States: Uttar Pradesh > Maharashtra > Karnataka > Tamil Nadu > Bihar. India is the second largest producer of sugarcane after Brazil. It can be grown on a variety of soils ranging from sandy loam to clay loam given these soils should be well drained.
OIL SEEDS	Temperature: Between 15-30°C Rainfall: Around 30-75 cm. Soil Type: Loam to clayey loam and well drained sandy loams. Top Oilseeds Producing States: Madhya Pradesh > Rajasthan > Gujarat > Maharashtra > Uttar Pradesh. Main oil-seeds produced in India are groundnut, mustard, coconut, sesamum (til), soyabean, castor seeds, cotton seeds, linseed and sunflower.
TEA	Temperature: Between 20-30°C Rainfall: Around 150-300 cm. Soil Type: Deep and fertile well-drained soil, rich in humus and organic matter. Top Tea Producing States: Assam > West Bengal > Tamil Nadu. India is the second largest producer of tea. It was introduced in the eastern hill slopes of India by the British. Slopes of eastern hills have humid climate and evenly distributed rainfall without water logging which are optimal conditions for terrace farming of tea.
COFFEE	Temperature: Between 15-28°C Rainfall: Around 150-250 cm. Soil Type: Well drained, deep friable loam soil. Top Coffee Producing States: Karnataka > Kerala > Tamil Nadu. India is the seventh largest producer. Coffee was initially brought from Yemen and introduced to the Baba Budan Hills. Hills with well-defined shade canopy, comprising evergreen leguminous trees provide the optimal condition for coffee cultivation that is why it is mainly concentrated in the hilly regions. The Indian variety of coffee 'Arabica' is famous worldwide.
RUBBER	Temperature: Above 25°C with moist and humid climate. Rainfall: More than 200 cm. Soil Type: Rich well drained alluvial soil. Top Rubber Producing States: Kerala > Tamil Nadu > Karnataka. It is an equatorial crop, but under special conditions, it is also grown in tropical and sub-tropical areas.
COTTON	Temperature: Between 21-30°C Rainfall: Around 50-100cm. Soil Type: Well drained black cotton soil of Deccan Plateau.

	Top Cotton Producing States: Gujarat > Maharashtra > Telangana > Andhra Pradesh > Rajasthan. India is believed to be the original home of the cotton plant. Cotton is one of the main raw materials for the cotton textile industry. Cotton needs 210 frost-free days and bright sun-shine for its growth.
JUTE	Temperature: Between 25-35°C Rainfall: Around 150-250 cm Soil Type: Well drained alluvial soil Top Jute Producing States: West Bengal > Bihar > Assam > Andhra Pradesh > Odisha. It is mainly concentrated in eastern India because of the rich alluvial soil of Ganga-Brahmaputra delta.

TRANSPORT & COMMUNICATION

THE ROAD TRANSPORT IN INDIA

- The transport system in India includes **Rail transport, Road transport, Air transport, water transport, and portal connectivity.** India has one of the largest road networks in the world, the **largest railway system in Asia, and the second-largest in the world.**

Road Transport in India

- **India has one of the largest road networks in the world with a total length of 5,897,671 kilometers (3,664,643 mi) as of 31 March 2017.** About 85 percent of passengers and 70 percent of freight traffic are carried by roads every year. Road transport is relatively suitable for shorter distance travel.
- For the purpose of construction and maintenance, roads are classified as
    - National Highways (NH),
    - State Highways (SH),
    - Major District Roads, and
    - Rural Roads.

National highways

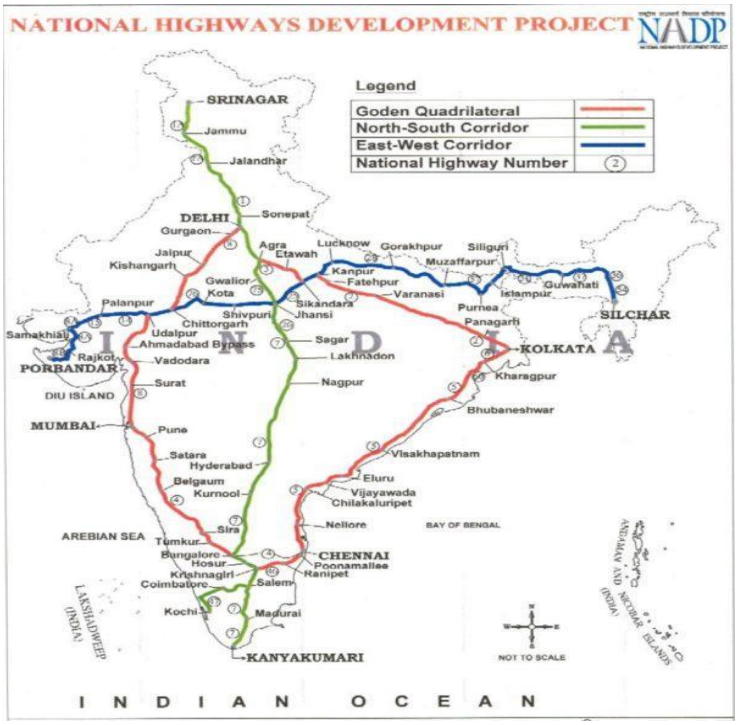
- The main roads which are **constructed and maintained by the Central Government** are known as the National Highways.
- These roads are meant for **inter-state transport and movement of defence men and material in strategic areas**.
- These **also connect the state capitals, major cities, important ports, railway junctions**, etc.
- India has 142,126 km (88,313 mi) of National Highways as of April 2019. The National Highways constitute only **2 percent of the total road length but carry 40 percent of the road traffic.**

Golden quadrilateral:

- Golden Quadrilateral comprises construction of a 5,846 km long 4/6 lane, high-density traffic corridor, to connect India's four big metro cities of Delhi-Mumbai-Chennai-Kolkata. With the construction of the Golden Quadrilateral, the time-distance and cost of movement among the megacities of India will be considerably minimized.

North-South and East-West Corridor:

- North-South corridor aims at connecting Srinagar in Jammu and Kashmir with Kanyakumari in Tamil Nadu (including Kochchi-Salem Spur) with a 4,076 km long road. The East-West Corridor has been planned to connect Silchar in Assam with the port town of Porbandar in Gujarat with 3,640 km of road length.



Some important National Highways

National Highway	Extension
NH-1	Delhi-Amritsar
NH-2	Delhi-Kolkata
NH-3	Agra-Mumbai
NH-4	Chennai-Thane
NH-5	Chennai-Cuttack
NH-6	Surat-Kolkata
NH-7	Varanasi-kanyakumari

NH-8	Delhi-Mumbai
NH-9	Pune-Machilipatnam
NH-15	Samakhiali(kutch)-Pathankot

State highways

- These are **constructed and maintained by state governments (PWDs)**. They join the state capitals with district headquarters and other important towns.
- **These roads are connected to the National Highways.**
- These constitute **4 percent of the total road length in the country.**

Name	Responsibility of	Connects
National Highways	Central Government	State capitals
State Highways	State Government	State Capital to District HQ
District roads	Zila Parishad	District HQ to tehsil and Blocks
Village roads	Gram Panchayat	Villages to neighbouring towns

District roads

- These roads are the **connecting link between District Headquarters and the other important nodes in the district.**
- They account for **14 percent of the total road length of the country**.

Rural roads

- These roads are **vital for providing links in the rural areas.**
- About **80 percent of the total road length in India are categorized as rural roads.**
- There is **regional variation in the density of rural roads because these are influenced by the nature of the terrain.**

Other Roads – Border roads and international highways

- **Other roads include Border Roads and International Highways**.
    - The **Border Road Organisation (BRO) was established in May 1960 for accelerating economic development and strengthening defence preparedness through rapid and coordinated improvement of strategically important roads along the northern and north-eastern boundary of the country.**
    - It is a **premier multifaceted construction agency.** It has **constructed roads in high altitude mountainous terrain joining Chandigarh with Manali (Himachal Pradesh) and Leh (Ladakh).** This road runs at an **average altitude of 4,270 metres above the mean sea level.**

    - Apart from the construction and maintenance of roads in strategically sensitive areas, the **BRO also undertakes snow clearance in high altitude areas.** The international highways are meant to **promote a harmonious relationship with the neighbouring countries by providing effective links with India.**
- The distribution of roads is not uniform in the country. The density of roads (length of roads per 100 square km of area) varies from only 12.14 km in Jammu and Kashmir to 517.77 km in Kerala with a national average of 142.68 km in 2011.
- The **density of roads is high in most of the northern states and major southern states.** It is **low in the Himalayan region, north-eastern region, Madhya Pradesh and Rajasthan.**

Areas factors influence in roadways

- **Terrain:** Nature of terrain and the level of economic development are the main determinants of the density of roads. Construction of roads is easy and cheaper in the plain areas while it is difficult and costly in hilly and plateau areas
- **Climate:** Quality of roads is relatively better in plains as compared to roads in high altitude areas, rainy and forested regions.
- **Economic development:** Areas with a high level of economic development will have more road density as compared to areas with a low level of economic development. E.g. Maharashtra has more road density than Himachal Pradesh
- **Industries:** Areas with more industrial concentration will have more road density as compared to areas with low industrial concentration. E.g. Jamshedpur has more road density than Patratu in Jharkhand.
- **Cities and towns:** Cities and towns will have more road density than rural areas.

Importance of Roads

- **Port connectivity**
    - **Roadways serve as special links for feeder roads to important railway routes and ports.** This is essential for the development of domestic and international trade.
    - Road connectivity for about 50 minor ports and road connectivity for 24 Airports serves the purpose of connecting basic infrastructure.

- **Rural areas -** All villages will be connected with all-weather roads by the end of the 12th five-year plan. They serve an important purpose in the growth of the rural economy.
- **Tribal areas**
    - Roads in Left-Wing Extremism (LWE) affected districts will be continued and works taken up earlier in the Eleventh Plan will be completed during the 12th five-year plan.
    - A Special Package for development of roads of around 1000 km length in the Scheduled Areas (under Fifth Schedule) has been taken up under Tribal Sub- Plan.

- **JK and North East**

- **Road Development in the North-East has been boosted by the initiation of the Trans-Arunachal Pradesh Highway Project.** The capacities of NHAI and BRO would be further developed for this purpose.
- State road projects in the state of J&K are being developed from strategic considerations.
- Reforms in the Motor Vehicles Act have been taken up to simplify inter-state movement with simplified procedures. There has been the creation of truck terminals to ease traffic congestion.

Some current initiatives in Roadways

Electronic Toll Collection (ETC)

- A **committee was set up under the chairmanship of Shri Nandan Nilekani for reforms in road infrastructure in India**.
- Recommendations of the Committee have been accepted and notified by the Ministry of Road Transport and Highways for the use of National Highways.
- A **Pilot project on ETC was inaugurated in 2012 on a section of NH-5 between Delhi and Parwanoo**. The **second pilot project will be on the Mumbai and Ahmadabad routes.**

NATRIP	SARDP-NE
• The **National Automotive Testing and R&D Infrastructure Project (NATRIP)** will be under the Department of Heavy Industry (with representatives from the automobile sector) • It aims to set up testing, validation, and R&D infrastructure across seven locations in India.	• The **special accelerated road Development program for North Eastern Region** has been rolled out for improving road connectivity between State Capitals and District HQs in North Eastern Region.

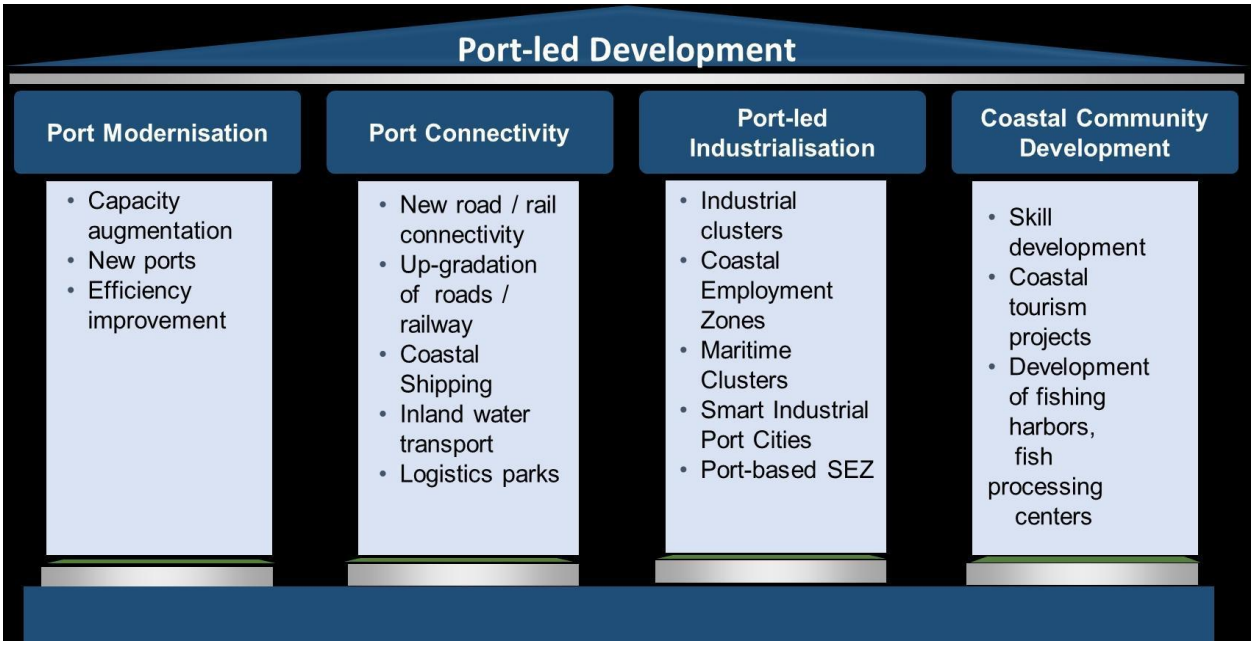
The "Bharat Mala" Project

- The **"Bharat Mala" project envisaged across 13 states** on a 5300 km stretch – **starting from Gujarat & passing through Rajasthan, Punjab, J&K, Uttarakhand, UP, Bihar, Sikkim, Assam, Arunachal Pradesh & ending across the Indo-Myanmar border of Manipur & Mizoram.**
- It involves an expenditure of Rs 12000 – 14000 crores during a three-year timeframe.
- **The road adorns the country like a Garland & hence the name "Bharat Mala"**

- This has a **strategic component that includes countering the impressive Chinese network build-up across the border & to provide accessibility to the border hugging regions & improve border trade.**
- Costs could increase if Nitin Gadkari's suggestion of using cement instead of bitumen is accepted.
- **Private participation to fund the difference may not fructify – considering their stretched balance sheets & therefore the onus shall be on the govt. to fund the project after accelerating the environmental clearances & land acquisition to complete the stretch within the stated timelines.**
- **This project in fact, is a late realization & a delayed response to the Chinese seamless road infrastructure on the other side & a dire necessity to prevent a repeat of the ignominy of the Indian defeat to the Chinese in 1962.**

<u>The "Sagar Mala" Project</u>

- The **Sagar Mala project, announced with much fanfare, on Aug 15th, 2003, by PM Vajpayee**, remained in limbo during the UPA tenure till **it was revived again under Modi's tutelage.**
- The new policy envisages a uniform policy framework for major parts – owned by the center & non-major ports owned by the states to develop a holistic policy encompassing the needs of industrialization trade, tourism & transportation,
- **It involves the development of 10 CER (Coastal Economic Region) along with India's vast 7000 Km coastline freight options – rail, land & inland waterways – for the smooth evacuation of cargo to & from ports.**
- This plan includes the development of port-based industrial parks, captive industries, and ancillary facilities such as ship repair, shipbuilding, ship-recycling, logistics parks, warehousing, maritime zones/ services, offshore storage, drilling platforms, bunkering, container freight stations, industries requiring significant import of raw materials and industries with large export potential to create more jobs.



- It will also reduce the congestion at ports.

Expressways in India

Expressways are the highest class roads in India.

- These are the highways with six to eight lane controlled access road networks.
- Basically, expressways are of high quality consisting of modern features like access ramps, grade separation, lane dividers and elevated sections.
- In expressways, roads are not multiple, controlled access is there where vehicles can enter through a limited place and no further or other road merges or crosses the expressway anywhere.
- Due to this the possibility of accidents is also less. But in the case of highways, multiple roads are there which merge with or cross the highways at many places.

About Freeways :

Freeway is basically designed for high speed vehicular traffic. It is the highest class of controlled access highway. Let us tell you that the national highway system has only two freeways in India, the Eastern Freeway and Western Freeway, to reduce traffic congestion in Mumbai island .

TRANSPORTATION THROUGH WATER

INLAND WATERWAYS (UPSC PRE 2014)

Waterways are the cheapest means of transport and are most suitable for carrying heavy and bulky materials having low specific cost

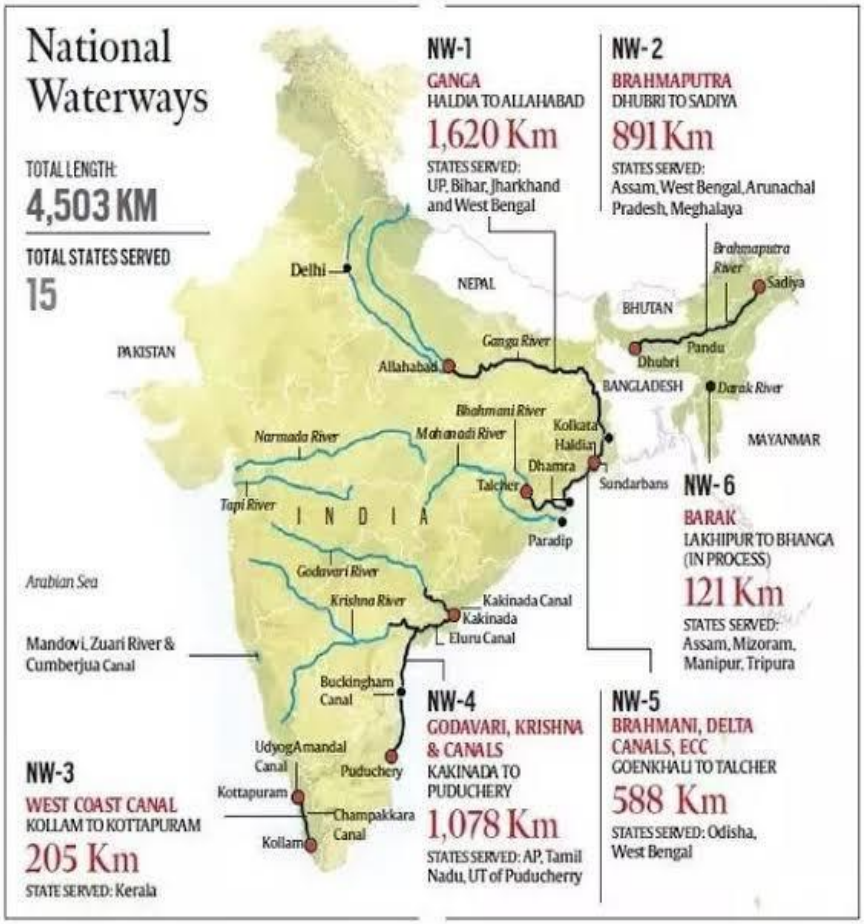
- Water transport is a **fuel efficient and environmental friendly mode of transportation** which has vast employment generation potential
- Currently, coastal and **inland waterways contribute 6%** of the country's freight modal mix, while adjacent developing economies, such as Bangladesh (16%) and Thailand (12%) have a higher share of water-based transport, highlighting the scope for improvement for India
- The exclusive **jurisdiction of the Central Government is only** in regard to shipping and navigation on inland waterways declared to be 'national waterways' by an act of Parliament. Utilisation/sailing of vessels, in other waterways, is within the ambit of the concurrent list or is in the jurisdiction of the respective state governments.

Inland Water Transport in India

India is endowed with various Inland Water Transport (IWT) options that comprise rivers, canals, backwaters, creeks, and tidal inlets

- India has over 5,000 km of navigable inland waterways under development.
- These not only form a competitive alternative mode of transportation with lower operating cost (30% lower than the railways and 60% lower than road) but also a sustainable mode in freight logistics and passenger transport
- To harness the potential of IWT, Inland Waterways Authority of India (IWAI) was established in 1986, and since has been working towards development and regulation of inland waterways
- In order to increase the significance of Inland Waterways and to improve their efficiency, the Government has identified few important Waterways, which are given the status of National Waterways

- From only five waterways recognised as National Waterways (NWs), the government of India notified 106 additional waterways as National Waterways, by the National Waterways Act, 2016.
- In addition to notification of NWs, the government has also undertaken initiatives for speeding infrastructure development. These include:
    - **Jal Marg Vikas Project** (JMVP) for NW-1.
    - **Arth Ganga and Arth Brahmaputra** for holistic and sustainable development leveraging NW-1 and NW-2 for freight and passenger movement.
    - Inland Vessels Bill.
    - Land Use Policy for Inland Waterways (IWs).
    - Dredging Policy for IWs.
    - Promoting private participation in terminal operations and maintenance.



- As a result, the total cargo volume transported through inland waterways in India reached 73.6 million tons per annum (MTPA) in 2019-20 and has grown at a CAGR of 19 per cent over the last five years.
- Rivers in south India are seasonal and are not much suited for navigation
- However, the deltaic areas of the Godavari, Krishna, Mahanadi, lower reaches of the Narmada, Tapi serve as waterways

- There are some navigable canals also, which serve as inland waterways

- Buckingham Canal in Andhra Pradesh and Tamil Nadu is one such canal, which provides water transport for a distance of 413km
- The other navigable canals are Son Canal, Odisha Canal, Damodar Canal

Advantages of Inland Waterways	Challenges related to Inland Waterways
• A well-coordinated inland waterways network could bring a **fundamental alteration in the logistics scenario** of the country • Waterways can **decongest roads,** including highways by moving cargo away • Waterways do **not involve challenges associated with land acquisition**, which has always been a sensitive issue, causing time and cost overruns of numerous projects • **Waterways are a cheaper mode** of transportation vis-à-vis the available alternatives, significantly reducing the point-to-point cost of goods • As per a study carried out by RITES in respect to the Integrated National Waterways Transportation Grid**, one litre of fuel will move 24 tons through one kilometre on road, 95 on rail and 215 kilometres on inland water transport.**	• **The channel draft** of the national waterways is not uniform at 2 meters throughout the year, as is required. Some of these rivers are seasonal and do not offer navigability through the year • Further, all the identified waterways require **intensive capital and maintenance dredging**, which could be resisted by the local community on environmental grounds, including displacement fears, thereby posing implementation challenges • The presence of waterfalls and sharp bends in the **course of river hinders** the development of waterways • **Silting of river beds** reduces the depth of water and creates problems for navigation. And Desilting of river beds is a costly affair • **Diversion of water for irrigation purposes** reduced the quantity of water in river channel, and hence should be done carefully • Also, the demand for **sufficient waterways needs to grow**, to make it an economically viable mode of transportation

Measures taken by Government :

The Indo-Myanmar protocol envisages multimodal connectivity between Kolkata and Mizoram, through Myanmar.

- The transit route comprises of shipping transport from Kolkata to Sittwe port (539 kms), inland waterway transport from Sittwe to Paletwa (River Kaladan – 158 km), Paletwa to Indo-Myanmar border (Myanmar side – 110 km) and from the border to NH 54 at Lawngtlai (India – 100 km).
- This presents an easier and faster transit route than the existing ‘chicken neck’ corridor through Siliguri.

- The **Indo-Bangladesh protocol facilitates export and import trade to and from Bangladesh** using both NW-1 and NW-2.
- The riverine trade through Bangladesh facilitates trade through Assam, as domestic movements on NW-2 between Assam and Haldia/Kolkata areas pass through a significant stretch in Bangladesh and are subject to the bilateral protocol.
- The waterways are also proposed to be **linked to the eastern and western Dedicated Freight Corridors (DFCs), a**s well as the **Sagarmala Project,** which aims to promote port-led direct and indirect development. The linkages are being planned in a manner such that commodities and cargo can be swapped/shifted from and to the waterways, the DFCs and road transport. The inland waterway in its full scope is conceived as part of an ambition to link several big infrastructure projects

SHIPPING (UPSC PRE 2016)

India has had a glorious past with respect to shipping & Indian maritime trade flourished in ancient times.

- Indian boats and ships have been sailing in the Indian ocean for the last 4,000 years taking merchandise to the Middle East
- Currently, shipping plays a significant role in the transport sector of the country's economy
- **Nearly 90% of India's trade Volume(**77% in terms of value), is moved by sea making shipping the backbone of trade and economic growth
- Today, India has the **largest merchant shipping fleet among the developing countries.**

Coastal Shipping

This involves movement of goods and passengers from one port to another port within a country

- India's long coastline, array of ports on the east & west coast; and a large & resilient domestic economy provides a perfect ecosystem for the country to develop a substantial coastal shipping industry.
- In India, domestic movement happens primarily through road, followed by railways and a meagre share is through waterways. Hence, Coastal shipping can be a great enabler to develop economy and reduce logistics costs as evident from the experiences in other developed regions.
- The European Union experience has demonstrated that cost of coastal movement of cargoes was about 20 percent and 40 percent that of road and rail movement, respectively. Hence, the need to capitalise when there is a long coastline resource at hand, for India.
- Currently, in India, the coastal shipping primarily handles POL, coal, and iron ore, which account approximately 80 percent of the total coastal movement

Ports in India

There are 13 major and 200 medium and small ports in India

- The **major ports are under the supervision of the Central Government,** while the minor ones are managed by the concerned state Governments
- The 13 major ports handle about 90% of our foreign trade

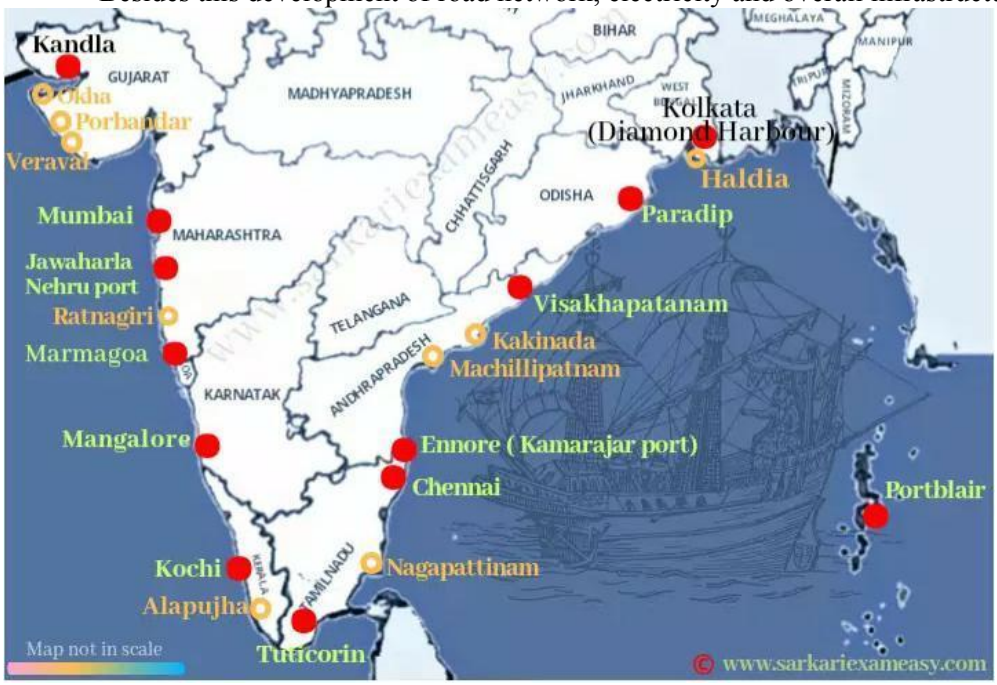
Challenges Faced By Shipping Industry in India

Institutional Challenges

- The rigidity of the Indian bureaucracy and its reluctance to give up control adds to the delay.
- Multiple involvement of the central, state and local governments with overlapping powers add to the chaos.
- Lack of a single window clearance system has made it challenging for shipping companies in India

Infrastructural Challenges

- Capacities of all major and minor ports in India need to be increased urgently.
- When compared to transhipment points in other countries, the cycle time of Indian cargoes has been rendered as uncompetitive on a global scale.
- Besides this development of road network, electricity and overall infrastructural development is also the need of the hour.



Financial Challenges

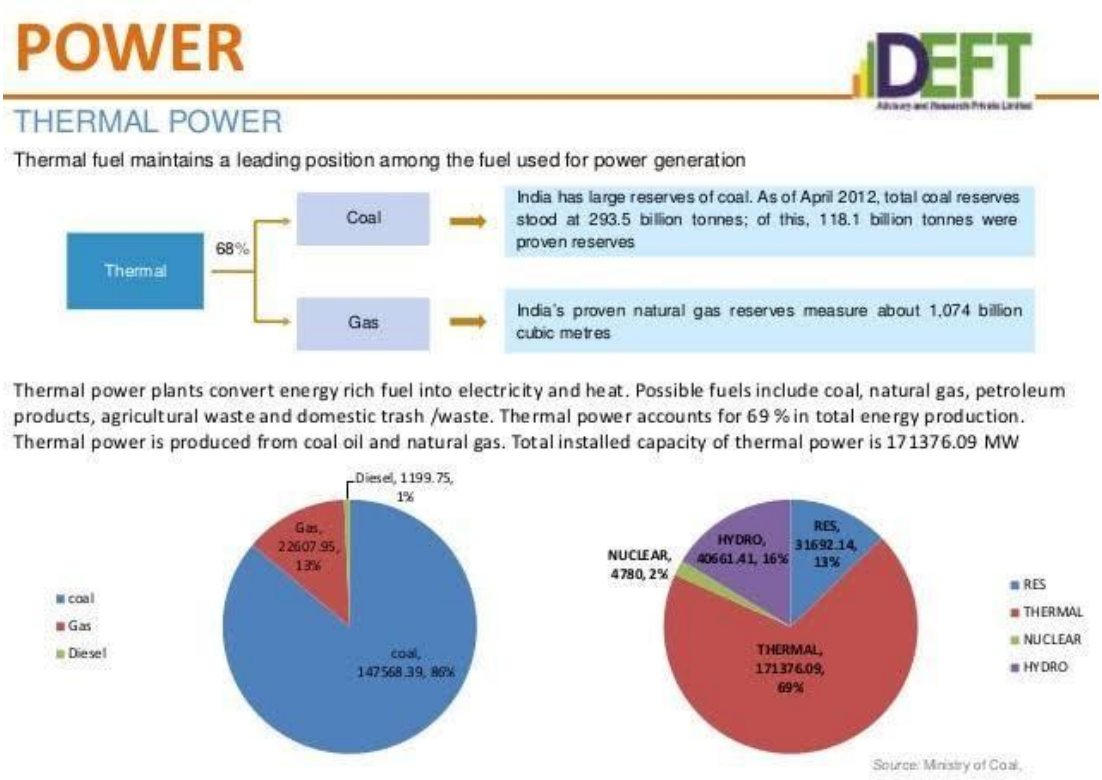
- The burden of taxes like Customs Duty on Bunkers, Landing Fees, Income Tax etc. without negligible exemptions have made it difficult for shipping industry to thrive

Vessel Size

- The sizes of vessels are getting bigger owing to the rise in demand for shipping services.
- While it might sound like an improved trend, many ports in India are still struggling to keep up, and many of these large vessels cannot be called on into most of the ports

POWER SECTOR IN INDIA

The announcement of enhanced targets for climate action by India, particularly for achieving net-zero emissions by 2070, has highlighted the importance of long-term planning for decarbonising the economy.



Why do we need a decarbonising strategy

The Government of India has responded to rapid reductions in the cost of renewable energy (RE) based power, with dramatic enhancements in the targets for RE.

- With this approach, India has done well and is on a path to fulfilling its Paris Agreement commitments for 2030.
- However, the road ahead will be challenging, and therefore, a coordinated strategy for decarbonising the economy efficiently and effectively will be required.

Strategy for decarbonising the economy

- **Factoring in the changes**: By 2070, there will be many changes in technology, environmental conditions, and the economy.
    - The planning horizon of about 50 years will need to be broken up into shorter periods so that new knowledge about emerging technologies can be incorporated into plans.
- **Monitoring of the progress**: Plans will need to be monitored so that the course can be corrected to respond to any unforeseen problems.
    - Five years, as the UK has used, seems like a reasonable "Goldilocks ideal."
    - An autonomous and technically credible agency, like the Climate Change Committee (CCC) in the UK, should be set up.

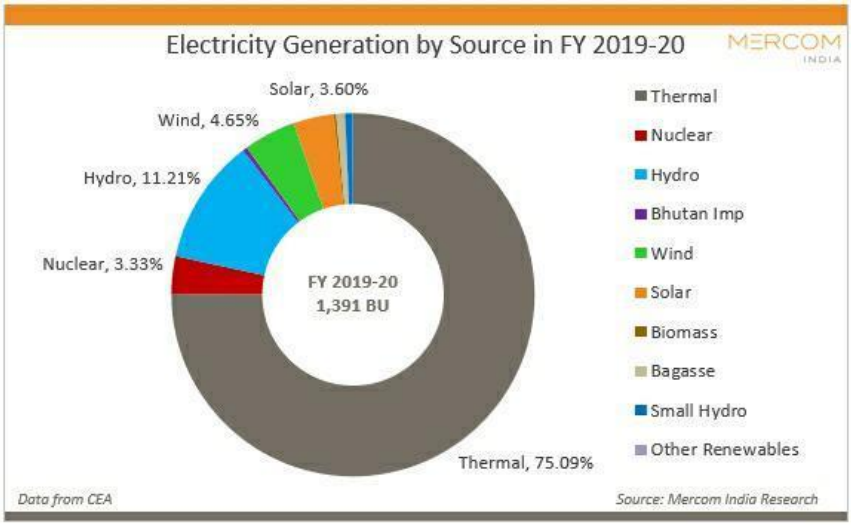
Decarbonising the power sector

- **Biggest source of GHG**: The power sector is the biggest source of GHG emissions and also the easiest one to decarbonise.

    - Reducing emission intensity is a good overarching objective; increased use of RE or non-fossil-fuel generation is a means to that end.
- **The four 2030 targets**: Non-fossil fuel generating capacity to be 500 GW, RE capacity to be 50 per cent of all generation capacity, reduction in emission intensity by 45 per cent, and avoidance of GHG emissions by 1 billion tonnes — are interrelated.

Suggestions to decarbonise the power sector

- **Set emission intensity targets**: Setting permissible emission intensity in terms of grammes of carbon dioxide equivalent per kWh of electricity sold, would be a good option for targets in the power sector.
- **Single emission-related objective**: In order to decarbonise the power sector, it would be best to have a single emissions-related objective so that an optimal strategy can be developed to achieve the objective at the lowest cost.
- **Avoid separate targets**: Currently there is a profusion of separate targets for almost every resource used to generate electricity.
    - For example, there are separate renewable purchase obligations (RPOs) for solar, non-solar RE, and hydropower.
    - Such an approach reduces the flexibility of distribution companies to select resources to meet their loads, resulting in a non-optimal resource mix, and a higher cost of electricity.
- **Reconsider RPO:** RPOs are usually imposed to support nascent technologies, and because RE is now competitive on costs with conventional generation, the need for RPOs should be reconsidered.
- The use of emission intensity targets is a better approach.



RENEWABLE ENERGY IN INDIA

The country's installed Renewable Energy (RE) capacity stands at 150.54 GW (solar: 48.55 GW, wind: 40.03 GW, Small hydro Power: 4.83, Bio-power: 10.62, Large Hydro: 46.51 GW) as on 30th Nov. 2021 while its nuclear energy based installed electricity capacity stands at 6.78 GW.

- India has the 4th largest wind power capacity in the world.

- This brings the total non-fossil based installed energy capacity to 157.32 GW which is 40.1% of the total installed electricity capacity of 392.01 GW.
- At the COP26 India is committed to achieving 500 GW of installed electricity capacity from non-fossil fuel sources by the year 2030

Initiatives Taken By Government :

PM-KUSUM	It was launched by the Ministry of New and Renewable Energy (MNRE) to support installation of off-grid solar pumps in rural areas and reduce dependence on grid, in grid-connected areas.
Production Linked Incentive (PLI) Scheme	Production Linked Incentive Scheme "National Programme on High Efficiency Solar PV Modules" was introduced with an outlay of Rs. 4500 crores to support and promote manufacturing of high efficiency solar PV modules, including the upstage vertical components like cells, wafers, ingots and polysilicon in India and thus reduce the import dependence in Solar PhotoVoltaic (PV) sector.
Solar Parks Scheme	To facilitate large scale grid connected solar power projects, a scheme for "Development of Solar Parks and Ultra Mega Solar Power Projects" is under implementation with a target capacity of 40 GW capacity by March 2022.
Rooftop Solar programme Phase-II	It provides for financial assistance of upto 4 GW of solar roof top capacity to the residential sector and there is a provision to incentivise the power distribution companies for incremental achievement over the previous year.
Central Public Sector Undertaking (CPSU) Scheme	A scheme for setting up 12 GW Grid- Connected Solar PV Power Projects by Central Public Sector Undertakings with domestic cells and modules is under implementation. Viability Gap Funding support is provided under this scheme.
Hydrogen Mission	The Prime Minister announced the launch of the National Hydrogen Mission and stated the goal to make India a global hub for Green Hydrogen production and export.
International Solar Alliance	The ISA is an intergovernmental treaty-based organisation with a global mandate to catalyse solar growth by helping to reduce the cost of financing and technology. Recently, the United States of America has become the 101st member country to join the ISA.

OSOWOG	The OSOWOG was jointly released by India and the UK at the COP26 Climate Meet in Glasgow.
National Wind-Solar Hybrid Policy	The main objective of the National Wind-Solar Hybrid Policy, 2018 is to provide a framework for promotion of large grid connected wind-solar PV hybrid systems for optimal and efficient utilization of wind and solar resources, transmission infrastructure and land.
National Offshore Wind Energy Policy	The National Offshore wind energy policy was notified in October 2015 with an objective to develop the offshore wind energy in the Indian Exclusive Economic Zone (EEZ) along the Indian coastline of 7600 km.
Other Renewables for Power Generation	Programme on Energy from Urban, Industrial and Agricultural Wastes/Residues Scheme to support Promotion of Biomass based cogeneration in sugar mills and other industries Biogas Power (Off-Grid) Generation and Thermal application Programme (BPGTP) New National Biogas and Organic Manure Programme (NNBOMP)

DEMOGRAPHY OF INDIA

Demographics refer to statistical data relating to the population in a region. This covers various factors like population growth rate, the percentage of different age groups within the population, the literacy rates, the sex ratio, urban-rural population ratios, etc.

- **According to the 2011 census, India has a 1.21 billion population.**
- It comprises of **17.5% of the world's population** with **2.4 % of the world's land area.**
- **In terms of population, India is the second-largest country of the world** and despite its growth rate declining, India continues to be a high-growth country.
- Approximately **one out of every six people in the world is from India.** India's population is almost equal to the combined population of the USA, Indonesia, Brazil, Pakistan, Bangladesh, and Japan.
- India's population is a little over twice the population of Latin America and **1.2 times the population of the whole of Africa.**

- **In terms of area, India stands seventh** preceded by **Russia, Canada, China, the United States of America, Brazil, and Australia**.

Stages of India's population growth

Phase 1 (1901-1921)- Period of stagnant population	• This phase is also known as the Primitive Demographic Transition Stage. It is the stage I of Demographic Transition Model Theory.
	• This stage is characterized by the following traits:
	  ◦ Very high Birth Rate and Death Rate (approximately 40/ thousand)
	  ◦ Epidemics, famines, droughts, lakhs of Indian soldiers in World War I.
	  ◦ Low life expectancy.
	• 1921 recorded an absolute decline in population numbers. The year 1921 is known as the year of the Demographic Divide.
	• From the view of population studies, India has been divided into **6 zones**
	• During 1901-21, the Northern Zone suffered a net loss in population due to famines and epidemics.
	• The North-East zone witnessed a very high growth rate due to large-scale in-migration (migration of laborers in Tea plantation estates of Assam) and fewer famines and epidemics.
	• The southern zone witnessed a normal Growth Rate since epidemics and famines were less.

Phase 2 (1921-1951)- Period of steady growth	• India entered in 2nd stage of the **Demographic Transition Model Theory**.
	• The birth rate was still high but the death rate reduced (around 20/thousand) therefore, the population due to less mortality induced growth. Reasons for high growth are:
	  ◦ Intervention by government
	  ◦ Vaccination
	  ◦ Medical revolution
	  ◦ PDS system led to the timely food supply in drought and famine area
	• The population increased from 251 million to 361 million.
	• **Spatial analysis**:
	  ◦ North, Eastern, Southern Zone registered growth rates close to the national average.
	  ◦ Central zone registered a low growth rate due to higher mortality and outmigration
	  ◦ Western zone registered high growth of 56% partially due to national growth and mainly due to in-migration

	caused by industrial growth in Mumbai, Ahmadabad, Vadodara, and Surat.
Phase 3 (1951-1981)- Period of rapid population growth	• India still in 2nd phase of Demographic Transition Model Theory • This stage is referred to as the period of population explosion. • There was a steep fall in mortality rate (12/1000 in 1981) but the fertility rate was still high (40/1000). • The population increased from 361 million to 683.3 million in 1981. • This population growth was due to improvements in health facilities and developmental activities. Thus it was called as fertility-induced growth. • The Northern Zone experienced a high growth rate whereas the Southern Zone experienced a low growth rate.
Phase 4 (1981-2011)- Period of high population growth rate with a definite sign of slowing down	• Although the growth rate was still high, it started declining after 1981 (highest growth rate was in 1971- 2.48%). • India experienced the 3rd phase of Demographic Transition Model Theory. • The North and South zones have the highest and lowest growth rate respectively. • The birth rate declined rapidly from 36/1000 to 22.5/1000 in 2009. • The death rate also continued to decline. • In the 2001 Census India added 182 million people over the 1991 Census. In 2011 180 million people were added to the 2001 Census which implies a definite decline in growth rate in percentage and absolute terms. • Since the 2001 census, India has had a consistent irreversible population growth rate. • In 2011 there was a decline in the child population below 14 years of age. • The policy objective is to stabilise India's population at 1.8 billion by the 2041 census and India is expected to exceed China's population by 2028 as per UNFPA report. • Further trends in population growth in India according to UN Economic and Social Affairs

Spatial patterns of growth rate in India

- India has high growth rates but the growth trends are different in different states. Thus there is spatial-temporal variation in population growth.

- The southern states of India (Kerala, Tamil Nadu, Andhra Pradesh) have nearly stabilized or are stabilizing their population.
- Northern Hindi belt continues to have a very high growth rate (Bihar has the highest growth rate of 25% followed by Jammu and Kashmir with 23.7% growth rate and Uttar Pradesh with 20% growth rate.
- Among the smaller states and union territories, Dadar and Nagar Haveli and Daman and Diu registered the highest growth rate of 55.5 and 53.54 percent respectively.
- In contrast, Lakshadweep, Andaman Nicobar Islands, and Goa have registered a low growth rate remaining in single digits only. A glaring downtrend in the growth has been observed in Nagaland, where there had been a steep fall in growth rate from 6453 per cent in 1991, 2001 to a negative growth rate of -0.47 per cent mainly due to conflicts, mortality and out-migration.
- The second minimum growth of 4.86 percent has been recorded by Kerala. This state has reached a high level of demographic transition and can be easily compared with the advanced countries of Europe and America.
- Some of the more populous states have registered a very high growth rate of over 20 percent. Among them, Bihar (25.07%), Jammu & Kashmir (23.71%), Chhattisgarh (2259%) and Jharkhand (2234) are worth noting. Some other states with a small population but a higher growth rate are Meghalaya (27.82%) and Arunachal Pradesh (25.92%).
- Some of the fastest-growing centres are the Industrial and Urban areas due to high immigration due to high employment aspects.

Population Growth in Empowered action group and Non-Empowered action group states

- For a close analysis, the Indian states and Union territories are divided into two broad groups namely Empowered Action Group (EAG) and non-Empowered Action Group (non-EAG).
- EAG includes Rajasthan, Uttar Pradesh, Uttarakhand, Bihar, Jharkhand, Madhya Pradesh, Chhattisgarh, and Odisha.
- The remaining states and union territories are included in the non-EAG.
- The EAG states hosted between 43 and 46 percent of India's population.
- During the period of two decades between 1951 and 1971, the population of both EAG and non-EAG states and union territories increased, which led to the overall increase in the population of India.
- From 1971 onwards, the growth rate in non-EAG states and union territories declined continuously due to declining fertility rate and the growth rate in EAG states almost stagnated around 25 percent.
- During 1991-2001, the growth rate for EAG states remained the same as that in the previous decade whereas there was a continuous reduction in the growth rate of non-EAG states and union territories. This was primarily responsible for bringing about a significant fall of about 23 percent in the growth rate of the country as a whole.
- During 2001-2011, for the first time in the demographic history of the country, the growth momentum for EAG states has given the signal of slowing down, falling by about 4 percent points. Thus, together with a similar reduction in non-EAG states and union territories has brought down the rate of growth for the country by 3.9 percent.

Reasons for India's high growth rate in India : Adam Smith stated that " Poverty creates ideal conditions for high fertility"

- Certain conservative communities like Catholics are against various methods like abortion, birth control operations, foeticides, etc.

REASONS FOR HIGH POPULATION GROWTH					
Biological	**Social**	**Economic**	**Environment**	**Demographic**	**Administrative problem**
• High fertility	• Religion • Rituals • Beliefs • Early marriage (e.g. Rajasthan→ early marriage on Teej) • Low female literacy • Lack of women empowerment	• Economic backwardness • illiteracy • unemployment • poverty • subsistence agriculture • landless labor→need for more helping hand	• Sickness • Slackness • Couple remain at house for longer period	• High IMR • High MMR • High Density	• Law and order problem • Riots • child trade • child labor

Suggestions according to the National Population Policy of India to control population growth:

- Delay in marriages and increase the age of marriage.
- Spacing between Children
- Awareness for girl child
- Dealing with attitudinal aspects of the patriarchal mindset.
- Vaccination program for mother and child.
- Reproductive Child Health program or Mother and Child Program- Objectives
    - Neonatal health care or postpartum (post-delivery) health care.
    - Nutritional programs
    - 100% institutional delivery and delivery by trained nurses and midwives
- Monetary incentives for pregnant and nursing mothers for institutional delivery and nutrition. E.g. Development of Women and Children Program (DWCRA)

GEOMORPHOLOGY

ORIGIN OF EARTH

The earth broke off about 4.5 billion years ago with an explosion. It was a burning hot white mass of gas and dust.

- Over a long period of **time, dust and gas gradually condensed** to form solid rock.

- Such condensation and shrinking made the earth heat up so much that the rock melted into a gluey liquid.
- After millions of years, the outer surface of the earth or the earth's crust cooled and formed hard rock again, just as melted chocolate or wax solidifies upon cooling.
- The interior of the earth is still very hot.
- The crust of the earth was formed from cooling and hardening of the molten lava . Similarly the crust hardened and formed the land.
- Cooling of the earth also condensed water vapour into liquid water, filling the depressions to form seas.

Theories related to origin of earth :

Nebular Hypothesis	Revised Nebular Hypothesis	Big Bang Theory
• Immanuel Kant, a German philosopher, gave this theory. • In 1796, a mathematician Pierre-Simon Laplace re-examined it. • According to this hypothesis, the planets were moulded out of a cloud of material associated with a young Sun, which was rotating slowly.	The Revised Nebular Hypothesis was propounded by Carl Weizascar in Germany and Otto Schmidt in Russia. • They regarded that a solar nebula surrounded the sun and that the nebula was chiefly hydrogen, helium and something called dust. • The collision of particles and the friction caused a disk-shaped cloud to be formed and then the planets were created via the accretion process.	Alternatively called the expanding universe hypothesis. • As per this theory, in the beginning, all matter or substance forming this universe existed at one place as a tiny ball. This tiny ball had an extremely small volume, infinite density and temperature. • At the Big Bang, this ball blasted fiercely and forcefully and started a substantial process of expansion which continues to this day. • Now it is accepted that this event took place 13.7 billion years ago.

Formation of Planets

The following are regarded as the stages in the planets' development:

- The stars are localised gas lumps inside a nebula.
- A core to the gas cloud as well as a spinning disc of dust and gas are created because of the gravitational force within the lumps.
- After this, the cloud of the gas condenses and the matter over the core is changed into tiny rounded objects.
- These small round objects develop into what are called phantasmal by a cohesion process.

- The smaller objects start forming larger bodies by colliding with one another and they stick together because of gravitational force.
- In the last stage, these large numbers of small phantasmal aggregate to develop into a smaller number of large bodies called planets.

SOLAR SYSTEM (UPSC PRE 2013,)

Our Solar system consists of eight planets.

- The nebula from which our Solar system is supposed to have been formed, started its collapse and core formation some time 5-5.6 billion years ago and the planets were formed about 4.6 billion years ago.
- Our solar system consists of the sun (the star), 8 planets, 63 moons, millions of smaller bodies like asteroids and comets and huge quantities of dust-grains and gases.
- Out of the eight planets, mercury, venus, earth and mars are called the inner planets as they lie between the sun and the belt of asteroids; the other four planets are called the outer planets.
- Alternatively, the first four are called **Terrestrial**, meaning earth-like as they are made up of rock and metals, and have relatively high densities.
- The other four are called **Jovian or Gas Giant planets.** Jovian means jupiter-like.
    - Most of them are much larger than the terrestrial planets and have a thick atmosphere, mostly of helium and hydrogen.
- The difference between terrestrial and jovian planets can be attributed to the following conditions:
    - The terrestrial planets were formed in the close vicinity of the parent star where it was too warm for gases to condense to solid particles. Jovian planets were formed at quite a distant location.
    - The solar wind was most intense nearer the sun; so, it blew off lots of gas and dust from the terrestrial planets. The solar winds were not all that intense enough to cause similar removal of gases from the Jovian planets.
    - The terrestrial planets are smaller and their lower gravity could not hold the escaping gases.
- All the planets were formed
- All the planets were formed in the same period sometime about 4.6 billion years ago.
- Till recently (August 2006), Pluto was also considered a planet. However, in a meeting of the International Astronomical Union, a decision was taken that Pluto like other celestial objects (2003 UB313)discovered in recent past may be called ‘dwarf planet’

Brief review of the solar system.

- **Mercury** is closest to the sun. It has a temperature range of 427ºC on its side facing the Sun and –270ºC, on its dark side. It has no atmosphere.
- **Venus** is the closest neighbour of the earth. It is about 40mkm away. It is an extremely hot planet with a temperature of 480ºC. Its atmosphere has 96% carbon dioxide and poisonous gases like sulphur dioxide and carbon monoxide.
- **Earth** is the only planet known to sustain life.
- **Mars** is also close to earth. It is called the red planet. It has 95% carbon monoxide and reddish dust. It is relatively a very cold planet and as of now the presence of life on it has not been conclusively established.

- **Jupiter** is the largest planet of the solar system. It is mainly a rapidly spinning ball of gas, especially clouds of ammonia, and has no solid surface.
- **Saturn** consists mainly of hydrogen and helium. Its atmosphere has 90% nitrogen and a temperature of (-184ºC). It is also made up of hydrogen cyanide which is a highly poisonous gas. It is characterized by a ring that surrounds it.
- **Uranus** is also a very cold planet. Uranus is a distant planet of the solar system and 7th in order from the sun. Uranus and Neptune are the outermost planets of the solar system. Uranus has a highly tilted rotation axis.
- **Neptune** is much smaller than earth, cold and dark with its surface coated with frozen methane.

INTERIOR OF THE EARTH :

The interior structure of the Earth is made up of three main shells: the very thin and brittle crust, the mantle, and the core.

- The core of the earth only occupies 15 percent of Earth's volume whereas the mantel occupies 84 percent and the crust occupies the remaining 1 percent.

Sources about Interior of the Earth

The earth's radius is 6,370 km. Most of our understanding about the interior of the earth is based on estimates and inferences.

Direct Sources of Information

- **Surface rock:** Surface rocks are the most readily available solid earth material to make direct observations. Laboratory experiments on surface rocks and minerals provide important information about the interior of the earth.
- **Mining** : Rocks that we get from mining areas are another source that gives us information about Earth's interior. World's deepest mining is limited only to the depth of fewer than 5 kilometres. Going beyond this depth is not possible due to excessive heat at this depth.
- **Deep Ocean Drilling Projects**: The deepest drill at Kola, in the Arctic Ocean, has so far reached a depth of 12 km. This and many deep drilling projects have provided a large volume of information through the analysis of materials collected at different depths.
- **Volcanic Eruptions :**Volcanic eruption forms an important source of obtaining direct information through laboratory analysis of the molten material (magma) that is thrown onto the surface of the earth, during a volcanic eruption. However, it is difficult to find out about the depth of the source of such magma.

Indirect Sources of Information

- **Meteors**: Meteors are bits of interplanetary material falling through Earth's atmosphere and heated to incandescence by friction. Meteors that at times reach the earth are an important source of information about the interior structure of the Earth.
- **Gravitation**: The reading of the gravity at different places is influenced by many factors viz. distribution of mass, distance from the centre of the Earth. Such a difference is called gravity anomaly. Gravity anomaly gives us information about the distribution of mass of the material in the crust of the earth.

- **Magnetic Field** - Magnetic surveys provide information about the distribution of magnetic materials in the crustal portion, and thus, provide information about the distribution of materials in this part.
- **Seismic Activity** : Seismic activity is one of the most important sources of information about the interior of the earth. Body waves, generated by an earthquake, especially S-waves, which travel only through solid material, have helped in understanding the interior structure of the Earth.

The Layers of the Earth

Earth's interior is divided into basically three layers Crust, Mantle and Core, which we shall discuss in detail as below:-

The Crust

The crust is the outermost layer of the earth and is brittle in nature.

- The crust of the Earth has two distinct types: continental crust and oceanic crust.
- These two types have different chemical compositions and physical properties and were formed by different geological processes.
- The thickness and density of the crust vary under the oceanic and continental areas.
- Oceanic crust is thinner as compared to the continental crust.
- The mean thickness of the oceanic crust is 5 km.
- The mean thickness of the continental crust is around 30 km. It is much thicker in the areas of major mountain ranges, extending up to 70 km in the Himalayan region.
- Oceanic crust is denser as compared to the continental crust.
- Continental crust has a mean density of 2.7 g/cm3. It is mainly composed of silicon and aluminium. Therefore, it is often termed SIAL.
- The mean density of material in the oceanic crust is 2.9 g/cm3. It is mainly composed of basaltic rocks.
- The crust makes up about 1% of Earth's volume.

The Mantle

Our knowledge of the upper mantle, including the tectonic plates, is derived from analyses of earthquake waves, heat flow, magnetic, gravity studies and laboratory experiments on rocks and minerals.

- The portion of the interior beyond the crust is called the mantle which extends from Moho's discontinuity to a depth of 2,900 km.
- It has an average density higher than that of the crust (3.4 g/cm3).
- The mantle is divided into upper and lower mantle.
    - **Asthenosphere** - The upper portion of the mantle is called asthenosphere, extending up to 400 km. The word astheno means weak. It is the main source of magma that finds its way to the surface during volcanic eruptions. It lies below the lithosphere.
    - **Lithosphere** - The crust and the uppermost part of the mantle are called lithosphere. Its thickness ranges from 10-200 km. The lithosphere is subdivided into tectonic plates.
- The lower mantle extends beyond the asthenosphere. It is in the solid state.
- Major constituent elements of the mantle are magnesium and silicon. Hence, this layer is termed SIMA.

- The mantle makes up about 84% of Earth's volume

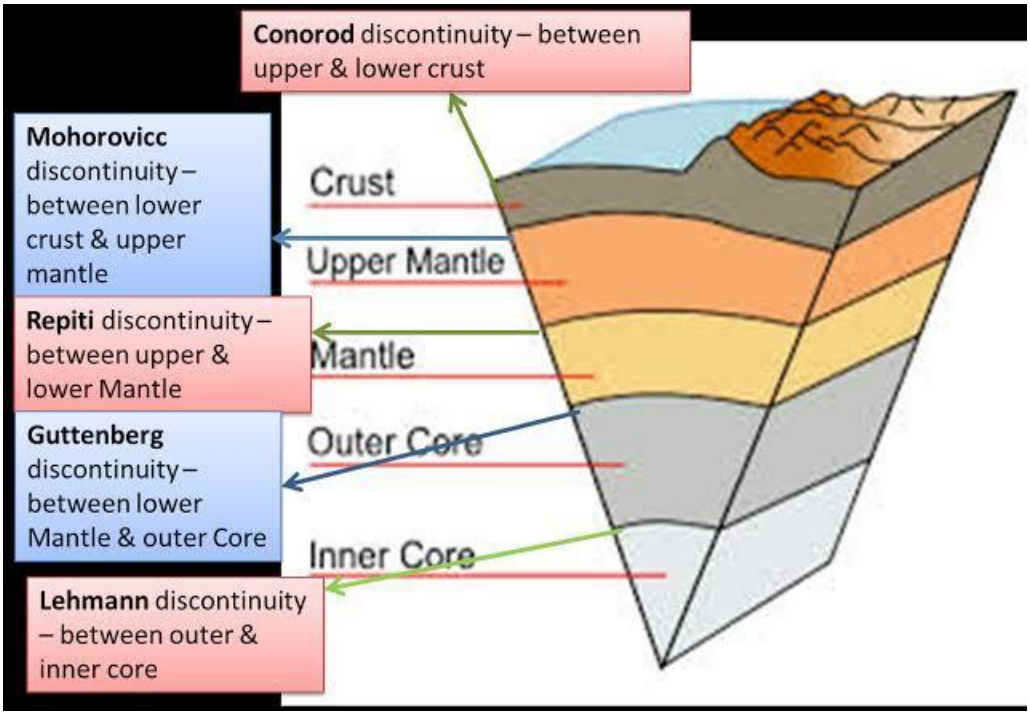
The Core

The earthquake wave velocities have helped in understanding the existence of the core of the earth.

- The innermost layer surrounding the earth's centre is called core, which is about 3500 km in radius.
- The core-mantle boundary is located at a depth of 2,900 km.
- The core consists of two sub-layers. The outer core is in the liquid state while the inner core is in the solid state.
- The core is the densest layer of the earth. The density of material at the mantle-core boundary is around 5 g/cm3, and at the centre of the earth at 6,300 km, the density value is around 13 g/cm3.
- The core is made up of very heavy material mostly made of nickel and iron. It is sometimes referred to as the NIFE layer.
- The core makes up about 15% of Earth's volume.

Seismic Discontinuities

Seismic discontinuities aid in distinguishing divisions of the Earth into the inner core, outer core, lower mantle, upper mantle, and the crust.



Temperature, Pressure and Density of the Earth s interior

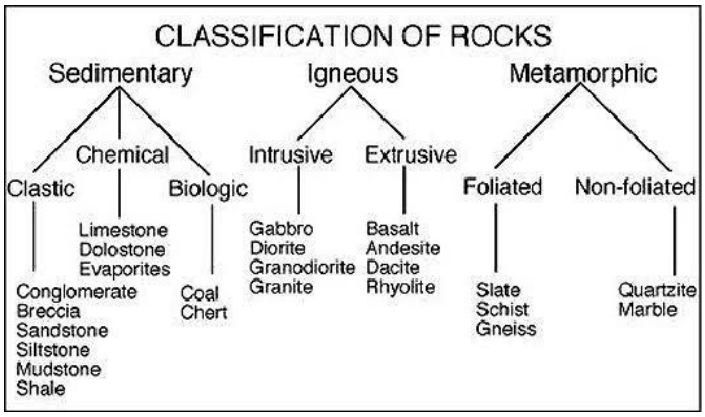
- The temperature increases towards the centre of the earth. However, the rate of increase of temperature is not uniform from the surface towards the earth's centre. It is faster at some places than at others.

- The temperature at the centre is estimated to lie somewhere between 3000 C and 50000C.
- Such a high temperature inside the earth may be due to chemical reactions under high-pressure conditions and disintegration of radioactive elements.
- The pressure also increases from the surface towards the centre of the earth due to the huge weight of the overlying rocks.
- Due to increase in pressure and presence of heavier materials towards the earth's centres, the density of earth's layers also continues increasing. The materials of the innermost part of the earth are very dense.

TYPES & CHARACTERISTICS OF ROCKS

The rocks are classified into three families based on their mode of formation.

Classification of Rocks:



Igneous Rocks

- It is formed out of magma and lava from the interior of the earth and known as primary rocks.
- When magma in its upward movement cools and turns into a solid form it is called igneous rock.
- The process of cooling and solidification can happen in the crust of the earth or on the surface of the earth.
- Igneous rocks are classified based on texture.
- If the molten material is cooled slowly at great depths, mineral grains may be very large.
- Sudden cooling at the surface results in small and smooth grains.
- Intermediate conditions of cooling would result in intermediate sizes of grains making up igneous rocks.

Sedimentary Rocks

Rocks of the earth’s surface area are exposed to denudation agents and are broken up into various sizes of fragments.

- These fragments are carried by various exogenous agencies and deposited & these deposits through compaction turn into rocks. This process is called lithification.
- In several sedimentary rocks, the layers of deposits maintain their characteristics even after lithification.

- Sandstone, shale are some of the examples for Sedimentary Rocks.

Metamorphic Rocks

These rocks form under the action of volume, pressure, and temperature (PVT) changes.

- Metamorphism happens when rocks are forced down to lower levels by tectonic processes or when molten magma rising through the crust comes in contact with the crustal rocks or the underlying rocks are exposed to great amounts of pressure by overlying rocks.
- The materials of rocks chemically modify and recrystallize due to thermal metamorphism.
- There are two types of thermal metamorphism :
    - **Contact metamorphism :** The rocks come in contact with hot intruding magma and lava and the rock materials recrystallize under high temperatures.
    - **Regional metamorphism :**The rocks experience recrystallization due to deformation caused by tectonic shearing together with high temperature or pressure or both.

FOLDING & FAULTING

Folding	Faulting
Folds are bends in the rocks that are due to compressional forces	Faults are due to tensional forces along which displacements of rocks take pace
Folding occurs when compressional force is applied to rocks that are ductile or flexible	Faults occur when forces operating in opposite directions leads to tension and as a result rocks develop cracks on the fissure
Rocks that lie deep within the crust and therefore are under high pressure are generally ductile and particularly susceptible to folding without breaking	Rock layers that are near the surface and not under high confining pressure are too rigid to bend into folds, but if the tectonic plates are too large rocks break
Folds form under varied conditions of stress, pore pressure, and temperature gradient, as evidenced by their presence in soft sediments, the full spectrum of metamorphic rocks	With normal dip-slip faults, the rock masses compress on each other vertically, and the rock moves heads downward.
Folds are commonly formed by shortening of existing layers, but may also be formed as a result of displacement on a non-planar fault	A fault plane is the plane that represents the fracture surface of a fault. A fault trace or fault line is a place where the fault can be seen or mapped on the surface.
A fold surface seen perpendicular to its shortening direction can be divided into hinge and limb portions, the limbs are the flanks of the fold and the hinge zone is where the limbs converge.	A fault zone is a cluster of parallel faults. However, the term is also used for the zone of crushed rock along a single fault.
Minor folds are quite frequently seen in outcrop; major folds seldom are except in the more arid countries. Minor folds can, however, often provide the key to the major folds they are related to	All faults have a measurable thickness, made up of deformed rock characteristic of the level in the crust where the faulting happened, of the rock types affected by the fault and of the presence and nature of any mineralising fluids.

Folding resulted in the Himalayan Mountains, Alps etc	Faulting results in the formation of block mountains and river valleys like the Narmada, Tapi

THEORIES OF CONTINENT FORMATION

CONTINENTAL DRIFT THEORY

Continental drift theory deals with the distribution of the oceans and the continents. It was first suggested by a German meteorologist, Alfred Wegener in 1912.

- According to the theory, all the continents formed a single continental mass- Pangea and mega ocean- Panthalassa surrounded it.
- Around 200 million years ago Pangaea started splitting and broke down into two large continental masses as Laurasia and Gondwanaland formed the northern and southern components respectively.
- Subsequently, Laurasia and Gondwanaland continued to break into various smaller continents that exist today.

Forces responsible for Movements of Continents :

Pole-fleeing or centrifugal force:

- The spinning of Earth on its own axis creates a centrifugal force i.e. force oriented away from the axis of rotation towards the equator.
- Wegener believed the centrifugal force of the planet caused the supercontinent to break apart and pushed continents away from the Poles toward the equator. Therefore, He called this drifting mechanism as the “pole-fleeing or centrifugal force”

Tidal force:-

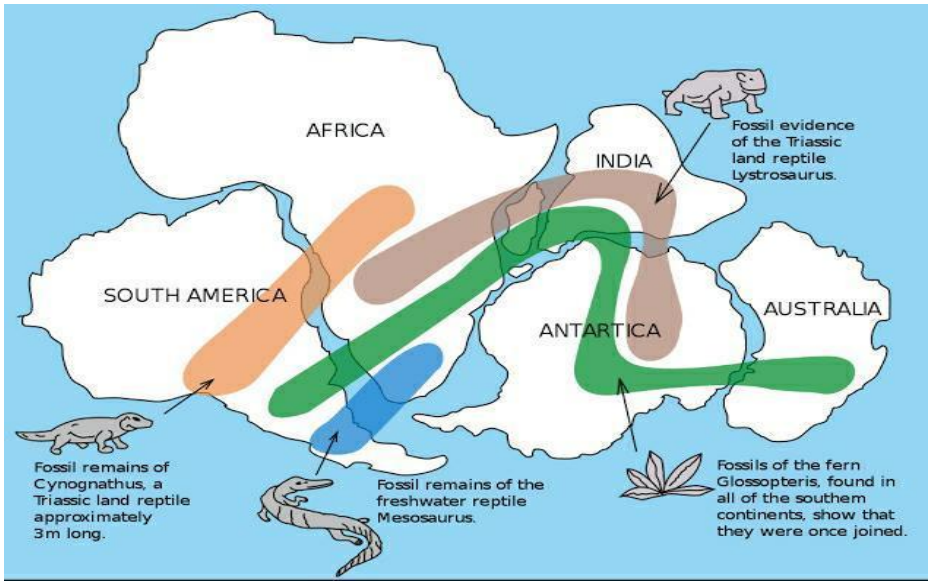
- Wegener tried to attribute the westward drift of the Americas to lunar-solar drag i.e. by invoking tidal force that is the gravitational forces of the sun and the moon .
- He also admitted that it is probable that pole- fleeing or centrifugal force and tidal force are responsible for the journey of continents. Wegener failed to devise a sound mechanism for the movement of the continents. For Wegener the drifting mechanism was the most difficult question to solve.
- Plate tectonics is the grand unifying theory of geosciences that explains

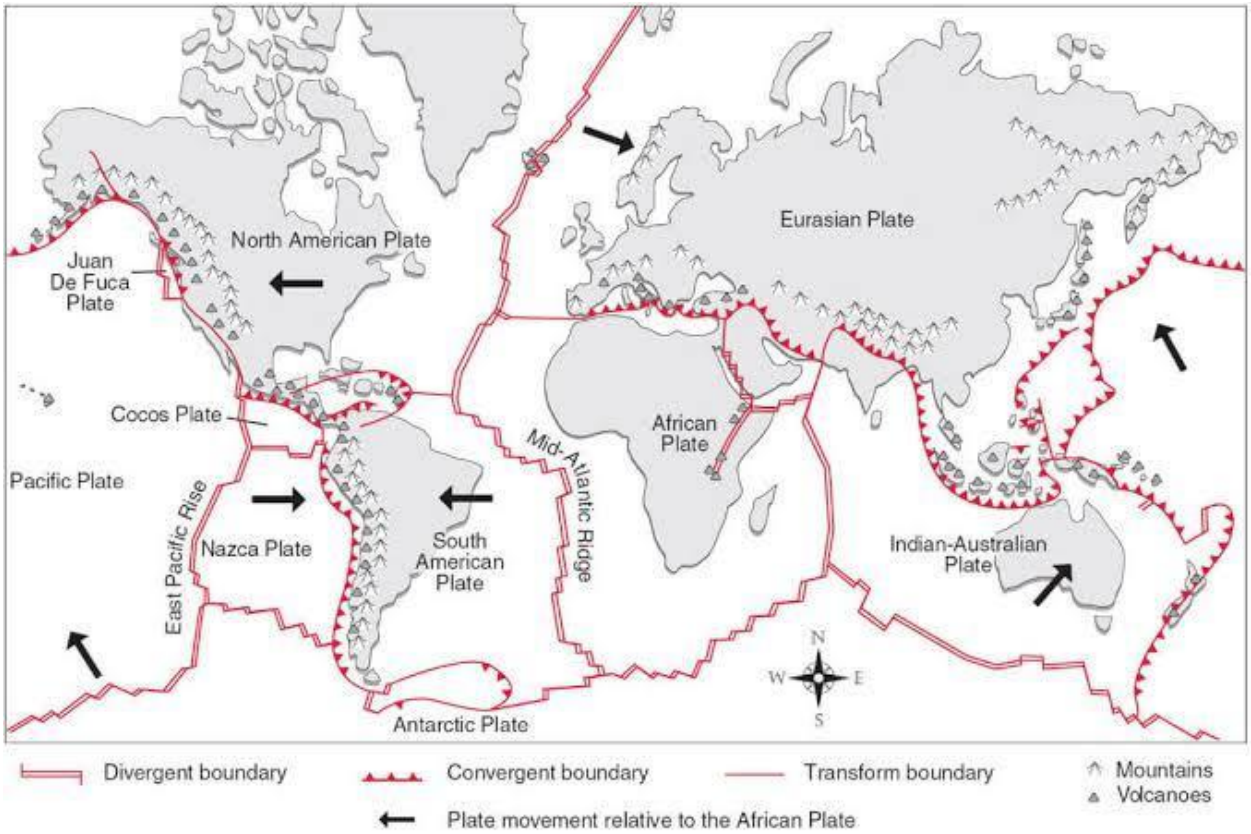
Evidence that supports the theory

- **The Matching of Continents (Jig-Saw-Fit):** The shorelines of Africa and South America facing each other match remarkably.
- **Rocks of Same Age Across the Oceans**: radiometric dating methods have correlated the rock formation in different continents.

- **Tillite**: The glacial tillite found in Gondwana system of sediments has its resemblance to six different landmasses of the Southern Hemisphere. Counterparts of this succession are found in Africa, Falkland Island, Madagascar, Antarctica and Australia besides India.

- **Placer Deposits**: The placer deposits of gold in the Ghana coast do not have source rock in the region. The gold deposits of Ghana have been derived from the Brazil plateau when the two continents lay side by side





- **Distribution of Fossils**: identical species of plants and animals adapted to living on land or in freshwater are found on either side of the marine barriers. For example, remains of Mesosaurus, a

freshwater crocodile-like reptile that lived during the early Permian (between 286 and 258 million years ago), are found solely in Southern Africa and Eastern South America.

PLATE TECTONIC THEORY

Plate tectonics(from the Late Latin tectonicus, from the Greek: τεκτονικός "pertaining to building")is a scientific theory describing the large-scale motion of 7 large plates and the movements of a larger number of smaller plates of the Earth's lithosphere, over the last hundreds of millions of years.

- Plate tectonics theory is a modern theory given by Mckenzie, Parker, and Morgan in 1967 that explains the current position of continents and ocean and it also explains the evolution of major landforms such as mountains, ridge, plateau, volcanic landforms, etc.
- As per the theory, the earth's crust is divided into many large and small plates and it moves horizontally and vertically over the asthenosphere.
- Earthquakes, volcanic activity, mountain-building, and oceanic trench formation occur along these plate boundaries. The relative movement of the plates typically ranges from zero to 100 mm annually.
- Tectonic plates are composed of oceanic lithosphere and thicker continental lithosphere, each topped by its own kind of crust.
- Along convergent boundaries, subduction carries plates into the mantle; the material lost is roughly balanced by the formation of new (oceanic) crust along divergent margins by seafloor spreading.

In this way, the total surface of the lithosphere remains the same. This prediction of plate tectonics is also referred to as the **conveyor belt principle**. Earlier theories, since disproven, proposed gradual shrinking (contraction) or gradual expansion of the globe.

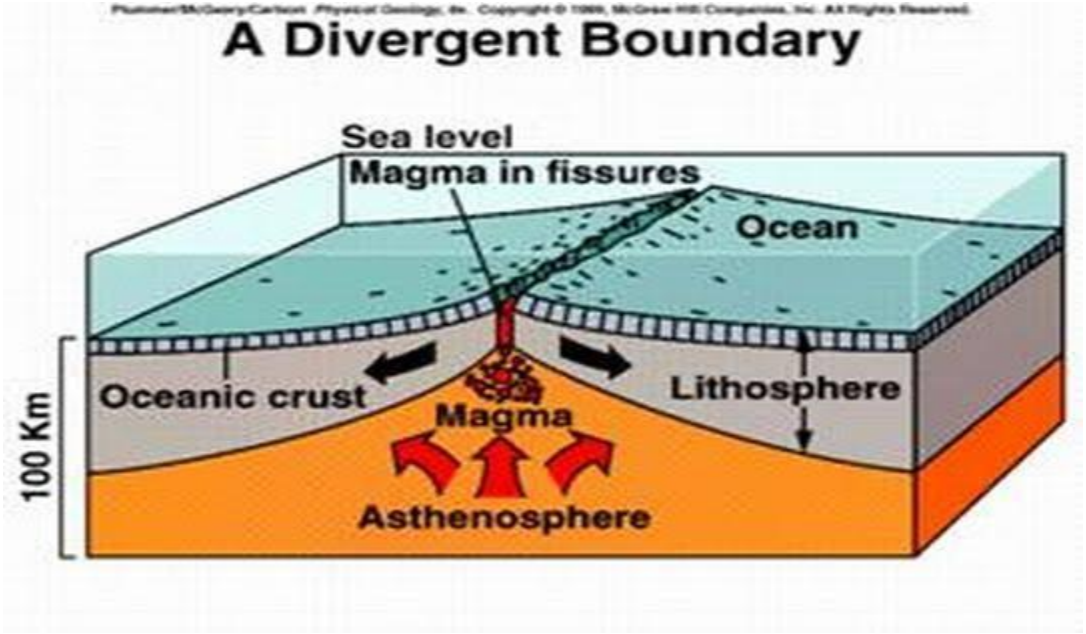
- Tectonic plates are able to move because the Earth's lithosphere has greater strength than the underlying asthenosphere.
- Lateral density variations in the mantle result in convection.
- Plate movement is thought to be driven by a combination of the motion of the seafloor away from the spreading ridge (due to variations in topography and density of the crust, which result in differences in gravitational forces) and drag, with downward suction, at the subduction zones.
- Another explanation lies in the different forces generated by tidal forces of the Sun and Moon.
- The relative importance of each of these factors and their relationship to each other is unclear, and still the subject of much debate.

Types of Plate Boundaries

A divergent boundary

- A divergent boundary occurs when two tectonic plates move away from each other
- Along these boundaries, lava spews from long fissures and geysers spurt superheated water.
- Frequent earthquakes strike along the rift. Beneath the rift, magma—molten rock—rises from the mantle.
- It oozes up into the gap and hardens into solid rock, forming new crust on the torn edges of the plates.

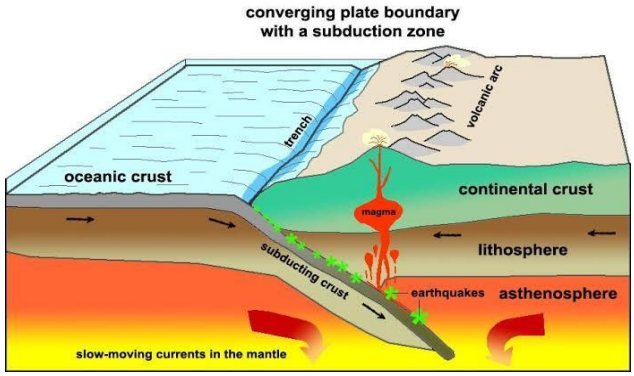
- Magma from the mantle solidifies into basalt, a dark, dense rock that underlies the ocean floor.
- Thus at divergent boundaries, oceanic crust, made of basalt, is created.



Convergent boundary

When two plates come together, it is known as a convergent boundary.

- The impact of the two colliding plates buckles the edge of one or both plates up into a rugged mountain range, and sometimes bends the other down into a deep seafloor trench.
- A chain of volcanoes often forms parallel to the boundary, to the mountain range, and to the trench.
- Powerful earthquakes shake a wide area on both sides of the boundary.
- If one of the colliding plates is topped with oceanic crust, it is forced down into the mantle where it begins to melt.
- Magma rises into and through the other plate, solidifying into new crust. Magma formed from melting plates solidifies into granite, a light colored, low-density rock that makes up the continents.

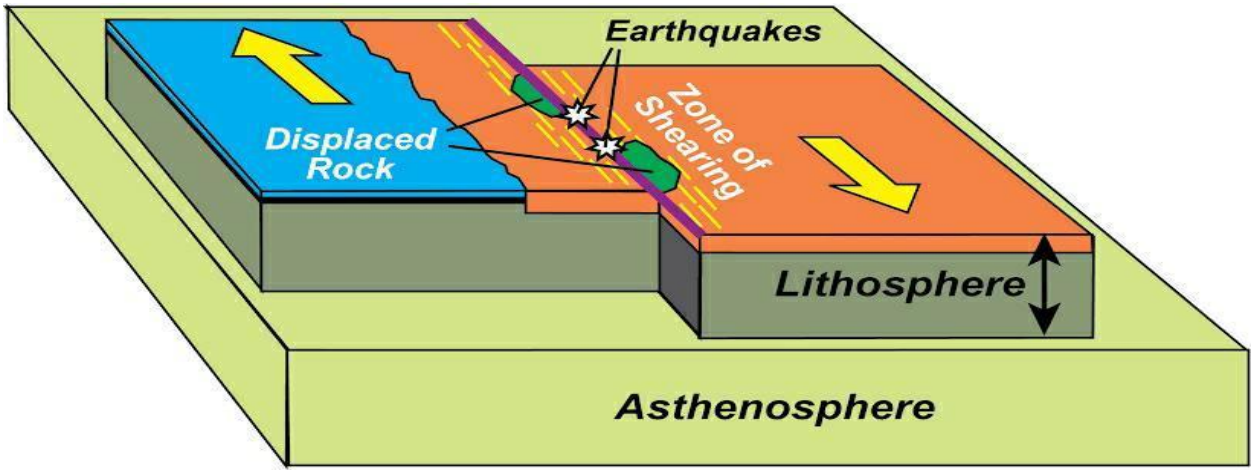


- Thus at convergent boundaries, continental crust, made of granite, is created, and the oceanic crust is destroyed.

Transform plate boundary

Two plates sliding past each other forms a transform plate boundary.

- Natural or human-made structures that cross a transform boundary are offset—split into pieces and carried in opposite directions.
- Rocks that line the boundary are pulverized as the plates grind along, creating a linear fault valley or undersea canyon.
- As the plates alternately jam and jump against each other, earthquakes rattle through a wide boundary zone.
- In contrast to convergent and divergent boundaries, no magma is formed.
- Thus, crust is cracked and broken at transform margins, but is not created or destroyed.



Latest findings made in understanding Plate Tectonics:-

- **Axial seamount** - It refers to a live recording of a volcano mountain. The volcano rising from Juan de fuca ridge demonstrates it. It supports the divergent movement.
    - After the 2012 Sumatra Indonesia earthquake in the Indian ocean, the Indo Australian plate broke into many plates. It was mainly due to the slipping of plates interpolated and hence the activation of the Barren volcano.
- **Zealandia**:-It's a new continent. It broke off from Antarctica 100 million years ago and from Australia 80 million years ago. Its formation supports movement of plates.
- Heat from the base of the mantle contributes significantly to the strength of the flow of heat in the mantle and to the resultant plate tectonics. Buoyancy is created by heat rising up from deep within the Earth's core.

How plate tectonics is an improvement over continental drift theory?

Plate tectonics explains the mechanism of the motion of the tectonic plates while continental drift theory left this question completely unanswered.

- Tectonic plates have been constantly moving over the globe throughout the history of the earth. It is not the continent that moves as believed by Wegener. Continents are part of a plate and what moves is the plate.
- Wegener had thought of all the continents to have initially existed as a supercontinent in the form of Pangaea. However, later discoveries reveal that the continental masses, resting on the plates, have been wandering all through the geological period, and Pangaea was a result of converging of different continental masses that were parts of one or the other plates.
- At the time that Wegener proposed his theory of continental drift, most scientists believed that the earth was a solid, motionless body. However, concepts of sea floor spreading and the unified theory of plate tectonics have emphasised that both the surface of the earth and the interior are not static and motionless but are dynamic.

Critical examination of plate tectonics theory:

The force of plate movements:

- As per the theory, it was assumed that the force of plate movement is convection current operation in the mantle.
- It is not clear how the convection current is operating in the mantle. As per physics law, there must be friction between the moving plates and the asthenosphere. The theory does not explain these facts and it also did not explain the balance between the plate and asthenosphere.
- As we know, the mantle has two parts i.e asthenosphere(in semi liquid form) and the lower mantle in solid form. The asthenosphere is a very thin layer about 180 km. We also know that lithospheric plate thickness varies from 15 to 200 km. The theory did not answer how the asthenosphere is balancing the lithospheric plate.

Regarding Mountain development:

In the case of folded mountains :

- As per the theory, fold mountains are originated in the convergence boundaries of the two plates; that is true. For example, the Himalayas, Andes, Rockies mountains, etc are evolved on the convergence boundary.
- The theory also helps in the understanding of the creation of blocks and volcanic mountains.
- So we can say, plate tectonics theory is able to explain the evolution of mountains correctly, but again it did not explain the things that balance the mountains.

Earthquake and seismic activities:

- Plate tectonics provide partial information about the seismic and earthquake activities. As per the theory, the epicenter of the earthquake is generally found in the boundary line of the plate; but in reality, it is uncertain to predict the epicenter of an earthquake; it can be anywhere on the earth's surface.

Regarding Volcanic eruption:

- Plate tectonic theory is correctly able to explain the volcanic activities at the mid-oceanic ridge and pacific ring of fire. But it is not able to explain the phenomenon of volcanic hotspots. For example, it is unclear the mechanism of the formation of the Deccan trap during the Indian plate movement.

Importance of the theory of Plate Tectonics

- For geologists, it is a fundamental principle for study. It is the unifying theory of geology, which further explains large-scale geological phenomena, such as earthquakes, volcanoes, and the existence of ocean basins and continents.
- Plate tectonics theory explains why there are lots of volcanoes in Iceland and Japan, but far fewer in Russia and Africa. This is because Iceland was created by a mid-oceanic ridge. Similarly, Japan is located on a fault line. The constant pressure around the fault line causes many earthquakes and volcanic eruptions.
- For geographers, the theory of Plate tectonics aids in the interpretation of landforms. It ultimately explains why and where deformation of Earth's surface occurs.
- Further, the concept of plate tectonics explains mineralogy. New minerals pour up from the core along with the magmatic ejections. The plate boundaries are the pathways through which rocks from the mantle come out as deposits on the lithosphere. These rocks are the source of many minerals. The famous Pacific Ring of fire known for its violent volcanic activity is also a ring of mineral deposits.

VOLCANOES & EARTHQUAKES

VOLCANOS

A volcano is a vent or fissure in Earth’s crust through which lava, ash, rocks, and gases erupt. An active volcano is a volcano that has erupted in the recent past.

- **Volcanism :**The process by which solid, liquid and gaseous material escape from the earth’s interior to the surface of the earth is called as Volcanism.
- The mantle contains a weaker zone known as the asthenosphere.
- Magma is the material present in the asthenosphere.
- Material that flows to or reaches the ground comprises lava flows, volcanic bombs, pyroclastic debris, dust, ash, and gases. The gases may be sulfur compounds, nitrogen compounds, and trace amounts of argon, hydrogen, and chlorine.

Lava & Magma :

- **Magma** is the molten rocks and related materials seen inside earth. A weaker zone of the mantle called the asthenosphere, usually is the source of magma.
- **Lava :** Once this magma came out to the earth surface through the vent of a volcano, it is called as the Lava. Therefore, Lava is nothing but the magma on the earth's surface.

Type of Lava :

Acidic or Andesitic or composite Lava	Basic or Shield or Basaltic Lava

• highly viscous and has a high melting point. • high percentage of silica content, low density and light colour. • flows slowly and they rarely travel far before solidification. This leads to the formation of the cone-like structure having steep sides. • Due to the rapid solidification of this acidic Lava, the openings obstruct the flow of new Lava, which results in loud **explosions and pyro clasts (volcanic bombs).**	• Highly fluid, and their temperature is about 1,000 C. • Poor in silica, but are rich in Iron and manganese. • Dark colour and high fluidity. • Due to their high fluidity, the basaltic Lava is not very **explosive, and they spread over great distances as thin sheets** of Lava. • The volcano formed by Basic Lava is gently sloping and forms a **flattened shield or dome with a wide diameter.**

Causes of Volcanism :

- **Temperature difference :**There is a huge temperature difference between the inner layers and the outer layers of the earth due to the differential amount of radioactivity.
- **Convection Currents :**This temperature difference gives rise to convection currents in the mantle.
    - The convection currents in the mantle create convergent and divergent boundaries (weak zones).
- **Divergent Plate Margins :** At the divergent boundary, molten, semi-molten and sometimes gaseous material appears on earth at the first available opportunity.
- **Fault Zones :**The earthquakes here may expose fault zones through which magma may escape (fissure type volcanoes).
- **Convergent plate Margins :**At the convergent boundary, the subduction of the denser plate creates magma at high pressure which will escape to the surface in the form of violent eruptions.

Types of Volcanoes :

Volcanoes are classified based on the nature of eruption and the form developed at the surface.

Shield Volcanoes	Composite Volcanoes	Caldera
The Shield volcanoes are the largest of all the volcanoes on the earth, which are not steep. • These volcanoes are mostly made up of basalt. • They become explosive if in some way water gets into the vent, otherwise, they are	Composite Volcanoes are characterized by outbreaks of cooler and more viscous lavas than basalt. • They are constructed from numerous explosive eruptions. • Large quantities of pyroclastic material and	Calderas are known as the most explosive volcanoes on Earth. They are generally explosive. • When they erupt, they tend to collapse on themselves rather than constructing any structure.

characterized by low-explosivity. ● The lava that is moving upwards does so in a fountain-form and emanates from the cone at the vent's top and then develops into a cinder cone. ● Eg: Hawaiian shield volcanoes **Mid-Ocean Ridge Volcanoes** There exists a system of mid-ocean ridges stretching for over 70000 km all through the ocean basins. ● The central region of this ridge gets frequent eruptions	ashes find their way to the ground along with lava. ● This material gathers near the vent openings resulting in the creation of layers. ● Examples : Mayon Volcano in the Philippines, Mount Fuji in Japan, and Mount Rainier in Washington are the major composite volcanoes in the world. ● The major **composite volcano** chains are the Pacific **Rim** which is known as the **"Rim of Fire"**.	● The collapsed depressions are known as calderas. **Flood Basalt Provinces** Flood Basalt Province volcanoes discharge highly fluid lava that flows for long distances. ● Many parts of the world are covered by thick basalt lava flows.

Volcanic Landforms :

Depending on the location of the cooling of lava, igneous rocks are classified as:

- **Extrusive igneous rocks :** Cooling of the rock occurs at the surface of the earth. E.g. Basalt, Andesite etc.
- **Intrusive igneous rocks :** Cooling takes place in the crust and not over the surface. E.g. Granite, Gabbro, Diorite etc. Intrusive igneous rocks are classed into the following types according to their forms.

Batholiths:	**Laccoliths**:	**Sheets/ sills:**
● A large body of magmatic material that cools in the deeper depth in the form of a large dome. These are granitic bodies. They sometimes appear on the earth's surface when the denudation processes remove	● Large dome shaped intrusive bodies with a level base and pipe-like conduit from below. Resembles a composite volcano structure, but beneath the earth. (Eg: Karnataka Plateau)	● They are the near horizontal bodies of intrusive igneous rocks. Thinner ones are called sheets and thick horizontal deposits are called sills.

the overlying materials.		
Lapoliths: • They are saucer shaped, concave to the sky.	**Phacoliths**: • Wavy materials which have a definite conduit to source beneath.	**Dykes**: • When the lava comes out through cracks and fissures, they solidify almost perpendicular to the ground to form wall like structures called dykes. (Eg: Deccan traps in Maharashtra region).

Distribution of Volcanoes :

Volcanism at Convergent Margins :

It is said that nearly 70 percent of earthquakes occur in the Circum-Pacific belt.

- Another 20 percent of earthquakes take place in the Mediterranean-Himalayan belt including Asia Minor, the Himalayas and parts of north-west China.
- The belts of highest concentration are the Aleutian-Kuril islands arc, Melanesia and New Zealand-Tonga belt.
- Only 10 per cent to 20 per cent of all volcanic activity is above the sea, and terrestrial volcanic mountains are small when compared to their submarine counterparts.

Circum pacific Ring of Fire :

Circum-Pacific region popularly termed the 'Pacific Ring of Fire', has the greatest concentration of active volcanoes. Volcanic belt and the earthquake belt closely overlap along the Pacific Ring of Fire'.

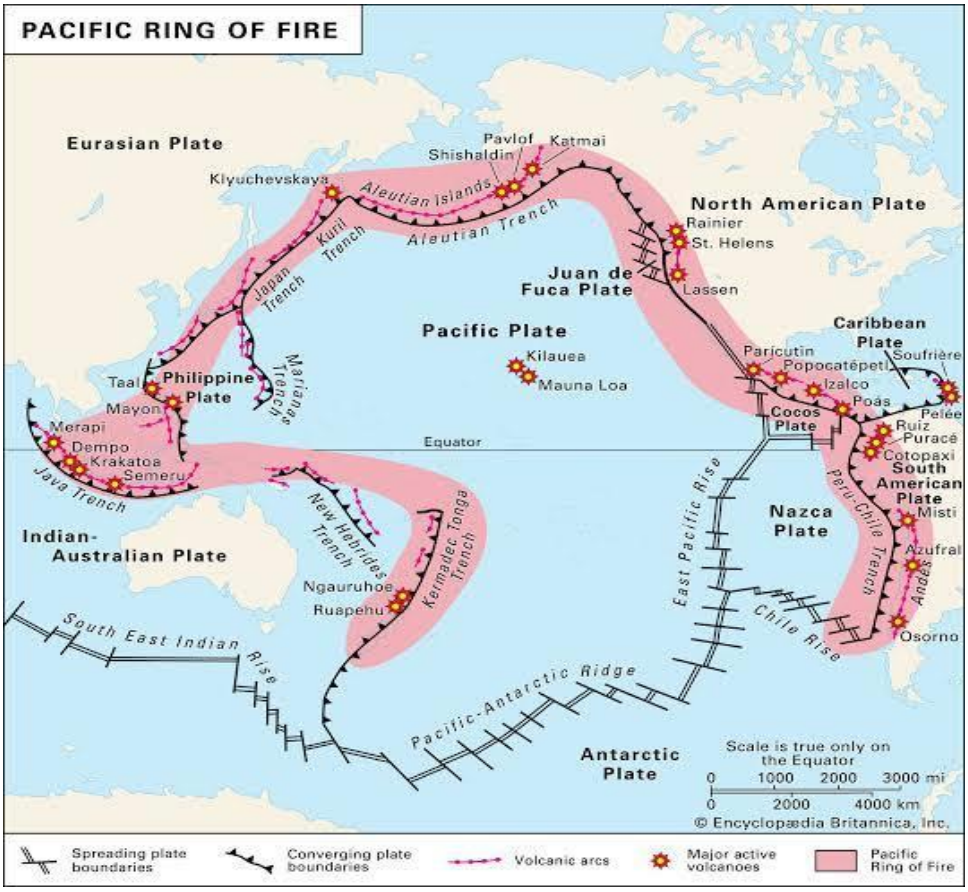
- The Aleutian Islands into Kamchatka, Japan, the Philippines, and Indonesia (Java and Sumatra in particular),
- Pacific islands of Solomon, New Hebrides, Tonga and North Island, New Zealand.
- Andes to Central America (particularly Guatemala, Costa Rica and Nicaragua), Mexico and right up to Alaska

Other Regions of Volcanism :

Along the Atlantic coast :

- In contrast, the Atlantic coasts have comparatively few active volcanoes but many dormant or extinct volcanoes, e.g. St. Helena, Cape Verde Islands and the Canary Islands etc.
- But the volcanoes of Iceland and the Azores are active.

The West Indian islands

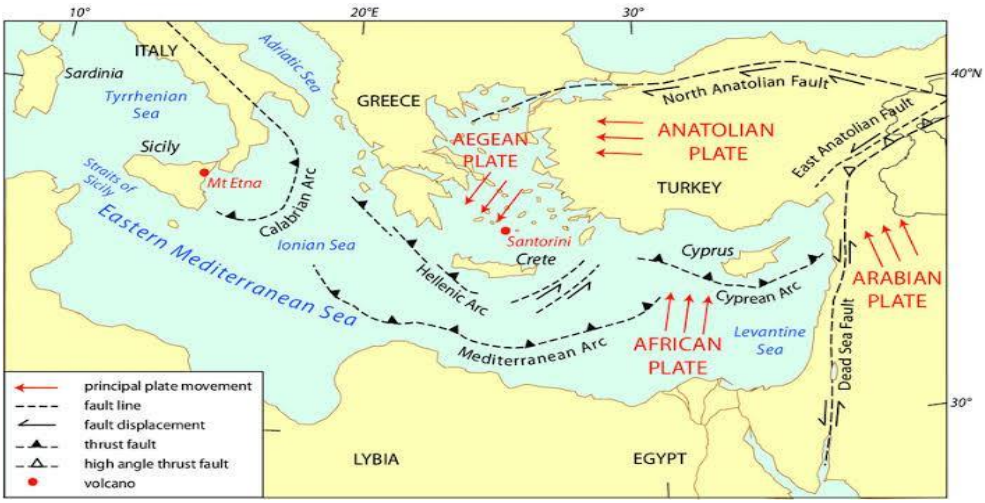


- The Lesser Antilles (Part of the West Indies Islands) are made up mainly of volcanic islands, and some of them still bear signs of volcanic liveliness.

Great Rift region

- In Africa, some volcanoes are found along the East African Rift Valley, e.g. Mt. Kilimanjaro and Mt. Kenya.

Volcanoes in Mediterranean Region :

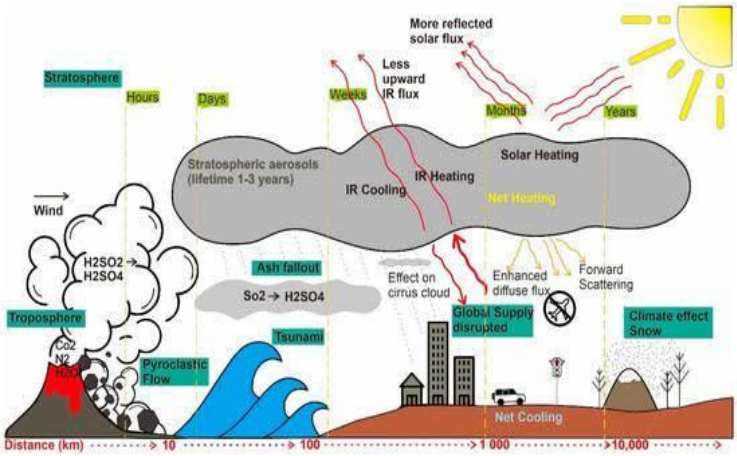


Volcanoes of the Mediterranean region are mainly associated with the Alpine folds,
e.g. Vesuvius, Stromboli (Light House of the Mediterranean) and those of the Aegean islands.

- A few continue into Asia Minor (Mt. Ararat, Mt. Elbrus).
- The volcanism of this broad region is largely the **result of convergence between the Eurasian Plate and the northward-moving African Plate.**
- This type of volcanism is mainly due to breaking up of the Mediterranean plate into multiple plates due to the interaction of African and Eurasian plate.

Impact of Volcanism

- There is spatial and Temporal impact of volcanoes both in Positive and Negative ways
- This can be assessed as :



EARTHQUAKES

Earthquake is the form of energy of wave motion transmitted through the surface layer of the Lithosphere.

- It may be **due to faulting , folding, plate movement, volcanic eruptions and anthropogenic factors like dams and reservoirs.**
- Earthquakes are by far the most unpredictable and highly destructive of all the natural disasters.
- **Minor earth tremors** caused by gentle waves of vibration within the earth's crust occur every few minutes while Major earthquakes usually caused by movement along faults, can be very disastrous particularly in densely populated areas.

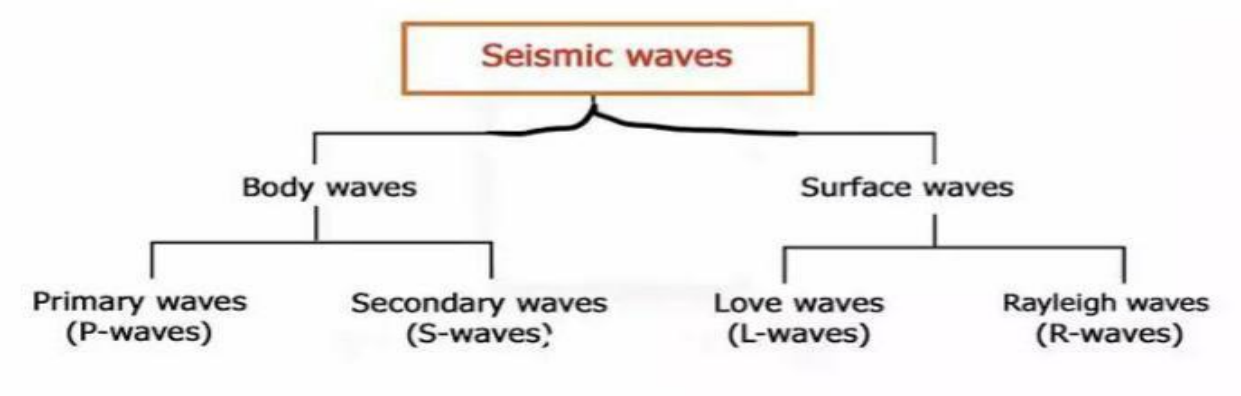
Focus and Epicentre

- **Focus :** The point within Earth where faulting begins is the **focus, or hypocentre.**
- **Epicentre :** The point directly above the focus on the surface is the epicentre. The intensity of the earthquake is highest at the epicentre and decreases with distance from the epicentre.

Seismic Waves

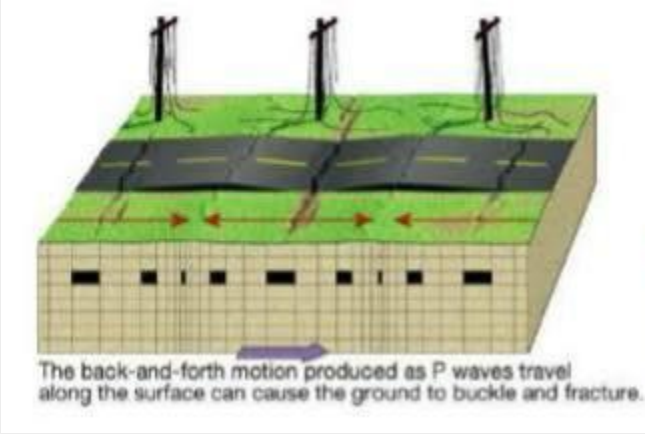
They are the energy that travels through the earth and is recorded on seismographs and caused by the sudden breaking of rock within the earth.

- The two main types of waves are body waves and surface waves.



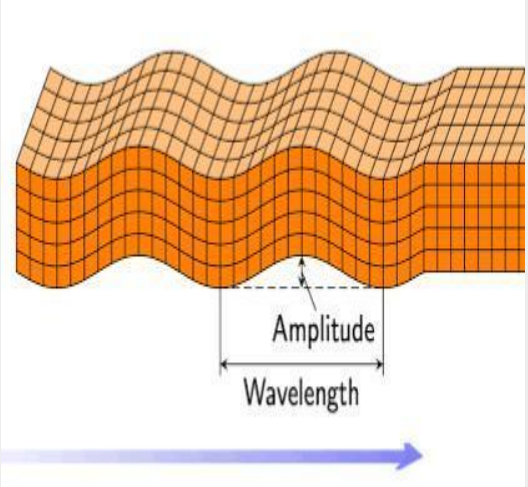
Primary waves (longitudinal wave)-

- This is the fastest kind of seismic wave.
- The P wave can move through gaseous, solid rock and fluids, like water or the liquid layers of the earth.
- It pushes and pulls the rock, it moves through just like sound waves push and pull the air.



Secondary waves (transverse wave)

- An S wave is slower than P wave and can only move through solid rock.
- This wave moves rock up and down, or side-to-side.
- S-waves arrive at the surface with some time Lag.



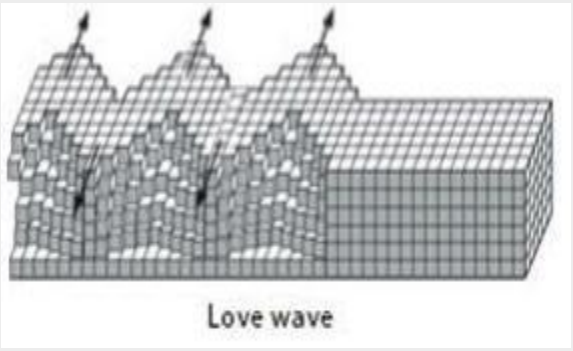
Love Waves

- The first kind of surface wave is called a Love wave, named after A.E.H. Love, a British mathematician.

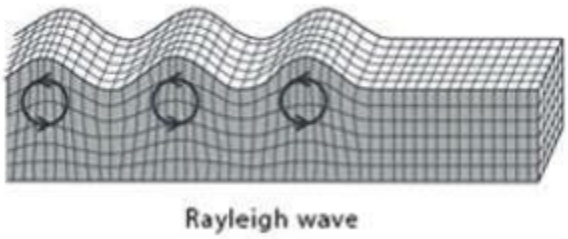
Rayleigh Waves

- A Rayleigh wave rolls along the ground just like a wave rolls across a lake or an ocean.

- It's the fastest surface wave and moves the ground from side-to-side.



- Because it rolls, it moves the ground up and down, and side-to-side in the same direction that the wave is moving.
- Most of the shaking felt from an earthquake is due to the Rayleigh wave, which can be much larger than the other waves.



World Distribution of Earthquakes

The world's distribution of earthquakes coincides very closely with that of volcanoes.

- Region of greatest seismicity are Circum-Pacific areas, with the epicenters and the most frequent occurrences along the 'Pacific Ring of Fire'.
- It is said that as many as 70% of earthquakes occur in the Circum-Pacific belt.
- Another 20% of earthquakes take place in the Mediterranean-Himalayan belt including Asia Minor, the Himalayas, and parts of north-west China.
- The remainder occur in the interiors of plates and on spreading ridge centers.

Earthquake Causes

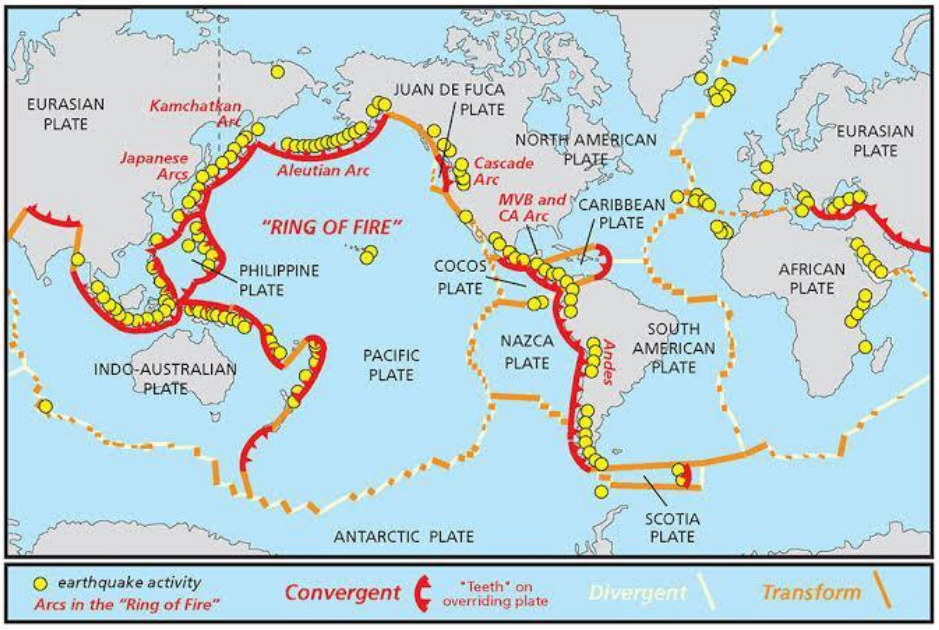
Earthquakes are caused mainly due to dis-equilibrium in any part of the crust of the earth. A number of causes have been assigned to cause dis-equilibrium or isostatic imbalance in the earth's crust.

Natural Reasons	Man-made/Anthropogenic Reasons
• Volcanic eruption • Faulting and folding • Up warping and down warping • Gaseous expansion and contraction inside the earth. • Plate Movement • Landslides	• Deep underground mining • Blasting of rock by dynamite for construction purposes. • Deep underground tunnel • Nuclear explosion • Reservoir Induced Seismicity (RIS) (E.g. Koyna Reservoir witnessed Earthquake in 1967 due to RIS) • Hydrostatic pressure of man-made water bodies like reservoirs and lakes.

	• Plate tectonics provides the most logical explanation of volcanoes and earthquakes.

There are 3 types of plate boundaries along which earthquake occurs

- **Convergent** – Like Eurasian plate & Pacific plate
- **Divergent –** Like Mid Atlantic Ridge
- **Transform –** the best example is Great African Rift Valley.



Earthquake prone areas in India

Earthquakes of mild intensity take place daily. Strong tremors causing large scale destruction are, however, less frequent. Earthquakes are more frequent in the areas of plate boundaries, especially along the convergent boundaries.

- In India, **the region of convergence** of the Indian Plate and the Eurasian Plate is more vulnerable to earthquakes. E.g. the Himalayan Region.
- **The peninsular part of India** is considered to be a stable block. The Koyna earthquake of 1967 and the Latur earthquake of 1993 are examples of earthquakes in peninsular regions.
- The experts of Indian Seismology have divided India into Four seismic zones namely Zone-II, Zone-III, Zone-IV, and Zone-V.

Consequences of Earthquake

- **Damage to human life and property** – For example Urban areas of Kathmandu suffered heavy damages with a death toll of 8 thousand people and an economic loss of 10 billion USD.

- **Landslides and Avalanches** : For Example The Sikkim earthquake of 2011 caused landslides and serious damage to life and property, especially the Singik and Upper Teesta hydel projects.
- **Floods** : For example The Assam earthquake of 1950 produced a barrier in the Dihang River due to the Accumulation of huge debris causing flash floods in the upstream section.
- **Tsunami :** For Example The Tsunami of 2004 of the Indian Ocean was caused by an earthquake off coast of Sumatra. It happened because of the subduction of the Indian plate under the Burmese plate. It killed about 2.4 lakh people in the countries in and around the Indian Ocean.

Earthquake Management

Earthquake management is the organization and management of the resources and responsibilities for dealing with all humanitarian aspects of emergencies.

- The aim is to reduce the harmful effects of the hazards. Earthquake management includes steps from pre-earthquake risk reduction to post-earthquake recovery.
- **Risk Recognition** – Certain areas are more vulnerable to earthquakes than others, so risk recognition is the first step.
- **Earthquake monitoring system/Early warning system**– Making a precise forecast about the occurrence of an earthquake in a region is still a difficult proposition. Seismologists are increasingly concentrating on the aspect of earthquake forecasting.
- It will help in reducing the impact of upcoming disasters.
- **Structural Solution–** Past earthquakes show that over 95% of the lives lost were due to the collapse of buildings that were not earthquake resistant. But, the construction of such quake-resistant buildings is more expensive than ordinary buildings.
- Therefore, a cost-effective solution remains a challenge for a country like India. Seismic strengthening can be done through prioritization of structures and to implement this, it is important to have an earthquake hazard map for various zones according to the vulnerability.

LANDFORMS

Erosional Landforms Due to Action of Wind

- **Pediplains**: These are the geographical structures/ landforms which have been created when the high relief structures in the desert areas have been reduced to low relief areas due to the action of wind.
- **Deflation Hollows**: Deflation refers to the removal of top layer / loose particles from the surface due to the blowing action of wind.
- When this removal results in the formation of shallow depressions on the surface due to the consistent blowing action of wind, the landform created is known as Deflation Hollows.
- **Mushroom Tables**: Mushroom tables are the ventifacts that have been given the shape of mushrooms.
- Ventifacts are referred to as the rocks that have been polished or abraded due to the wind-driven particles / loose particles of sand that hit the rocks.
- These are typically found in arid areas where there might be very little to no vegetation with strong winds.

Erosional Landforms Due to Action of Rivers

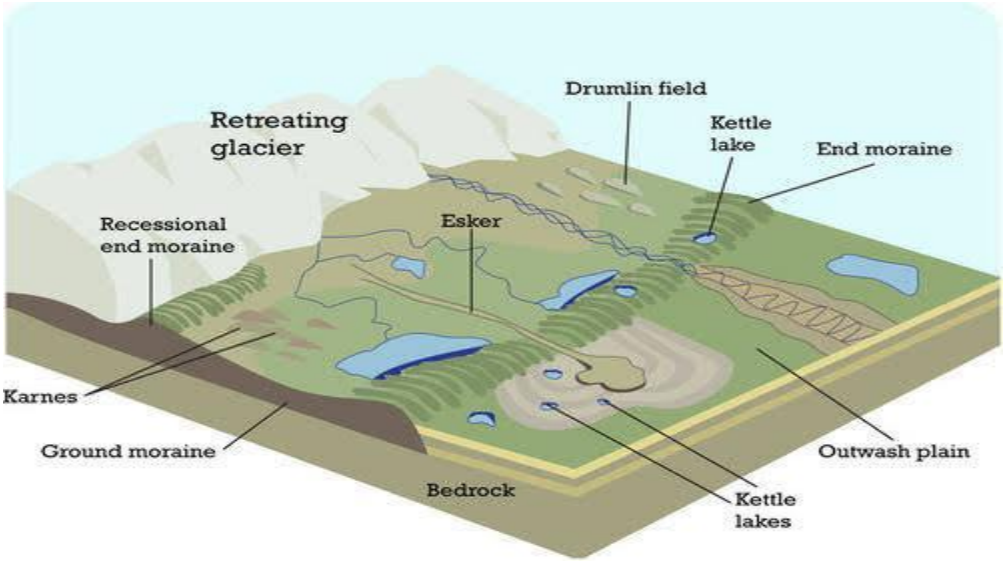
- **River valley**: The valleys are usually V-shaped that have been carved out by the flowing river and the carrying away of the sand particles from the surface, but the shape of the valley may differ from the original shape that has been carved out due to the varying speed of the flowing water at various levels.
- The two sides of the V-shaped valleys are always in touch which is caused due to the increased rate of down–cutting known as Valley – deepening / Vertical erosion. The valleys have been classified into two types:
- Gorges
- Canyon
- **Potholes:** Potholes are small depressions usually of the cylindrical shape which have been made on the bed of the river valleys. These potholes are formed generally on rocky/coarse-grained areas.
- Potholes are formed due to the potholing or the drilling mechanism of the river water.
- In such a mechanism (potholing), eddies are formed in the river water which then starts to rotate in a circular manner and drills out the materials of the surface creating potholes.
- **River Terraces**: River terraces are the narrow flat surfaces that have formed on either side of the river valleys. In some cases, the river terraces are formed in multilayers on either sides which when arranged/viewed simultaneously mountain.
- **Peneplains** : Peneplains are referred to as low relief undulating plains which have been formed due to protracted erosion.
- **Ox – Bow Lakes:** Ox – bow lakes are U – shaped lakes that have been formed due to cutting off a wide meander of a river which results in formation of free standing of a body of water. It is formed due to the eroding banks of the rivers.
- The ox – bow term can also be referred to as a U – shaped bend in a river, whether or not there are any cuts in the mainstream of rivers.

Erosional Landforms Due to Actions of Sea Waves

- **Cliffs**: Cliffs are referred to as vertical coasts raised above the seawater. The steepness of the cliffs depends on the rate of erosion caused due to the sea waves.
- The sea waves hit the lower areas of the cliffs resulting in the erosion of the lower surfaces.
- If the marine erosion of the cliff exceeds the rate of weathering of the cliff due to subaerial agents, it results in the formation of a very steep cliff.
- The beginning of the formation of the cliff is marked by the erosion of the coastal rocks by the hydraulic mechanisms or the abrasion of the lighter rocks by the high-speed waves.
- **Sea Caves**: Sea caves are created/formed along with the coastal areas of the seas due to the gradual removal of the loosely packed particles by the upstream waves.
- These are then widened into larger cavities in the areas which are again enlarged due to the gradual erosion action of the waves and forming coastal caves.
- **Sea Arches**: When a certain portion of the coast has extended to a considerable distance, the sea waves that are working from the opposite direction resulting in the cutting of a passage through the soft rocks.
- The beginning of the sea arches is marked by narrow small holes in the soft rocks which are then enlarged into bigger holes called Sea Arches.
- **Sea Stacks**: Sea stacks are formed when the roof of the sea arches collapses either due to eroding action by any of the agents / due to its own weight.
- When the roof collapses, the solitary mass of rocks that joins the arch standing in the river is known as Sea Stacks. Small stacks that stand underwater are termed STUMPS.

Erosional Landforms Due to Actions of Ice/ Glaciers

- **Cirque**: When the snow is collected at the upper end in the shape of a bowl, it is known as a cirque.



- **Eskers**: These are the ridges that have been formed due to the deposition of the sand/ gravels due to the melting ice which flows through the tunnels and even under the glaciers.

- **Drumlins**: Drumlins are termed as the elongated, teardrop shaped hills of rocks, and sand which has been formed under the moving ice of glaciers. These can be long enough upto 1.2 miles (~ 2 kilometres).

WEATHERING

Weathering is the process of breaking down or dissolving rocks and minerals on the surface of the Earth.

- Water, ice, acids, salts, plants, animals, and changes in the temperature of the environment are all the agents of weathering.
- Weathering and erosion constantly change the rocky features of Earth.

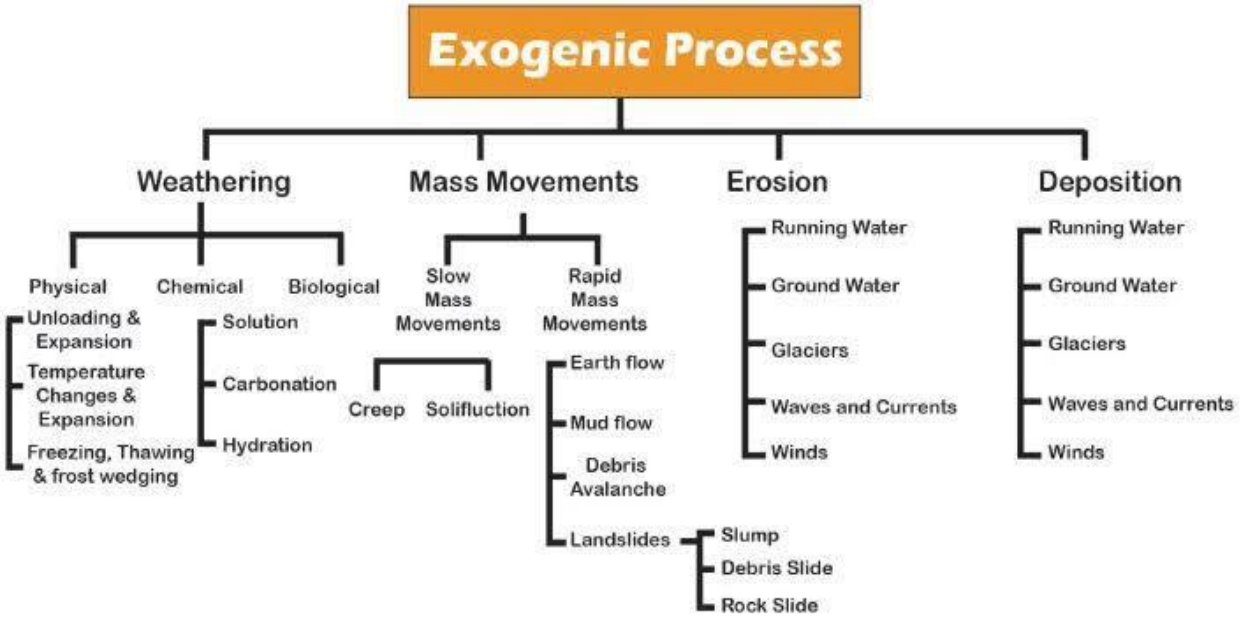


Figure 4.1 Exogenic processes

Mechanical Weathering	Chemical Weathering	Biological Weathering
It is also called physical weathering. It causes rocks to crumble. ● The change in temperature can also contribute to the mechanical weathering in a process called thermal stress. ● Change in temperature causes the rock to expand with heat and contract with cold. ● As this happens, again and again, the structure of the	Chemical Weathering changes the molecular structure of rocks and soil. It involves multiple modes like Solution, Carbonation, Oxidation and Reduction, etc. ● Sometimes, It dissolves large portions of limestone or other rock on the surface of the Earth to form a landscape called karst. ● One of the world's best examples of karst is the Stone Forest, near Kunming, China.	It is the subsequent fragmentation of rocks by animals, plants, and natural habitats. ● It is a process that plays a part in both Physical and Chemical Weathering.

rock weakens and after some time, it breaks.		

Major Causes of Weathering and Erosion

Weathering and erosion are two different, but related processes. Weathering is the breakdown of materials through physical or chemical actions.

- Erosion occurs when the weathered materials such as soil and rock fragments are carried by wind, water or ice.
- Many forces are commonly involved in both weathering and erosion, including both natural and man-made causes.

Physical

- It is caused by **atmospheric changes** such as heat or cool temperatures.
- Plants also cause **weathering with the roots growing** under the rocks by breaking the rock apart.
- Insects such as **earthworms often disrupt** and break the rock apart by burrowing and digging.

Chemical

- It is caused by the **chemical alteration of the minerals.**
- It can also occur when iron in **rock rusts.**
- Some types of **lichens and fungi growing** on the rock surfaces secrete acids that affect stone surfaces.

Water Erosion

- **Heavy rainfall** can wash the soil, rock and sediment into rivers and streams.
- Water erosion restructures the shorelines and deposits the soil in new locations.
- Materials can be swept away by dissolving in the water and washed away.
- In addition, when organic material, that helps to retain soil structure, is washed away from topsoil, the soil becomes more prone to erosion.

Wind Erosion

- Wind is a powerful erosive force, especially when soil is dry.
- Sand and soil are raised up and carried away in the form of dust.

Gravity

- Gravity is another force that leads to erosion, especially when it gets combined with slope.
- Gravity pulls rocks and snow down from mountains and glaciers.

Significance of Weathering to Human Life

Soil Formation : Weathering is the first stage of formation of soil.

- This process is responsible for the fragmentation of the rocks into smaller fragments and making the way for the creation of not only soils but also mass movements and erosion of soil.
- Weathering helps in the formation of Sedimentary Soil.

Natural Resources : It produces many other natural resources, for example, clay which is used for making bricks.

Mining : Another significance of weathering is it weakens the rocks, making them easier for people to exploit and break, for example, by mining and quarrying.

Promotes Biodiversity : Biodiversity, and Biomes are the result of vegetation, and forests rely upon the depth of weathering wraps.

- Root penetration cannot happen if the rocks are not weathered.

Relief Formation : It aids erosion, mass wasting, reduction of relief, and modifications in landforms.

Minerals Augmentation : Weathering of rocks helps in the augmentation and concentrations of some ores of manganese, aluminium, iron, and copper, etc. which have a great demand in the economy of the country.

CLIMATOLOGY

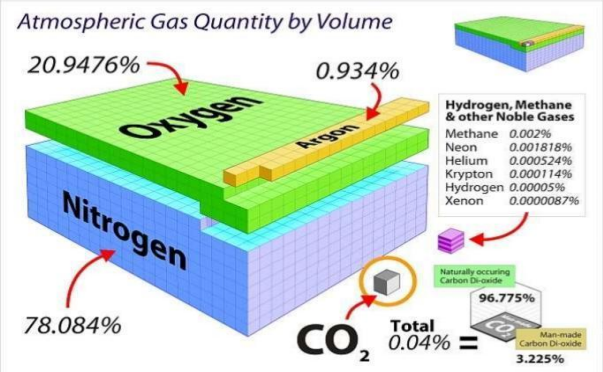
ATMOSPHERE & ITS STRUCTURE

The atmosphere is a significant component of the biospheric ecosystem because life on the earth's surface is because of this atmosphere otherwise the earth would have become barren like the moon.

- It protects the **earth from the harmful radiatio**n from the sun. It acts as a greenhouse by allowing short-wave radiation (from the Sun) and trapping long-wave terrestrial radiation (from Earth's surface).
- The atmosphere also **takes care of extra-terrestrial objects like meteors t**hat get burnt up while passing through the atmosphere (mesosphere to be precise) due to friction.
- The gases of the present atmosphere are **not the direct residue of the early stage of earth's formation.** They are a product of **progress through volcanic eruptions, hot springs, chemical breakdowns of solid matter and redistribution** from the biosphere

Composition of the atmosphere

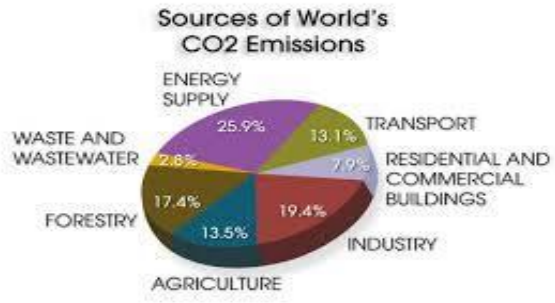
- The atmosphere is a mixture of many gases. In addition, it contains huge numbers of solid and liquid particles, collectively called aerosols.



Gases

Nitrogen and oxygen make up nearly 99% of the clean, dry air. The remaining gases are mostly inert and constitute about 1% of the atmosphere.

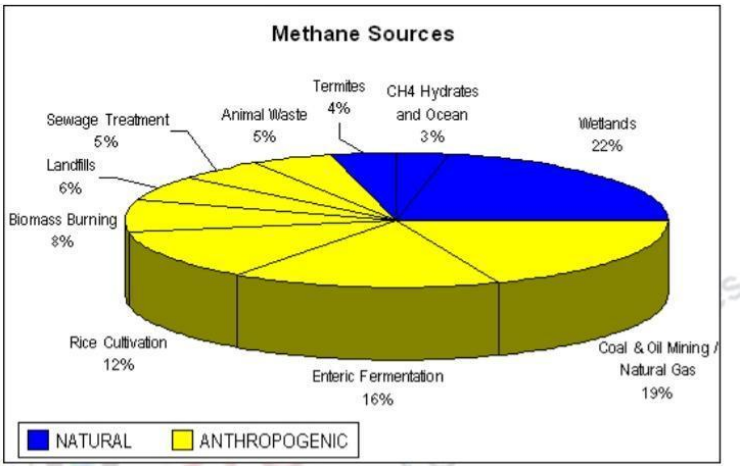
- **Oxygen**, although constituting only 21% of the total volume of the atmosphere, is the most important component among gases. All living organisms inhale oxygen. Besides, oxygen can combine with other elements to form important compounds, such as oxides. Also, combustion is not possible without oxygen.
- **Nitrogen** accounts **for 78% of total atmospheric volume**. It is a relatively **inert gas** and is an important constituent of all organic compounds.
    - The main function of nitrogen is to **control combustion by diluting oxygen**. It also **indirectly helps in the oxidation** of different kinds.
- **Carbon Dioxide** which constitutes **only about 0.038%** of the dry air and is a product of combustion. Green plants, through photosynthesis, absorb carbon dioxide from the atmosphere and use it to manufacture food and keep other biophysical processes going.
    - Being an **efficient absorber of heat, carbon dioxide is considered to be of great climatic significance.** Carbon dioxide is considered to be a very important factor in the heat energy budget.
    - **Carbon dioxide and water vapour** are found only up to **90 km from the surface** of the earth.



- **Argon** The third important gas is Argon which constitutes only about 0.93%.
- **Ozone (O3)** is another important gas in the atmosphere, which is actually a type of oxygen molecule consisting of three, instead of two, atoms.
    - It is between 20 km and 25 km altitude that the greatest concentrations of ozone are found. It is **formed at higher altitudes and transported downwards.**
    - Ozone plays a crucial role in blocking the harmful ultraviolet radiation from the sun.
- **Other gases** found in almost negligible quantities in the atmosphere are neon, helium, hydrogen, xenon, krypton, methane
- **Vapour -** content in the atmosphere ranges from 0 to 5 % by volume.
    - Vapour depends on temperature and therefore it decreases from the equator poleward in response to decreasing temperature towards the poles.
    - More than 90% of the total atmospheric vapour is found up to the height of 5 km.
    - The moisture content in the atmosphere creates several forms of condensation and precipitation e.g. clouds, fogs, dew, rainfall, frost, hailstorm, ice, snowfall, etc.

- Vapour is almost transparent for incoming shortwave **solar radiation so that the electromagnetic radiation** waves reach the earth's surface without many obstacles but **vapour is less transparent for outgoing longwave terrestrial radiation** and therefore it helps in **heating the earth's surface and lower portion of the atmosphere** because it absorbs terrestrial radiation.

- **Particulate Matter :**The Solid Particles present in the atmosphere consist of sand particles (from weathered rocks and also derived from volcanic ash), pollen grains, small organisms, soot, ocean salts; the upper layers of the atmosphere may even have fragments of meteors which got burnt up in the atmosphere.
  - These particulates help in the **absorbing, reflecting, and scattering of the solar radiation** which adds the varied **charming colour of red and orange at sunrise and sunset.**
  - The sky **appears blue in colour due to the selective scattering of solar radiation** by dust particles.
  - **Salt particles become hygroscopic nuclei** and thus help in the **formation of water drops, clouds, and various forms of condensation and precipitation.**
  - **Hygroscopic nucleus –** a microscopic particle (e.g. of sulphur dioxide, salt, dust, or smoke) in the free air, on to which water vapor may condense to form droplets.
- **Methane** : Methane is also a greenhouse gas which absorbs the radiation and causes more temperature of the air. Paddy cultivation also generates methane in the air. It is also produced . Its amount in the atmosphere is variable.

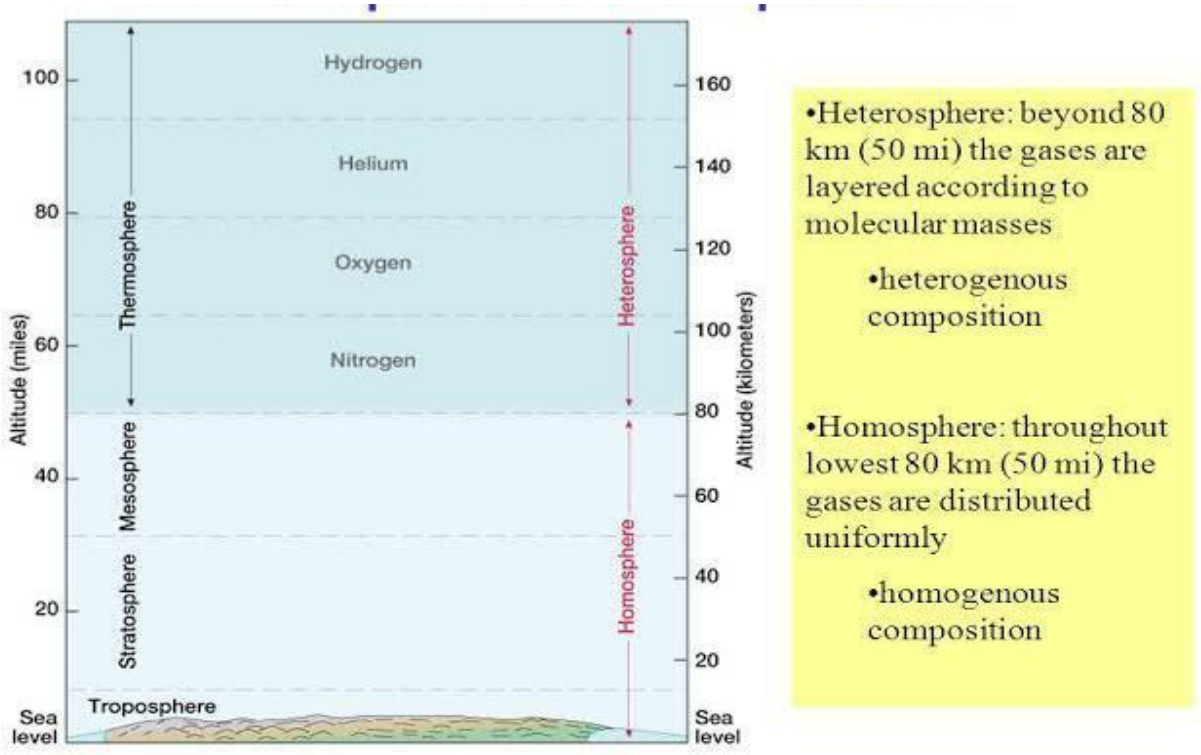


Structure of the Atmosphere

The atmosphere can be divided into different layers according to composition, density, pressure, and temperature variations.

Based on Composition:

According to its composition, broadly it is divided into two layers as shown in figure :



Based on Change in temperature

The atmosphere can be divided into five layers according to the diversity of temperature and density. They are:

Troposphere:

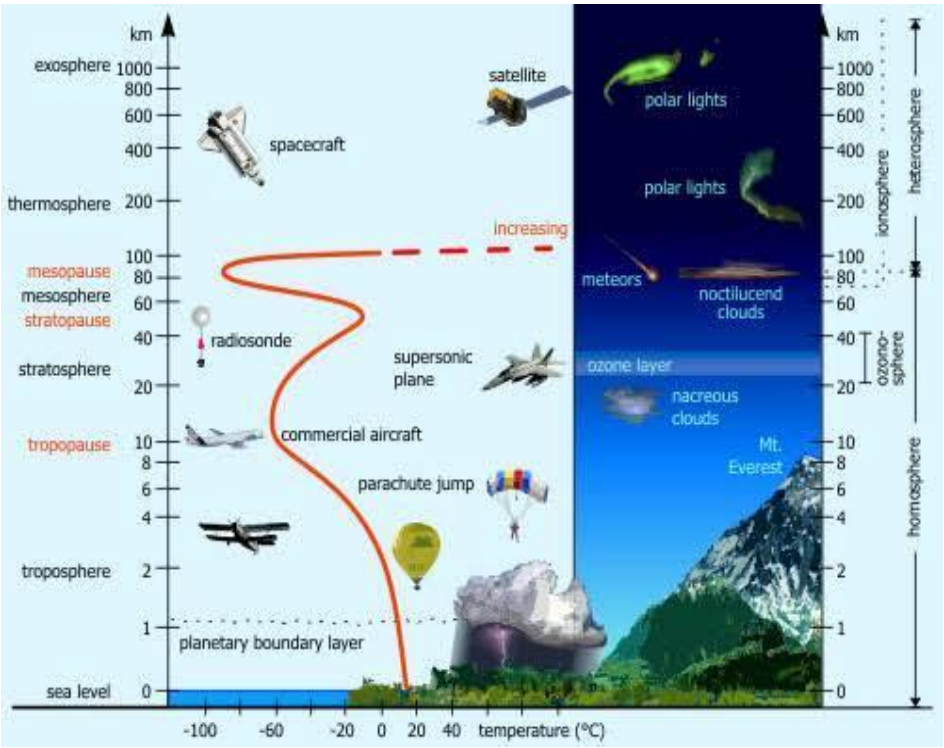
It is the lowermost layer of the atmosphere. It extends up to 18km at the equator, 13 km at mid-latitude and about 8km at poles.

- It contains **approximately 90% of the total mass** of the atmosphere.
- The entire **weather phenomenon takes place in this layer**. It contains all the water vapour, dust particles, clouds, etc.
- In this, the temperature decreases with an increase in height.
    - The **average rate of decrease of temperature** with height is called a **normal lapse rate** and it is equal to 6.4 degrees C/km. The rate of decrease of temperature is not constant everywhere.
    - The local rate of decrease is called the local lapse rate. The minimum temperature attained in this layer is -57 degree C.

Tropopause: It is the topmost layer of the troposphere. It acts as a boundary between the troposphere and stratosphere. This layer is marked by constant temperatures.

Stratosphere:

- It lies above the troposphere and extends uniformly across the globe up to 50km.



- In this layer, the **temperature increases with an increase** in **height**. The **temperature varies from -57 to 0 degree C.**
- This layer is characterized by the presence of the Ozonosphere. **Ozone is a highly reactive oxygen** molecule made up of three atoms.
- **Ozone** absorbs the high-frequency ultraviolet radiation. Because of this absorption the temperature of the layer increases.
- The energy absorbed is used in chemical reactions causing the formation of ozone gas.
- Ultraviolet rays are highly harmful to living organisms including plants, animals as well as humans. Absorbing these radiation ozone layers makes a protective layer around us.

Mesosphere:

The mesosphere extends from 50 – 80 km.

- The **temperature again decreases** in this layer and reaches its **minimum mark averaging -90**℃. Although this temperature can vary.
- The **homogenous layer extends up to the mesosphere**. At the upper boundary of the mesosphere, there exists a layer of ions extending in the other layer. This layer of ions or charged particles is helpful in reflecting the radio waves and helps in telecommunication.

Thermosphere:

This is a region extending from 80km to 480km.

- It contains a **functional ionosphere**. The temperature rises very sharply in this layer as the gas molecules absorb the short wave radiation coming from the sun.
- The temperature can reach as high as 1200o C, but despite such high temperatures, the thermosphere is not as ‘hot’ as we expect it to be.

- As the density of air is so low in this layer, the energy is not easily transferred; hence the hotness is not felt.

Ionosphere:

This is the zone containing charged particles called ions. It lies from the upper mesosphere to the thermosphere.

- The charged particles are ionized by absorption of cosmic rays, gamma rays, X-rays and shorter wavelengths of ultraviolet rays.
- It is in this layer that **incoming space vehicles and meteorites begin to heat due to friction.**
- Above this layer i.e. above 480km, **atomic oxygen is prevalent and beyond that first helium is more common** and then hydrogen atoms predominate.
- The ionosphere is a deep layer of **electrically charged molecules and atoms** (which are called ions) in the middle and upper mesosphere and the lower thermosphere, between about 60 and 400 kilometers (40 and 250 miles). The ionosphere is significant because it aids long-distance communication by reflecting radio waves back to Earth.
- It is also known for its **auroral displays,** such as the "northern lights" that develop when charged atomic particles from the Sun are trapped by the magnetic field of Earth near the poles. In the ionosphere, these particles "excite" the nitrogen molecules and oxygen atoms, causing them to emit light, not unlike a neon light bulb.

Exosphere

- The exosphere is the uppermost layer of the atmosphere.
- Gases are very sparse in this sphere due to the lack of gravitational force. Therefore, the density of air is very less here.

HEAT & TEMPERATURE (UPSC PRE 2021,2020,2013)

The interaction of insolation with the atmosphere and the earth's surface creates heat, which is measured in terms of temperature.

- While heat represents the molecular movement of particles comprising a substance, temperature is the measurement in degrees of how hot (or cold) a thing (or a place) is. The distribution of temperature varies both horizontally and vertically.
- Temperature indicates the relative degree of heat of a substance.

Factors Affecting the Temperature Distribution

The temperature of the air at any place is influenced by the following factors:

- The latitude of the place
- The altitude of the place
- Distance from the sea, the air-mass circulation
- The presence of warm and cold ocean currents
- Local aspects
- Vegetation Cover

Global Temperature Distribution

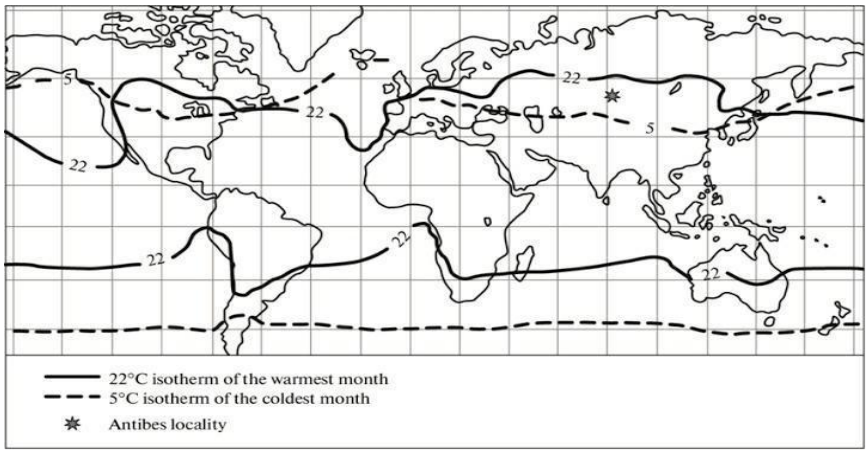
The temperature distribution globally can be explained in two ways:

- Horizontal Temperature Distribution
- Vertical Temperature Distribution

Horizontal Temperature Distribution

The distribution of temperature across the latitudes over the surface of the earth is called its horizontal distribution.

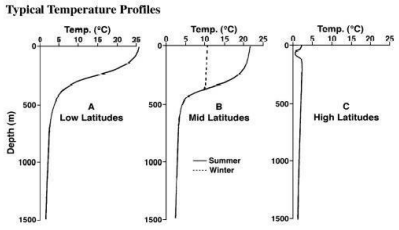
- On maps, the horizontal distribution of temperature is commonly shown by “Isotherms”, lines connecting points that have equal temperatures.
- In general, the equatorial region is hot, and its temperature is high throughout the year.
- Generally, from the equator to poleward, the temperature keeps on declining.
- The lowest temperature is at and near the poles.
- The horizontal distribution of temperature over the globe can be studied easily from the maps of the January and July months since the seasonal extremes of high and low temperature are most obvious in both northern and southern hemispheres during these months.



Vertical Temperature Distribution

Normally, temperature decreases with an increase in elevation. It is called the normal lapse rate.

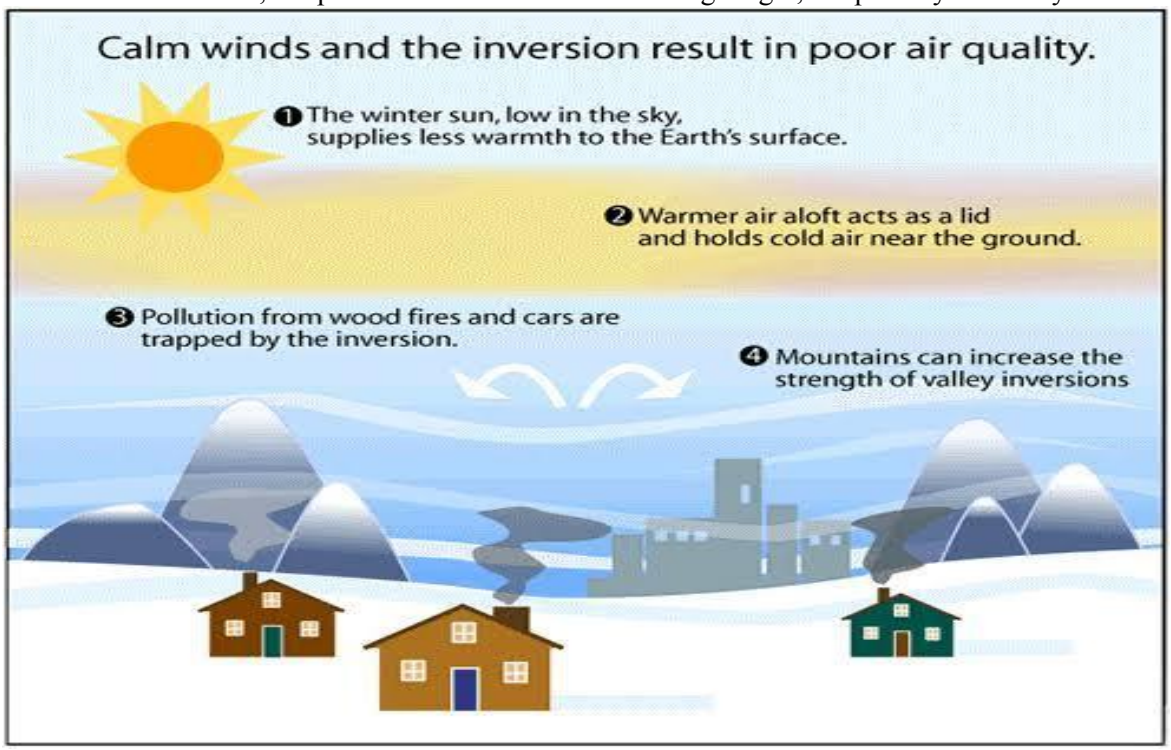
- The average rate of temperature decrease upward in the troposphere is about 6 °C per km, extending to the tropopause.
- This is also termed as vertical temperature gradient.
- The normal lapse rate is not always the same, but it differs depending upon height, season, latitude or other numerous local factors.



Inversion of Temperature

At times, the situations are reversed and the normal lapse rate is inverted. It is called Inversion of temperature.

- In other words, temperature increases with increasing height, temporarily or locally.



PRESSURE

Pressure Belts Of The Earth

A column of air exerts weight in terms of pressure on the surface of the earth.

- The weight of the column of air at a given place and time is called air pressure or atmospheric pressure.
- Atmospheric pressure is measured by an instrument called a barometer.

Factors Controlling Pressure Systems –

There are two main causes, thermal and dynamic, for the pressure differences resulting in high and low-pressure system .

Thermal Factors :

- As temp expands and, hence, its density decreases. This naturally leads to low pressure. On the contrary, cooling results in contraction. This increases the density and thus leads to high pressure.
- Formation of equatorial low and polar highs are examples of thermal lows and thermal highs, respectively.

Dynamic Factors

- Apart from variations of temperature, the formation of pressure belts may be explained by dynamic controls arising out of **pressure gradient forces and rotation of the earth (Coriolis force).**

Vertical Distribution

The columnar distribution of atmospheric pressure is known as the vertical distribution of pressure.

- The mass of air above in the column of air compresses the air under it hence its lower layers are denser than the upper layers; As a result, the lower layers of the atmosphere have higher density, hence, exert more pressure.
- Conversely, the higher layers are less compressed and, hence, they have low density and low pressure.
- The temperature of the air, the amount of water vapor present in the air, and the gravitational pull of the earth determine the air pressure of a given place and at a given time.
- Since these factors are variable with a change in height, there is a variation in the rate of decrease in air pressure with an increase in altitude.
- Rising pressure indicates fine, settled weather while falling pressure indicates unstable and cloudy weather.

Horizontal Distribution

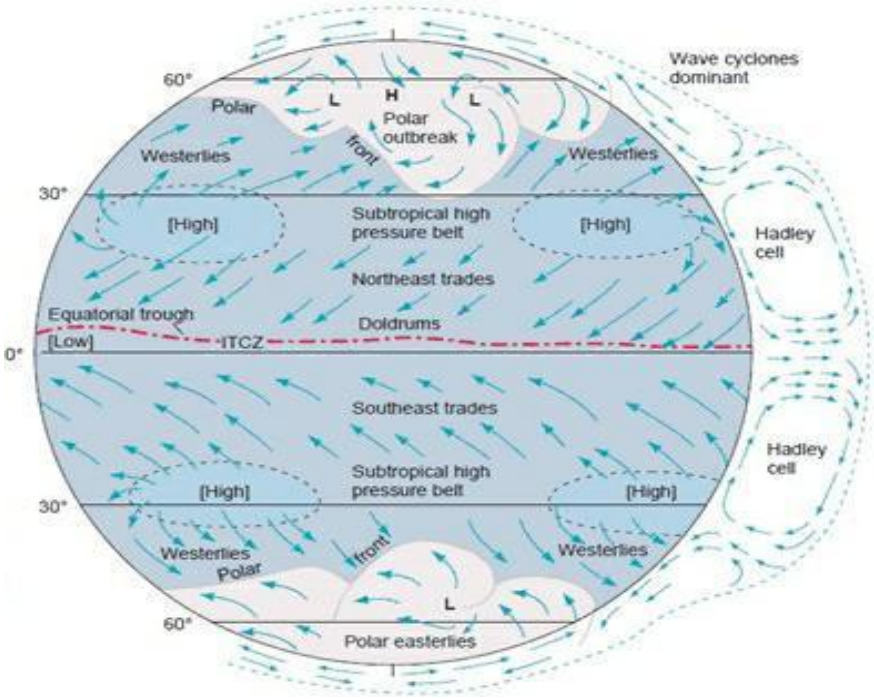
The factors responsible for variation in the horizontal distribution of pressure are as follows:

- **Air temperature – Equator Polar regions :** Earth is not heated uniformly because of unequal distribution of insolation, differential heating and cooling of land and water surfaces
- **The earth's rotation – Coriolis force:** The earth's rotation generates centrifugal force. This results in the deflection of air from its original place, causing a decrease of pressure.
- **Presence of water vapour – Inversely related to pressure**: Air with a higher quantity of water vapour has lower pressure and that with a lower quantity of water vapour has higher pressure.
- **Air Temperature :** Low air pressure in equatorial regions is due to the fact that hot air ascends there with a gradual decrease in temperature causing thinness of air on the surface.

World Pressure Belts

On the earth's surface, there are seven pressure belts. They are –

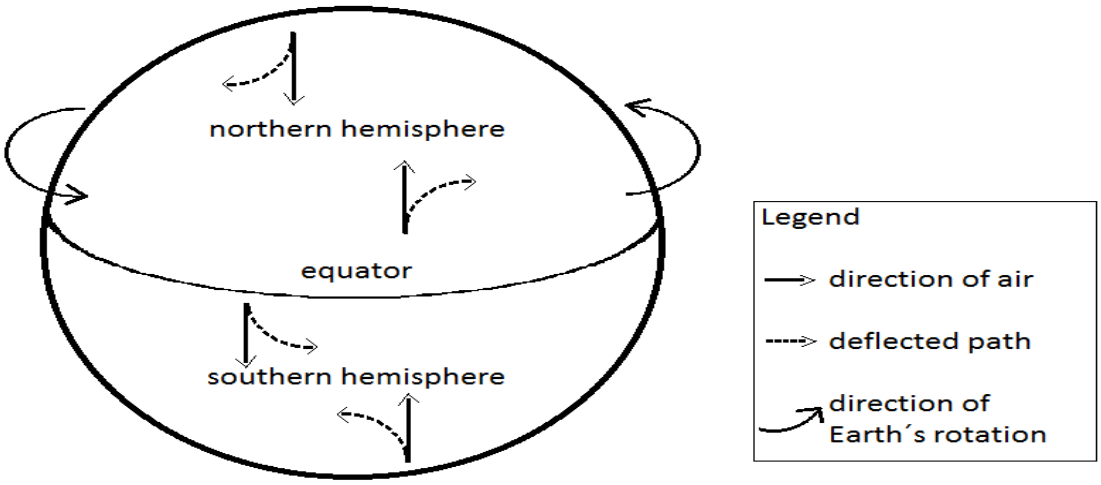
- Equatorial Low
- The two Subtropical Highs
- The two Subpolar Lows
- The two Polar Highs.



Equatorial Low Pressure Belts ● **0 to 5° North** and South of the Equator. ● Due to the vertical rays of the sun here, there is intense heating. The air, therefore, expands and rises as a convection current causing low pressure to develop here. ● This low-pressure belt is also called as **doldrums** because it is a zone of total calm without any breeze.	**Subtropical High Pressure Belts** ● At about 30°North and South of the Equator lies the area where the ascending equatorial air currents descend. This area is thus an area of high pressure. ● It is also called the **Horse latitude.** ● Winds always blow from high pressure to low pressure. So the winds from the subtropical region blow towards the Equator as Trade winds and another wind blow towards Sub-Polar Low-Pressure as Westerlies
Circum-polar Low Pressure Belts ● These belts located between 60° and 70° in each hemisphere are known as Circum-polar Low-Pressure Belts. ● In the Subtropical region, the descending air gets divided into two parts. ● One part blows towards the Equatorial Low-Pressure Belt. The other part blows towards the Circum-polar Low-Pressure Belt.	**Polar High Pressure Areas** ● At the North and South Poles, between 70° to 90° North and South, the temperatures are always extremely low. ● The cold descending air gives rise to high pressures over the Poles. ● These areas of Polar high pressure are known as the Polar Highs.

• This zone is marked by the **ascent of warm Subtropical air over cold polar air blowing from poles**. Due to earth's rotation, the winds surrounding the Polar region blow towards the Equator. • **Centrifugal forces operating** in this region create the low-pressure belt appropriately called Circum-polar Low-Pressure Belt. • This region is marked by violent storms in winter.	• These regions are characterized by permanent Icecaps.

The Coriolis Effect



- The rotation of the earth about its axis affects the direction of the wind and this force is called the Coriolis force.
- It is directly proportional to the angle of latitude.
- It deflects the wind to the left direction in the southern hemisphere and the right direction in the northern hemisphere

Atmospheric circulation

Atmospheric circulation is the large-scale movement of air and together with ocean circulation is the means by which thermal energy is redistributed on the surface of the Earth.

The Hadley Cell

Solar heating at the equator is strongest, causing rising convective air which is pushed north and south at the tropopause (troposphere/stratosphere boundary).

- At 30° latitude it has deflected enough by the Coriolis force to be moving almost due east. Here, it meets air moving down from the north (Ferrel Cell air) and both meet and descend, warming and drying
- The return of the air, now a surface wind, to the equator is called the “trade winds”.

Mid-latitudes – The Ferrell Cell

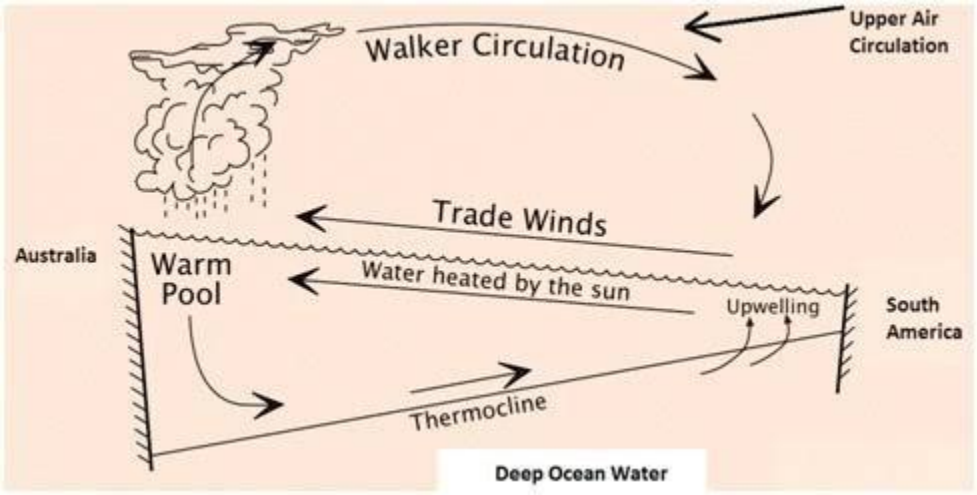
Convective rising air near 60 deg latitude arrives at the tropopause, moves (in part) to the south, deflection by Coriolis to the west, till it meets the northerly moving air from the tropical Hadley cell, forcing both to descend

- These are the “Horse Latitudes' ' at 30°North & south latitude. Descending air dries. Desserts here (e.g. Sahara, Mojave/Sonora)
- Northerly moving surface winds deflected east – “the Westerlies” – carrying heat from the lower latitudes to higher mid-latitudes
- The primary circulation on Earth is driven by the **equatorially** heated **Hadley Cell and the polar cooled Polar Cell**.
- The Ferrel cell is a weaker intermediate zone, in which weather systems move through, driven by the polar jet stream and the tropical jet stream (the boundary between Ferrell and Hadley cells, at the tropopause).
- The jet streams have irregular paths as the convective instabilities migrate, and these drive the many cold and warm fronts which move through the Ferrel Cell.

Walker circulation

The Southern Hemisphere has a horizontal air circulation cell called as Walker Cell responsible for upwelling along the South American Coast and bringing rains in Australia.

- The Walker circulation is the result of a difference in surface pressure and temperature over the western and eastern tropical Pacific Ocean.
- A pressure gradient from east to the west creates an air circulation from the Eastern pacific (i.e. along the coast of Peru-Chile) to the western Pacific (Australia-New Guinea). This air circulation displaces surface water towards the western pacific causing cold water from beneath the ocean to move upward.
- Surface waters of the ocean are warm and the water under oceanic beds is cold and contains various types of nutrients that are helpful for aquatic life.
- Sea birds along the coast of South America (eastern pacific) get plenty of Phytoplankton and produce Guano which again is helpful for Aquatic life. So, fishing is a thriving occupation along the eastern coast of South America.
- the western Pacific and Australia receive precipitation due to Walker circulation.
- On the other hand, When the Trade Winds are weak, The warm water of the central Pacific Ocean slowly drifts towards the South American coast and replaces the cool Peruvian current. Such an appearance of warm water off the coast of Peru is known as El Nino.



The Polar Cell

Easiest of the cells to understand – rising air from the 60-degree latitude area in part moves north to the pole, where it's cold enough to densify, converge with other northerly winds from all longitudes, and descend.

- This makes a "desert" at the north and south poles.

WIND (UPSC PRE 2015,2018)

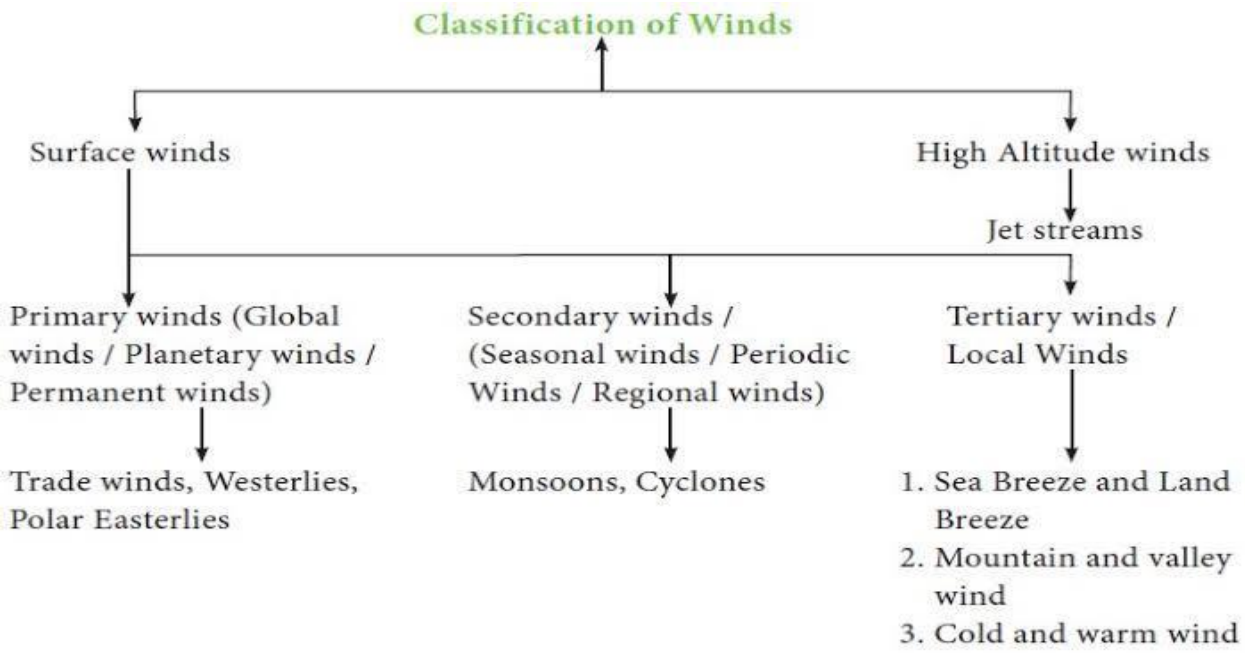
It is an air movement having both direction and speed. It is made up of gusts and eddies that can only be felt and not seen, unlike rain and snow.

- Wind makes the leaves fall, sand move, trees wave, hair fly, etc. Since it cannot be seen, a conventional instrument is used to measure wind direction called **weathercock or weather vane.**

Primary Winds or Prevailing Winds or Permanent Winds or Planetary Winds :

These winds blow extensively over continents and oceans.

- **Trade Winds:** Winds which are blowing from the subtropical high pressure areas towards the equatorial low pressure belt are called trade winds. Such winds are confined within a region of 30°N and 30°S throughout the earth's surface.
- **Westerlies**: Winds blowing from the subtropical high pressure belts towards the sub polar low pressure belts are called westerlies. These winds are best developed between 40° and 65°S latitudes.
- **Polar easterlies**: Winds which are dry, cold prevailing winds blowing from north-east to south-west direction in the Northern Hemisphere and south-east to north-west in the Southern Hemisphere are called polar easterlies.



Secondary / Seasonal Winds

Winds which can change their direction with change in season are called secondary winds. Best example of such wind is monsoons as they show large-scale modification of the planetary wind system.

- **Monsoons**: Winds which are traditionally explained as land and sea breezes on a large scale are called monsoons. Because of this monsoons are considered as a conventional circulation on a giant scale. Monsoons can also be categorised by seasonal reversal of wind direction.
- **Land Breeze and Sea Breeze**: Different amounts of heat are transferred and absorbed by land and sea. As during day time the heating capacity of land is faster and becomes warmer than the sea.
    - Because of this the air rises giving rise to a low pressure area, whereas the sea is relatively cool and the pressure over sea is relatively high.
    - This built-up pressure gradient from sea to land is created and the wind blows from the sea to the land as the sea breeze.
    - In the night, the condition is totally reversed. During night land loses heat faster and is cooler than the sea and resulting pressure gradient is from the land to the sea and hence land breeze results.

Tertiary Winds or Local Winds

Wind which is produced by local differences in temperature and pressure is called tertiary wind or local winds.

- Such winds are present in the lowest level of the troposphere.

MONSOON (UPSC PRE 2014, 2015,2017)

The climate of India is 'tropical monsoon' type. The term 'monsoon' has been derived from the Arabic word 'mausim' or the Malayan word 'monsin' which means season.

- It is characterized by a **seasonal reversal in the direction of wind.**
- They flow from sea to land during the summer and from land to sea during the winter due to differences in temperature and pressure.
- Monsoons are especially **prominent within the tropics** on the eastern sides of the great landmass, but in Asia, it occurs also outside the tropics in China, Korea and Japan.

Inter Tropical Convergence Zone

The Inter Tropical Convergence Zone (ITCZ,) is a broad trough of low pressure in equatorial latitudes.

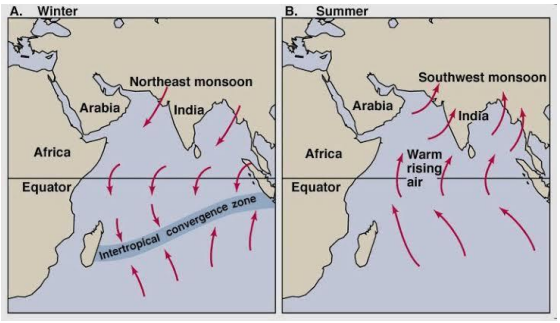
- This is where the northeast and the southeast trade winds converge. This convergence zone lies more or less parallel to the equator but moves north or south with the apparent movement of the sun.
- .

Factors Influencing South-West Monsoon Formation

- **The differential Cooling & Heating of Landmasses** : The **differential heating and cooling of land** and water creates a low pressure on the landmass of India while the seas around experience comparatively high pressure.
- **Position of ITCZ :**The shift of the position of Inter Tropical Convergence Zone (ITCZ) in summer, over the Ganga plain (this is the equatorial trough normally positioned about 5°N of the equator. It is also known as the monsoon-trough during the monsoon season).
- **Tropical Easterly Jet (African Easterly Jet).**
- **Madagascar High :** The presence of the high-pressure area, east of Madagascar, approximately at 20°S over the Indian Ocean. The intensity and position of this high-pressure area affect the Indian Monsoon.
- **Heating of Tibetan Plateau :** The Tibetan plateau gets intensely heated during summer, which results in strong vertical air currents and the formation of low pressure over the plateau at about 9 km above sea level.
- **Westerly Jet stream :** The movement of the westerly jet stream to the north of the Himalayas and the presence of the tropical easterly jet stream over the Indian peninsula during summer
- **Southern Oscillation (SO):** Normally when the tropical eastern south Pacific Ocean experiences high pressure, the tropical eastern Indian Ocean experiences low pressure. But in certain years, there is a reversal in the pressure conditions and the eastern Pacific has lower pressure in comparison to the eastern Indian Ocean. This periodic change in pressure conditions is known as SO

Mechanism Of Monsoon :

Onset of the South-West Monsoon



- The location of ITCZ shifts north and south of the equator with the apparent movement of the Sun.
- During the month of June, the sun shines vertically over the Tropic of Cancer and the ITCZ shifts northwards.
- The southeast trade winds of the southern hemisphere cross the equator and start blowing in southwest to northeast direction under the influence of Coriolis force.
- These winds collect moisture as they travel over the warm Indian Ocean.
- In the month of July, the ITCZ shifts to 20°-25° N latitude and is located in the Indo-Gangetic Plain and the south-west monsoons blow from the Arabian Sea and the Bay of Bengal. The ITCZ in this position is often called the Monsoon Trough.
- The shift in the position of the ITCZ is also related to the phenomenon of the withdrawal of the westerly jet stream from its position over the north Indian plain, south of the Himalayas.
- The easterly Jet Stream (Somali Jet) sets in at 15°N latitude only after the western jet stream has withdrawn itself from the region. This easterly jet stream is held responsible for the burst of the monsoon in India.
- As these winds approach the land, their south-westerly direction is modified by the relief and thermal low pressure over northwest India. The monsoon approaches the Indian landmass in two branches:

The Arabian Sea branch - The monsoon winds originating over the Arabian Sea.

The Bay of Bengal branch - The Arakan Hills along the coast of Myanmar deflect a big portion of this branch towards the Indian subcontinent. The monsoon, therefore, enters West Bengal and Bangladesh from south and southeast instead of from the south-westerly direction.

- Another phenomenon associated with the monsoon is its tendency to have ‘breaks’ in rainfall. The monsoon rains take place only for a few days at a time. They are interspersed with rainless intervals. These breaks in monsoon are related to the movement of the monsoon trough.
- Despite an overall unity in the general pattern, there are perceptible regional variations in climatic conditions within the country.

Retreating Monsoon Season

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, the mercury begins to fall rapidly, particularly in northern India.
- The weather in the retreating monsoon is dry in north India but it is associated with rain in the eastern part of the Peninsula. Here, October and November are the rainiest months of the year.
- The widespread rain in this season is associated with the passage of cyclonic depressions which originate over the Andaman Sea and manage to cross the eastern coast of the southern Peninsula. These tropical cyclones are very destructive.
- A bulk of the rainfall of the Coromandel Coast is derived from these depressions and cyclones.
- Unlike the rest of the country, which receives rain in the southwest monsoon season between June and September, the northeast monsoon is crucial for farming and water security in the south.

Impact of Monsoons on Life in India

POSITIVE	NEGATIVE
• About 64% of people in India depend on agriculture for their **livelihood** and **agriculture** itself is based on monsoon. • **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. • Regional variations in monsoon climate help in growing **various types of crops**. • Regional monsoon variation in India is reflected in the vast **variety of food, clothes and house types.** • Monsoon rain helps **recharge dams and reservoirs,** which is further used for the generation of hydro-electric power. • Winter rainfall by temperate cyclones in north India is highly **beneficial for Rabi crops.**	• **Variability of rainfall** brings **droughts** or **floods** every year in some parts of the country. • Sudden **monsoon burst creates a problem of soil erosion** over large areas in India. • In hilly areas **sudden rainfall brings landslide** which damages natural and physical infrastructure subsequently disrupting human life economically as well as socially.

Global Warming and Monsoon

A drastic change in the monsoon rainfall intensity, duration, frequency and spatial distribution can be attributed to climate change. However, it is too soon to arrive at a conclusion.

- If all this is in response to global warming then it can be permanent and might accelerate. If not then the monsoon system will revert to a more normal state.
- More data and reanalysis is needed to get a clear picture on the complete separation of the global warming impact from natural climate variability (such as El Niño).

EL NINO & LA NINA

EL NINO EVENT

This is related to the reversal of the Walker cell**.** This reversal occurs because in the normal condition there is a descending limb of year over Peru, Chile creating high pressure. Therefore wind blows from the East coast of the Pacific to the West Pacific , driving away the warm surface water.

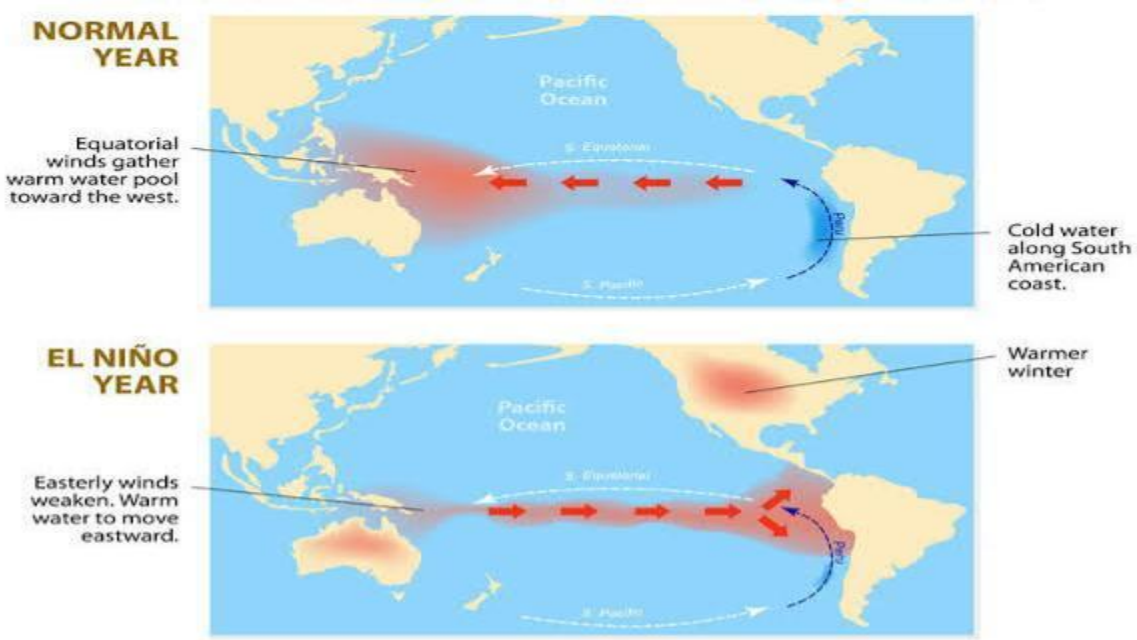
- This causes Upwelling cold **Peruvian current.**

El Nino conditions.

- The trade winds in the southern Pacific become weak therefore the removal of surface water from the Peru Chile coast stops or is reduced.
- As this happens, the upwelling of the cold Humboldt current stops.
- Hence the warm counter Equatorial current flows along the Peru, Chile coast during the southern summer.
- This will be called El Nino.

Impact of El Nino.

Impact on southern America.



- The pressure conditions were reversed and subsequent low pressure caused heavy rainfall near Peru, Chile coast.
- This rainfall will cause soil erosion landslide and flash floods
- It also destroys the fishing and fertiliser industry based economy of the Area.

Impact on Australia and Indonesia.

- The droughts are caused due to the settling down of air mass in Australia and Indonesia. Region causes forest fires.
- Large scale Coral bleaching occurs

Impact on Northern America

- Winters are warmer than normal. This reduces cyclone conditions.

India and Monsoon region of Asia.

- In India and the ASEAN region of monsoon, there are high chances of drought.
- It also affects agriculture productivity and results in higher Food inflation.
- The agricultural subsidy and banking credit supply is mainly determined by the variation in the monsoon

Impacts on global Ecology.

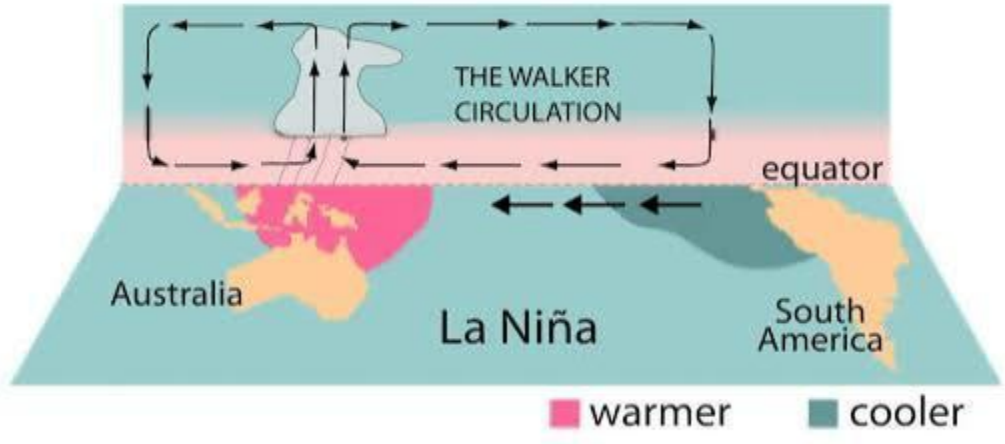
- The warming and subsequent rise in the sea level will happen.
- This will reduce marine productivity.
- The warm phase will cause the melting of ice sheets.
- There are more cyclones in the Western Pacific and Indian Ocean region.
- This will also cause the forest fire

LA NINA

It is also known as cold ENSO phase. This will cause more than normal cooling on the eastern central southern Pacific

Conditions.

- The trade winds blow with a higher intensity or stronger than the normal. Due to this, there is greater removal of warm surface water along Peru, Chile coast.
- As huge volume of water is removed from the surface, the cold dense water in large amount upwells from the bottom.
- This more than normal ocean current is known as La Nina.



Impact.

- The worker cell is intensified, therefore huge volume of air descends over the Peru Chile, increasing the aridity.
- This helps in the fishing and fertilizer industry.

- The greater volume of water moves from east to West in the Pacific.
- Heavy rainfall over Australia and Indonesia.
- The monsoon in India is also more than normal.

CLOUDS & PRECIPITATION (UPSC PRE 2013)

CLOUDS

An accumulation or grouping of small droplets of water and ice crystals suspended in the atmosphere of the earth is called clouds.

- They are noticeable by naked eye as they are masses of enormous density and quantity.
- Clouds play various essential roles like change in the climate system, such as being the bright objects in the visible portion of the solar spectrum, reflecting light to space effectively and thus helping the planet to cool down.

Formation of Clouds :

When the air gets saturated and filled with water vapour then they lead to the formation of Clouds.

- As there is more water vapour in the warm air than cold air. Because they are formed from humid air they are cloudy in nature.
- When the moist air gets colder, the water vapour and ice crystals of these clouds become larger and fall on the earth surface by precipitation process in the form of rainfall, snowfall, hail, sleet, etc.

Types of Clouds:

Classification of Clouds is mainly based on two factors: their shape and their altitude.

Classification of Clouds Based on Their Shape:

- Based on the shape, clouds are classified into three types: **cirrus, cumulus, stratus**.
    - **Cirrus**: these types of clouds are thin and often wispy. They are mainly found at the height of more than 20,000 feet and are composed of ice crystals which originate from the freezing of supercooled water droplets.
    - **Cirrostratus**: touch clouds are very thin and made up of uniform layers. Along with that they are composed of ice crystals and because of this it is difficult to detect them. Search clouds are capable of forming halos when the cloud takes the form of thin cirrostratus nebulosus.
    - **Cirrocumulus**: search clouds are small rounded puffs like shapes. They appear in the form of long rows of fire in the sky and mainly they are of white colour but sometimes they also appear in grey..

Types of Cloud Based on Altitude or Height:

On the basis of altitude or height clouds are classified into three types they are high clouds, middle clouds and low clouds.

- **High clouds:** The clouds with a height above 6020 thousand feet are called high clouds. They are also known as cirrus clouds and they are usually thick and made up of ice. Touch clouds often indicate fair weather and they do not produce rain.
- **Middle clouds:** cloud switches are formed between the height of 65 feets and from 2000 to 6000 metres are called middle clouds. They are also named as Alto clouds. They mainly signify an approaching Storm and sometimes also produce virga i.e. a minor rain or snow that does not reach the ground surface of the earth.
- Middle clouds are further classified into two types:
    - **Altostratus**: The clouds which are formed from continuous sheets and are grey or blue grey in colour are called altostratus clouds. They are mainly made up of ice crystals and water droplets. In the area of such clouds the sun is visible in the form of a round dim disk. Such clouds are ahead of storms with continuous rainfall or snowfall.
    - **Altocumuls**: Such clouds are grey sheets and are characterized by global masses or rolls in layers . These clouds are smaller than stratocumulus clouds.
- **Low clouds**: Clouds which lie below the height of 6500 feet i.e. from the surface to 2,000 metres are called low clouds. They are also known as stratus clouds. Set appearance is dense, dark and rainy and can also be Courtney white bumps which spread themselves with blue sky.
- Further low clouds are also categorised into three types, they are:
    - **Strato cumuls**: Such clouds are large dark rounded and usually in the form of groups, lines or waves.
    - **Stratus**: Such clouds look like a huge grey blanket that hangs low in the sky that resembles fog. They are made up of uniform layers and appear dull. In case these clouds are warm it shows rain and if they are cold it shows snowfall.
    - **Nimbostratus**: Such clouds are dark thick along with that they are also accompanied by light to moderately calling precipitation i.e. rainfall or snowfall. They are also known as rain clouds.

Clouds Appear to Be White in Colour

As the common colour of the cloud is white because its small droplet of water and ice crystals inside them are closely packed and because of this most of the sunlight falling on these masses are getting reflected back.

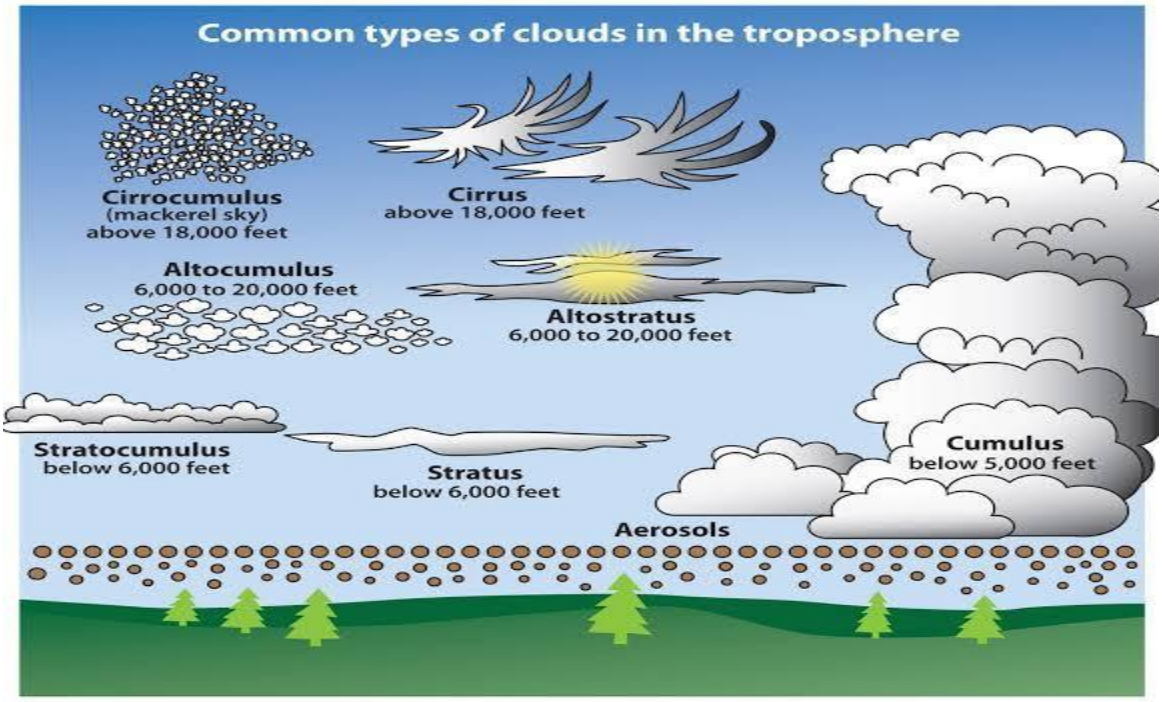
- As cloud particles show Dispersion of all light colours equally which make the viewer perceive all sunlight is white colour. But, at the time of rainfall, clouds are dark in colour because of their particular density.
- This happens as raindrops are joined together by water vapour which leaves a larger space between the drops of water.
- Because of this the reflection of light is very less which emits a darker appearance of the rain clouds.

Cloud Seeding

An artificial way to induce moisture in the cloud for rain is called cloud seeding.

- In this process **silver iodide or dry ice** is spreaded over the clouds.

- In this spreading process, artificially guns or aircraft are being used.
- Once these molecules reach the clouds there they act as a condensation nucleus and result in rainfall or snowfall.



International Cloud Atlas

The International Cloud Atlas provides the system for classifying clouds and meteorological phenomena.

- This classification procedure is used by all World Meteorological Organization Members.
- The features they include for classifying clouds are manual standards and photographs of clouds and weather phenomenon.
- The new version of International cloud atlas was published in 2017 which has many additions.

RAINFALL

Precipitation is the process where the local air becomes saturated with vapor and it starts to pour as it no longer can hold the moisture.

- **Rainfall** can be defined as precipitation in the liquid form. There are various types of rainfall based on the origin which are discussed in the article below.

Types of Rainfall

Rainfall has been classified into three main types based on the origin –

COVENTIONAL RAINFALL	OROGRAPHIC RAINFALL	CYCLONIC RAINFALL
The air on getting heated becomes light and rises in convection currents.	When the saturated air mass comes across a mountain, it is forced to rise.	Cyclonic activity causes cyclonic rain and it occurs along the fronts of the cyclone.

• As the air rises, it expands and drops the temperature and subsequently, condensation takes place and cumulus clouds are formed. • Heavy rainfall with lightning and thunder takes place which does not last long. • Such rain is usually in the summer or the hotter part of the day. • This type of rainfall generally takes place in the equatorial regions and internal parts of the continents, predominantly in the northern hemisphere. • This rainfall is usually associated with hail and graupel.	• The rising air expands, eventually, the temperature falls, and the moisture gets condensed. • The principal characteristic of this type of rain is that the windward slopes get more rainfall. • After giving rain on the windward side, when these winds reach the other slope, they drop away, and their temperature increases. • Then their ability to take in moisture increases and hence, these leeward slopes remain dry and rainless. • The region situated on the leeward side is known as the rain-shadow area.	• When two masses of air of unlike density, temperature, and humidity meet then it is formed. • The layer that separates them is known as the front. • A warm front and the cold front are the two parts of the front. • At the warm front, the warm lighter wind increases slightly over the heavier cold air. • As the warm air rises, it cools, and the moisture present in it condenses to form clouds • This rain falls gradually for a few hours to a few days.

Types of Rainfall based on Intensity

The types of rainfall based on intensity can be classified as:

- **Light rain** – Rate of rain varies between 0 to 2.5 millimetres
- **Moderate rain** – Rate of rain varies between 2.6 millimetres to 7.6 millimetres
- **Heavy rain** – Rate of rain is beyond 7.6 millimetres

CYCLONES & ANTICYCLONES (UPSC PRE 2013, 2015)

CYCLONES

The word Cyclone is derived from the Greek word Cyclos meaning the coils of a snake. It was coined by **Henry Paddington** because the tropical storms

Rainfall: drop size more than 0.5 mm.

Virage: raindrops evaporate before reaching the earth.

Drizzle: light rainfall; drop size less than 0.5 mm.

Mist: evaporation occurs before reaching the ground leading to foggy weather.

Snowfall: fine flakes of snow fall when the temperature is less than 0°C

in the Bay of Bengal and the Arabian Sea appear like coiled serpents of the sea.

- Cyclones are **rapid inward air circulation** around a **low-pressure area**. The air circulates in an **anticlockwise direction** in the **Northern hemisphere** and **clockwise in the Southern hemisphere.**
- Cyclones are usually accompanied by violent storms and bad weather.

Classification of Cyclones :

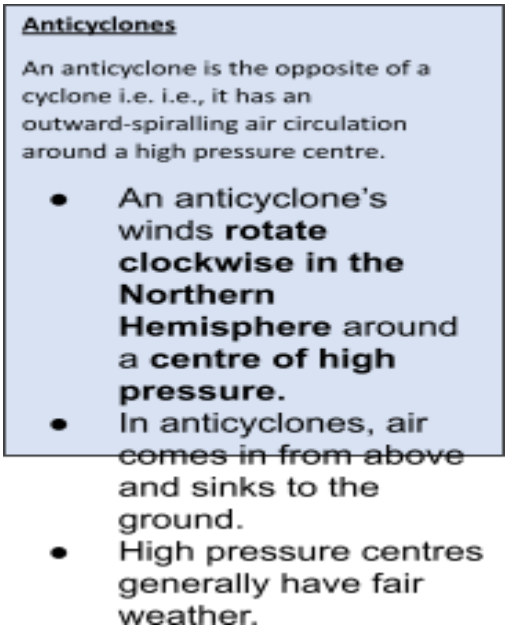
These can be classified in 2 parts as :

- **Tropical cyclones :** The World Meteorological Organisation uses the term 'Tropical Cyclone' to cover weather systems in which **winds exceed 'Gale Force'** (minimum of 63 km per hour)
    - Tropical cyclones develop in the region between the Tropics of Capricorn and Cancer.
    - They are large-scale weather systems developing over tropical or subtropical waters, where they get organized into surface wind circulation.
- **Extra Tropical cyclones** : They are also called Temperate cyclones or middle latitude cyclones or Frontal cyclones or Wave Cyclones.
    - Extra tropical cyclones occur in temperate zones and high latitude regions, though they are known to originate in the Polar Regions.

Tropical Cyclones

Tropical cyclones are violent storms that originate over oceans in tropical areas and move over to the coastal areas bringing about large scale destruction caused by violent winds, very heavy rainfall and storm surges.

- Tropical Cyclones are one of the most devastating natural calamities in the world.
- Tropical cyclones **originate and intensify over warm tropical oceans.**
- The **conditions favourable** for the formation and intensification of tropical storms are:
    - **Large sea surface** with **temperature higher** than 27° C.
    - Presence of the **Coriolis force.**
    - Small variations in the **vertical wind speed.**
    - A **pre-existing weak low- pressure area** or low-level-cyclonic circulation.
    - **Upper divergence** above the sea level system.

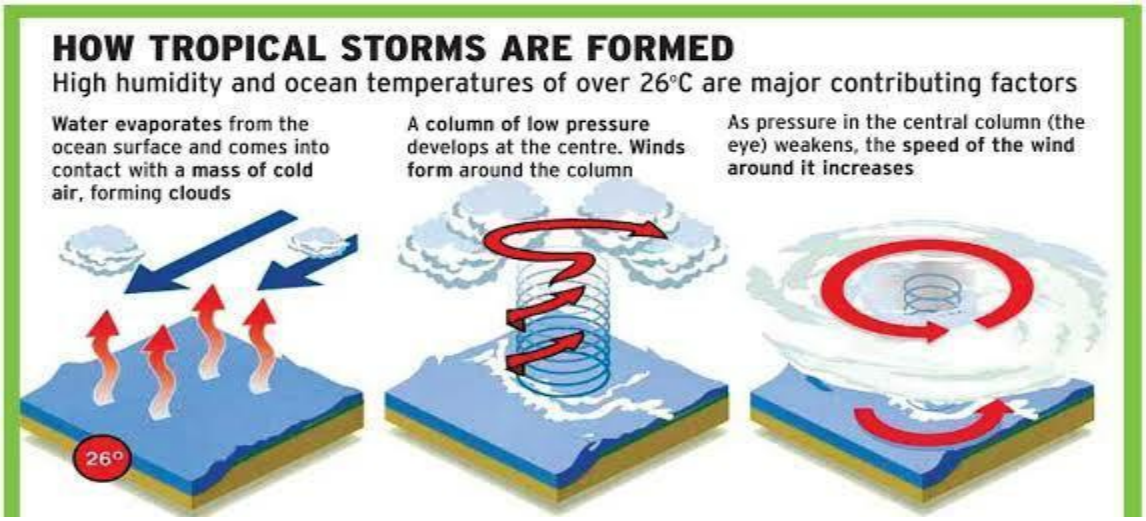


Stages of Formation of Tropical Cyclones

The development cycle of tropical cyclones may be divided into three stages:

Formation and Initial Development Stage	Mature Stage	Modification & Decay

The formation and initial development of a cyclonic storm **depends upon the transfer of water vapour** and **heat** from the warm ocean to the overlying air, primarily by evaporation from the sea surface. ● It encourages **formation of massive vertical cumulus clouds** due to **convection with condensation of rising air** above the ocean surface.	When a tropical storm intensifies, **the air rises in vigorous thunderstorms and tends to spread out horizontally at the tropopause level.** ● Once air spreads out, a **positive pressure at high levels** is produced, which accelerates the downward motion of air due to convection. ● With the **inducement of subsidence,** air warms up by compression and a **warm 'Eye' (Low pressure centre) is generated**. The main physical feature of a mature tropical cyclone in the **Indian Ocean is a concentric pattern of highly turbulent** giant cumulus thundercloud bands.	A tropical cyclone begins to weaken in terms of its central low pressure, internal warmth and extremely high speeds, as soon as its source of warm moist air begins to ebb or is abruptly cut off. ● This happens after its **landfall or when it passes over cold waters.**



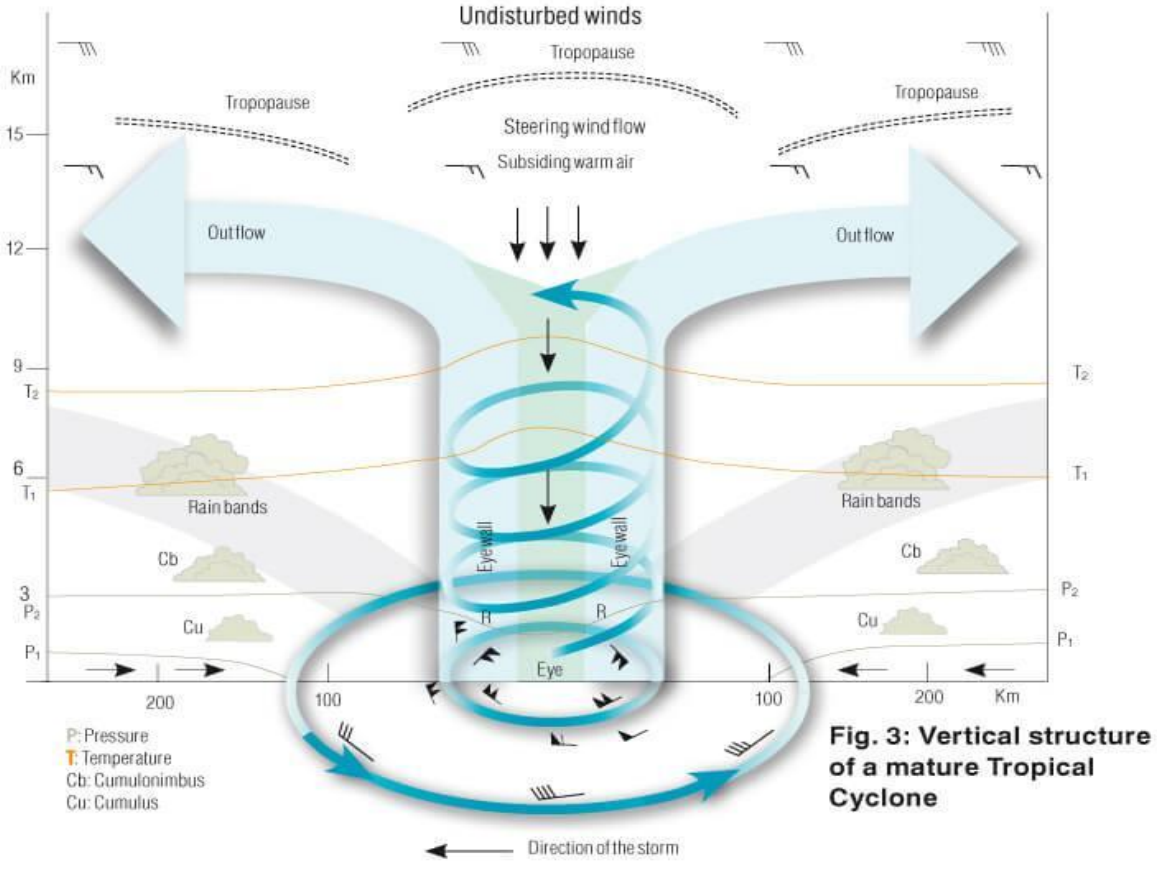


Fig. 3: Vertical structure of a mature Tropical Cyclone

Extratropical Cyclone

Extratropical cyclones are referred to as mid-latitude depressions, temperate cyclones, frontal depressions and wave cyclones.

- These are active above the **mid-latitudinal region between 35° and 65° latitude in both hemispheres**.
- The direction of movement is from west to east and more pronounced in the winter seasons.
- It is in these latitude zones the polar and tropical air masses meet and form fronts

Formation of Extratropical Cyclones

The origin and development of temperate cyclones is best explained by th**e Polar Front theory**.

- According to this theory, the **warm-humid air masses** from the **tropics meet the dry-cold air masses from the poles** and thus a polar front is formed.
- The cold air mass is denser and heavier and due to this reason, warm air mass is pushed up.
- This interaction of cold and warm air masses creates instability and a low pressure is created at the junction particularly in the centre of interactions.
- Thus, a void is created because of lessening of pressure. The surrounding air rushed in to occupy this void and coupled with the earth's rotation a cyclone formed.
- Extratropical cyclones present a contrast to the more violent cyclones or hurricanes of the tropics, which form in regions of relatively uniform temperatures.

Air Mass

Air Mass is an extremely large body of air whose properties of temperature and moisture content (humidity), at any given altitude, are fairly similar.

- It can cover hundreds of thousands of square miles of area.
- It may have only a little horizontal variation in temperature and moisture throughout the air mass.
- When an air mass remains over a homogenous area for a sufficiently longer time, it acquires the characteristics of the area. The homogenous regions can be the vast ocean surface or vast plains.

Fronts

When two different air masses (having distinctly different properties) meet, the boundary zone between them is called a front.

There are four types of fronts:

- **Stationary front**: When the front remains stationary, it is called a stationary front.
- **Cold front:** When the cold air moves towards the warm air mass, its contact zone is called the cold front,
- **Warm front**: If the warm air mass moves towards the cold air mass, the contact zone is a warm front.

Nomenclature of Tropical Cyclones

The naming of tropical cyclones is a recent phenomenon. The process of naming cyclones involves several countries in the region and is done **under the aegis of the World Meteorological Organization (WMO).**

- For the Indian Ocean region, a formula for naming cyclones was agreed **upon in 2004.**
- Eight countries in the region - Bangladesh, India, Maldives, Myanmar, Oman, Pakistan, Sri Lanka and Thailand - all contributed a set of names which are assigned sequentially whenever a cyclonic storm develops.
- Hudhud, Titli, Phethai, Fani, Vayu and Amphan are among the names of cyclones in the Indian Ocean region.

Worldwide Terminology of Tropical Cyclones

They are given many names in different regions of the world :

- **Occluded front**: If an air mass is fully lifted above the land surface, it is called the occluded front.

The fronts occur in **middle latitudes and are characterised by steep gradients in temperature and pressure.**

They bring abrupt changes in temperature and cause the air to rise to form clouds and cause precipitation.

Cyclones in India

There are mainly 2 cyclones in India as – Tropical Cyclone & Western Disturbance.

Tropical Cyclones

Tropical cyclones **originate over the Bay of Bengal, Arabian Sea** and the **Indian ocean.**

- These tropical cyclones have very high wind velocity and heavy rainfall and hit the Indian Coastal states of Tamil Nadu, Andhra Pradesh, West Bengal,Odisha and Gujarat (These five states are more vulnerable to cyclone disasters than others in India).
- Most of these cyclones are very destructive due to high wind velocity and torrential rain that accompanies it.
- There are **three elements associated** with cyclones which cause destruction during its occurrence. These are-
    - **Strong Winds/Squall:** It damages installations, dwellings, communications systems, trees etc., resulting in loss of life and property.
    - **Torrential rains and inland flooding**: Rain is a serious problem for the people who become shelter less due to the cyclone. Heavy rainfall is usually spread over a wide area and causes large-scale soil erosion and weakening of embankments.
    - **Storm Surge:** It is an abnormal rise of sea level near the coast caused by a severe tropical cyclone. Due to storm surge sea water inundates low lying areas of coastal regions drowning human beings and livestock, causes eroding beaches and embankments, destroys vegetation and leads to reduction of soil fertility.

Western Disturbance

Western Disturbance is a common weather phenomena in India. A western disturbance is an **extratropical cyclone** originating in the **Mediterranean region** that brings **sudden winter rain to the north-western parts** of the Indian subcontinent.

- They are the cause of the most winter and pre-monsoon season rainfall across North-West India (such as Punjab, Haryana, Delhi and western Uttar Pradesh).
- This phenomenon is **usually associated with cloudy sky, higher night temperatures and unusual rain.**
- This precipitation during the winter season has **great importance in agriculture particularly for Rabi crops i**ncluding wheat.
- It is estimated that India gets close to 5-10% of its total annual rainfall from western disturbances.

Distribution of Cyclone :

Why are cyclones more common on Eastern Coast of India ?

This community is shaped because of the following features :

- **Shape of Land :** On the eastern coast, the shape of the land around the Bay of Bengal ensures that the winds are slower and weaker over the ocean.
- **Mixing of Water :** This part of the Indian Ocean is also fed by a constant source of freshwater from giant rivers such as the Ganga and the Brahmaputra.
    - This water that empties into the Bay of Bengal takes up the space of the evaporated top layers, warming up at the surface and rising up as moisture.

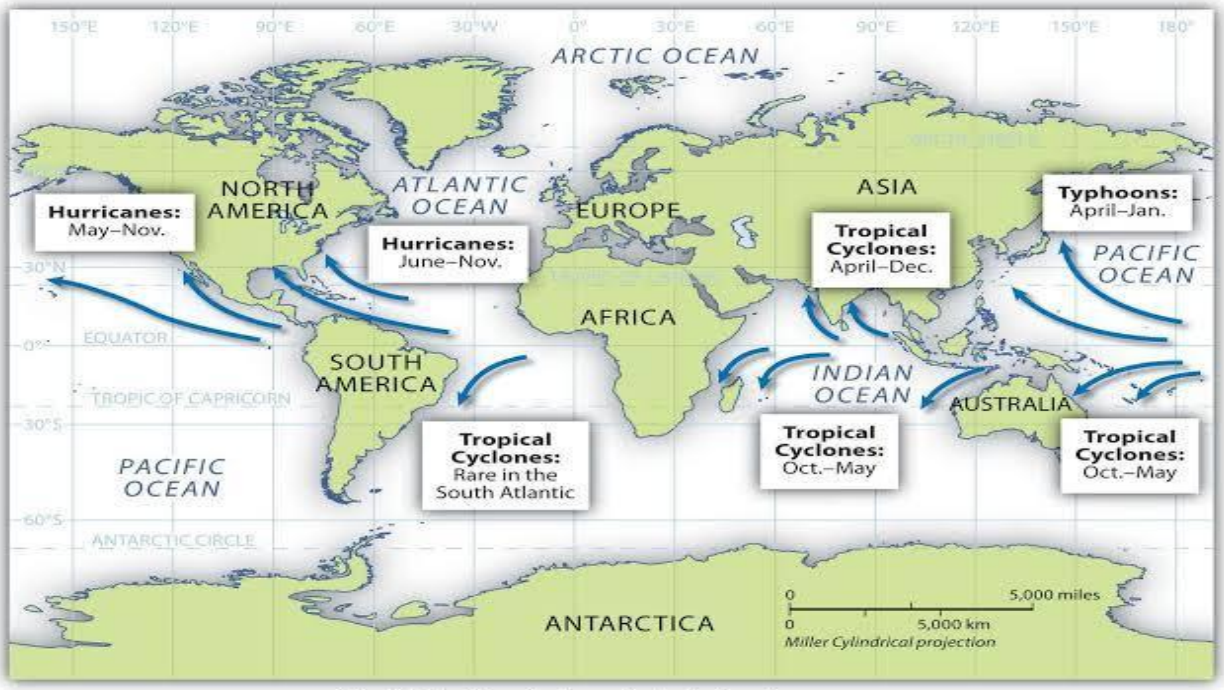


Fig: Distribution of cyclones in tropical regions.

    - This makes it difficult for the warm layers of water to mix properly with the cooler layers of water below, keeping the surface always warm and ready to feed any potential cyclone over it.
- **Impact of Pacific heat in Bay of Bengal :** Furthermore, the Bay of Bengal also welcomes cyclones formed over the Pacific. As there is no landmass big enough to stop these Pacific cyclones, they pass through Malaysia and the Gulf of Thailand and enter the Bay of Bengal
- **Temperature & Humidity :**Surface sea temperatures and humidity are directly related to the formation of cyclones. Since the Bay of Bengal receives high average rainfall, the possibility of cyclone formation is also high.
- **Sluggish Winds :**The winds over the Bay of Bengal are said to be a lot more sluggish compared to the Arabian Sea and therefore, the winds fail to reduce the surface temperature of the sea.
- **Intensified warm Currents :**The average temperature in the Bay of Bengal around the year is high – about 28 degrees. Warm air-currents intensify this.

Why is it less frequent in the Arabian Sea?

- **Dry air intrusion**: Dry winds blow from West to East, bringing air devoid of moisture from the Arabian Peninsula (desert region). Dry air (without water vapour) will literally choke tropical cyclones.
- **Strong wind shear**: The monsoon trough causes strong wind shear in the region, which hampers cyclone development.
- Most cyclones formed along the western coast of the country veer towards Oman — 58 per cent of the storms that form in the Bay of Bengal (BOB) hit the coast while only 25 per cent of those in the Arabian Sea does
- .The country's western coast is helped by mountains in East Africa that tend to direct a lot of wind towards the Arabian Peninsula, dissipating heat much more efficiently throughout the Arabian Sea

Difference between Tropical & Temperate Cyclone

TROPICAL CYCLONE	TEMPARATE CYCLONE
Tropical cyclones move from east to west.	These cyclones move from west to east
A tropical cyclone has an effect on a comparatively smaller area than a Temperate cyclone.	Temperate cyclones affect a much larger area
The velocity of wind in a tropical cyclone is much higher and it is more damaging.	The velocity of air is comparatively lower
Tropical cyclones form only on seas with temperatures more than 26-27 degree C and dissipate on reaching the land.	Temperate cyclones can be formed on both land and sea
A tropical cyclone doesn't last for more than 7 days	Temperate cyclone can last for a duration of 15 to 20 days

OCEANOGRAPHY

OCEAN BOTTOM RELIEF :

The hydrosphere covers nearly 71% of the total surface area of the earth.

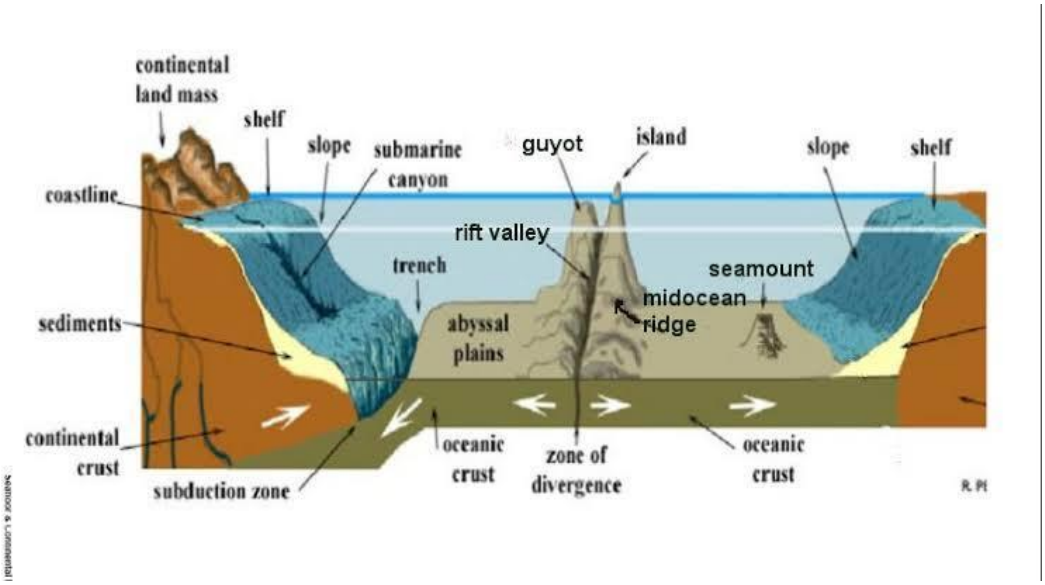
- The Hydrosphere is divided into Oceans, Inland Seas, Small enclosed seas, Bays, etc. on the basis of their size and location.
- The four major oceans of the earth are Pacific Ocean, Atlantic Ocean, Indian Ocean and Arctic Ocean.

Subterranean Water Body:

- The World's largest underground ocean, i.e. Subterranean Water Body was discovered in the year 2007. This massive underground ocean extends from Indonesia to the northern tip of Russia for a length of 700 km – 1400 km below the ground surface

- The ocean floors are characterized by four relief zones – Continental Shelf, Continental Slope, Deep Sea Plain and Oceanic deep or trench.
- The average depth of ocean is 3,800 m against the 840 m average height of lithosphere

Ocean Bottom Relief : (UPSC PRE 2015)



Continental Shelf :

The Continental marginal areas, shallow **submerged** under oceanic water with **average water depth of 100 fathoms** and **gently sloping (1°-3°) towards the sea, are** called Continental Shelves.

- Continental Shelf is the extended margin of each continent occupied by relatively shallow seas and gulfs.
- The shelf typically ends at a very steep slope, called the **shelf break.**
- The **width of continental shelves** largely depends on the nature of the coastal land. They are :
    - The **shelves are narrow, where high mountains are very close and parallel to the coast**. For Example the Shelf parallel to Mount Andes are almost absent or very narrow along some of the margins like the coasts of Chile).
    - The **shelves are wider where the coast lands are wide plains.** For example - The Siberian shelf in the Arctic Ocean, the largest in the world, stretches to 1,500 km in width.

Continental Shelf in India

- The **continental shelves** along the **Eastern and Western coasts of India a**re 50 km and 150 km wide respectively.
- The shelves are **narrow (30-35 km) off the mouths** of the Ganga, the Mahanadi, the Godavari, the Krishna and the Cauvery rivers.
- These **shelves are wider off the estuaries** of the Narmada, the Tapi and the Mahi rivers.

Economic Significance of Shelf :

- **Minerals & Hydrocarbon :**Most commercial exploitation from the sea, such as **metallic-ore, non-metallic ore, and hydrocarbon extraction,** takes place on the continental shelf.
- **Richest fishing Zone :**The shallowness enables sunlight to penetrate through the water, which encourages the growth of minute plants and other microscopic organisms – planktons (food for fishes). Thus continental shelves are the richest fishing grounds in the world. E.g. Grand Banks of Newfoundland, the North Sea and the Sunda shelf.
- **Transportation :**Their limited depth and gentle slope increase the height of tides. Since ships can only enter and leave port on the tide, most of the World's greatest seaports including Southampton, London, Hong Kong, Singapore and Rotterdam are located on Continental Shelves.

Continental Slope :

The zone of steep slope extending from the Continental shelf to the deep sea plains is called Continental Slope which varies from **5°to more than 60°** at different places.

- At the edge of the Continental Shelf, there is an abrupt change of gradient, forming the Continental Slope.
- Generally, the steep gradient of the continental slopes does not allow any marine deposits.
- The gradient of the slope region varies between **2-5°** and **depth varies between 200 and 3,000 m.**
- Submarine Canyons and trenches are significant reliefs in this region, generally transverse to the continental shelves and the coasts.

Deep sea plain :

Deep Sea Plain is the **flat and rolling submarine plain lying two or three miles below sea level**, and covering two-thirds of the ocean floor, generally termed as **Abyssal Plains.**

- These are gently sloping areas of the ocean basins cover 75% of the total area of the ocean to the other.
- These are the flattest and smoothest regions of the world.
- Modern sounding services reveal that the abyssal plain is not being level and it has extensive submarine plateaux ridges, trenches, guyots basins and oceanic islands)
- These plains are covered with **fine-grained sediments like clay and silt.**
- The submarine ridges with steep side-slopes reach the sea level and even project above the water surface and appear as islands. E.g. Mid-Atlantic ridge.

Ocean deeps / Trenches :

Ocean deeps represent depressions and trenches (reaches depths of 5,000 fathoms) on the ocean floors, and are the deepest parts of the ocean basins.

- Ocean deeps are grouped into
    - Deeps: very deep but less extensive depressions.
    - Trenches: long and narrow linear depressions. (E.g. Mariana Trench located to the west of Philippines in the North Pacific Ocean is the deepest trench (11,000 metres)).
- These are generally located parallel to the coasts facing mountains and along the islands. They are more often found close to the continents, particularly in the Pacific Ocean.

- They occur at the bases of continental slopes and along island arcs and are associated with active volcanoes and strong earthquakes.

MINOR RELIEF FEATURES

Apart from the above mentioned major relief features of the ocean floor, some minor but significant features predominate in different parts of the oceans.

Mid Oceanic Ridges :

A mid-oceanic ridge is composed of two chains of mountains separated by a large depression.

- The mountain ranges can have peaks as high as 2,500 m and some even reach above the ocean's surface.
- Iceland, a part of the mid- Atlantic Ridge, is an example.

Seamounts :

It is a mountain with pointed summits, rising from the seafloor that does not reach the surface of the ocean.

- Seamounts are volcanic in origin and can be 3,000-4,500 m tall.
- The Emperor seamount, an extension of the Hawaiian Islands in the Pacific Ocean, is a good example.

Submarine Canyons

These long, narrow and very deep valleys located on the continental shelves and slopes with vertical walls resembling the continental canyons are called submarine canyons.

- They are sometimes found cutting across the continental shelves and slopes, often extending from the mouths of large rivers.
- Submarine canyons are classified on the morphogenesis as –
    - Glacially eroded canyon
    - Non-glacial canyons
- The Hudson Canyon is the best known canyon in the world.

Guyots :

It is a flat topped seamount.

- They show evidences of gradual subsidence through stages to become flat topped submerged mountains.
- It is estimated that more than 10,000 seamounts and guyots exist in the Pacific Ocean alone.

Atoll

These are low islands found in the tropical oceans consisting of coral reefs surrounding a central depression.

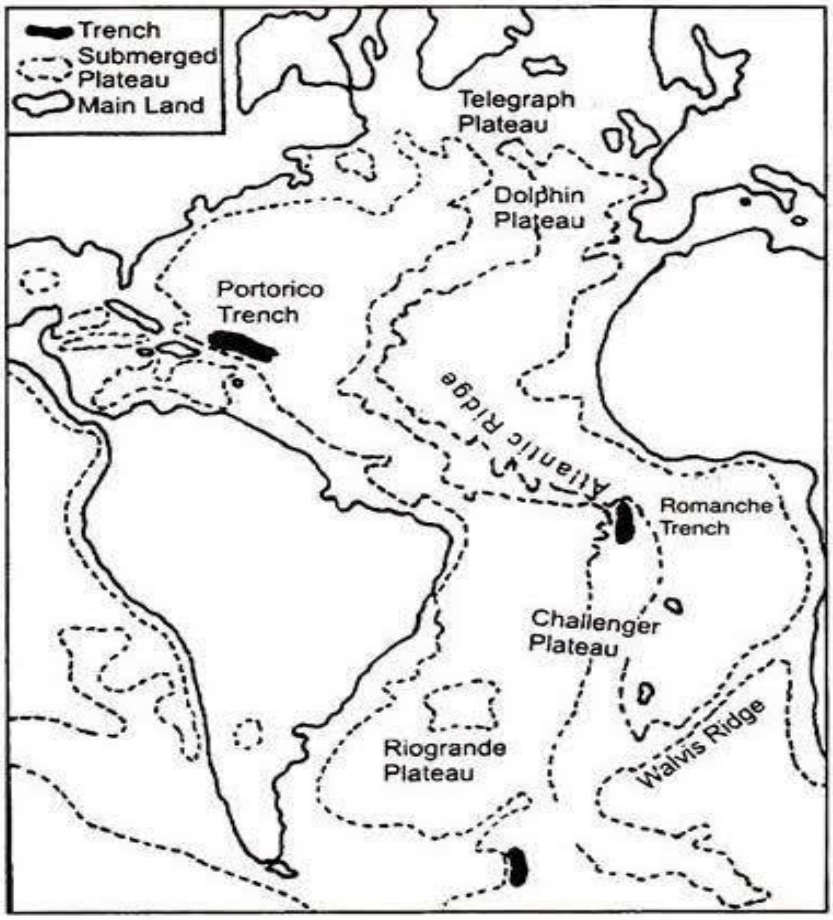
- It may be a part of the sea (lagoon), or sometimes form enclosing a body of fresh, brackish, or highly saline water.

The Ocean Bottom Reliefs :

Atlantic Ocean :

The ocean was formed due to drifting of North and South America to the west due to plate tectonics. It covers one-sixth of the geographical area of the earth.

- The 'S' shape of the ocean indicates the fact that landmasses (continents) on its either side were once a contiguous part.



Bottom configuration of the Atlantic Ocean

Important Features :

- Important features of Mid Atlantic Ridge Wyville Thompson ridge – between Scotland & Ireland, Telegraphic plateau – between Greenland & Iceland (first cables laid down), Newfoundland rise, Azores rise, Sierra Leone rise, Para rise, Guinea ridge, Walvis ridge and Rio Grande rise are some of the important relief features in Mid Atlantic ridge.

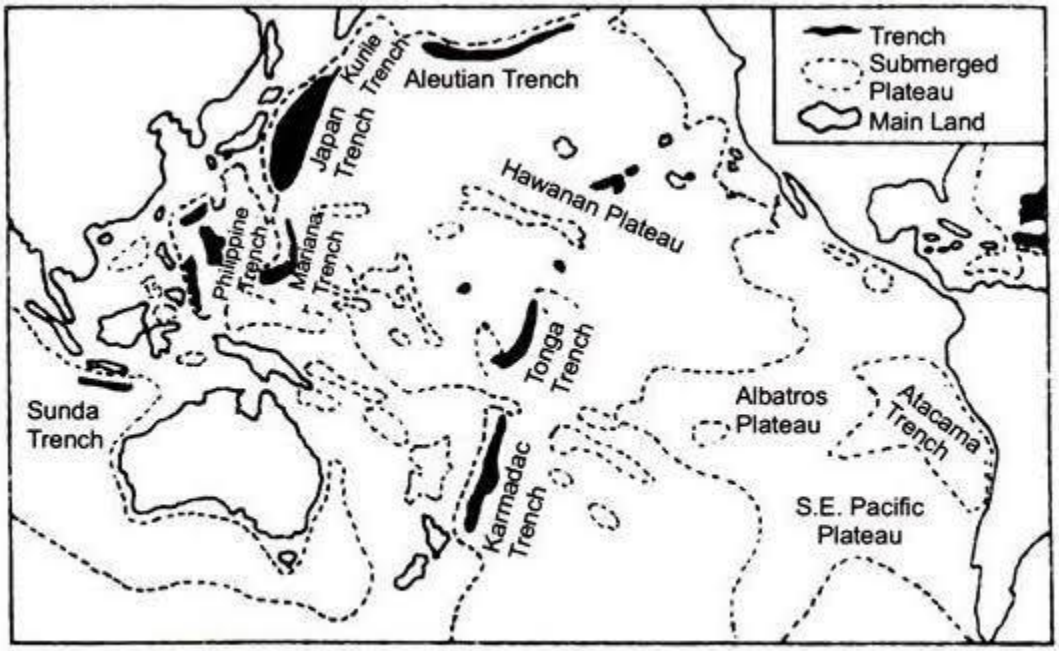
- The mid-Atlantic Ridge divides the Atlantic Ocean into two major basins- East and West Atlantic Basins.
- The number of deeps in the Atlantic Ocean is far less than in the Pacific Ocean because of the absence of effects of Tertiary orogenic movements along the Atlantic coasts.
- The Mediterranean Sea, Caribbean Sea and Gulf of Mexico are significant marginal seas in the Atlantic Ocean.

The Bottom relief of Pacific Ocean :

The Pacific Ocean is the largest ocean in the Earth covering one-third area.

Important features :

- The Shelves are broad and extensive along the Eastern coasts of Australia and Asia where the width varies from 160 – 1600 km and the depth ranges between 1000 – 2000 m.
- Several Islands are seated on broad continental shelves. E.g. Kuril Islands, Japanese Islands, Philippines etc.



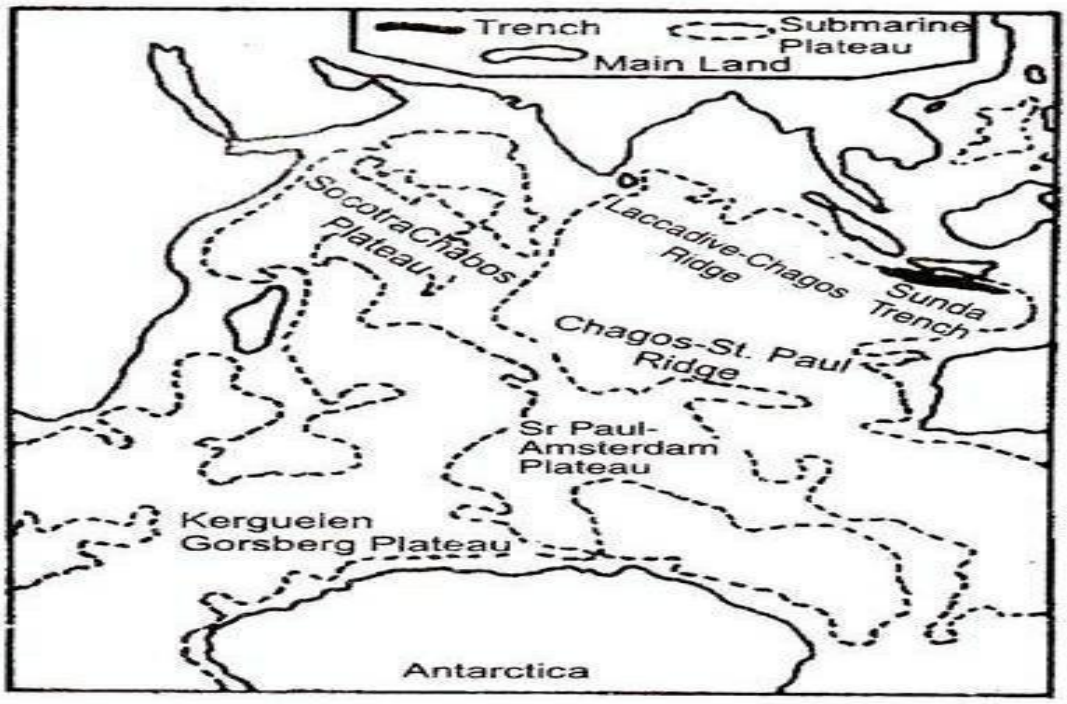
Bottom configuration of the Pacific Ocean

- The Pacific Ocean does not have mid-oceanic ridge like the Atlantic or Indian Ocean (only a few scattered ridge of local importance).
- The East Pacific Rise or Ridge known as Albatross Plateau is 1600 km wide and it extends from north of New Zealand to the Californian coast.
- There are several trenches and deeps in the Pacific Ocean. These depressions are located either along the island arcs or mountain chains.
- These trenches are found mainly in the western Pacific Ocean.

The Bottom relief of Indian Ocean :

The Indian Ocean is the third largest ocean by area and it is bounded by Asia in the north and east, Africa in the west, Australia in the south-east and Antarctica in the south.

- Major parts of the coastal lands are formed by the Block Mountains of Gondwana land.
- Continental shelves are extensive along the margins of the Bay of Bengal, Arabian Sea, Eastern coast of Africa and Madagascar (lying on continental shelf itself).
- The Central ridge or mid-oceanic ridge known as Mid-Indian Oceanic Ridge extends from southern tip of Indian peninsula to Antarctica in the south almost in North-South direction and forms a continuous chain of hills
- Oceanic Ridge divides the Indian Ocean into two major basins – the Eastern and the Western basins. These are further divided into many basins as –
    - Oman Basin
    - Arabian Basin
    - Somali Basin
- There are very few deeps and trenches in the Indian Ocean. Some are Sunda trench, Ob trench, Mauritius trench, Amirante trench, etc.



Bottom configuration of the Indian Ocean

TEMPERATURE DISTRIBUTION (UPSC PRE 2013, 2020)

The temperature of ocean water varies from place to place both at the surface and at great depths.

- Generally, the mean annual temperature of the surface ocean water decreases from 21° C in equatorial areas to around 12.7° C in 45° N and S latitudes and drops almost to freezing point at the poles.

Layers of Temperature

- The top layer of warm oceanic water is 500 m thick with temperature ranging between 20° and 25° C. This layer is **present in the Tropics throughout the year, but it is present in mid-latitudes only during summer.**
- **Thermocline layer** represents vertical zone of oceanic water below the first layer and is characterised by rapid rate of decrease of temperature with increasing depth.
- **Cold layer** is very cold and extends upto the deep ocean floor. The Polar areas have only one layer of cold water from the surface to the deep ocean floor.

The Factors affecting Distribution of Temperature :

The following factors affect the distribution of temperature of ocean water.

- **Latitudes:** The temperature of surface water decreases from equator towards the poles, as the insolation of sun decreases poleward.
- **Unequal distribution of Land and Water:** The temperature of ocean water varies in the northern and southern hemispheres because of dominance of land in northern hemisphere and water in southern hemisphere.
    - The temperature in the enclosed seas at low altitudes becomes higher because of the surrounding land areas.
- **Prevailing Winds:** The winds blowing from the land towards the oceans and seas (offshore) reduces the temperature, whereas the onshore winds raise the temperature in ocean.
- **Ocean Currents:** Warm currents raise the temperature of the affected areas, whereas Cold currents lower down the temperature.
    - Warm currents raise the temperature more in the northern hemisphere than in the southern hemisphere.
- **Other Minor Factors:** These includes the **Submarine ridges, Local weather conditions like cyclones, hurricanes, fog, etc. Location and shape of the sea, Longitudinal and Latitudinal extensions of the seas, Open and enclosed seas** are the other minor factors that determine the distribution of temperature in the ocean.

The distribution of Temperature

Horizontal Distribution :

On an average, the temperature of surface water of the ocean is 26.7° C and the temperature gradually decreases from Equator towards the poles. The **average annual temperature of all the oceans is 17.2° C while in the Northern Hemisphere – 19.4°C and Southern Hemisphere – 16.1° C .**

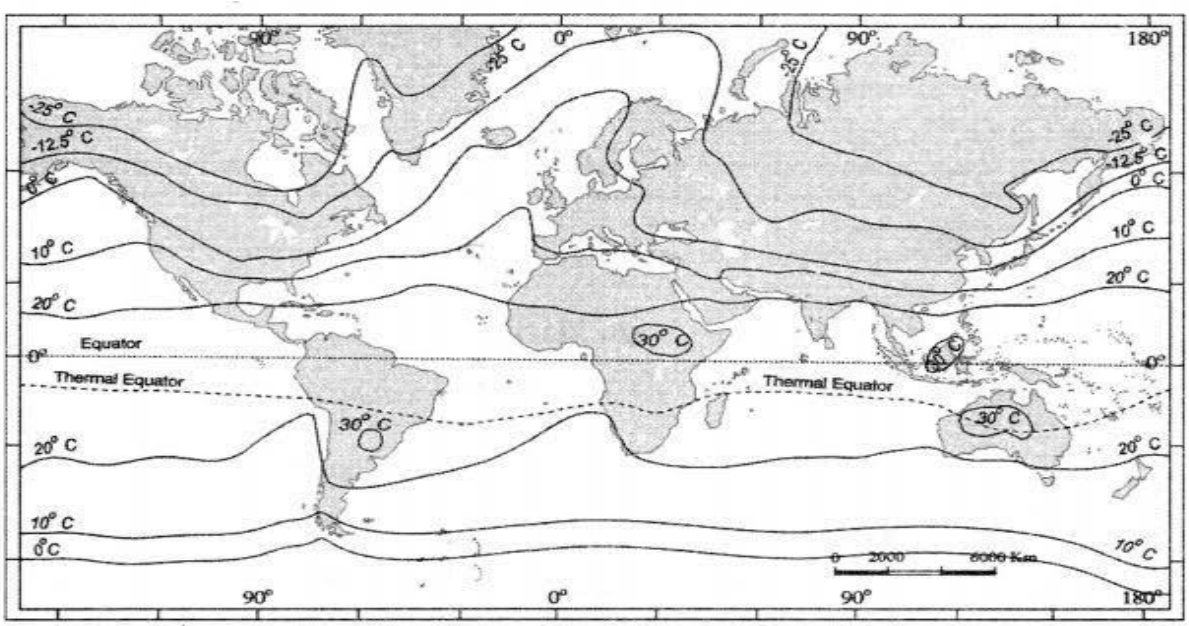


Fig: The distribution of surface air temperature in the month of January.

- The rate of decrease of temperature with increasing latitudes is generally 0.5° F per latitude.
- The oceans in the northern hemisphere record a relatively higher average temperature than in the southern hemisphere.
- The temperature of the surface water of the oceans is higher than the air temperature above the ocean surface
- Average annual temperature of the Pacific Ocean is higher than the Atlantic Ocean and Indian Ocean.
- In the Atlantic Ocean, Decrease of temperature with increase in latitudes is very low because of warm ocean currents.

The Vertical Distribution :

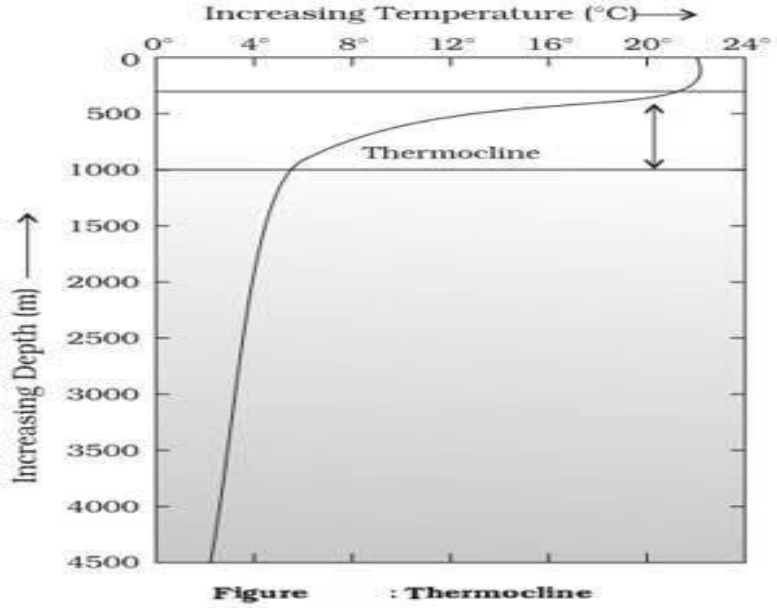


Figure : Thermocline

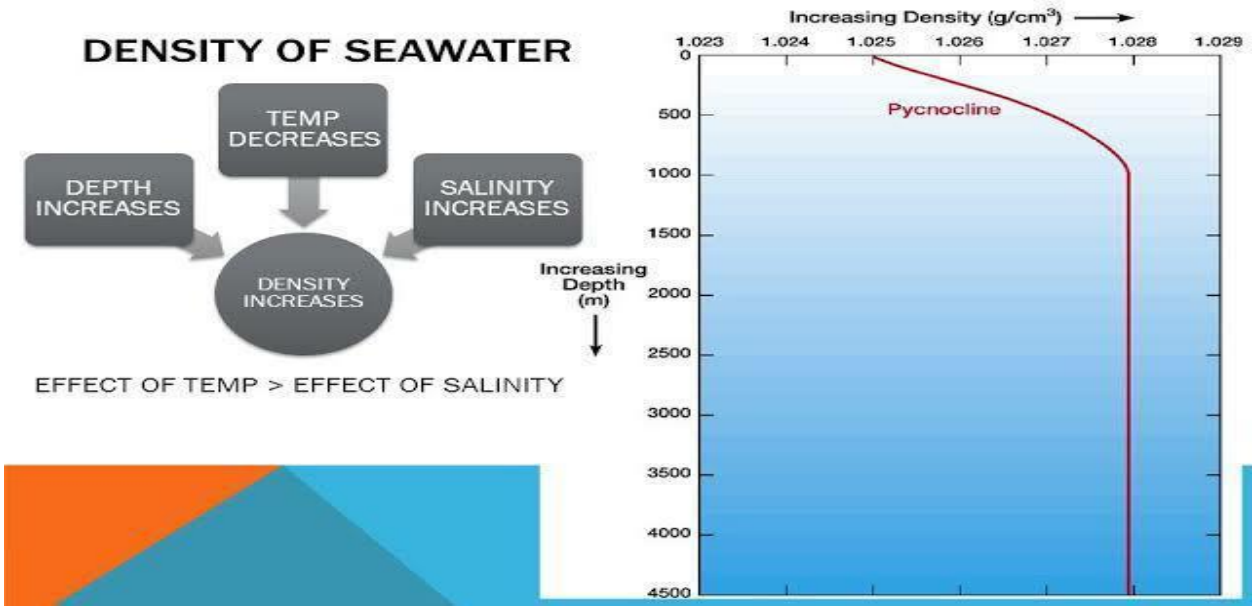
The maximum temperature of the oceans is always at their surface, because it directly receives the insolation and the heat is transmitted to the lower sections of the oceans through a conduction mechanism.

- The solar rays very effectively penetrate upto 20 m depth and do not go beyond 200 m depth.
- The rate of fall of temperature is very rapid upto the depth of 200 m (1°F for every 10 fathoms) and thereafter the rate of decrease of temperature is slowed down.
- The temperature decreases from the ocean surface with increasing depth and it is not uniform.
- The oceans are vertically divided into two zones. They are –
    - **Photic or Euphotic zone:** It represents the upper surface upto the depth of 200 m and receives solar radiation.
    - **Aphotic zone:** It extends from 200 m depth to the bottom and does not receive solar rays.

OCEAN DENSITY

Density refers to the amount of mass per unit volume of a substance and it is generally measured in g/cm3.

- The density of sea water gradually increases with decreasing temperature and the highest density is recorded at the temperature of -1.3° C.
- The density determines the dynamics of ocean water. Relatively lighter sea water floats and moves horizontally, whereas heavier seawater sinks.



Factors affecting the Density of the Ocean :

The factors which are essential in determining the density are as follows :

- **Temperature :** The role of temperature in controlling water density is more pronounced in low latitudes, whereas the importance of temperature in controlling seawater decreases poleward.

- The temperature of seawater below freezing point cannot increase sea water density because at 0° C temperature water starts freezing with the formation of ice crystals, which do not allow water molecules to come closer and coalesce.
- Since, there is less variation in temperature of sea water in polar areas, and hence the role of temperature as a controlling factor of sea water density is minimised.

- **Pressure :** Pressure is directly positively related to ocean water through its compressive effects, seawater density increases with increasing pressure and vice versa.
  - The pressure is considered a minor factor of seawater density.
  - The density of seawater at the bottom of tranches is 5% higher than that of surface area.
- **Salinity :** On an average, seawater density increases with increasing salinity and vice versa. This is due to the fact that dissolved salt in sea water becomes denser than pure water.

SALINITY

Salinity is defined as 'the total amount of solid material in grams contained in 1 kg of sea water and is expressed in parts per thousand'.

- Rivers bring salts in solution from the continental areas to Ocean.
- The Volcanic Ash also contributes to Ocean Salinity.

Composition of Sea Water :

The average salinity varies 33% – 37% in different oceans and seas.

Salts	Percentage
1. Sodium chloride	77.8%
2. Magnesium chloride	10.9%
3. Magnesium sulphate	4.7%
4. Calcium sulphate	3.6%
5. Potassium sulphate	2.5%

The Factors Affecting the Ocean Salinity

There is a wide range of variation in the spatial distribution of salinity within the oceans and the seas. This variation is caused by few factors as –

- **Evaporation :** There is a direct positive relationship between salinity and evaporation. That is, greater the evaporation, higher the salinity and vice versa.

- Evaporation due to high temperature with low humidity (dry condition) causes more concentration of salt and overall salinity becomes higher.
- Salinity is higher near the tropics than at the equator because both the areas (Tropic of Cancer & Tropic of Capricorn) record a high rate of evaporation with dry air over it.
- It is to be noted that salinity also controls evaporation.

- **Precipitation :** Precipitation is inversely related to salinity. That is, higher the precipitation, lower the salinity and vice versa.
  - Therefore, the Equatorial zone (regions of high rainfall) records comparatively lower salinity than sub-tropical high pressure belts (comparatively low rainfall).
  - The melt water (of polar icebergs) from the polar region is supplied to the temperate regions, which increases the volume of water and reduces the salinity.
- **Influx of River water:** When big and voluminous river pour down immense volume of water into the oceans, salinity is reduced at their mouths, which is observed in mouths of Ganga, Congo, Amazon, St. Lawrence, etc.
  - The effect of the influx of river water is more pronounced in the enclosed seas. E.g. Danube, Dneister, Dneiper, etc. reduce the salinity in Black sea (18%).
- **Atmospheric Pressure and Wind direction:** Anticyclone conditions with stable air and high temperature increases salinity of the surface water of the oceans. E.g. Subtropical high pressure belts represent such conditions.
  - Winds also help in redistribution of salt in the oceans and the seas (winds drive away saline water to lesser saline areas).
  - Westerlies increase the salinity along the western coasts of the continents whereas they decrease the salinity along the eastern coasts of the continents.
- **Circulation of Oceanic Water:** Equatorial warm currents drive away salts from the western coastal areas of the continents and accumulate them along the eastern coastal areas.
  - The North Atlantic Drift increases salinity along the north-western coasts of Europe.
  - Similarly, salinity is reduced along the north eastern coast of North America due to the cold Labrador Current.

Horizontal Distribution of Salinity :

Horizontal distribution of oceanic salinity is studied in relation with latitudes, but regional distribution is also considered.

Latitudinal distribution:

On an average, salinity increases from the equator towards the poles.

- The highest salinity is not recorded near the equator (high temperature and evaporation, but rainfall reduces salinity. Hence, it records only 35% salinity.
- The highest salinity is observed between 20° – 40° N is 36%, because this zone is characterised by high temperature and high evaporation, but comparatively low rainfall.

Isohaline :

The spatial distribution of surface salinity of the oceans and the seas is represented by Isohalines which are the lines that join the places of equal salinity at the sea surface.

Thermocline zone: It is the layer of ocean between the depth zones of 300 – 1000 m characterised by sharp change of temperature in the vertical section of sea water.
Halocline: denotes a zone of sharp salinity change in the vertical section of the oceans between 300-1000 m depth.

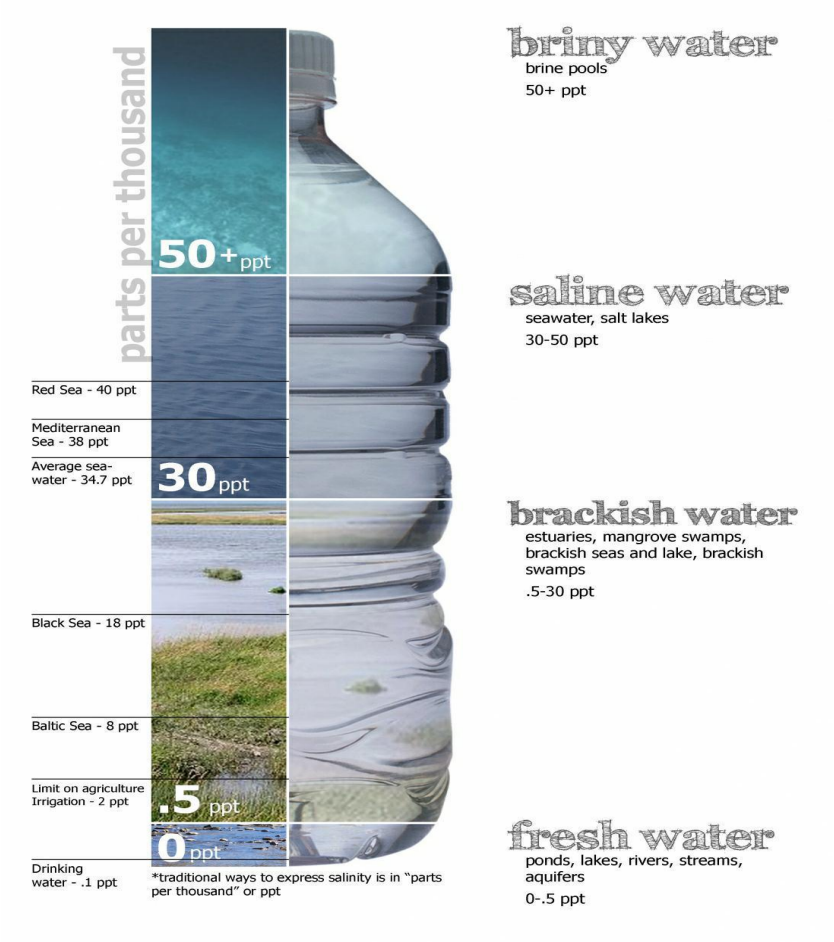
- The zone between 40°- 60° latitudes in both hemispheres records low salinity of 31% and 33% in the northern and southern hemispheres respectively.
- Salinity further decreases in the polar zones because of the influx of polar melt water.
- On an average, the northern and the southern hemisphere records average salinity of 34% and 35% respectively.

Vertical distribution of Salinity :

No definite trend of distribution of salinity with depth, because both the trends of increase and decrease of salinity with increasing depths have been observed.

The following are the characteristics of vertical distribution of salinity:

- Salinity increases with increasing depth in high latitudes.
- The trend of increase of salinity with increasing depths is confined to 200 fathoms from the surface in middle latitudes beyond which it decreases with increasing depths.
- Salinity is low at the surface at the Equator, due to high rainfall and transfer of water through equatorial currents (but salinity is observed below the surface). It again becomes low at the bottom.
- Maximum salinity is found in the upper layer of the oceanic water. Salinity decreases with increasing depth.
- Thus, the upper zone of maximum salinity and lower zone of minimum salinity is separated by a transition zone known as Thermocline zone (above which high salinity and below which low salinity are found).



Significance of Salinity :

The ocean salinity has significant effects on the physical property of seawater and other aspects of the oceans as follows:

- The **freezing and boiling points** are greatly affected and controlled by addition or subtraction of salts in seawater. The **saline freezes slowly in comparison to fresh water**.
- **Evaporation** is controlled by the salinity of the oceans. **More saline water evaporates** than less saline water. Similarly, more evaporation reduces the volume of seawater and hence the concentration of salts increases.
- Spatial variation in seawater salinity becomes a potent **factor in the origin of ocean currents.**
- The ocean salinity also **affects the marine organisms and plant community.**
- Salinity determines **compressibility, thermal expansion, temperature, density, absorption of insolation, evaporation,** and humidity.

Salinity of Marginal Seas

- **The North Sea**, in spite of its location in higher latitudes, records higher salinity due to more saline water brought by the North Atlantic Drift.
- **Baltic Sea** records low salinity due to the influx of river waters in large quantities.

- **The Mediterranean Sea** records higher salinity due to high evaporation.
- Salinity is, however, very low in the **Black Sea** due to the enormous freshwater influx by rivers.

Inland seas and lakes

- The salinity of the inland Seas and lakes is very high because of the regular supply of salt by ‘ the rivers falling into them.
- Their water becomes progressively more saline due to evaporation.
- For instance, the salinity of the **Great Salt Lake, (Utah, USA), the Dead Sea, and the Lake Van in Turkey are 220, 240, and 330** respectively.
- The oceans and salt lakes are becoming saltier as time goes on because the rivers dump more salt into them, while freshwater is lost due to evaporation.

OCEAN CURRENTS (UPSC PRE 2015)

Ocean currents are the continuous flow of huge amounts of water in a definite direction.

- The ocean currents are classified based on their depth as surface currents and deep water currents:
  - **Surface currents** constitute about 10 percent of all the water in the ocean, these waters are the upper 400 m of the ocean
  - **Deep water** currents make up the other 90 percent of the ocean water.
- Ocean currents are classified on the basis of temperature into two types. They are Warm currents and Cold currents.
- They are also divided on the basis of velocity, dimension and direction into Drifts, Currents and Streams.

Factors affecting the Ocean Currents :

- **Heating by solar energy** : This causes the water to expand. That is why, near the equator the ocean water is about 8 cm higher in level than in the middle latitudes. This causes a very slight gradient and water tends to flow down the slope.
- **Blowing Winds :** Wind blowing on the surface of the ocean pushes the water to move. Friction between the wind and the water surface affects the movement of the water body in its course.
- **Gravitation force :** Gravity tends to pull the water down to pile and create gradient variation.
- **Coriolis Force :**The Coriolis force intervenes and causes the water to move to the right in the northern hemisphere and to the left in the southern hemisphere.
- **Accumulation of Water :** These large accumulations of water and the flow around them are called Gyres. These produce large circular currents in all the ocean basins.
- **Density :** Differences in water density also affect vertical mobility of ocean currents.

Factors Modifying the Ocean Currents :

Rotation of Earth :	Ocean related Factors :	Atmosphere Related Factors :
● The rotation of the earth on its axis from west to east results in the origin of deflective force or **Coriolis force** which deflects the general	● **Temperature Difference :** Due to high temperature in the equatorial region, the water density decreases because of greater	● **Air Pressure and Winds:** Air pressure on the oceanic water causes ocean currents through density

direction of ocean current.

- The rotational force of the Earth causes **movement of the ocean water near the equator in opposite directions** and Equatorial currents are generated (It flows from east to west).
- Some ocean waters move in the direction of rotation of earth (from west to east) and form Counter Equatorial currents.

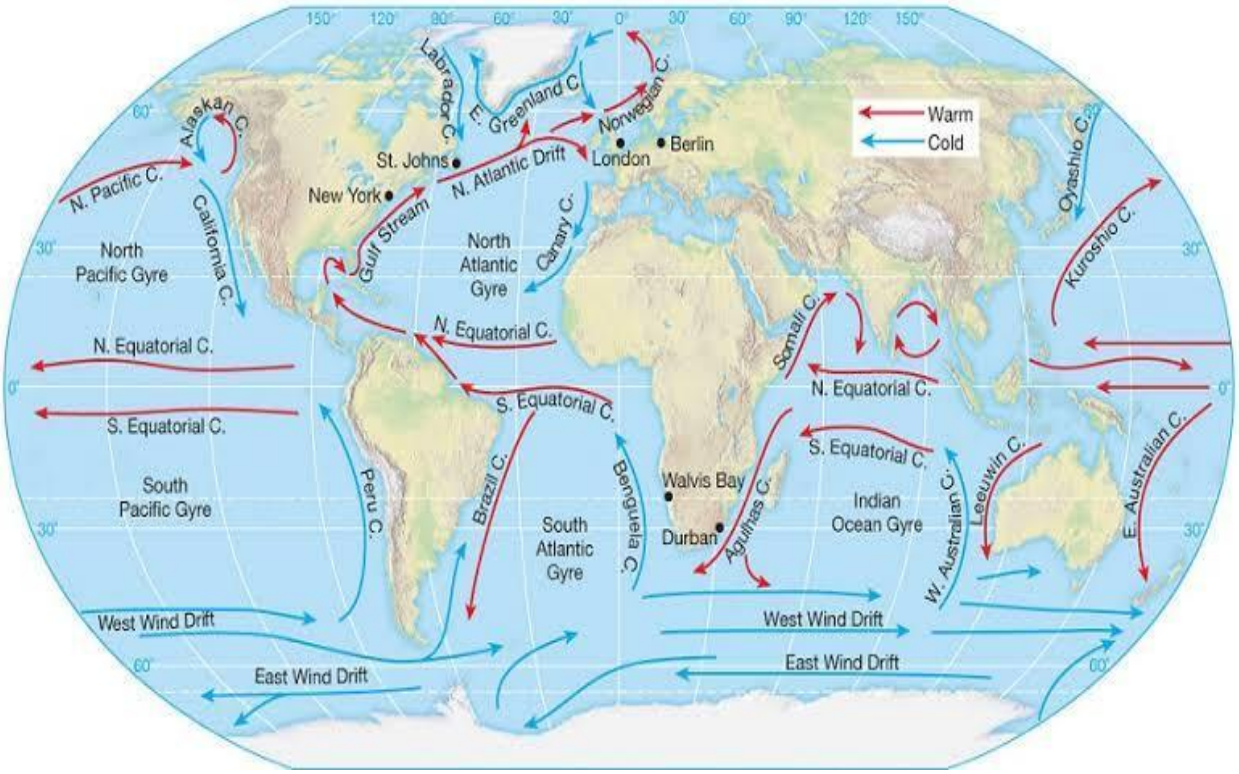
expansion of water particles whereas the density of sea water becomes comparatively greater in polar areas.
    - Consequently, water moves due to expansion of volume from the equatorial region to polar areas.
- **Salinity Difference:** Oceanic salinity affects the density of ocean water (salinity increases the density) and density variation causes ocean currents.
    - Ocean currents on the water surface are generated from the areas of low salinity to the areas of high salinity.
- **Density Difference:** Water moves from area of lower density to areas of higher density. The high density water then moves sub-surface current from greater density to lesser density below the water surface.

variations. Areas of high atmospheric pressure are characterised by low volume of water and vice versa.
    - The wind blowing on the water surface also moves water in its direction due to its friction with water; therefore most of the ocean currents of the world follow the direction of prevailing winds.
- **Rainfall and Evaporation:** The sea water level becomes relatively higher in the areas of low evaporation and high rainfall. Such regions have low salinity and low water density.
    - Therefore, ocean currents originate near the low latitudes (high water level) and move towards

		the high latitudes.
● **Direction, shape and configuration of coast lines:** The disposition of coast line perpendicular to the natural flow direction of ocean currents obstructs them, as a result, the ocean currents start flowing parallel to the coastline. o Brazilian coast bifurcate the Equatorial current into Gulf Stream and Brazil current (parallel to Brazilian coast).	● **Bottom reliefs:** The irregularities of the bottom reliefs of the oceans modify the ocean currents at the surface as well as at the bottom. o The submarine ridges usually deflect the course of currents.	● **Seasonal variations** : This is seasonal change in the directions of currents in some areas in response to seasonal change in weather conditions. E.g. Currents of Indian Ocean show seasonal changes in their flow directions due to monsoons.

Impacts of Oceanic Currents :

- **Local Climate:** Warm and Cold currents affect the local climate of a region. E.g.: the North Atlantic Drift keeps the coasts of the North Sea (western coast of Europe) warm which is unusual for such high latitudes.
    - Similarly, the warm waters of the Kuroshio current in the North Pacific ocean keep the ports of the Alaskan coast ice-free in winter.
- **Precipitation**: Warm currents flow along the east coast of continents resulting in warm and rainy climates while cold currents flow along the west coast of continents.
- **Desert Formation:** Cold ocean currents have a direct effect on desert formation in west coast regions of the tropical and subtropical continents. E.g.: Peru Current, also called Humboldt Current, is a cold-water current of the southeast Pacific Ocean and a primary reason for the aridity of the Atacama desert (driest desert of the world).
- **Moderating effect:** They are responsible for moderate temperatures at coasts. eg: Warm North Atlantic Drift in England, Canary cold current in Spain, Portugal etc.
- **Tropical cyclones:** They pile up warm waters in tropics and this warm water is the major force behind tropical cyclones.



- **Fishing**: The mixing of warm and cold currents help to replenish the oxygen and favour the growth of planktons which are regions rich in microscopic marine plants and animals.
    - For example, the Great Banks near Newfoundland is formed by the mixing of cold Labrador Current with the warm Gulf Stream.
- **Navigation**: The atmospheric circulation of the winds and the oceanic circulation of the currents are almost coincidental and together they aid in the navigation of the ships.
    - Ocean currents flow for great distances and together with the winds creates a conveyor belt kind of system for navigation of the ships.

OCEAN TIDES, WAVES & TSUNAMI

TIDES (UPSC PRE 2015,2018)

The horizontal and vertical motions are common in ocean water bodies. The horizontal motion refers to the ocean currents and waves.

- The vertical motion refers to tides. The vertical motion refers to the rise and fall of water in the oceans and seas.
- This rise and fall of seawater due to gravitational forces of the sun and the moon are called Tides.
- On average, every place experiences tides twice a day.
- **A** particular tide centre takes 24 hours 52 minutes to come under the moon but by that time there is another tide at the opposite side of the referred tide centre and this happens after 12 hours 26 minutes.

Types of Tides

The oceanic tides are caused due to tide producing forces of the sun and the moon.

- There is a lot of temporal and spatial variation in the tide producing forces because of different positions of the sun and the moon with the earth.

High Tide Water: The rise of seawater and its movement towards the coast is called tide and resultant high water level is known as High Tide Water.

Low Tide Water: The fall of seawater and its movement towards the sea is called ebb and the resultant low water level is called Low Tide Water

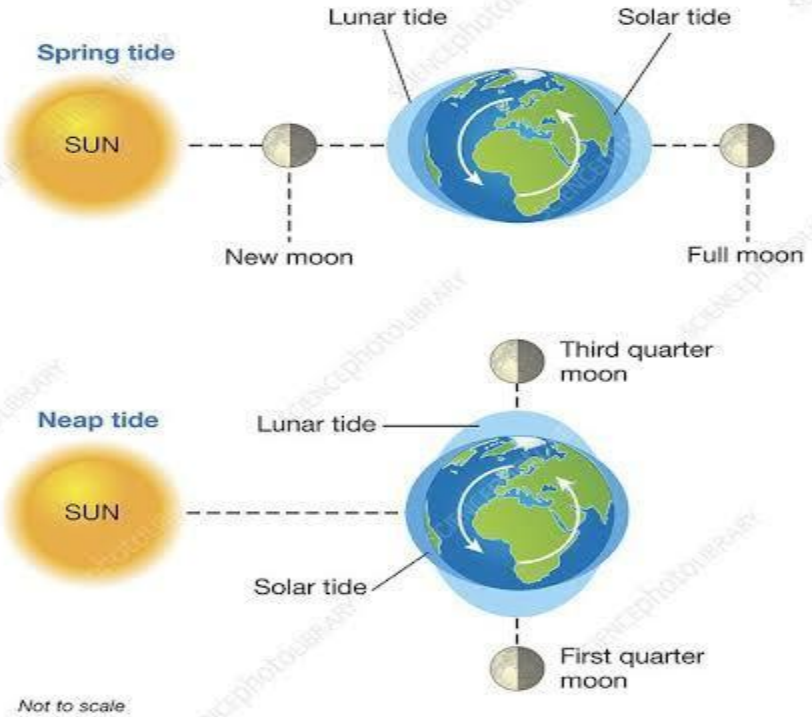
Tidal Range: The **difference between high tide water and low tide** water is called Tidal Range. There is much variation in the height of high and low tides at different places in different oceans because of varying depths of ocean water, geography of sea coasts and coastlines and openness or closeness of the seas.

Spring tides

- Very high tides are caused when the sun, the moon and the earth are almost in the same line. Such high tides are called spring tides.
- The height of such spring tides is 20% more than normal tides. Such tides occur twice every month (during new moon & full moon) and their timing is fixed.

Neap tides

- The sun, the earth and the moon come in the position of quadrature (form right angle) on the seventh or eighth day of every fortnight of a month and thus the tide producing forces of the sun and the moon work in opposite directions, with the result, low tide is caused.



Tropical & Equatorial tides

- When there is maximum declination of the moon to the north equator, the moon's rays fall vertically on the tide centres (near the Tropic of Cancer) and hence spring tides are caused. Such tropical tides move westward along the Tropic of Cancer.

Apogean and Perigean tides

- The tidal force of the moon is most powerful during this position and high tides are caused and such tides are called perigean tides (15-20% higher than normal tides).
- The tidal force of the moon is minimum during the position of apogee (farthest distance – 4,07,000 km). Such tides are called apogean tides (20% lower than normal tides).

Equinoctials Spring Tides

- These tides recurring at an interval of 6 months due to the revolution of the earth around the sun and sun's varying declination are called equinoctial tides.

Factor affecting the Tides :

- The **relative distances and positions of the sun, moon and Earth** all affect the size and magnitude of the Earth's two tidal bulges.
- At a smaller scale, the magnitude of tides can be strongly influenced by the **shape of the shoreline**.
- **Narrow inlets and shallow wate**r also tend to dissipate incoming tides. Inland bays such as Laguna Madre, Texas, and Pamlico Sound, North Carolina, have areas classified as non-tidal even though they have ocean inlets
- **Local wind and weather** patterns also can affect tides. Strong offshore winds can move water away from coastlines, exaggerating low tide exposures
- **High – pressure systems** can depress sea levels, leading to clear sunny days with exceptionally low tides.

Impacts of Tides :

- **Sustenance of life:** Tides affect various aspects of oceanic life, including the reproductive activities of fish and ocean plants. Floating plants and animals ride the tidal currents between the breeding areas and deeper waters.
- **Source of habitat and food:** Sea creatures like Crabs, mussels, snails, seaweed etc. inhabit the tidal zone and the most important point to remember is that without the regular washing of the tides, these complex and abundant creatures would die and food resources would diminish.
- **Moderate temperature**: The tides and tidal currents mix arctic water that can't absorb sunlight when compared with warmer tropic water that does. Tides stir the ocean water that makes habitable climatic condition and help in maintaining the temperatures around marine ecological habitat.

Ebb: The time between the high tide and low tide, when the water level is falling, is called the ebb.

Flood : The time between the low tide and high tide, when the tide is rising, is called the flow or flood.

- **Pollutant removal :**Tides remove pollutants and circulate nutrients required for survival of ocean plants and animals. e.g. Seawater in and out of tidal bays and estuaries.
- **Mangroves :**Tides play a vital role for the growth and formation of mangroves, its canopy and formation of zones in the mangrove ecosystem and associated diversity.
- **Habitation :**Tides also help to maintain mudflats that provide habitation for flora and fauna.

Tidal bore :

When a tide enters the narrow and shallow estuary of a river, the front of the tidal wave appears to be vertical owing to the piling up of water of the river against the tidal wave and the friction of the river bed.

- The steep-nosed tide crest looks like a vertical wall of-water rushing upstream and is known as a tidal bore.
- **The favourable Conditions :** strength of the incoming tidal wave, slimness and depth of the channel and the river flow.
- The Amazon River is the largest river in the world. It empties into the Atlantic Ocean. The mouth of the Amazon is not narrow, but the river still has a strong tidal bore. A tidal bore develops here because the mouth of the river is shallow and dotted by many low-lying islands and sandbars.
- In India, tidal bores are common in the Hooghly river. Most powerful tidal bores occur in Qiantang River in China.
- A tidal bore takes place during the flood tide and never during the ebb tide (Tidal bores almost never occur during neap tides. Neap tides happen during quarter moons, when tides are weakest).

WAVES

Waves are actually the energy, not the water as such, which moves across the ocean surface. Water particles only travel in a small circle as a wave passes.

- Wind provides energy to the waves.
- Waves travel because wind pushes the water body in its course while gravity pulls the crests of the waves downward.
- The falling water pushes the former troughs upward, and the wave moves to a new position.
- The actual motion of the water beneath the waves is circular.

TSUNAMI

The series of extremely long waves, Tsunami are very long wavelengths of water caused by a large and sudden displacement of the ocean due to earthquakes, volcanic eruptions etc.

- These are also called seismic sea waves and are one of the most powerful and destructive natural forces.
- When they reach the coast, they can cause dangerous coastal flooding and powerful currents that can last for several hours or days.
- Most tsunamis are caused by large earthquakes. Though, not all earthquakes cause tsunamis.

Characteristics of Tsunami

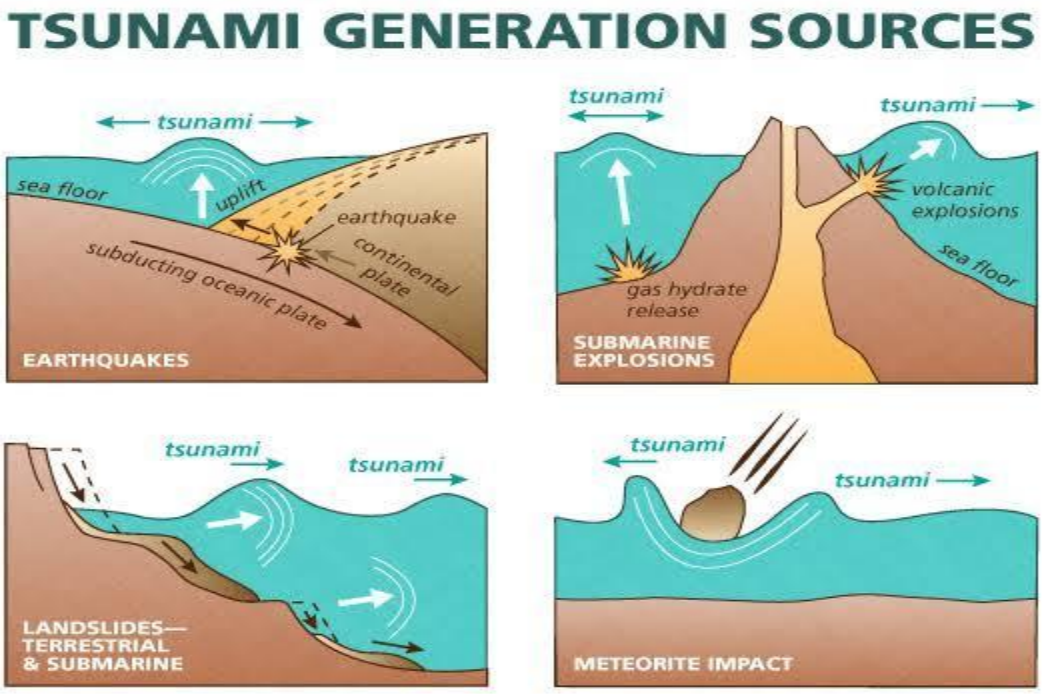
Tsunamis are among Earth's most infrequent hazards and most of them are small and non-destructive.

- Over deep water, the tsunami has very long wavelengths (often hundreds of kilometres long) when a tsunami enters shallow water, its wavelength gets reduced and the period remains unchanged, which increases the wave height.
- Tsunamis have a small amplitude (wave height) offshore. This can range from a few centimetres to over 30 m in height. However, most tsunamis have less than 3 m wave height.
- It radiates in all directions from the point of origin and covers the entire ocean.
- It generally consists of a series of waves, with periods ranging from minutes to hours.
- These are the waves generated by tremors and not by earthquakes themselves.
- There is no season for tsunamis and not all tsunamis act the same. It cannot be predicted where, when and how destructive it will be. A small tsunami in one place may be very large a few miles away.
- An individual tsunami may impact coasts differently. A tsunami can strike any ocean coast at any time. They pose a major threat to coastal communities. The effect of Tsunami would occur only if the epicentre of the tremor is below oceanic waters and the magnitude is sufficiently high.
- The speed of the wave in the ocean depends upon the depth of water. It is more in the shallow water than in the deep ocean. As a result of this, the impact of a tsunami is more near the coast and less over the ocean

Causes of Tsunami

A Tsunami can be generated only through the vertical movement of the seafloor. Most Tsunamis are generated by earthquakes. Volcanic eruption, underwater explosion, landslides and meteorite impacts are some other causes of Tsunami.

- **Earthquake** – Tsunami is generated by the earthquake because of the disturbance of the seafloor and is formed generally with vertical displacement. Most tsunamis are generated by earthquakes that occur along the subduction boundaries of plates along the ocean trenches. The size of the Tsunami is related to the size of the earthquake.
- **Underwater explosion** – A Nuclear Testing by the US generated Tsunami in 1940 and 1950s in Marshall island.
- **Volcanic eruption** – Volcanoes that occur along the Coastal waters can cause several effects that can cause a tsunami.
- **Landslides** – Earthquake and volcanic eruptions generally generate landslides, these landslides when moving into the Oceans, bays and lakes can generate Tsunami.
- **Meteorite Impacts** – Though no historic example as such of meteorite impact has caused Tsunami, the apparent impact of a meteorite about 5 million years ago produced Tsunami leaving deposits along the Gulf Coast of Mexico and the United States.



CORAL REEFS AND ATOLLS (UPSC PRE 2018, 2014)

Coral reefs are the colonies of tiny living creatures that are found in oceans. They are the underwater structures that are formed of coral polyps that are held together by calcium carbonate.

- Coral reefs are also regarded as the tropical rainforest of the sea and occupy just 0.1% of the ocean's surface but are home to 25% of marine species.
- They are usually found in shallow areas at a depth less than 150 feet. However, some coral reefs extend even deeper, up to about 450 feet.
- Coral polyps are the individual corals that are found on the calcium carbonate exoskeletons of their ancestors.
- Corals can be found in all the oceans but the biggest coral reefs are **mostly found in the clear, shallow waters of the tropics and subtropics.**
- The largest of these coral reef systems, The Great Barrier Reef in Australia, the largest coral reef is more than 1,500 miles long.

Growth conditions for Coral Reefs

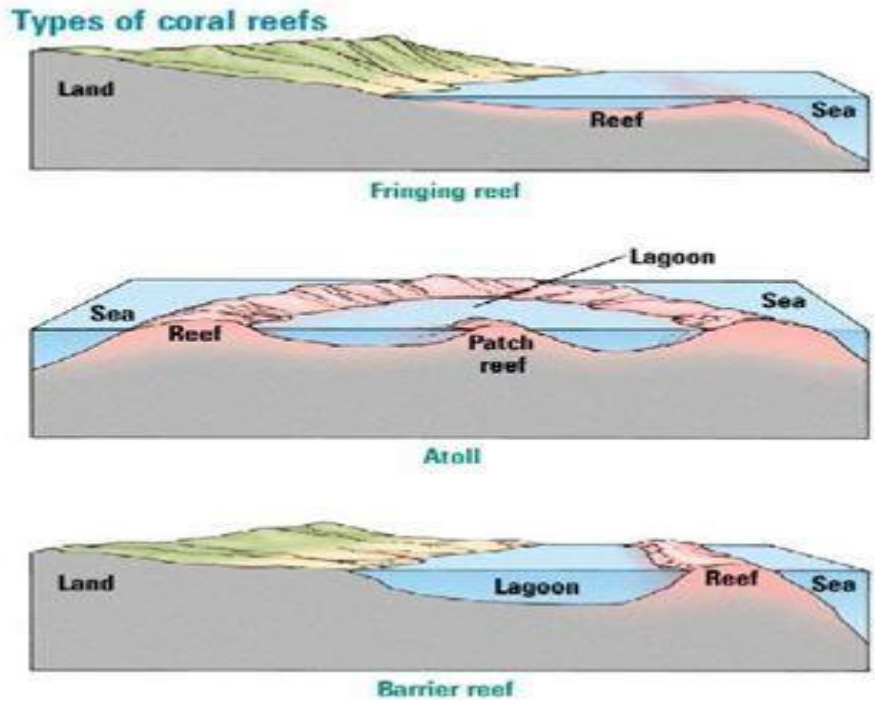
- The **temperature** of the water should not be below 20°C. The most favourable temperature for the growth of the coral reefs is between 23°C to 25°C. The temperature should not exceed 35°C.
- Corals can survive only under saline conditions with an **average salinity between 27% to 40%**.

- Coral reefs grow better in shallow water having a **depth less than 50 m**. The depth of the water should not exceed 200m.

Types of Coral Reefs

- **Fringing Reef:** The coral reefs that are found very close to the land and forms a shallow lagoon known as Boat Channel are called Fringing Coral Reefs.
    - The Fringing Reefs develop along the islands and the continental margins.
    - They grow from the deep bottom of the sea and have their seaward side sloping steeply into the deep sea.
    - Fringing Reefs are the most commonly found coral reefs among the three. For example Sakau Island in New Hebrides, South Florida Reef.
- **Barrier Reef**: Barrier Reefs are considered as the largest, highest and widest reefs among the three coral reefs.
    - They develop off the coast and parallel to the shore as a broken and irregular ring.
    - Being the largest reef among them all, they run for 100kms and are several kilometres wide. One example of a Barrier Reef is the Great Barrier Reef of Australia which is 1200 mile long.

- **Atolls**: An atoll can be defined as a reef that is roughly circular and surrounds a large central lagoon.
    - This lagoon is mostly deep, having a depth of 80-150 metres.
    - The atolls are situated away from the deep sea platforms and are found around an island or on a submarine platform in an elliptical form.
    - For example Fiji Atolls, Suvadiva in Maldives and Funafuti Atoll of Ellice.



Factors affecting Coral Reefs

- **Extreme climate conditions:** High temperature of water leads to the declination of these corals as they cannot survive in high temperature. As estimated by scientists, most of the coral reefs of the world will soon decline with the increasing rates of ocean warming.
- **Overfishing**: It is another major concern as it is leading to an ecological imbalance of the coral reefs.
- **Coastal development**: Development of coastal infrastructure and tourist resorts on or close by these coral reefs causes significant damages.
- **Pollution**: The toxic pollutants which are dumped directly into the ocean can lead to the poisoning of the coral reefs as it increases the nitrogen level of the seawater leading to an overgrowth of algae.
- **Sedimentation**: Construction along the coasts and islands lead to soil erosion increasing the sediments in the river. As a result, it can smother corals by depriving them of the light needed to survive.

Importance of Coral Reefs

Coral Reefs play an important role in the following ways.

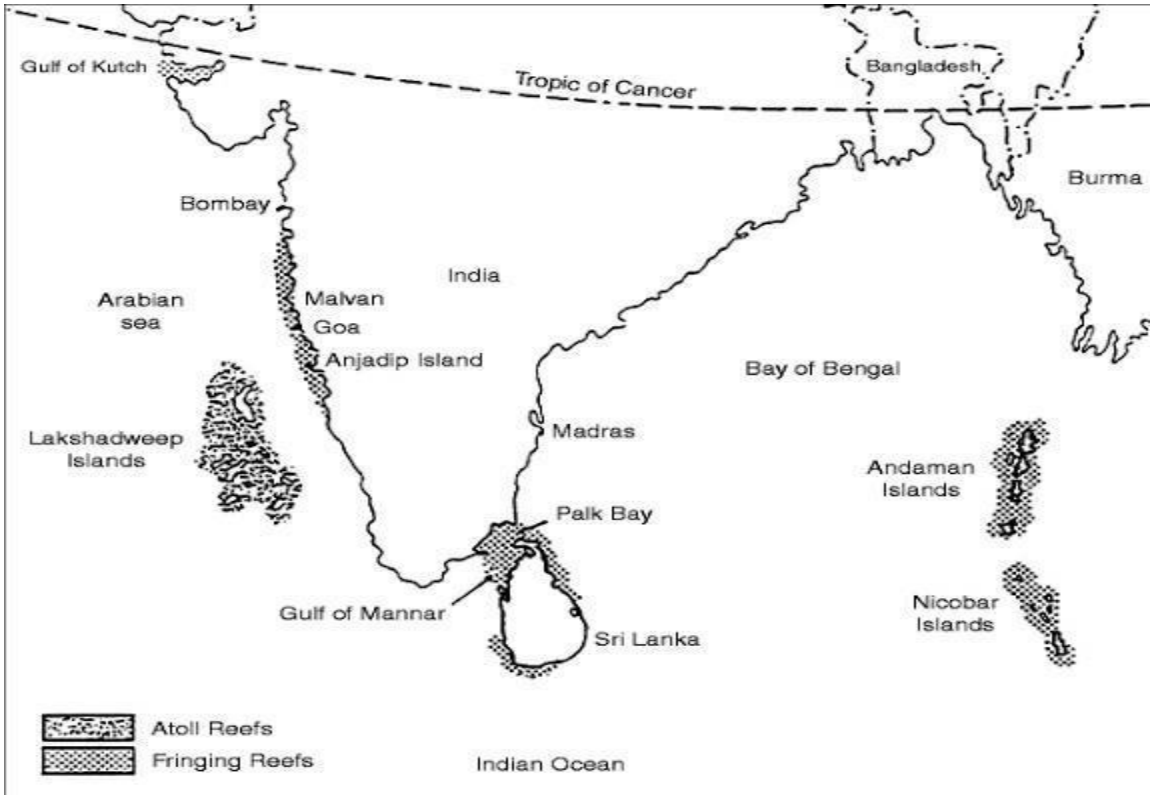
- They **protect coastlines** from the damaging effects of wave action and tropical storms.
- They **provide habitats** and shelter for many marine organisms.
- They are the **source of nitrogen** and other essential nutrients for marine food chains.
- They assist in **carbon and nitrogen-fixing.**
- They help with **nutrient recycling.**

- The study of coral reefs is essential for scientifically testable records of **climatic events over the past million years.**
- The **fishing industry** depends also on coral reefs. Many fish spawn there, and juvenile fish spend time there before making their way to the open sea. The Great Barrier Reef generates more than 1.5 billion dollars annually for the Australian economy from fishing and tourism.
- Coral reefs are also key **indicators of global ecosystem health.** They serve as an early warning sign of what may happen to other less sensitive systems, such as river deltas if climate change is not urgently addressed.

Coral Reefs in India

India has its coastline extending over 7500 kilometres. Due to the subtropical climatic conditions, there are very few coral reefs in India.

- The major coral reefs in India include the Palk Bay, the Gulf of Mannar, the Gulf of Kutch, the Andaman and Nicobar Islands and Lakshadweep Islands.
- Among all these coral reefs, the Lakshadweep reef is an example of atoll while the rest are all fringing reefs.



Coral Bleaching

The coral and the zooxanthellae share a symbiotic relationship and 90% of the nutrients that are produced by the algae are transferred to the coral hosts.

- But this relationship gets affected under severe environmental stress which causes the loss of symbiotic algae (zooxanthellae).
- As a result, the white calcium-carbonate exoskeleton is visible through its transparent tissue leading to a condition known as Coral Bleaching.
- The corals become vulnerable in the absence of the algae and begin to die if the temperature of the sea remains high for weeks.

Threats to Coral Reefs:

- **With rising global temperatures**, mass coral bleaching events and infectious disease outbreaks have become more frequent.
- **Ocean acidification:** Carbon dioxide absorbed into the ocean from the atmosphere has been reducing calcification rates in reef-building and reef-associated organisms by changing chemical properties of seawater through a decrease in pH. This can ultimately lead to dissolving coral reefs.
- **Increased frequency and intensity of tropical storms**: Violent storms will lead to coral breakage, dislocation and degradation from wind and waves
- **Changes in precipitation**: increased precipitation will lead to more freshwater runoff. Freshwater run-off reduces salinity levels, may cause bleaching, and brings increased nutrients and sediments, which can lead to disease outbreak
- **ENSO:** Sudden exposure of reef flat corals to the atmosphere during events such as extreme low tides, ENSO-related sea level drops or tectonic uplift can potentially induce bleaching. The consequent exposure to high or low temperatures, increased solar radiation and sea water dilution by heavy rains could lead to zooxanthellae loss and also cause coral death.
- **Marine Pollution**: Zooxanthellae loss occurs during exposure of coral to increased concentrations of various chemical contaminants and oil. Plastic and garbage at the seaside often ends up in the sea and disrupts the coral reefs' delicate environment.
- **Overfishing and destructive fishing practices** – such as purse seining, fine-mesh fishing, 'moxy' nets, cyanide fishing and blast fishing result in unsustainable damage to coral reefs
- **Coral mining** (for example in south and south-east Asia) which involves blasting of reefs and coral being removed, cause immediate destruction but also result in indirect detrimental effects such as sand erosion and sedimentation
- **Sedimentation:** Erosion caused by construction, mining, logging, and farming has lead to increased sediment in rivers. The sediment drastically reduces the amount of light reaching coral reefs and destroys them.

Snowflake Coral – A Threat to Biodiversity

Carijoa Riisei also known as snowflake coral is an invasive species discovered recently by the scientists off the coast of Thiruvananthapuram and Kanyakumari.

- These fast-growing species were found at a depth of 10m off Kovalam in Thiruvananthapuram and at a depth of 18m off Enayam in Kanyakumari.
- The snowflake coral is known to cause a serious threat to the marine ecosystem due to the following reasons:
  - According to a survey conducted on Maui Black Coral Bed in 2001, it was found that the snowflake corals killed 60% of the black coral trees which was found between 80 metres to 150 metres depth.
  - They consume large quantities of the zooplanktons which can

- **Poorly managed tourism** has both direct and indirect negative effects on coral reefs. Snorkelling, diving and boating can cause direct physical damage to reefs. Overexploitation of reef species as food, for aquaria and as curios for tourist markets can threaten the survival of species.
- **Indiscriminate Exploitation of coral reefs** for wildlife trade has also emerged as a major threat to coral ecosystems.
- **Massive outbreaks of predatory starfish**, invasive species also pose threat to survival of corals

MARITIME ZONES

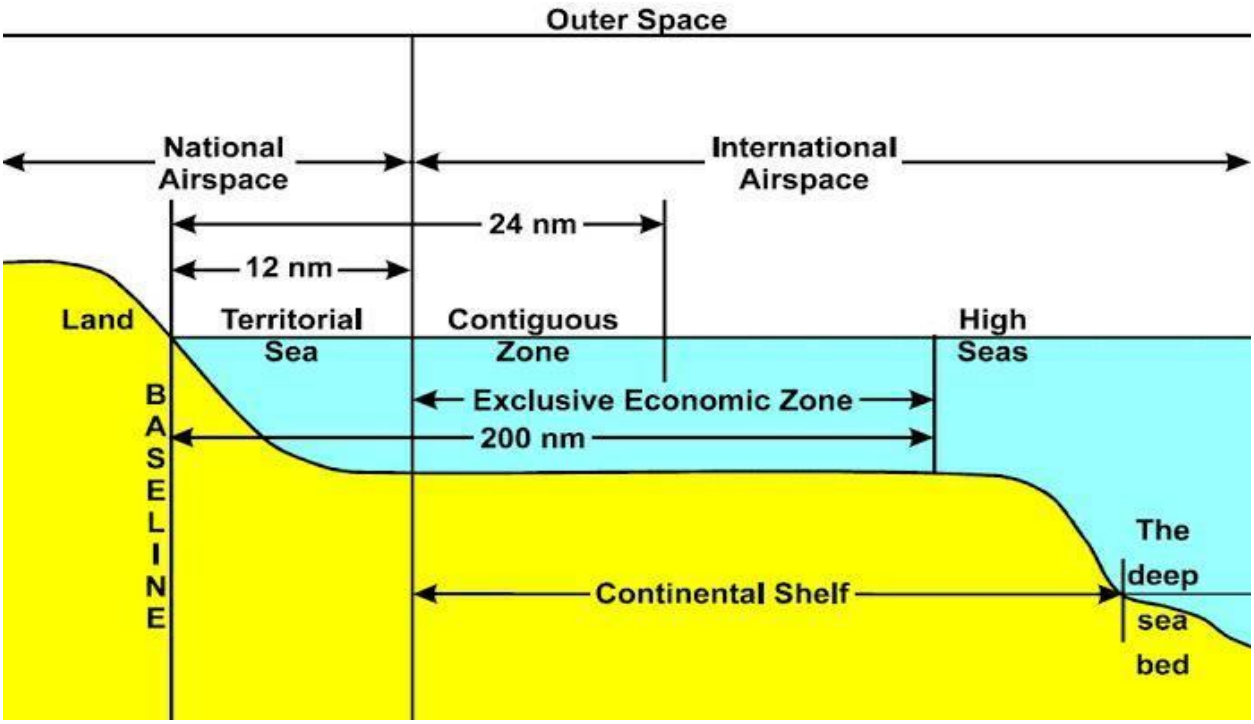
Maritime zones have been divided from time to time into different zones on the basis of different purposes viz. Sovereignty, exploitation of marine resources, trade and transport, recreation, war practices etc. and a number of international laws have been enacted to give them legal recognition.

- The offshore areas of a country have been divided into 3 zones e.g. territorial sea, exclusive economic zone and high sea. Besides, a few more terms are in practice such as internal waters, marine belt, marginal sea, contiguous zone etc.

Territorial Sea

The shore and coastlines of a coastal country are never straight rather are crenulated and indented.

- The imaginary line joining the land projecting towards the sea is called the baseline.
- Sea water lying between coastline and baseline is called internal water which is never contiguous.
- The seaward water from the coastland of a nation is called territorial sea, the distance of which is measured from the base line generally upto 12 nautical miles towards the sea.
- The coastal nation has the right of its sovereignty over its territorial sea and has the full and exclusive right of its use. No other country can enter the territorial sea of a country without the permission of the convened country.



Exclusive Economic Zone

This zone extends upto a distance of 200 nautical miles from the baseline.

- The concerned coastal state has the exclusive right of the survey, exploitation, conservation and management of mineral resources of ocean deposits, ocean floor (crust), marine water energy, water and marine organisms within this Exclusive Economic Zone (EEZ).
- No other country can venture in any economic activity (e.g. fishing, mining etc.) in this zone without the permission of the concerned coastal state but this zone is open for laying down submarine cables, navigation of ships, flying of aeroplanes for other states.
- Such rights are enjoyed by other states only outside the seaward limit of the territorial sea.

High Sea

The High Sea extends beyond the seaward limit of the exclusive economic zone and includes vast oceanic areas.

- All the countries have equal rights of navigation, aviation, fishing, mining, laying down of submarine cables, scientific research, exploration etc.

BIOGEOGRAPHY

SOIL : ORIGINE & TYPES

The uppermost layer of the earth's crust is known as soil. It is a mixture of rock fragments and organic matter which has decomposed into constituent nutrients.

- Soil formation is influenced by the **weathering and erosion processes** that are defined by a region's climate. Apart from this, the **nature** of the **parent rock, topography, vegetation cover** etc., also determines the type of soil that is formed.
- Pedogenesis is the process of soil formation under the action of various forces of nature such as wind, flowing water etc.

Soil Types

Soil can be classified into three types based on the texture of grains:

Sandy soils if the size of soil grain is in the range of 2 to 0.05 mm. Sandy soils have enough gaps between their grains to drain water quickly. Hence, these soils tend to be dry, light in weight, and well aerated.	**Clayey soils** if the size of soil grain is less than 0.002 mm. Clay soils are more tightly packed, because of the smaller grain size, leaving a little gap for air. They do not allow water to easily pass through them. They tend to retain water in the pore spaces in between them. Hence, these soils are heavy.
Loamy soils	**Silt**

• It is a mixture of sand, clay, and silt. This is considered to be the best kind of topsoil for growing plants. The soil pores hold the right amount of water. These soils also have a good humus content.	• if the size of soil grain is in the range of 0.05 to 0.002 mm. It is usually found on the river beds

Soil Profile

The different layers of the soil are arranged in a **vertical manner,** which is known as the soil profile.

- The layers are usually horizontal in orientation, parallel to the soil surface.
- Each layer differs the ones adjacent to it in terms of colour, texture, chemical composition, and depth.
- Each layer of the soil is termed a horizon.
- Soil horizons are mainly **identified based on their physical features** such as colour **and texture.**

O-horizon

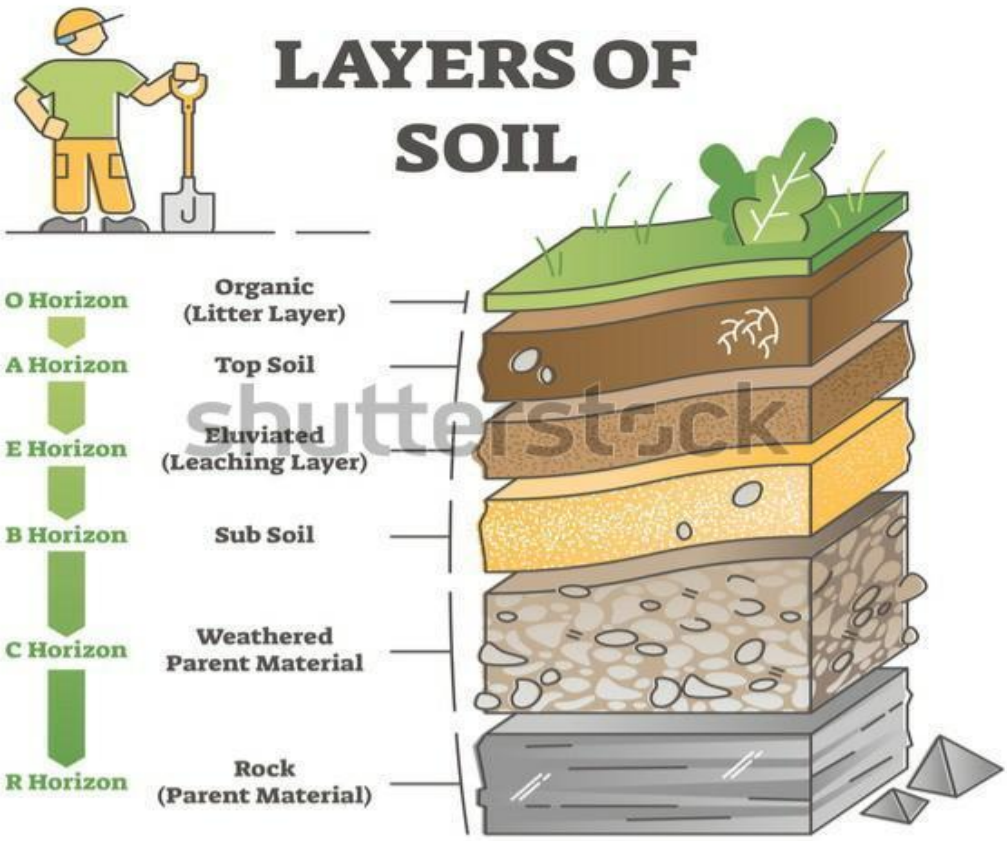
This layer contains organic matter which is either undecomposed or partially decomposed. It includes leaves, twigs, mosses, and lichens.

- This layer lies on the top of the decomposed organic matter and the weathered rock material.

A-horizon

Also known as the surface soil or the topsoil.

- It contains decomposed organic matter which is mixed with weathered rock minerals.
- Nutrients like iron, aluminium, clay, and organic matter are sometimes dissolved and carried out this layer.
- When the erosion is more pronounced, an eluviated layer appears at the subsurface or the base of the A-horizon.



E-horizon

It is a light coloured eluviated layer that is eroded of its nutrients.

- It underwent significant leaching which took away the nutrients like iron, aluminium, clay etc., leaving behind resistant, dissolvable materials like quartz, sand, and silt.
- It is an older layer usually found between the A-horizon and the B-horizon.

B-horizon

Also known as the subsoil, this layer lies below the A-horizon and the E-horizon.

- It contains minerals which reflect the physical and chemical alteration of the parent rock.
- It is a zone of illuviation i.e., the nutrients that are leached out of the A-horizon and E-horizon get accumulated here.
- Hence it is rich in iron, aluminium oxides, clay, and organic compounds.

C-horizon

Also known as the parent rock, it comprises the parent rock material which eroded from the layers below and got accumulated in this horizon.

- It is in the form of large rocks which are sometimes unbroken.

- It also acts as a zone of accumulation of soluble inorganic compounds which percolate down to this horizon.

R-horizon

Also known as bedrock, this forms the bottommost layer of the soil profile.

- It comprises largely unbroken rock strata, as a continuous hard mass.
- In situ, soils exhibit many features of the bedrock strata.

Soils of the world

It is very difficult to achieve a classification of soils that is both meaningful to the geographer and at the same time an accurate reflection of all soil types and gradations.

- Two main types of classification used today may be recognized as those based on the assumed origins of the soil and these are – **Zonal system & Intrazonal System.**

Zonal System

One of the most popular classifications of soils has been the zonal system. This was **proposed many years ago by Russian pedologists** (Dukuchaiev, Glinka) who recognized the strong relationship between climate, vegetation, and soil zones throughout the world. Three main classes of soil are recognized.

- Zonal soils are those that are **well developed and reflect the influence of climate** as the major soil-forming factor.
- Intrazonal types are **well-developed soils formed where some local factor is dominant**.
- Azonal soils are those that are **immature or poorly developed.**

Zonal Types

These soils occur in broad geographical areas or zones. They are **influenced more by the climate and vegetation of the area rather than the rock-type**. They are **mature**, as a result of **stable** conditions over a **long period of time.**

Podzols (ash-soil):

The effect of the cheluviation process is to produce soils with a characteristic **bleached E horizon**.

- In some profiles, the humus is washed down the profile and accumulates as a **humus-enriched B horizon**, forming a humus podzol.
- In others, there is a marked **concentration of iron oxide** at this level, forming an iron podzol.
- Sometimes this takes the form of an iron-pan, impeding drainage, and **resulting in a gley podzol.**
- Podzols of these three types are most **widespread in the cool climates** immediately south of the tundra region and are found typically in association with coniferous forests.

Brown Earth:

These soils are found on the equator of the main podzol zone in milder climates supporting a deciduous forest cover.

- the soils still **exhibit leaching**, but of a far less intense nature than podzols.

- Although **free calcium is absent** from the upper part of the profile, there is no downward movement of sesquioxides, and their dispersed distribution gives rise to the overall brown colour of the soil.
- In addition, **humus is well distributed** throughout the profile and is **less acidic than in podzols.** Brown earths are **widespread in Britain,** except in the highland areas.

Tundra Soils:

The great variations that exist in the patterns of ground ice in the tundra cause equally complex variations in soils.

- Where **slope conditions are fairly stable,** the slow rate of plant decomposition usually results in the presence of a peaty layer at the soil surface.
- In areas of active slope movement, soils are inevitably thin. In the most extreme conditions where there is **no plant growth, the soils are humic.**
- The **brown polar desert soils of the Antarctic are of this nature.**
- By way of contrast, the birch-forested tundra margins in the northern hemisphere possess Arctic brown forest soils, characterized by a thick dark organic A horizon.

Sierozems:

Sierozems of **desert and semi-desert areas** can be regarded as extreme forms of chestnut soils in which lime and gypsum come even nearer to the surface because of upward capillary attraction.

- Since most of the plants are adapted to arid conditions, there is little leaf fall, and organic matter in these soils is low.
- However, when irrigated, Sierozems can be very fertile, because of their high base status.

Chernozem Soils:

The best examples of chernozems and their variants are found in association with steppe or prairie vegetation.

- The **light rainfall of these areas leads to incomplete leaching** and the formation of a **calcium-rich horizon** deep in the profile.
- Above this is a deep dark layer of soil which can be up to a meter thick.
- The **humus content of this layer is surprisingly often no more than ten percent,** the dark colour being associated with the base(alkaline)-rich mineral matrix.
- Chernozems have a **well-developed crumb structure.** The ideal parent material for this soil seems to be loess, which is widespread in the **midwest of North America, Russia and northern China.**

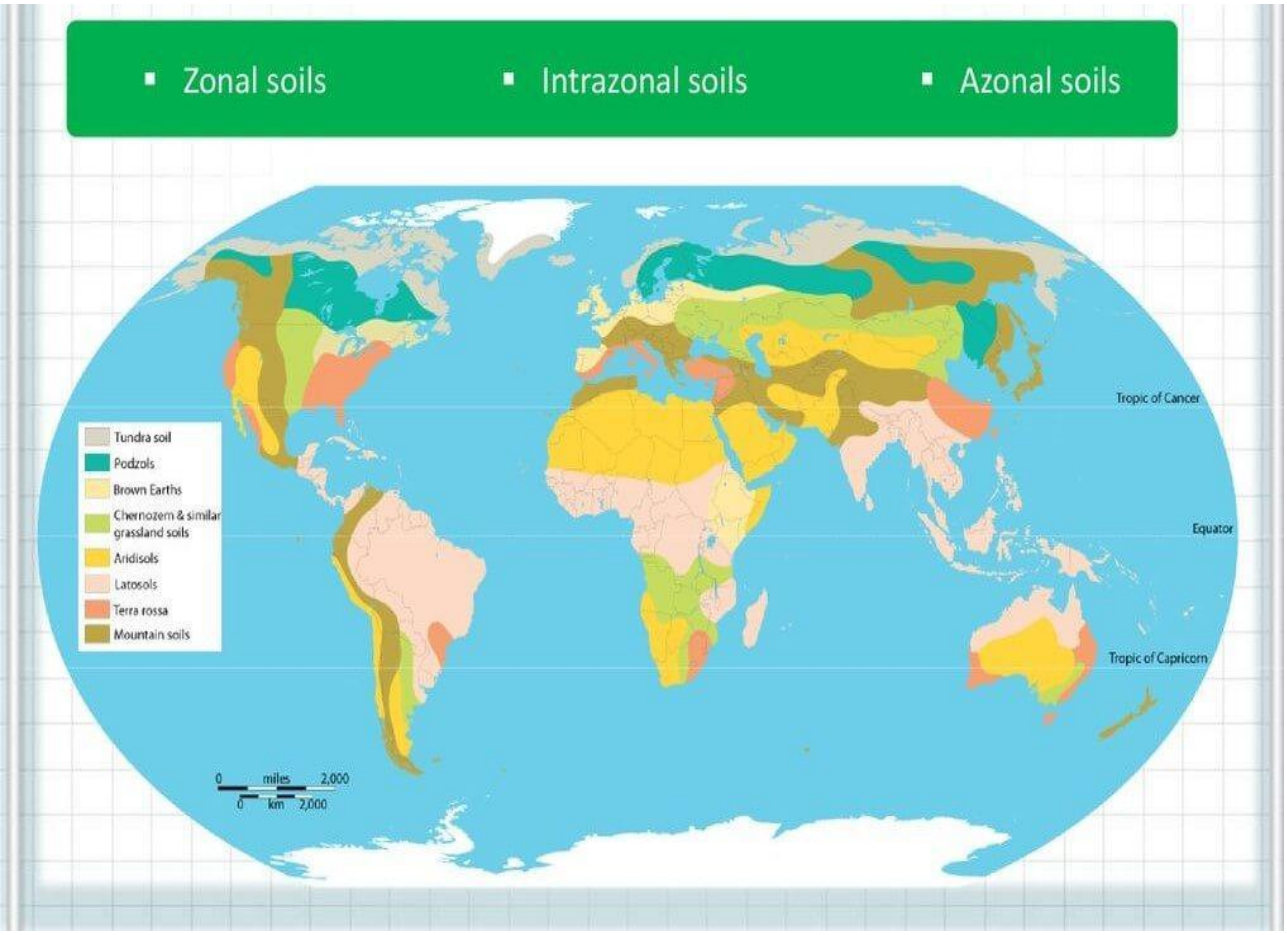
Chestnut soils:

Chestnut soils occur on the arid side of the Chernozem belt under natural vegetation of low grass-steppe.

- The **alluvial carbonate layer is closer** to the surface than in **chernozems** and they have a lower organic content.

Prairie soils:

Prairie soils occupy the **transition zone of increasing wetness** between chernozems and forest brown earth



Grumusols:

These are **dark clayey soils of savanna or grass-covered** areas that have a warm climate with wet and dry seasons.

- There are no eluvial or illuvial horizons, but the whole **solum is rich in bases, especially calcium, and hence its dark colour.**
- These soils are characterized by a high degree of dry-season cracking.

Ferralsols:

Soils of intertropical areas are often referred to as lateritic, but strictly speaking, laterite is a weathering product and not a soil type.

- Most tropical soils are, however, **rich in ferric oxide and are collectively known as Ferralsols.**
- The abundance of **sesquioxides of iron and aluminium accounts for the red**, brown or occasionally yellow colour of the soil.

- The **A horizon makes up the first meter of a typical profile** and is usually acidic with a low humus content.
- The **B horizon** commonly extends to fifteen meters or more and is predominantly clayey.
- Ferralsols soils are low in fertility because of the lack of humus and bases.

Intrazonal Types

These soils occur within other zonal soils. It is a **well-developed soil reflecting the influence of some local factor of relief**, parent material, or age rather than of climate and vegetation.

Hydromorphic soils

Hydromorphic soils are those which have undergone gleying and are associated with marshes, swamps or poorly drained uplands.

- Two main types can be recognized, according to the position of the water-table in the profile:
- **groundwater gleys,** where groundwater is below the surface
- **surface-water gleys.**
- Gleying is essentially the **process of waterlogging** and reduction in soils.
- In waterlogged soils where water replaces air in pores, oxygen is quickly used up by microbes feeding on soil organic matter.

Calcimorphic soils

Calcimorphic soils develop on **calcareous parent material.** Rendzinas are **dark, organic rich, and are associated with chalk rock in Britain.**

  - Another **Calcimorphic soil is terra rossa,** which by contrast is a predominantly mineral soil and is found mainly in the Mediterranean region.
  - The upper horizons are rich in clay and reddish in colour, sharply contrasting with the parent material.

Halomorphic (saline) soils

Halomorphic (saline) soils are mostly found in deserts. There are three common types in this group.

- **Solonchak** (white alkali soils) develop in **depressions and exhibit white salt crusts in dry periods**.
- **Solonetz** (black alkali soils) are the **product of intense alkalinisation** and are characterised by the presence of sodium carbonate.
- **Solodic soils** develop when **leaching in the presence of excess sodium** causes the loss of clays and sesquioxides, forming a bleached, eluviated horizon looking rather like a podzol.

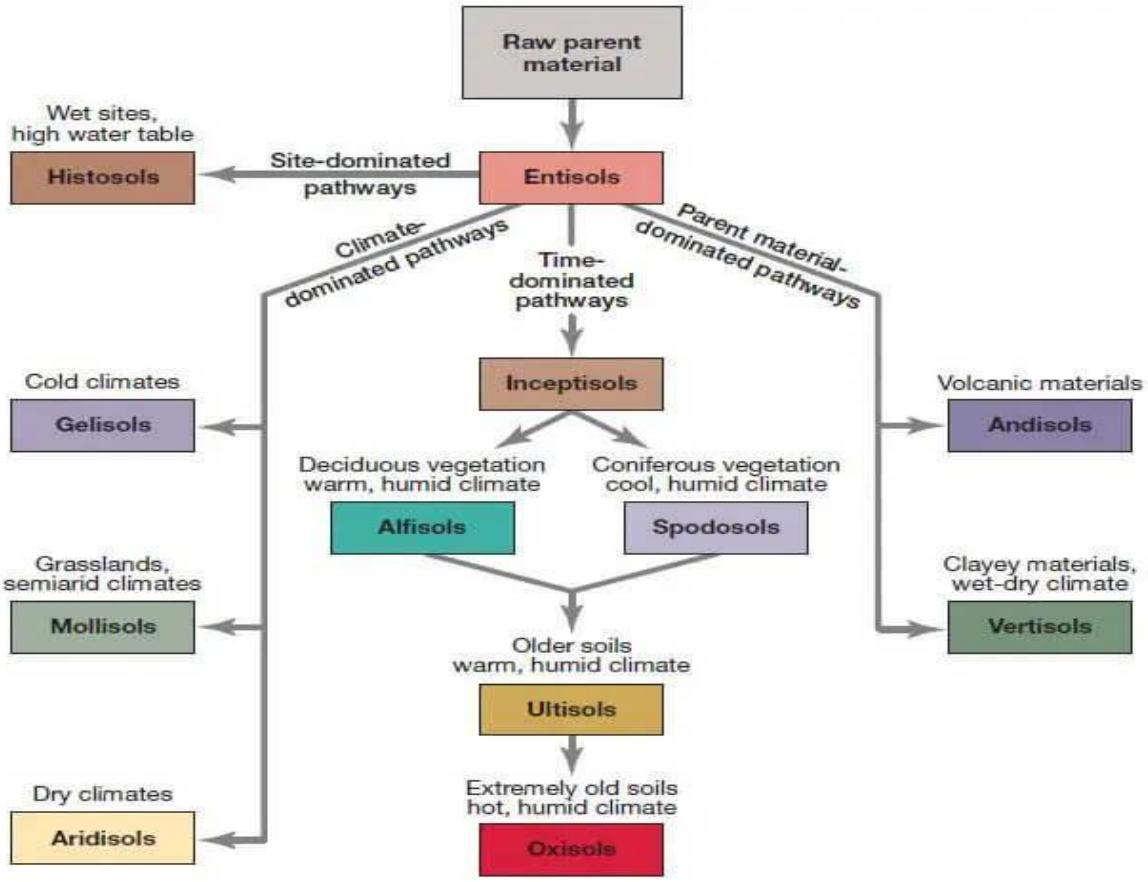
Azonal Soils

It is that soil that has been developed by the process of deposition by the agents of erosion.

- It means that it has been **made by the fine rocky particles transported** from the far-off regions.
- These are **immature soils and lack** well-developed soil profiles.

- This may be due to the **non-availability of sufficient time for them to develop fully** or due to the location on very steep slopes which prohibits profile development.
- Immature soils may exist because of the characteristics of the parent material or the nature of the terrain, or simply the lack of time for development.
- Such situations typically occur in areas where fresh parent material is being deposited or exposed.
- For example, on active flood-plains, alluvial soils have little or no profile development, because of their frequent burial under new sediments;
- **Regosols** are composed of dry and loose dune sands or loess.
- **Lithosols** are accumulations of imperfectly weathered rock fragments on steep slopes where erosion rates remove soil almost as fast as it is formed.

USDA CATEGORISATION OF SOILS



TRIBES OF WORLD

- **Abhors**: Mongolian living between Assam and Eastern tribes
- **Afridis**: North West Frontier (Pakistan)

- **Aleuts**: Alaska
- **Ainus**: Japan
- **Bantus**: Negros living in Central and South Africa
- **Bedouin**: Sahara and Middle East
- **Bindibu** or **Aborigines**: Australia
- **Boers**: Dutch settlers of South Africa
- **Bushman**: Kalahari
- **Chukchi**: NE Asia, USSR, North Siberia
- **Cossacks**: Southern and Eastern frontiers of Russia
- **Eskimos**: Greenland, North Canada, Alaska, N Siberia, Arctic region
- **Fulani**: Western Africa
- **Fleming**: People of Belgium
- **Gobi Mongols**: Gobi
- **Guicas**: Amazon forest area
- **Hamites**: North-West Africa
- **Hausa**: North Nigeria
- **Hottentots**: Hot tropical Africa
- **Ibanas**: Equatorial rain forest region of South-East Asia
- **India Tribes**: Amazon basin
- **Kalmuk**: Central Asia
- **Kazakhs**: Kazakhstan
- **Kirghiz**: People living in Central Asia
- **Koryaks**: N. Siberia, Eurasian
- **Kurds**: Kurdistan, Iraq
- **Lapps**: N. Finland, Scandinavian country
- **Magyar**: Hungary
- **Maoris**: New Zealand
- **Masai**: East & Central Africa
- **Meos**: Myanmar
- **Negros**: Mostly found in Africa
- **Orang Asli**: Malaysia
- **Pygmies**: Short sized people found in Congo basin in Africa
- **Red Indian**: North America
- **Semangs**: East Sumatra
- **Semites**: Caucasian people of ancient times
- **Tapiro**: Papua New Guinea
- **Turrets**: Sahara
- **Yakuts**: Siberia
- **Zulus**: People of South Africa living in a certain part of Natal

LOCAL WINDS OF WORLD

Local Winds	Nature of Wind	Places
Chinook (Snow eaters)	Hot, dry wind	The Rockies mountains

Foehn	Hot, dry wind	The Alps
Khamsin	Hot, dry wind	Egypt
Siroco	Hot, moist wind	Sahara to the Mediterranean Sea
Solano	Hot, moist wind	Sahara to the Iberian Peninsula
Harmattan (Guinea Doctor)	Hot, dry wind	West Africa
Bora	Cold, dry wind	Blows from Hungary to North Italy
Mistral	Cold wind	The Alps and France
Punas	Cold dry wind	The western side of Andes Mountain
Blizzard	Cold wind	Tundra region
Purga	Cold wind	Russia
Levanter	Cold wind	Spain
Norwester	Hot wind	New Zealand
Santa Ana	Hot wind	South California
Karaburun (black storm)	Hot dusty wind	Central Asia
Calima	Dust-laden dry wind	Saharan Air Layer across the Canary Islands
Elephanta	Moist wind in monsoon	Malabar coast

SETTLEMENTS GEOGRAPHY

Settlement refers to the cluster of houses over space which manifests the socioeconomic conditions and the environmental constraints. Thus, a settlement has both physical and social structures.

- It is not only about concrete houses but also about who resides there.
- The settlement is an expansion of the socio-historic, cultural, and religious perception of a man in a given geographic environment.
- The villages which had non-agricultural surplus developed into 'Mandis' and the transportation routes connected the Mandis and hence developed the urban settlements.

Criteria For Settlements

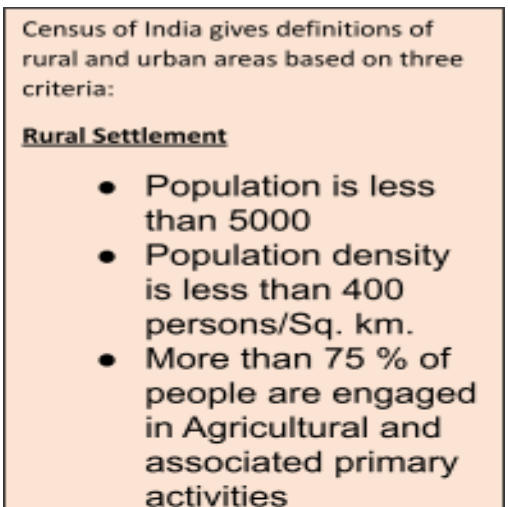
There are five criteria to differentiate between rural settlement and urban settlement

- **Morphology (the physical structure):** The urban structures are marked by tall buildings, wide roads, administrative and recreation centres in contrast to rural settlements which are usually agrarian landscapes.
- **Function (Primary, Secondary, Tertiary):** Rural areas basically have the majority of its population involved in primary functions whereas in urban areas people have secondary (manufacturing) and tertiary functions (services) as their major occupations.
- **Demography (high or low population density):** Urban areas are marked by high population density and compact settlements in comparison to rural areas where population density is relatively low and settlements are scattered.
- **Cultural traits:** The urban areas are marked by class stratification in contrast to the rural areas where the cast and religious stratification is more prominent.
- **Infrastructure:**
- **Economic infrastructure**: Economic infrastructure includes transportation, communication, etc. which is more developed in urban areas than rural areas.
- **Social infrastructure**: It includes health, education, recreation, etc. where urban areas score over rural areas.

Rural settlement

Any settlement in which most of the people are engaged in primary activities such as agriculture, forestry, mining, or fishing is known as a rural settlement.

- Rural settlements are the clusters of **unorganized, amorphous, closely knitted houses with poor ventilation and sewage/drainage pattern** and lanes meandering (meandering roads/not properly planned) and abruptly ending into houses.
- It **includes not only the village but also agricultural fields and areas of forestry and**



livestock raising which are functionally integrated with the village.

- They have **strong currents of social bonding**. Rural settlement signifies great centripetal force due to strong bonding between the people.
- Rural settlement constitutes both physical morphology and social morphology.
- Rural settlement comprises of the aggregate of the village, agricultural land, forestry, and livestock area.
- Rural settlement manifests socio-economic aspiration, their adaptability, the historical progression of a living civilization, and economic functionality.

Hamlet

A hamlet is a small human settlement.

- In British geography, a hamlet is considered smaller than a village and distinctly without a church.
- Officially, a hamlet differs from a village in having no commercial premises, but has residences and may have community buildings such as churches and public halls.

Village

A village is a clustered human settlement or community, larger than a hamlet but smaller than a town, with a population ranging from a few hundred to a few thousand.

- In the past, villages were a usual form of community for societies that practice subsistence agriculture, and also for some non-agricultural societies.
- According to the 2011 census of India, 68.84% of Indians (around 833.1 million people) live in 640,867 different villages.

Rurban (Rural + Urban)

Transitional Phase in between Rural and Urban settlements

- Run by Gram Panchayats
- Population is more than 5000 but less than 10,000.

Town

A town is a medium-sized human settlement. Towns are generally larger than villages but smaller than cities, though the criteria which constitute them vary considerably in different parts of the world.

- Large town – 20,000 to 1 lakh people
- Town – 5,000 to 20,000 people.
- Census towns are defined as places that satisfy the following criteria:
- Minimum population of 5,000
- At least 75% of male working population engaged in non-agricultural pursuits
- Density of population at least 400/km2. (1,000 per sq. mile).

City

A city is a large human settlement. Cities generally have extensive systems for housing, transportation, sanitation, utilities, land use, and communication.

- Their density facilitates interaction between people, government organizations, and businesses, sometimes benefiting different parties in the process.
- City – 1 lakh to 3 lakh Population
- Large City – 3 lakh to 1 million population.

Metropolis

A metropolis is a large city or conurbation which is a significant economic, political, and cultural center for a country or region, and an important hub for regional or international connections, commerce, and communications.

- The term is Ancient Greek and means the "mother city" of a colony (in the ancient sense), that is, the city that sent out settlers.
- Minimum Population – 1 to 3 million.
- **Conurbation** – 3 to 10 million people.

Megalopolis

The term was used by Patrick Geddes in his 1915 book Cities in Evolution. Jean Gottmann popularised this term in 1961.

- A megalopolis (sometimes called a megapolis; also megaregion, or supercity) is typically defined as a
chain of roughly adjacent metropolitan areas, which may be somewhat separated or may merge into a
continuous urban region.
- Megalopolis is derived from Greek:(mégas) meaning 'great' and (pólis) meaning 'city', therefore literally a 'great city'. This term is closer in meaning to megacity.
- A megalopolis, also known as a mega-region, is a clustered network of cities.
- Gottmann defined its population as 25 million.
- Doxiadis defined a small megalopolis as a similar cluster with a population of about 10 million.

Primate City

A primate city (Latin: "prime, first rank") is the largest city in its country or region, disproportionately larger than any others in the urban hierarchy.

- First proposed by the geographer Mark Jefferson in 1939.
- He defines a primate city as being "at least twice as large as the next largest city and more than twice as significant."
- Among the best known examples of primate cities are **London** and **Paris**.
- Other major primate cities include Athens, Baghdad, Bangkok, Budapest, Buenos Aires, Cairo, Dublin, Jakarta, Kuala Lumpur, Lima, Mexico City, Seoul, Tehran, and Vienna.

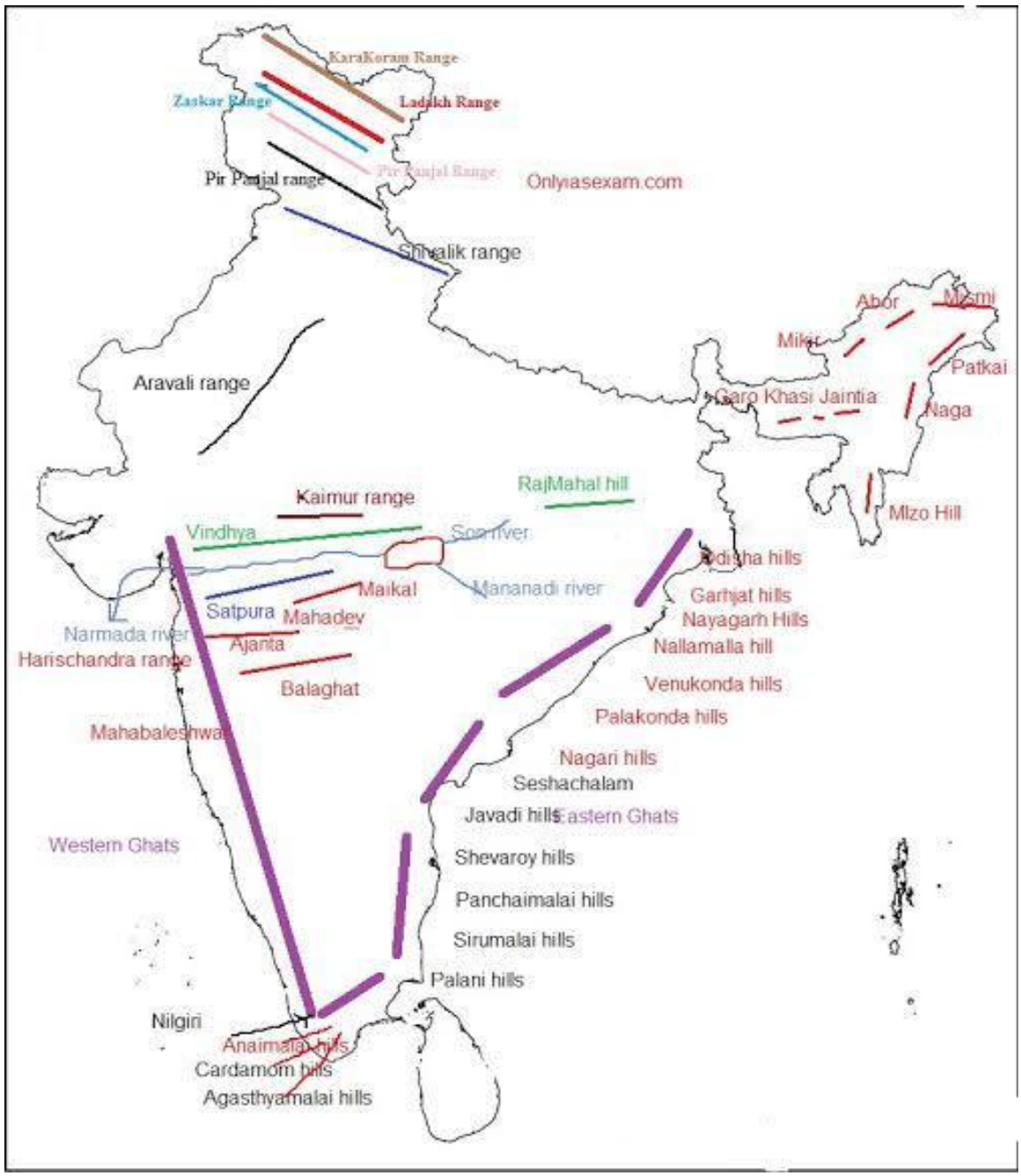
Top of Form

Bottom of Form

MAJOR MAP WORK

MOUNTAINS OF WORLD

THE MOUNTAINS OF WESTERN & EASTERN GHATS



INLAND SEAS OF WORLD

MAJOR RIVERS OF WORLD

MAINS Question (GS 1) – GEOGRAPHY

Topic: Salient Features of World Physical Geography; Important Geophysical phenomena (earthquakes, tsunami, volcanoes, cyclones); Geographical features and location;

Differentiate the causes of landslides in the Himalayan region and Western Ghats.	2021
Mention the global occurrence of volcanic eruptions in 2021 and their impact on regional environment	**2021**
Why is India considered as a sub-continent? Elaborate your answer	
Briefly mention the alignment of major mountain ranges of the world and explain their impact on local weather conditions, with examples	
Discuss the geophysical characteristics of Circum-Pacific Zone.	2020
The process of desertification does not have climatic boundaries. Justify with examples.	2020
Why is Indian Regional Navigational Satellite System (IRNSS) needed? How does it help in navigation?	2018
Define mantle plume and explain its role in plate tectonics.	2018
How does the Juno Mission of NASA help to understand the origin and evolution of the Earth?	2017
"The Himalayas are highly prone to landslides." Discuss the causes and suggest suitable measures of mitigation.	2016
Explain the formation of thousands of islands in Indonesian and Philippines archipelagos.	2014
Why are the world's fold mountain systems located along the margins of continents? Bring out the association between the global distribution of Fold Mountains and the earthquakes and volcanoes.	2014
What do you understand by the theory of continental drift? Discuss the prominent evidences in its support.	2013
There is no formation of deltas by rivers of the Western Ghat. Why?	2013
Major hot deserts in northern hemisphere are located between 20-30 degree north and on the western side of the continents. Why?	2013
Bring out the causes for more frequent landslides in the Himalayas than in Western Ghats	2013

Topic: Critical geographical features, flora, fauna (changes and effects thereof)

what are the environmental implications of the reclamation of the water bodies into urban land use? Explain with examples	2021
How do the melting of the Arctic ice and glaciers of the Antarctic differently affect the weather patterns and human activities on the Earth? Explain	2021
How will the meeting of Himalayan glaciers have a far-reaching impact on the water resources of India?	2020
Assess the impact of global warming on coral life system with examples.	2019
How do ocean currents and water masses differ in their impacts on marine life and the coastal environment? Give suitable examples?	2019
Discuss the causes of depletion of mangroves and explain their importance in maintaining coastal ecology.	2019

How can the mountain ecosystem be restored from the negative impact of development initiatives and tourism	2019
What is water stress? How and why does it differ regionally in India?	2019
What are the consequences of spreading of 'Dead Zones' on marine ecosystem?	2018
In spite of adverse environmental impact, coal mining is still inevitable for development." Discuss.	2017
Mention the advantages of the cultivation of pulse because of which the year 2016 was declared as the International Year of Pulses by the United Nations.	2017
How does the cryosphere affect global climate?	2017
Account for variations in oceanic salinity and discuss its multi-dimensional effects.	2017
In what way can flood be converted into a sustainable source of irrigation and all-weather inland navigation in India?	2017
What characteristics can be assigned to monsoon climate that succeeds in feeding more than 50 percent of the won population residing in Monsoon Asia?	2017
Discuss the concept of air mass and explain its role in macro-climatic changes.	2016
Explain the factors responsible for the origin of ocean currents. How do they influence regional climates, fishing and navigation?	2015
How far do you agree that the behavior of the Indian monsoon has been changing due to humanizing landscapes? Discuss.	2015
Tropical cyclones are largely confined to South China Sea, Bay of Bengal and Gulf of Mexico. Why?	2014
Most of the unusual climatic happenings are explained as an outcome of the El-Nino effect. Do you agree?	2014
Bring out the relationship between the shrinking Himalayan glaciers and the symptoms of climate change in the Indian sub-continent.	2014
The recent cyclone on the east coast of India was called "Phailin". How are the tropical cyclones named across the world?	2013
Bring out the causes for the formation of heat islands in the urban habitat of the world.	2013
What do you understand by the phenomenon of temperature inversion in meteorology? How does it affect the weather and the habitants of the place?	2013

Topic: Distribution of key Natural Resources (world, S. Asia, Indian subcontinent)

Despite India being one of the countries of the Gondwanaland, its mining industry contributes much less to its Gross Domestic Product(GDP) in percentage. Discuss.	2021
Discuss the multi-dimensional implications of uneven distribution of mineral oil in the world.	2021
The interlinking of rivers can provide viable solutions to the multi-dimensional inter-related problems of droughts, floods and interrupted navigation. Critically examine.	2020
India has immense potential of solar energy though there are regional variations in its development. Elaborate.	2020
Examine the status of forest resources of India and its resultant impact on climate change.	2020
Can the strategy of regional-resource based manufacturing help in promoting employment in India?	2019
Why is India taking keen interest in resources of Arctic Region?	2018

The effective management of land and water resources will drastically reduce the human miseries. Explain	2016
South China Sea has assumed great geopolitical significance in the present context. Comment.	2016
Present an account of the Indus Water Treaty and examine its ecological, economic and political implications in the context of changing bilateral relations.	2016
Enumerate the problems and prospects of inland water transport in India.	2016
In what way micro-watershed Development projects help in water conservation in drought prone and semi-arid regions of India.	2016
What are the economic significances of discovery of oil in Arctic Sea and its possible environmental consequences?	2015
India is well endowed with fresh water resources. Critically examine why it still suffers from water scarcity.	2015
The states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand reaching the limits of their ecological carrying capacity due to tourism. Critically evaluate.	2015
Critically evaluate the various resources of the oceans which can be harnessed to meet the resource crisis in the world.	2014
How does India see its place in the economic space of rising natural resource rich Africa?	2014
With growing scarcity of fossil fuels, the atomic energy is gaining more and more significance in India. Discuss the availability of raw material required for the generation of atomic energy in India and in the world.	2013
It is said the India has substantial reserves of shale oil and gas, which can feed the needs of country for quarter century. However, tapping of the resources doesn't appear to be high on the agenda. Discuss critically the availability and issues involved.	2013

Topic: Factors responsible for location of Industries (primary, secondary, tertiary; India, world)

What are the main socio-economic implications arising out of the development of IT industries in major cities of India	2021
Account for the present location of iron and steel industries away from the source of raw material, by giving examples.	2020
Discuss the factors for localization of agro-based food processing industries of North-West India.	2019
Define blue revolution, explain the problems and strategies for pisciculture development in India.	2018
What is the significance of Industrial Corridors in India? Identify industrial corridors, explain their main characteristics.	2018
Petroleum refineries are not necessarily located nearer to crude oil producing areas, particularly in many of the developing countries. Explain its implications.	2017
Whereas the British planters had developed tea gardens all along the Shivaliks and Lesser Himalayas from Assam to Himachal Pradesh, in effect they did not succeed beyond the Darjeeling area. Explain.	2014
Account for the change in the spatial pattern of the Iron and Steel industry in the world.	2014
Why did the Green Revolution in India virtually by-pass the eastern region despite fertile soil and good availability of water?	2014
Do you agree that there is a growing trend of opening new sugar mills in the Southern states of India? Discuss with justification	2013

Analyze the factors for highly decentralized cotton textile industry in India	2013

Topic: Urbanization: problems and remedies

Account for the huge flooding of million cities in India including the smart ones like Hyderabad and Pune. Suggest lasting remedies.	2020
How is efficient and affordable urban mass transport key to the rapid economic development of India?	2019
"The ideal solution of depleting ground water resources in India is water harvesting system." How can it be made effective in urban areas?	2018
The growth of cities as I.T. hubs has opened up new avenues employment but has also created new problems. Substantiate this statement with examples. Urbanization	2017
With a brief background of quality of urban life in India, introduce the objectives and strategy of the 'Smart City Programme'.	2016
Major cities of India are becoming more vulnerable to flood conditions. Discuss.	2016
Mumbai, Delhi and Kolkata are the three mega cities of the country but the air pollution is much more serious problem in Delhi as compared to the other two. Why is this so?	2015
Smart cities in India cannot sustain without smart villages. Discuss this statement in the backdrop of rural urban integration.	2015
Discussion the various social problems which originated out of the speedy process of urbanization in India.	2013

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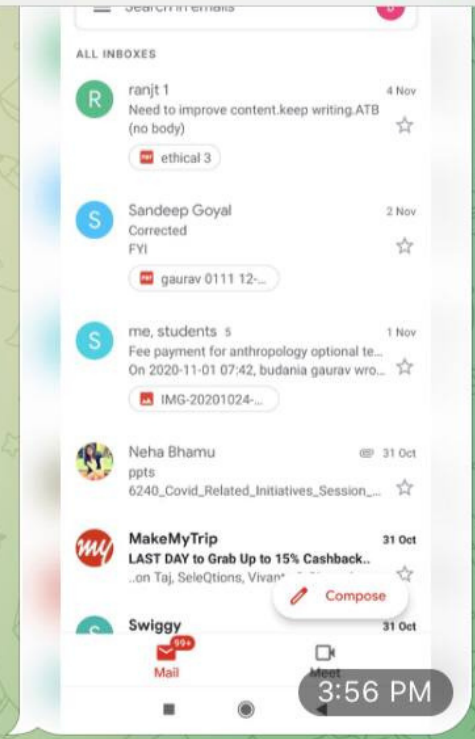


November 29, 2020

Hey 9:54 AM

January 20

Thank you sir to you and your team 7:06 PM

For answer writing 7:06 PM

We all the friends got benefited from your team and their analysis ....now hoping for good results 7:07 PM

YouTube channel link for our video series 9:44 PM

https://m.youtube.com/c/IASNETWORK 9:44 PM

Can use questions from any source though 9:44 PM

Yes sir , rest i know all about procedure 9:45 PM

Ok sir 9:49 PM

September 24

Hey 8:32 PM

Congratulations 9:27 PM

If I am correct 9:27 PM

Rank 13 9:27 PM

Hearty congratulations 9:38 PM

September 25

Thank you sir 4:40 AM

Gaurav Singh Rank 1 BPSC

last seen recently

Sir.. 65th BPSC AIR-1 6:04 PM

You secured 1st rank ? 6:06 PM ✓✓

Whoa !!!! 6:06 PM ✓✓

Congratulations 🎉 6:07 PM ✓✓

> IAS NETWORK
> You secured 1st rank ?

Yes sir 6:22 PM

Congratulations, Enjoy your moments 6:22 PM ✓✓

> IAS NETWORK
> Atleast clearing exam

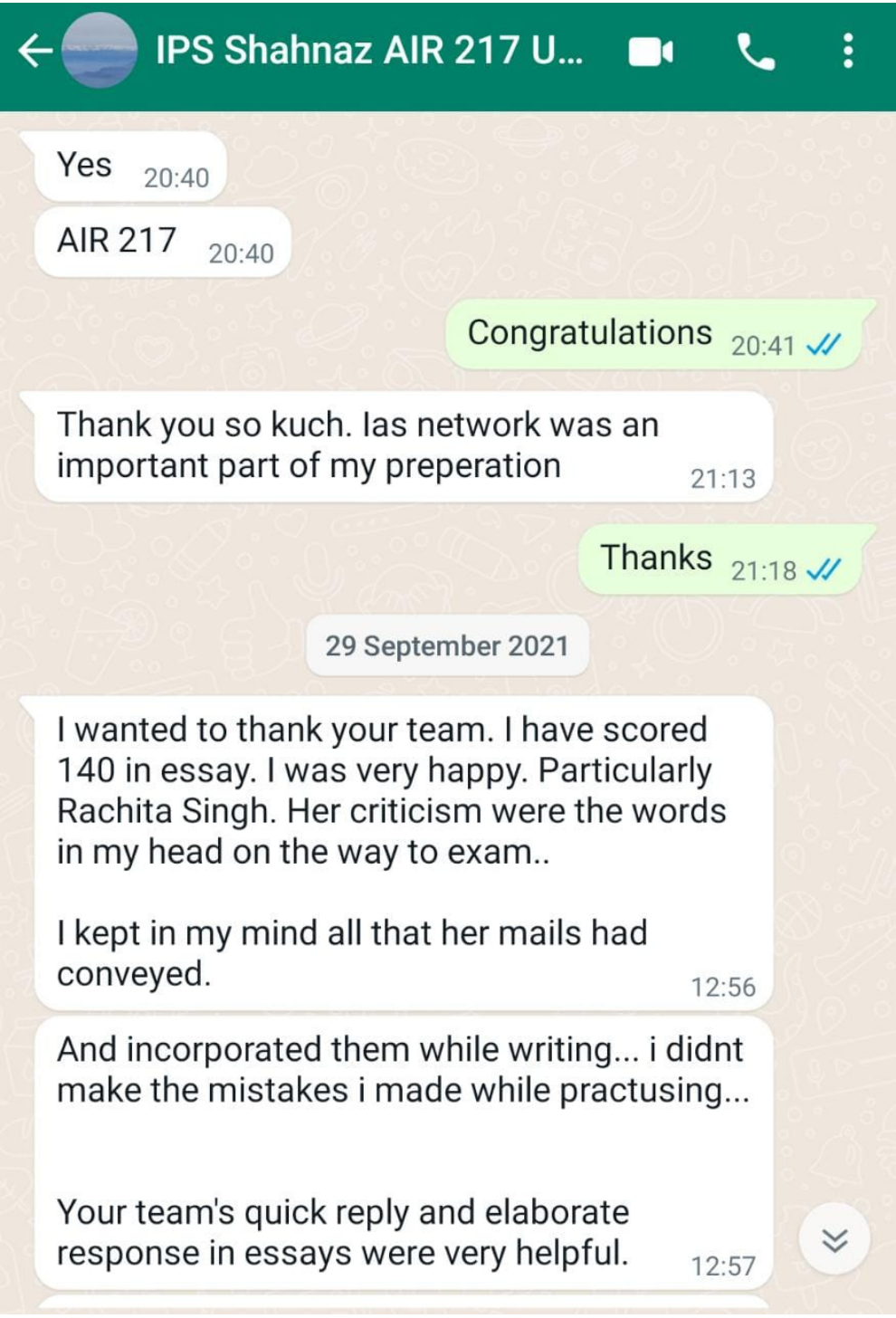
Also this 6:23 PM ✓✓

You should be happy now 😀😀 6:23 PM ✓✓

😌😌 6:23 PM

Yes sir 6:23 PM

Enjoy Bro, You deserve it 👍👍


IPS Shahnaz AIR 217 U...
Yes 20:40
AIR 217 20:40
Congratulations 20:41
Thank you so kuch. Ias network was an important part of my preperation 21:13
Thanks 21:18
29 September 2021
I wanted to thank your team. I have scored 140 in essay. I was very happy. Particularly Rachita Singh. Her criticism were the words in my head on the way to exam..
I kept in my mind all that her mails had conveyed. 12:56
And incorporated them while writing... i didnt make the mistakes i made while practusing...
Your team's quick reply and elaborate response in essays were very helpful. 12:57

Thank you so kuch. las network was an important part of my preperation 21:13

Thanks 21:18

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And incorporated them while writing... i didnt make the mistakes i made while practusing...

Your team's quick reply and elaborate response in essays were very helpful. 12:57

O have referred you to couple of aspirants!

Keep up the good work! Kudos tp u and ur team 12:58

Thanks 👍 12:57

Swathika GS PSIR 10K

Can you please resend your queries 14:07 ✓

20 December 2020

?? 10:34 ✓

Today

Good evening Sir 00:12

I am Swathika. Got 593 rank 00:12

I am truly grateful for your timely evaluation of my GS and PSIR answer papers 😀 00:13

I will need your continued support to improve the rank further Sir 😀 00:13

Congratulations 00:36 ✓✓

 00:36 ✓✓

> **Swathika GS PSIR 10k**
> I will need your continued support to improve the rank further Sir 😀

Sure 00:47 ✓✓

Congratulations 7:07 PM

Thank you friend 7:21 PM

442 rank 7:21 PM

Today

Getting good marks in mains is very vital for getting into the final list. For this, continuous practice is a must. But practice without unbiased assessment fails to explain to us our mistakes. This is where IAS NETWORK has helped me. It provided a precise, unbiased, and to the point evaluation of my answers. Which helped me to improve the content and structure of my answers. The eassy and optional evaluation also helped me tremendously. Moreover, they provide the evaluation in less than 2 days, which helps in constantly modifying and improving our answers in accordance with the feedback. Thank you IAS NETWORK! 3:14 PM

Thanks 3:15 PM

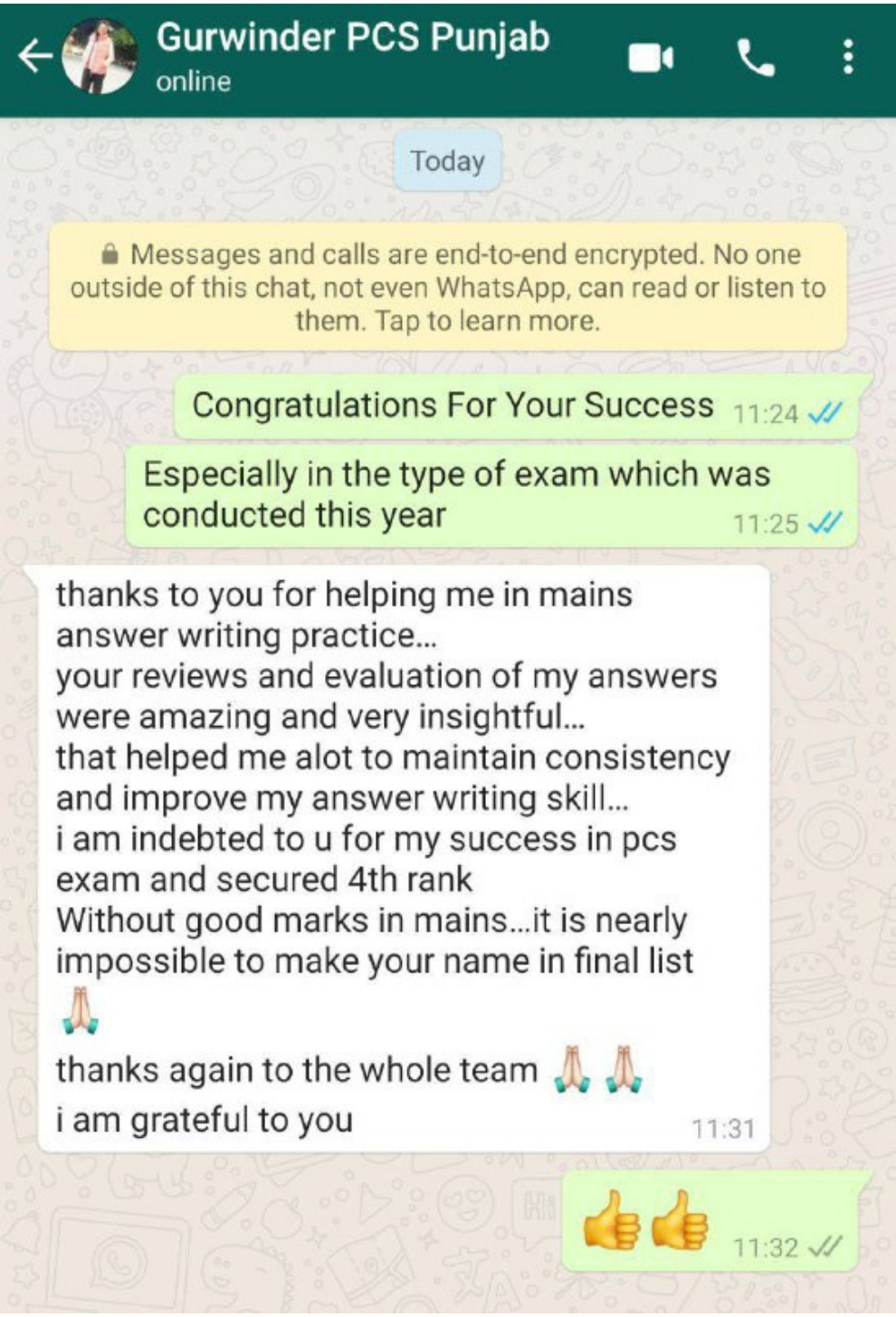
So I took this attempt very lightly (being my first one). Didn't study even Vision Mains 365 or monthlies, didn't take a single test series for GS or PSIR. Only thing I did for GS was go through IAS Network's GS 1,2,3,4 notes, and SR Ma'am notes for PSIR. Along with it, I made my frameworks and short notes of 45 pages for all the papers of GS. So this was my Mains prep last time, don't want to commit the mistake again 16:19

Hmm, Thanks 16:20

BTW good to see that you got a rank from our notes only, don't know how many more toppers we have, whom we are not in touch with, are notes were freely shared 16:21

> **You**
> BTW good to see that you got a rank from our notes only, don't know how many more toppers we have, whom we are not in touch with, are not...

You are doing a great service. I also used to watch the daily answer writing videos of Nagesh Sir, and one more person, sometimes during the 3 months of Mains prep. That was helpful too. 16:23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Today
Messages and calls are end-to-end encrypted. No one outside of this chat, not even WhatsApp, can read or listen to them. Tap to learn more.
Congratulations For Your Success 11:24
Especially in the type of exam which was conducted this year 11:25
thanks to you for helping me in mains answer writing practice...
your reviews and evaluation of my answers were amazing and very insightful...
that helped me alot to maintain consistency and improve my answer writing skill...
i am indebted to u for my success in pcs exam and secured 4th rank
Without good marks in mains...it is nearly impossible to make your name in final list
thanks again to the whole team
i am grateful to you 11:31
11:32