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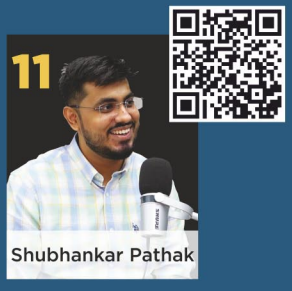

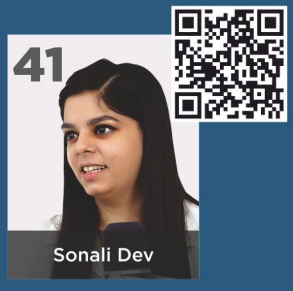

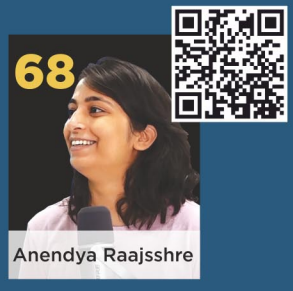

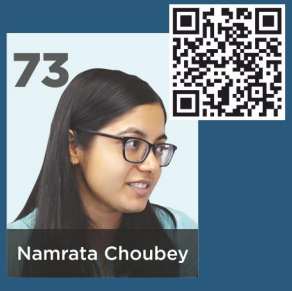

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PREFACE

Dear Aspirants,

This special issue of mains compass is focused on core geography topics and industrial geography topics in paper I of the General Studies mains syllabus. Earlier, we used to have a combined book catering to both Geography and Environment, but on the demand of students and considering the bulky size of the book we have decided to make separate Mains Compasses for Geography and Environment for this year.

The focus of this book is not to teach geography in its entirety but to cater to specialised knowledge especially from the mains exam point of view. We have tried to cover contemporary issues, which are always of interest for the UPSC exam.

Hopefully students will gain from this book and appreciate our efforts. For best results, students are advised to follow our mains QIP courses along with this book, where these topics will be discussed.

Hoping that you shine like a diamond.

Rau's IAS Study Circle

CONTENTS

Syllabus Geography

GEOGRAPHY (GS PAPER-1)

- Salient features of world's physical geography.
- Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclone etc.
- Geographical features and their location-changes in critical geographical features (including water bodies and icecaps) and in flora and fauna and the effects of such changes.

Previous Year Questions and Theme Map

THEME 1: PHYSICAL GEOGRAPHY	
YEAR	**UPSC MAINS QUESTIONS**
2021	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	Briefly mention the alignment of major mountain ranges of the world and explain their impact on local weather conditions, with examples.
2020	Discuss the geophysical characteristics of Circum-Pacific Zone.
2020	The process of desertification does not have climatic boundaries. Justify with examples
2019	How do ocean currents and water masses differ in their impacts on marine life and the coastal environment? Give suitable examples.
2018	Define mantle plume and explain its role in plate tectonics.
2015	Explain the factors responsible for the origin of ocean currents. How do they influence regional climates, fishing and navigation?
2014	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.
2013	What do you understand by the theory of continental drift? Discuss the prominent evidences in its support.
2013	Major hot deserts in northern hemisphere are located between 20-30 degree north and on the western side of the continents. Why?
2013	There is no formation of deltas by rivers of the Western Ghats. Why?
2013	Major hot deserts in northern hemisphere are located between 20-30 degree north and on the western side of the continents. Why?

THEME 2: INDUSTRIAL LOCATIONS & RESOURCES	
YEAR	**UPSC MAINS QUESTIONS**
2021	Discuss the multi-dimensional implications of uneven distribution of mineral oil in the world.
2021	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.
2020	Account for the present location of iron and steel industries away from the source of raw material, by giving examples.
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	Describe the benefits of deriving electric energy from sunlight in contrast to the conventional energy generation. What are the initiatives offered by our government for this purpose?
2019	Can the strategy of regional resource-based manufacturing help in promoting employment in India?
2019	Discuss the factors for the localisation of agro-based food processing industries of North-West India.
2018	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	Why is Indian Regional Navigational Satellite System (IRNSS) needed? How does it help in navigation?
2016	Give an account of the current status and the targets to be achieved pertaining to renewable energy sources in the country. Discuss in brief the importance of National Program on Light Emitting Diodes (LEDs).
2015	To what factors can the recent dramatic fall in equipment costs and tariff of solar energy be attributed? What implications does the trend have for the thermal power producers and the related industry?
2014	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?
2013	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

PHYSICAL GEOGRAPHY

Previous Year Questions

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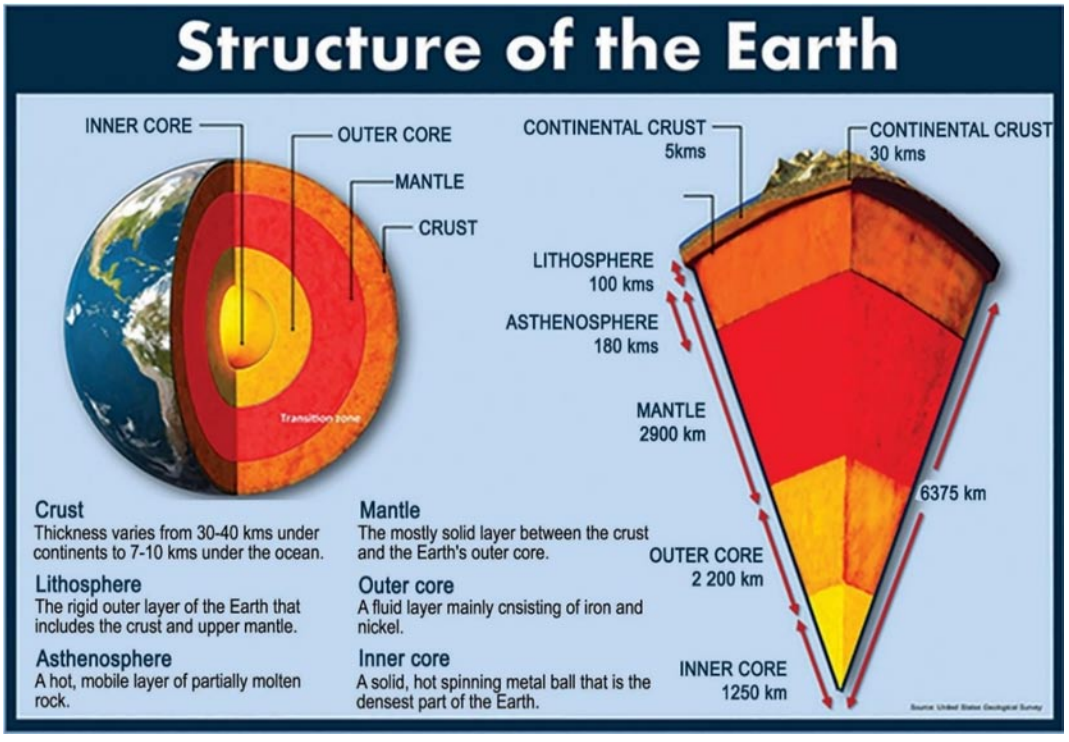
GEOMORPHOLOGY

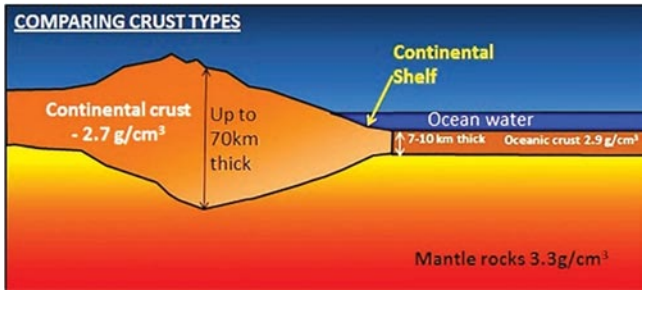
►STRUCTURE OF EARTH



LAYERS OF EARTH

CRUST

- It is the outermost solid part of the earth.
- Brittle in nature.
- Average density of the outer and lower crust is 2.8 and 3.0, respectively. Seismological evidence suggests similarity of structure and composition of these two layers. The lower crust being denser because of supper incumbent load.
- Thickness of crust varies under oceanic & continental areas.
- Oceanic crust is thinner as compared to the continental crust. The mean thickness of Oceanic crust is 5 km whereas that of continental is around 30 km.
- Continental crust is thicker in areas of major mountain systems. For ex. 70 km thick in Himalayan region.



MANTLE

- Portion of interior beyond the crust is called mantle.
- Mantle extends from Moho's discontinuity to a depth of 2,900 km. It is extending up to 400 km.
- Upper portion of mantle is called asthenosphere. The word astheno means weak. Asthenosphere is lower part of the lithosphere and is in a partially molten condition whereby molten magma is in motion.
- Main source of magma that finds its way to surface during volcanic eruptions.
- Crust and uppermost part of mantle are called lithosphere. Its thickness ranges from 10-200 km.
- Earlier, Mantle was divided into two zones: (i) Upper Mantle from Moho's discontinuity to 1000 km depth (ii) Lower Mantle from 1000 to 2900 km depth.
- Now, according to International Union of Geodesy and Geophysics, Mantle is divided into three zones.
    - Zone 1: Moho's discontinuity to 200 km depth
    - Zone 2: 200 – 700 km depth
    - Zone 3: 700 – 2900 km depth
    - Velocity of seismic waves relatively slows down in uppermost zone of upper mantle for a depth of 100-200 km. This is called as zone of low velocity.
- Lower mantle extends beyond asthenosphere. It is in

solid state.

CORE

- Core-mantle boundary is located at depth of 2,900 km.
- Outer core is in liquid state while inner core is in solid state. S-Waves disappear in outer core (5150 km is the boundary line)
- Core is made up of very heavy material mostly constituted by nickel and iron.
- It is sometimes referred to as the nife layer.

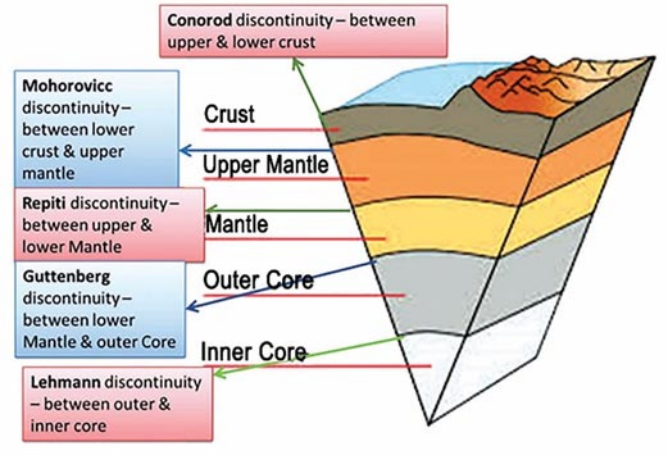
DISCONTINUITY

There are layers within Earth which have different characteristics. All these layers are separated from each other through a transition zone. These transition zones are called discontinuities.

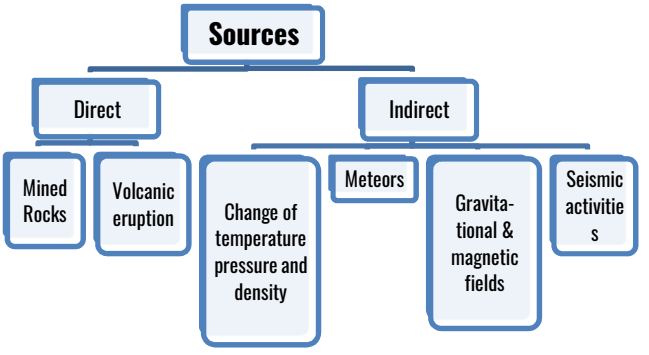
They are marked by clear-cut variations in density of material, velocity of seismic waves, temperature and pressure conditions.

Five discontinuities in Earth are:

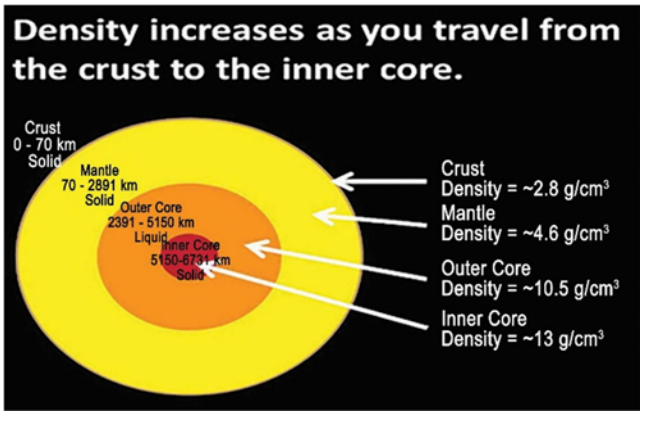
- Conrad Discontinuity: Transition zone between SIAL and SIMA.
- Mohorovic Discontinuity: Transition zone between the Crust and Mantle.
- Repiti Discontinuity: Transition zone between Outer mantle and Inner mantle.
- Gutenberg Discontinuity: Transition zone between Mantle and Core.
- Lehman Discontinuity: Transition zone between Outer core and Inner core.



►SOURCES OF INFORMATION ABOUT EARTH'S INTERIOR



- Mined rocks give us samples for direct observation. We get rocks directly from below the earth surface. However, there is a limit to mining. Going beyond 4 km of depth is not feasible as the temperature rise is very significant beyond this depth.
- Volcanic eruption: As and when the molten material (magma) is thrown onto surface of the earth, during volcanic eruption it becomes available for laboratory analysis. However, it is difficult to ascertain the depth of the source of such magma. Further it also hints towards the presence of molten/ semi molten layer (magma chamber) within the solid Earth.
- Rate of change of temperature, pressure and density indirectly help us to ascertain the structure, composition and thickness of the earth.
  - Observable density of outer crust is around 3.0-3.5 and by Newton's gravitational law avg. density of Earth is near 5.5. This means that density successive layers must increase and must be more than 5.5. This further proves that Earth is made up of different materials whose density increases with increasing depth. (SiAl > SiMa > NiFe)
  - Temperature rise per km is around 25^{o} C. If this is true, then temperature at 2900 km depth would be around 72500 ^{o} C, way beyond the melting point 1200 ^{o} C. At such a high temperature, Earth would have melted. Thus, even though temperature rises with depth inside Earth, but rate of temperature rise decreases with increasing depth.



Meteors that at times reach the earth. However, it may be noted that the material that becomes available for analysis from meteors, is not from the interior of the earth. The material and the structure observed in the meteors are like that of the earth. They are solid bodies developed out of materials same as, or like our planet. Hence, this becomes yet another source of information about the interior of the earth.

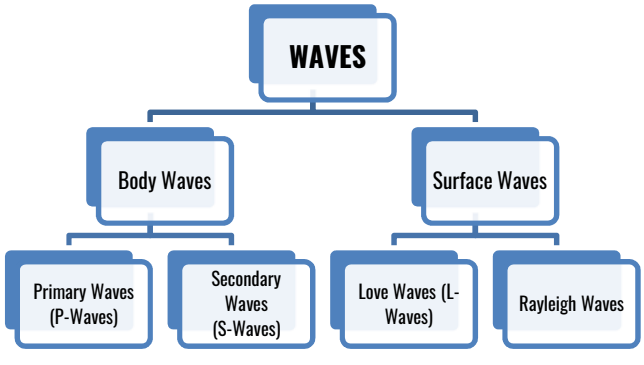
Meteoroids: Before the small bit of comet or asteroid enter Earth's atmosphere, it floats through interplanetary space and is called a meteoroid.

Meteors: Meteoroids which enter atmosphere and burn up completely.

Meteorites: Meteoroids reaching Earth's surface.

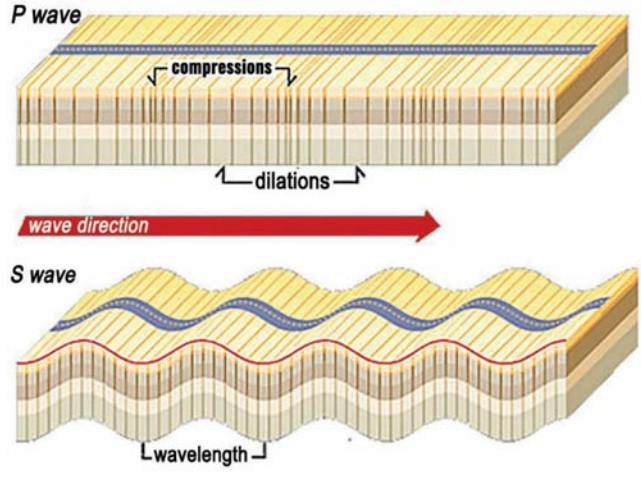
- Gravitational force is different at different latitudes on the surface (greater near the poles and less at the equator because of higher distance from the centre at the equator). The uneven distribution of mass of material within the earth influences this value. These readings differ from the expected values. Such a difference is called gravity anomaly. Gravity anomalies give us information about the distribution of mass of the material in the crust of the earth.
- Seismic waves travel differently in different mediums. Their direction and velocity change upon entering new mediums. Further the shadow zones of different seismic waves also differ. This helps us to understand the compositions of the Earth's interior.

►EARTHQUAKE WAVES



BODY WAVES

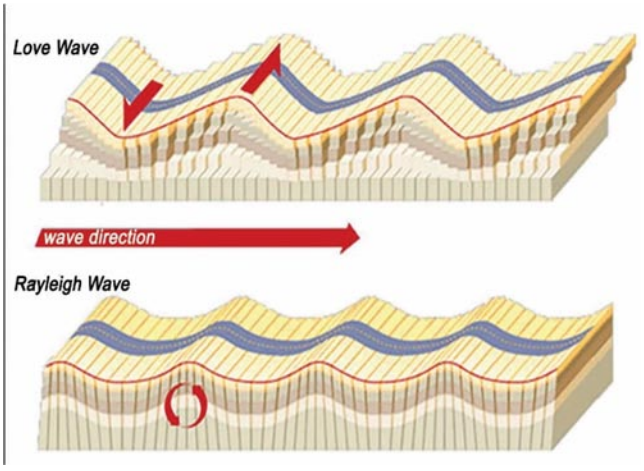
- Generated due to release of energy at the focus and travel in all directions within the body of the Earth.
- The velocity as well as direction of waves changes as they travel through materials with different densities. The denser the material, the higher is the velocity. Reflection causes waves to rebound whereas refraction makes waves move in different directions



P- WAVES (PRIMARY WAVES)	S-WAVES (SECONDARY WAVES)
• Move faster and are first to arrive at surface.	• Arrive at surface with some time lag.
• Travel through gaseous, liquid and solid materials.	• Can travel only through solid materials.
• Vibrate parallel to direction of the wave *(Longitudinal waves).* This leads to density differences in material because of stretching and squeezing of the material.	• Direction of vibrations is perpendicular to wave direction in vertical plane *(Transverse Waves).* Hence, they create troughs and crests in material through which they pass.
• Also called as 'compressional waves'	• Also called as 'distortional waves'

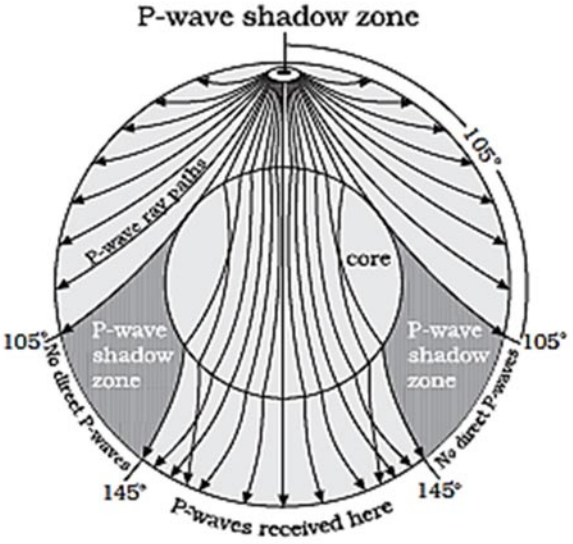
SURFACE WAVES

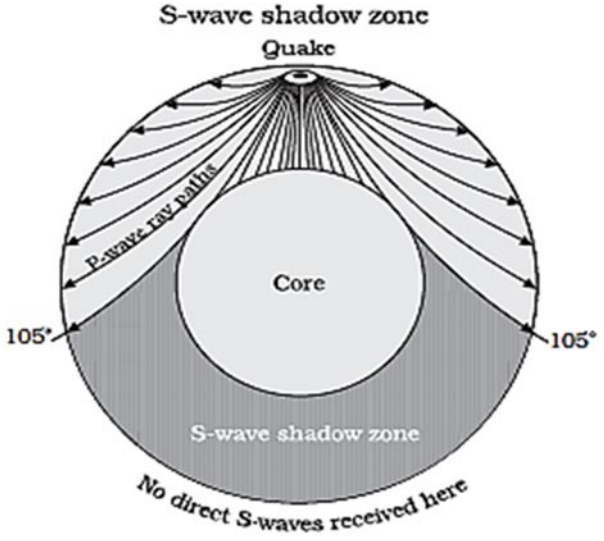
- The body waves when interact with surface rocks, they generate new waves called as surface waves.
- Also called as long period waves.
- Surface waves are last to report on seismograph, but they cover longest distance of all seismic waves.
- These waves are more destructive. They cause displacement of rocks, and hence, the collapse of structures occurs.



CONCEPT OF SHADOW ZONES

- Shadow zones are angular areas from the given earthquake where the seismographs do not record any earthquake waves. These are different for P and S waves. Further, they also vary with each earthquake.

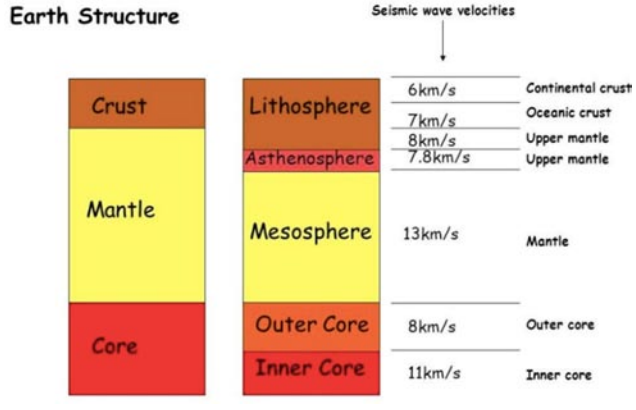




- Angles are measured with respect to the Epicentre.
  - < 105 degrees = No shadow zone for P as well as S waves (Both waves are recorded by seismograph)
  - 105-145 degree = Shadow zones for both (Both P & S waves are not recorded)
  - > 145 degrees = Shadow zone for S waves (P waves recorded)

ROLE OF SEISMIC WAVES IN UNDERSTANDING EARTH'S INTERIOR

- Non-linear travel path confirms that the Earth's structure in not homogeneous rather heterogeneous.
- Curved path tells us that on an average there is an increase in density as one move deeper into the earth.
- Based on change of velocity of these waves it is proved that there are three locations where there are major velocities changes hence help us to infer that there are three zones/layers of varying densities inside the Earth.
- Bouncing back of the waves after hitting the abrupt boundary between two layers help to determine the depth of the discontinuities and thickness of various layers.
- Absence of S-waves inside the core confirms the presence of liquid core at the depth of 2900 km.
- The velocity decreases in upper part of the upper mantle for a depth of 100-200 km which confirms the presence of lighter material in between.



►FORCES ACTING ON EARTH

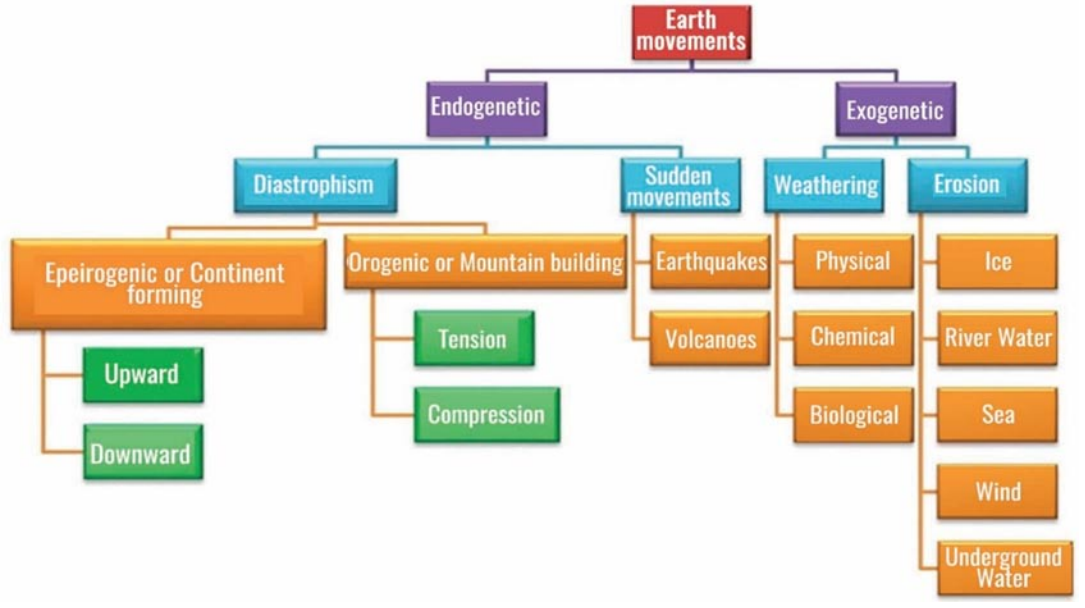
The configuration of the earth is the result of various processes operating within as well as outside the earth. Multiple forces affect the earth's crust.

ENDOGENETIC FORCES

- Present within the earth hence also called as internal

forces.

- These lead to vertical and horizontal movements and result in subsidence, land upliftment, volcanism, faulting, folding, earthquakes, etc.
- They are land building forces that play a crucial role in the formation of the earth's crust.
- Primordial heat, radioactivity, tidal and rotational friction from the earth results in the creation of these forces.



- Diastrophic forces are slow movements. It involves epeirogenetic and orogenetic movements.
  - Epeirogenetic movements are the vertical forces and are responsible for continent building. These vertical movements can lead to submergence as well as emergence.
  - Orogenetic movements are the horizontal forces and are responsible for mountain building. They can be categorized into two major pressures such as the pressure of tension and pressure of compression.
- Catastrophic forces are fast movements like earthquakes.

EXOGENETIC FORCES

- Forces acting outside the earth hence are called as external forces.
- They are land modifying forces because they cause land to wear down because of their action; therefore, they are referred to as land wearing forces/denudational forces.
- Exogenic processes include weathering, mass wasting, erosion, and deposition.
- Geomorphic agents are natural elements capable of performing these exogenic processes (or exogenic geomorphic agents). For example, the wind, water, and waves.
- They draw their power from the solar energy.

►POSITION OF PRESENT-DAY OCEANS & CONTINENTS

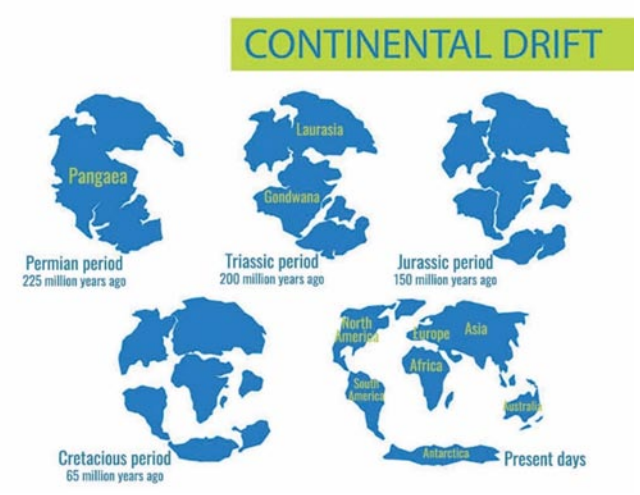
The Earth is dynamic in nature. The endogenetic forces keep on changing the location of the continents and the oceans. There are various theories which explain the evolution of our planet.

CONTINENTAL DRIFT THEORY

- Put forward by Alfred Wegner in 1912.
- Also called 'displacement hypothesis'
- He believed in three-layer system; outer layer of sial, intermediate layer of sima and lower layer of nife. (Sial is restricted to continent only and sialic masses float over).
- According to Wegener, all the continents formed a single continental mass (PANGEA), and mega ocean (PANTHALASSA) surrounded the same.
- Around 200 million years ago, Pangaea first broke into two large continental masses as Laurasia (Present day- N. America, Europe and Asia) and Gondwanaland (Present day S. America, Africa, Peninsular India, Australia and Antarctica). Subsequently, Laurasia and Gondwanaland continued to break into various smaller continents that exist today.
- Force for Drifting- Wegener suggested that the movement responsible for the drifting of the continents was caused by pole-fleeing force and tidal

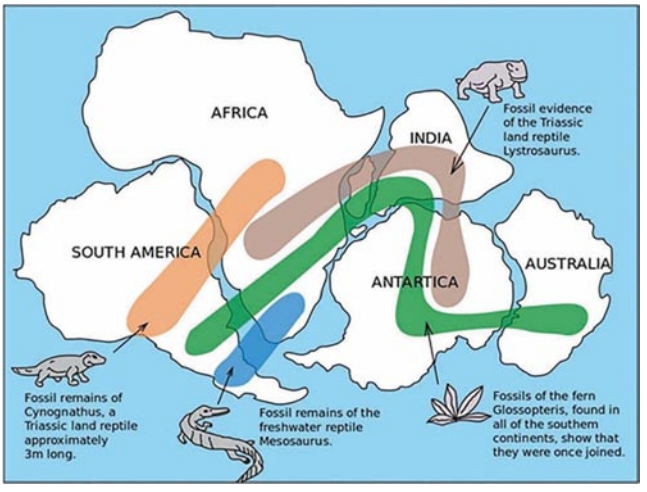
force.

- Polar-fleeing force relates to the rotation of the earth.
- Tidal force is due to the attraction of the moon and the sun. Wegener believed that these forces would become effective when applied over many million years. However, most of scholars considered these forces to be inadequate.



EVIDENCE FOR CONTINENTAL DRIFT THEORY

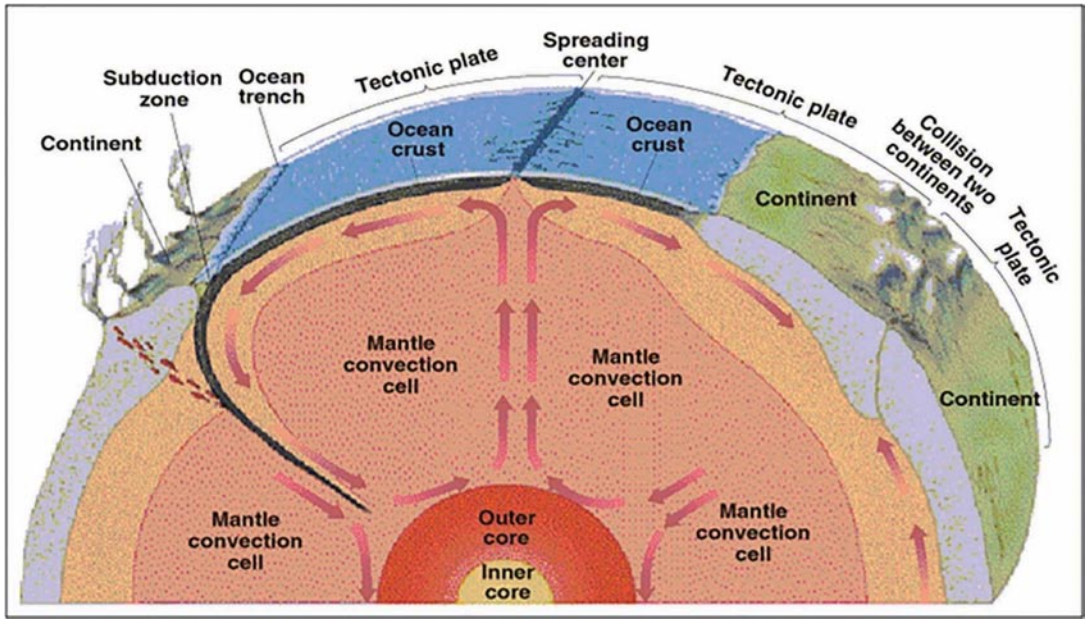
- Jig Saw fit theory: The shorelines of Africa and South America facing each other have a remarkable and unmistakable match and can be refitted together.
- Rocks of Same Age across the Oceans: The belt of ancient rocks from Brazil coast matches with those from western Africa. Appalachians of N. America are compatible with mountain system of Ireland and North-western Europe.
- Gondwana system of sediments from India is known to have its counterparts in six different landmasses of the Southern Hemisphere.
- Placer Deposits: Brazil has the gold bearing veins but the gold is also found at the coast of Ghana which has absolute absence of source rock.
- Distribution of Fossils: Observations that Lemurs occur in India, Madagascar and Africa led some to consider a contiguous landmass 'Lemuria' linking these three landmasses.
- Carboniferous glaciation of Brazil, Falkland, S. Africa and peninsular India further prove the unification of landmasses during carboniferous period.
- Sea floor spreading & Plate tectonic theory proved that lands and seas are not stationary, and they keep on drifting.

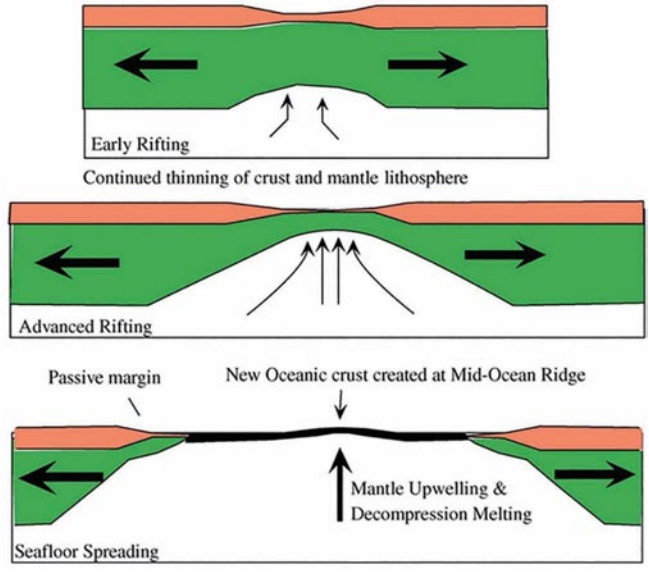


- Paleomagnetic studies laying foundation of sea floor spreading theory: When molten hot lava produces thermal convection current along the M.O.R and gets cooled and solidified, these lavas also get materialised in accordance with the then geomagnetic field and thus alternate bands of magnetic anomalies are formed on either side of M.O.R. These findings validate following things:
- There is a reversal in main magnetic field of Earth.
- Normal and reverse magnetic anomalies are found in alternate manner on either side of the M.O.R
- There is a complete parallelism in the magnetic anomalies on either side of the M.O.R
- There is parallelism in time sequence of paleomagnetic epochs.

SEA FLOOR SPREADING THEORY

- By Prof Harry Hess.
- Mid oceanic ridges are situated on the rising thermal convection currents coming up from the mantle.
- Constant eruptions at the crest of oceanic ridges cause the rupture of the oceanic crust and the new lava wedges into it, pushing the oceanic crust on either side. The ocean floor thus spreads.
- Molten lava cools down and solidifies to form new crusts along the trailing ends of divergent oceanic crusts.
- Spreading of one ocean does not cause the shrinking of the other because of the consumption of the Oceanic crust at the oceanic trenches.





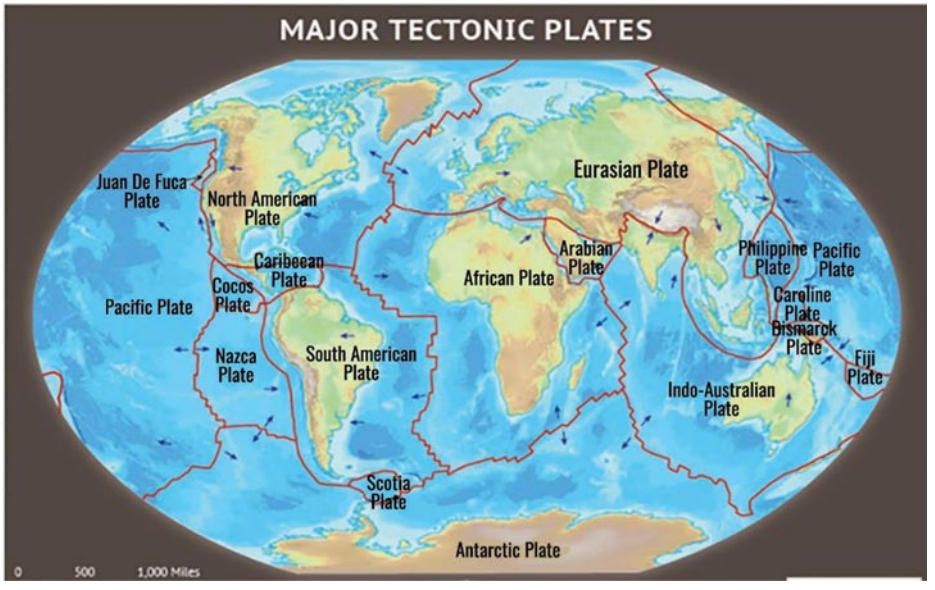
EVIDENCE FOR SEA FLOOR SPREADING THEORY:

- The rocks equidistant on either side of crest of mid-oceanic ridges show remarkable similarities in terms of period of formation and chemical composition.
- Rocks on either side of the M.O.R have similar magnetic properties in terms of magnetic anomaly and time sequence of magnetic epochs.
- The age of the rocks increases as one moves away from the crest.
- The ocean crust rocks are much younger than the continental rocks. The age of rocks in the oceanic crust is nowhere more than 200 million years old. Some continental rock formations are as old as 3,200 million years.
- The sediments on the ocean floor are unexpectedly very thin.

PLATE TECTONICS THEORY

- By McKenzie and Parker.
- A tectonic plate (also called lithospheric plate) is a massive, irregularly - shaped slab of solid rock, generally composed of both continental and oceanic lithosphere.
- Plates move horizontally over asthenosphere as rigid units.
- Forces responsible for such movements- Heat beneath Earth is generated because of two factors:
  - Radioactive decay
  - Residual heat
- The lithosphere includes the crust and top mantle with its thickness range varying between 5 and 100 km in oceanic parts and about 200 km in the continental areas.
- A plate may be referred to as the continental plate or oceanic plate depending on which of the two occupy a larger portion of the plate.

Evidence of Plate Tectonics: Evidences of Continental drift, palaeomagnetism and sea floor spreading theory can be combined. Continental drift proves that there has been a motion i.e., 'tectonics. Palaeomagnetism and sea floor spreading theory explains process behind this movement.



THREE TYPES OF PLATE BOUNDARIES

- Divergent: Where new crust is generated (Constructive margins) as plates pull away from each other and new crusts are formed because of solidification of upwelling molten material. Alsp called spreading sites. Ex. Mid-Atlantic Ridge (American Plate being separated from Eurasian and African Plates).
- Convergent: Where crust is destroyed (destructive margins) as one plate dives under another. Also known as consuming plate margins. Location where sinking of a plate occurs is called subduction zone. Three ways in which convergence can occur.
  - Ocean-Ocean convergence
  - Ocean-Continent convergence
  - Continent-Continent convergence
- Transform: Where crust is neither produced nor destroyed as plates slide horizontally past each other. They are generally perpendicular to mid-oceanic ridges. They are formed due to differential movement. Also, rotation of the earth has its effect on separated blocks of plate portions.

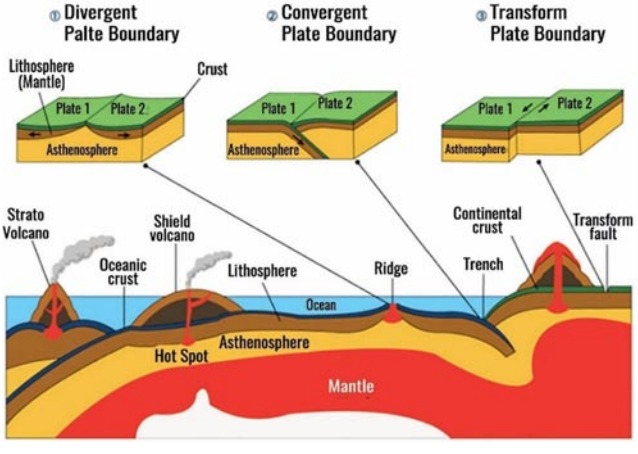


PLATE TECTONICS IMPROVEMENT OVER CONTINENTAL DRIFT THEORY

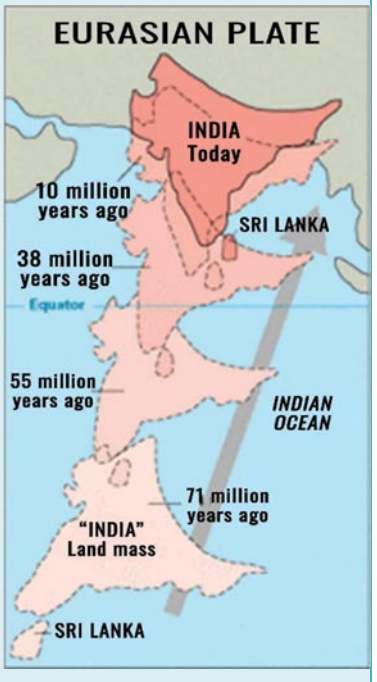
Continental Drift Theory	Plate Tectonic Theory
• Only landmass (Continent) moves.	• Lithospheric slab moves which might be continental or oceanic or both.
• Forces responsible were incompetent.	• Forces were well explained and reasonable.
• Much evidence was unscientific. For ex. Jig-saw fit theory could not be proven because both coasts of Atlantic Ocean cannot be completely refitted.	• Evidence was based on palaeomagnetic studies and various other researched theories like convection current theories and sea floor spreading theory.
• Could not explain satisfactorily formation of various landforms like volcanic arcs and fold mountains.	• Theory explained formation of fold mountains, plateaus, island arcs, mid oceanic ridges etc.

►MOVEMENT OF INDIAN PLATE

- Indian plate includes Peninsular India & Australian continental portions.
- Subduction zone along Himalayas forms northern plate boundary in form of continent—continent convergence.
- In east, it extends through Rakinyoma Mountains of

Myanmar.

- Western margin follows Kirthar Mountain of Pakistan. It further extends along Makrana coast and joins spreading site from Red Sea rift south eastward along Chagos Archipelago.
- Boundary between India and Antarctic plate is also marked by oceanic ridge (divergent boundary)
- India was a large island situated off Australian coast, in a vast ocean. The Tethys Sea separated it from the Asian continent till about 225 million years ago.
- India started her northward journey about 200 million years ago at the time when Pangaea broke. Tibetan block was closer to the Asiatic landmass.
- India collided with Asia about 40-50 Mn years ago causing rapid uplift of the Himalayas (Still rising).



FORMATION OF HIMALAYAS AND TIBETAN PLATEAU

- During northward movement of Indian plate, Tethys Ocean floor subducted. Most thick sediments on the Indian margin of the ocean were scraped off and accreted onto the Eurasian continent. Continent-continent convergence (India – Eurasian plate convergence) led to folding and crumbling of these marine sediments. Because of the same nature of both the plates there was not much density difference and hence there was no clear-cut subduction as is generally in case of continent-ocean or ocean-ocean convergence. C-C convergence produced 'double layering effect' and hence the thickness of the crust in that area increased.
- This is the main reason behind tremendous height of Himalayas and Tibetan Plateau. Further, because the collision is still undergoing, the height of Himalayas is still rising. Folding took place in three successive phases giving rise to three layers of Himalayas.

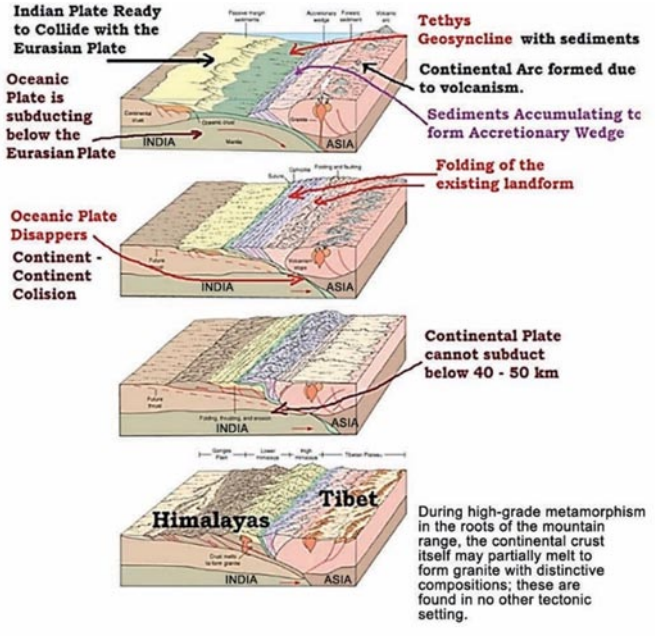
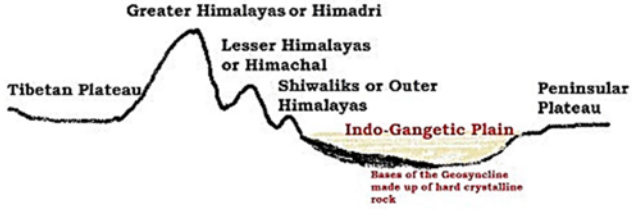


PLATE TECTONICS & NORTHERN PLAINS

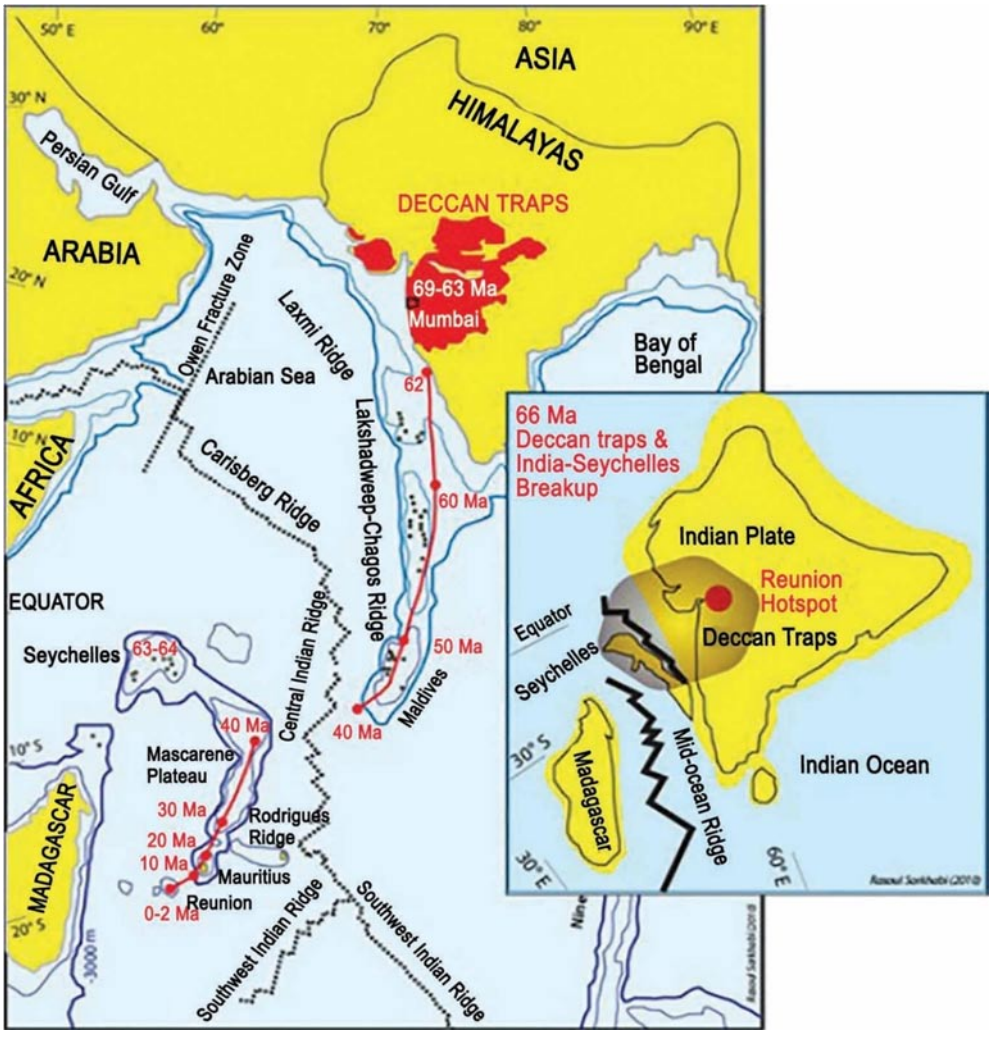
Due to uplift of Himalayas in Tethys Sea, northern flank of Indian Peninsula got subsided and formed a large basin/trough. That basin was filled with sediments from rivers coming from mountains in north and from peninsula in south. Thus, an extensive flat land of alluvial soil was formed which is known as Northern Plains of India.



FORMATION OF DECCAN PLATEAU

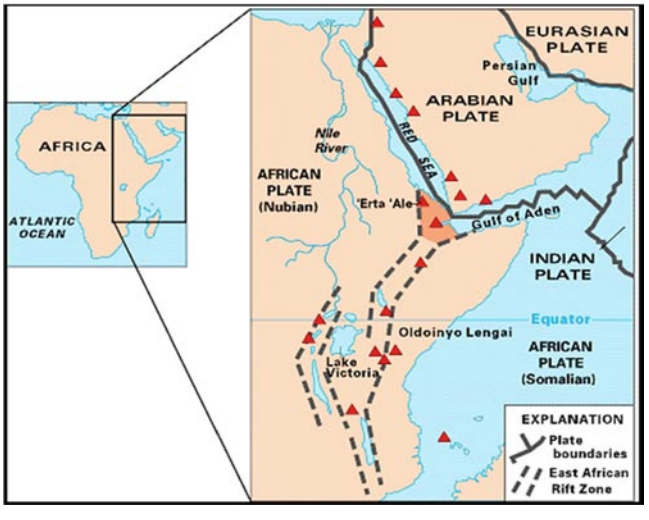
During northward march of Indian plate towards Eurasian plate, there was outpouring of lava and formation of Deccan Traps. This started around 60 million years ago and continued for a long period.

The area of long-term eruption (the hotspot), known as the Réunion hotspot, is suspected of both causing the Deccan Traps eruption and opening the rift that once separated the Seychelles plateau from India. Seafloor spreading at the boundary between the Indian and African Plates subsequently pushed India north over the plume, which now lies under Réunion island in the Indian Ocean, southwest of India. It was formed when molten lava solidified and turned to rock. The Deccan Traps date back to around 66 million years ago, when magma from deep inside Earth erupted to the surface.



FORMATION OF EAST AFRICAN RIFT VALLEY

East African Rift Valley is a developing divergent plate boundary in East Africa. Here eastern portion of Africa, Somalian plate, is pulling away from rest of the continent that comprises Nubian plate. Nubian and Somalian plates are also separating from Arabian plate in the north, thus creating a 'Y' shaped rifting system.



►EARTHQUAKES

- Major tectonic events associated with plate boundaries are ruptures and faults along constructive plate boundaries, faulting and folding along destructive plate boundaries and transform faults at conservative plate boundaries. All sorts of disequilibrium are caused due to different types of plate motions and consequently earthquakes of varying magnitudes are caused.
- At divergent boundaries, shallow foci (25-45 km) and moderate earthquakes occur because rate of rupture of crust and upwelling of lavas due to fissure is also slow. E.g., at mid-Atlantic ridge, mid-Indian oceanic ridge and east pacific rise.
- At convergent boundaries, earthquakes of high magnitude and deep foci occur because of deeper subduction of one plate. Here mountain building, faulting and violent volcanic eruptions cause disastrous earthquake. E.g.- Circum-Pacific Belt.

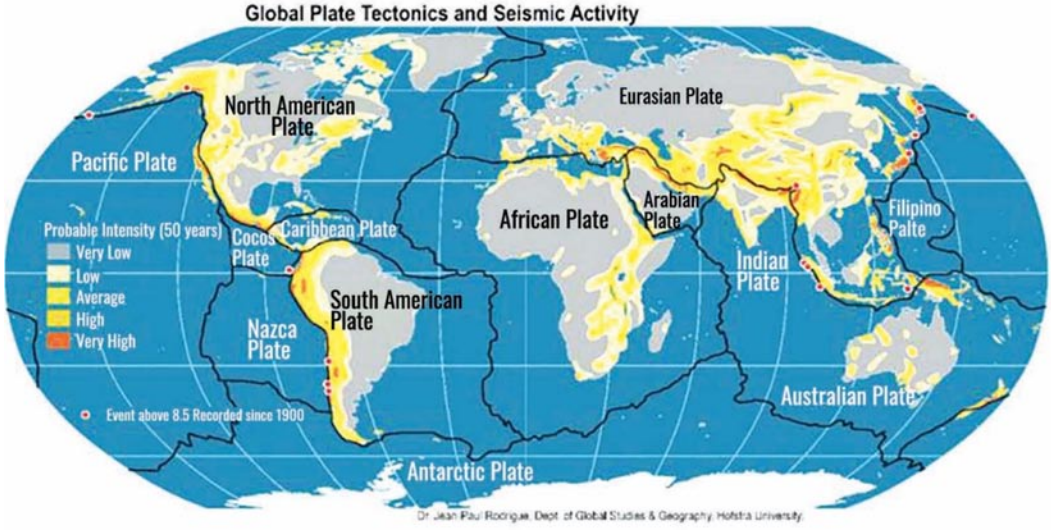
WORLD DISTRIBUTION OF EARTHQUAKES

Circum-Pacific Belt: Coastal Margins of North and South

America and East Asia representing the margins of Pacific. 65% of the global Earthquakes occur in this region. It has ideal conditions of (i)C-O convergence and subduction zones, (ii)zone of young, folded mountains and (iii) zone of active volcanoes.

Mid-Atlantic Belt: Epicentres located along mid Atlantic ridge. Earthquakes are because of transform faults and fractures because of splitting of plates

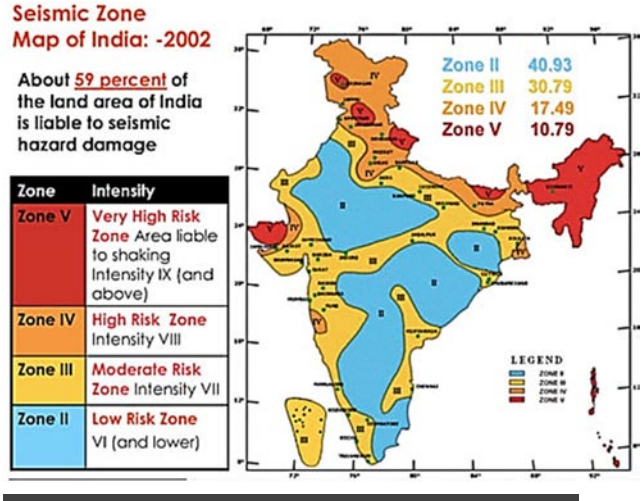
Mid-Continental Belt: Alpine-Himalayan belt representing collision of continental plates. 21% of global earthquakes occur in this region. They represent weaker zones of folded mountains and fault induced earthquakes.



INDIA'S DISTRIBUTION OF EARTHQUAKES

India has been classified into different zones indicating intensity of damage or frequency of earthquake occurrences.

11% in very high-risk zone V, 18% in high-risk zone IV and 30% moderate risk zone III. The capital cities of Guwahati and Srinagar are in seismic zone V, while national capital of Delhi is in zone IV and mega cities of Mumbai, Kolkata and Chennai are in zone III. 38 cities with population of half a million and above each and a combined population of million are in these three regions.



WHY HIMALAYAS ARE PRONE TO EARTHQUAKES?

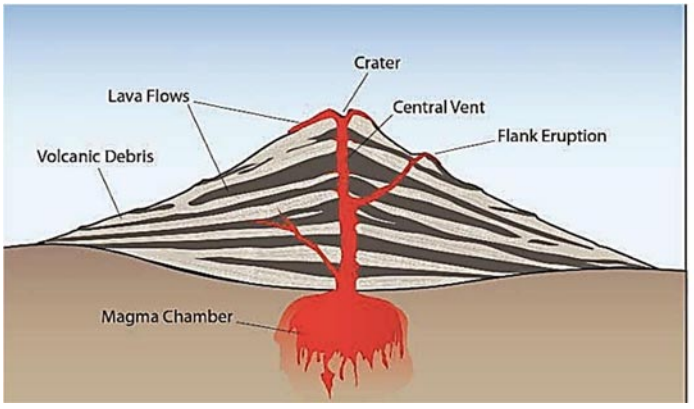
- Active C-C convergence zone leading to continuous shaking of ground.
- Double-layering effect produces shallow foci earthquakes which strike the surface fastest.
- Regions of young, folded mountains with sedimentary rock formations have geologically weaker zones & numerous faults.
- Underlying stress been accumulated for over thousands of years when release their energy; produces tremors and vibrations.
- Steep slopes lead to frequent landslides in turn leading to earthquakes.
- Increasing human induced supper incumbent load in form of roads, rails, buildings etc further destabilises the region.

►VOLCANISM AND VOLCANICITY

- A volcano on Earth is a vent or fissure in the planet's crust through which lava, ash, rock and gases erupt.
- Sometimes begin with an accumulation of gas-rich magma (molten underground rock) in reservoirs near Earth's surface, they can be preceded by emissions of steam and gas from small vents in ground.
- One feared phenomenon accompanying some explosive eruptions is nuée ardente, or pyroclastic flow, a fluidized mixture of hot gas and incandescent particles that sweeps down a volcano's flanks,

incinerating everything in its path.

VOLCANO ANATOMY



When volcanoes erupt, magma moves upward from a magma chamber and into a vent or conduit. It flows out from a crater at the top, or sometimes emerges at a secondary site on the side of the volcano resulting in a flank eruption. Erupted materials accumulate around the vent forming a volcanic mountain. The accumulated material might consist of layers of solidified lava, called lava flows, but it might also include fragments of various sizes that have been thrown from the volcano.

MECHANISM & CAUSES OF VULCANISM

Mechanism of volcanism is associated with several interconnected processes.

- Gradual increase of temperature with increasing depth at the rate of 1 degree Celsius per km.
- Origin of magma due to lowering of melting point caused by reduction in the pressure of overlying supper incumbent load.
- Origin of gases and vapour due to heating of water which reaches underground through percolation
- Ascent of magma forced by enormous volume of gases and vapour.
- Occurrence of volcanic eruptions.

WHY LESS VOLCANOES IN HIMALAYAS?

- Not much rise of temperature as the subduction angle is not much due to C-C type convergence.
- Absence of oceanic plate has not allowed much water to be heated up and form vapours
- Interlocking of plates do not allow the plates to move to grater depths and melt to form magma.
- Double layering has increased the crustal thickness which do not allow magma to outpour in the form of lava.

GLOBAL DISTRIBUTION OF VOLCANOES

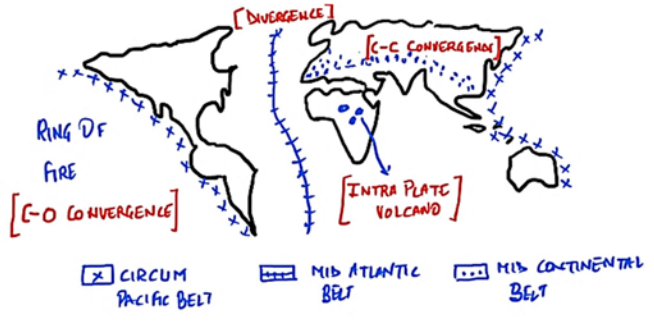
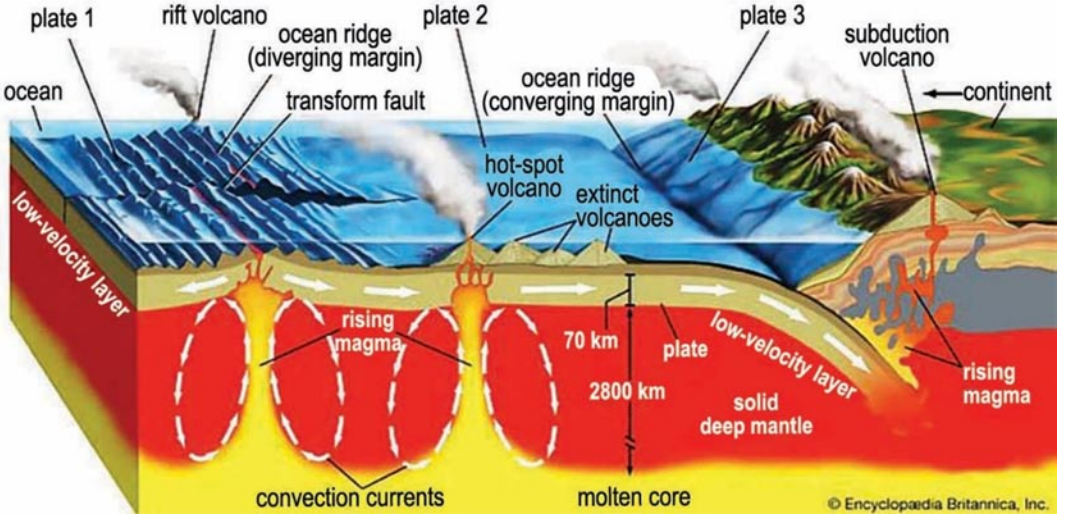


PLATE TECTONICS AND VOLCANISM



- Stratovolcanoes tend to form at subduction zones, or convergent plate margins, where an oceanic plate slides beneath a continental plate and contributes to the rise of magma to the surface.

- At rift zones, or divergent margins, shield volcanoes tend to form as two oceanic plates pull slowly apart and magma effuses upward through the gap.
- Volcanoes are not generally found at strike-slip zones, where two plates slide laterally past each other.
- "Hot spot" volcanoes may form where plumes of lava rise from deep within the mantle to Earth's crust far from any plate margins.

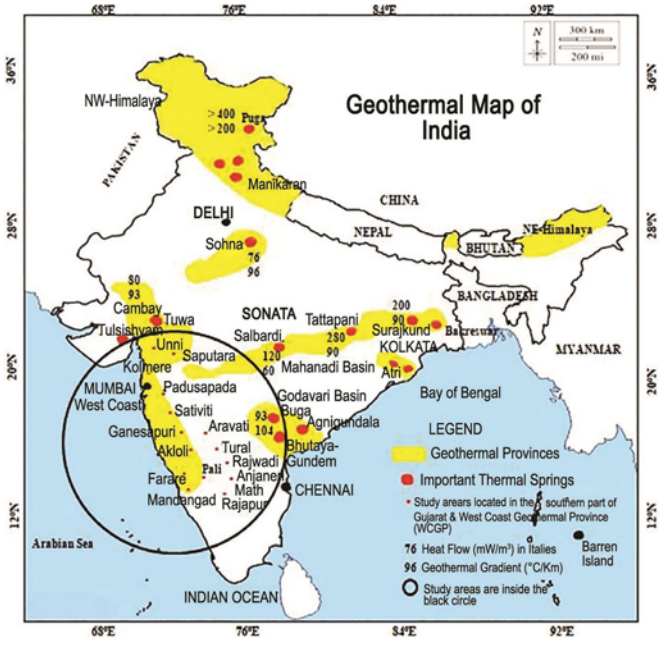
EFFECT OF VOLCANOS ON CLIMATE

1) Cooling effect
   - Volcanic ash or dust released into atmosphere during eruption shade sunlight and cause temporary cooling.
   - Smallest particles of dust get into stratosphere and can stay in stratosphere for months, blocking sunlight and causing cooling over large areas of the Earth.
   - Volcanoes emit sulphur dioxide which combines with water to form sulfuric acid aerosols. This in turn makes a haze of tiny droplets in the stratosphere that reflects incoming solar radiation, causing cooling of the Earth's surface.
   - E.g., According to studies, Pinatubo spewed about 15 million tons of sulphur dioxide into the stratosphere. The total mass of SO2 in the volcanic cloud was 20 tons. Researchers recorded 0.5 degrees Celsius (°C) drop in the average global temperature over large parts of the earth between 1992 and 1993.
2) Warming effect: Volcanoes also release large amounts of greenhouse gases such as water vapor and carbon dioxide. There have been times during Earth history when intense volcanism has significantly increased global warming.
3) Ozone layer depletion: Sulphate aerosols can deplete ozone layer too.

►HOT WATER SPRINGS IN INDIA

Thermal springs or hot water springs are formed due to geothermally heated water emerging onto the earth's surface through cracks. This heat comes from deep inside the earth's surface. The heat produced is either through the magma within the Earth's crust or through the movement of fault in the crust. The heated water being less dense rises upwards.

Geological Survey of India (GSI) has identified more than 340 hot spring locations.



SIGNIFICANCE

- High geothermal energy potential
- Presence of warm water provide relief to people living in colder areas.
- Host communities of microorganisms like extremophile.
- Responsible for weathering of silicate rocks
- Release carbon dioxide in the atmosphere
- Presence of dissolved mineral make it relevant for therapeutic uses
- High tourist attraction
- Beneficial for animals during extremely cold season.

►MINERALS AND ROCKS

MINERALS

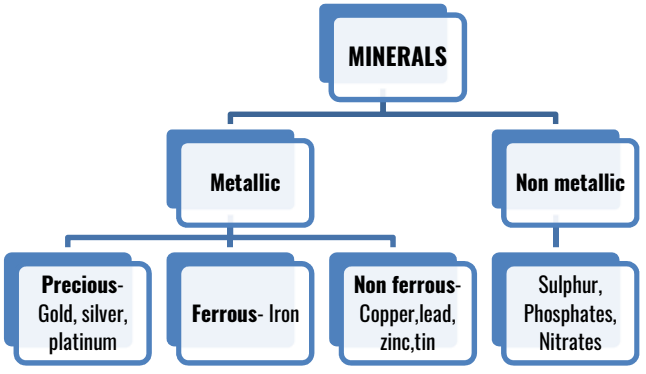
- Mineral is a naturally occurring organic and inorganic substance, having an orderly atomic structure and a definite chemical composition and physical properties.
- A mineral is composed of two or more elements. But sometimes single element minerals like sulphur, copper, silver, gold, graphite etc. are found.
- Though the numbers of elements making up the lithosphere are limited they are combined in many different ways to make up many varieties of minerals.

Whole Earth		Crust	
Iron	33.3	Oxygen	45.2
Oxygen	29.8	Silicon	27.2
Silicon	15.6	Aluminium	8.2

Magnesium	13.9	Iron	5.8
Nickel	2.0	Calcium	5.1
Calcium	1.8	Magnesium	2.8
Aluminium	1.5	Sodium	2.3
Sodium	0.2	Potassium	1.7

Fig: Chemical composition of the entire Earth and Earth's crust respectively

The basic source of all minerals is the hot magma in the interior of the earth. When magma cools, crystals of minerals appear, and a systematic series of minerals are formed in sequence to solidify to form rocks.



ROCKS

- A rock is an aggregate of one or more minerals.
- Rocks do not have definite composition of mineral constituents.
- Feldspar and quartz are the most common minerals found in rocks.
- There are three family of rocks classified based on mode of formation:
  - Igneous Rocks
  - Sedimentary Rocks
  - Metamorphic Rocks

IGNEOUS ROCKS

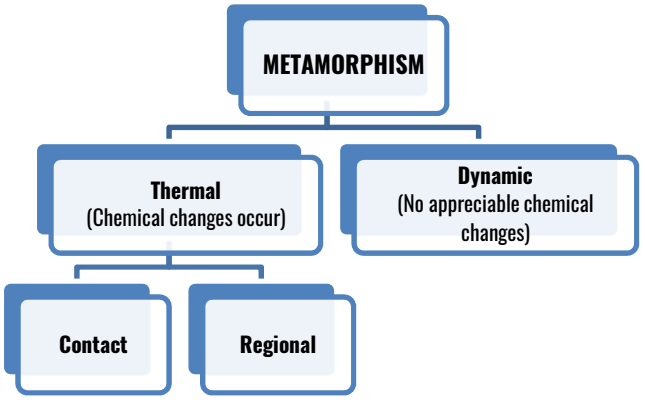
- They are formed out of magma and lava (when it cools and solidifies) from the interior of the earth, hence are known as primary rocks.
- The process of cooling and solidification can happen in the earth's crust or on the surface of the earth.
- If molten material is cooled slowly at great depths, mineral grains may be large.
- Sudden cooling (at the surface) results in small and smooth grains.
- Intermediate conditions of cooling would result in intermediate sizes of grains.
- Examples of igneous rocks- Granite, gabbro, pegmatite, basalt, volcanic breccia and tuff.

SEDIMENTARY ROCKS

- They are formed by the process of lithification- The rocks (Igneous, sedimentary and metamorphic) undergo denudation and the sediments are transported and deposited at a place which under continuous accumulation and compaction change into solid rocks.
- Sometimes, we see several layers of varying thickness in sedimentary rocks like
- sandstone, shale etc.
- Depending upon the mode of formation, sedimentary rocks are classified into three major groups:
  - Mechanically formed — sandstone, conglomerate, limestone, shale, loess etc.
  - Organically formed—geyserite, chalk, limestone, coal etc.
  - Chemically formed — chert, limestone, halite, potash etc.

METAMORPHIC ROCKS

- The word metamorphic means 'change of form.'
- Metamorphism is a process by which already consolidated rocks undergo recrystallisation and reorganisation of materials within original rocks due to change of temperature, pressure and volume.
- E.g.- schist, gneiss, quartzite and marble.



Contact Metamorphism: When rocks encounter hot intruding magma and lava, rock materials recrystallise under high temperatures.

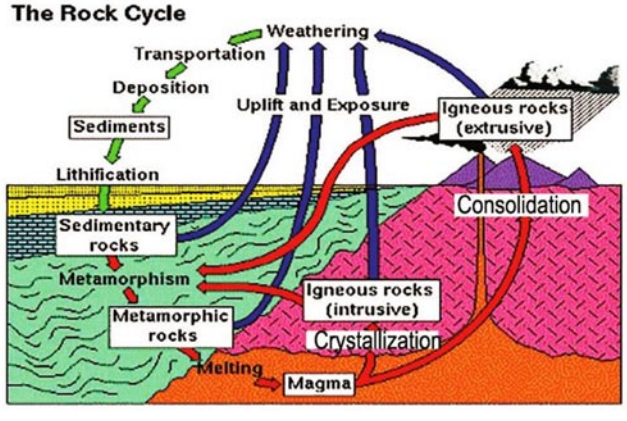
- Regional metamorphism: When rocks undergo recrystallisation due to deformation caused by tectonic shearing together with high temperature or pressure or both.
- Examples of metamorphic rocks- Gneissoid, granite, syenite, slate, schist, marble, quartzite etc.

- FOLIATION/LINEATION: Arrangement of minerals or grains in layers in metamorphic rocks.
- BANDING: Arrangement of minerals or grains into alternating thin to thick layers appearing in light and dark shades. Such a structure in metamorphic rocks is called banding and rocks displaying banding are called banded rocks.

ROCK CYCLE

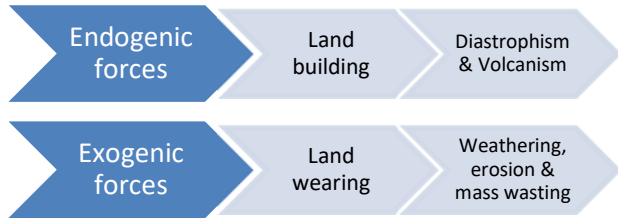
- A continuous process through which old rocks are transformed into new ones.
- Igneous rocks are primary rocks and other rocks (sedimentary and metamorphic) form from these primary rocks.
- Igneous rocks can be changed into metamorphic rocks. The fragments derived out of these rocks form into sedimentary rocks. Sedimentary rocks themselves can turn into fragments and the fragments can be a source for formation of new sedimentary rocks.

The crustal rocks (igneous, metamorphic and sedimentary) once formed may be carried down into the mantle and the same melt down due to increase in temperature and turn into molten magma, the original source for igneous rocks.



►GEOMORPHIC PROCESSES

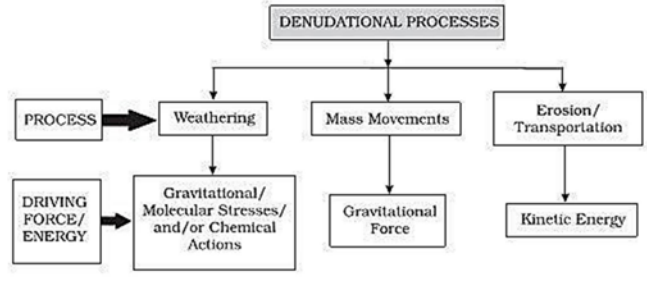
- The actions of exogenic forces result in wearing down (degradation) of relief/ elevations and filling up (aggradation) of basins/ depressions, on the earth's surface.
- The phenomenon of wearing down of relief variations of the surface of the earth through erosion is known as gradation.



- The endogenic and exogenic forces causing physical stresses and chemical actions on earth materials and bringing about changes in the configuration of the surface of the earth are known as geomorphic processes.
- Geomorphic agents are ground water, surface water, waves, currents ice, wind and gravity.
- Gravity besides being a directional force activating all downslope movements of matter also causes stresses on the earth's materials.

EXOGENIC FORCES

- Derive their energy from two sources: a) Solar energy b) Gradient created by tectonic factors.
- Basic reason that leads to weathering, mass movements, and erosion is development of stresses in the body of the earth materials.
- Force applied per unit area is called stress.
- All the exogenic geomorphic processes are covered under a general term, denudation. The word 'denude' means to strip off or to uncover.



- Geomorphic processes depend upon multiple factors like a) structure of rocks (folds, faults, orientation and inclination of beds, presence of joints, hardness or of constituent minerals, permeability etc), b) time and c) processes which operate on the rocks.
- These processes further depend upon various factors like latitude, season, land and water spread on the surface of the earth, density, type and distribution of vegetation, altitudinal differences, variation in the amount of insolation received, differences in wind velocities and directions, amount and kind of precipitation, evaporation, daily range of temperature, freezing and thawing frequency, depth of frost penetration etc.

WEATHERING

- Mechanical disintegration and chemical decomposition of rocks.
- It is an in-situ or on-site process.

Chemical Weathering: Decomposition, dissolution, reduction or oxidation of rocks in the presence of water, air and heat

Mechanical Weathering: Disintegration due to overlying pressure, hydraulic action, shearing stresses, crystal growth etc

Biological weathering: Disintegration due to burrowing microorganisms or ionic exchanges due to plant's root actions

Exfoliation: Flaking off curved sheets of shells from over rocks or bedrock resulting in smooth and rounded surfaces. It is not the process but a result of weathering.

Exfoliation domes are created due to removal of the super incumbent load (unloading). Exfoliated tors are created due to thermal expansion.

Enrichment: When rocks undergo weathering, some materials are removed through chemical or physical leaching by groundwater and thereby the concentration of remaining (valuable) materials increases. Without such a weathering taking place, the concentration of the same valuable material may not be sufficient and economically viable to exploit, process and refine.

MASS MOVEMENTS

- Transfer the mass of rock debris down the slopes under the direct influence of gravity.
- Weathering is not a pre-requisite for mass movement though it aids mass movements. Mass movements are very active over weathered slopes rather than over unweathered materials.
- Air, water or ice do not carry debris with them from place to place but on the other hand the debris may carry with it air, water or ice.
- Mass movements are aided by gravity and no geomorphic agent like running water, glaciers, wind, waves and currents participate in the process of mass movements.
- Heave (heaving up of soils due to frost growth and other causes), flow and slide are the three forms of movements.
- Landslides are relatively rapid and perceptible movements. The materials involved are relatively dry.
- Slump is slipping of one or several units of rock debris with a backward rotation with respect to the slope over which the movement takes place.
- Debris slide is rapid rolling or sliding of earth debris without backward rotation of Mass.
- Debris fall is nearly a free fall of earth debris from a vertical or overhanging face.
- Rockslide is sliding of individual rock masses down bedding, joint or fault surfaces
- Solifluction is the flowage of water-saturated soil down a steep slope. Because permafrost is impermeable to water, soil overlying it may become oversaturated and slide downslope under the pull of gravity.

EROSION AND DEPOSITION

- It involves acquisition and transportation of rock debris which are formed because of weathering.
- Erosional geomorphic agents like running water, groundwater, glaciers, wind and waves remove and transport it to other places.
- Though weathering aids erosion it is not a pre-condition for erosion to take place.
- Deposition is a consequence of erosion. The erosional agents lose their velocity and hence energy on gentler slopes and the materials carried by them start to settle themselves.
- In other words, deposition is not actually the work of any agent. The coarser materials get deposited first and finer ones later.
- The same erosional agents viz., running water, glaciers, wind, waves and groundwater act as aggradational or depositional agents also.

EFFECT OF CLIMATE ON WEATHERING

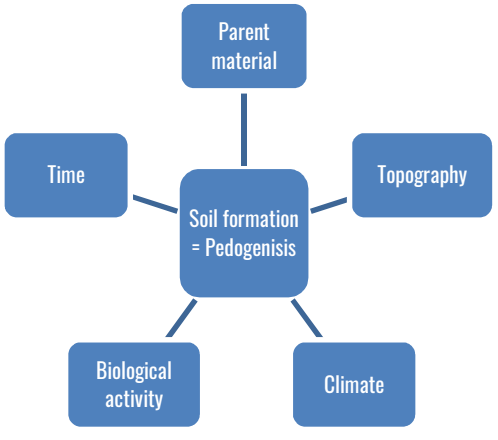
- Rate of weathering: Humid climate increases the rate of weathering. High rain, humidity and heat break down the rocks faster.
- Type of weathering: Arid climate favour mechanical weathering whereas Humid climate favours chemical weathering. Biological weathering is also relatively higher in humid climate because of high vegetation and organisms in those areas.
- Types of rocks: Limestone weathers rapidly in areas with wet climates, where rainwater mixed with carbon dioxide in soil or creates a weak acid that dissolves the limestone to form crevices and valleys. Sandstone, by contrast, weathers more rapidly in dry

climates, because the quartz in the sandstone is largely invulnerable to chemical weathering but can fall prey to fracturing caused by ice formed when water freezes and expands in cracks in the stone.

SIGNIFICANCE OF WEATHERING

- Geomorphic significance
  - Break down the rocks and thus form the soils.
  - Lead to various geomorphic processes like wasting and mass movements thus causing disasters like landslides.
  - Weathering aids erosion and thus allow the development as well as evolution of various landforms.
- Ecological significance: Biomes and biodiversity is basically a result of forests (vegetation) and forests depend upon the depth of weathering mantles.
- Economic significance: Weathering of rocks and deposits helps in enrichment and concentrations of certain valuable ores of iron, manganese, aluminium, copper etc., which are of great importance for national economy.

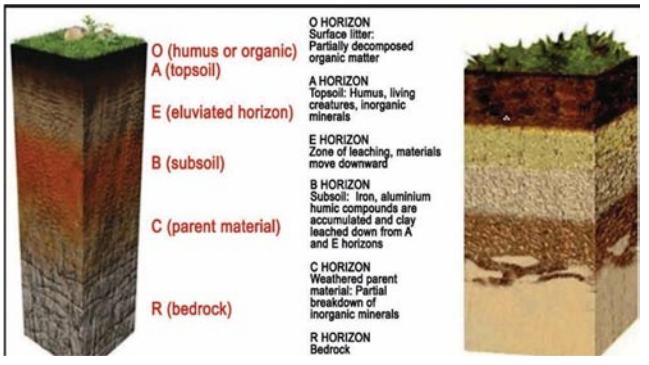
►SOIL FORMATION



- Parent material is a passive control factor. Soils can be any in-situ (residual soils) or transported deposits (transported soils). But the weathered material from the parent rocks directly influences the chemistry of the Soil. For e.g.- Black soils from Basaltic lava rocks.
- Climate: Temperature and moisture amounts cause different patterns of weathering and leaching. Wind redistributes sand and other particles especially in arid regions. Amount, intensity, timing, and kind of precipitation influence soil formation. Seasonal and daily changes in temperature affect moisture effectiveness, biological activity, rates of chemical reactions, and kinds of vegetation.
- Topography: Steep slopes facing sun are warmer. Steep soils (Mountainous soil) may be eroded and lose their topsoil as they form. Thus, they may be thinner than nearly level soils that receive deposits from areas upslope (Alluvial soil). Deeper, darker coloured soils may be expected on the bottom land.
- Biological factors: Animals and micro-organisms mix soils and form burrows and pores. Organisms decompose the leaves and mix them with the upper part of the soil. Plant roots open channels in the soils. Grass roots easily decompose and add organic matter. Humans can mix the soil so extensively that the soil material is again considered parent material.
- Duration of time soil forming processes operate, determines maturation of soils and development. A soil becomes mature when all soil-forming processes act for a sufficiently long time developing a profile. Soils developing from recently deposited alluvium or glacial till are considered young and they exhibit no horizons or only poorly developed horizons

SOIL PROFILE

A vertical section (or cutting) through the soil showing the different layers of soil is called soil profile. A soil horizon is a layer generally parallel to the soil surface, whose physical characteristics differ from the layers above and beneath. Each layer differs in feel (texture), colour, depth and chemical composition.



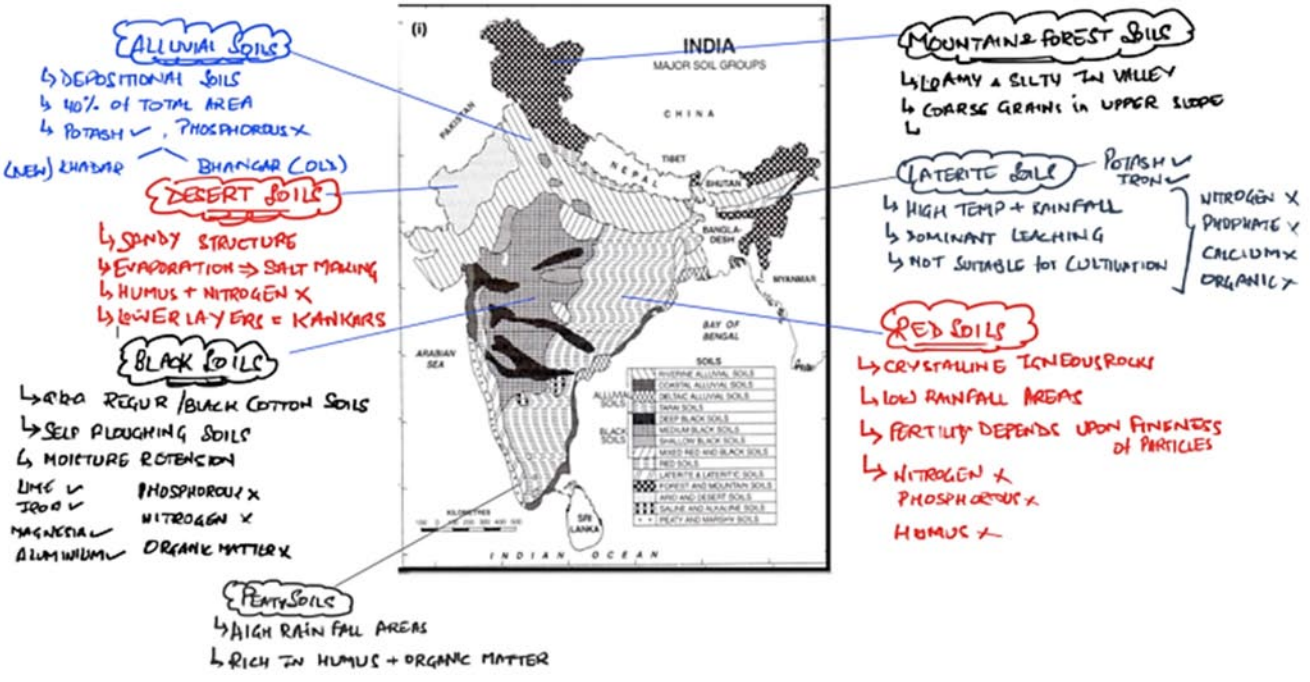
INDIAN SOILS

India has varied relief features, landforms, climatic realms and vegetation types. These have contributed to

the development of various types of soils in India.

Based on genesis, colour, composition and location, the soils of India have been classified into:

(i) Alluvial soils
(ii) Black soils
(iii) Red and Yellow soils
(iv) Laterite soils
(v) Arid soils
(vi) Saline soils
(vii) Peaty soils
(viii) Forest soils.

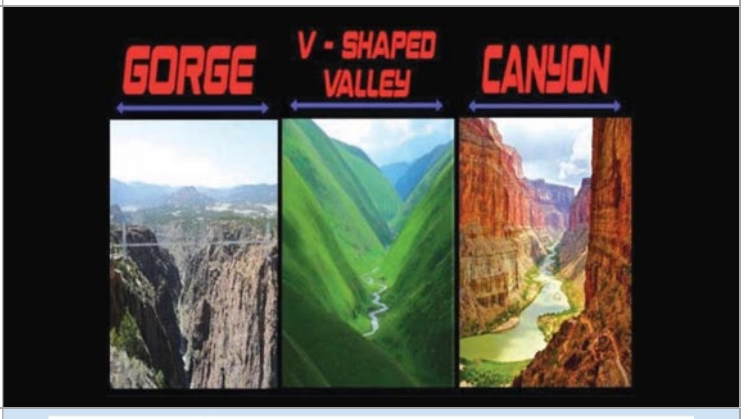
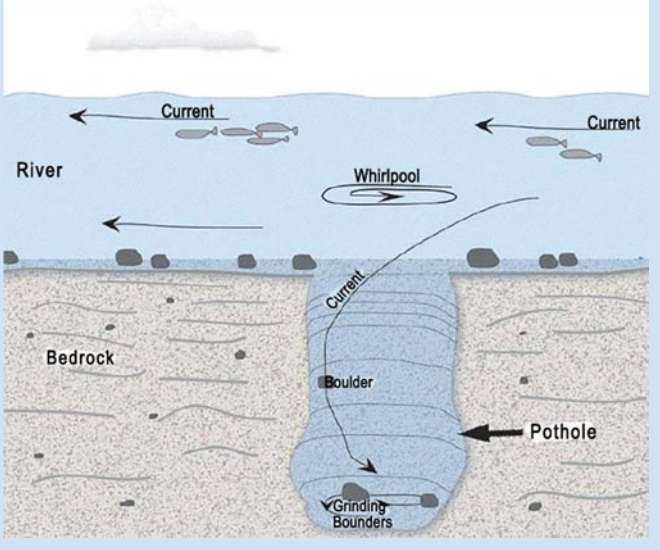
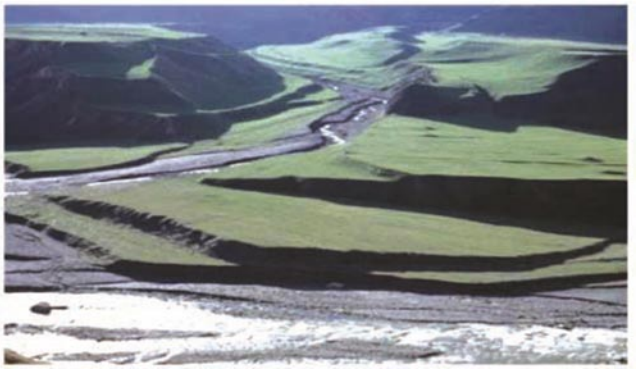


►LANDFORMS AND THEIR EVOLUTION

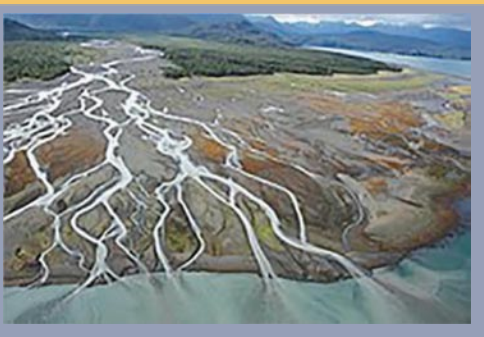
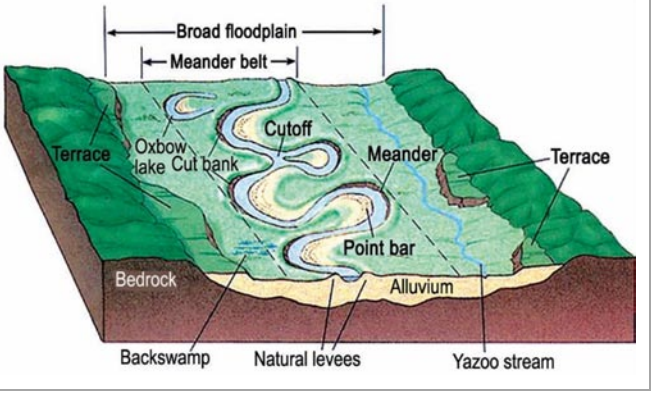
FLUVIAL LANDFORMS

- Dominant in humid regions.
- In the early stages, down-cutting dominates.
- In the middle stages, streams cut their beds slower, and lateral erosion of valley sides becomes severe.
- The divides between drainage basins are likewise lowered until they are almost completely flattened leaving finally lowland of faint relief with some low resistant remnants called monadnocks.
- This type of plain forming because of stream erosion is called a peneplain (an almost plain).
- Youth stage
  - Streams are few with poor integration showing shallow V-shaped valleys with no floodplains or with very narrow floodplains.
  - Streams divides are broad and flat with marshes, swamp and lakes.
  - Meanders if present develop over these broad upland surfaces. These meanders may eventually entrench themselves into the uplands.
  - Waterfalls and rapids may exist.
- Mature stage
  - Streams are plenty with good integration.
  - The valleys are still V-shaped but deep.
  - Trunk streams are broad enough to have wider floodplains within which streams may flow in meanders confined within the valley.
  - Waterfalls and rapids disappear.
- Old stage
  - Smaller tributaries during old age are few with gentle gradients.
  - Streams meander freely over vast floodplains showing natural levees, oxbow lakes, etc.
  - Divides are broad and flat with lakes, swamps and marshes.

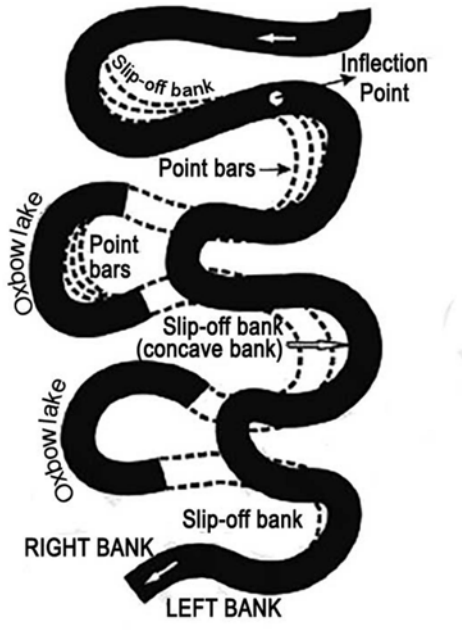
EROSIONAL LANDFORMS

DETAILS	REPRESENTATION
• A gorge is a deep valley with very steep to straight sides. It is almost equal in width at its top as well as its bottom. • Canyon is characterised by steep steplike side slopes. It is wider at its top than at its bottom. • Canyons commonly form in horizontal bedded sedimentary rocks and gorges form in hard rocks.	
• Potholes are circular depressions formed because of stream erosion aided by the abrasion of rock fragments. • Plunge pools: are large, deep potholes commonly found at the foot of a waterfall. They are formed because of the sheer impact of water and the rotation of boulders	
• Incised/entrenched meanders: Meanders which are particularly well developed and occur when a river's base level has fallen giving the river a large amount of vertical erosion power, allowing it to down cut. • Very deep and wide meanders can also be found cut in hard rocks.	
River terraces are surfaces marking old valley floor or floodplain levels. • They may be bedrock without any alluvial cover or with alluvial cover. • They result due to vertical erosion by the stream into its own depositional floodplain. • The river terraces may occur at the same elevation on either side of the rivers in which case they are called paired terraces.	

DEPSITIONAL LANDFORMS

DETAILS	REPRESENTATION
• Alluvial fans are formed when streams flowing from higher levels break into foot slope plains and the sediments get dumped and spread as a broad low to high cone shaped deposit. • Many channels and distributaries form. • In humid areas normally low cones with gentle slopes are formed and in arid and semi-arid areas high cones with steep slopes are formed.	
• Deltas are like alluvial fans but develop at a different location. • The load spreads and accumulates as a low cone. • Unlike in alluvial fans, the deposits making up deltas are very well sorted with clear stratification. • The coarsest materials settle out first and the finer fractions like silts and clays are carried out into the sea.	
• Floodplain: It is formed when normally, fine sized materials like sand, silt and clay are carried by relatively slow-moving waters in gentler channels usually found in the plains and deposited over the bed. • A riverbed made of river deposits is the active floodplain and the floodplain above the bank is inactive floodplain. • Such areas over flood plains built up by abandoned or cut-off channels contain coarse deposits. • The flood deposits of spilled waters carry relatively finer materials like silt and clay. • The flood plains in a delta are called delta plains.	
Natural Levees and Point Bars: Natural levees are found along the banks of large rivers. • They are low, linear and parallel ridges of coarse deposits along the banks of rivers. • Point bars are found on the concave side of meanders of large rivers and are sediments deposited in a linear fashion by flowing waters along the bank. • They are almost uniform in profile and in width and contain mixed sizes of sediments.	

- Meanders are loop like channel patterns developing over floodplains.
- Meander is not a landform but is only a type of channel pattern.
- This is formed because:
  - Water moves laterally over gentle gradients.
  - Water exerts pressure laterally on the unconsolidated nature of alluvial deposits making up the banks.
  - Coriolis force acting on the fluid water deflects it.
- Active deposition takes place along the concave bank and undercutting along the convex bank.
- The concave bank is known as cut-off bank and the convex bank presents a long, gentle Profile.
- As meanders grow into deep loops, the same may get cut-off due to erosion at the inflection points and are left as ox-bow lakes.



LANDFORMS ASSOCIATED WITH GROUNDWATER

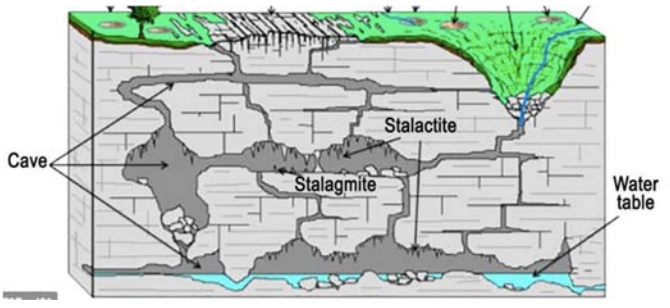
- Groundwater through the chemical process of solution develop varieties of landforms in rocks like limestones or dolomites rich in calcium carbonate.
- The topography so produced is called as Karst topography.

Conditions for development of Karst Topography:

- Widely distributed limestone rocks in both areal and vertical dimensions.
- Massive, thickly bedded limestone rocks
- Non-porous rocks to avoid water passage and consequent collapse
- Folded and fractured rocks
- Enough presence of water to dissolve carbonate rocks
- Rocks should be close to ground surface to allow easy rain-water infiltration.

EROSIONAL LANDFORMS

DETAILS	REPRESENTATION
• Swallow holes are small to medium sized round to sub-rounded shallow depressions on the surface of limestones through solution. • Sinkholes are funnel shaped openings ranging from a few sq. m to a hectare and with depth from a less than half a metre to thirty metres. • Dolines are the collapse sinks. • Uvalas (valley sinks) are formed when sink holes and dolines join because of slumping of materials along their margins or due to roof collapse of caves.	

Caves: Long and narrow to wide voids. • They are mainly formed in areas where there are alternating beds of rocks (shales, sandstones, quartzites) with limestones or dolomites in between or in areas where limestones are dense, massive and occurring as thick beds. • Caves normally have an opening through which cave streams are discharged. • Caves having openings at both the ends are called tunnels.	

DEPOSITIONAL LANDFORMS

DETAILS	REPRESENTATION
• Stalactites hang as icicles of different diameters. Normally they are broad at their bases and taper towards the free ends. • Stalagmites rise from the floor of the caves. In fact, stalagmites form due to dripping water from the surface or through the thin pipe, of the stalactite, immediately below it • The stalagmite and stalactites eventually fuse to give rise to columns and pillars of different diameters.	

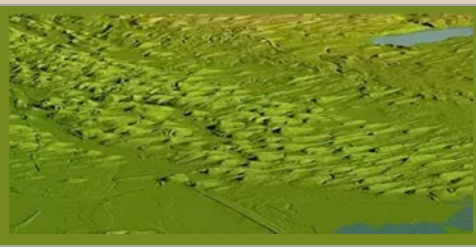
GLACIAL LANDFORMS

EROSONAL LANDFORMS

DETAILS	REPRESENTATION
• Cirques are deep, long and wide troughs or basins with very steep concave to vertically dropping high walls at its head as well as sides. • A lake of water can be seen quite often within the cirques after the glacier disappears. Such lakes are called cirque or tarn lakes.	
• Horns are high, sharp pointed and steep sided peaks formed when three or more radiating glaciers cut headward until their cirques meet. • Artes (serrated ridges) are formed when the divides between cirque side walls get narrow because of progressive erosion	

• Fjords/fiords are very deep glacial troughs filled with sea water and making up shorelines (in high latitudes).	

DEPOSITIONAL LANDFORMS

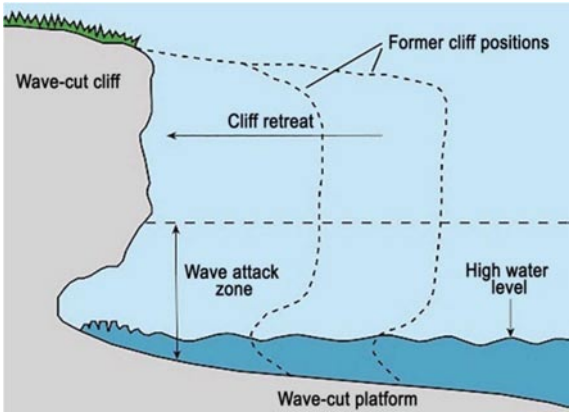
DETAILS	REPRESENTATION
• Moraines are accumulations of dirt and rocks that have fallen onto the glacier surface or have been pushed along by the glacier as it moves. • Eskers are ridges made of sands and gravels, deposited by glacial meltwater flowing through tunnels within and underneath glaciers, or through meltwater channels on top of glaciers. • Outwash Plains are plains at foot of glacial mountains covered with glacio-fluvial deposits in the form of broad flat alluvial fans which may join to form outwash plains of gravel, silt, sand and clay.	
• Drumlins are elongated, teardrop-shaped hills of rock, sand, and gravel that formed under moving glacier ice. They can be up to 2 kilometers (1.25 miles) long. • They form "baskets of egg" topography	

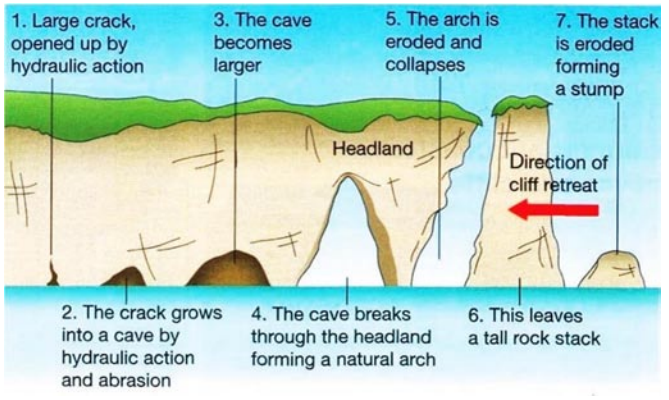
MARINE LANDFORMS

EROSIONAL LANDFORMS

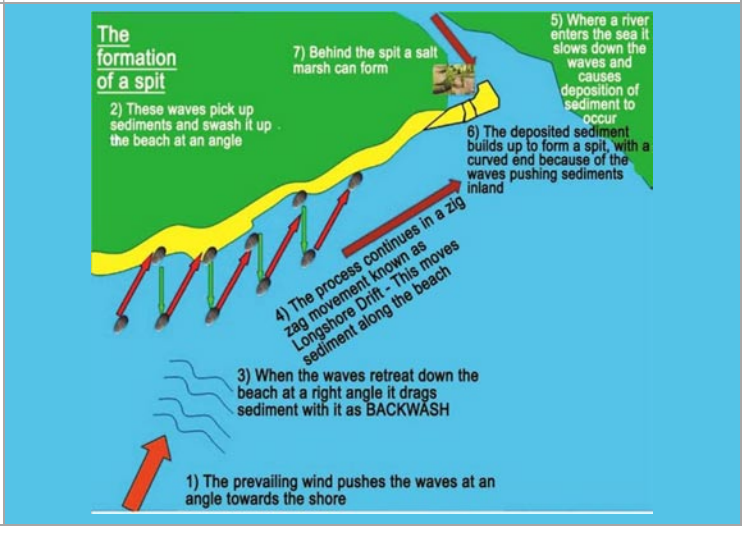
DETAILS
• Cliffs are steep sided vertical walls ate the coast of the sea. • Wave cut terraces are flat or gently sloping platform covered by rock debris, formed at the foot of such cliff. • Caves are the hollows created by lashing of the waves at the cliff. • Sea stacks are the remnants of rock standing isolated as small islands just off the shore due to the retreat of the cliffs. • Sea stacks are also temporary and eventually coastal hills and cliffs disappear because of wave erosion giving rise to narrow coastal plains, and with onrush of deposits from over the land behind may get covered up by alluvium or may get covered up by shingle or sand to form a wide beach.

REPRESENTATION



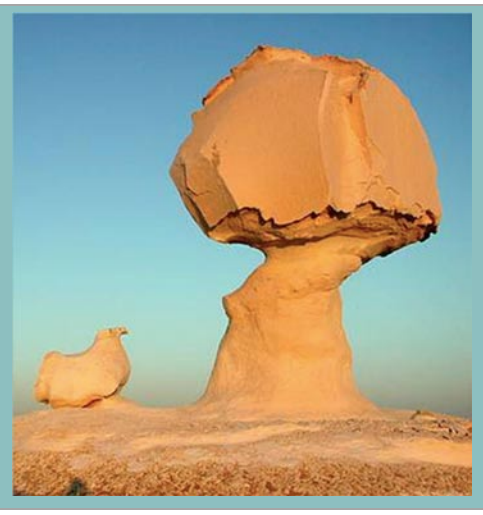


DEPOSITIONAL LANDFORMS

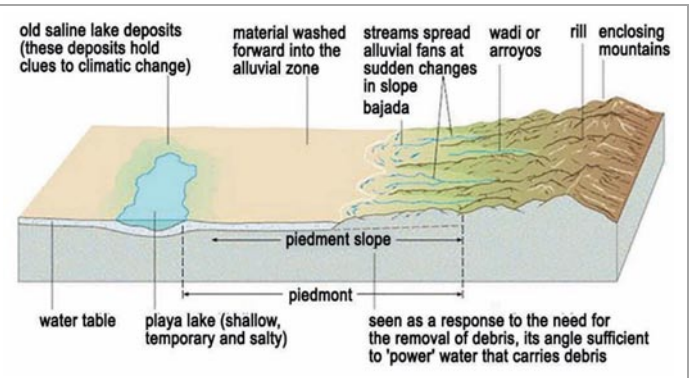
DETAILS	REPRESENTATION
• Beaches are made by sediment coming from land carried by the streams and rivers or from wave erosion. Beaches are temporary features. • Bars, barriers and spits: A ridge of sand and shingle formed in the sea in the off-shore zone lying approximately parallel to the coast is called an off-shore bar. • An offshore bar which is exposed due to further addition of sand is termed a barrier bar. • Sometimes such barrier bars get keyed up to one end of the bay when they are called spits.	

AEOLIAN LANDFORMS

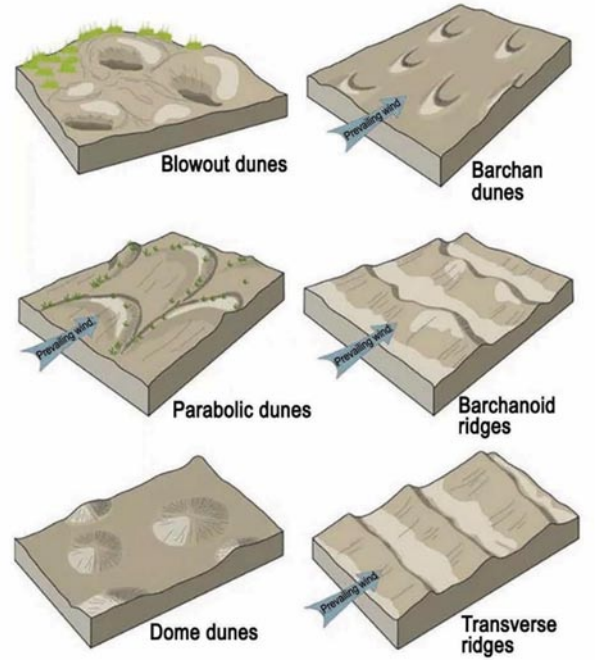
EROSIONAL LANDFORMS

DETAILS	REPRESENTATION
• Pediments: Gently inclined rocky floors close to the mountains at their foot with or without a thin cover of debris are called pediments. Such rocky floors form through the erosion of mountain front through a combination of lateral erosion by streams and sheet flooding. • Pediplains: Through parallel retreat of slopes, the pediments extend backwards at the expense of mountain front, and gradually, the mountain gets reduced leaving an inselberg which is a remnant of the mountain. That is how the high relief in desert areas is reduced to low featureless plains called pediplains.	

- Playas: A playa is a dry, vegetation-free, flat area at the lowest part of an undrained desert basin. It is a location where ephemeral lakes form during wet periods, and is underlain by stratified clay, silt, and sand, and commonly, soluble salts. Playas occur in intermountain basins.
- Mushroom rocks: The erosive power of wind becomes very high at a certain height from the ground level. The resistant rocks take the shape of mushroom having large top and a small neck.



DEPOSITIONAL LANDFORMS

DETAILS	REPRESENTATION
Sand dunes: deposition occurs due to obstruction to the winds caused by various factors. Depending upon their shape and alignment with respect to wind direction they are classified as: • Barchans • Parabolic dunes • Transverse dunes	

►ECONOMIC SIGNIFICANCE OF LANDFORMS

Storehouse of resources: Plateaus and volcanic landforms are known for metallic deposits, great plains and deltas are known for alluvial soil and mountains are known for biotic resources, timber, medicinal herbs etc.

Energy generation: Hydroelectricity can be generated from water coming from mountains, wave & tidal energy can be tapped at coasts and geothermal energy can be exploited at volcanic landforms.

Climate: Mountainous areas have lower temperatures. They serve as climatic divide between two adjoining regions. For ex. Himalaya forms a barrier to movement of cold winds from Central Asia towards Indian subcontinent. They also force Southwest Monsoons to ascend and cause rainfall on their southern slopes

Tourism: Unique landforms like valleys, craters, playas and caves offer wide range of tourism potential.

Agriculture & animal rearing: Plateaus have large grassland areas suitable for animal-rearing specially sheep, goat and cattle. Plains have rich alluvial deposits and groundwater reservoirs suitable for irrigation.

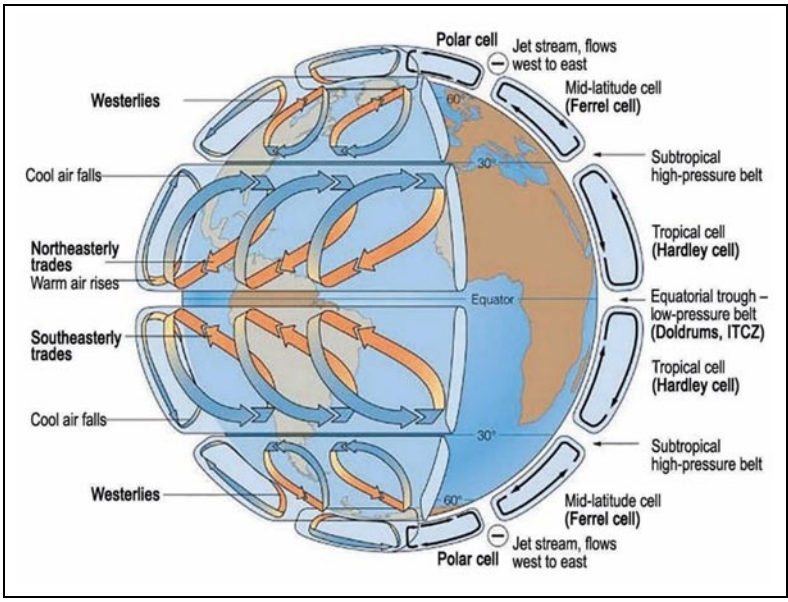
Industries & Infrastructure: Basaltic lava plateaus having black soil invite cotton and sugarcane industries. Deltas are famous for jute hence invites textiles. Similarly plateau regions invite heavy industries.

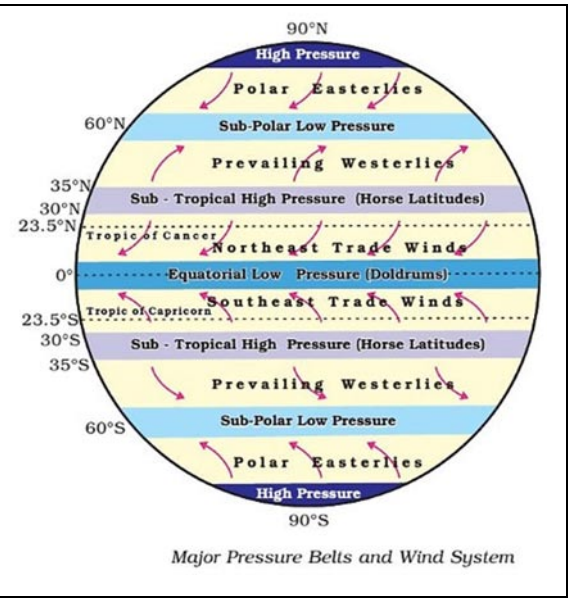
CLIMATOLOGY

►PLANETARY WINDS

They are also called as primary winds or permanent winds because they remain same throughout the year

and are distributed across the globe. These winds are related to thermally and dynamically induce pressure belts and rotation of the earth.





Major Pressure Belts and Wind System

Tropical Easterlies: They blow from the sub-tropical high-pressure areas towards the equatorial low-pressure belt. They flow as the north-eastern trades in the northern hemisphere and the south-eastern trades in the southern hemisphere. The trade winds from two hemispheres meet at the inter tropical convergence zone, and due to convergence, they rise and cause heavy rainfall. Their off – shore nature on the western side of the continents are one of the reasons behind formation of deserts in those areas.

Sub-Tropical Westerlies: They blow from the sub-tropical high - pressure belts towards the sub polar low-pressure belts. They blow from south-west to north-east in the northern hemisphere and north-west to south-east in the southern hemisphere. These winds produce wet spells and variability in weather.

Polar Easterlies: They blow from the polar high-pressure areas of the sub-polar lows. The Polar easterlies are dry, cold prevailing winds blowing from north-east to south-west direction in Northern Hemisphere and south-east to north-west in Southern Hemisphere.

General circulation of Atmosphere

The pattern of the movement of the planetary winds is called the general circulation of the atmosphere. Factors which affect general circulation:

- Latitudinal variation of atmospheric heating
- The emergence and shifting of pressure belts
- The distribution of continents and oceans
- The rotation of the earth

SIGNIFICANCE OF PLANETARY WINDS

Climatic significance

- Balances the heat budget by transporting the excessive heat of tropics towards poles.
- Form the dynamic pressure belts – Sub Polar low-pressure belt is formed due to convergence and upliftment of sub-tropical westerlies and Polar easterlies.
- Cyclone formation and movement – Their convergence form the fronts at sub polar low-pressure belt and thus create extra tropical cyclone. Trade winds move the Tropical cyclones from west to East.
- Regional Climate- Monsoon in Indian subcontinent is caused due to eastward shift of SE trades after crossing the equator under the effect of Coriolis force.

Oceanic significance

- Movement of oceanic currents- North and South Equatorial currents move East to West under the influence of Trade winds. Gulf stream moves toward North-east and hit the NW coast of Europe under the influence of Sub-tropical Westerlies.
- Formation of gyres- Primary winds affected by Coriolis form the circulatory motion of current thereby forming the Gyres.

Geomorphic significance: Formation of deserts- Tropical Easterlies form the desert on the western margins of the Continents as they become dry when reach there and act as offshore winds.

Ecological significance:

- Their effect on Oceanic current movement allows transport of nutrients and thrive biodiversity in form of fisheries, planktons, and corals.

- Certain studies point out that some insects move in the direction of prevailing winds.
- Dust storms: They carry particles from Saharan sand and dust storms can blow across islands in the Caribbean Sea and the U.S. state of Florida.

SHIFTING OF PRESSURE BELTS

Wind belts depend on temperature, so temperature changes can move the belts and change wind patterns.

Relative position of the earth with the sun changes within a year due to earth's revolution and thus the position of all the pressure belts except the polar high pressure belts changes with the northward and southward migration of the sun.

- During summer solstice, Sun is vertical over the tropic of Cancer (June 21) and therefore all pressure belts belt shift north-ward. Thus, all wind belts associated with the said pressure belts also shift north-ward.
- The sun becomes vertical over the equator at the time of equinoxes hence all the pressure belts which shifted to the north occupy their normal positions.
- After this there is southward migration of the sun which becomes verti-cal over the tropic of Capricorn at the time of winter solstice (23 December) and hence the pressure and wind belts shift southward.

These seasonal changes in the relative positions of the pressure and wind belts introduce the following typical climatic conditions:

(i) Mediterranean climatic regions are found in western parts of the continents within the latitudinal zone of 30°-45° in both the hemispheres. Subtropical belt shifts towards the equator at the time of winter solstice in the northern hemisphere, consequently, the zone between 30°-40° latitude is characterized by westerlies which give much precipitation during winter season because they come from over the oceans. Therefore, the Mediterranean regions are characterized by dry summers and wet winters.

(ii) Regions lying between 60°-70° latitudes are characterized by two types of winds in a year because of shifting of pressure and wind belts. With northward migration of sun during summer solstice the polar easterlies are weakened during northern summer because westerlies extend over these areas due to northward (poleward) shifting of sub-polar low-pressure belt while situation is opposite in southern hemisphere because polar easterlies extend over the areas of westerlies due to equator - ward shifting of sub-polar low-pressure belt. The situation is reversed during winter solstice.

(iii) Monsoon climate: Due to northward migration of the sun in northern hemisphere during summer solstice north intertropical convergence (NITC) is extended upto 30°N latitude over Indian subcontinent, south-east Asia and parts of Africa. Thus, equatorial westerlies are also extended over the aforesaid regions.

These equatorial westerlies become south-west or summer monsoons. NITC is withdrawn from over Indian subcontinent and south-east Asia because of southward shifting of pressure and wind belts due to southward migration of the sun at the time of winter solstice.

Thus, north-east trades are re-established over aforesaid areas. These north-east trades are north-east or winter monsoons.

►LOCAL WINDS

Local Winds originate due to the local factors like pressure difference, topography, thermal differences etc acting over a very smaller area. They are also affected by diurnal and seasonal changes. There are several region-specific winds which are significant in multiple ways.

LOCAL WINDS ACROSS GLOBE

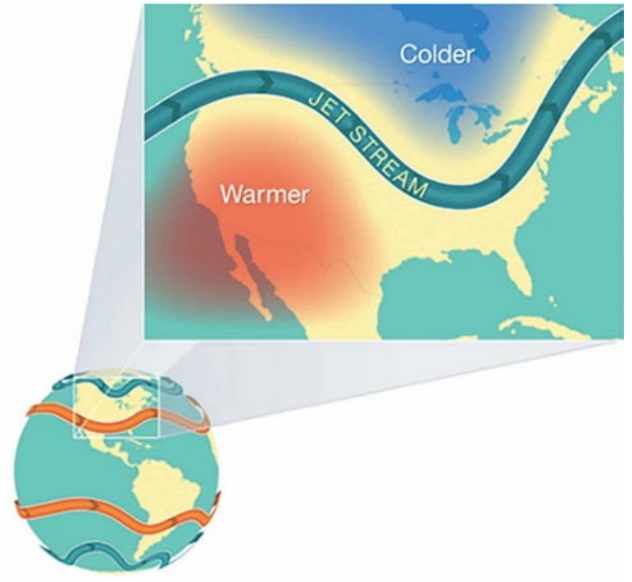
LOCAL WINDS IN INDIA

Winds	Region	Importance
Land & Sea breeze	Coastal regions	Make weather pleasant especially in summers.
Mountain & valley breeze	Hill regions	Cause precipitation on slopes and frost in the valleys.
Chinook & Foehn	USA & Switzerland respectively	Warming effect in valleys, melting of snow, early sowing of spring wheat, ripening of grapes & green pastures.
Harmattan	Sahara Desert	Pleasant weather at the coast prevents diseases (doctor winds) and sometimes leads to dust storms.
Sirocco	Sahara to Mediterranean	Blood rain in Italy, harmful for agriculture.
Mistral	Spain - France	Adversely affects the airflight and drops the temperature to sub-zero levels.
Blizzard	Siberia, Canada, USA	Cold waves
Bora	Shores of Adriatic Sea	
Loo	North Indian plains	Heat waves and heat strokes
Mango shower	Kerala and Karnataka	Early ripening of mangoes.
Blossom shower	Kerala	Coffee flowers
Norwesters / Bardoli cheerha	West Bengal & Assam	Helpful in tea, rice & jute cultivation.

►JETSTREAMS

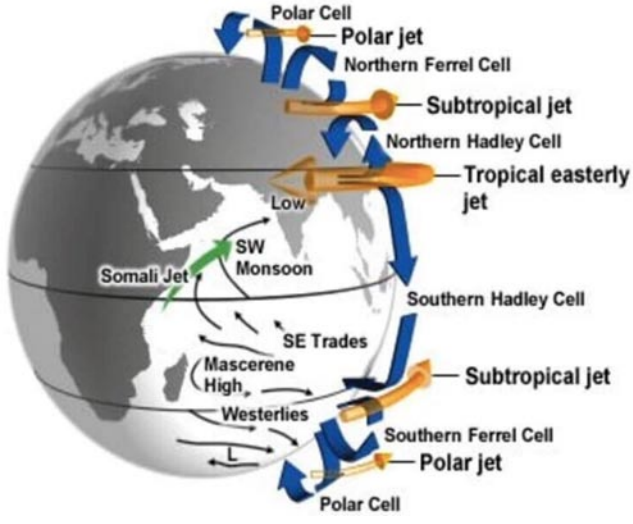
Jet streams are long, narrow, high-speed, meandering, circumpolar winds that typically flow north-eastward, eastward, and south-eastward in the middle and upper troposphere or lower stratosphere.

Jet streams are characterized by wind motions that generate strong vertical shearing action, which is thought to be largely responsible for clear air turbulence.



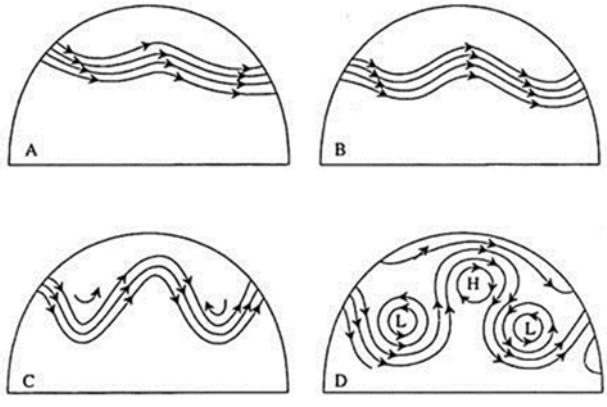
FORMATION

- Jet streams form when warm air masses meet cold air masses in the atmosphere. The Sun does not heat the whole Earth evenly. That is why areas near the equator are hot and areas near the poles are cold. So, when Earth's warmer air masses meet cooler air masses, the warmer air rises higher in the atmosphere while cooler air sinks down to replace the warm air. This movement creates an air current, or wind. A jet stream is a type of air current that forms high in the atmosphere.



HARACTERISTICS OF JET STREAMS

- They generally move from west to east in a narrow belt of a few thousands' km of length, hundred km of width and few km of thickness moving at the height of 7.5 -14 km in the upper tropo-sphere.
- Generally, their circulation is observed be-tween poles and 20° latitudes in both the hemispheres.
- The minimum velocity of jet stream is 30m/second (108 km/hour).
- The vertical wind shear of jet streams is 5-10m/second (18-36 km/hour), meaning thereby the wind velocity above or below jet stream decreases by 18-36 km/hour.
- Their circulation path (trajectory) is wavy and meandering. Meandering jet streams are called as Rossby waves.



- Their velocity increase during winter season and the wind velocity becomes twice the velocity during summer season. Maximum wind velocity is 480 km (per hour).
- The extent of jet streams narrows down during summer season because of their northward shifting while these extend upto 20° latitudes during winter season.

TYPES OF JET STREAMS

- Polar Front Jet Streams: formed above convergence zone (40-60 lat.) of the surface polar cold air mass and tropical warm air mass. These are rather irregular.
- Subtropical Westerly Jet Streams: formed in the upper troposphere to the north of subtropical high-pressure belt above 30°-35° latitudes. They are most regular and continuous.
- Tropical Easterly Jet Streams: develop in the upper troposphere above surface easterly trade winds over India and Africa during summer season due to intense heating of Tibetan plateau and play important role in the mechanism of Indian monsoon.
- Polar Night Jet Streams: also known as stratospheric sub-polar jet streams, develop in winter season due to steep temperature gradient in the strato-sphere around the poles at the height of 30 km.
- Local Jet Streams: formed locally due to local thermal and dynamic conditions and have limited local importance. E.g.- Somali Jetstream.

SIGNIFICANCE OF JET STREAMS

- Climate: Jet streams can transport weather systems across the world, affecting temperature and precipitation. For E.g.- they carry temperate cyclones from eastern coast of USA to Western coast of Europe. Their presence & withdrawal over Gangetic planes directly affects the monsoonal pattern in India.
- Predicting weather: Weather satellites, such as the Geostationary Operational Environmental Satellites-R Series (GOES-R), use infrared radiation to detect water vapor in the atmosphere. With this technology, meteorologists can detect the location of the jet streams. Monitoring jet streams can help meteorologists determine where weather systems will move next.
- Ozone layer depletions: Jet streams may transport ozone depleting substances higher up in the atmosphere upto stratosphere. This vertical air circulation causes rapid rate of mixing of air between troposphere and stratosphere, which helps in the transport of an-thropogenic pollutants from troposphere to stratosphere.
- Disasters: Recently climate change studies have proved the link of Jet streams and disasters like floods, fires and cyclones.
- Travel & Transportation: if an airplane flies in a powerful jet stream and they are traveling in the same direction, the airplane can get a boost reducing the fuel need. Opposite may lead to turbulence and resistance.

CLIMATE CHANGE AND JET STREAM

Rising global temperatures from global warming are affecting jet stream and, in turn, the weather. Because Earth's polar regions are warming more quickly than rest of the world, the temperature contrast that drives jet streams has decreased. Slower, weaker jet streams have been linked to melting in Greenland and a potential rise in deadly weather events because they can lock weather systems into place, stalling them over regions.

Studies have linked a warming Arctic with more severe winter weather in United States, even though other reports note that on average, winter cold snaps are getting warmer because of climate change. Part of this

link involves the polar vortex, a swirling low-pressure centre at the North and South poles. An unstable polar vortex can expand and send cold Arctic air into jet stream, leading to frigid winter weather and storms southward.

PLANETARY CIRCULATIONS

Planetary circulation includes Primary winds, Ocean currents, Jet streams as well as Thermohaline circulations.

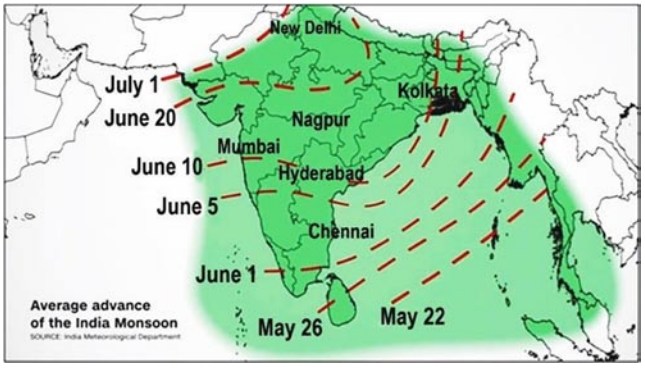
►MONSOON

India is situated in the tropical and subtropical zones. About half area of country extends to north of Tropic of Cancer. Northern part of the country experience not only sub-tropical but even some temperate weather phenomena, especially during winter. In terms of overall climatic conditions, however, India is more of a tropical land as tropical weather conditions cover most of the country in almost all seasons. Climate conditions in India are affected the most by tropical monsoon. It is only during the winter season and that too in only in northern parts that sub-tropical or temperate climatic phenomenon and their influences are experienced. Due to overwhelming influence of tropical monsoon on Indian climate, India is called a tropical country.

SIGNIFICANCE OF MONSOON

Important source of irrigation in Agriculture

Agriculture is mainstay of majority of Indians and agriculture being rain dependent, monsoon becomes extremely important in India. Agriculture sector employs close to 50% of total work force and has a share of about 16% in GDP. Besides agriculture is a source of raw material for industrial production and serves as a huge market for the industrial products and service sector.



Even those engaged in trade and commerce and allied occupations are affected by the success or failure of monsoon. Agriculture being the source of raw material for several industries, industrial production is also affected by monsoon. Agricultural production determines the purchasing power of a large population thereby affecting the trade and commerce. Due to its great importance in national economy monsoon, it is often called the 'Real Finance Minister of India'.

CLASSICAL THEORY OR THERMAL CONCEPT

First scientific description of monsoon winds goes to the Arab scholars**.** Al Masudi, 10th century Arab scholar, provided detailed description of monsoon winds and their seasonal reversal characteristic.

Thermal origin of monsoons was explained by Sir Edmund Halley in 1686 (Known as 'classical theory' of origin of Asiatic monsoon). According to this concept, monsoons are land and sea breezes on gigantic scale produced by differential seasonal heating and cooling of continental and oceanic areas.

The sun is vertical over Tropic of Cancer in summer season of northern hemisphere and Indian landmass currently gets heated to a greater extent than the neighbouring sea. This leads to formation of low-pressure conditions over Indian subcontinent in comparison to over Indian Ocean. Therefore, thermally induced pressure gradient is produced from ocean towards Indian sub-continent leading to the onset of south-westerly winds blowing from Indian Ocean towards India. These winds, called southwest monsoon, blowing from sea towards land carry a large amount of moisture and cause copious rainfall over the landmass.

Land also cools faster. Hence, Indian Ocean is warmer than Indian subcontinent in winter. This causes the pressure gradient to be reversed towards sea. This altered pressure gradient leads to onset of winds blowing from northeast to southwest, i.e., winds blowing from Indian subcontinent towards Indian Ocean. This wind system is called northeast monsoon. Since winds are currently blowing from land towards sea, they carry little moisture. The winter season over Indian landmass thus remains largely dry.

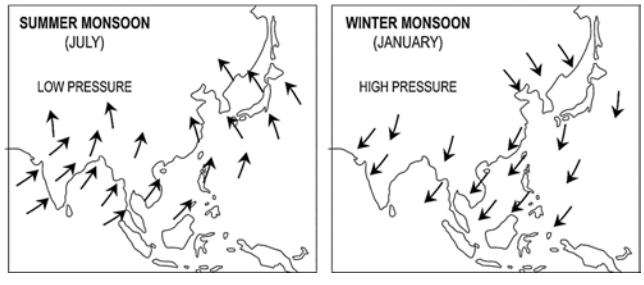


Fig. 1 Monsoon - the Traditional View

Thermal theory of monsoon treats this system as a system of land and sea breezes operating at sub-continental level. The direction of winds reverses seasonally rather than daily, unlike the true local land and sea breeze.

CRITICISM OF THERMAL THEORY OR CLASSICAL THEORY OF MONSOON

1) Visualizes monsoon as regional surface winds only.

2) Fails to explain the uncertain and irregular character of dynamic monsoon.

3) Modern climatologists express doubt about thermal origin of low (summer) and high (winter) pressure areas over land (Indian sub-continent). Since, position of low and high-pressure areas changes suddenly. These sudden changes are not exclusively related to thermal conditions rather to dynamic factors. Winter high is outcome of anticyclonic conditions prevailing over Indian sub-continent due to presence of southerly westerly jet streams. Summer season low pressure areas are also associated with the cyclonic lows.

4) Monsoon rainfall is not wholly orographic rather it is an amalgamation of all three types: orographic, cyclonic and convectional.

DYNAMIC CONCEPT OR SHIFTING OF INTER TROPICAL

H. Fohn suggested that monsoon system experienced in tropical Asia is a result of seasonal changes in planetary wind system resulting from the seasonal swing of temperature and pressure belts in this region in association with changes in overhead position of sun.

Planetary winds of tropics are trade winds. In March and September, when sun is overhead in equatorial area low pressure belt is created near equator and north-east trade winds of northern hemisphere and south-east trade winds of southern hemisphere converge in this belt of low pressure. This zone is known as Inter tropical Convergence Zone or ITCZ.

ITCZ is associated with zone of highest temperature and lowest pressure. It is due to low pressure here that Trade Winds of northern and southern hemispheres converge here. When ITCZ is situated close to Equator, Trade Winds converge near equator (Also known as doldrums or calm area). In this equatorial zone, planetary winds are equatorial westerlies.

During summer solstice, Sun's rays are vertical over Tropic of Cancer. Therefore, all wind and pressure belts of globe shift towards North. At this point, ITCZ shifts northwards and becomes NITCZ (Northern Inter Tropical Convergence Zone). It extends up to 30° N Latitude in South and South-East Asia. Excessive heating of Indian sub-continent further intensifies this process.

At this point, Equatorial Westerlies of doldrums shift northward and get extended as south-west monsoon winds. They become south-westerly under influence of Coriolis force as they cross equator. NITCZ also result into tropical disturbances which play significant role in surface weather conditions.

Heavy rainfall is received during summer season become south-west monsoon winds are onshore. During winter season, due to southward shifting of ITCZ pressure and wind belts of north-east trade winds gets re-established over this region. These are called north-east winter monsoons. They prevail over majority area as offshore winds. Therefore, are generally dry and devoid of rains. But on Tamil Nadu coast, they are onshore and bring precipitation in winter months. The SITCZ (Southern Inter Tropical Convergence Zone) position is associated with north-west monsoon rainy season over northern part of Australia.

When ITCZ shifts towards Tropic of Capricorn in winter, Trade Winds of northern hemisphere will cross equator, will be deflected to left hand side and southern hemisphere tropical zone will experience north westerly winds. The reversal of wind direction occurs in both hemispheres in the tropical zone.

This theory does not negate the effect of differential heating of land and sea. However, instead of explaining monsoon as an Asian phenomenon, dynamic theory considers it as a circum-global phenomenon of tropical zone. The low-pressure area extends over northern India even beyond Tropic of Cancer is explained by the effect of differential heating of land and sea.

On extensive ocean areas this shift is confined to tropical zone only. However, reversal of wind direction occurs even over wide oceanic areas away from large landmasses. The dynamic concept also fails to explain the complex monsoon mechanism. The classic concept of Halley and dynamic concept of Flohn fail to explain the intricacies of monsoons. In both these concepts, scholars have ignored upper atmospheric circulations and teleconnections.

CURRENT UNDERSTANDING OF INDIAN MONSOON

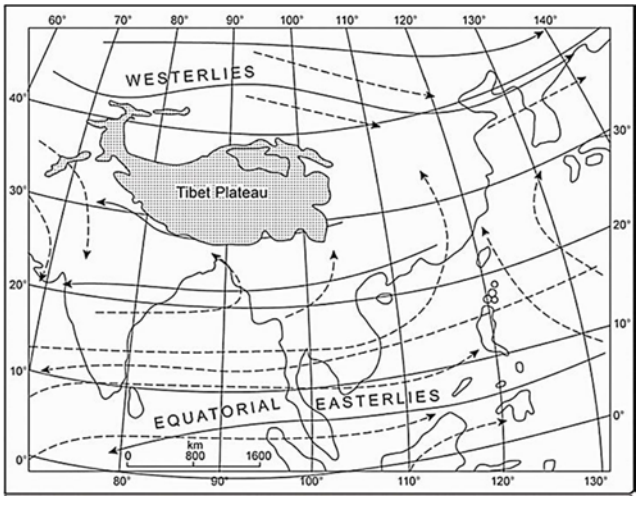
Monsoon is the result of interaction of regional and planetary factors, both at surface and in upper troposphere. There seems to be a link between meteorological events which are separated by long distances known as meteorological teleconnection. Teleconnections are defined as linkages over great distances of atmospheric and oceanic variables.

Meteorological data from sites distributed over oceans, continents, upper troposphere, remote-sensing data using satellites and modern computing techniques such as 3D modelling have helped us better understand monsoons. Current research focuses on role of jet streams and Tibetan plateau and ENSO (El Nino and Southern Oscillation). Walker observed teleconnection

between ENSO events and lower-than-normal monsoon rainfall over South and South-East Asia.

ROLE OF JET STREAMS, TIBETAN PLATEAU AND ENSO

Upper Air Circulations over Tibetan Plateau and position and intensity of sub-tropical westerly jet stream and tropical easterly jet stream play a significant role in the onset, withdrawal and intensity of Indian monsoon.



Upper Air Circulation and Monsoon

The sub-tropical westerly jet occupies a position over north India in winter season and Himalayas and Tibet plateau led to bifurcation of this jet stream into two branches. The northern branch occupies a position to the north of Tibetan Plateau and the southern branch is located over north India to the south of Himalayas**.** In upper troposphere a 'high' pressure system (anticyclonic conditions with clockwise air circulation) develops towards south of southern branch of sub-tropical jet stream over Afghanistan and north-west Pakistan.

Consequently, winds tend to descend over north-western parts of India, resulting into atmospheric stability and dry conditions**.** It contributes to the flow of northeast monsoon winds of winter season. Sub-tropical westerly jet streams help western disturbances to enter Indian sub- continent and affect its weather. On an average 4-6 disturbances (temperate cyclones) per month pass over northern India between November to April. These disturbances result into snow fall in western Himalaya and rainfall in Great Plains and provide moisture to Rabi season crops.

During summer season (April, May and June) due to shift in overhead position of sun**,** low pressure areas develop at the surface near Peshawar (Pakistan) and north-west India. Winds descending from upper air high pressure restrict ascend of winds from surface low pressure. This results into warm and dry weather conditions**.** Therefore, months of April and May (hottest month) are dry despite high temperature and evaporation. Contrary to it, upper air low pressure is formed in eastern Himalayan region due to upper air seasonal easterly jet streams. Due to these conditions the winds coming from southern Myanmar are forced to ascend and produce rainfall in Myanmar, Bangladesh and Northeast India. Pre-monsoon showers are very common in this part.

After first week of June, southern branch of sub-tropical westerly jet steam disappears, and only northern branch operates to north of Tibetan plateau. This results into a dynamic depression over north-western part of Indo-Pakistan. As this dynamic depression gets established over the thermal depression present in this area, burst of monsoon takes place. The burst of monsoon depends on upper air circulations. Koteswaram established relationship between upper air circulations and atmospheric conditions over Tibetan plateau. He concluded that northward movement of sub-tropical jet stream is first indication of onset of monsoon over India.

In summer season, Tibetan Plateau gets heated and acts as a high-altitude heat source which produces a thermal anti- cyclone over this region (in the upper atmosphere). This anti-cyclone weakens westerly sub-tropical jet stream south of Himalayas and gives rise to the tropical easterly jet stream at 80° E longitude and intensifies the high-pressure cell over the Indian Ocean. Thus, a surface pressure gradient is produced from the Indian Ocean towards India and it activates south-west monsoon.

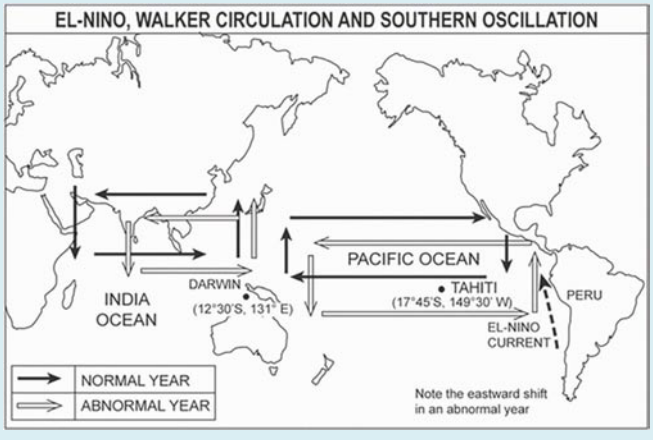
Seasonal easterly jet stream has its core at a height of about 13 km and it may extend from southern tip of peninsula up to 20° N latitude. The periodic shifts of the jet streams are often indicators of onset and subsequent withdrawal of the monsoon. In fact, northward shifting of subtropical westerly jet stream is the first indication of onset of monsoon over Indian sub-continent.

Tibetan Plateau plays the role of a heat engine. The altitude of the plateau ranges between 4000 and 5000 m and extends over 4.5 million sq. km area. There is poor vegetation cover and snow clad mountain ranges. Therefore, it gets heated in summer and is around 2°C to 3°C warmer than air over adjoining region. When summer temperature over Tibetan Plateau remains high for a sufficiently long duration, it provides strength to easterly jet stream and results in heavy rainfall over India. Whenever it remains snow covered for longer duration in summer it results in a poor monsoon. Heating of Tibet plateau was the most important factor in the causation and maintenance of monsoonal circulation over India.

IMPACT OF EL-NINO & SOUTHERN OSCILLATION

El Nino is a temporary warm ocean current which

appears off the coast of Peru in December in some years. 'El Nino' in Spanish means child Christ and it is named so as it appears around Christmas. Sir Gilbert Walker in 1920 noticed that when pressure was high over equatorial south Indian Ocean, it was low over equatorial south Pacific and vice-versa. This pressure variation gives rise to circulation along equator known as Walker Circulation. The pressure variation is stated as Southern Oscillation Index (SOI) and it is measured as difference in pressure between Tahiti in French Polynesia, representing southern Pacific Ocean and Port Darwin, in northern Australia, representing Indian Ocean.



HOW IT IMPACTS THE MONSOON?

- Positive: Tahiti pressure greater than that of Darwin
  - Pressure high over east pacific and low over west pacific.
  - Low rainfall over east pacific and prospects of good monsoon over Indian Ocean.
- Negative: Darwin pressure exceeds that of Tahiti
  - High pressure over western pacific and low over eastern pacific
  - Low rainfall in west pacific and poor monsoon in India.

Conclusion: Monsoon is complex phenomenon which is dynamic in nature. Indian monsoon climate is affected by factors such as, latitudinal position (latitude), altitudinal variations (relief), mountain wall of north i.e., Himalayas, distribution of land and sea, distance from sea, jet streams (westerlies and easterlies), Tibetan plateau, tropical cyclones and western disturbances, El Nino and Southern Oscillation (ENSO).

Monsoon climate is basically a sub-system within global climate system. There are teleconnections. Till scholars are not able to identify all elements involved in this mechanism and intensity and dynamics of their roles, correct prediction will remain a challenge even after using super computers and dynamic models. Climate change has further increased intensity of this challenge.

►CHALLENGES IN MONSOON PREDICTION

- Monsoon is complex inter-hemispheric and inter oceanic phenomenon which makes the predictions very difficult.
- Tropical weather is highly variable as compared to temperate weather and is still not understood well.
- Complex topography of Indian subcontinent comprising loftiest mountains, expansive deserts; longest and deepest valleys surrounded by ocean from three sides make the monsoon highly variable in spatial and temporal contexts.
- Data insufficiency: IMD collects weather data like temperature, humidity, wind and precipitation through 679 automatic weather stations, 550 surface observatories, 43 radiosonde or weather balloons, 24 radars and three satellites. However, this data is not enough given the size of India. However, more data is required to make the predictions accurate. Further, there are major data gaps, like those involving dust, aerosols, soil moisture and maritime conditions.
- Lack of infrastructure: Automatic weather stations are of substandard quality. They need to be calibrated and cleaned regularly, which doesn't happen often. That affects the quality of data. Dynamical models require huge amount of computations, for which supercomputers are required.
- Adoption of western models which are not fine-tuned as per the Indian needs.
- Impact of pollution: Increased concentration of aerosols in atmosphere tends to change shape and characteristics of rain-bearing clouds, leading to extreme rainfall events but weakened monsoons.

►NATIONAL MONSOON MISSION

National Monsoon Mission aims to build models which are adept at predicting the monsoon. To set up a state-of-the-art coupled ocean-atmospheric climate model for:

- Improved prediction of monsoon rainfall on extended range to seasonal time scale (16 days to one season)
- Improved prediction of temperature, rainfall and extreme weather events on short to medium range time scale (up to 15 days) so that forecast skill gets quantitatively improved further for operational services of India Meteorological Department (IMD).

Targets were to develop a state-of-the-art dynamical prediction system for monsoon rainfall (over Indian region) on different time scales (e.g., short range, medium range, extended range and seasonal time scales) with reasonably good prediction skill. Due to these government efforts statistical model along with dynamical model is improving the monsoon predictions.

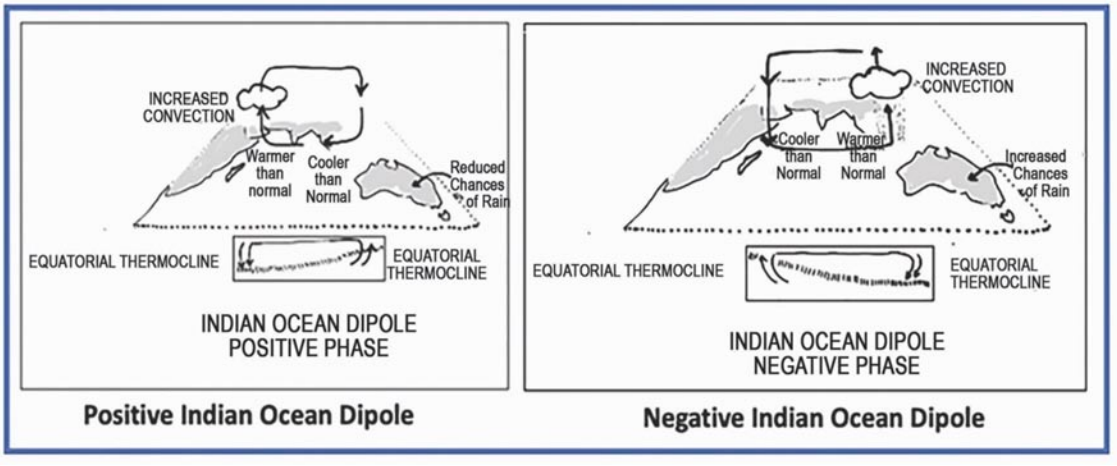
Thus, only if the monsoon forecast is improved drastically, India will be better prepared to face the uncertainties of monsoon and climate change. Also, it will help in effectively managing the disasters.

►INDIAN OCEAN DIPOLE

IOD measures differences in sea surface temperatures between western and eastern parts of Indian Ocean. It is basically like El Nino weather system that develops in Pacific Ocean. It is characterized by an irregular oscillation of sea-surface temperatures in the eastern and western Indian Ocean

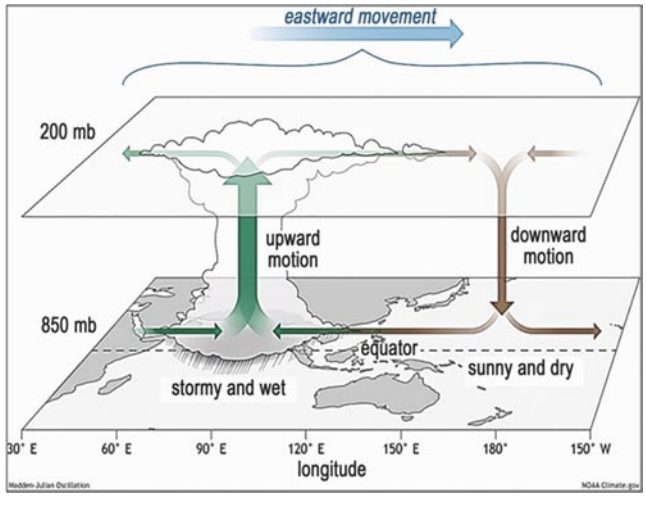
IMPACT ON WEATHER PATTERNS

- IOD alters wind, temperature, and rainfall patterns in the Indian Ocean region.
- Positive IOD event is known to bring floods to eastern Africa and droughts and bushfires to eastern Asia and Australia. Example - 2020 Australian Bushfires.
- Positive IOD is known to increase intensity of Monsoon in Subcontinent and leads to above normal rainfall. A simultaneous occurrence of Positive IOD and El Nino balances the negative impact of El Nino on Indian Monsoon rainfall. Example - above normal rainfall in India in 2019.
- Negative IOD coupled with El - Nino leads to poor Monsoon rainfall. Ex. Deficient rainfall in 1992.



►MADDEN JULIAN OSCILLATION

Distinct patterns of lower-level and upper-level atmospheric circulation anomalies accompany the MJO-related pattern of enhanced or decreased tropical rainfall across the tropics. These circulation features extend around the globe and are not confined to only the eastern hemisphere. The Madden–Julian oscillation moves eastward at between 4 m/s and 8 m/s across the tropics, crossing the Earth's tropics in 30 to 60 days—with the active phase of the MJO tracked by the degree of outgoing long wave radiation, which is measured by infrared-sensing geostationary weather satellites. The lower the amount of outgoing long waves radiation, the stronger the thunderstorm complexes, or convection, is within that region.



Enhanced surface (upper level) westerly winds occur near the west (east) side of the active convection. Ocean currents, up to 100 metres (330 ft.) in depth from the ocean surface, follow in phase with the east-wind component of the surface winds. In advance, or to the east, of the MJO enhanced activities, winds aloft are

westerly. In its wake, or to the west of the enhanced rainfall area, winds aloft are easterly. These wind changes aloft are due to the divergence present over the active thunderstorms during the enhanced phase.

Its direct influence can be tracked pole ward as far as 30 degrees latitude from the equator in both northern and southern hemispheres, propagating outward from its origin near the equator at around 1 degree latitude, or 111 kms, per day.

PHASES OF MADDEN-JULIAN OSCILLATION

MJO consists of two parts or phases. Strong MJO activity often dissects the planet into halves. One half within the enhanced convective phase and the other half in the suppressed convective phase.

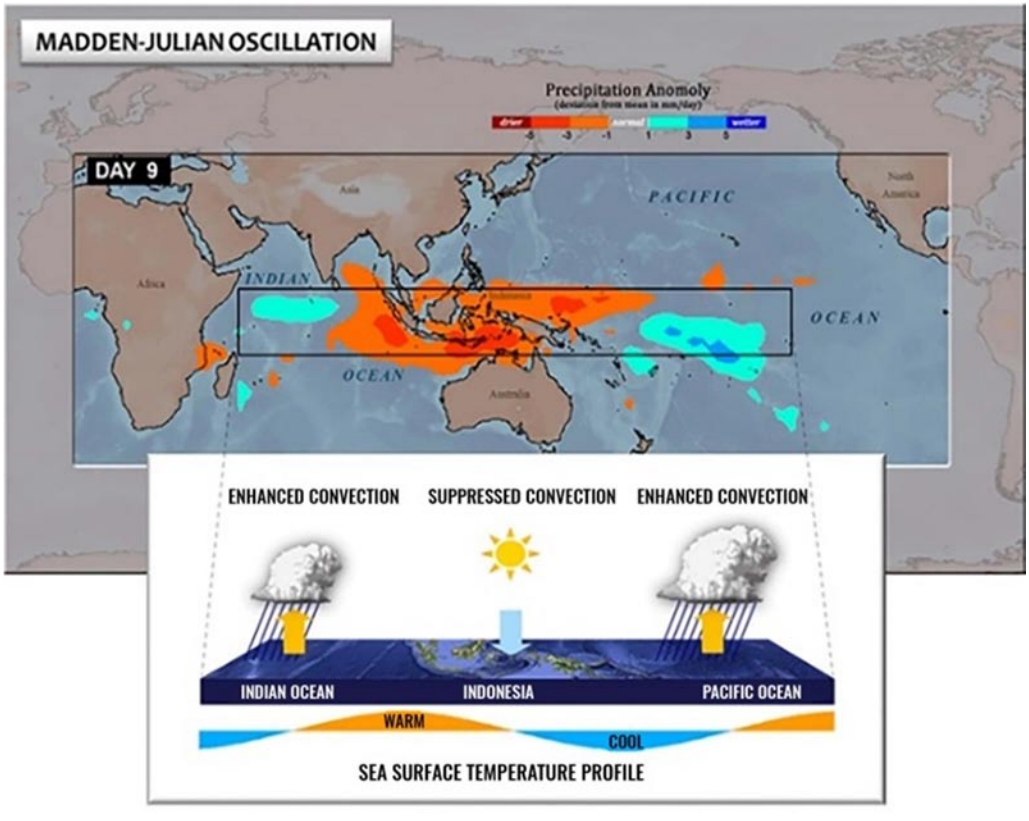
Enhanced rainfall (or convective) phase: winds at the surface converge, and the air is pushed up throughout the atmosphere. At the top of the atmosphere, the winds reverse (i.e., diverge). Such rising air motion in the atmosphere tends to increase condensation and rainfall.

Suppressed rainfall phase: winds converge at the top of the atmosphere, forcing air to sink and, later, to diverge at the surface. As air sinks from high altitudes, it warms and dries, which suppresses rainfall.

Impact of MJO on Indian Monsoon: When it is over Indian Ocean during Monsoon season, it brings good rainfall over Indian subcontinent. On the other hand, when it witnesses a longer cycle and stays over the Pacific Ocean, MJO brings bad news for Indian Monsoon.

IRREGULARITIES OBSERVED IN MJO

- Effect of Global Warming: Due to global warming: Change in the residence time of MJO clouds has altered the weather across the world
- Impact over global climate: MJO clouds are altering the residence time in Indian and Pacific Ocean. This has implications for global climate: Increased the rainfall over Northern Australia & Declining rainfall in Central Pacific and along west coast of Africa.



►CYCLONES

Cyclones are the centres of low pressure surrounded by closed isobars having increasing pressure outward and closed air circulation from outside towards the central low pressure. The winds move anti clockwise in northern hemisphere and clockwise in southern hemisphere.

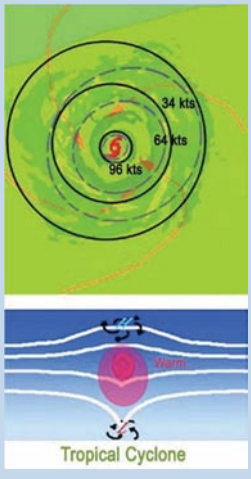
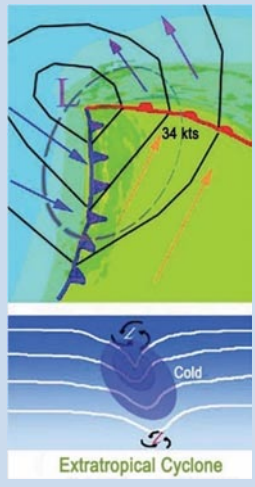
Based on location, cyclones are classified in two major types:

- Tropical cyclones
- Extra Tropical cyclones

Similarities: Tropical cyclones and extratropical cyclones are both symmetrical. They also have surface areas of low pressure with winds that rotate counter-clockwise. Both produce very heavy precipitation and often results

in flooding. Both tropical cyclones and mid-latitude cyclones can last for several days, and sometimes if a week or more. Often, a tropical cyclone will transform into an extra-tropical cyclone as it recurves poleward. Occasionally, an extra-tropical cyclone may lose its frontal features, develop convection near the centre of the cyclone and turn into a tropical cyclone.

But there are certain differences as well:

Tropical Cyclones	Extra-Tropical cyclones
	
• Formed at Tropical areas	• Formed at Mid latitudes
• Derive their energy from the latent heat of condensation	• Derive their energy from horizontal contrast in temperatures.
• They move from East to West under trade winds	• Move from West to East under Sub Tropical Westerlies.
• Can originate only in deep warm oceans	• Can originate over oceans as well as land
• They have warm core	• They have cold core
• They have convectional formation	• They have frontal formation
• There diameter ranges from 50-300 km, they can attain velocity upto 250 km/hr.	• Their diameter ranges from 150 km to 3000 km, have avg. velocity of 30-50 km/hr.
• No temperature variation in different parts.	• Have considerable temperature variation because of different fronts (warm & cold)

CLIMATE CHANGE INCREASING CYCLONIC INTENSITY AND FREQUENCY

According to Council on Energy, Environment and Water, in last 50 years India has recorded a 12-fold surge in number of associated cyclonic events such as extreme rainfall, floods, sea-level rise, and thunderstorms.

- Increased sea surface temperature: Over the past 50 years, the global ocean has absorbed 90% of the excess heat generated due to man-made climate change leading to higher convection and rapid intensification of cyclones.
- Rising sea level: on account of Antarctic melting has increased the moisture availability for cyclones.
- Micro-climatic changes on land: local heating of coastal land is pulled by the adjacent ocean further heating it up.
- Changing weather events: El-Nino and rising marine heat waves lead to prolonged warm periods over oceans by reducing the ocean upwelling.
- Higher Atmospheric moisture: due to anthropogenic global warming increase cyclonic precipitation rates thereby increasing the frequency.
- Changes in wind systems: Occasionally intense winds drive the low-pressure regions to other areas rising the frequency in those areas. E.g.- Gulab cyclone shifted to Arabian sea from B.O.B
- Rapid Intensification: According to NOAA, when the speed of a storm increases by 55km/hr within the span of 24 hours.

RECENT UNIQUE CYCLONIC PHENOMENON IN INDIA OCEAN

- Twin cyclones, Asani and Karim developing

simultaneously in North and South of Equator (May 2022). Madden-Julian Oscillation helped fuel the twin storms by promoting convection and strong westerly winds.

- Shifting of Gulab from B.O.B to Arabian sea under the influence of trade winds (Sept 2021).
- 'Gaja', crossed Tamil Nadu and Puducherry coast in November 2018 and re-emerged in Arabian sea.
- Amphan (Super cyclonic storm in B.O.B)
- Ockhi (Nov 2017) intensified from a deep depression to a cyclonic storm in less than six hours and developed near the south-eastern coast of Sri Lanka's teardrop. (There are only three instances of such a path being taken by any cyclone on record. The last time a track like this was witnessed was in 1925.)
- Fani had a longer span (more than 10 days) and it developed close to equator.

RECURVING CYCLONES

One of the most important aspects of cyclone track forecasting is recurvature, A cyclone track is said to recurve when it changes its path from the predominant zonal flow (normally westwards) to predominant meridional flow (normally northwards) and often again back to zonal flow in the opposite direction (normally eastwards). The recurvature is said to be abrupt if the meridional flow is short-lived and there is sudden change in the direction of more than 60°.

Tropical cyclones in both the Northern and Southern Hemispheres tend to move westward and drift slowly poleward and then eastward. Trade winds are responsible for the general westward motion of tropical cyclones *(Environmental steering).*

REASONS FOR RECURVING

- Coriolis force drifts the cyclones towards right in N.H *(ferrel's law)* and hence pole wards and then eastwards *(Beta Drift).*
- Presence of subtropical highs, over the oceans poleward of the trade winds. These regions of clockwise circulation in the Northern Hemisphere make the winds on the western edges of these large-scale circulations move toward the poles.
- Interaction of tropical cyclones with mid latitude westerlies change the original westward path of tropical cyclones towards north and then eastwards.
- Upper air jet streams further push the cyclones towards right.
- Local topography of the coast.
- Interaction among several cyclonic wind systems, a new avg. point of centre is made, and cyclones change its path (Fujiwara effect).

►AIR MASS

It is a large body of air whose physical properties like temperature, moisture content and lapse rate are uniform horizontally for hundreds of kilometres.

It might be so extensive that it might cover an entire continent and it may vertically extend through troposphere.

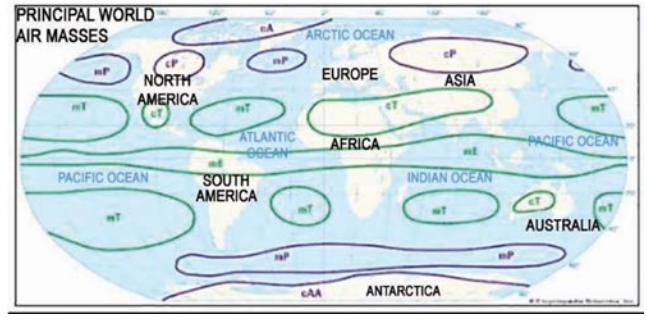
The air masses are classified according to the source regions.

There are five major source regions.

- Warm tropical and subtropical oceans.
- The subtropical hot deserts.
- The relatively cold high latitude oceans.
- The very cold snow-covered continents in high latitudes.
- Permanently ice-covered continents in the Arctic and Antarctica.

Accordingly, following types of airmasses are recognised:

- Maritime tropical (mT)
- Continental tropical (cT)
- Maritime polar (mP)
- Continental polar (cP)
- Continental arctic (cA)



CLIMATIC SIGNIFICANCE OF AIR MASSES:

- Cause precipitation: E.g., maritime-tropical airmass over Atlantic Ocean causes precipitation east of Rocky Mountains.
- Modify temperature: Airmasses developed over North Atlantic brings moderating effect on NW coast of Europe.
- Modify the weather of regions where they visit. E.g.- cP airmass produces 'lake snow' effect at the shores of great lakes in North America.
- Cyclones and anti-cyclones: Convergence of opposite air masses create fronts and lead to temperate cyclones.

- Droughts: Hot dry airmass can increase the evaporation and lead to drought situation.

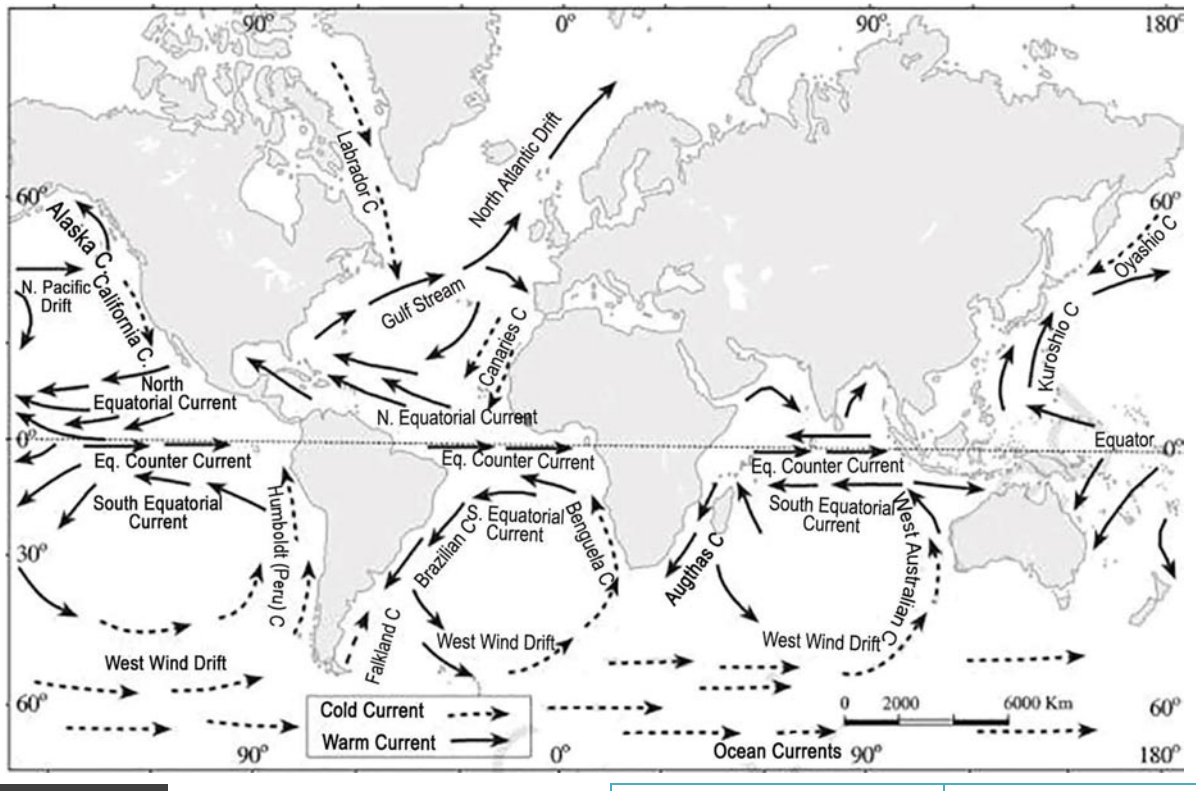
►HIMALAYA'S SIGNIFICANCE FOR INDIA'S CLIMATE

- Acts as climatic divide as it obstructs the passage of cold continental air from the north into India in winters.
- Provides climatic diversity on account of altitudinal variations as well as different slope gradients. E.g.- town of Mussoorie, at an elevation of about 1,900 metres, receives 92 inches of precipitation annually, compared with 62 inches in the town of Shimla. The eastern Himalayas, which are at a lower latitude than the western Himalayas, are relatively warmer.
- Forces the south-westerly monsoon (rain-bearing) winds to give up most of their moisture before crossing the range northward.
- Brings winter rainfall by deviating the SW jet streams to its south which brings the moisture from Mediterranean. *(These reasons have prevented India from being a desert.)*
- During winter, low-pressure weather systems advance into Himalayas from the west and cause heavy snowfall.

OCEANOGRAPHY

►OCEAN CURRENTS

Ocean currents are the continuous, predictable, directional movement of seawater driven by gravity, wind (Coriolis Effect), and water density. Ocean water moves in two directions: horizontally and vertically. Horizontal movements are referred to as currents, while vertical changes are called upwellings or downwellings.



TYPES OF CURRENTS

Based on depth

Surface currents	Sub Surface currents
Found upto 400 m of depth.	Beyond 4oo m depth.
Constitute around 10% of the total water in ocean.	90% of the total water.
Formed at lower latitudes as higher temperature reduces the density, expands the water and hence the water floats on the surface.	Mainly formed at higher latitudes as lower temperature increases the density and cause them to sink.

Based on Temperatures

Warm Currents	Cold currents
Bring warm water into cold water areas	Bring cold Water into warm water areas.

Observed on the east coast of continents in the low and middle latitudes (both hemispheres)	Found on the west coast of the continents in the low and middle latitudes (both hemispheres).
In the northern hemisphere they are found on the west coasts of continents in high latitudes.	Found on the east coast in the higher latitudes in the Northern Hemisphere.
Thermal expansion and floatation drive these currents.	Thermal contraction and sinking drive these currents.

FACTORS AFFECTING CURRENTS

Originating factors

- Earth's rotation: the rotational force of the earth causes movement of ocean water near the equator in opposite direction to the west to east rotation of the earth and thus Equatorial currents are generated.
- Oceanic factors: Temperature, salinity and density differences are responsible for expansion, floatation and sinking of water. E.g. – Labrador current moves as sub surface currents from pole towards equator.
- Atmospheric factors: Winds drive ocean current in direction in which they move. Rainfall and evaporation create level differences and thus moves the water.

Modifying factors

- Direction, shape and configuration of coastline: currents flow parallel to coastline. equatorial current after being obstructed by Brazilian coast gets bifurcated into two branches and then moves along the coast.
- Bottom reliefs: North Atlantic drift is deflected to the right when it crosses Wyville Thompson ridge.
- Coriolis effect: deflective force affects the direction. Currents flowing from north pole towards equator deflects towards right.
- Seasonal changes: They alter the direction of motion. E.g. - Indian ocean currents show regional shifts under the influence of monsoonal winds.

Temperature & salinity affecting Ocean circulation:

Temperature and salinity affect the density of water, resulting in water moving up or down through the ocean layers and moving as currents around the ocean.

- Salinity increases the density of ocean water. This denser water sinks and moves as subsurface current whereas less saline water moves towards greater saline water as surface current. *Ex:* The current flowing from the Atlantic Ocean to the Mediterranean Sea via Gibraltar Strait is caused by salinity difference.
- Due to high temperature in the equatorial region the water density decreases because of greater expansion of water particles whereas the density of sea water becomes comparatively greater in the polar areas. Consequently, water moves due to expansion of volume from equatorial region of higher temperature to polar areas of relatively very low temperature. ***Ex:*** The Gulf Stream and Kuroshio warm currents move from equator towards north due to the temperature difference**.**
- As warm water flows northwards it cools and some evaporation occurs, which increases the amount of salt. Low temperature and a high salt content make the water denser, and this dense water sinks deep into the ocean. The cold, dense water slowly spreads southwards, several kilometers below the surface. Eventually, it gets pulled back to the surface and warms in a process called "upwelling" and the circulation is complete. ***Ex:*** Atlantic Meridional Overturning Circulation (AMOC)

SIGNIFICANCE OF OCEAN CURRENTS

Geomorphic

- Ocean current along with waves erode, modify and develop coastal as well as submarine landforms.
- Longshore currents carry along with themselves vast quantities of material and sediments.
- Currents help to move eroded debris and deposit it as silt, sand, and gravel along the coasts
- Desert formation: Cold Ocean currents have a direct effect on desert formation in west coast regions of the tropical and subtropical continents.

Climatic

- Manage global climate by transporting excessive heat from equator towards pole.
- Modify the coastal climate. E.g.- Gulf stream brings heat to the north-western Europe and lead to moderate conditions.
- Phenomenon like El-Nino and La-Nina are associated with oceanic currents.
- Currents along with the wind lead to regional climatic changes. E.g.- Currents along the Indian coast impact the monsoon.
- Rainfall and fogs are also associated with oceanic currents.

Ecological

- Distribute oceanic heat and balances the temperature conditions.

- Carry nutrients and food to organisms that live permanently attached in one place and carry reproductive cells and ocean life to new places. E.g.- Upwelling Benguela current brings the nutrients to the coast of Africa
- Oceanic gyres are known to trap pollutants thus causing garbage patches. Ex. Great Pacific Garbage Patch.

Economic

- Commercial fishing grounds are formed where warm and cold current mix. E.g.- Labrador current mixing with Gulf stream near newfoundland.
- Aids as well as hinder navigation. Current support ships moving in the same direction, but it blocks their way when they carry large amount of ice bergs along with them, especially the colder currents.
- Currents offer a vast potential to be transformed into energy sources.

Social

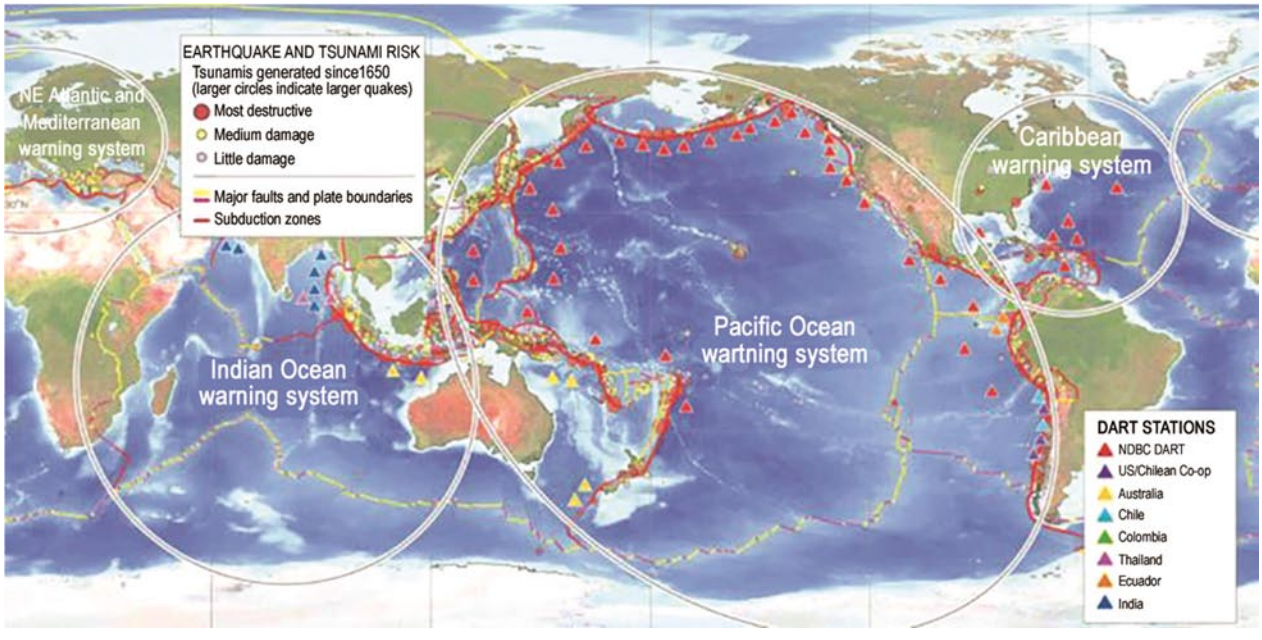
- Play an important role in determining settlements in a coastal region.
- Impact health of population by altering climatic conditions.

►TSUNAMI

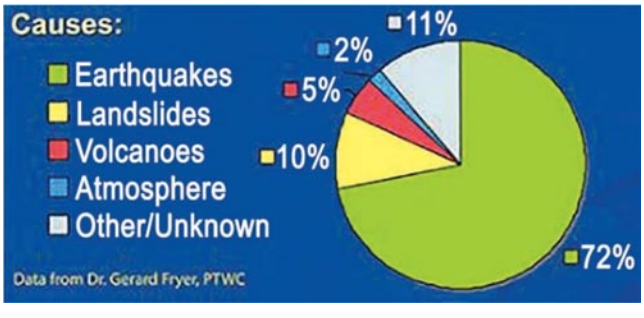
Tsunami comprises the Japanese word tsu (meaning harbour) and nami (meaning wave). A tsunami is a series of enormous waves created by an underwater disturbance usually associated with earthquakes occurring below or near the ocean.

Tsunamis are caused by violent seafloor movement associated with earthquakes, landslides, lava entering the sea, seamount collapse, or meteorite impact. The most common cause is earthquakes.

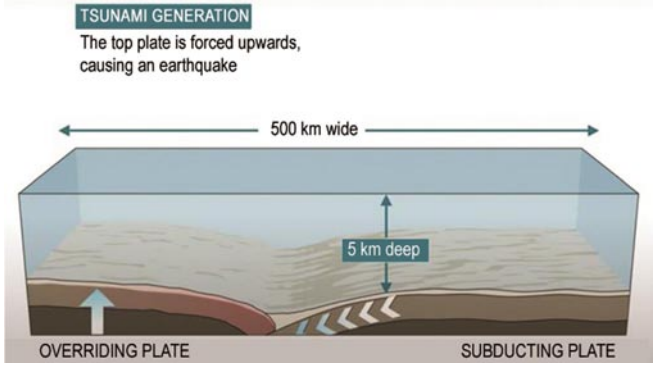
GLOBAL HOTSPOTS OF TSUNAMI

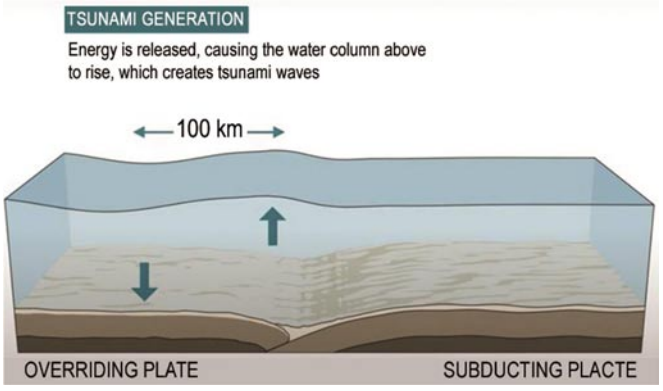


CAUSES OF TSUNAMI



- Plate movement and earthquake: Most strong earthquakes occur in subduction zones where an ocean plate slides under a continental plate or another younger ocean plate. Earthquake on the ocean floor can result in sudden rise or fall of the earth's crust. This movement can cause water to rise and fall, creating tsunami waves.

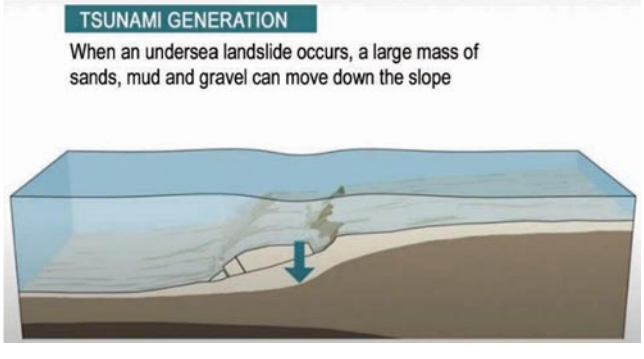




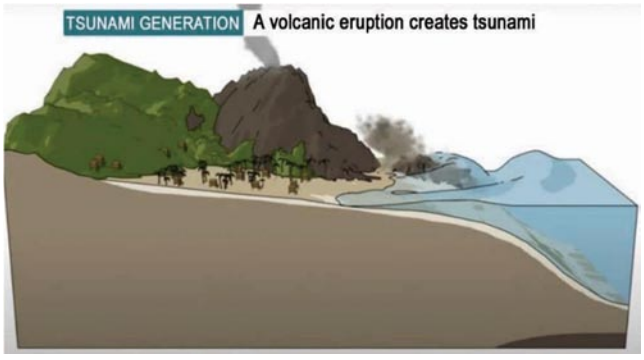
All earthquakes do not cause tsunamis. There are four conditions necessary for an earthquake to cause a tsunami:

- The earthquake must occur beneath the ocean or cause the material to slide into the ocean.
- The earthquake must be strong, at least magnitude6.5 on the Richter Scale
- The earthquake must rupture the Earth's surface and it must occur at shallow depth – less than 70km below the surface of the Earth.
- The earthquake must cause vertical movement of the seafloor (up to several meters).

- Landslides: They can happen on the seafloor, just like on land. Areas of the seafloor that are steep and loaded with sediment, such as the edge of the continental slope, are more prone to undersea landslides. When an undersea landslide occurs (perhaps after a nearby earthquake) a large mass of sand, mud and gravel can move down the slope. This movement will draw the water down and may cause a tsunami that will travel across the ocean.



- Volcanic eruptions: They occur in several ways:
  - destructive collapse of coastal, island and underwater volcanoes which result in massive landslides
  - pyroclastic flows, which are dense mixtures of hot blocks, pumice, ash and gas, plunging down volcanic slopes into the ocean and pushing water outwards
  - a caldera volcano collapsing after an eruption causing overlying water to drop suddenly.



- Extra-terrestrial impacts: scientists realize that if these celestial bodies should strike the ocean, a large volume of water would undoubtedly be displaced to cause a tsunami. Scientists have calculated that if a moderately large asteroid, 5-6 km in diameter, should strike the middle of the large ocean basin such as the Atlantic Ocean, it would produce a tsunami that would travel all the way to the Appalachian Mountains in the upper two-thirds of the United States.

►GROUNDWATER POTENTIAL IN INDIA

Ground water is the water that seeps through rocks and soil and is stored below the ground. The rocks in which ground water is stored are called aquifers. Aquifers are typically made up of gravel, sand, sandstone or limestone. The area where water fills the aquifer is called the saturated zone. The depth from the surface at which ground water is found is called the water table.

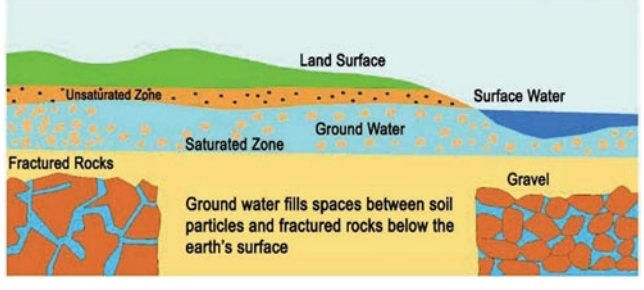


Figure 1: Graphical representation of ground water and associated terms

The underground (hydrogeological) setting of ground water defines the potential of this resource and its vulnerability to irreversible degradation. This setting in India can be divided into following categories, which are described below:

i) Northern Mountainous Terrain and Hilly areas:

- Characterized by steep slopes and high runoff.
- This region is underlain mostly by rocks such as granites, slate, sandstone and limestone. Very little

scope for groundwater storage.

ii) Indo-Gangetic-Brahmaputra Alluvial Plains:

- Comprises the vast plains of Ganges and Brahmaputra rivers.
- Underlain by thick piles of alluvial sediments, constitute the most potential and productive ground water reservoir in the country.
- Due to excessive ground water extraction and low recharge rates, these aquifers are at the risk of irreversible overexploitation.

iii) Peninsular Shield Area:

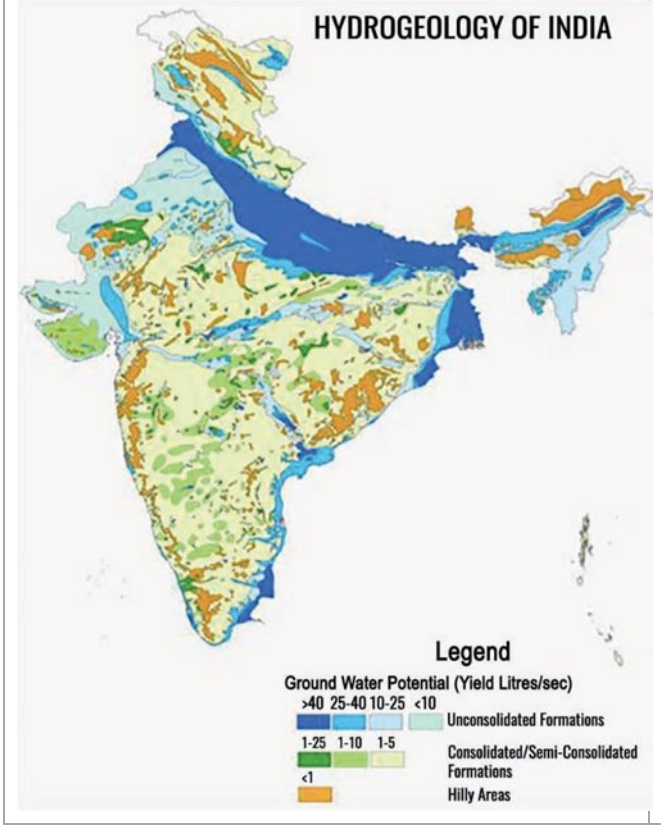
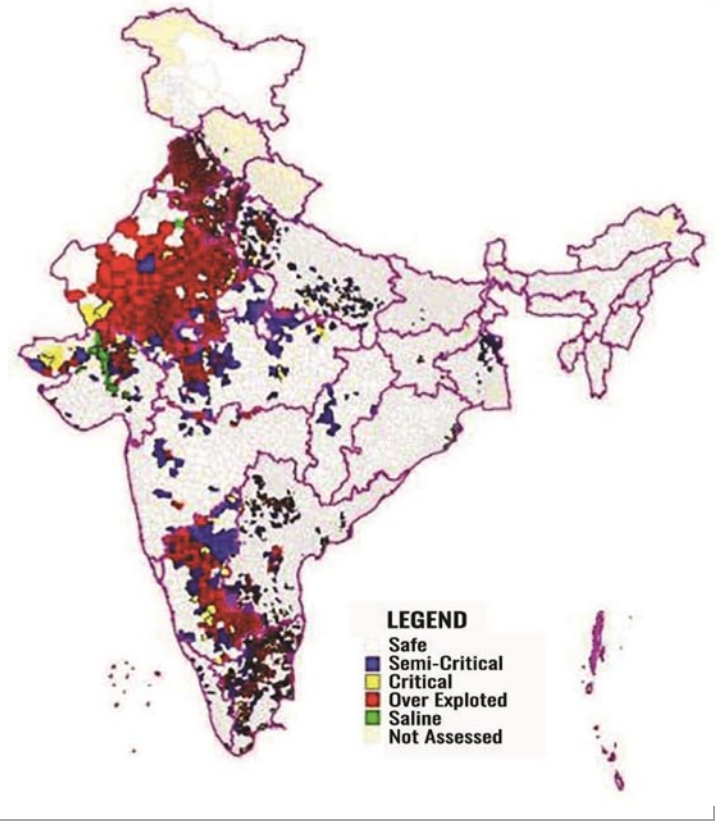
- Consist mostly of consolidated sedimentary rocks, Deccan Trap basalts and crystalline rocks limited ground water potential.
- Poor permeability which limits their recharge through rainfall.
- Ground water occurs mainly in the weathered and fractured zones of rocks.
- This implies that water in these aquifers is non-replenishable and will eventually dry out due to continuous usage.

iv) Coastal Area:

- Coastal areas have a thick cover of alluvial deposits and form potential multi-aquifer systems.
- However, inherent quality problems and the risk of seawater ingress impose severe constrains in the development of these aquifers.

v) Cenozoic Fault Basin and Low Rainfall Areas:

- This region has been grouped separately owing to its peculiarity in terms of presence of three discrete fault basins, the Narmada, the Purna and Tapti valleys.
- The aquifer systems in arid and semi-arid tracts of this region in parts of Rajasthan and Gujarat receive negligible recharge from the scanty rains and the ground water occurrence in these areas is restricted to deep aquifer systems tapping fossil water.
- For example, in parts of Purna valley the ground water is extensively saline and unfit for various purposes.

Groundwater Distribution & Potential	Groundwater Crisis
	

INDUSTRIAL LOCATIONS & RESOURCES

Previous Year Questions

YEAR	UPSC MAINS QUESTIONS
2021	Discuss the multi-dimensional implications of uneven distribution of mineral oil in the world.
2021	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.
2020	Account for the present location of iron and steel industries away from the source of raw material, by giving examples.
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	Describe the benefits of deriving electric energy from sunlight in contrast to the conventional energy generation. What are the initiatives offered by our government for this purpose?
2019	Can the strategy of regional resource-based manufacturing help in promoting employment in India?
2019	Discuss the factors for the localisation of agro-based food processing industries of North-West India.
2018	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	Why is Indian Regional Navigational Satellite System (IRNSS) needed? How does it help in navigation?
2016	Give an account of the current status and the targets to be achieved pertaining to renewable energy sources in the country. Discuss in brief the importance of National Program on Light Emitting Diodes (LEDs).
2015	To what factors can the recent dramatic fall in equipment costs and tariff of solar energy be attributed? What implications does the trend have for the thermal power producers and the related industry?
2014	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?
2013	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

►TYPES OF INDUSTRIES

PRIMARY SECTOR	SECONDARY SECTOR	TERTIARY SECTOR
Producing goods using natural resources directly.	Natural products are changed into other forms using manufacturing processes.	They themselves do not produce any good.
Forms the base of all other sectors.	It is a next step after primary sector. Also called, industrial sector.	They provide services to primary and secondary sectors. Also called, "service sector".
E.g. – Dairy, fisheries, agriculture	E.g. – Using sugarcane to make sugar or Gur.	E.g. – Transportation services.

Industries are classified into two broad categories, based on the weight of the product.

Weight losing Industries	Weight gaining industries
Raw material is heavier compared to final product.	Raw materials are lighter as compared to final product.
E.g. - Iron and steel industry.	E.g. – Bakery industry
Tend to locate near the raw material to reduce transportation costs of raw materials.	Tend to locate near the market to reduce the transportation cost of product to market.

GENERAL LOCATIONAL FACTORS FOR INDUSTRIES

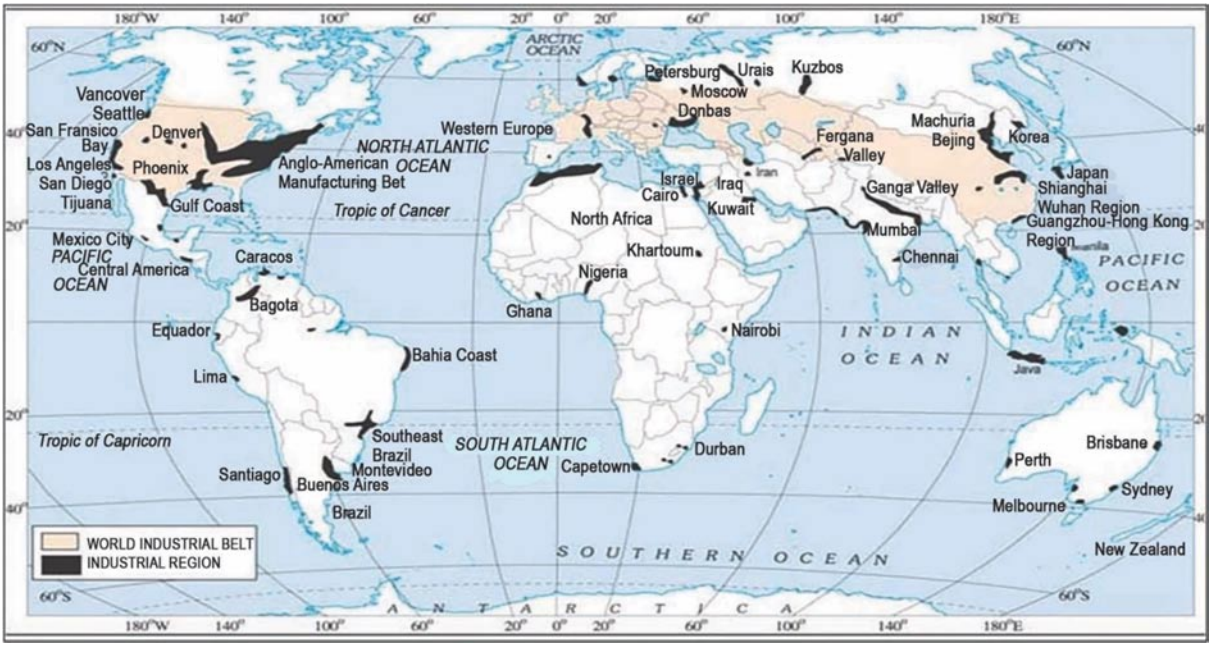
- Availability of raw materials.
- Nature of industry i.e., weight loosing or gaining.
- Transportation cost
- Availability of cheap and skilled labour.
- Clusterisation and development of inter-industrial linkages. Benefits of agglomeration.
- Capital, entrepreneurship and innovation.
- Electricity, fuel and energy.
- Proximity to market and regular demand.
- Government policies like public investment ease of doing business and FDI norms etc.

LOCATIONAL FACTORS FOR INDUSTRIES

►INDUSTRIAL REGIONS IN INDIA

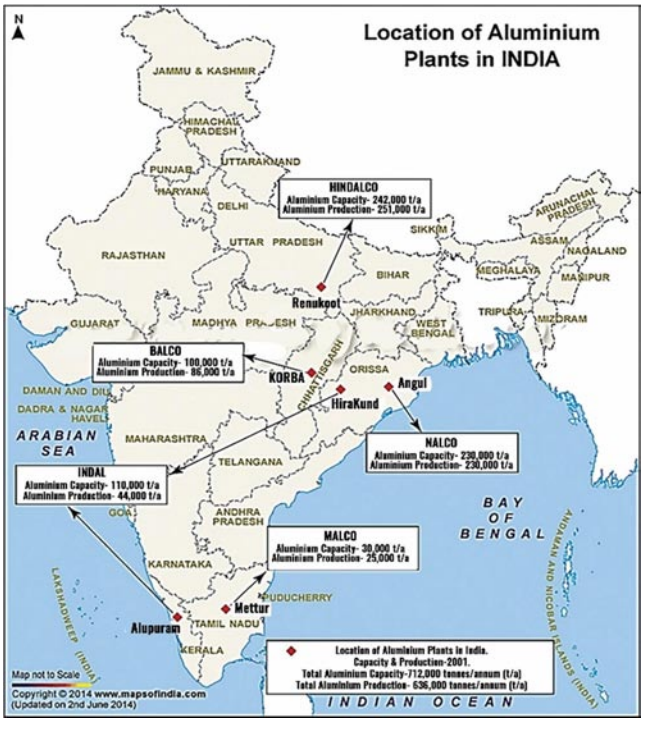
Fig. India : Industrial Regions

►INDUSTRIAL REGIONS IN THE WORLD



►ALUMINIUM INDUSTRY

- Proximity to raw materials areas (Bauxite, caustic soda, aluminium fluoride).
- Electricity as a continuous source of energy.
- Effective transportation to carry huge weight.
- Industrial clusters to serve as immediate market.



ISSUES IN ALUMINIUM INDUSTRY

- Production concentrated in few units like BALCO, HINDALCO, NALCO etc.
- Rising cost of domestic production due to increase in energy cost, coal cess and other duties.
- Over reliance on imports for coal, scrap and strategic metals.
- Administrative issues like delays in environmental clearances, complex laws and frequent change in policies.
- Aluminium is a very important industry due to its lightweight nature. It is increasingly replacing steel in automobile industry as aluminium-based vehicles are less in weight and are more fuel efficient. Also in aircrafts, railways etc.

►AUTOMOBILE INDUSTRY

FACOTRS RESPONSIBLE FOR THEIR LOCATION

- Raw materials: steel is the basic raw material thus proximity to iron & steel plants. E.g. - Detroit, Chicago, Stuttgart, Jamshedpur etc.
- Existing industrial regions to have effective inter – industrial linkages and uninterrupted power supply.
- Capital for continuous R&D as the industry is highly competitive.
- Demography: areas having high youth population will have higher demand of two wheelers and four wheelers. E.g. - Delhi-Gurgaon region.
- Economic setup of region: E.g. - agrarian economies will be having higher demand for machines like tractors, thrashers and harvesters.

Ancelirisation: OEMs typically use ancillary parts in manufacturing end products. Thus, development of extensive ancillary network attracts other automobile manufacturers.

ISSUES IN AUTOMOBILE INDUSTRY

- Slump in domestic demand due to Covid induced lockdown.
- Complex migration and digitized transportation (OLA, UBER) discourages the permanent purchase of vehicles and affects demand.
- Bend towards electric & hybrid vehicles for which smaller companies do not have resources to invest.

FACTORS AFFECTING LOCATION OF ELECTRIC VEHICLES INDUSTRIES

Availability and price of raw material: Lithium, cobalt, manganese, nickel and palladium are the main raw materials. Location which offers their availability at low prices are the most favoured ones.

Existing industrial region: to provide streamlined forward – backward linkages.

Labour & Entrepreneurs: Skilled technology friendly labour and innovative entrepreneurs.

Government policies: Subsidies offered on purchases, higher focus towards climate friendly policies, better public transportation and tax incentives.

Market and demand: Urban areas where average daily driving distance is smaller.

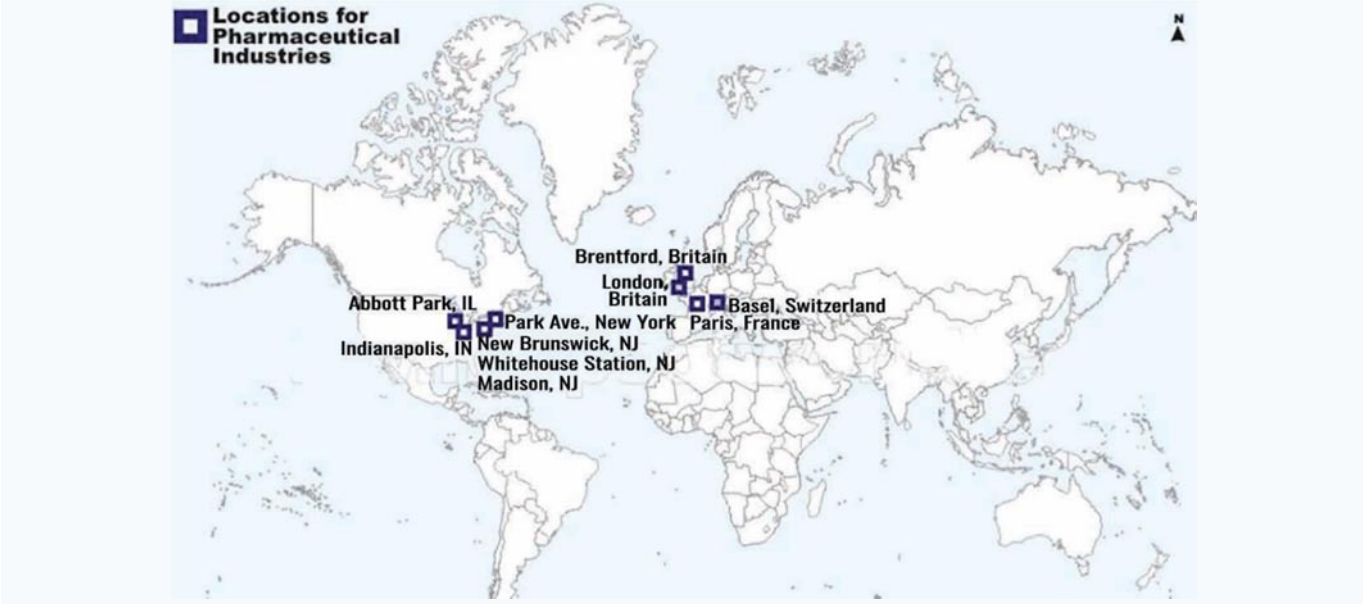
►PHARMACEUTICAL INDUSTRIES

- A footloose industry and hence mainly located near the market.
- Government policies play huge role, e.g.- Pharma industries in Baddi (Himachal)
- Requires skilled labour, efficient transportation and research centres.

ISSUE IN PHARMACEUTICAL INDUSTRIES

- High dependence on China for active pharmaceutical ingredients
- Issues in patent regime on account of evergreening and compulsory licensing which discourage the foreign investors to invest in India.
- Pirated version of medicines, black marketing and hoarding.

- Inaccessibility to European market on account of lower standards.
- Lack of R&D in sectors like biotechnology and nanotechnology.



PHARMACEUTICAL INDUSTRIES ARE LOCATED MORE ON WEST COAST

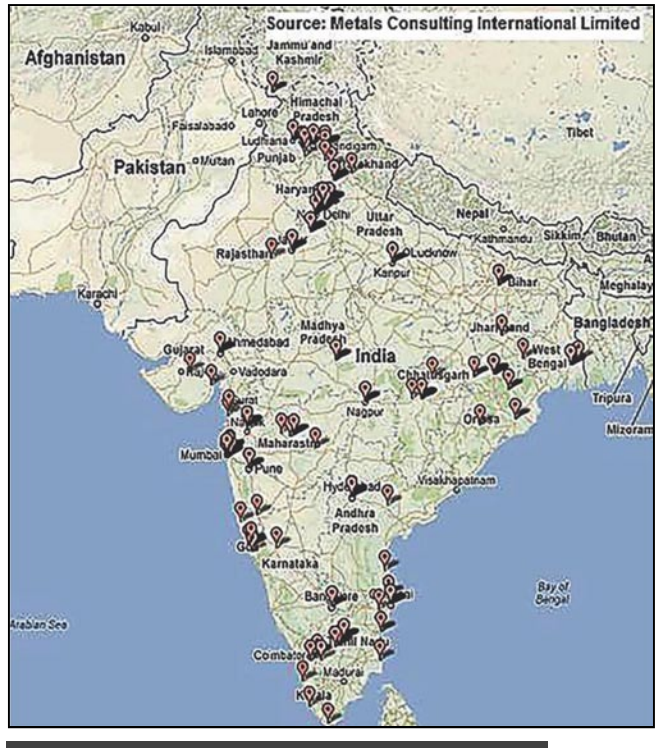
- Proximity to petrochemical hubs near Gujarat and Mumbai which provides raw materials. (Active Pharmaceutical Agents are mostly imported into India, which is the chief constituent of pharmaceutical industries).
- Proximity to ports for easy exports of medicines and imports of active pharmaceutical ingredients.
- Nearness to Africa which serves as a huge market for Indian pharma.
- Higher availability of capital, entrepreneurship and availability of skilled labor.
- Higher per capita income in western India, where local consumption of drugs is also higher.
- Presence of industrial inertia and higher ease of doing business in western states.

►IRON & STEEL INDUSTRY

Traditionally, this industry was very capital intensive. Integrated steel plants were built near the raw materials and energy sources. E.g., TISCO. Important raw materials were iron, dolomite and limestone, coking coal.

ISSUES IN IRON AND STEEL INDUSTRY

1. Low potential utilisation. E.g. - Durgapur steel plant is working at 50% capacity.
2. Shortage of metallurgical coal.
3. Erratic power supply.
4. Cheap imports due to dumping by countries like China.
5. Global economic slowdown and subdues demand.

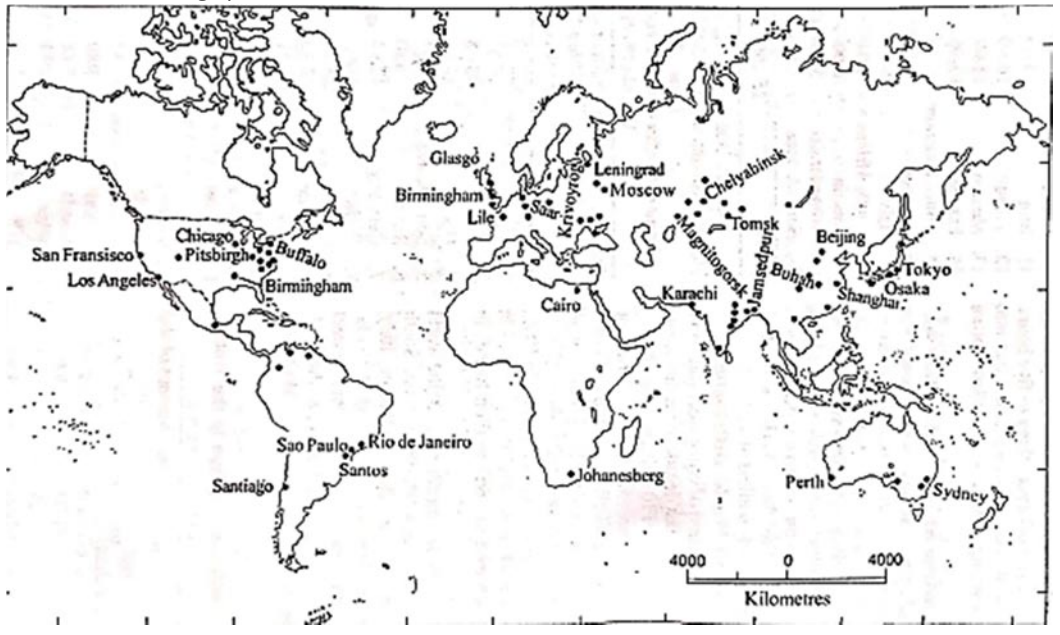


RECENT SHIFTS IN IRON AND STEEL INDUSTRY

- Mini steel plants are being built near the market (as opposed to near the raw material) especially the urban centers. The big cities generate huge waste and out of that a scrap iron is used as a raw material for mini steel plants. E.g. - Delhi. (Example of circular economy).
- These mini steel plants typically employ electric arc process for steel refining, hence are need large

amounts of electricity.

- Government is undertaking policies to reduce the logistics cost which is allowing the industrialists to setup industries near the market.



- Old iron ores mines have depleted hence pushing the industries away from traditional locations.
- Shifts in fuel – industries moving from coal rich areas to oil and gas rich areas. E.g. – industries in Lorraine, France and south Luxembourg.

►SEMICONDUCTOR MANUFACTURING

A semiconductor is a material that allows electrical conductivity between a conductor and an insulator. Semiconductors are made from pure elements like silicon or germanium, or compounds such as gallium arsenide. Sometimes their conductivity is changed through doping.

Doping is a process of adding small amounts of impurities to these pure elements, causing large changes in the conductivity of the material.

Semiconductors make the devices more compact, less expensive, and more powerful. For instance, mobile phones weighed about 2 lbs, cost around $4,000, and held a charge for only about 30 minutes of talk time during their initial phase. However today an individual can buy a smartphone for 5000 rupees that would give a 1-day charge.

LOCATION FACTORS FOR SEMI-CONDUCTOR MANUFACTURING INDUSTRY

- Workforce: Technically skilled workforce is required. Along with this lawyers, accountants, and management consultants are also very important.
- Cost: Cost of labour, operations and services is important.
- Financial incentives and subsidies: They attract the investors to set up the plant.
- Transportation: to ensure forward-backward linkages. Continuous supply of end products to consumers is very important.
- Infrastructure: water, electricity, internet access.
- Market availability- lifestyle.

SIGNIFICANCE OF SEMICONDUCTOR MANUFACTURING INDUSTRY

Economic development:

- Semiconductors are the building blocks of today's technology.
- Indigenous manufacturing of chips will build its smartphone assembly industry and strengthen its electronics supply chain.
- This will create numerous employment opportunities for the Indian youth.
- Indigenous capacity would attract local taxes and boost the export potential.
- India would be required to import fewer semiconductor chips which would decrease import bill.

Meet rising demand:

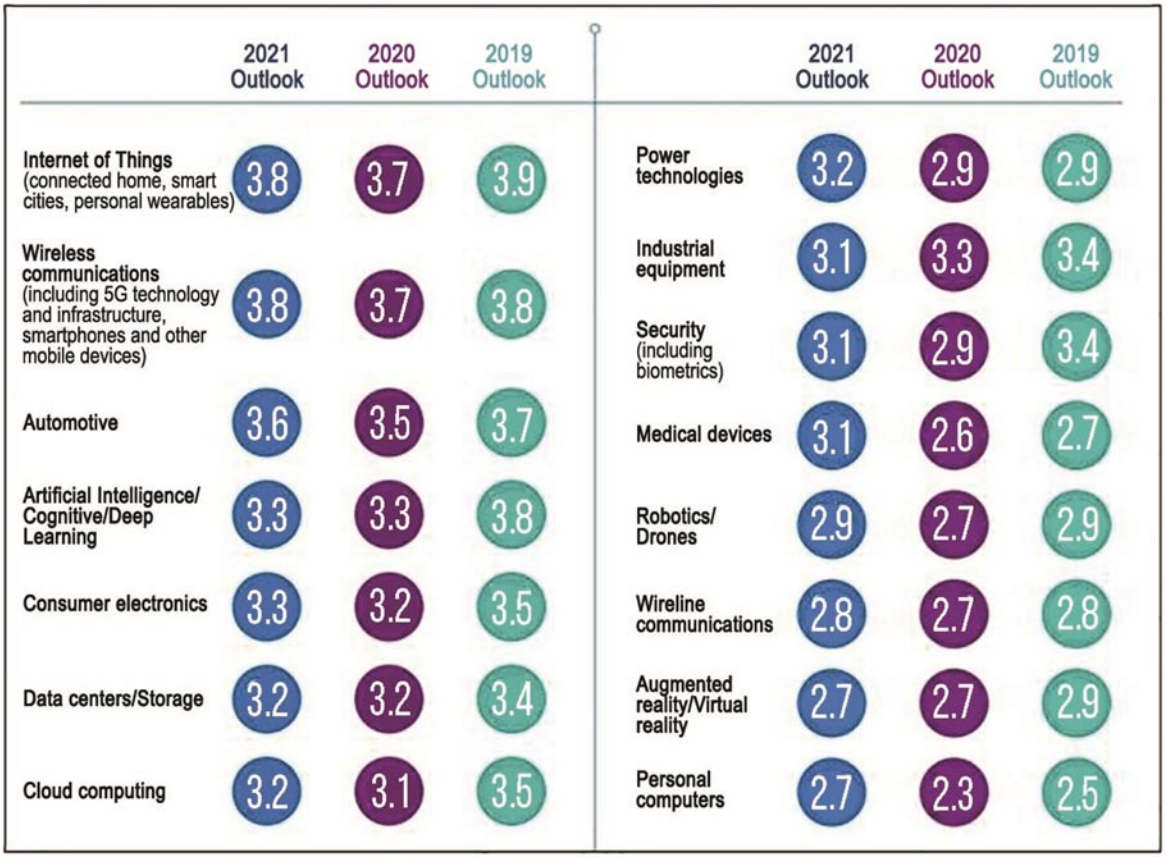
- Experts estimate that around 50 crore people will join the internet in the next decade thereby demanding more phones and laptops.
- Work from home culture warrants an enhanced demand for servers, internet connectivity, and cloud usage.

Geopolitical Benefits: driven by data and the digital revolution. Further self-sufficiency will decrease reliance

on Chinese chip imports especially during hard times like the recent Galwan Valley border clash.

Enhanced Security: Chips made locally will be designated as "trusted sources" and can be used in products ranging from CCTV cameras to 5G equipment. This would improve the national cybersecurity profile.

KEY GROWTH DRIVERS OF THE INDUSTRY



INDIA'S POSITION IN SEMI-CONDUCTOR MANUFACTURING

Globally, entire value chain has seeped in interdependence between a handful of countries like the USA, Taiwan, Japan, China, and some European nations.

- India has done well in design and verification for semiconductor industry. Most global semiconductor companies having an R&D footprint in India.
- However, 100% of our chips, memory, and display are imported into the country. In 2020, India spent $15bn on electronic imports, with 37% coming from China.
- Although India has two fabs — SITAR, a unit of the Defence Research and Development Organisation (DRDO) in Bengaluru, and a semiconductor laboratory in Chandigarh. These build silicon chips for strategic purposes like defense and space and not for commercial use.

INITIATIVES TO PROMOTE INDIGENOUS SEMICONDUCTOR CAPACITY

- National Policy on Electronics 2019: It envisions positioning India as a global hub for Electronics System Design and Manufacturing (ESDM) sector. It aims to encourage the development of core components, including chipsets.
- Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors (SPECS): Government will provide a financial incentive of 25% on capital expenditure for a list of products that constitute the supply chain of electronic products. This includes products such as electronic components, semiconductors, and specialized sub-assemblies.
- India would be offering more than $1 billion in cash to each semiconductor company that sets up manufacturing units in the country.
- Modified Electronics Manufacturing Clusters (EMC 2.0) Scheme: Government will provide support for the setting up of Electronics Manufacturing Clusters (EMCs) and Common Facility Centres (CFCs).
- Production Linked Incentive Scheme (PLI): Government will provide an incentive of 4% to 6% on goods manufactured in India and covered under target segments to eligible companies for a period of five years.
- Foreign Direct Investment: Government has allowed

100 percent (FDI) under the automatic route in the Electronics Systems Design & Manufacturing sector.

CHALLENGES IN DEVELOPING LOCAL SEMICONDUCTOR FABS

- High Cost of establishment: As per a government estimate, it would cost roughly $5-$7 billion to set up a chip fabrication unit in India.
- Low Ease of doing business: Process of establishing an indigenous semiconductor facility requires clearances and approvals from multiple government departments.
- Technological Constraint: Indigenous manufacturing of semiconductors requires use of high-end technologies. These technologies are licensed from patent holders at a very high price.
- Structural constraint: FDI in electronics is less than 1% of the total FDI inflow because of dearth of skilled labor, delays in land acquisition, and uncertain tax regime.
- Unstable power supply: Smooth production of semiconductors requires the availability of an uninterrupted 24*7 power supply.

SUGGESTIONS

- Government should provide adequate funding to augment R&D potential of technical institutes. For instance, IIT Madras developed a microprocessor named 'Moushik' with funding support from the Ministry of Electronics and Information Technology.
- Proposed Sovereign Patent Fund (SPF) under National Policy on electronics should be established expeditiously. It is a Government-backed entity that aims to bolster domestic businesses through acquisition and licensing of patented technology.
- Manufacturers need to be given an assurance of minimum domestic procurement by the government and private sector. The focus should be on manufacturing economical and technically viable options like 28nm chips.
- Government should also support businesses in acquisition of semiconductor manufacturing units in other countries. This is easier than setting up a domestic facility and can be done swiftly for ensuring a continuous supply of chips.

►PETROCHEMICAL INDUSTRIES

- Proximity to petroleum refineries or areas where gas pipelines reach. Mumbai is the hub of petrochemical industries.
- Efficient transportation to ensure continuous supply without any leakages.
- Port facilities for easy export of final products.
- Market availability: Petrochemical plants are not present in West Asian countries, because although there are refineries there is no large local market for the end products of the industry.

Difference between petrochemical industry and petroleum refineries: The petroleum refinery converts crudes into products such as Gas, Naphtha, Gasoline, Kerosene, Diesel, residue, lubricant oil.

The Petrochemical Industry uses the above products as raw materials. It takes mainly Naphtha, Petrol, Gas, and other products and produces various types of products such as Polymer (complex carbon compound).

The petrochemical industry is not one industry; there are many industries that get the raw material from the by-product of crude oil processing, collectively called the petrochemical industry.

►OIL REFINING

- Work of refining is to breakdown various hydrocarbons into their respective groups or factions through a complex process of distillation.
- Not only split into many components but impurities are also removed.
- Changes in oil-refining space: Much larger capacity refineries are being set up, advent of Electric Vehicles has led to shutting down of capacity in Europe. However, demand for petroleum products is still increasing in developing world which continue to expand refining capacity. India is still adding capacity to its refining capacity with new refineries planned at Nagapattinam, Tamil Nadu, Barmer Refinery, Rajasthan etc.

LOCATION OF OIL REFINING

- Most of world's oil is produced in countries which do not have much demand hence it must be traded.
- Most major refineries are therefore situated on the coast, whether they are in producing or consuming countries.
- Petrochemical industries are located close to refineries, but they also tend to locate near their major markets.
- Market based refineries: N. America, Europe and Japan have market-oriented refineries.

OIL FIELD BASED REFINERIES

- Greatest advantage of such refineries is the proximity of crude oil, transport costs are saved and refining can begin as soon as oil is brought to the surface.
- Chief disadvantage of such locations are the refineries will be useless when the field is exhausted.
- They are distant from petroleum products markets.
- Creating refining facilities in sparsely populated, inhospitable terrain or inclement weather conditions is difficult.
- If field-based refineries get located at or near the coast they have added advantage of easy import of machineries/tools/labor and easy export of the finished goods. EG: Saudi Arabia.
- Apart from economic reasons other factors such as political unrest, fear of nationalization of refineries and as a basis of industrial development in underdeveloped countries.
- Developing refineries also provide employment and supply fuel requirement, better value of export and increased revenue. That's why many developing or underdeveloped nations insist that at least some of the oil must be refined locally. Ex. Venezuela and Middle East.

INTERMEDIATE LOCATIONS

- Guided by consideration other than market or fuel.
- Difficult approach to the coast because of shallow and narrow coastal entrance waters: Venezuela: The oil fields of Lake Maracaibo do not have refining facilities there but at nearby islands of Aruba and Curacao which are more easily accessible and not far from Venezuelan oil fields.
- Ready market as well big export hub: Singapore has no oil of its own, but it is surrounded by countries (Indonesia and Brunei) which extract a lot of crude oil. Refining facilities have come up in Singapore because of large volume of international trade takes place at the port.
- Deep harbour positions have an advantage of capacity to handle larger tankers and hence the refineries tend to get located close to nearest deepest harbour to the market. Ex. Rotterdam.

MARKET LOCATIONS

Main oil consuming regions are areas of dense population and big industries.

- Establishment of refineries in urban and industrial regions has several advantages. Such as:
  - Availability of technicians, skilled labor, construction material and commercial know how.
  - High standard of living ensures continuous demand and large markets.
  - Petrochemical industries (Plastic, synthetic fiber & rubber) also have main markets in these countries.
  - Refineries at these locations tend to be massive and provide a large range of finished products than refineries at the field locations.
  - All fractions of oil have some end use. Hence, it makes sense to transport single product, raw material i.e., crude oil, than transporting 8-9 fraction products. Hence, refineries tend to be located near demand centres.
- Any location in big consuming nation will be categorized as market locations. Ex.: Rotterdam & Antwerp refineries in Europe. Most refineries in UK are located on the Thames River.

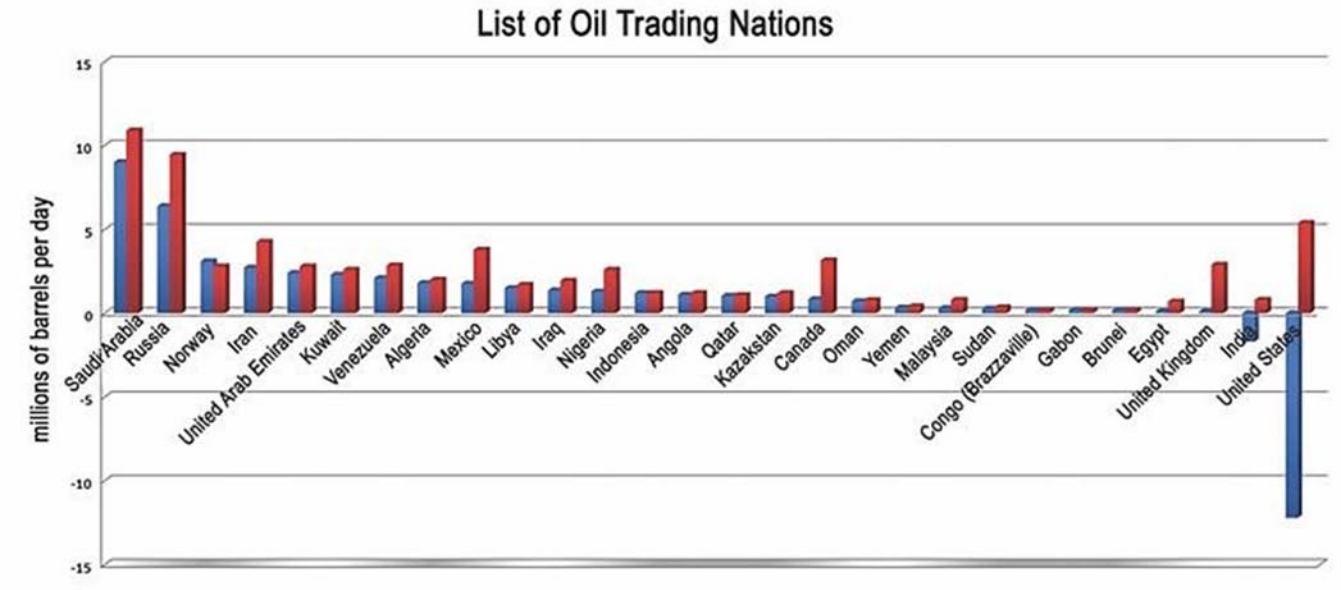
LONG TERM FUTURE OF OIL INDUSTRY

- Continued exploration: Ongoing exploration have identified many areas and are likely to identify many more areas in future in some inaccessible like Arctic.
- Reserves at depth: Significant reserves may lie beyond

depth of technical detection and current technical knowhow to exploit it. This factor becomes significant when reserves occur offshore. Deep sea drilling has inhibiting cost. Ex. huge reserves of Oil have been discovered in Pre-Salt basin off Brazilian Atlantic coast.

- Improved drilling techniques: Enhanced oil recovery techniques which use CO_2 pumping for increased oil supply from depleting values.
- Improved refining techniques**:** Reduced wastage and allows maximum possible extraction.
- Development of new oil sources: Oil shales
- Fuel saving transport systems: Such as Electric Vehicles, Ethanol mixed petrol, Hydrogen fuel cell based etc.
- Development of alternative fuels**:** Both renewable and non-renewable have been developing rapidly. For ex. Solar energy and electric transportation can shift the demand away from Oil & Gas. Also, environmental concerns around fossil fuels have led to search and development for alternative fuels. There is increased legislation and policy related interventions in many countries to move away from fossil fuels. Such as emphasis on net-zero emissions, carbon taxation etc.
- Geopolitical factors: The increased geopolitical threat due to Russian aggression on Ukraine and continuous crises in the Middle East sector reduces the reliability and trust of consumers on oil & gas as an energy source. Countries across the globe are thus looking for renewable energy solutions over which they have more control, are locally produced and more reliable.

WORLD TRADE AND PRODUCTION



Net Exports	9	6.4	3.1	2.721	2.4	2.3	2.1	1.8	1.756	1.5	1.367	1.3	1.2	1.1	1.04	1	0.832	0.714	0.333	0.3	0.28	0.2	0.2	0.2	0.2	0.1	0.1	-1.7	-12.2
Production	10.9	9.44	2.8	4.259	2.8	2.6	2.855	2	3.791	1.7	1.942	2.6	1.2	1.2	1.08	1.2	3.151	0.781	0.41	0.8	0.36	0.2	0.2	0.2	0.7	2.9	0.8	5.4	

►FERTILIZER INDUSTRY

- Raw materials: naphtha, rock phosphate, Sulphur and gypsum.
- Energy sources: a) Coal based (Durgapur, Rourkela), b) Gas based (Gujarat, Maharashtra) and c) Lignite based (Neyvelli).
- Inter-industrial linkages: Mostly located near petro-refineries as they require Naphtha as raw material which is derived from crude oil.
- Transportation: In recent years, transportation of naphtha and gas via rails and pipelines have redistributed across the country. For ex. Construction of HBJ pipeline has led to decentralization of this industry towards interiors of the country. IFFCO plants in Phoolpur etc.
- Demand: Dominance in Gangetic plains is on account of huge demand due to agriculture as a dominant activity there.
- Policies: Cooperatives such as IFFCO and KRIBHCO have played an important role in the development of this industry.

CHALLENGES WITH FERTILIZER INDUSTRY

- Import dependent: India has very limited domestic production rock phosphates (used in phosphatic

fertilisers) and potash (used in potassic fertilisers). Hence, it is mainly dependent on imports for these.

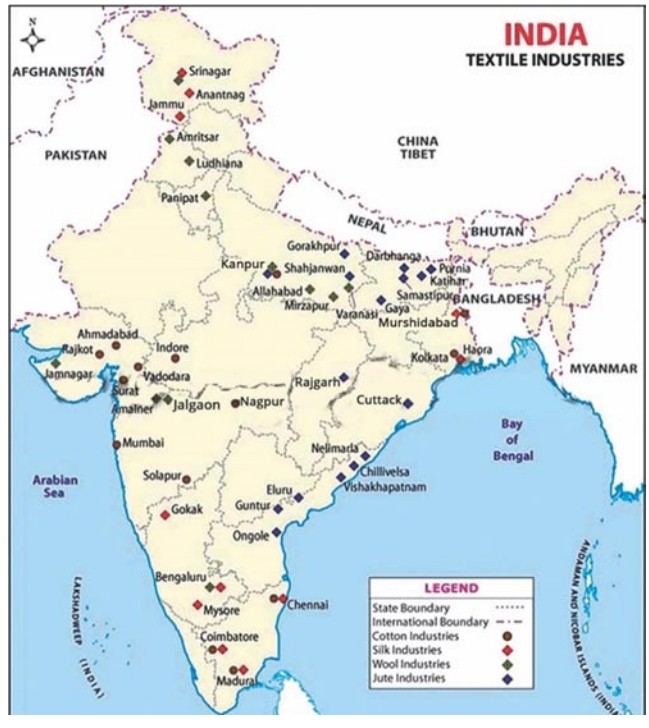
- Overuse of urea by farmers: The ideal ratio of fertilizer usage 4:2:1 for N: P: K. However, Indian farmers overuse Urea and under Potassic and Phosphorus based fertilisers.
- Environmental impact of this industry.
- Geopolitical concerns: The recent Russia-Ukraine conflict has increased the challenge for India in securing fertilisers. Russia is a the second largest producer of ammonia, urea, potash and 5th largest producer of complex phosphates. Black sea is an important port for handling fertilizer exports. Russia-Ukraine conflict has led to uncertainty in global fertilizer value chain and increased prices compromising food security.
- Fiscal challenges: Increased prices of fertilizer has led to increased outgo of government on subsidies compromising fiscal deficit.

WAY FORWARD

- Boost domestic production.
- Modernise existing domestic industry.
- Seek diversification of sources for imports of raw materials.
- Farmers to be made aware of judicious use of fertilizer.
- Strict action against black marketing, diversion and hoarding.
- Promoting integrated use of fertilisers. For ex. Use of NPK mix in place of DAP.
- Promotion of alternative fertilisers such as Nano Urea and Bio Fertilisers. (Vermi-composting)

►TEXTILE INDUSTRY

- Textile industries comprise of cotton, jute, woolen and silk. Natural as well as human factors play their role.
- Proximity to raw material areas- jute in east coast, cotton in central India.
- Availability of cheap labour as these industries are highly labour intensive. E.g. – Textiles in southern USA and Japan owe their origin to this factor.
- Market availability - most important factor. E.g.-High demand of wool in temperate areas facilitated woolen textile in Europe and USA.
- The industry is going rapidly at the rate of 12% CAGR.



ISSUES IN TEXTILE INDUSTRIES

- Stiff competition from international players like China, Bangladesh and Vietnam.
- Obsolete machinery and automation.
- Highly unorganised nature.
- Increase in cost of raw material. For e.g. - cotton price has rose by Rs2000 per quintal.

TECHNICAL TEXTILES

Technical textiles are engineered products with a definite functionality. They are manufactured using natural as well as man-made fibres such as Nomex, Kevlar, Spandex, Twaron that exhibit enhanced functional properties such as higher tenacity, excellent insulation, improved thermal resistance etc. Based on usage, there are 12 technical

textile segments: Agrotech, Meditech, Buildtech, Mobiltech, Clothtech, Oekotech, Geotech, Packtech, Hometech, Protech, Indutech and Sportech.

GROWTH ENABLERS

- Growth of industrial sectors like automobiles, healthcare, infrastructure, space etc.
- Rising demand due to increase per capita income, aspirational class and acceptance of modern products.
- Government policies like technological mission on technical textiles and relaxed FDI.

DECENTRALISED NATURE OF TEXTILE INDUSTRY

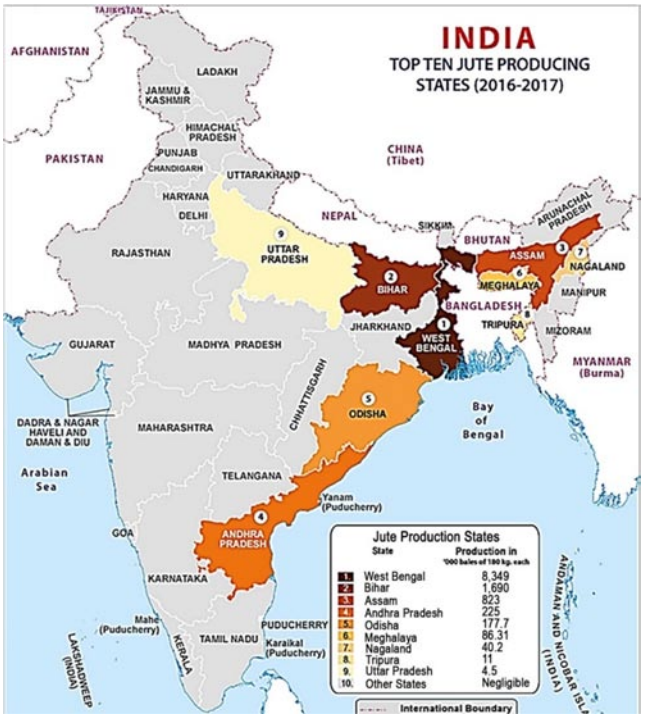
- Constant demand across the world as everyone needs clothes to wear.
- Raw materials like cotton, jute, wool is grown extensively across the world.
- Mechanisation has allowed textile mills to run without skilled labour. Thus, allowing developing economies having no background or industrial skills to develop textile industries.
- Fibers are easily transported, allowing the countries to establish industries even if they are not producing fiber on their own.

►JUTE INDUSTRY

- Known as golden fiber.
- Natural renewable and biodegradable fiber.
- Mostly located in Brahmaputra valley, West Bengal terai region and east coast areas.
- Humid climate, abundant water and coal as source of energy are required.
- Replacement fabric to single use plastic.

CONCENTRATION OF JUTE MILLS IN HUGLI BASIN

- Proximity to raw material- Ganga – Brahmaputra delta grows about 73% of India's jute.
- Proximity to energy sources – Raniganj coalfields are nearby.
- Good transportation network – road, rails and waterways
- Humid climate – good for spinning and weaving
- Proximity to port – Kolkata port provides easy export – import.
- High demand – due to high population density in west Bengal-Bihar-UP areas.
- Capital availability - presence of capitalistic class and financial services due to banks.



►COTTON INDUSTRY

- India produces all four types of cottons – (a) American cotton, (b) Asian cotton, (c) Egyptian cotton and (d) African cotton.
- Availability of quality raw cotton (Black soil and moist climate).
- 80% of the industry is coterminous with cotton growing tracts of the country. Areas- Ahmedabad, Sholapur, Nagpur, Coimbatore.
- Proximity to market (domestic + foreign) as cotton is a pure raw material and does not lose much weight in process of manufacturing.
- Nearness to the port facilities to export the products.
- Cheap labour availability.
- Replacement fabric to single use plastic.

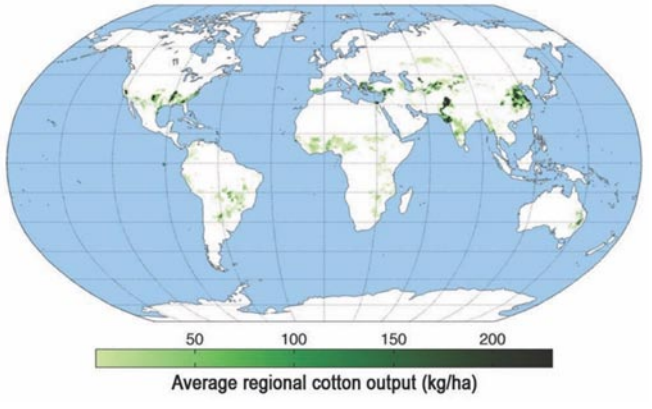
COTTON TEXTILE MANUFACTURING

- Most of the cotton producing countries have now developed textile industries too.
- There are some countries which still import raw cotton and where textile production is important:
- Traditional producers:
  - Industrial countries of Europe like Britain, France, and Italy etc.
  - Industrialisation in 18th and 19th century, long tradition of high-quality production and domestic market has ensured its continuity
  - In Britain, Lancashire was important region because of cheap availability of large, skilled labour, coal

supplies for power, plenty of water for finishing processes, easy access to imports from America through Liverpool.

- This industry declined due to increase in labour cost and competition from lower cost Asian producers.

- Newer producers
  - Since labour is the most important factor in location of textile manufacturing industry, easy availability of cheap labour enabled Asian countries to start textile industries.
  - Japan, Hong-Kong and South Korea became important regions for manufacturing even when they don't grow cotton because of easy transportation of raw cotton and availability of low-cost labour.
  - Textiles played a major role in industrialization of Japan which was previously an agricultural country. Textile industry flourished in areas of Nagoya, Kyoto, Kobe, Osaka etc.
  - In western countries, synthetic material is mixed with cotton. This has replaced cotton as most important fiber as it can be made locally than being imported.

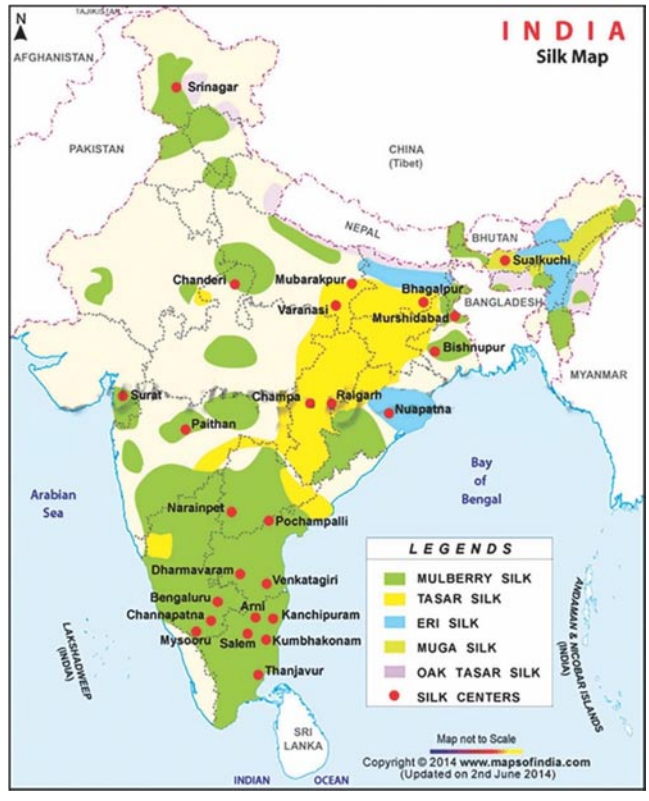


Reasons for shift of cotton industries from old nuclei (Mumbai) to new nuclei (Coimbatore, Nagpur, Bangalore, Indore etc.)

- Better transportation - Railway lines penetrating deeper into peninsula.
- Nearness to coal producing areas for power – Nagpur
- Wide markets with port facilities – Kolkata.
- Better financial facilities – Kanpur.
- Cost of land increased rapidly in Mumbai.
- Shift of the cotton industry from large integrated mills to power loom. This led to informalization and setting up of textile sector in smaller sectors.

►SILK INDUSTRY

- India is the only country producing all 5 varieties of silk: (a) Mulberry silk, (b) Tropical tassar, (c) Oak tassar, (d) Eri silk, e) Mugga silk. Mulberry silk is maximum produced and maximum priced. Mugga silk is restricted exclusively to Assam (Brahmaputra valley)

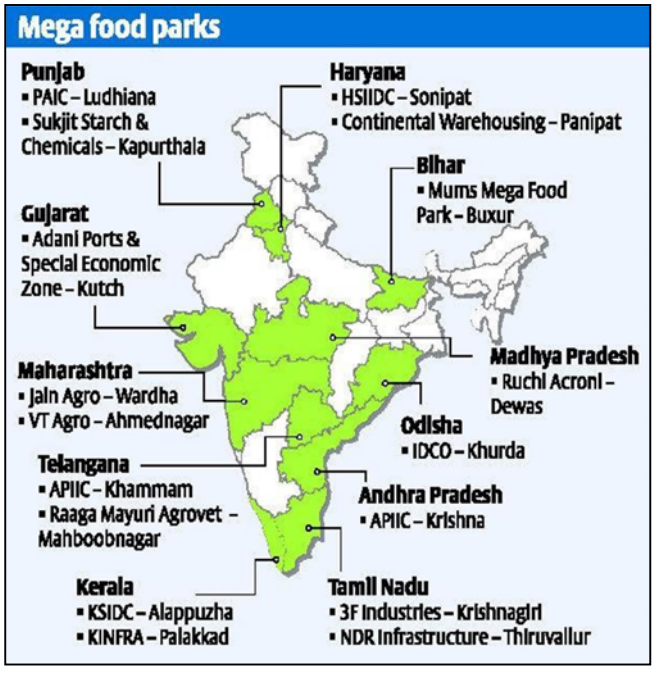


►FOOD PROCESSING INDUSTRY

- Centralised procurement is important hence efficient supply chains and multimodal logistics id needed to ensure faster delivery of agro produce.
- Cold storage and warehousing facilities.
- Vast stretches of land to establish mega food parks.
- Popper testing infrastructure to ensure standards of hygiene.
- Continuous electricity.

ISSUES FACING OUR FOOD PROCESSING INDUSTRIES

- High Yield Varieties seeds reducing diversity of crops
- Climatic changes and frequent droughts and floods.
- Land acquisition challenges.
- Erratic power supply.
- Lack of integrated agriculture marketing and corporate farming.



DISTRIBUTION OF RESOURCES

►PETROLEUM

ORIGIN AND OCCURRENCE OF OIL

- Derived from decaying marine organic matters (usually zooplanktons and algae) trapped at seabed, compacted under high pressure and temperature which leads to formation of oil.
- Found only in variety of sedimentary rocks of various ages. (Mudstone, Shale, Sandstone, Limestone).
- Found in pore spaces of rocks and hence permeability and porosity of rocks drastically affect the availability of oil in that rock. (Sandstone>Shale)
- Whenever there is a cap rock (Nonporous rock) a sequence of gas, oil, water.

TRANSPORT OF OIL

- Oil is one of the few liquid commodities which can be transported in large quantities over long distances.

Different medium of transporting it:

- By road in oil trucks
- By rail in tank wagons
- By sea in oil tankers
- Even by aircraft for military or emergency purposes.

PIPELINES ARE THE MOST IMPORTANT WAY OF TRANSPORTING OIL

- Either to refineries or coastal shipping terminals
- Expensive to build and once built, their route is fixed and not easy to change.
- Therefore, before laying pipelines, it is important for oil companies to be sure there will be steady flow of oil through the line and a constant demand at the market end of the line.
- If the above condition is met, then pipelines are the most economical way of transporting inflammable liquid like oil.
- Where flexibility of routes essential to serve varied or fluctuating markets, or where pipelines insecure for political reasons, tanker transport by sea is more preferred.
- Crude oil pipeline, Product pipelines (Carrying refined)
- Natural gas is also carried to the destination.
- There are pumping stations along the pipelines which provide pressure to maintain the continuous flow.

Problems with pipelines

- Each section will have to be brought to the location, welded carefully sealed.
- Underground if inhabited so that no effect on land use.
- Continuous maintenance. Corrosion.
- Leakage must be monitored (Airplanes in uninhabited areas, trained dogs, 'beat walkers', tribals in Saudi and UAE who are paid well to guard the section)
- Political turmoil (can be destroyed by saboteurs from enemy nations.

►COAL

RECENT COAL CRISIS IN INDIA

India's thermal power plants faced a severe coal shortage, with coal stocks having come down to an average of four days of fuel across an increasing number of thermal stations.

India is facing its worst power crisis in over six years as a heatwave bakes vast swathes of South Asia, causing widespread power outages.

EXTENT OF INDIA'S DEPENDENCE ON COAL

- India is the world's second-largest producer and consumer of coal.
- As of February 2022, the installed capacity for coal-based power generation across the country was 2.04 lakh megawatt (MW). This accounts for about 51.5% of power from all sources.
- The India Energy Outlook 2021 report of the International Energy Agency (IEA) said energy use in India has doubled since 2000, with 80% of demand still being met by coal, oil and solid biomass.
- According to the IEA's Coal Report 2021, India's coal consumption will increase at an average annual rate of 3.9%.

REASONS FOR RECENT COAL CRISIS IN INDIA

- Drastic increase in demand: A surge in air-conditioning demand due to an unrelenting heatwave this year, and an economic recovery due to removal of all COVID-related curbs on industrial activity, pushed power demand to record highs
- Supply chain constraint: Indian railways could not supply adequate coal to the utilities despite record production by coal India.
- Reduction in import because of Russia-Ukraine war.
- Untimely rainfall: Coal mining areas were hit hard, and their production and delivery got stalled which didn't allow the utilities to build up their pre-monsoon stock

STEPS THAT CAN BE TAKEN IN THIS REGARD

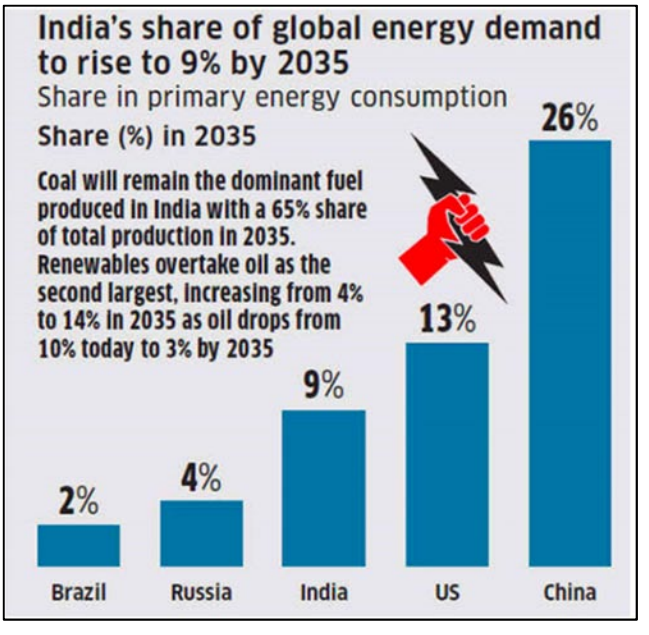
- Removing import restrictions can allow the utilities to meet the upsurge in demand.
- Centre can buy coal in bulk (for better negotiation) from international market and then distribute it to the states.
- Railway reforms to ensure smooth supply of coal. Freight corridors can be of great help.
- Operationalizing all the plants which are presently shut down
- Viable alternative resources like natural gas and renewables must also be used to meet the growing demand of power in India
- India must diversify its energy basket and must reduce the energy consumption and increase energy efficiency.

WHY MOVING AWAY FROM COAL IS IMPORTANT?

- Environmental:The threat of global warming looms over the planet, promising to bring about unprecedented natural calamities.
- An effective way to keep the danger at bay is to cut the use of fossil fuels — coal, natural gas and oil. Coal emits nearly twice as much carbon dioxide as natural gas and about 60% more than oil.
- Economic: Coal based thermal plants are capital intensive but on the other hand decentralised solar plants can be installed by farmers on their private land. This can further boost employment opportunities as well as generate extra source of revenue.
- Social: Combusting coal also leaves behind partially burnt carbon particles that feed pollution and trigger respiratory disorders.
- International commitments: At COP26, India has come out with 'Panchamrit' strategy which includes increasing the share of renewables to 50% by 2030 and to achieve net zero emissions by 2070.

ASSOCIATED CHALLENGES AND ISSUES

- High dependence on coal: Still the major portion of India's energy demand is met through coal. Coal mines also provide huge employment avenues for local population
- Rising energy demands of India: Rapid urbanisation, post Covid economic recovery and increase in general temperature will require much energy.



- Cheaper and abundant availability: a cumulative total of around 320 billion tonnes of Geological Resources of Coal have so far been estimated in the country.
- Variable nature of renewables: Alternatives to coal, like renewables have low reliability. For E.g.- solar energy cannot be generated during cloudy weather or during

nights.

- High economic cost involved: Evidence from rich countries shows how costly it can be to transition to green power. In the United States, closing coal mines has created mass unemployment and devastated local communities.

STEPS THAT CAN BE TAKEN IN THIS REGARD

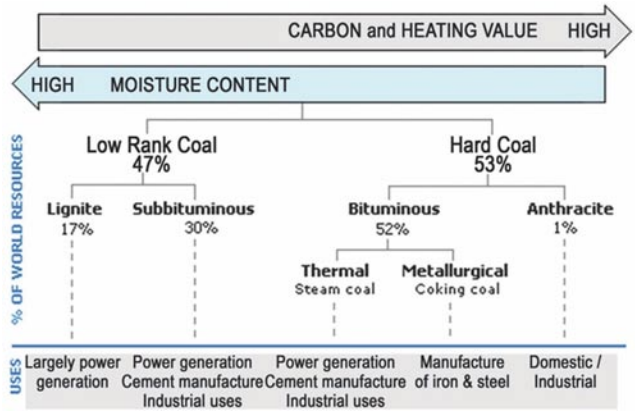
- Discouraging new plants: Reducing the number of clearances to new coal-based plants.
- Improving efficiency of the existing coal-based plants to reduce the per unit emission. Coal washing must be promoted.
- Incentivising renewable usage: Reducing the power tariffs and subsidising the installation of decentralised plants.
- Technological innovations: Batteries that can store electricity at utility scale and act both as a large base-load plant (like a coal-fired power plant that continuously supplies a constant amount of electricity) as well as a peaking plant (like a gas-fired power plant that can start immediately and provide instantaneous peaking power). Carbon sequestration can further be also encouraged.
- Reducing dependence on fossil fuel by moving towards electric vehicles and induction-based cooking.

COMPOSITION OF COAL

- It is black or brown rock consisting mainly of carbon,
- Formed by compressed vegetative matter.
- Most deposits of carboniferous age.
- Most recent deposits of Tertiary age are mainly of lignite or brown coal and peat which represent an early stage of formation and still being formed today.

STAGES IN FORMATION OF COAL

- Luxuriant trees & ferns of swampy deltaic areas with hot & humid weather
- Trees die and fell on ground
- Fallen material accumulate on swampy grounds (Carboniferous)
- Compressed into peaty layers
- Heat from below and pressure from above
- During decomposition of wood, hydrogen originates in the form of methane and water, oxygen in the form water and carbon dioxide.
- During the process of change from wood to coal, amount of O, N decrease and proportion of Carbon increases.
- Coal seams separated by sediment layers for 50 feet of coal bed, 500 feet of decayed vegetation required.



COKING COAL

- High grade bituminous coal
- When heated in coking ovens, turns into coking coal
- Used in iron and steel smelting.
- Difficult to transport due to heavy weight
- Found at very few places in the world therefore must be imported and becomes very expensive.
- Now its use is therefore desirable but not indispensable in steel industry

DECLINE OF COAL IN WORLD FUEL SUPPLIES

- Overall production increasing but its share as a fuel is decreasing.
- Competition from other resources.
- Strong trade unionism in coal industry

DISADVANTAGES OF COAL

- It is a bulk material, hence transport is a challenge.
- Low calorific value as compared to oil and gas.
- Dirtiness & pollution: Coal is dusty, sooty, and causes air pollution. Oil is also a polluter but its cleaner to use. Electricity generation using coal also produces pollution, but it is easier to legislate for effective pollution control for few power plants than for innumerable small homes than factories.
- Displacement: Coal mining often leads to displacement of large number of people. Also, coal seams are often overlaid by forest regions, thus making space for coal mining leads to loss of forests. There has been demands in India to declare no-go zones in certain areas bearing coal which are critical from the perspective of biodiversity.
- Environmental degradation: Coal mining leads to unavoidable scars on mining landscape. Open cast: reclamation cannot restore its original conditions.
- Underground mining: subsidence, waste material removed from tunnelling unsightly tip heaps. These

further degrade the soil.

ROLE OF COALFIELDS IN INDUSTRIAL LOCATION

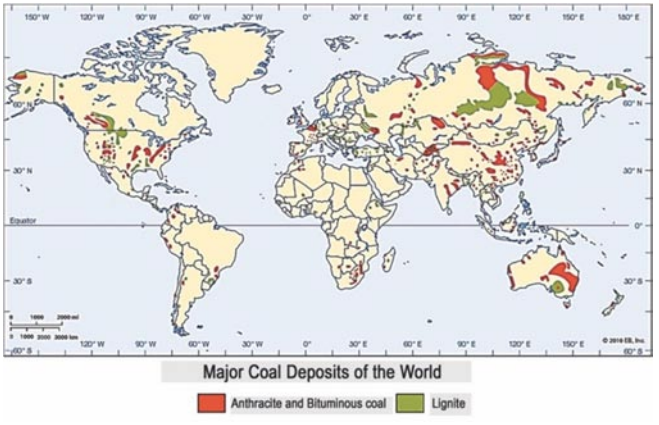
- Before Industrial Revolution industries derived power from running water or from wood. Power resources were small, output was small, transport not well developed therefore markets were not well developed. Large labor supplies were not required; hence industries could be set up anywhere.
- Developments in 19th century which completely changed the pattern:
  - Invention of steam engine
  - Making metallurgical coke from coal.
  - Hence coal became the basis of IR in 19th century
- Coal→ greater power→ industrial output increased→ large no of people employed→ rapid migration into Industrial coal field areas→ railways dependent on coal developed→ access to much larger markets→ development of steam ships (Access to world markets).
- Coal mining areas which became major industrial centers
  - Ruhr and Saxony coal fields in Germany
  - Damodar valley of India
  - Manchuria of China
- Japan and Italy were few industrially developed countries which based their production on alternative energy or imported coal supplies.
- Many factors are working today to create a new distribution of industries: This may be a drift away from coal mining areas or growth of new locations.
- New industrial areas, which might not be in direct competition with coal mining areas, have grown at a much faster rate leading to relative decline of coal field areas.

INDUSTRIAL INERTIA

- Even though coal has been overtaken by other fuels, world's coal fields remain major industrial areas because of their accumulated advantages.
- Concentration of capital (Factories, Infrastructure, Services, Facilities): Discouraged the relocation
- Transport networks were developed keeping coal fields at center. Investing in new location would mean to build altogether a new set of transport systems.
- Markets: Dependent industries, for ex component manufacturers relied on market provided by makers of finished products. Relocating them would mean losing market and hence offset any advantage.
- Labor: Greater and high supply of skilled labor force would be difficult to obtain in newer areas.
- Therefore, the world's major coal fields are still some of the most industrially developed areas especially when coal fields have an advantage of coastal locations, making importation of raw material and importation of raw material or alternative fuel easier.

MAIN REASONS FOR DECLINING PULL

- Fuel efficiency: The input requirement of many industries dependent heavily on coal has reduced drastically. (For ex. Earlier - 12 tons of coal to smelt a tone iron & now only 1 tone is required) and hence it is not the overwhelming concern.
- Re - localization of iron & steel industry: A coastal location, rather than near to coal fields, would be more preferred for easy access to iron ore supplies and export. For e.g., steel mills from Pittsburgh to Atlantic Seaboard.
- Inland location: Although transport network exists in these areas, it is difficult to expand these locations. Laying down of new transport systems like high-speed rail is difficult.
- Decline in coal mining: Many accessible coal mines are getting exhausted and production decreasing-> cost increasing. Hence, industries would not be located there.
- Population migration: young people tend to leave industrial towns on the coal fields in search of congenial living conditions. Therefore, newer industries which tend to hire educated and highly skilled workers, tend to locate in more pleasant and urbanized areas (IT industry in India). This makes it progressively less attractive for next generations.
- Alternative fuels: Easily transported fuels such as electricity and natural gas have led to dispersion of industries. There use is creating new patterns of industrial location.
- External factors: Changing production techniques, world market scenario and skills have a strong influence on distribution. For e.g.: the effect of labour on production of textile is so great that despite traditional advantages, Lancashire textile industries are fast degrading due stiff competition from India, Bangladesh.



►COAL BED METHANE

- India has *the fifth-largest coal reserves in the world,* and CBM has been looked at as *a clean alternative fuel with significant prospects.*
- India's CBM resources are estimated at around *92 trillion cubic feet (TCF), or 2,600 billion cubic meters (BCM).*
- The country's coal and CBM reserves are *found in 12 states of India,* with the Gondwana sediments of eastern India holding the bulk.
- Damodar Koel valley and Son valley are prospective areas for CBM development.

WHAT IS COALBED METHANE (CBM)?

It is an unconventional form of natural gas found in coal deposits or coal seams.

CMB is formed during the process of coalification, the transformation of plant material into coal.

USES OF COAL BED METHANE

1. In Power generation.
2. As Compressed natural gas (CNG) auto fuel.
3. As feedstock for fertilizers.
4. Industrial uses such as in cement production, rolling mills, steel plants, and for methanol production.

CHALLENGES AND CONCERNS

1. Methane is *a greenhouse gas* emitted through CBM extraction. *Global methane emissions* from *coal mines are projected to account for approximately 8 percent of total global methane emissions.*
2. Disturbance of lands drilled and its effect on wildlife habitats results in *ecosystem damage.*
3. CBM production behavior is complex and difficult to predict in the early stages of recovery.
4. Another concern is the effect *water discharges from CBM development could potentially have on downstream water sources.*
5. *Disposal of the highly salinized water that must be removed to release the methane creates a challenge,* as its introduction into freshwater ecosystems could have adverse effects.

OTHER CLEAN COAL USES BEING PROPOSED

1. Coal usage with carbon capture and storage technology.
2. Coal gasification: This involves use of chemical process to transform coal into natural gas or other chemicals which are environmentally less degrading. This is especially useful in India context, where India has surplus coal capacity and is deficient in other fossil fuels such as crude oil and natural gas. Thus, coal seam can be used to transformed into natural gas which is a much cleaner fuel.
3. Using coal washing and coal grading techniques to reduce tar.
4. Promoting sustainable rehabilitation and promotion of renewable energy at mine sites after end of their life to salvage the mine site.
5. Employing local people in coal mining industry, giving royalty for local development, Corporate Social Responsibility.

►ELECTRICITY

- Principal source of energy in the world.

ADVANTAGES

- Inexhaustibility: There are many sources of electricity generation and hence they will replace each other. Currently, for India Thermal > Hydro > Nuclear power generation. In Japan where hydroelectric power plants were the important.
- Cleanliness: Electricity is much cleaner compared to other sources like coal and oil. It is an invisible source of energy i.e., usage of electricity leaves no mark. However, a lot of pollution is done while producing electricity.
- Easy to use: It is highly adaptable. Current flow and voltage can be monitored to suite the requirements. Ideal for use in highly complex industries: precision is very important
- Convenient to Transport: Unlike coal or oil, it does not require physical transport, loading and unloading, electricity can be transferred efficiently over long-distance grids. Thus, it has an advantage of reaching difficult and uneconomic areas over coal and oil.
- Industrial importance: Indispensable in Information communication, internet and electronic equipment. It

has led to decentralisation of manufacturing sector. Earlier access to energy was one of the main considerations for industries to locate. However, since electricity can be easily transported and easy to use, manufacturing industries have decentralized. For ex. Electric arc technology-based steel mills located in NCR region, Automobile industry using manufacturing robots located near NCR, Chennai & Pune etc.

DISADVANTAGES

- Electricity can only be transported at relatively short distances as compared to coal and oil and only over the grids, if grid is not there it cannot be transported.
- Electricity cannot be stored: It must be used instantaneously. This creates a lot of problems as there is no reserve to fall back to as in the case of coal and oil.
- In industrial areas demands are high when production is going on while in city demand peaks during the day. So, the production must be varied accordingly. This is achieved by running big power plants in full capacity and keeping others on partial capacity so that their production can be altered to meet the variation.

Fossil Fuel		
Coal	2,04,080	51.1%
Lignite	6,620	1.7ft
Gas	24,900	6.3%
Diesel	510	0.1%
Total Fossil Fuel	**2,36.109**	**59.1%**
Non-Fossil Fuel		
RES (Incl. Hydro)	**1,56,608**	**39.2%**
Hydro	**46,723**	**11.7 %**
Wind. Solar & Other RE	1,09.885	27.5%
Wind	40,358	10.1%
Solar	53,997	13.5%
BM Power/Cogen	10,206	2.6%
Waste to Energy	477	0.1%
Small Hydro Power	4,849	1.2%
Nuclear	6,780	1.7%
Total Non-Fossil Fuel	**1,63,388**	40.9%
Total Installed Capacity	**3,99,497**	**100%**

►HYDRO-ELECTRIC POWER

- Independent source of energy
- Produced from Multipurpose River projects which requires pondage and run of the river projects, these projects do not require pondage.
- Waterpower: Running water from river streams, glaciers have been a source of motive power since ancient times and have been the earliest industrial locations even though they are in remote and often in relatively sparse mountainous areas.
- Three important inventions which allowed waterpower to be used to generate electricity and has enhanced its importance as a source of power which was earlier overshadowed by use of fossil fuels.
  1. Development of hydro turbine
  2. Dynamo
  3. Cement: big dams

FACTORS AFFECTING DEVELOPMENT OF HEP

1. Head of water: Potential energy or gradient of water flow is necessary for hydropower generation. Thus, naturally occurring sites close to waterfalls and rapids are preferred. Examples: Alps, Scandinavia, Rocky Mountains. Rivers with massive discharge flow but low gradients are also viable for example Volta River in Ghana. Many countries possess **fall line (**At which mountain streams fall to coastal plains, all along the eastern side of Appalachian**)**. There are also artificial dams.
2. Large volume of water: Power generation is proportional to volume of water. Ex: Nile, Indus and Zaire.
3. Regular and reliable supply of water: To ensure continuity and avoid fluctuation of power production. Thus, perennial rivers are preferred. Ex: long draughts in monsoon in Savana and Mediterranean lands decrease discharge in temperate latitudes, its freezing of water. Rainfall should be well distributed throughout the year therefore it is important to build dams to store water and hence river flow can be regulated.
4. Presence of lakes during river**:** Very useful is seasonal rainfall areas. This obviates the need of reservoir. Allows flood water can be stored easily. In the glaciated areas: Corries and ribbon lakes (Swiss and Britain)
5. Space for reservoir: Suitable location for lake creation (for ex. the destruction to human, agriculture). Gorges have natural advantages: deep, steep slopes, large capacity and usually do not have any other use like agriculture.
6. Large market: Since electricity cannot be stored or transported to large distances, hence there should be a ready market for their production. Availability of

alternative fuels should be considered. Multipurpose schemes: power forms the minor component and irrigation and other uses are primary. Here HEP may form the basis of industrial development.

7. Heavy capital outlay: This is due costs of land acquisition and compensation, dam erection, power plant and transmission & round the year maintenance. Since the initial costs are so high, therefore these projects are usually undertaken by government especially the multipurpose projects.

►THERMAL ELECTRICITY

Thermal electricity is produced by burning other fuels like coal, petroleum and natural gas in thermal generators or specially designed furnaces.

FACTORS AFFECTING LOCATION OF THERMAL POWER

- Fuel supply: Many thermal power plants are located near coal fields, oil & natural gas fields or at importing points. Nearness to fuel can greatly reduce the transportation cost of raw materials such as coal.
- Water supply: It is required for cooling purposes, because much heat is produced and needed to be released and hence nearness to the river lake, estuary or coastal site is preferred.
- Market: There are several advantages of nearness to the market. It reduces transmission cost of the generated current. Also, allows the plant to work at full capacity.
- Economic and political stability: Many of thermal power plants are privately owned in general. Hence, profitability and economic viability is important. Also, stable political and policy environment is required.

WORLD THERMAL ELECTRICITY GENERATION

- Shows a very similar pattern to the distribution of densely populated industrial areas.
- Favoured areas for Thermal Power Plants (TPP) are:
  - Major coal fields of the world. (Lignite and even peat is used)
  - Chief oil and natural gas fields where these are near markets.
  - Major oil importing and refining ports.
  - Major industrial regions.
  - Highly urbanized region where there are large demands.

COMPARISON OF HEP AND THERMAL ELECTRICITY GENERATION

- Effect on environment: HEP is completely clean source while TPP generates a lot of pollution.
- Effect on local environment and area: TPP do little change to the area, while HEP tend to change the surroundings by flooding in an otherwise scenic and biologically diverse areas, especially if there is a plan to attract a large amount of industries dependent on HEP. There is a growing opposition of HEP.
- Conservation of resources: TPP use fossil fuels, while HEP uses freely flowing water.
- Economics of development and operation:
  - Initial cost of power generation in TPP is lower.
  - TPP is a standard plug and play model. But each HEP plant is carefully designed and meticulously planned to suit local geology, population and market.
  - Maintenance cost TPP is higher than HEP. Because of tremendous heat output of the TPP. In HEP, de-silting and weeding out must be done regularly.
  - Fuel cost of TPP, while HEP is free.
  - Transmission cost HEP> TPP
  - Labour cost TPP>>HEP
  - Output
  - TPP<HEP
  - Output easily controlled in HEP than in TPP
- Value in the National economy
  - Value of the HEP is not limited to the power as they are part of the larger Multipurpose projects. But TPP are solely for power and serve no other purpose.
  - HPP and TPP most of the times complement each other with most countries building both. Developed countries like USA have constructed a national grid, to which all the power generating units are connected.
  - TPP's constantly run on full or stable capacity and HEPs (which can be easily and immediately regulated) are altered to meet the changing demands.
- Future development:
  - TPP more preferred because they are cheaper to construct and take less time to install. Private. Companies usually take the lead unlike HEPs which are very expensive and hence mostly executed by the government and most often they must take loans and foreign support.
  - HEP bring along many other associated

problems:
- Diseases. E.g., mosquitoes.
- Siltation of dam → greater eroding power for the river downstream

►GEOTHERMAL ENERGY

It is heat derived within the sub-surface of the earth. Water and/or steam carry the geothermal energy to the Earth's surface.

ADVANTAGES	CHALLENGES
Renewable and sustainable	High upfront costs for construction and installation
Not dependent on weather conditions	Connection costs to the local electricity grid may be quite high
Stable energy supply	It cannot be installed where the geothermal gradient is low.
Not dependent on weather conditions	
Low unit price for energy	
Large future expansion prospects	
Creation of local jobs	
Independence from other countries	
No dependence on fossil fuels hence unaffected by their price fluctuations	

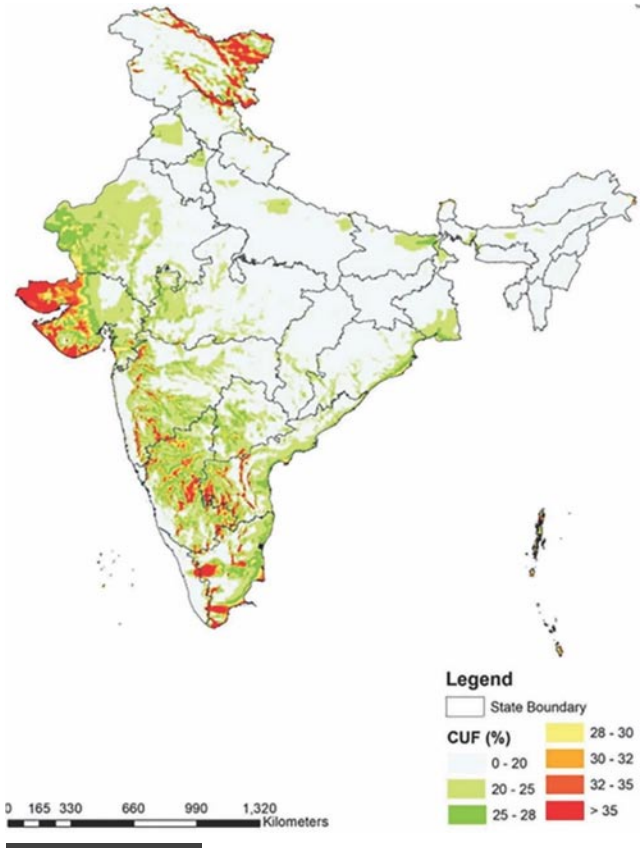
►WIND ENERGY

WIND POWER POTENTIAL

- Viable wind power potential across globe is 72TW, which is four times more than the current world's total energy demand.
- India's wind power potential at 120 meters height is estimated to be 695 GW. Current, installed wind power in India is 38 GW.
- Wind power capacity in India can be further enhanced with increase in hub heights, with more turbines going up to 150 m.

STRENGTHS OF WIND ENERGY

1. Wind power constitutes a significant share of India's renewable energy capacity. (46%)
2. India's wind energy sector is mature. India has the world's fourth largest wind capacity.
3. Large degree of indigenization of wind power industry. All wind turbines are made in India and more than 80% of components are made domestically.
4. Water smart electricity: Wind energy is the least water consuming source of electricity. Water requirement is negligible after commissioning as against other forms of electricity generation.
5. Technological advancement: Wind Turbine technology has evolved with focus on greater energy capture and improved capacity utilization. Turbines with larger rotor diameter and higher hub heights are being developed.



SHORTCOMINGS

1. Land focused wind power policy: India wind power capacity is entirely land based. There is a need to develop offshore wind power capacities.
2. The earliest wind power projects were established at sites with highest wind power capacity. Thus, India's best wind power sites are not being adequately harnessed for wind power generation.

WAY FORWARD

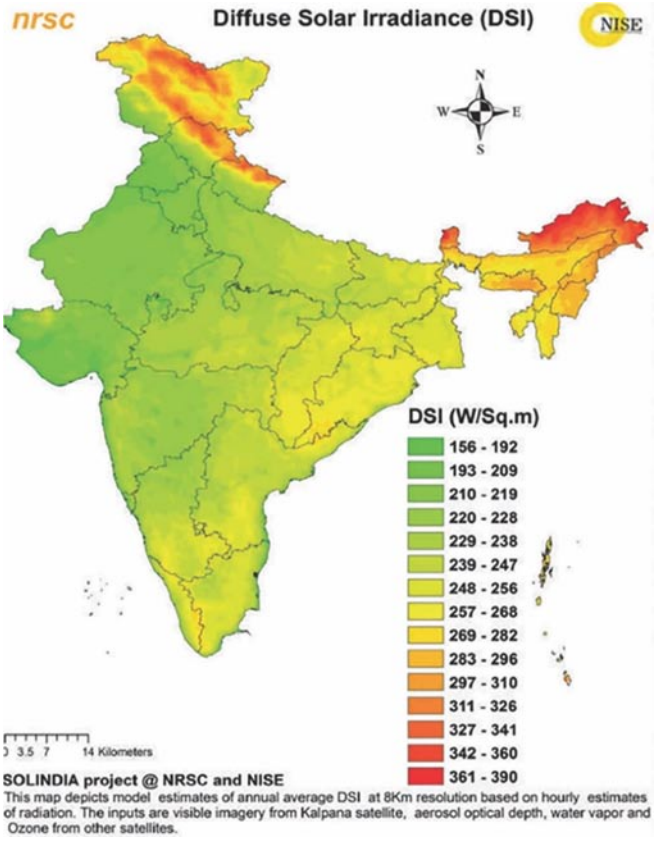
- Exploring manufacturing and deployment of wind turbines with higher hub heights of 150m and larger turbine size.

- Harnessing offshore wind power potential.
- Supporting and developing domestic manufacturing capacity for efficient and state of art wind turbines.
- Repopulating older and legacy wind power sites with modern turbines at 120 m and above heights and larger turbine capacity.

Advantages	Disadvantages
New and Renewable resource	Fluctuating wind speeds alter the production projections.
No greenhouse gas emissions	Threats to avian fauna.
Cheapest among all renewable resource	Create noise pollution
	Land use competition (Agriculture, Housing)
	Often built on remote locations.

►SOLAR ENERGY

Solar Energy Generation Potential in India



REGIONAL VARIATION IN SOLAR DSI ACROSS INDIA

1. The Himalayan region has very high potential of developing solar energy.

DEFECTS IN SOLAR PV MODULES

Defects come in Solar PV modules which lead to lower efficiency of conversion of solar energy to electricity. Some of the common defects in Solar PV modules are:

1. Due diligence should be exercised while selecting and procuring modules.
2. Degradation of PV modules in hot climates as compared to cooler climates. This is particularly important for India,
3. Micro-cracks caused due to transport and installation phases.
4. Solar power plants should be developed in the cold and sunny areas of Himalayas. This region has very low degradation rates of solar PV modules & high-performance ratios. This region is also endowed with highest irradiance in India and easy availability of large stretches of land.

WAY FORWARD

1. Developing solar power plants in regions with high Diffused Solar Irradiance. For ex. Ladakh, Northeast, Odisha etc. and other similar areas for expansion of solar power generation. Grids should be constructed for evacuation of power from this region.
2. Developing solar power plants in wasteland areas.
3. Using better quality and higher efficiency silicon PV modules in solar power plants. For ex. Perovskite solar cells etc.
4. Promoting non-power usages of solar energy such as solar water.
5. Promotion of solar power plants over canals.

Advantages	Disadvantages
New and Renewable resource	Fluctuating wind speeds alter the production projections.
No GHG emissions, water pollution.	Threats to avian fauna.
Cheapest among all renewable resource	Create noise pollution
Very easy to install and get started	Land use competition (Agriculture, Housing)
	Often built on remote locations.

►OSOWOG

One Sun One World One Grid (OSOWOG) initiative has the potential to radically alter the energy landscape across the world. But it is not without its challenges.

Discuss (10 marks, 150 words.)

OSOWOG is India's initiative to build a global ecosystem of interconnected renewable energy resources. The blueprint for the OSOWOG will be developed under the World Bank's technical assistance program. OSOWOG will be implemented to accelerate the deployment of grid connected rooftop solar installations.

OSOWOG IS PLANNED TO BE COMPLETED IN THREE PHASES

- Phase I: Will entail interconnectivity within the Asian continent
- Phase II: Will add Africa to the grid.
- Phase III: Internationalize the project.

BENEFITS OF THE PROGRAM

- Seamless access to clean and renewable energy.
- Incentivize investment in solar energy.
- Especially beneficial for Countries like Bangladesh and Singapore.

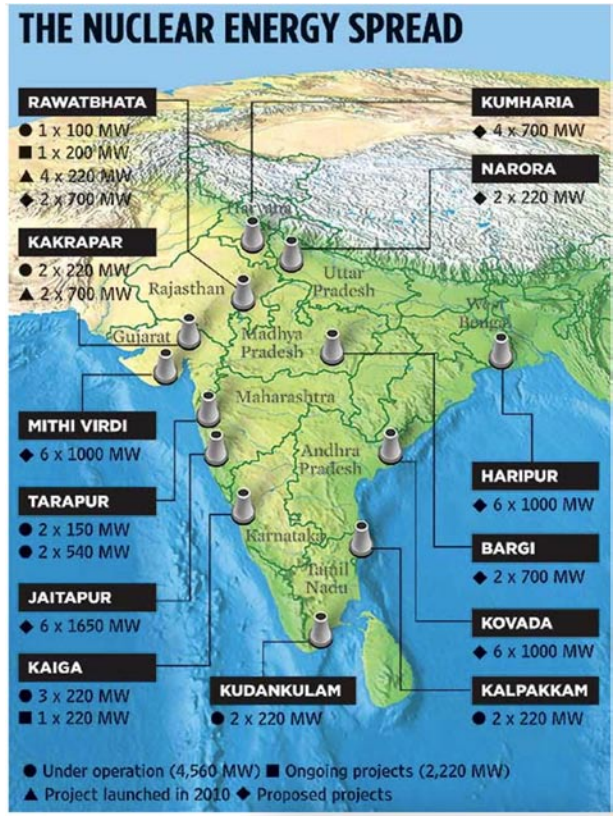
ISSUES WITH THE PROJECT

- Cost Sharing will be difficult because of disparate priorities of participating countries.
- Geo-Politics: India-Pakistan, Saudi- Iran
- Multiple Jurisdiction:
  - Dealing with different governments and market forces will be a dreadful experience for the developers that can be easily extrapolated from the experience of the renewable energy (RE) developers in India.
  - There is a difference in voltage, frequency and specifications of the grid in most regions. Maintaining grid stability with just renewable generation would be technically difficult.

►NUCLEAR POWER PLANTS

Among all the developing nations, India is the only one to have generated electricity using indigenously developed, demonstrated, and deployed nuclear reactors. India ranks 3rd in terms of electricity production worldwide.

India also stands at 7th position in terms of the number of nuclear reactors, with over 23 nuclear reactors in 7 power plants across the country.



POINTS IN FAVOUR OF NUCLEAR ENERGY:

- Nuclear is a zero-emission clean energy source: It generates power through fission, which is the process of splitting uranium atoms to produce energy. The heat released by fission is used to create steam that spins a turbine to generate electricity without the harmful by products as emitted by fossil fuels.

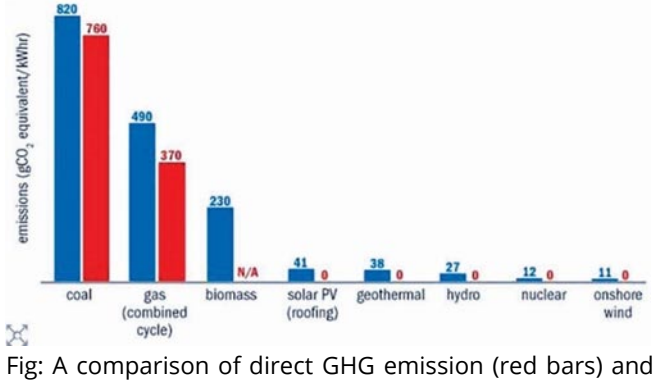
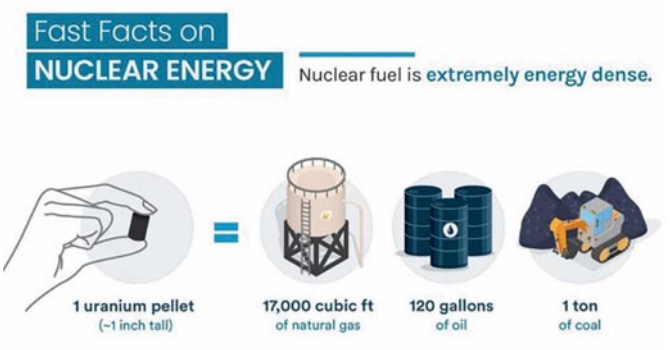


Fig: A comparison of direct GHG emission (red bars) and full life cycle emissions (blue bars)

- Nuclear energy's land footprint is small: Despite producing massive amounts of carbon-free power, nuclear energy produces more electricity on less land than any other clean-air source. A typical 1,000-megawatt nuclear facility needs a little more than 1 square mile to operate which is 360 times less than wind plant and 75 times less than solar plant.
- India has one of the world's largest reserves of

monazite sands located on the coasts of Kerala and Tamil Nadu, which are a rich source of Thorium. Thorium can be exploited to produce nuclear power.

- Nuclear energy produces minimal waste: nuclear fuel is extremely dense. It's about 1 million times greater than that of other traditional energy sources and because of this, the amount of used nuclear fuel is not as big as you might think.



POINTS AGAINST NUCLEAR ENERGY:

- A typical reactor will generate 20 to 30 tons of high-level nuclear waste annually. There is no known way to safely dispose of this waste, which remains dangerously radioactive for a quarter of a million years.
- The mining, milling and enrichment of uranium into nuclear fuel are extremely energy-intensive and result in the emission of carbon dioxide into the atmosphere from the burning of fossil fuels.
- Estimated "energy recovery time" for a nuclear power plant is about 10 to 18 years. This means that a nuclear power plant must operate for at least a decade before all the energy consumed to build and fuel the plant has been earned back and the power station begins to produce net energy. By comparison, wind power takes less than a year to yield net energy, and solar or photovoltaic power nets energy in less than three years.
- Thermal pollution from nuclear power plants adversely affects marine ecosystems.

Nuclear Plant	Thermal Plant	Hydro Plant
Located in isolated areas away from population.	Located where water and coal and transportation facilities are adequate.	Located where large reservoirs or dams can be created like in hilly areas.
Initial cost is highest as cost of reactor construction is very high.	Initial cost is lower than hydro and nuclear.	Initial cost high due to large dam construction.
Cost of running is low as very less amount of fuel is required.	Running cost is higher than nuclear and hydro due to amount of coal required.	Practically nil as no fuel is required.
Uranium is fuel source along with platinum rods. So enough is available.	Coal is source of power. So limited quantity is available.	Water is source of power which is not a dependable quantity.
Cost of fuel transportation is minimum due to small quantity required.	Cost of fuel transportation is maximum due to large demand for coal.	No cost for fuel transportation.
Better friend of environment than steam power plant.	Least environment friendly.	Most environment friendly.
More efficient than steam power.	25% overall efficiency.	Around 85% efficient.
Maintenance cost is the highest as highly skilled workers are required.	Maintenance cost is very high.	Maintenance cost is quite low.
Less standby losses.	Maximum standby losses as boiler keep running even though turbine is not.	No standby losses.

►MINING

A ROBBER INDUSTRY

Unlike agriculture or forestry where crops can be grown repeatedly, mining is a robber industry.

- However large the deposit of a given mineral it, continuous mining will exhaust the ores.
- With better technology, we can extract more and more from existing reserves as well as discover new reserves but cannot restore the reserve we have already exploited.

- The mineral resources have been formed by geological processes over a long period of time. Therefore, their exploitation at a faster rate would deplete them.

OCCURRENCE OF MINERALS

- Wide variety of minerals are found in a variety of conditions. Therefore, a good understanding of these conditions is required to extract them economically:
- Veins and loads:
  - Rocks have crevices, fractures, faults etc. where the fluids can enter. These fluids are a result of either metamorphic or igneous activities. Hence, they are found mostly in igneous and metamorphic rocks and sedimentary rocks found in close vicinity of these rocks. Pre Cambrian rocks which have undergone maximum metamorphosis have the highest probability of occurrence of these deposits. Veins and loads are also found in aureoles (rocks surrounding igneous intrusions).
  - Veins are smaller in size than loads. Other characteristics are same.
  - Many of the major minerals such as tin, copper, silver, lead and zinc are found in veins and loads.
  - Silver, lead and zinc are often found in association and hence mined together. Are
  - Those deposits are found which can precipitate from either solution or melt.
- Beds and Seams:
  - Formed as a result deposition, accumulation and concentration in horizontal of earth's crust
  - Coal, some grades of iron ore (concentrated because of long period under great heat and pressure), gypsum, potash salts, common salts (evaporation of lakes in dry areas).
  - Some depositions are also taking place at ocean floor today (Iron manganese nodules)
- Weathering products:
  - Ex. Bauxite is found in Laterite formation. Fe, Ni and Mn are also found in these conditions.
  - The distribution of Aluminium ores is so dispersed and almost never found alone (native). Aluminium has highest concentration in bauxite. Therefore, it is the most valuable ore.
- Alluvial or placer deposits:
  - Only highly inert (corrosion resistant), dense and hard to weather elements like Gold, tin and platinum.
  - These metals get detached from the source and they flow with the streams into the river valleys where they are then found with clay, sands, pebbles etc. and they must be recovered by placer mining methods.

FACTORS AFFECTING EXPLOITATION OF MINERAL RESOURCES

1. Distribution: It is highly uneven. Some elements like Tin, Cobalt, Gold, Platinum, vanadium and nickel, asbestos have very localized occurrences.

2. Factors affecting exploitation:

- Value of metal and mineral
- Mining costs
- Size of deposit
- Grade of ore
- Method of mining
- Transport costs
- Labour

IMPACT OF MINING ON NATIONAL ECONOMY

- The importance of coal in development of industries and industrial regions has already been discussed.
- Employment: likely to affect developing countries more
- Development of transport systems: Inaccessible areas become connected to the rest of the part. Mining stimulates the development of such systems. Congo: Benguela railways (Copper), Malaysia: North South rail and road network (Tin).
- Migration: Large population migrates to these sites hence cities development provides employment in services and processing industries associated with minerals.
- Export earnings and royalty: Very good for underdeveloped countries.
  - Domestic industries associated with metals may be stimulated in agricultural or little industrialized countries.
  - Mining in the long term has detrimental effects in the form of dereliction.
  - Declining mining will leave the area depressed and increased level of unemployment.
- Environmental impact: Decrease water table, pollution and deforestation. Often area becomes uninhabitable.
- Resource Curse: Most of the mineral rich states despite being rich in minerals and income from mining have low human development and high incidence of poverty, Area becomes uninhabitable. For ex. Odisha, Jharkhand and Chhattisgarh despite being rich in

mineral resources have remained large backward. This is also true for many African countries.

CASE STUDIES

- Mauritania: Iron ore → traditional Agri society in South and nomadic herding in North transformed to mining based economy in North leading to development in North.
- Zaire/Congo: (Effect of political instability on mining): Copper belt: Mining started under colonialism → growth of towns and transport links → subsequent independence and instability (Biggest drawback of a landlocked mining areas) → Decline in output → successive political stability → regaining production.
- Malaysia: Tin**:** led to the development of North South running road and rail network and east west linking every region to Strait of Malacca. It also led to immigration of Chinese laborers which subsequently settled there and now Chinese form a significant percentage of population. Rubber, Cocoa and oil palm are providing the cushion effect of decline in Tin industry
- Australia: Gold rush: brought many people here. Wide variety minerals discovered in the interior desert and Savanna regions-> development of transport links. Australia, being a developed country, mining forms a very small component of either employment or total contribution to the economy.

►IRON

- Makes up 5% of the earth's crust
- Has been worked since pre-historic times
- Most widely distributed
- An important commodity in world trade
- Scrap iron can be recycled to produce steel. This has decentralized iron industry.

DIFFERENT TYPES OF IRON ORE

- Does not occur as native metals but as compounds
- Magnetite Fe_3O_4: Iron content up to 70%. Exceptional magnetic properties and hence used in electrical industry. Arctic Sweden, Liberia, Magneto Gorsk.
- Hematite Fe_2O_3: Lower iron content than magnetite (50-60%). Red ores derived from sedimentary rocks. Lake Superior region in US, Labrador and Quebec in Canada. Venezuela, Minas Gerais in Brazil, Guiana Highlands.
- Limonite $2Fe_2O_3.H_2O$: Brown ore occurring in thick beds in sedimentary rocks. Also occur in swarms known as bog Iron. Formed from weathering of iron bearing rocks. Iron content less than 50% with many impurities.
- Siderite $FeCo_3$: Ash grey in color. Found Interbedded with sedimentary rocks especially with carbonaceous rocks, in coal fields. It is also a residual ore like limonite. Most important deposits are of Jurassic age. Occurring in beds between limestone layers in England, France and in Luxemburg.

WORLD DISTRIBUTION

- Found in every continent.
- China > Australia > Brazil > India > Russia > Ukraine > South Africa > US
  - China: Shen Yang in Manchuria, Wu Han, Tai-yeh, Shan Dong peninsula, Hand Zhong, Cha-char, and Chai Nan Island regions. ISI established is almost all major cities. Shanghai, Guang Zu, Manchuria.
  - Australia: Mainly concentrated in West Pilbara region, Mounts Gold worthy etc. New South Wales and Tasmania have also some deposits.
  - Brazil: World's largest deposit of high-grade ore. In Caracas region. Minas Girias in southern part of the Brazilian highlands. Some deposits in Chile and Venezuela region.
  - India: Major producing states are Orissa, Jharkhand, Chhattisgarh, Karnataka, Goa, Andhra Pradesh and Tamil Nadu. Rich Hematite in Singhbhum region with support industries in Damodar basin.
  - Russia: Kursk region, earlier number one because of Ukraine.
  - Ukraine: Karivoy Rag region in Ukraine was the largest region.
  - South Africa: Transvaal
  - US: Lake Superior region and Mesabi range in North Minnesota

►COPPER

- Brownish in colour
- Found in solely in igneous and metamorphic rocks.
- Usually found in metal state and hence one of the earliest metals which was exploited by humans.
- Though copper is very soft, mixing with Tin makes bronze which is harder and tougher and useful for making weapons and tools. Hence Bronze age.
- Present day industrial significance began with electricity where copper wires are very efficient in electricity transmission.

DISTRIBUTION

- Chile: 30 % of world resources, largest deposit in Chuquicamata district
- Peru: Cerro De Pasco region
- USA
- Indian distribution:
  - Singbhum, Hazaribagh, Khetri
  - Arguncha-rampura in Bhilwara

►ALUMINIUM

- Most abundant metal, 8% of the earth's crust.

Aluminium mining done at ore sites, but industries related to smelting of aluminium will be found at locations with cheap and surplus electricity.

WORLD DISTRIBUTION AND TRADE

- Large deposits of bauxite occur in Australia, Brazil, Guinea and Jamaica and the primary mining areas for the ore are in Australia, Brazil, China, India, Guinea, Indonesia, Jamaica, Russia and Suriname.
- India: Jharkhand, MP, Odisha, Maharashtra, Karnataka and Tamil Nadu

►LEAD & ZINC

- One of the earliest metals used by humans. They are soft and malleable.
- Uses of Lead (Pb): Used in pigments, glass making, medicine, sheets & pipes
- Uses of Zinc (Zn): For coating, galvanizing iron and steel plates, making alloys like brass, bronze, German silver, manufacturing of batteries and electrical appliances.
- The chief rock types associated with the sulphide ores of Pb and Zn is pyrite.
- Major producers:
  - Lead: US, Russia, Australia, Canada.
  - In India for Pb and Zn: Rajasthan, Gujarat, Andhra Pradesh

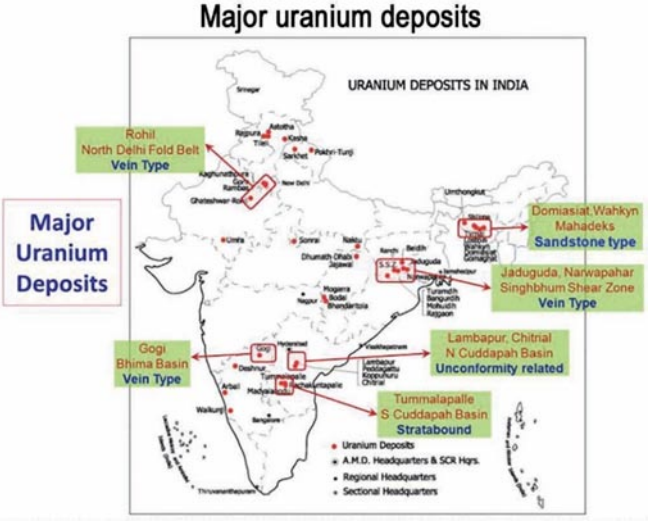
►URANIUM

- Ores: Uranyl, Pitch blende

PRODUCTION

- Worldwide production of U3O8 (yellowcake) in 2013 amounted to 70,015 tons, of which 32% was mined in Kazakhstan. Other important uranium mining countries are Canada (2nd), Australia (3rd), Niger, Namibia and Russia.
- Australia has 31% of the world's known uranium ore reserves and world's largest single uranium deposit, located at the Olympic Dam Mine in South Australia. There is a significant reserve of uranium in Bakouma a sub-prefecture in the prefecture of Mbomou in Central African Republic.
- Uranium production is carried out in 20 countries, producing a cumulative total of 54,610 tons of uranium. Since 2009 the in-situ leach (ISL) operations of Kazakhstan are producing the largest share of world uranium.
- India: Jaduguda, Tumalapalle, Bhatin, Narwapahar, Turamdih. Recently, large reserves for Uranium have been found in Rohil in Sikar district of Rajasthan.

MAJOR URANIUM DEPOSITS IN INDIA



WORLD RESOURCES AND THEIR DISTRIBUTION

→AGRICULTURAL RESOURCES

►CEREALS

- A collective term used for all types of grass like plants which have starchy edible seeds
- Rice>Wheat (738 Mt>713 Mt)
- Loam soils generally contain more nutrients, moisture, and humus than sandy soils, have better drainage and infiltration of water and air than silty soils, and are easier to till than clay soils.

►RICE

- Genesis from swampy area
- Chinese and India (3000-year-old texts from both places mention it)

REQUIREMENTS FOR WET PADDY CULTIVATION

- Water Supply:
  - More than 110 Cm of annual rainfall, notwithstanding evaporation.
  - Better if around 200-300cm
  - Flooded condition (Water in state of gentle movement, not stagnant otherwise low soil aeration and nitrate formation impeded)
- Temperature:
  - High light intensity (Abundant sunshine essential during 4 months of growth)
  - 20-27 degree C (15 degree for germination)
  - One of the very few crops which can sustain excess of heat if there is sufficient water
- Soil:
  - Can be grown on wide range of soils, provided condition one and two are met.
  - Ideal soil: Heavy clayey and loamy soil that is moisture retentive, so that water does not readily percolates through and is acidic in reaction. pH 4-6.5
- Level ground: Flat lands are preferred for easy flooding and irrigation. Therefore, ideal habitats are alluvial delta and flood plains. For E.g.: Ganga, Irrawaddy, Mekong.
  - Even in highlands, the fields are carefully levelled to create flooding conditions and edges are carefully bounded to retain water and silt.
  - High population of hills in Monsoon Asia makes this task widely practiced.
- Labor: Extremely labor intensive. Whole family is involved throughout the year. Mechanization is extensive in developed parts of the world and China.
- Fertilizer:
  - Require N, P, K
  - Traces of Fe, Mn and B especially in calcareous and sandy salts are beneficial to paddy plants.

REGIONS

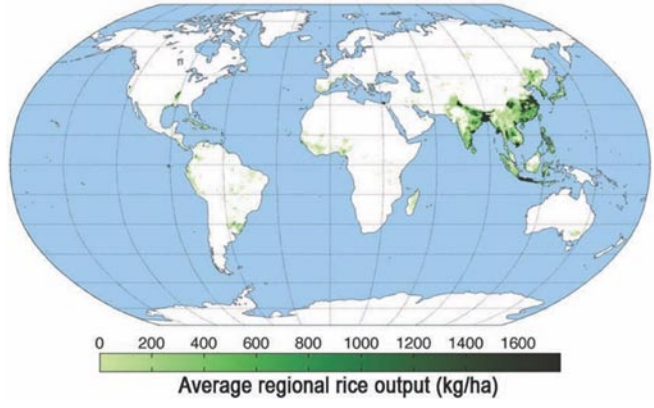
1. Tropical, Sub tropical and monsoon climates
2. Warm temperate lands of southern Europe and US
3. Mainly Irrigated lowlands, flooded plains, Deltas swamp conditions
4. Its growing conditions are inhibiting causes for other major food crops, hence it is unique

DIFFICULTY OF FARM MECHANIZATION IN PADDY

1. Machines should be robust enough to work in flooded fields.
2. Desirability of small flat lands separated by bunds make the movement of tractors tougher.
3. Most of the paddy regions of the world are also the most populated regions and hence cheap labor is abundantly available, hindering mechanization.

PRODUCTION DISTRIBUTION

1. China, India, Bangladesh, Japan (Highest Productivity)
2. Outside monsoon Asia (Nile Delta)
3. Southeast Brazil



►WHEAT

- Bread grain of European civilization
- Origination: Asia Minor (near east i.e., Syria, Iraq, Turkey), Middle East gradually spreading across Mediterranean and European countries and then taken over to new world through colonization.

QUALITIES WHICH MAKE IT CONSUMPTION HIGH

1. High Gluten content
2. Superior quality grain
3. Ease of storage and handling.

REGIONS

1. Mid-latitude grassland region of temperate zone
2. Warm temperate
3. Western margin Mediterranean region
4. Sub-tropical eastern margin (China type)
5. Tropical monsoon
6. Savanna lands
7. Desert and semi-desert margins with irrigation.
8. Can also be grown in equatorial uplands where there are cool conditions.

NUTRITIONAL ASPECT

1. Carbohydrate (70%)
2. Protein, fat, Sugar
3. Traces of Calcium, Thiamine, Riboflavin, Iron

4. By products of milling such as Bran and "shorts" (Daliya) are valuable dairy feeds

GEOGRAPHICAL REQUIREMENTS FOR CULTIVATION OF WHEAT

Temperature: Optimum temperature: 15.5 degree C; Warm and moist during early stage, dry and sunny during late stage and harvest.

Moisture: Amount required varies between 38-48 cm. Light shower just before the harvest swells the grains and results in good harvest. Excess of moisture can be detrimental to wheat therefore minimum wheat cultivation in tropical areas. It cannot grow in areas of very low rainfall or with prolong drought conditions. Through irrigation and dryland farming practices only.

Soils: Ideal: Light clay or heavy loam which is relatively stiff and gives the plant a firm support. Best wheat comes from Chernozem soils of Ukrainian steppes, dark brown prairies soils of N. American prairies, grey, brown podzolic soils of deciduous forest regions. Peaty soils least suitable.

Fertilizer: Nitrate exhaustive crop hence systematic manuring is required with animal dungs and fertilizers such as sulphates of ammonia, nitrate of soda, potash or lime will help to improve yields. Crop rotation with leguminous crops.

Topography: Open, rolling topography as it provides adequate drainage and facilitates use of machinery. All the mid-latitudes grasslands are undulating and where all the processes are mechanized. Rugged terrains and steep slopes always avoided. Terraced wheat farming rare except few poor regions where flat lands are scarce. Very sensitive to frost, therefore, frost resistant varieties or frost-free period required in higher latitudes. This is seldom an issue in lower latitudes.

Wheat strains that are drought resistant or cold resistant reduce the effect of climatic hazards in marginal wastelands, and advances in farm technology have enhanced the prospects of increased world wheat production.

Two types of wheat:

- Spring (Sown in spring and harvested in late summer or autumn)
- High latitude
- Canadian Prairies, Siberia where seeds can be germinated only after frost is over.
- Winter (Sown in late autumn or early winter and harvested in early summer)
- Mid-Latitudes, Sub tropical
- Mediterranean (Rainy winter, warm dry spring)
- Indo-Gangetic (Western disturbance, irrigation, warm dry spring)
- 80% wheat is winter wheat

INTERNATIONAL TRADE

1. It is grown in the sparsely populated regions of the new world; therefore, enough surplus is generated.
2. Hence, amount of wheat which enters in international trade is far greater than that of rice
3. EU > China > India > US > Russia > France > Canada

Factors which led to rise of Canadian prairies as one of the leading granaries of the world. (Same applies to some wheat growing areas in western US where Prairies extend South of the border)

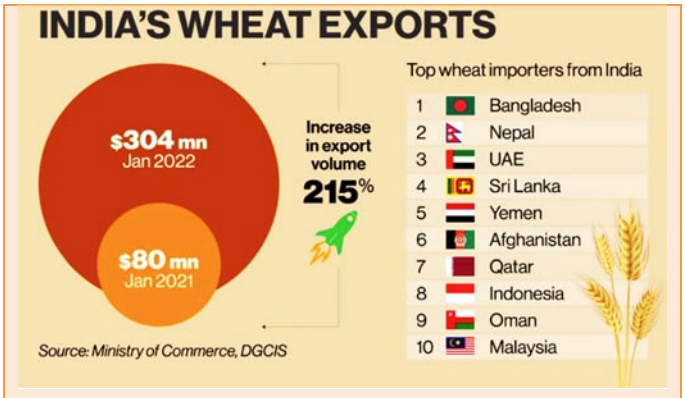
- Availability of extensive cheap Land
- Extension of railways to the prairies.
- In migration of farmers and excess to world market.
  - Fertile prairie soil (Chernozem, less leached not so acidic)
  - Undulating topography
- Well drained
- Allows machines
- Suitable climate
  - Temperature and Rainfall match that of required conditions
  - Chinook winds
- Access to markets

►WHEAT EXPORT

India is the world's second largest producer of wheat. But most of it was being consumed by the country itself -- leaving little room for export. And whatever little we exported; it mostly went into neighbouring countries. Like 55% of our wheat went to Bangladesh.

But over the years, our wheat export has been on the rise. In FY 22, India exported a record 7.85 million tons of wheat. It was a 270% jump from 2.1 million tons the previous year.

And this year, when Russia invaded Ukraine, India found itself in a spotlight. Scores of countries which used to purchase wheat from the two countries looked towards New Delhi to fill the void.



TRENDS IN WHEAT PRODUCTION

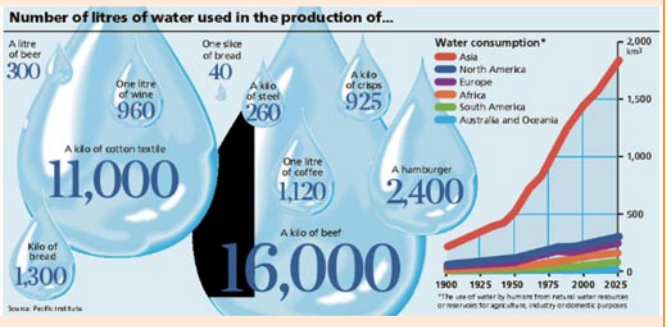
- Global Production:
  - Top Global Producers: China, India and Russia. These 3 countries alone account for 40% of global wheat production.
  - Top Exporters: Russia (20%), USA and Canada.
- Domestic Production:
  - Area under Wheat: Wheat accounts for second largest percentage of area under cultivation (16%) after Rice.
  - Stagnation in percentage of area in the last decade.
  - Production: Fluctuating trend in the last decade i.e., increased in some years while it decreased in others. But overall, there was increase in production. Increased from 86 MT (2010-11) to 108 MT (2019-20).
  - Top Wheat producing States: UP, MP and Punjab.

WHY WAS EXPORT OF WHEAT BANNED?

- Sudden spike in global prices of wheat raised the food inflation.
- Russia-Ukraine war had disrupted the food supply chains hence reducing the wheat import.
- Higher domestic procurement of wheat by private traders and exporters due to higher export demand further blocked the wheat supplies in domestic market.
- Prolonged heatwave in India reduced the wheat yield in India.
- Lower procurement of wheat by FCI further affected the domestic supply.

►VIRTUAL WATER TRADE

Virtual water trade (also known as embedded or embodied water) is the hidden flow of water in food or other commodities that are traded from one place to another.



The concept of virtual, or embedded, water was first developed as a way of understanding how water scarce countries could provide food, clothing and other water intensive goods to their inhabitants. The global trade in goods has allowed countries with limited water resources to rely on the water resources in other countries to meet the needs of their inhabitants. As food and other products are traded internationally, their water footprint follows them in the form of virtual water. This allows us to link the water footprint of production to the water footprint of consumption, wherever they occur.

India's agriculture export of crops like rice and sugarcane export is the same as the export of 50.4 billion cubic metres (rice 35.4, sugar 15 billion cubic metres) of water by the current generation from the legitimate resource share of the future.

Virtual Water Trade (VWT) is slowly altering the global hydrological cycle in many ways and hence A sound VWT-related policy should address several salient points:

- Fix the upper limits of national VWT
- List the products and regions that need to be excluded from it
- Set the benchmark for water footprint for the different products
- Specifications on water types to be used
- Specification on water quality to be used
- Water use efficiency norms for different products
- Wastewater treatment and reuse

A national guideline needs to be designed to help map the volumes of water already lost from the hydrological cycle due to export and ways to offset the loss through improved management strategies:

- Precision technology to be adopted to trail water use by export farms and industries
- Water footprint estimation guidelines to be adopted by the different production systems
- Regions barred for VWT export (groundwater

overexploited zones / water quality concern / coastal seawater intrusion and other vulnerable zones)

- Approaches to restoring and redistributing the virtual water lost for a positive water balance
- Design 'water renewal credit' like 'Carbon credit'
- All export houses shall treat wastewater equivalent to the virtual water exported
- 'Water renewal credit' to be acquired in advance to be eligible for export
- 'Water renewal credit' shall adopt tertiary wastewater treatment technology prescribed by the pollution control board
- 'Water renewal credit' is the first step to revive wastewater into productive use within the hydrologic cycle for irrigation / non-drinking use
- 'Water renewal credit' overtime needs to be extended to bottling water plants, commercial water users, bulk water users involved with entertainment and sports.

►MAIZE

- Indian corn
- Originated in America (Cultivated by Red Indians)
- Introduced in Europe by Columbus
- Adapted to wide range of climates (in and outside Tropics)
- Its yield is drastically high (More than 50% as compared to wheat), in general
- Follows C4 mechanism of photosynthesis, making it more resilient to climate change.
- Important crop for producing feed for livestock sector.

GEOGRAPHICAL CONDITIONS

1. Temperature

- Most widely cultivated crop (Both warm temperate and tropical).
- 18-27 during day, 14 during night.
- 140 frost free days (Most important).

2. Rainfall

- Annual ppt 63 cm to 114 cm
- But can survive in areas less than 38 cm and more than 508 cm
- Irrigation may be utilized to make up for shortage

3. Soil

- Deep rich soils of subtropics where there is abundant nitrogen
- Grows in wide range of soils
- Can survive on slopes with thin soils when other crops fail.

4. Topography

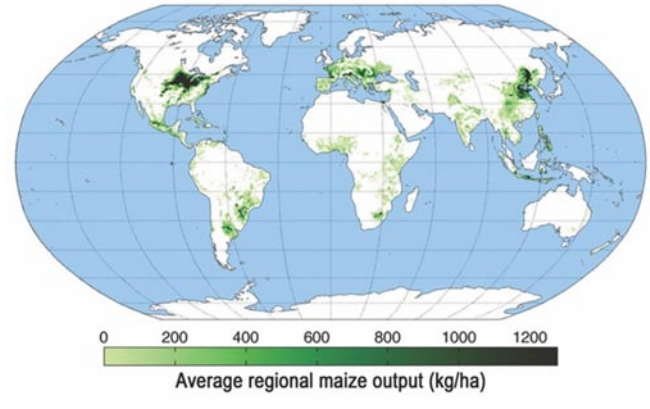
- Well drained plains in warm humid environment preferred
- For use of machinery also
- Undulating topography of the Corn Belt (USA) is ideal for large scale cultivating

WORLD PRODUCTION AND TRADE

- US is the largest producer as well exporter.
- Exported to countries with high density of livestock's (Western Europe).
- Argentina and Brazil are other major exporters.

MAIZE CULTIVATION IN US CORN BELT

- Distinctive agricultural region where dominant crop is corn
- Immediate south of the dairying belts of the great lakes
- Climatic conditions ideal for corn
- High summer T and rainy summer
- Rich prairie earth and rolling topography
- Highly developed mixed farming region (Variety of crops and animals)
- Animals are let loose in the field with standing crops
- They get food
- Farmers do not have to work
- Animal dung is directly added as manure
- One of the most prosperous agricultural regions of the world
- Thoroughly mixed economy with several important crops
- Livestock rearing industry
- Wide range of Industrial development.
- Prosperity of Chicago, Cincinnati can be attributed to Corn and animals



►BARLEY

- Swiss lake dwellers of Stone Age, Chinese, Mediterranean region.

GEOGRAPHICAL REQUIREMENTS

- Optimum condition same as that of wheat, but more tolerant to dry condition and ripes at lower temperature.
- Therefore, grown in wide range of topographical and soil environment where wheat or other cereals fail.
- Can be grown in difficult areas like even beyond Arctic circle & semi-arid regions. Barley has the greatest tolerance of arid conditions, grown on fringes of Sahara, Thar desert of India & dry Mediterranean regions.
- High Altitudes: Dry + Cold perennial cold Peru and Bolivia
- Steep hill slopes: Can survive steep slopes where other cereals do not take roots
- Light limy soil: best crop to grow on chalk and limestone uplands

USES

- Human food and animal feed
- Malting (Beer and whisky)

►MILLETS AND SORGHUM

- 2018 was observed as the 'National Year of Millets" and UN General Assembly adopted an India-sponsored resolution to mark 2023 as the "International Year of Millets".
- Also known as nutria-cereals.
- Sorghum (Jowar)
- Pearl Millet (Bajra)
- Finger Millet (Ragi)

GROWING CONDITIONS:

Temperature: Generally, Millets are grown in tropical and sub-tropical up to an altitude of 2,100m. It is a heat loving plant and for its germination minimum temperature required is 8- 10°c. A mean temperature range of 26-29°c during the growth is best for proper development and good crop yield.

Rainfall: It is grown where rainfall ranges from 500-900mm. Kodo Millet has a heavy water requirement which grows well in moderate rainfall of 50-60cm.

Soil: Millet has wide adaptability to different soil from very poor to very fertile and can tolerate a certain degree of alkalinity. The best soils are alluvial, loamy and sandy soil with good drainage.

Topography: Kodo millet can be grown in gravelly and stony soil such as in the hilly region.

Field preparation: The first ploughing should be done deep with a soil turning plough at the onset of monsoon. Fine tilth is imperative for proper germination and crop establishment

PROPERTIES AND ASSOCIATED BENEFITS

- Can withstand high Temperature and long period of drought.
- Poor soils and difficult terrain also support millet
- Can grow in sub topical and tropical areas with low or seasonal rainfall. Less than 76 cm or as dry crop in rotation.
- Millets are anti acidic; gluten free; Helps to prevent type 2 diabetes; Effective in reducing blood pressure; Reduces risk of gastrointestinal conditions like gastric ulcers or colon cancer; Eliminate problems like constipation, excess gas, bloating and cramping; Millet act as a probiotic feeding micro flora in our inner ecosystem.
- It will also be critical for climate change measures in drylands and important for smallholder and marginal farmers.
- Bioethanol can be created using sorghum (jowar) and pearl millet (bajra), and that this fuel could bring down carbon emissions by about half.
- United Nations has declared the year 2023 as the International Year of Millets and preparations are being made to celebrate the International Year of Millets at the global level.

DISTRIBUTION

- India, Nigeria and China are the largest producers of millets in the world, accounting for more than 55% of the global production. For many years, India was a major producer of millets. However, in recent years, millet production has increased dramatically in Africa.
- Major producers in India include Rajasthan, Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, Maharashtra, Gujarat and Haryana.

WHY IS INDIA SLOW IN ADOPTING MILLET-BASED PRODUCTS?

The average annual growth of millet consumption in India from 1999 to 2016 was only 4.56 %. The highest rise in domestic millet consumption in India was noticed in the years 2002-2003, in which the growth rate reported was about 115.15%. Year by year, the growth rate of millet consumption is declining by the country to an extremely low growth rate of 8.33% in the years 2019-2020.

For all millets there is a dramatic decrease in cultivated area. Dramatic also is the decrease in total production of small millets - 76%.

- General perception is that the millets are increasingly seen as "poor person's food". Therefore, it is necessary to re-brand coarse cereals/millets as nutri-cereals and promote their production and consumption.
- Historical policy neglect of these crops.
- Lower or near absence of production support when compared to the support enjoyed by other crops
- Near lack of reach of improved methods of production and technologies
- Lack of appropriate post-harvest processing technologies for small millets except finger millet
- Competition from other market friendly remunerative crops
- Changes in preference patterns in consumption moving away from them (Sanskritization), mainly due to inclusion of only rice and wheat into the Public Distribution System (PDS)
- Absence of public or private funded promotion of millets as a nutritious food category

GOVERNMENT STEPS TAKEN

- Integrated Cereals Development Programmes in Coarse Cereals ICDP-CC based Cropping Systems Areas under Macro Management of Agriculture -MMA.
- Initiative for Nutritional Security through Intensive Millet Promotion – INSIMP a part of Rashtriya Krishi Vikas Yojana" – RKVY which is the only comprehensive initiative to support millet production.
- Rainfed Area Development Programme – RADP: a component of the Rashtriya Krishi Vikas Yojana – RKVY.

FUTURE STRATEGY

- Additional areas should be brought under millets which will significantly increase the cropping intensity in dryland agriculture and contribute to higher output and farm revenues.
- Use post-kharif fallow lands with residual soil moisture in high rainfall regions like central and eastern Indian states.
- Promote millet based intercropping systems.
- MGNREGA funds can be used to develop common wastelands into cultivable lands, and an integrated and target-oriented strategy may be drawn up for this purpose.
- Establishment of primary processing facilities at the farm gate/village level; hence, primary processing units should be included under the National Food security Mission (NFSM) and agriculture machinery schemes of the Ministry of Agriculture.
- Advocate and promote awareness about nutri-cereals among consumers across the country to create demand
- Millets like sorghum are a good fodder source; as a result, integration of nutri-rich millet fodder with existing millet supply chain models in beneficial to contribute to enhanced farmers' income.

►OILSEEDS

- Oilseeds are generally, seeds grown primarily to produce edible (i.e., cooking) oils. India is one of the major oilseeds' grower and importer of edible oils.
- The diverse agro-ecological conditions in the country are favourable for growing 9 annual oilseed crops, which include 7 edible oilseeds (groundnut, rapeseed & mustard, soybean, sunflower, sesame, safflower and niger) and two non-edible oilseeds (castor and linseed).
- India has been forced to go in for large imports of edible oils since the domestic production of oilseeds falls short of demand. The self-sufficiency in oilseeds attained through "Yellow Revolution" during early 1990s, could not be sustained beyond a short period.

GROWING CONDITIONS

Temperature: most of them (E.g. -groundnut) require warm temperature 20°-30°C. However, rapeseed and mustard are cool climate crops.

Rainfall: 50-75 cm rainfall. Dry winter is needed at the time of ripening. 91 per cent of the total area under groundnut is devoted to kharif crop.

Soil: Well drained light sandy loams, loams, red, yellow and black cotton soils are well suited for cultivation.

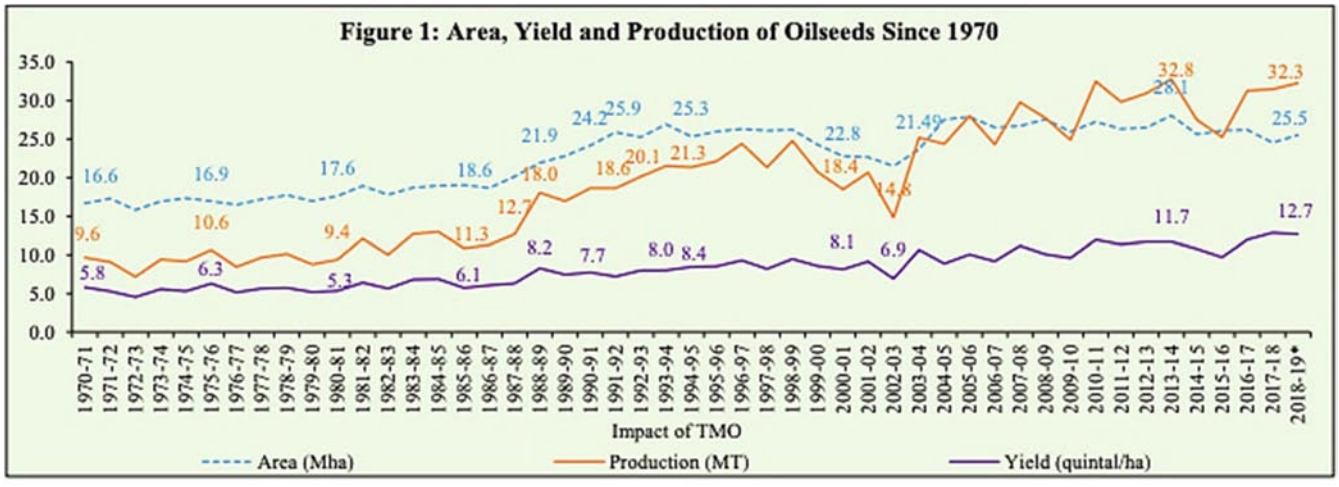
Susceptibility: They are highly susceptible to frost, prolonged drought, continuous rain and stagnant water.

DISTRIBUTION

- After China, India is the second largest producer of groundnut and is third in position in the production of Rapeseed after China and Canada.
- Major Oilseeds Producing Areas in India are Rajasthan, Gujarat, Tamil Nadu, Madhya Pradesh, Haryana, Maharashtra, Karnataka, Andhra Pradesh.

PRESENT STATUS

India accounts for about 15-20 per cent of global oilseeds area, 6-7 per cent of vegetable oils production, and 9-10 per cent of the total edible oils consumption.



SPARKLING YELLOW REVOLUTION AGAIN IN INDIA

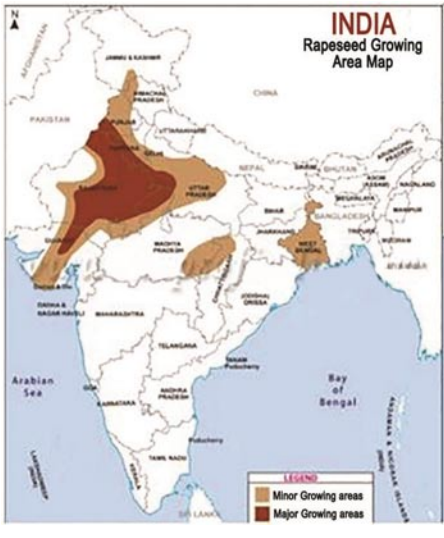
Yellow Revolution improved productivity but could not help in increasing oilseeds production significantly owing to following reasons:

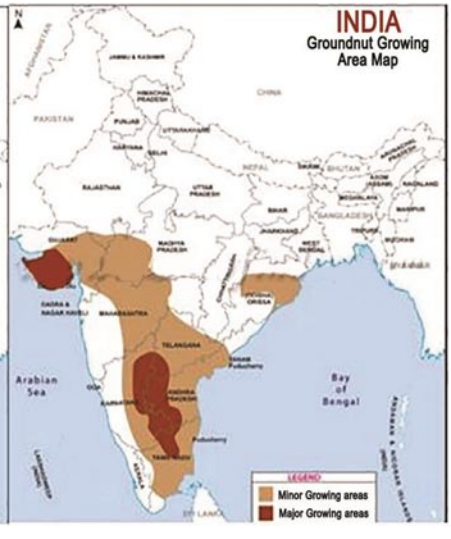
- Lack of irrigation especially micro-irrigation- When it comes to crop-wise coverage of irrigated area (2016-17) almost 70 per cent of cereals and 52 per cent of foodgrains are covered under irrigation. But when it comes oil seeds, the coverage of the irrigated area is 27.8 per cent
- Lack of quality seeds- domestic availability of oilseeds in India falls way short of needs in domestic demand for edible oil.
- Poor marketing infrastructure
- Lack of cohesive government policies
- lack of awareness
- Change in cropping pattern leading to significant decrease in area under oilseeds production.

As of now, there is no comprehensive strategy when it comes to the production of oil seeds

Strategies for enhancing the productivity (and profitability) of oilseeds as under:

- Increasing seed production and distribution of newly released varieties.
- Low-cost technologies with high impact on productivity will result in higher income which will encourage farmers to go for oilseeds farming.
- Strategies with emphasis on quality improvement and value addition leveraging technologies with a bearing on the employment through skill/ entrepreneurship development.
- Promotion of GM seeds.





- The GOI launched Integrated Scheme for Oilseeds, Oil palm, Pulses and Maize Development Programme (ISOPOM) to provide flexibility to the states in implementation based on regionally differentiated approach to promote crop diversification.
- Recently, government has started Pradhan Mantri Annadata Aay Sanrakshan Abhiyan (PM-AASHA) scheme to promote robust procurement mechanism and incentivise farmers to produce oilseed crops.
- Under Make in India, large processing plants should be mandated as well as incentivised to establish backward linkages to produce more oilseeds in the country. These processing plants can work in partnership with farmer producers organisations (FPOs) to boost oilseeds (raw material) output. FPOs can play a critical role in efforts to boost domestic oilseed production

BEVERAGES

►TEA

- Leaves of the tropical shrub Comellia, which is native to hill slopes of monsoon Asia.
- Originated in Yangtze, Chang Jiang valley of China as early as 6 century AD and consumed there and in Japan since then.
- Introduced in Britain and rest of Europe in 17th Century. Massive plantation cultivation in former colonies (India, Sri Lanka and Bangladesh) has made this beverage extremely cheap and in reach of common man. (Initially a luxury).
- Tea faces competition from soft drinks and Coffee.

TEA PLANT

- Hardiest tropical shrub
- Two species
- Assam (Black tea, consumed with milk and sugar, popular in US and Europe): Typical of India and Sri Lanka, Taller with large leaves. Best suited for large scale commercial cultivation.
- Chinese (Green Tea, widely consumed in Far East): Short and smaller leaves.
- Cross between two, combining good features are also available.
- It contains tiny oil cells which gives it peculiar flavor.
- Tannic acid or thein is also found in leaves.

GROWING CONDITIONS

- Climatic conditions
  - More than 21 C during growing seasons for more than 8 months
  - Warm summer and frequent rain reproduction increase the number of annual picking.
  - Cannot tolerate frost but below freezing temperatures.
  - Severe Cold spells hinder the rapid growth, Reduce yield and damage plants
- Highlands
  - Tea plant cannot tolerate standing water and waterlogged lowlands
  - It is best grown on well drained hill slopes or high lands.
  - Almost all black Tea comes from Highland districts.
- Soil
  - Reasonably deep and friable to facilitate root penetration.
  - Most suitable soils: Slightly Acidic and without Calcium, Presence of Iron desirable.
  - Volcanic ash: well porous, aerated and drained: Excellent.
  - Intake of Nitrogen is very high and hence regular manuring essential.
  - Soil erosion problem:
- Planting tea bushes in line along the contours.
- Planting trees also help provide shading and checking soil erosion.
- Shade: Grow better wen shielded from strong sunlight and violent winds. Therefore, trees are planted.
- Labour:
  - Tea cultivation and picking and processing are labour intensive.
  - Female labour preferred for tea picking because of a tedious job requiring skill and patience.
  - Picking entirely done by hands and workers paid by piece rate i.e., amount of tea picked during the day.

TEA CULTIVATION

- Best in monsoon lands of Tropics and subtropics.

- Land preferably on hill slopes is first cleared.
- Plants of around feet are transplanted.
- Weeding and manuring very important.
- Restocking after around 50 years is necessary.

WORLD PRODUCTION AND TRADE

- India > Sri Lanka > China > Japan > Indonesia > Bangladesh > Malaysia
- Kerala: Nilgiris Hills, High quality
- Assam and Khasi hills: 3500 Ft, Greatest yield because of huge estates
- Darjeeling: 4500 Ft, Best quality Tea

DISTRIBUTION ACROSS INDIA

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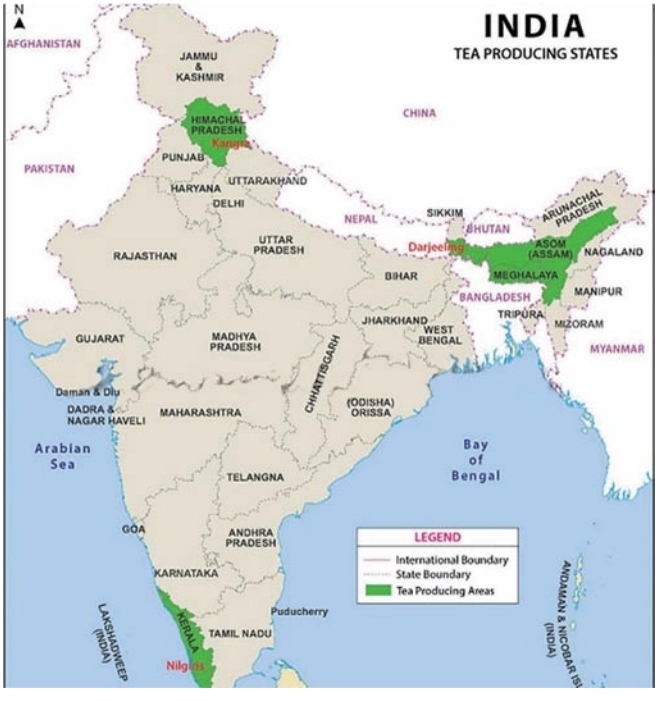
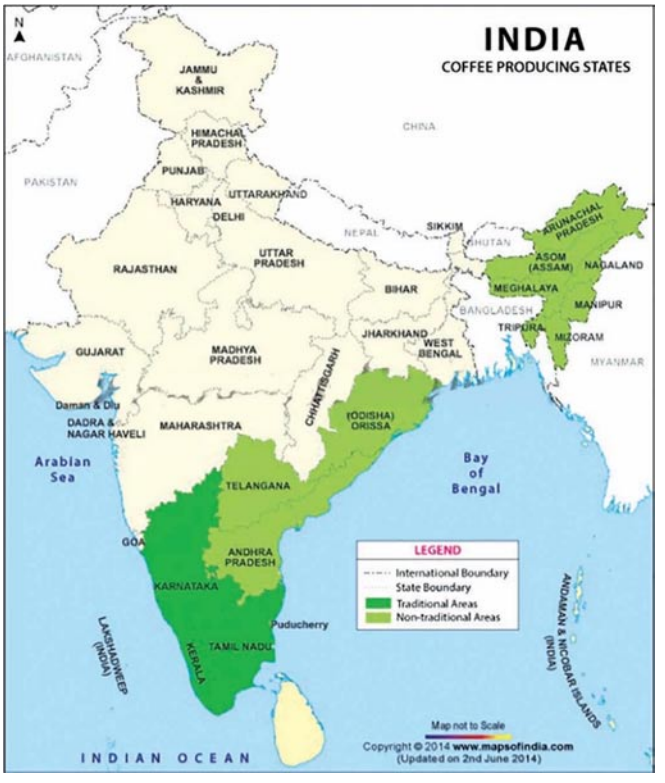


►COFFEE

- More expensive than tea and yields less beverage than tea.
- Native of highlands of Southern Ethiopia (District of Kaffa).
- Ethiopia → Saudi Arabia→ Middle East→ Europe
- Contains Caffeine as stimulants.
- In 18th century first plantation cultivation started in Dutch east indies
- Leadership monopoly: Arabia (Mocha coffee), Jamaica (Blue Mountain coffee), Java coffee, Brazil.

DISTRIBUTION ACROSS INDIA



THREE MAJOR CULTIVATED SPECIES ARE

ARABICA

- Most important in world trade
- Finest coffee for flavor
- Originated from Mocha
- Least hardy

ROBUSTA

- West African variety
- Hardy but poor quality
- Disease resistant

LIBERICA

- Hardy disease resistant
- Indigenous to Liberia
- Suited to lowlands than uplands
- Instant coffee varieties are Robusta and Arabica.

GROWING CONDITIONS

1. Temperature
   - Mean monthly 14-26, Growth most rapid in hot and rainy season
   - During cool and dry season berries ripen and are ready for picking
   - Should not drop below 11 C in the coldest month
   - Cultivation is almost invariably restricted to Tropical areas.

2. Rainfall:
   - Needs high rainfall and should be well distributed (100-200 cm)
   - In Ethiopia, thick sea mist compensates for less rainfall (50 cm)
   - Cannot tolerate stagnant water.
   - Dry period for harvesting and drying is ideal.
3. Shade:
   - Should be sheltered from direct sun light especially when young
   - Tall leguminous plants are sometimes used.
4. Uplands conditions:
   - Well drained, cool conditions.
   - Best quality comes from high elevation and slopes.
   - 2000-6000 ft.
   - Slopes which face sea benefit from sea mist
5. Soils:
   - Yield dependent on soil nutrients, decline sharply when soil is exhausted.
   - Well drained volcanic soil like Terra Roxa of Brazil which contain much potash as well as organic material.
6. Labour:
   - Handpicked therefore no machine.
   - Every stage requires.

FIBRE CROPS

►WOOL

GEOGRAPHICAL REQUIREMENTS FOR WOOL

- Temperature: Warm, dry ideal (Temperate>tropical) - 21 degree in summers,
- Rainfall: 38-89 cm.
- Dry ground more preferred because damp and wet conditions encourage diseases like foot rot and allow spread of parasites.
- Pastures: Moderate food supply consisting of grasses and herbs. Therefore, grassland regions ideal. E.g.: Grasslands of New Zealand and Britain, Australia (Tussocky)

LOCATION OF WOOLEN INDUSTRIES

- With exception of areas around Caspian and central Asia, most production is in southern continents.
- Warmer climates related to limited southerly extent of continents as compared damper cooler conditions of temperate areas of north.
- Dry climates of interior climates of Australia and South Africa and Rain shadow of Patagonia and Argentina are ideal for wool production.
- Extensive Sheep farming is not the most economical land use in Northern continents.
- Economies of scale work in favor of southern locations so much so that final production including transportation costs of wool becomes cheaper than locally produced wool in north.

Location of woollen manufacturing industries is not in wool producing countries, as compared to cotton:

- Woollen textiles require greater skill and fewer workers and therefore well suited to industrialized nations.
- Market for woollen goods is much higher in northern colder areas. While on the other hand, cotton goods have advantage in underdeveloped countries of both cheap available labor and large home market in mainly tropical areas.
- Sparse population
- Smaller market.
- Higher wage rate.

MAJOR PRODUCERS

- Australia: Merino, exports 90 %
- New Zealand: Cross bred
- South Africa: Merino
- Argentina: poor grade

SHEEP FARM ACTIVITIES (E.G., AUSTRALIA)

- Very large farms in natural grasslands.
- Paddock system (reduce over grazing, ensure even use pasture, reserve for draught)
- Draught a recurring problem in Australia. Successive draughts can create great loss.
- Availability of water critical. More dependence on equally spaced well as streams are scarce.
- Shearing done once or twice a year by expert teams which migrate from one farm to another for this work.
- Wool sent to local wool market where auctions take place.

►COTTON

BETTER THAN OTHER FIBERS (WOOL AND SILK)

- Large market for both clothing and industrial use
- Cheap and light-> ideal for clothing in tropics, summer in temperate unlike wool only winter and silk a luxury

fabric.

- Strong, durable, absorbent, easy to launder.

REGION

- Major crop in China, India, Egypt for centuries.
- Luxury in Europe until 18th Century. (Before Industrial revolution mechanized spinning and weaving started)
- In 19th century, US and UK became major centers of textile manufacturing
- At current, China and India are the largest producer.

GEOGRAPHICAL CONDITIONS

1. Temperature

- Warm climate (25 or more)
- Plenty of sunshine during growing seasons cooler during harvest therefore cultivated between 30-30 N-S.
- Long growing periods of at least 200 frost free days necessary for plants to grow.
- Extremely sensitive to frost

2. Rainfall

- Moderate to light (51 o 110 cm) without irrigation
- Better quality fiber can be obtained in semi-arid and even arid conditions with irrigation facilities. Because dry environment inhibits the spread of pests and irrigation provides controlled supply of water.

3. Soils: Medium loam with good drainage which give good support in windy or stormy weather. Mineral nutrient requirement high. Very exhaustive of soil. Therefore, high demand of fertilizer and manures.
4. Land: Best grown on flat (no flooding) or undulating lands which facilitate use of machinery. US and developed regions have highly mechanized farms -> economies of scale. Flat and gently sloping land best for irrigation.
5. Labour: Highly labour intensive, except in developed world. In the USA, there was slavery in the cotton industry before mechanization.

►JUTE

GEOGRAPHICAL REQUIREMENT

- Climate: Hot tropical conditions with plenty of moisture and heavy rainfall are essential.
- Soil: Rich soils and thrives on river alluvium, especially where annual floods renew the fertility of soil.
- Land: Grown under flooded conditions. Same region as that of wet paddy but as cash crops.
- Labour: Labour intensive which is easily available in populated tropical areas where it is chiefly grown.

JUTE GROWING AND PROCESSING

- Sown in spring, harvested before flood.
- Transported on boats
- Leaves removed from stems -> allowed to rot in water to release in fiber -> loosely spun and woven.

INTERNATIONAL PRODUCTION

- Almost all comes from Indian and Bangladesh.
- Climate, river system for easy transportation, port facility.
- Jute substitute Kenaf is grown in several Asian countries especially China and Thailand where it can be grown in drier condition.

►LIVESTOCK

PROBLEMS OF CATTLE REARING IN TROPICS

Temperate regions are traditional areas of commercial cattle rearing but many also kept in tropical grasslands or Savanna of Africa, South America and Australia. With few exceptions, for ex in Southern Africa and northern Australia cattle rearing in these regions is generally poorly developed and financial returns are poor. Reasons are as follows

- Climate and vegetation
  - Unevenly distributed rainfall- frequent floods and droughts.
  - While during dry season grass, water shortage.
  - Savannah has coarse tall grass and scattered trees, Xerophytic shrubs unpalatable.
  - Solutions: irrigated pastures for both food and pastures.
- Cattle breed:
  - Quality of tropical breeds is less than that of temperate breeds.
  - Solution: Cross breeding.
- Diseases:
  - Cattle in tropics are prey to wide variety of pests and diseases. Locust attack destroys vegetation and deprives the cattle of pasture.
  - Solution: through better veterinary services, quick action in case of outbreak and education.
- Traditional farming practices No selective breeding, overgrazing of pastures, no modern technique of cattle rearing but nomadic herding, Over stocking because of societal significance of cattle as wealth and status.
  - Solution: education and training.
- Capital for development:

- Cattle ranching and rearing if done properly is extremely capital intensive.
- Tropical areas (mostly affected by colonialism) lack wealth.

►FISHING

- An umbrella term for catching of aquatic animals (Fish whales pearls crustaceans (lobster, prawns) molluscs (oysters) sponges and see weeds)
- It is a robber industry (rate of extraction<= rate of replenishment).
- Fish concentration depends on Temperature, depth of water, ocean currents, salinity which determines the amount of fish food or planktons.
- Overfishing and wasteful fishing (catching young) needs to be checked on international basis because oceans have no boundaries.
- Value of fish:
  - Source of essential minerals (which is in relatively greater proportion than in other food).
  - Fish liver oil is rich source of Vitamin A and D.
  - **Products:** Oils, fertilizer, Glue, cosmetics, clothing.
  - **Dependent industries**: Ship building and repairing, manufacture of nets and other equipments, construction of tin containers.

WORLD CONSUMPTION OF FISH

- Asia > Europe > North America > Advanced countries tend to consume little fish.
- Per capita consumption varies because of two reasons:
  - Cheaper than meat. Therefore, in demand in developed and underdeveloped countries.
  - Important source of food and nutrients where agricultural potential is low.
  - Mountainous Japan and Norway are there for large consumers.

REASONS FOR TEMPERATE AREAS BEING RICHER IN FISH COMPARED TO TROPICAL AREAS

- Availability of Planktons: Collective term for millions of microscopically small organisms which are found in sea water. They drift on water surface. The important conditions for presence of planktons are as follows:
  - Shallow water conditions: shallow continental shelves, sunlight conditions. World's most extensive continental shelves are shelves of mid to high latitudes in Northern Hemisphere (Newfoundland, western Europe, North Sea & Sea of Japan)
  - Cool water: They are plentiful in areas where cold and warm current meet in polar areas for example, Newfoundland banks and Sea of Japan where cold water from the ocean floor wells up to the surface as it does of the west coast of South America.
  - Land derives minerals: they are nourished by minerals brought from rivers.
- Cool climate:
  - Marine life is best developed in Temperatures less than 20-degree C.
  - Fish easily deteriorate in tropical climate. Although refrigeration has somewhat lowered the influence of climate but due to high cost, its use is still restricted.
- Physical and environmental influences:
  - High indented coastlines of Atlantic and Pacific high latitudes backed by strong relief provide ideal locations for fishing ports. E.g., Boston, St Johns, Grimsby.
  - Rugged mountain terrain and short growing season of Alaska, Norway, Iceland, and Hokkaido restrict agricultural activities, therefore prominent fishery.
  - Temperate woodlands provide wood for fishing boats and hence traditional advantage.
- Tropical diversity: Tropical areas have more diversity in fishes but for commercial exploitation same variety of species are more profitable.
- Extensive research and capital: Temperate countries are better with capital and technology hence takes lead in developing commercial fisheries.

WHO OWNS THE OCEAN?

- Zones of Jurisdictions: According to UNCLOS,
  - Territorial waters: 19 Km from the coast or from base line drawn round an indented coast to include fjords, estuaries and land between the mainland and offshore islands as internal waters. This allows country like Indonesia to claim waters between its Islands
  - Contiguous Zone: In which the coastal state can act against those who break the law within the true

Territorial water

- Exclusive Economic Zone: 320 km or 200 miles, Within the EEZ, the coastal state has the right to exploit all economic resources like fish, minerals, oil and gas and energy production.
- Continental shelf: states can extend their rights of EEZ to the edge of the shelf as much as 800 miles in some cases. But it does not include rights of the sea beyond to 200.
- High Seas: Beyond all the zones in which individual countries can lay claim. They are free to navigation by vessels of all nations. They may be used freely for laying of submarine cables and the airspace over them is also free. Unfortunately, they may also be used as a dumping ground for waste material by all.
- Oceans may be freely fished by all nations, but some international agreements put voluntary restrictions on fishing and whaling to secure future catches.
- Fishery is often a cause of friction between the countries.

ECONOMIC POTENTIAL OF OCEANS

- Fish and other forms of animal life
- Seaweed farming used in variety of products.
- Potential for generation of Ocean Thermal Power using tidal energy.
- Tourism potential.
- Minerals resources from oceans:
  - Polymetallic Nodules (Mn nodules rich in copper, nickel and rare earth metals found in Pacific and Indian oceans).
  - Finer silts: copper and zinc rich silt found in red sea
  - Placer deposits
  - Oil and natural gas.
  - Vast Methane hydrates deposits.
- Water itself
- Vast free transport system.

LOCATION OF MAJOR FISHING GROUNDS

Major commercial fishing grounds are in cool waters of northern hemisphere in comparatively high latitude:

(a) Northwest Pacific Region (Japan): Commercial fishing is best developed because of highly organised industry with modern fishing methods.

(b) Northeast Atlantic and adjacent waters of Arctic: European countries especially Norway, Denmark, Spain Iceland and the United Kingdom. Shallow waters of the North Sea especially the most exploited *Dogger bank* are important areas where fishing is carried out all round the year.

(c) Northwest Atlantic: It includes Grand Bank and the Georges Bank area of the Northwest Atlantic. The convergence of the Gulf Stream and the Labrador Current in that region enhances productivity.

(d) North – East Pacific: Extending from Alaska to California along the western shores of North America form the fourth large fishing area of the world. Salmon is the most valuable fish of this region but tuna, halibut and sardines also important.

(e) Southeast Pacific: Lying off the coast of South America is known for the anchovy harvest off the coast of Peru. The northward flowing Peru Current provides an ideal environment for the anchovy culture because it is associated with a coastal upwelling of nutrient rich colder water laden with plankton on which the anchovy feeds.

(f) West Central Pacific: Extends from the Philippines and Indonesia southward to the Australian coast.

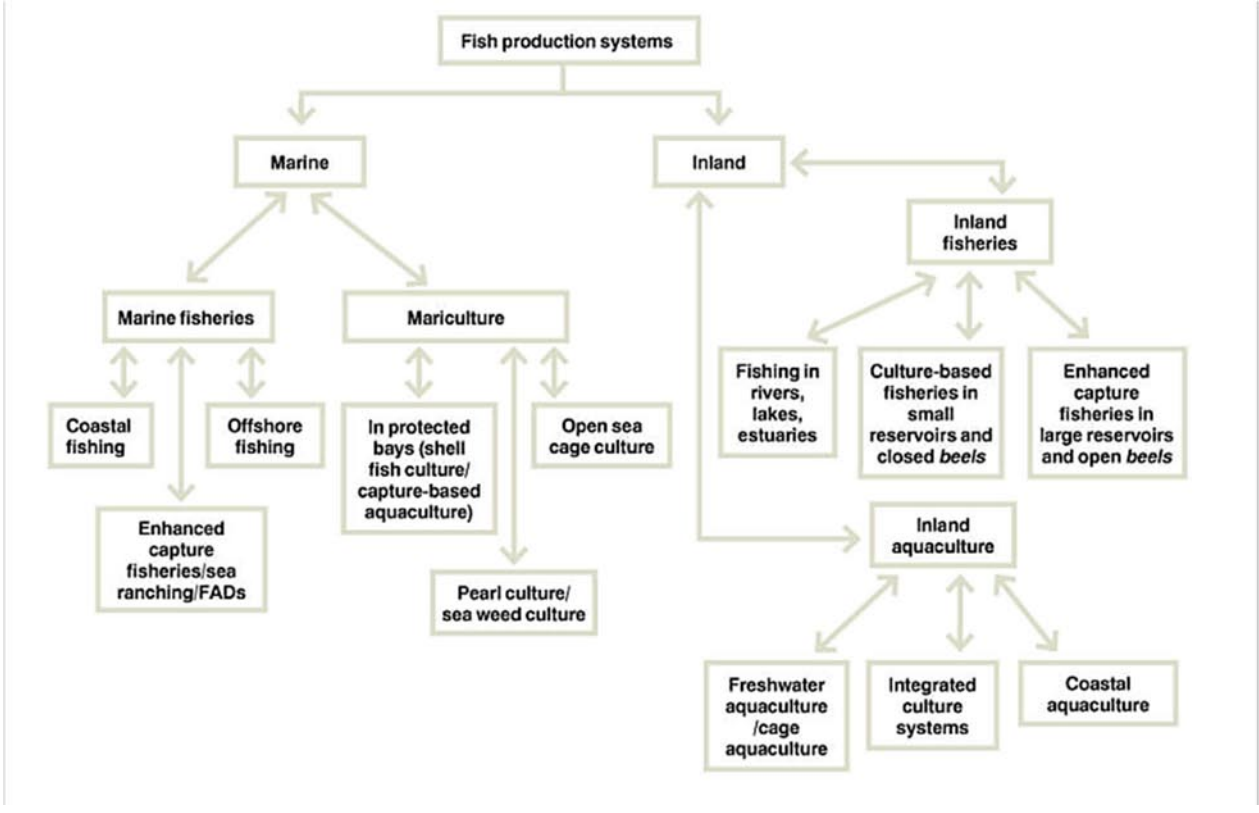
REASONS FOR DEVELOPMENT OF FISHING IN ABOVE AREAS

- Vast continental shelves.
- High availability of planktons.
- Intermixing of Cold and warm currents.
- Lack of natural resources on land. Agricultural land is restricted, and growing season is short.
- Presence of similar varieties of species.
- Cool temperate climate not only favors large scale commercial fishing, but also preservation and storage of fishing.
- Availability of technology and capital.

REASONS FOR DOMINANCE OF INLAND FISHERIES IN INDIA

Till 2000, marine fish production dominated India's total fish production. However due to practice of science-based fisheries, Inland fisheries in India has seen a turnaround and presently contributes ~70 % of total fish production.

FISH PRODUCTION SYSTEMS IN INDIA



- India has rich inland water resources—rivers, ponds, lakes, reservoirs and floodplain wetlands.
- Marine fisheries require capital intensive, technology-based trawlers to compete with other players.
- Huge chunk of population livers along the riverbanks.
- Inland city centres provide huge market.
- Agriculture-fisheries combination is very dominant in northern plains of UP and Bihar. Rice fields are also used to rear fishes.

STEPS TO PROMOTE INLAND FISHERIES IN INDIA

- Develop national inland fishery policy for resource sustenance and promotion of fishery related livelihood and update the Inland fishery policy of each state through a stake holder-based approach.
- Shift priority to bringing more water resources under fish production with equal importance to indigenous species. Emphasis should be given to ecosystem protection, biodiversity and above all socio-economic benefit. Equal importance to be given to capture, capture cum culture and culture fisheries.
- Research to investigate promoting more multi species composite culture shifting from the 3 species or 6 species system to 10-16 species system as in China or Bangladesh and review the relevance of strict eradication of" "weed" and predatory fishes.
- Genuine inland fisher cooperative societies to be promoted, strengthened and necessary financial support given for taking up culture and capture fisheries.
- Increase budgetary allocation for inland fishery program, and fishery dept should be made independent.
- Proper market development support, financial support and value chain development support needs to be provided.

DEEP SEA FISHING IN JAPAN

1. Japan is the most advanced deep sea fishing nation.
2. Situated on broad continental shelf of North-West pacific.
3. Shallow water and meeting of warm and cold currents. (Kuroshio current with Oyashio current). This helps to produce ideal conditions for plankton growth. Pelagic and demersal fish are therefore abundant.
4. Japan is made of about 3000 islands. It has highly indented coastline providing good harbors.
5. Lack of other nutritious sources: Japan in mountainous country with limited lowlands. Rice is the main agricultural crop. Livestock and dairy farming are not so well developed. Fish, therefore, is the main source of nutrition.
6. Being industrially and technologically advanced, Japan

has developed highly efficient fishing industry.

7. Presence of large and well-off home market as well access to export markets in the Asian market.

►SEAWEED CULTIVATION

Seaweeds are macroscopic algae growing in the marine and shallow coastal waters and on rocky shores. Seaweeds are wonder plants of the sea, the new renewable source of food, energy, chemicals and medicines with manifold nutritional, industrial, biomedical, agriculture and personal care applications.

IMPORTANCE OF SEAWEED CULTIVATION

1. Seaweed cultivation is a highly remunerative activity involving simple, low cost, low maintenance technology with short grow-out cycle.
2. Areas of occurrence in ice-creams, Agar-agar.
3. Fertilizer of future: Acts as bioenhancer and stimulates the internal growth of plants.
4. Medicinal properties and healthcare applications: nutraceutical products, from anti-obesity tablets to anti-arthritic and anti-diabetic pills. They are termed as the 'Medical Food of the 21st century.
5. Industrial uses: They are a source of agar, agarose and carrageenan used in laboratories, pharmaceuticals, cosmetics, cardboard, paper, paint and processed foods.
6. Social impact of seaweeds farming: empowerment of women and can be promoted to address the unemployment problems in coastal areas and boost incomes of the region.

CHALLENGES

1. India's production of seaweed is not even enough to meet its domestic demand.
2. There is a slow decline in seaweed production due to the decreasing virility of seeds.
3. Continuous, indiscriminate and unorganised harvesting has resulted in depletion of natural resources.

WAY FORWARD

1. Import of better-quality seeds for countries such as Philippines.
2. Increase the area under seaweed cultivation.
3. Mass production of spores
4. Farming of red seaweed along Gujarat Coast for promoting inclusive economic growth in coastal rural settings through participation of coastal fisher population.

►FOREST

- Not a major contributor to economy compared to other sectors like agriculture or mining but provides us with variety of valuable products like:
  - Timber for construction
  - Wood as a fuel
  - Wood for paper & pulp
  - Minor forest products critical for sustenance of tribal and other forest dwellers.
  - Raw materials for synthetic fibers like Rayon & Acetate.
- Forestry is an extractive or robber industry.
- **Areas which cannot support forests**
  - Tundra region: Due to frozen ground for most of the year, short growing season & very low rainfall.
  - Desert: Due to scanty rainfall, low atmospheric humidity and poor quality of soil which are thin in layer, often sandy and saline.
  - Upper slopes of mountains: Due to thin soil cover and extremely cold climate with low precipitation.
- **Areas which can support but do not have forests:**
  - Tropical and temperate grasslands have capability to support forests but due to extensive human interventions, the forests have been reduced or eliminated.
  - For ex, Savannas around tropical areas may have degenerated from forests because of burning by pastoralists.
  - Asiatic steppes are treeless because of aridity.

CLASSIFICATION OF FORESTS

Three main types of forests in humid and tropical areas and they are differentiated based on climate, dominant types of trees and the wood they yield.

- **Tropical hard wood forests:**
  - Includes evergreen rain forests and tropical monsoon forests.
  - Trees do not occur in stands like in coniferous forests.
  - Broad leaved and hardwood would submerge in water. Hence, difficult to transport. Felled by ring barking system. Ex. Teak, Ebony, Mahogany and ironwood.
  - Coastal areas in tropics have mangrove forests which have many uses, but areal roots make it difficult to exploit them.
- Areas of Occurrence

1. Amazon basin of Latin America
2. Zaire Basin of Africa (Zaire, Ubangi and Kasai)
3. Southeast Asia and Indian subcontinent

- **Temperate hardwood forests**
  - Found in 30-50 degree north and south latitude.
  - Display seasonality, but not as sharp as coniferous forests.
  - Mostly deciduous trees.
  - Variety of hardwood, not as heavy as tropical.
  - Difficult to extract compared to soft woods.
  - Chief commercial species are oak, ash, beech.
  - Suffered greatest destruction by man because of favourable climate and rapid expansion of human habitation in these areas.
  - Today, these forests are limited to inhospitable and remote areas.
- Areas of occurrence:

1) Northern China, Japan where agricultural populations have lived for thousands of years.
2) West, South and Central Europe where growth of agriculture and industry has made very great inroads into the forest.
3) Eastern North America where recently expansion of agriculture and industry has been extremely rapid. Here massive exploitation of the accessible eastern forest in 19th and 20th century has greatly reduced their strength or reduced their value.
4) Found in Australia, Swanland and Tasmania.

- **Coniferous Forests:**
  - Broad belt in both North America and Eurasia (50–70-degree North).
  - Most abundant in Western North America.
  - Also grow on uplands or mountains or in areas of sandy and porous soil in milder temperate areas because they are better adapted to cold and draught than the broad-leaved trees.
  - Tall, straight, evergreen trees with narrow needle like leaves. They take their names from cones in which they bear seeds.
  - Only a few coniferous are deciduous for example larch.
  - They are soft wood trees. Light in weight and therefore easier to cut and transport.
  - Occur in pure stands
  - Spruce, pine, fir and larch families.
- Areas of occurrence

1. Western north America
2. Central and Eastern North America
3. Southern US
4. Northern Europe
5. Asiatic USSR

LUMBERING

Extraction of timber from forests

Silviculture:

- Extraction of timber from planted forests.
- Better than extraction from virgin forests because:

- Forests are especially cared for by the foresters therefore they are of similar age and similar quality and often single species. Hence, they can be cut by clear cutting methods with no young trees to be avoided.
- Extraction easier as plants have been planted keeping in mind transportation. Also allows easy access for inspection, spraying of insecticide etc.
- Reforestation is normal part of their activity and not an enforced one.
- No perpetuation of ecological destruction.
- Factors affecting lumbering

- Different climatic zones, different technique, economies of exploitation, degree of degradation
- Underdeveloped economies of tropical area do not realize full potential compared to temperate and developed temperate areas.

Reasons for Temperate lumbering being more developed compared to tropical lumbering

Temperate region usually has forests rich in softwood while tropical areas have forests rich in hardwood.

- Stands of Timber:
  - Single species stand in temperate forests make it easy to locate and extract.
  - Easy to adopt clear felling due to lack of dense undergrowth as well as absence of buttress roots.
  - Trees smaller and lighter, easy to transport over frozen ground in water.
- Mechanical extraction: Industrial development is high in temperate region.
- Living conditions: Intensification of settled farming rather than seasonal activity lumbermen. Now, settled community treats trees as crops and performs mixed farming.
- Steady demand for timber:
  - Conifers are cheap source of cellulose (paper and

pulp, textile)
    - Low quality products like paperboard and particle board from other varieties.
    - Temperate areas are location of the major paper and pulp industry.
    - Traditional use of softwood as timber continues because of their ready availability, compared to hardwoods which are in short supply and tropical hardwoods which need to be imported.
- Sound forestry techniques:
    - Government intervention in monitoring and care of forest has ensured less devastation and ensuring assured supply to future generation.
    - Reforestation, sound felling practice (cutting in swathes along contours) and careful replanting after felling have minimized erosion.
- Transportation:
    - Very easy as compared to tropical areas (low undergrowth, single stands; smaller, lighter and thinner logs).
    - Longer colder season makes it easier to transport.
    - Transportation cost is minimized since the Paper and Pulp industry are raw material based and require large quantities of water and hence, they are inevitably located near the same streams very near to forests and hence transportation is never a problem. This contrasts with situation in Burma where Teak takes around a year to reach Rangoon which is then necessarily exported.
- Access to market:
    - Almost all the major temperate forests are near most developed region of the world and hence there is a constant demand.
    - All those conical forests which are located away from the industrially developed regions like USSR are very less exploited.
    - International trade is majorly carried out in paper & pulp industry which are very easy to transport.

PROBLEMS OF FOREST

- In Tropical forests:
    - Shifting agriculture.
    - Wood as a main source fuel.
    - Low yielding agricultural practices mean that expansion to reclaim more lands from forests.
    - Regions: African, South Asian and South American
- In Temperate forests:
    - Agricultural clearing
    - Industrial development
- Charcoal as fuel
- Wood for shipbuilding industry led to depletion of temperate hardwood.
- Use of logs in coal mining industry.
- For railway sleepers
- Pulp and paper (fastest growing)
    - Regions: Europe and north America

PROBLEMS DUE TO OVER EXPLOITATION OF FOREST

- There rapid exploitation considering them to be inexhaustible has led to degradation and removal.
- People have recently realized that forests would take substantially long time to regenerate.
- Soil erosion in hilly and sloppy areas which has led to silting of riverbeds and therefore frequent and intense flooding in low lying areas as well as reduced possibilities of navigation.
- Economic implications:
    - Over exploitation and almost removal of temperate forests has led to the govt. intervention and establishments of forest commission or departments for restoration.
    - Replanting of forests was deterred because of very long maturity period (100-150 years for oak, 50-70 years for temperate for conifers, 50-100 for tropical) and realization of the fact that they themselves would reap no benefits. And hence only far-sighted foresters did that.
    - Shifting cultivation also depletes forests because they burn mature forests to make way for food and fodder crops:
- In Malaysia and Philippines (world's leading hard wood exporter) where forestry is practiced on commercial scale, other problem arises like difficulty of controlling.
- Plantation cultivation in topical areas of European colonies (Tea and coffee in India and Sri Lanka, Banana in Central America, Rubber and Sugar cane in Philippines etc.)
- Low level of research in tropical countries leads to poor forest conservation methods.
- Forest fires: Natural in hot and dry weather or ignited by human factors.

►FOREST CONSERVATION AND MANAGEMENT

ADVANTAGES OF FOREST CONSERVATION

- Conservation and protection of ecology

- Continual supply of forest produce (Timber and other minor forest produce)
- Recreational and sporting, enjoyment,
- Preservation of water supplies by protection of watershed areas.
- Flood control.
- Afforestation
  - Replanting is a must (most countries have law and incentivization, social forestry program in India)
  - Replanting f=does not restores the original forest but it is mostly done by fast growing and high pulp yielding conifers. Many exotic varieties for other end uses may also be planted like Eucalyptus.
  - Apart from deforested areas, forestation can be done in areas of marginal land use, agricultural land, sandy beaches and fallow lands.
  - In Europe, Afforestation programs have been so successful that they have doubled the forest cover as compared to pre-world war levels.

IMPROVED FOREST CUTTING METHODS

- Selective cutting
  - Matured, weak and deceased to be cut
  - Advantage: Enough trees left to prevent erosion; species can regenerate ecology intact.
  - Disadvantage: During felling and extraction, much of the younger lot is destroyed.
- Clear cutting
  - Initially wasteful but replacing with saplings will minimize erosion.
  - Cheaper and easier to operate.
  - Sustained yield of timber through long term land rotation.
  - Desired species could be planted.
  - On ill slopes clear cutting on strips parallel to contour and in areas of high wind erosion, perpendicular to the direction of wind.

FOREST PROTECTION

- Forest fires
  - Natural and manmade
  - Research to understand the causes
  - Early detection is the only way to protection
  - Watch towers inside deep forests and continuous air monitoring.
  - Utilization of GIS and remote sensing techniques.
- Pests and diseases
  - have capacity to destroy forests very rapidly
  - Continuous forest visits to identify and start treatment by spraying of insecticides.
  - Many a times, pests are introduced to control a local variety and they themselves become threatening.
- Reduction of wastage
  - There is a need to minimize wastage at the industry.
  - Whatever quality of pulp is obtained should be use rather than wastage.
  - Reuse of wastepaper.
  - Using trees intensively.

►ECONOMIC VALUE OF FOREST

FOREST PRODUCTS OTHER THAN TIMBER

- Rubber and other gums
- Used in ship building industry
- Origin of chemicals such as resin, pitch, tar, turpentine: Today used in chemical industry
- Cork: Thick bark of Cork oaks. Used in stoppers, sports goods etc.
- Tannin: Foundin bars of some trees. It is used in conversion of raw hides into leather.
- Palm and creeper products**:** Palm oil is the world's largest consumed oilseed crop.
- Creeper products are used for producing handicrafts.
- Medicinal plants: Cocaine, morphine, Tobacco have their origin in trees. Forests also produce variety of fruits, nuts and spices. Brazil nuts, ivory nuts and beetle nuts are the most Important.
- Lac is produced from forests in India by interaction of lac insect with trees such as Kusum trees in Jharkhand and Odisha. Lac dye is used for polishing wooden products and certain medicinal plants.
- Tribals especially are dependent on thi s minor forest produce for their livelihood. Government of India has given tribals the right over these minor forest produce. Recently, MSP has been announced for more than 50 minor forests produce and procurement has started for these by state agencies leading to economic empowerment of tribal people.

USES OF TIMBER

- As a Fuel: Depends on availability of other fuels, degree of control exercised over forests by govt. and fuel requirement of countries and main end use of forest (like in Malaysia rubber). Underdeveloped forestry leads more use as fuel and vice versa.
- As a Construction material: Traditionally most important use after fuel. Despite other building

materials like concrete and steel, the amount of timber used for this purpose has increased due to increasing population. Used in following:

- Shipbuilding
- Hardwood timber
- Softwood: Construction, matches, pitprops.
- Swan woods
- Plywood and veneers
- Fibreboards

- Raw material for Pulp and paper industry
  - Most important in terms of value.
  - Wood made up of *lignin* and *cellulose.* The aim of pulping is to extract the cellulose from which paper and synthetic textiles are made.
  - Both Hardwood and softwoods can be used to extract cellulose, but the ease of handling softwoods make them prominent raw material.
  - Supplementary sources like vegetable fiber crops, bananas, sugar bagasse, paddy straw and old rubber trees are being experimented with so that burden on forests could be reduced. Rags and papers Can also be reused but only for producing low quality paper.
  - Processing of paper: Refining and bleaching
  - There are three processes by which paper/pulp is produced:

1. Mechanical method
   - Wood is chopped and ground to dissolve it into water to produce fibrous mass.
   - Disadvantages: Can only deal with softwood trees with low resin. Thus, mainly restricted to spruces.
   - Mainly used for low quality paper and newsprint.
2. Chemical method
   - More versatile and can deal with a wide range of raw materials.
   - Timber is soaked in acid and alkalis to dissolve lignin content of the wood.
   - Produces high quality paper.
   - Advantages: highly shot after process in areas where trees have high resin content like American pines. Less demanding of electricity and water supplies.
   - Disadvantages: Huge chemicals required, Expensive, more wasteful, polluting.
3. Semi-chemical method
   - Chips of woods are first treated with chemicals to remove some of lignin and afterwards wood is broken down mechanically to extract cellulose.
   - Advantages: hardwoods
   - Disadvantages: low quality products.
   - Synthetic textiles: Wood cellulose is the basis of the synthetic textiles known as Rayon. Main source: spruce wood pulp, Cotton linters
   - Other uses: Dye stuffs, chemicals, resins and drugs.

LOCATION FACTORS OF PAPER AND PULP INDUSTRY

- Pulp making is raw material oriented: For this reason, Sweden makes pulp only because of small market for paper
- Paper making is market oriented: England has only paper market because of lack of raw materials.
- Wood: Pulp industry should be located as close as possible to the raw material (Heavy logs). Riverside site is ideal. Rigorous surveying of nearby forests is necessary so that the location remains profitable for long time.
- Water: To make a ton of pulp, 100 tons fresh water is required. Thus, suitable sites for paper and pulp industry should be ideally close to rivers or other water bodies.
- Power: Vast power supplies are essential for paper production. Thus, locations should be rich in coal, wood, hydrothermal electricity.
- Transport: Although the transportation cost is minimized by locating it near to the raw material, newsprint and pulp is still heavy. For this reason, the mills are located near the coast where logs arrive floating on rivers and pulp and paper produced is loaded on the ship to be transported.
- Labor: Highly mechanized and require little manpower
- Capital: Highly capital intensive because of large mechanized and specialized. Larger the plant, larger is the economies scale and hence larger is the initial start-up costs.
- Market: Pulp and paper combined industries usually produce low quality news-stands. High quality paper making plants are usually market oriented and small, they import pulp.
- Best suited locations are thinly populated, forested areas with low amount of industrialization.

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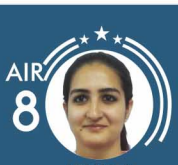
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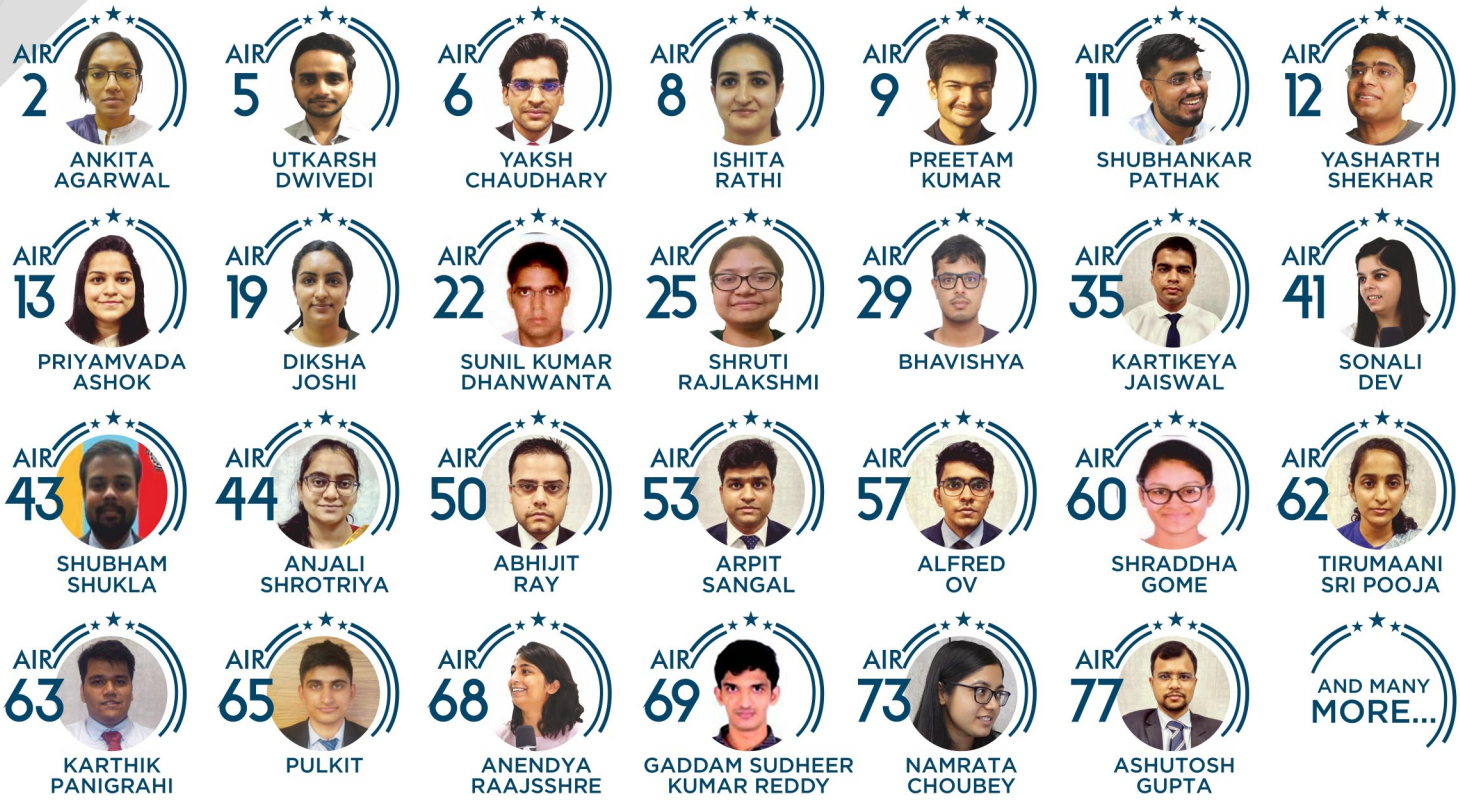

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