5.Geography

Coffee

1. Coffee is a tropical plantation crop.
2. **Ideal conditions**
    1. **Climate**
        1. Coffee requires an average temperature between 20°-27°C.
        2. Needs abundant rainfall, i.e., 100 to 200 cm annually. The hill slopes which receive orographic rainfall are thus best for coffee cultivation.
    2. **Shade:** Direct sunlight is harmful for coffee plants; therefore, these are planted under shade of taller trees such as bananas.
    3. **Topography:** Coffee is grown on slopes having height between 600 to 1,800 metres. Water stagnation is very harmful for coffee plants; therefore, hill slopes are best suitable for it.
    4. **Soils:** Well drained loamy soil.
    5. **Economic conditions**
        1. **Labour:** Coffee cultivation required a large number of labour forces because coffee is to be hand-picked. Labour is required for year-round preparation, transplanting, cultivating, pruning, weeding and of course harvesting.
        2. **Capital:** Plantation of coffee is a capital-intensive activity.
3. **Coffee growing states in India**

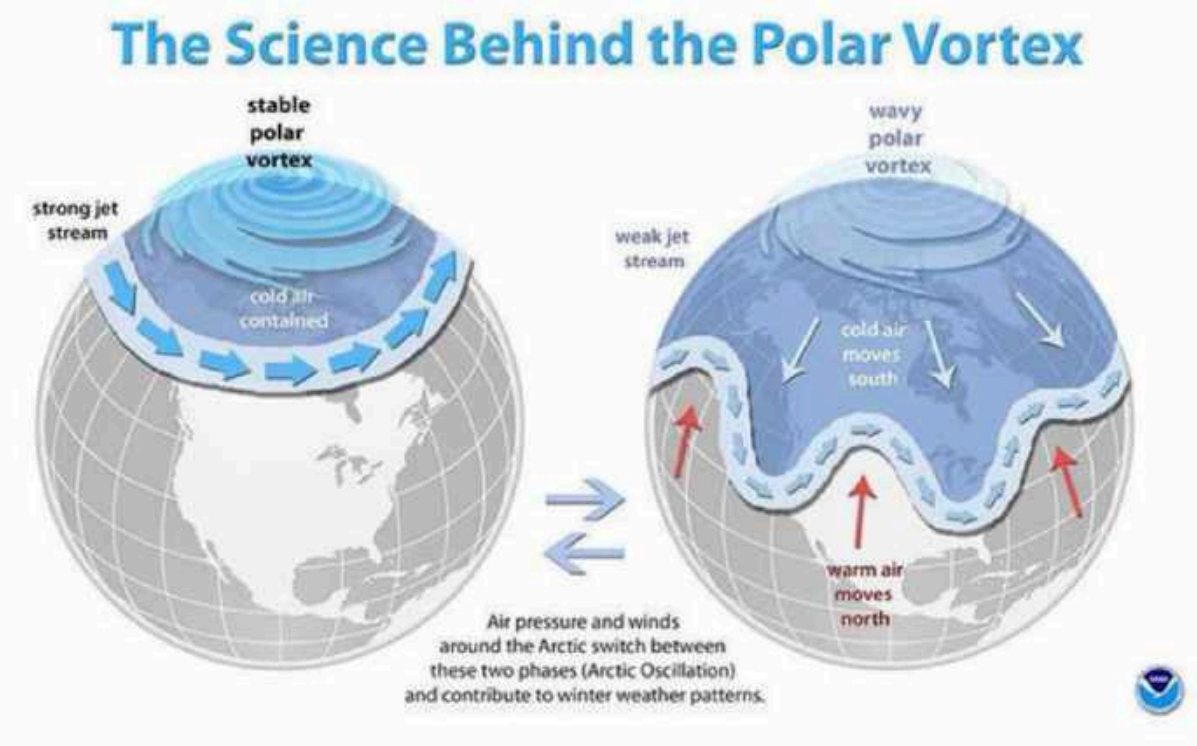
1. 
2. Karnataka is the largest coffee producing state in the country, accounts for nearly 71 percent. Chikmagalur, Kodagu and Hassan districts of Karnataka are major coffee producer regions of the state.
3. The malabar region of Kerala accounts for 21% of coffee production.
4. Tamil Nadu state accounting for 5% of overall coffee production in India at Nilgiris District.
5. Araku Valley Hill station in Andhra Pradesh.
6. North-eastern states like Tripura, Nagaland are also producers of coffee.

4. **Coffee growing countries**
    1. Brazil is the largest producer of coffee followed by Vietnam, Columbia, Indonesia and India.
5. **Challenges facing coffee producers**
    1. Pests, diseases, & fungi.
    2. Heavy unpredictable rains due to climate change can cause issues during harvesting.

3. Labour shortages.
4. Supply chain bottlenecks and middlemen.
5. Fall in international prices of coffee.

6. **Initiatives to promote coffee**
    1. In order to educate the small coffee growers about the integrated management of the major pests and diseases, 15 mass communication programmes were conducted covering 960 small growers in different zones of traditional coffee growing areas. Subsidy was extended to eligible individual coffee growers irrespective of the size of the holdings.
    2. Support for mechanisation of coffee estate operations: This scheme is aimed to provide support to coffee growers to encourage the use of farm machineries.

Cold wave in US



1. **What is a polar vortex**
    1. The polar vortex is a large area of low pressure and cold air surrounding both of the Earth's poles.

    2. The system has a whirling mass of cold air circulating in the mid to upper-levels of the atmosphere, flowing counter-clockwise. This flow of air helps in containing the colder air within the poles.
2. **What is a "polar vortex" event**
    1. Normally, when the vortex is strong and healthy, it helps keep the jet stream travelling around the globe in almost a circular path. This jet stream contains the cold air north of it and the warm air south of it. In winter, in the northern hemisphere, the polar vortex sometimes becomes less stable and expands. This occurs when there is a lack of a strong low-pressure system, resulting in jet stream losing the hold to keep it in line, and becoming wavy.
    2. So a wave of cold air will be pushed down south. This is called a polar vortex event, defining the “breaking off” of a part of the vortex.

Earthquake Swarm

1. Palghar district has been hit by some 30 low-intensity earthquakes since November 2018. The magnitudes of the quakes ranged between 3 and 4.1 on the Richter scale.
2. Earthquake swarm is a series of many low magnitude earthquakes without a discernible main shock. They occur in a localised region and over a period of time ranging from days, weeks to even months, without a clear sequence of foreshocks, main quakes and aftershocks. When seismic energy piles up inside the Earth and is released in small amounts from certain points, such a series of earthquakes can occur.
3. Deccan Plateau is not an earthquake-prone zone because of its hard rock crust, as seismic waves travel faster in hard rocks which helps the tremors dissipate faster. But there is also loose soil which makes the waves stay longer, release more energy and cause more damage.
4. These tremors have been caused due to intra-plate seismicity i..e occurrence of earthquakes within the tectonic plates. Swarms are normal in peninsular India.

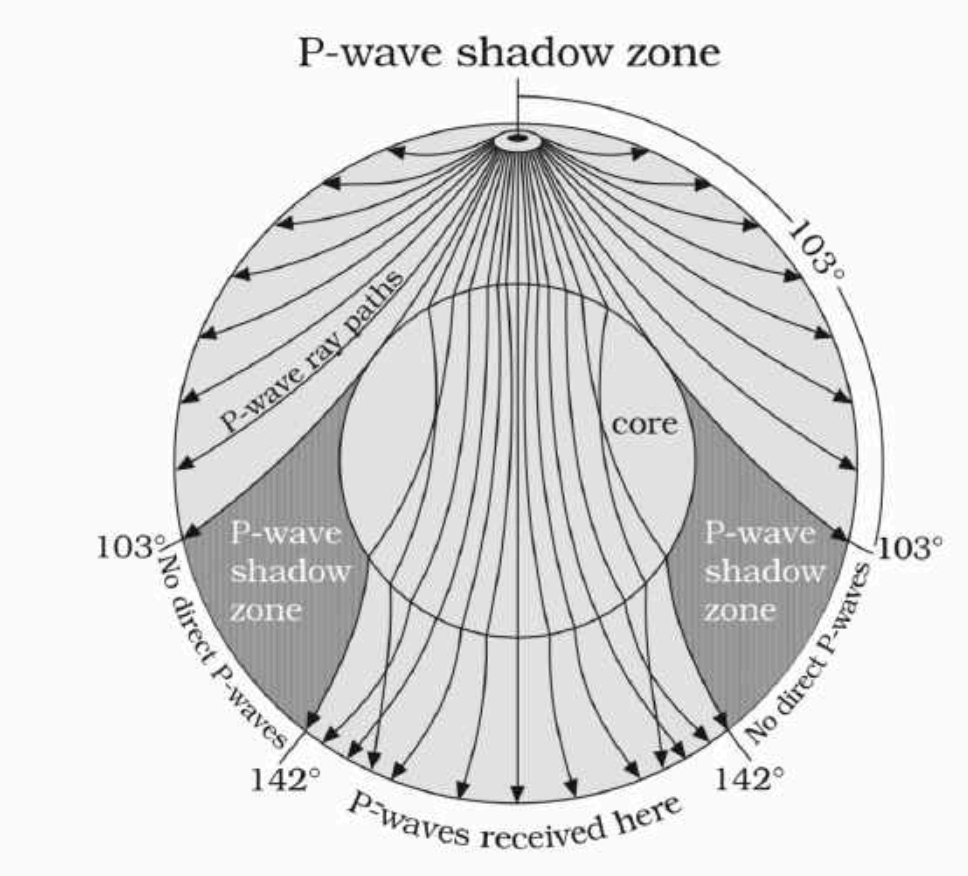
Earthquakes

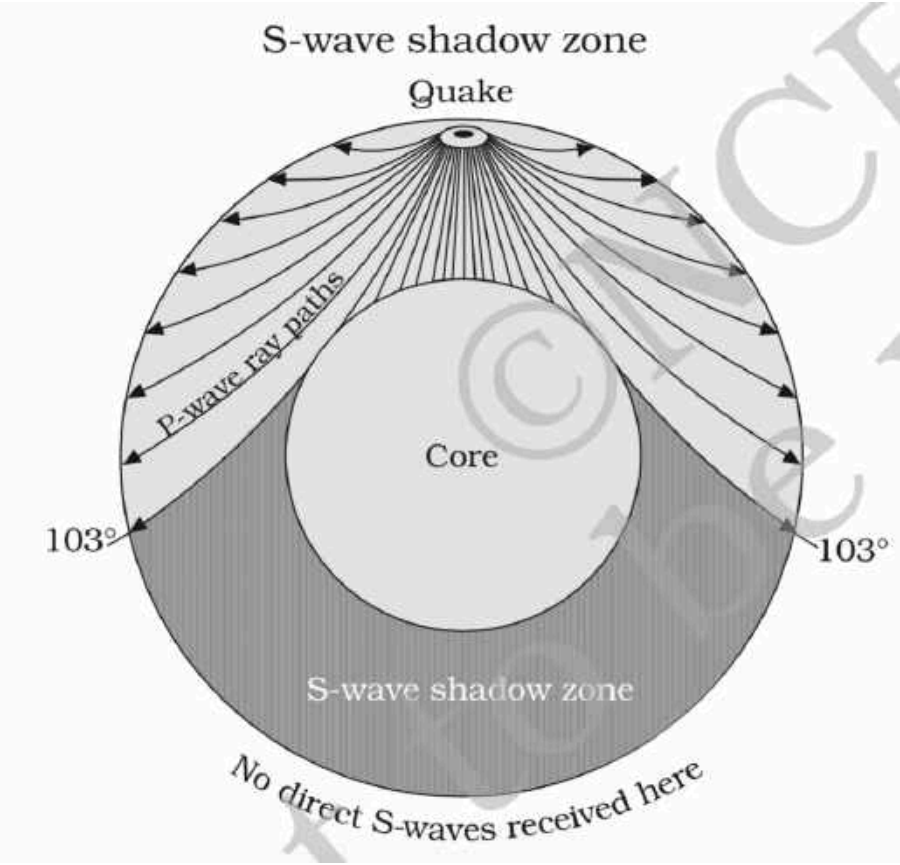
1. A fault is a sharp break in the crustal rocks. Rocks along a fault tend to

move in opposite directions. As the overlying rock strata press them, the friction locks them together. However, their tendency to move apart at some point of time overcomes the friction. As a result, the blocks get deformed and eventually, they slide past one another abruptly. This causes a release of energy, and the energy waves travel in all directions.

2. **Earthquake magnitude:** Earthquake magnitude refers to amount of energy released. It is determined by the use of a seismograph which is an instrument that continuously records ground vibration. The scale was developed by a seismologist named Charles Richter. An earthquake with a magnitude 7.5 on the Richter scale releases 30 times the energy than one with 6.5 magnitudes. An earthquake of magnitude 3 is the smallest normally felt by humans.
3. **Earthquake intensity:** Intensity refers to the impact felt in a locality. So intensity scale measures the effects of an earthquake where it occurs. Thus an earthquake may have different intensities in different locations. The most widely used scale of this type was developed by Mercalli an Italian seismologist. The scale was extended and modified to suit the modern times. Range of intensity scale is 1-12 and that of magnitude scale which is a logarithmic scale which is 0-10.
4. **Types of earthquakes**
    1. The most common ones are the tectonic earthquakes. These are generated due to sliding of rocks along a fault plane.
    2. A special class of tectonic earthquake is sometimes recognised as volcanic earthquake. However, these are confined to areas of active volcanoes.
    3. In the areas of intense mining activity, sometimes the roofs of underground mines collapse causing minor tremors. These are called collapse earthquakes.
    4. Ground shaking may also occur due to the explosion of chemical or nuclear devices. Such tremors are called explosion earthquakes.
    5. The earthquakes that occur in the areas of large reservoirs are referred to as reservoir induced earthquakes.
5. **Body waves**
    1. Body waves are generated due to the release of energy at the focus and move in all directions travelling through the body of the earth.
    2. **Primary (P) waves:** First to arrive at surface. They are

longitudinal waves, so can pass through solids, liquids and gases. They create density differences in the material leading to stretching and squeezing of the material. The higher the density of medium the higher their velocity.

3. **Secondary (S) waves:** They are transverse waves, so can't pass through liquids. As they vibrate perpendicularly, these waves create crests and troughs.
4. It was observed that seismographs located at any distance within 105° from the epicentre, recorded the arrival of both P and S waves. However, the seismographs located beyond 145° from epicentre, record the arrival of P-waves, but not that of S-waves. Thus, a zone between 105° and 145° from epicentre was identified as the shadow zone for both the types of waves. The entire zone beyond 105° does not receive S-waves. The shadow zone of S-wave is much larger than that of the P-waves.
5. 



6. **Surface waves**
    1. The body waves interact with the surface rocks and generate new set of waves called surface waves. These waves move along the surface. They are the last to report on seismograph. These waves are more destructive. They cause displacement of rocks, and hence, the collapse of structures occurs.
    2. **Love (L) waves & Raleigh (R) waves:** They are surface waves and don't go deeper into the earth. L waves are faster than R waves. So the sequence of arrival is PSLR. R waves are analogous to water waves i.e. movement of particles takes place in the vertical plane. In L waves movement of particles takes place in the horizontal plane only but at 90 to the direction of propagation of the wave. L waves are most destructive. The surface waves get significantly amplified when they pass through a soft ground like alluvial deposits. There is compression and rolling over of soft alluvial deposits which is called liquefaction.
7. **Earthquake zones in India**
    1. 60% of Indian land mass is prone to earthquakes.

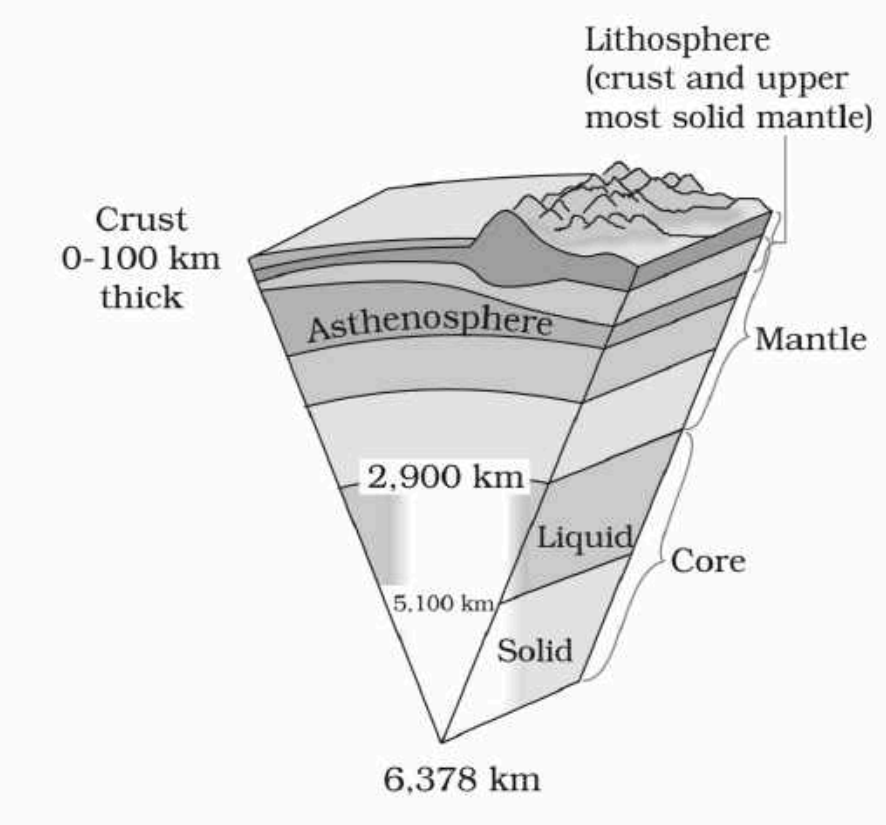
2. **Himalayan range:** The Himalayan range consisting of regions in J&K, North East, Uttarakhand, Bihar etc. These regions being on the border of the tectonic plate, are very much vulnerable to the Earthquakes. Seismic zoning map identified these areas as zone 4 and 5 indicating high vulnerability. Even Gujarat comes under this zone though it is prone to intra-plate earthquake unlike Himalayan region.
3. **Indo-Gangetic plain:** Delhi, some regions of Kashmir and Maharashtra are in zone 4.
4. **Western ghats:** This region comes under zone 3 of the seismic zoning map. Being block mountains, there are fault planes across this region making the region susceptible to earthquakes.
5. **Andaman and Nicobar:** These islands are of volcanic origin and hence are prone to Earthquakes due to volcanism. They are identified as zone 5 region.

8. **Consequences**
    1. **Landforms:** Ground shaking, differential ground settlement, land and mud slides, soil liquefaction, ground lurching and avalanches.
    2. **Damage of property:** When earthquake occurs, buildings are greatly damaged. Underground pipelines and railway lines are damaged or broken. Dams on river collapse, resultant floods cause havoc.
    3. **Human loss:** Duration of tremors of earthquake is normally of only few seconds, but thousands of people may die in this short period.
    4. **Tsunamis:** Earth quakes can often result in tsunamis. It wreaks havoc on settlement of coastal areas.
    5. **Fountains of mud:** Due to the intense impact of earthquake, hot water and mud appear on the surface and take a form of fountains. In Bihar earthquake of 1934, the fields of farmer were covered by knee-deep mud and the crops were destroyed.
9. **Mitigation measures**
    1. Establish earthquake monitoring centres (seismological centres) for regular monitoring and fast dissemination of information among the people in the vulnerable areas.
    2. Preparing a vulnerability map of the country and dissemination of

vulnerability risk information among the people and educating them about the ways and means minimising the adverse impacts of disasters.

3. Community preparedness is very vital for mitigating earthquake impact. The most effective way to save you even in a slightest shaking is DROP, COVER and HOLD. It can be created through sensitisation and training programme for community, architects, engineers, builders, masons, teachers, government functionaries teachers and students.
4. The Bureau of Indian Standards (BIS) has published building codes and guidelines for safe construction of buildings against earthquakes. Building plans have to be compulsorily checked by the municipality.
5. Architectural and engineering inputs need to be put together to improve building design and construction practices. The soil type needs to be analysed before construction. Building structures on soft soil should be avoided.
6. A SAARC seismological agency needs to be set up. This should be independent of the member countries meteorological departments and keep all member-states informed of seismicity's as regularly as the MET office informs us about the weather.
7. An earthquake plan for the Himalayas needs to be drawn up. Details need to be worked out on how rescue and relief operations can be conducted by air, land and water, in rough weather conditions and elusive terrains.
8. The sites for all large dams and nuclear installations in the region need to be reevaluated from a seismic point of view.

Earth structure



Volcano

1. A vent or opening in the Earth crust is known as Volcano. The material that reaches the ground includes lava flows, pyroclastic debris, volcanic bombs, ash and dust and gases such as nitrogen compounds, sulphur compounds and minor amounts of chlorine, hydrogen and argon. Most volcanoes are nearly conical in shape. Lava blown out quickly cools down in small solid pieces known as cinders. The pieces of cooled lava collected around the vent gives rise to cinder cone.
2. **Volcanic types**
    1. **Shield volcanoes:** Shield volcanoes are the largest of all the volcanoes on the earth. These volcanoes are mostly made up of basalt, a type of lava that is very fluid when erupted. So, these volcanoes are not steep. They become explosive if water gets into the vent. Volcanoes in Hawaiian islands are this type.
    2. **Composite volcanoes:** These volcanoes are characterised by eruptions of cooler and more viscous lava than basalt. This material accumulates in the vicinity of the vent openings leading to formation of layers, and this makes the mounts appear as

composite volcanoes. They are found at destructive plate margins. Examples of composite volcanoes include Mount Fuji (Japan), Mount St Helens (USA) and Mount Pinatubo (Philippines).

3. **Caldera:** These are most explosive of the Earth's volcanoes. They are usually so explosive that when they erupt they tend to collapse on themselves rather than building any tall structure. The collapsed depressions are called calderas. Ex: Lonar lake in Maharashtra.
4. **Flood basalt:** These volcanoes outpour highly fluid lava that flows for long distances. Some parts of the world are covered by thousands of sq. km of thick basalt lava flows. The Deccan traps from India, presently covering most of the Maharashtra plateau, are a much larger flood basalt province. It is believed that initially the trap formations covered a much larger area than the present.
5. **Mid-ocean ridge volcanoes:** These volcanoes occur in the oceanic areas. There is a system of mid ocean ridges more than 70,000 km long that stretches through all the ocean basins. The central portion of this ridge experiences frequent eruptions.

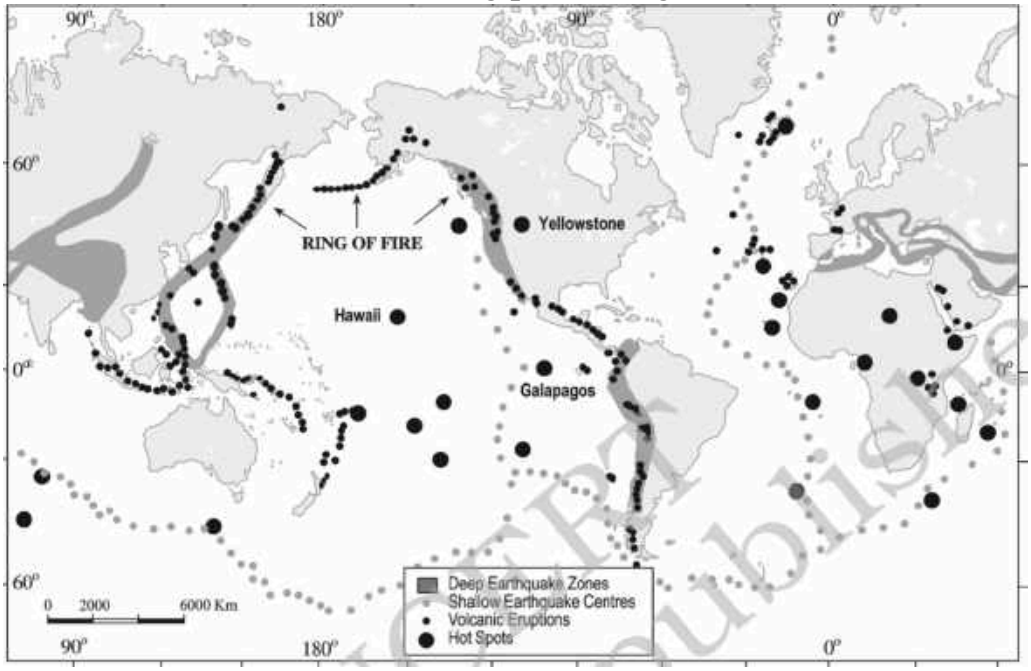
3. **Causes of volcano**
    1. Volcano can be caused along convergent, divergent and some continental plate boundaries.
    2. Subduction of one plate under other in case of converging plate boundary results in melting of rocks due to high temperature and pressure which rises along the fissures of rocks.
    3. In case of diverging boundaries, thinning of upper crust leads to reduction in overlying pressure of rocks causing decrease in rock melting point and formation of magma which rises and erupts as lava from fissure volcanoes.
    4. Some continental volcanoes located away from plate boundaries due to stressing of plates and creation of faults.
4. **Why hazard**
    1. Air pollution and resulting effects on human, livestock, air transport, climate, ozone.
    2. Loss of human life and property due to primary effects of lava and ashes, rocks etc. Loss of vegetation and wildlife of the surrounding areas.
    3. Secondary disasters like tsunami, earthquakes, mud flow, floods

etc caused by volcanic eruption.

4. Climate change due to large amount of dust and ash in air which causes small ice age.
5. Increase in temperature of surrounding area.

5. **Benefits**
    1. Volcanic rocks upon weathering and decomposition can yield very fertile soils. The ash and dust are found very fertile for fields and orchards.
    2. They have great deal of scenic beauty in the form of geysers, springs of hot water. The cinders and clots are sold to tourists visiting such areas, for their fantastic shapes.
    3. These geysers and water springs have potential to be developed as geothermal electricity.
    4. They add extensive plateaus and volcanic mountains.
    5. Volcanic activity produces valuable minerals and gases.
6. **Ring of fire**
    1. The Ring of Fire is a long chain of volcanoes and other tectonically active structures that surround the Pacific ocean.
    2. The chain runs up along the western coast of South and North America, crosses over the Aleutian Islands in Alaska, runs down the eastern coast of Asia past New Zealand and into the northern coast of Antarctica.
    3. The Ring of Fire is one of the most geologically active areas on Earth, and is a site for frequent earthquakes and powerful volcanic eruptions. Many of these volcanoes were created through the tectonic process of subduction whereby dense ocean plates collide with and slide under lighter continental plates. The material from the ocean floor melts as it enters the Earth's interior and then rises to the nearby surface as magma. Ex: Mount St. Helens in the USA, Mount Fuji in Japan and Mount Pinatubo in the Philippines.
    4. The deepest part of the ocean on Earth, the Mariana Trench, is located along the Ring of Fire in the western portion of the Pacific Ocean Basin.
    5. In general, foci of the earthquake in the areas of mid-oceanic ridges are at shallow depths whereas along the Alpine-Himalayan belt as well as the rim of the Pacific, the earthquakes are deep-

seated ones. The majority of Earth's earthquakes occur in the Ring of Fire. These earthquakes are caused by the sudden lateral or vertical movement of rock along plate margins.



7. The lava that is released during volcanic eruptions on cooling develops into igneous rocks. The cooling may take place either on reaching the surface or in the crustal portion. Depending on the location of the cooling, igneous rocks are classified as volcanic rocks (cooling at the surface) and plutonic rocks (cooling in the crust).
8. **Volcanic landforms**
    1. **Batholiths:** A large body of magmatic material that cools in the deeper depth of the crust. They develops in the form of large domes.
    2. **Laccoliths:** These are large dome shaped intrusive bodies with a level base and connected by a pipe-like conduit from below. Ex: Karnataka plateau is spotted with Domal hills of granite rocks.
    3. **Lapolith:** A portion of lava moves in a horizontal direction wherever it finds a weak plane. In case it develops into a saucer shape, concave to the sky body, it is called lapolith.
    4. **Phacolith:** Rocks found at the base of synclines or at the top of anticline in folded igneous country. These are called the phacolith.
    5. **Sill:** The near horizontal bodies of the intrusive igneous rocks are called sill.

6. **Dykes:** Lava solidifies almost perpendicularly to the ground. Such structures are called dykes. These are considered the feeders for the eruptions that led to the development of the Deccan traps.

Retreat of Glaciers

1. "Hindu Kush Himalaya Assessment" reveals that more than 35% of the glaciers in the region could retreat by 2100. Glacier is a dense body of ice that has been formed where the accumulation of snow exceeds its ablation over many years. Glaciers aren't formed instantly. They need centuries for their formation. Hence their melting must raise a concern.
2. **Causes**
    1. Rising emissions of Green House Gases (GHGs).
    2. Deforestation.
    3. Ice breaking ships.
    4. Open water has a lesser ability to reflect back sun rays than ice does, thus the water takes in more of the heat. This ends up heating the water and in consequence melting more ice.
3. **Major consequences**
    1. Large-scale warming could drastically alter the river flows in many countries. The receding glaciers could cause a deluge in the rivers during the monsoon season while the flows are likely to plummet during the dry seasons, with serious implications for irrigation, hydropower and ecosystem services.
    2. The ICIMOD study offers clues that the receding glaciers might be the reason for the changing monsoon pattern, the number of intense precipitation days and intensity of extreme precipitation have increased overall in the last five decades.
    3. Increase of the level of the oceans. This can drastically affect the life in low lying coastal areas. This can lead to intrusion of salt water into agricultural fields and ground water.
    4. Biodiversity loss. There are a lot of living organisms that rely mainly on glaciers for continued existence. Ex: Penguins, blue bear. Certain birds also rely on fish that are found in freshly melting glaciers.
    5. Coral Reefs will disappear. When water levels increase due to glacier melting, sufficient sunlight will not be able to reach the

corals.

6. Recontamination of the environment. Chemical pollutants and pesticides like DDT became airborne and finally got deposited in the chilly places that contain glaciers. The rapid melting of glaciers is now discharging the chemicals back into the surroundings and water bodies.
7. Scarcity of fresh water. Only 2% of the water available is fresh water that people can consume. Over 70% of it is in the form of glaciers and snow.
8. Global warming. Glaciers play a significant role in reflecting and absorbing the heat on earth. This means that as glaciers keep on melting, temperatures all over the world will at the same rate keep on increasing.

Aravali Range

1. The Aravalli Range is a range of mountains running approximately 692 km in a southwest direction, starting in North India from Delhi and passing through southern Haryana, through to Western India across the states of Rajasthan and ending in Gujarat. It is the oldest range of fold mountains in India.
2. Aravali had gone through the process of orogenesis about 400 to 440 millions years ago. The range rose in a Precambrian event called the Aravalli-Delhi orogen. Due to continuous denudation it has been reduced to such a small height and called as relict folded mountain.
3. **Significance of Aravalli range**
    1. The 690-km Aravali range, spanning parts of Delhi, Haryana, Rajasthan and Gujarat, serves as the lungs for the highly polluted National Capital Region (NCR) besides acting as a natural shield against the creep of the Thar Desert.
    2. It hinders the dust-laden winds from Rajasthan to enter the NCR where the air quality is already grievously poor.
    3. It also plays a critical role in recharging the groundwater of the region around it.
    4. Moreover, it is the source of origin of several rivers and rivulets,

including Sabarmati, Luni, Chambal and Krishnavati.

5. It harbours rich biodiversity, hosting numerous species of plants, birds and animals. It is the corridor between Asola Bhatti sanctuary in Delhi and Sariska in Rajasthan for several kinds of animals, including leopards, hyenas, jackals, mongoose and others.

4. Considering that Haryana has the lowest forest cover in the country, barely 3%, any action that would further curtail the forested land is indefensible.

Himalayas

1. Himalayas for a natural and climatic barrier between South Asia and Eurasia.
2. **Formation of Himalayas**
    1. The Himalayas, one of the youngest and active mountain ranges in the world, rose when the North-ward moving Indian tectonic plate rammed against the Asian plate.
    2. As there is a difference in the relative movements of these two plates, the faster moving Indian plate is pushing under the Asian plate, prompting the Himalayas to gain height continuously, albeit in a small measure.
    3. As the Indian plate ducks under the Asian plate, the friction between the plates is stored as strain energy, which needs to be released every now and then.
    4. This release of energy along the fault lines causes earth quakes. The collision of continent-continent plate convergence produces earth quakes of higher magnitude.
3. **Significance of Himalayas**
    1. Divide the Sub-Tropical jet stream into northern and southern branches. Only after withdrawal of southern branch does the high pressure system recedes and the monsoon advances.
    2. Intercept the summer monsoon winds and cause rainfall.
    3. They prevent the cold continental air masses of Central Asia from entering into India. Thus it prevents India from becoming a cold desert.
    4. Snowfall in the Himalayas causes cold waves in North India.

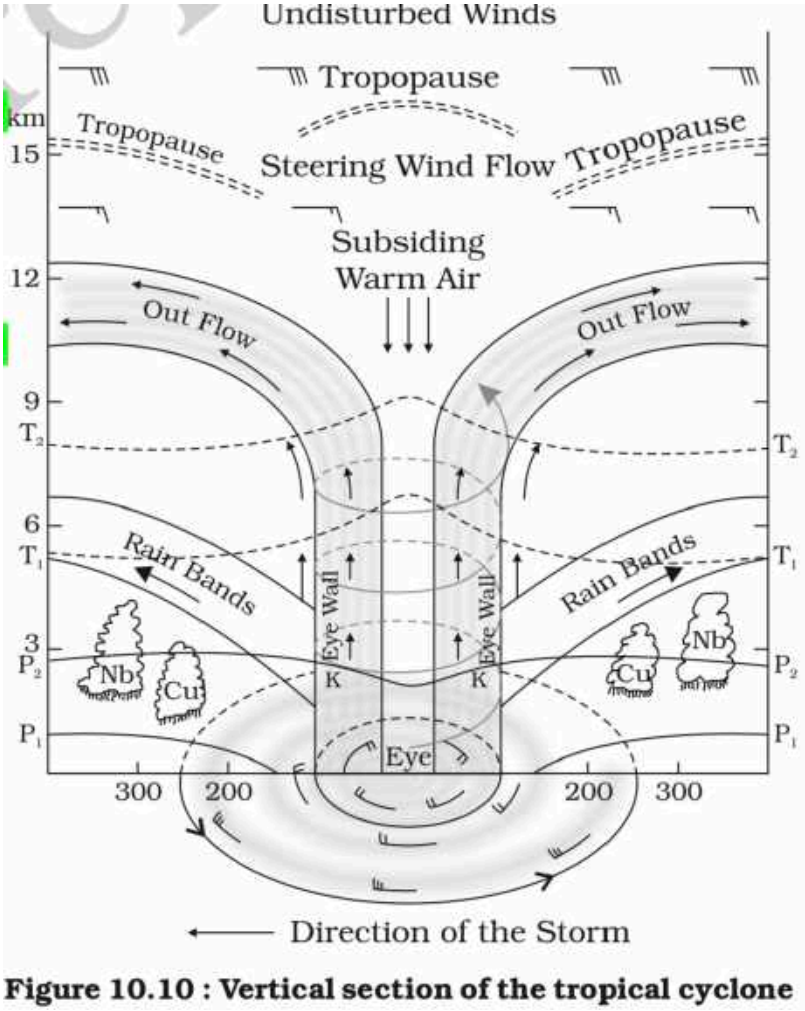
5. It is an abode of bio-diversity. Valley of flowers, Hemis-high altitude, Rajaji national park are some of the national parks present in the region. The forests provide valuable wood and herbs and are also a natural home to many kinds of birds and animals.
6. Many rivers originate from Himalayas. Ex: Ganga, Brahmaputra, etc. The rivers originating from the Himalayas carry fertile soil from the mountains to the plains. They also help in generating hydroelectricity.
7. Contains wetlands of international importance. Ex: Tso Moriri, Pangong Tso.
8. Many health resorts and holy places have been developed, which are visited by thousands of people every year.

4. **Changes observed**
    1. Average annual temperature has increased in the foothills, middle mountains as well as the higher Himalayas in the past few years.
    2. Total annual precipitation changes are quite variable, decreasing at one site and increasing at a site nearby, indicating erratic nature of rainfall.
    3. Reduced snowfall in frequency and amount has caused reduction in extent and duration of snow cover and in flow of rivers.
    4. Tree lines have been moving to higher elevation due to increasing temperature.
    5. Diversion of rivers has affected natural flows.
    6. Frequency of hazardous events such as cloud bursts, breach of glacial dammed lakes as well as seismicity has increased.
5. **Anthropogenic causes behind the change**
    1. Greenhouse gases induced global warming is the most important cause of erratic climatic changes.
    2. Deposition of soot and aerosols near the ground has significantly impacted the albedo, such as in Tibetan glaciers.
    3. Multiple dams, such as those by China on the Tsangpo or by India on tributaries of Ganga/Yamuna/Indus in the Himalayan region have affected flow of rivers in the area. While dams do act as a buffer to absorb excess water flows, they seriously impact water ecology.
    4. Unintended releases can also cause floods in downstream areas.

Besides, seepage of water causes loosening of rocks and can cause earthquakes.

Tropical cyclones

1. Cyclone is a region of low atmospheric pressure surrounded by high atmospheric pressure accompanied by powerful winds. Winds blow in anticlockwise direction in the Northern Hemisphere and in the clockwise direction in the Southern Hemisphere. They occur mainly in the tropical and temperate regions of the world. Heavy destruction is caused by storm surge, high velocity winds and heavy rainfall.They quickly dissipate over land as their moisture supply is cut off and cause heavy rains with thunderstorms but rain is short lived.
2. **Conditions necessary**
    1. Large sea surface with temperature higher than 27° C.
    2. Presence of coriolis force. So, they can only form between 8-20 degree north and south of equator.
    3. A pre-existing weak low pressure area or low level cyclonic circulation.
    4. Upper divergence above the sea level system.



5. **Figure 10.10 : Vertical section of the tropical cyclone**

3. **How do they form**
    1. Because of high sea temperature (>26.5C), a low pressure is developed over the sea. If there is sufficient upper level divergence in the atmosphere, the air which rises from below does not accumulate. This leads to continuous rise of moist air rise.
    2. Moisture condense at higher levels and gives out latent heat of condensation. Due to release of heat of condensation, area warms up resulting into further fall in pressure. This process continues and a low pressure system gradually intensifies into a cyclonic storm.
4. **Initial state of formation**
    1. A warm sea temperature in excess of 26 degree centigrade which provides abundant water vapour in the air by evaporation. High relative humidity of the atmosphere, facilitates condensation of water vapour into droplets and clouds, releases heat energy and

induces drop in pressure.

2. Atmospheric instability (an above average decrease of temperature with altitude) encourages considerable vertical cumulus cloud convection when condensation of rising air occurs. A location of at least 4-8 latitude degrees from the Equator, so that coriolis force can prevent filing of low pressure and can induce cyclonic wind circulation.

5. **Fully matured state of formation**
    1. The main feature of a fully mature tropical cyclone is a spiral pattern of highly turbulent giant cumulus thundercloud bands. These bands spiral inwards and form a dense highly active central cloud core which wraps around a relatively calm zone. This is called the eye of a cyclone.
    2. The eye is composed of air that is slowly sinking. The eye's warm temperatures are due to subsiding warm air. There is little or no precipitation and sometimes blue sky or stars can be seen. The eye looks like a black hole or a dot surrounded by thick clouds.
    3. The outer circumference of the thick cloud is called the eye wall. The eye wall has a net upward flow as a result of many moderate and occasionally strong updrafts and downdrafts.
    4. A tropical cyclone begins to weaken as soon as its source of warm moist air is abruptly cut off. This is possible when the cyclone hits the land, or the cyclone moves to a higher altitude or when there is the interference of another low pressure.
6. **How are tropical cyclones named**
    1. The World Meteorological Organisation (WMO) has devised a mechanism where countries submit a list of names from time to time. Names of cyclones are chosen from this pool.
    2. For tropical cyclones developing in the North Indian Ocean, India, Sri Lanka, Bangladesh, Maldives, Myanmar, Oman, Pakistan and Thailand send their names to the regional tropical cyclone committee. At present, all eight countries have submitted eight names each for naming future cyclones.
7. **Extra-tropical cyclone**
    1. Cyclone forming beyond the tropics are called the middle latitude or extra tropical cyclones. Extra tropical cyclones form along the polar front. Initially, the front is stationary. But the if the front is

disturbed, temperate cyclone result.

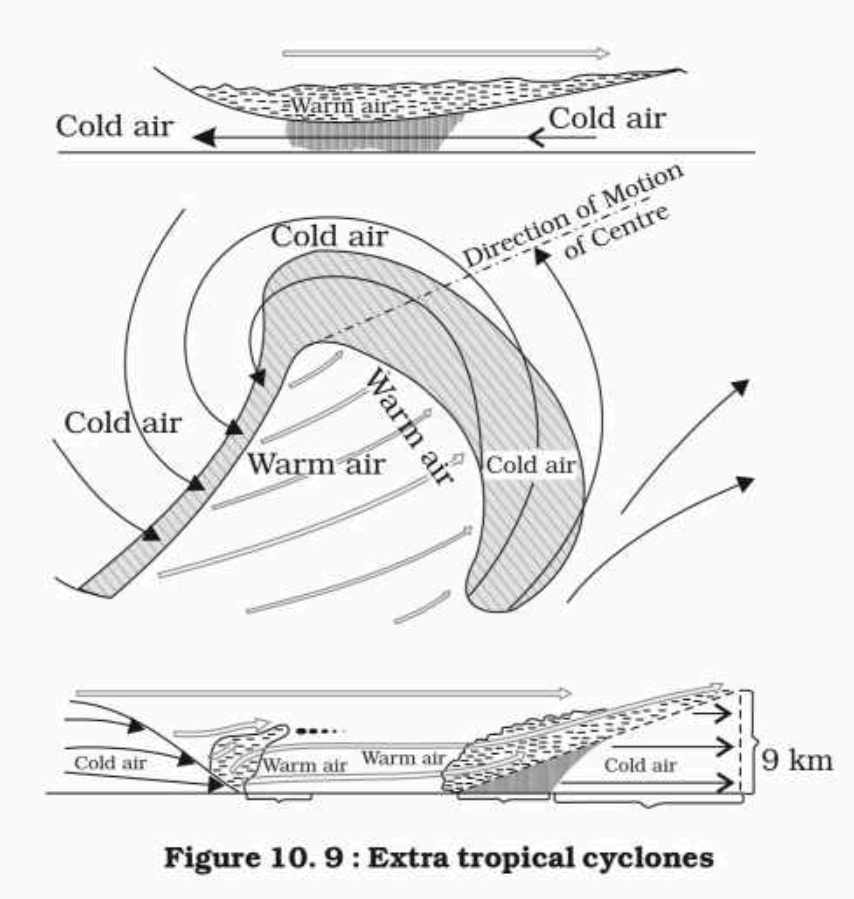
2. In the northern hemisphere, warm air blows from the south and cold air from the north of the front. When the pressure drops along the front, the warm air moves northwards and the cold air move southwards, setting in motion an anti-clockwise cyclonic circulation.
3. As a result of such motion, the warm air glides over the cold air and a sequence of clouds appear over the sky and cause precipitation. The cold front approaches the warm air from behind and pushes the warm air up. As a result, cumulus clouds develop along the cold front.
4. The cold front moves faster than the warm front ultimately overtaking the warm front. The warm air is completely lifted up and the front is occluded and the cyclone dissipates.
5. 

Figure 10. 9 : Extra tropical cyclones

8. **Difference between tropical and extra-tropical cyclones**
    1. Extra tropical cyclones have a clear frontal systems, which is absent in tropical cyclone.

2. Extra tropical cyclones originate over both land and sea. Whereas the tropical cyclones can originate only over the seas and on reaching the land they dissipate.
3. Tropical cyclones occur in tropical regions except between 5N-5S because of absence of coriolis force. Temperate cyclones form most frequently in regions of convergence of Air Masses. Generally they occur between 35-60 latitudes.
4. The extra tropical cyclones move from west to east but tropical cyclones move from east to west.
5. Tropical cyclone system moves under the influence of trade winds and attains velocities upto 300 kmph. Temperate cyclones rarely reach velocities more than 100 kmph.
6. Tropical cyclones die off as soon as they make landfall, as their source of energy is cut-off. Whereas, temperate cyclones bring longer duration weather changes that last from a few days to weeks.
7. Tropical cyclones cause heavy destruction in coastal areas due to their high intensity. Temperate cyclones are not as violent and are a constantly occurring phenomenon in high latitudes.
8. Tropical cyclones are common in Bay of Bengal, Caribbean Sea, Gulf of Mexico, South China Sea, East coast of Australia, etc. Temperate cyclones are common on western coast of Europe and east coast of USA.
9. Tropical cyclones form in summer and autumn, when the sea surface temperature is maximum. Temperate cyclones occur round the year, although more frequently in winters when the temperature contrast is greater.

9. **Tropical cyclones rotate counter-clockwise in the Northern Hemisphere**
    1. Earth's rotation sets up a coriolis force that pulls the winds to the right in the Northern Hemisphere (and to the left in the Southern Hemisphere).
    2. So when a low pressure starts to form north of the equator, the surface winds will flow inward trying to fill in the low and will be deflected to the right and a counter-clockwise rotation will be initiated. The opposite will occur south of the equator.
    3. This force is too tiny to affect rotation in water that is going down

the drains of sinks and toilets.

4. The rotation in those will be determined by the geometry of the container and the original motion of the water. Thus one can find both clockwise and counter clockwise flowing drains no matter what hemisphere you are located.

10. **Fewer cyclones over the Arabian Sea as compared to the Bay of Bengal**
    1. Cyclones that form over the Bay of Bengal are either those develop insitu over southeast Bay of Bengal and adjoining Andaman Sea or remnants of typhoons over Northwest Pacific and move across south China sea to Indian Seas.
    2. As the frequency of typhoons over Northwest Pacific is quite high (about 35 % of the global annual average), the Bay of Bengal also gets its increased quota.
    3. The cyclones over the Arabian Sea either originate insitu over southeast Arabian Sea or remnants of cyclones from the Bay of Bengal that move across south peninsula. As the majority of cyclones over the Bay of Bengal weaken over land after landfall, the frequency of migration into Arabian Sea is low.
    4. In addition to all the above the Arabian Sea is relatively colder than Bay of Bengal and hence inhibits the formation and intensification of the system.
11. **Very few tropical cyclones during southwest monsoon season**
    1. The southwest monsoon is characterised by the presence of strong westerly winds in the lower troposphere (below 5 km) and very strong easterly winds in the upper troposphere. This prevents upward movement of air.
    2. Also the potential zone for the development of cyclones shifts to North Bay of Bengal during southwest monsoon season. During this rainy season, the low pressure system upto the intensity of depressions form along the monsoon trough, which extends from northwest India to the north Bay of Bengal. The depression forming over this area crosses Orissa-West Bengal coast in a day or two. These systems have shorter oceanic stay which is also one of the reasons for their non-intensification into intense cyclones.
12. **Cyclone Fani**
    1. Fani originated quite close to the Equator, around latitude 2°, well

below the Sri Lankan landmass.

2. Tropical cyclones over the Bay of Bengal have a lifespan of 4-7 days, whereas Fani traveled long which allowed it to gather a lot of moisture and momentum, resulting in strong winds.
3. Fani was initially headed north-westwards, towards the Tamil Nadu coast but changed its course midway and moved northeast away from the coastline to reach Odisha. The recurve it has taken gave it more time over the sea and has ensured that it has gathered unusual strength.
4. Most cyclones that generate exclusively in the Bay of Bengal become relatively weaker by the time they reach the Indian landmass. Cyclone Fani made a landfall in Odisha with wind speeds of more than 170 km/h.
5. It started developing in April, a month that has historically seen very few cyclones that were categorised as extremely severe.

Knowledge of interior of the Earth

1. Most of our knowledge about the interior of the earth is largely based on estimates and inferences. Yet, a part of the information is obtained through direct observations and analysis of materials.
2. **Direct sources**
    1. The most easily available solid earth material is surface rock or the rocks from mining areas. Gold mines in South Africa are as deep as 3-4 km. Besides mining, scientists have taken up a number of projects to penetrate deeper depths to explore the conditions in the crustal portions. Scientists world over are working on two major projects such as "Deep Ocean Drilling Project" and "Integrated Ocean Drilling Project".
    2. Volcanic eruption forms another source of obtaining direct information.
3. **Indirect sources**
    1. We know through the mining activity that temperature and pressure increase with the increasing distance from the surface towards the interior in deeper depths. Knowing the total thickness of the earth, scientists have estimated the values of temperature,

pressure and the density of materials at different depths.

2. Another source of information are the meteors that at times reach the earth.
3. The other indirect source is gravitation. The gravity values differ according to the mass of material. The uneven distribution of mass of material within the earth influences this value.
4. Magnetic surveys also provide information about the distribution of magnetic materials in the crustal portion, and thus, provide information about the distribution of materials in this part.
5. Seismic activity is one of the most important sources of information about the interior of the earth.

Continental drift theory

1. There was a super continent Pangea and a mega ocean Panthalassa. Tethys sea divided the Pangaea into two huge landmasses known as Laurasia to the north and Gondwanaland to the south of Tethys. Drift started around 200 million years ago, and continents began to break up and drift away from one another. Wegener proposed tidal force as a reason behind the drift theory.
2. **Evidences**
    1. **Shorelines match:** South America and Africa seem to fit in with each other, especially, the bulge of Brazil fits into the Gulf of Guinea.
    2. **Ancient rocks:** Using radioactive dating technique it was found that ancient rocks of brazil coast match with those from western Africa.
    3. **Placer deposits:** The occurrence of rich deposits of gold in the Ghana coast and the absolute absence of source rock in the region. Source rock is present in Brazil.
    4. **Tilite:** A sedimentary rock formed out of deposits of glaciers. These are found to exist in Africa, Madagascar, Antarctica, Falkland island and Australia besides India.
    5. **Fossils:** Lemurs occur in India, Madagascar and Africa led some to consider a contiguous landmass Lemuria linking these three landmasses.

3. **Drawbacks of continental drift theory**
    1. Wegener failed to explain why the drift began only in Mesozoic era and not before.
    2. The theory doesn't take oceans into consideration.
    3. Proofs heavily depend on assumptions and are very general in nature.
    4. Forces like buoyancy, tidal currents and gravity are too weak to be able to move continents.
    5. Modern theories accept the existence of Pangaea and related landmasses but give a very different explanation to the causes of drift.

Sea floor spreading

1. Post World War I, there were more attempts made to understand the spread of continents and oceans. Two major milestone reached were the mapping of ocean floor and paleo magnetic studies of rocks, which supported Hess observation.
2. **Ocean floor configuration**
    1. Mapping of the ocean floor may be segmented into three major divisions based on the depth as well as the forms of relief. These divisions are continental margins, deep-sea basins and mid-ocean ridges.
    2. **Continental margins:** These form the transition between continental shores and deep-sea basins. They include continental shelf, continental slope, continental rise and deep-oceanic trenches.
    3. **Abyssal plains:** These are extensive plains that lie between the continental margins and mid-oceanic ridges.
    4. **Mid-Oceanic ridges:** This forms an inter connected chain of mountain system within the ocean. It is the longest mountain chain on the surface of the earth though submerged under the oceanic waters. The rift system at the crest is the zone of intense volcanic activity.
3. **Mapping of ocean floor gave various results**
    1. It revealed that the ocean floor is not just a vast plain but it is full

of relief with mountain ranges, deep trenches, etc.

2. It was realised that all along the mid oceanic ridges, volcanic eruptions are common and they bring huge amounts of lava to the surface in this area.
3. The ocean crust rocks are much younger than the continental rocks.
4. The sediments on the ocean floor are very thin. If the ocean floors were as old as the continent, ocean floor would have a complete sequence of sediments for a period of much longer duration.
5. Trenches have deep seated earthquake occurrences while in the mid-oceanic ridge areas, the quake foci have shallow depths.

4. **Sea floor spreading theory**
    1. The idea that the seafloor itself moves as it expands from a central axis was proposed by Harry Hess. Hess argued that constant eruptions at the crest of oceanic ridges cause the rupture of the oceanic crust and pushes the oceanic crust on either side. The ocean floor, thus spreads.
    2. He further maintained that the ocean floor that gets pushed aside sinks down at the oceanic trenches and gets consumed. On some (not all) continental margins this pushes continental plates to move. Sea floor spreading is the driving force behind continental drift.
5. **Convectional current theory**
    1. According to this theory, the intense heat generated by radioactive substances in the mantle seeks a path to escape, and gives rise to the formation of convention currents in the mantle.
    2. Wherever rising limbs of these currents meet, oceanic ridges are formed on the sea floor and wherever the failing limbs meet, trenches are formed.

Plate tectonics

1. The advent of Plate Tectonic Theory further supported the Sea floor spreading theory. A tectonic plate is a massive, irregularly shaped slab of solid rock. According to the theory of plate tectonics, the Earth's lithosphere is broken into distinct plates which are floating on

asthenosphere (upper mantle). Plates move horizontally over the asthenosphere as rigid units. It is not the continent that moves as believed by Wegener. Continents are part of a plate and what moves is the plate.

2. **Convergent boundaries**
    1. Places where plates crash together are called convergent boundaries. For example, if an oceanic plate has crashed into a continental plate, the edge of the continental plate folded into a huge mountain range, while the edge of the oceanic plate has formed a trench.
    2. Folding and faulting causes earthquakes. As the edge of the oceanic plate goes into Earth's hot interior, some of the rocks in it melts. The melted rock rises up through the continental plate, causing earthquakes on its way up, and forming volcanic eruptions where it finally reaches the surface.
    3. Ex: Oceanic Nazca Plate is crashing into the continent of South America. The crash formed the Andes mountains, the long string of volcanoes along the mountain crest, and the deep trench off the coast in the Pacific ocean.
    4. There are mainly three ways in which convergence can occur between an oceanic and continental plate, between two oceanic plates, and between two continental plates.
3. **Continent-continent convergence**
    1. In ocean-ocean convergence and continent-ocean convergence, atleast one of the plates is denser and hence the subduction zone is quite deep. At continental-continental convergence both of the continental crustal plates are too light to subduct into a trench.
    2. In continent-continent convergence, oceanic sediments are squeezed and upthrust between the plates and these squeezed sediments appear as fold mountains along the plate margins.
    3. Oceanic crust is only 5-30 km thick. But the continental crust is 50-70 km thick. Magma cannot penetrate this thick crust, so there are no volcanoes. Metamorphic rocks and earthquakes are common because of the stress the continental crust experiences.
    4. There were many rivers which were flowing into the Tethys Sea (older than Himalayas). Sediments brought by these rivers were deposited on the floor of the Tethys Sea. These sediments were

subjected to powerful compression due to the northward movement of the Indian Plate. Once the Indian plate started plunging below the Eurasian plate, these sediments were further folded and raised. And the folded sediments, after a lot of erosional activity, appear as present day Himalayas.

4. **Ocean-ocean convergence**
    1. In Ocean-Ocean convergence, a denser oceanic plate subduct below a less denser oceanic plate forming a trench along the boundary. As the ocean floor crust loaded with sediments subduct into the softer asthenosphere, the rocks on the continental side in the subduction zone become metamorphosed under high pressure and temperature.
    2. Constant volcanism above the subduction zone creates layers of rocks. As this process continues for millions of years, a volcanic landform is created which in some cases rises above the ocean waters.
    3. Such volcanic landforms all along the boundary form a chain of volcanic islands which are collectively called as Island Arcs (Indonesian Island Arc or Indonesian Archipelago, Philippine Island Arc, Japanese Island Arc).
    4. Orogenesis sets in motion the process of building continental crust by replacing oceanic crust. For example, new islands are born around Japan in every few years. After some million years Japan will be a single landmass because continental crust formation is constantly replacing the oceanic crust (more and more volcanism creates much bigger landform).
5. **Divergent boundaries**
    1. As the name itself suggests, in this kind of interaction, the plates diverge i.e move away from each other. Here, the basaltic magma erupts and moves apart. This leads to formation of Mid-oceanic ridges. Ex: Mid-Atlantic ridge. Oceanic ridges rise a kilometer or so above the ocean floor and form a global network tens of thousands of miles long.
    2. On continents, East African rift valley is the most important feature formed due to divergence of African and Somali plates. Where a divergent boundary crosses the ocean floor, the rift valley is much narrower, only a kilometer or less across, and it runs

along the top of a mid oceanic ridge. Earthquakes (shallow focus) are common along divergent edges.

6. **Transform boundaries**
    1. Formed when two plates move past each other. In this kind of interaction, two plates grind against each other and there is no creation or destruction of landform but only deformation of the existing landform. In oceans, transform faults are planes of separation generally perpendicular to the mid-oceanic ridges.
    2. San Andreas Fault along the western coast of USA is the best example for a trans-current edge on continents. Although transform boundaries are not marked by spectacular surface features, their sliding motion causes lots of earthquakes.
7. **Significance of plate tectonics**
    1. For the earth scientists, it is a fundamental principle for study.
    2. For physical geographers, this approach aids in interpretation of landforms.
    3. New minerals are thrown up from the core with the magmatic eruptions. Economically valuable minerals like copper and uranium are found more frequently near the plate boundaries.
    4. On the basis of present knowledge of crustal plate movement, the shape of landmasses in future can be guessed. For instance, if the present trends continue, North and South America will separate. A piece of land will separate from the east coast of Africa. Australia will move closer to Asia.
8. **Some minor plates**
    1. Cocos plate between Central America and Pacific plate.
    2. Nazca plate between South America and Pacific plate.
    3. Arabian plate covers mostly the Saudi Arabian landmass.
    4. Philippine plate is between the Asiatic and Pacific plate.
    5. Caroline plate is between the Philippine and Indian plate (North of New Guinea).
    6. Fuji plate covers North-east of Australia.
9. **Indian plate boundaries**
    1. The subduction zone along the Himalayas forms the northern plate boundary in the form of continent-continent convergence.
    2. In the east, it extends through Rakinyoma (Rakhine) Mountains of

Myanmar towards the island arc along the Java trench. The eastern margin is a spreading site lying to the east of Australia in the form of an oceanic ridge in SW Pacific.

3. The western margin follows Kirthar mountains of Pakistan. It further extends along the Makrana coast (Pakistan and Iranian coasts) and joins the spreading site from the Red Sea rift (Red Sea rift is formed due to divergence of Somali plate and Arabian plate) southeastward along the Chagos Archipelago (formed due to hotspot volcanism).
4. The boundary between India and the Antarctic plate is also marked by oceanic ridge (divergent boundary) running in roughly W-E direction and merging into the spreading site, a little south of New Zealand.
5. The two major plates (Indian-Australian plate and eurasian plate) were separated by the Tethys sea and the Tibetan block was closer to the Asiatic landmass. During the movement of the Indian plate towards the Asiatic plate, a major event that occurred was the outpouring of lava and formation of the Deccan traps near Reunion Island.

10. **Why no island forms over divergent boundary**
    1. Basaltic magma flows out along the divergent edge. Basaltic magma has less silica which has less viscosity. So, it flows over a large distance and hence causes sea floor spreading but not volcanic islands.
    2. On the other hand, along convergent boundary, acidic magma flows out. Acidic magma has more silica content and hence higher viscosity. So, it doesn't move quick and also solidifies quickly. This helps in building layer over layer in a narrow region, so huge volcanic mountain.

Rocks

1. **Rock cycle**
    1. Rocks do not remain in their original form for long but may undergo transformation. Rock cycle is a continuous process through which old rocks are transformed into new ones.
    2. Igneous rocks can be changed into metamorphic rocks. The

fragments derived out of igneous and metamorphic rocks form into sedimentary rocks. Sedimentary rocks themselves can turn into fragments and may be source for formation of sedimentary rocks. The crustal rocks once formed may be carried down into the mantle through subduction process and may turn into molten magma.

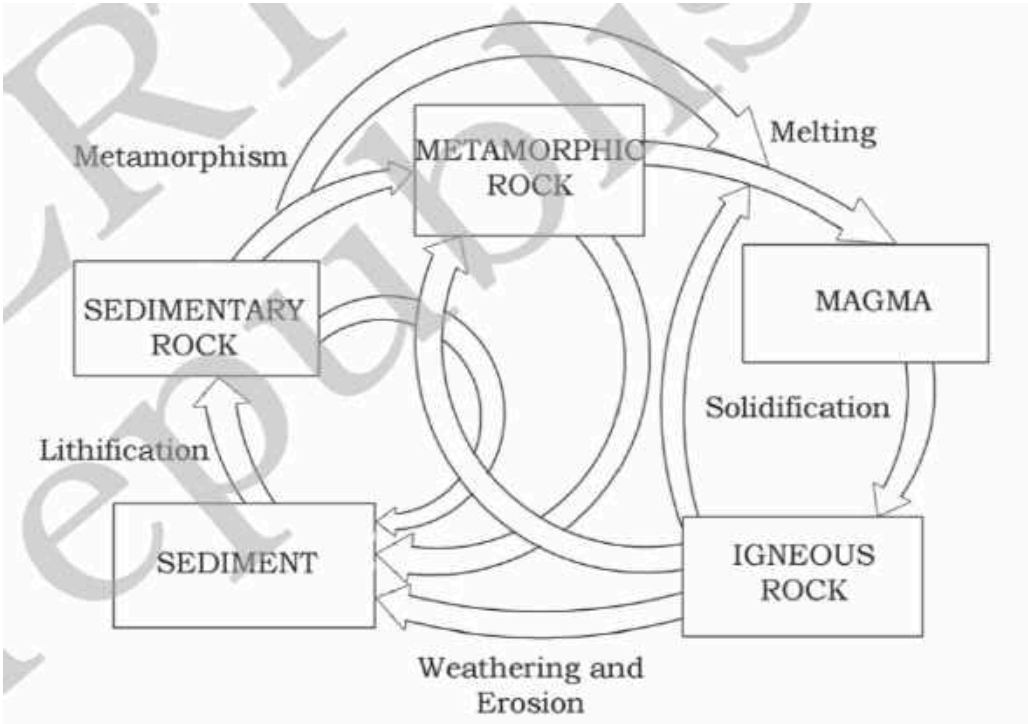


Fig 5.1 : Rock Cycle

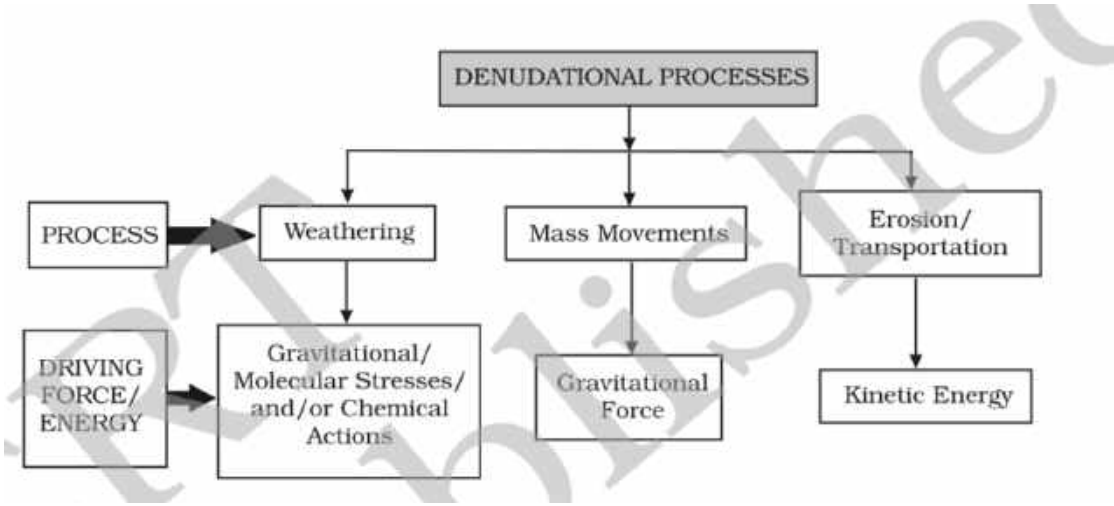
2. **Four major mineral belts in India**
    1. **The North-eastern plateau region:** This belt covers Chotanagpur, Orissa, West Bengal and parts of Chhattisgarh. It has variety of minerals viz. iron ore, coal, manganese, bauxite, mica.
    2. **The South-western plateau region:** This belt extends over Karnataka, Goa, Tamil Nadu uplands and Kerala. This belt is rich in ferrous metals and bauxite. It contains high grade iron ore, manganese and limestone. This belt does not have as diversified mineral deposits as the north-eastern belt. Kerala has deposits of thorium, bauxite. Goa has iron ore deposits.
    3. **North-western region:** This belt extends along Aravali in Rajasthan and part of Gujarat and minerals are associated with

Dharwar system of rocks. Copper, zinc have been major minerals. Rajasthan is rich in building stones i.e. sandstone, granite, marble. Dolomite and limestone provide raw materials for cement industry. Gujarat is known for its petroleum deposits. They also have rich sources of salt.

4. **Himalayan belt:** The Himalayan belt is another mineral belt where copper, lead, zinc, cobalt and tungsten are known to occur. They occur on both the eastern and western parts. Assam valley has mineral oil deposits. Besides oil resources are also found in off-shore areas near Mumbai coast (Mumbai High).
5. The vast alluvial plain tract of north India is devoid of minerals of economic use. Over 97 percent of coal reserves occur in the valleys of Damodar, Sone, Mahanadi and Godavari.

Geomorphic processes

1. The earth's surface is being continuously subjected to by external forces originating within the earth's atmosphere and by internal forces from within the earth. The external forces are known as exogenic forces and the internal forces are known as endogenic forces. The endogenic and exogenic forces causing physical stresses and changes in the configuration of the surface of the earth are known as geomorphic processes.
2. Weathering, mass wasting, erosion and deposition are exogenic geomorphic processes. The actions of exogenic forces result in wearing down (degradation) of relief and filling up (aggradation) of depressions, on the earth's surface. Geomorphic agents like water remove the materials and transport them over slopes and deposit them at lower level. Diastrophism and volcanism are endogenic geomorphic processes.

3. 

4. **Diastrophism**
    1. All that processes that move, elevate or build up portions of the earth's crust come under diastrophism. They include: (i) orogenic processes involving mountain building through severe folding; (ii) epeirogenic processes involving uplift or warping of large parts of the earth's crust; (iii) earthquakes involving local relatively minor movements; (iv) plate tectonics involving horizontal movements of crustal plates.
5. **Weathering**
    1. It is defined as mechanical disintegration and chemical decomposition of rocks through the actions of various elements of weather and climate. As very little or no motion of materials takes place in weathering, it is an in-situ or on-site process.
    2. The alternate expansion and contraction of the outer surface sometimes results in its peeling off in the form of concentric shells. It is called exfoliation.
    3. Chemical weathering includes carbonation, hydration, oxidation. They act on the rocks to decompose, dissolve or reduce through chemical reactions.
    4. Physical weathering processes depend on some applied forces. They gravitational forces, load and shearing stress, expansion forces due to temperature changes, water pressures controlled by wetting and drying cycles.
    5. With rise in temperature, every mineral expands and contracts. This process is most effective in dry climates and high elevations where diurnal temperature changes are drastic.

6. Frost weathering occurs due to growth of ice within pores and cracks of rocks during repeated cycles of freezing and melting. This process is most effective at high elevations in mid-latitudes.
7. Salts in rocks expand due to thermal action, hydration and crystallisation.
8. Biological weathering by burrowing by earthworms, termites, rodents etc., help in exposing the new surfaces to chemical attack and assists in the penetration of moisture and air.
9. Humans by disturbing vegetation, ploughing and cultivating soils, also help in mixing and creating new contacts between air, water and minerals in the earth materials. Algae utilise mineral nutrients for growth and help in concentration of iron and manganese oxides. Plant roots exert a tremendous pressure on the Earth materials mechanically breaking them apart.

6. **Uses of weathering**

1. Erosion cannot be significant if the rocks are not weathered. That means, weathering aids mass wasting, erosion and reduction of relief and changes in landforms are a consequence of erosion.
2. Weathering helps in increasing concentration of remaining valuable materials. Without such a weathering, it may not be economically viable to exploit, process and refine. This is what is called enrichment.
3. Weathering processes are responsible for breaking down the rocks into smaller fragments and preparing the way for formation of regolith and soils.
4. Biomes and biodiversity is basically a result of forests. Forests depend upon the depth of weathering mantles.
5. As weathering breaks rocks into their mineral components, it also creates various new compounds.

Soils

1. Soil is the top layer of earth surface made up of organic and inorganic materials. Soil erosion is movement of soil from one place to another due to wind, water or some other erosion agents. According to a 2015 report of Indian institute of remote sensing, 147 million hectares of land

is eroded in India. Every year India loses 68 billion rupees due to soil erosion.

2. **Factors controlling formation of soils**
    1. **Parent material:** When soils are very young they show strong links with the type of parent rock. Also, in case of some limestone areas soils will show clear relation with the parent rock. Parent material is a passive factor in soil formation.
    2. **Topography:** It decides amount of exposure of a surface to sunlight and to drainage. Soils will be thin on steep slopes and thick over flat upland areas. In middle latitudes, North facing slopes with cool, moist conditions have different soils than South facing soils.
    3. **Precipitation:** Precipitation gives soil moisture content which makes the chemical and biological activities possible which change composition of soil.
    4. **Temperature:** Chemical activity is increased in higher temperatures. That is why, tropical soils show deeper profiles and in the frozen tundra regions soils contain largely mechanically broken materials. Hot summer and low rainfall leads to black soil in TN irrespective of parent rock.
    5. **Biological activity:** Humus accumulates in cold climates as bacterial growth is slow. In humid tropical, leaching is intense leaving very low humus content in the soil. Further, bacteria (Rhizobium) fix gaseous nitrogen. Animals like ants, termites, earthworms, rodents rework the soil up and down.
    6. **Time:** Determines maturation of soils and profile development. Soils developing from recently deposited alluvium or glacial till are considered young and they exhibit no horizons or only poorly developed horizons.
3. **Soil profile**
    1. **Horizon A:** It is the topmost zone, where organic materials have got incorporated with the mineral matter, nutrients and water which are necessary for the growth of plants.
    2. **Horizon B:** It is a transition zone between the horizon A and horizon C, and contains matter derived from below as well as from above. It has some organic matter in it, although the mineral matter is noticeably weathered.

3. **Horizon C:** It is composed of the loose parent material. This layer is the first stage in the soil formation process and eventually forms the above two layers.

4. **Different types of soils**
    1. Alluvial soil
    2. Black soil -- This type of soil is typical of the Deccan trap.
    3. Arid soil -- In areas of high temperature and accelerated evaporation.
    4. Red soils -- In areas of low rainfall in the eastern and southern part of the Deccan plateau.
    5. Laterite soil -- Areas of high temperature and high rainfall. Red laterite soils in Tamil Nadu, Andhra Pradesh and Kerala are more suitable for crops like cashew nut.
    6. Saline soils -- Occur in arid and semi-arid regions, and in water-logged and swampy areas.
5. Desertification is land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities.
6. **Reasons for desertification**
    1. **Mining:** The dust from the mining areas settles and retards water infiltration. Jharkhand, Chhattisgarh and Orissa.
    2. **Overgrazing:** In states like Gujarat, Rajasthan, Madhya Pradesh and Maharashtra.
    3. **Defforestation:** Shifting cultivation in North-eastern states.
    4. **Over-irrigation:** In the states of Punjab, Haryana, western Uttar Pradesh, over irrigation is responsible for land degradation. Due to water logging leading to increase in salinity and alkalinity in the soil.
    5. **Industrial effluents:** Industrial effluents as waste have become a major source of land and water pollution in many parts of the country.
    6. **Urbanisation and land development projects:** These put huge pressure on land which is expected to grow further in future.
7. **Steps to combat desertification**
    1. The village of Sukhomajhri and the district of Jhabua have shown that it is possible to reverse land degradation. Tree density in

Sukhomajhri increased from 13 per hectare in 1976 to 1,272 per hectare in 1992.

2. India being a signatory to UNCCD has taken many steps to combat desertification such as National Action Programme to Combat Desertification, Integrated Watershed Management Programme (IWMP), National Afforestation Programme, Fodder and Feed Development Scheme etc. However, the gradual increment of desertification shows that steps taken by the government have not been very effective.

8. **Effects of soil erosion**
    1. Hike in food prices.
    2. Decrease in farmer's income.
    3. Agriculture production is reduced. It will increase hunger and poverty, so one of the SDG to be achieved by 2030 will be missed. It will also increase unemployment, etc.
    4. Widening fiscal deficit due to loan waivers, etc.
    5. Large scale soil erosion may lead to ravine topography like Chambal river and land becomes waste land.
    6. Due to soil erosion top layer organic matter is lost so water holding capacity of soil is reduced. It may lead to reduced water table.
9. **Ways to address soil erosion**
    1. **Mulching:** The bare ground between plants is covered with a layer of organic matter like straw. It helps to retain soil moisture.
    2. **Careful tilling:** Since tilling destroys the top soil.
    3. **Contour barriers, Contour ploughing, Rock dams and Terrace farming:** They can reduce surface run-off and soil erosion.
    4. **Inter-cropping:** Different crops are grown in alternate rows and are sown at different times to protect the soil from rain wash.
    5. **Shelter belts:** In the coastal and dry regions, rows of trees are planted to check the wind movement to protect soil cover. These shelter belts have contributed significantly to the stabilisation of sand dunes and in stabilising the desert in western India.
    6. **Strip farming:** Large fields can be divided into strips. Strips of grass are left to grow between the crops. This breaks up the force of the wind. This method is known as strip cropping.

7. **Afforestation:** Tree roots bind with the soil which in turn reduces soil erosion.
8. **Check over-grazing:** Over-grazing normally leads to loss of top soil. This will help in preventing soil erosion.
9. **Mangrove cover:** Coastal regions.
10. **Irrigation technique:** Micro-irrigation methods like sprinkling can reduce soil erosion.

10. According to report of national centre for coastal research, India lost one – third of its coastline due to soil erosion. Various government initiative like Vanotsva, soil health card are steps in right direction to save the gift of nature.

Landslides

1. The collapse of mass of Earth or rock from a high cliff is called as land slide. Besides the Himalayas, the North-eastern hill ranges, the Western Ghats, the Nilgiris, the Eastern Ghats and the Vindhyas are affected by Land slides. In India, debris avalanche and landslides occur very frequently in the Himalayas.
2. **Why Himalayas are prone**
    1. **Natural reasons**
        1. The Himalayas are tectonically active. Drifting of Indian plate causes frequent earth quakes and resultant instability.
        2. They are mostly made up of sedimentary rocks and unconsolidated and semi-consolidated deposits.
        3. The slopes are very steep.
        4. Heavy snow fall in winter and melting in summer induces debris flow, which is carried in large quantity by numerous streams and rivers.
    2. **Anthropogenic**
        1. Shifting cultivation in North-east.
        2. Dams.
        3. Tourism.
        4. Grazing in highlands.
3. **Less frequent in western ghats**
    1. Less occurrence of earth quakes because they’re on more stable

part of Indian plate.

2. While steep slope on western side with high rainfall creates ideal condition for landslide but gentle eastern slope with low rainfall and rivers in senile stage, does not.

4. **Mitigation**

    1. The problem needs to be tackled for mitigation and management for which hazard zones have to be identified and specific slides to be stabilised and managed in addition to monitoring and early warning systems to be placed at selected sites.
    2. It is always advisable to adopt area specific measures to deal with landslides. Hazard mapping should be done to locate areas commonly prone to landslides.
    3. Restriction on the construction and other developmental activities such as roads and dams, limiting agriculture to valleys and areas with moderate slopes, and control on the development of large settlements in the high vulnerability zones, should be enforced.
    4. Promote large scale afforestation programmes and construction of bunds to reduce the flow of water.
    5. Terrace farming should be encouraged in the northeastern hill states replacing Jhumming or shifting cultivation.
    6. Retaining walls can be built of mountain slopes to stop land from slipping.

Insolation and Temperature

1. At 45 latitude, insolation is nearly 75% of that of equator. At 66.5 latitude it is 50% and at poles it is 40% of that of equator. Maximum insolation is received over the subtropical deserts, where the cloudiness is the least. Equator receives comparatively less insolation than the tropics.
2. **Factors causing variation in insolation**
    1. The rotation of earth on its axis. This causes variation of insolation received in day and night.
    2. The angle of inclination of the sun's rays. More inclination leads to less amount of insolation. The slant rays are required to pass through greater depth of the atmosphere resulting in more

absorption, scattering and diffusion.

3. The length of the day.
4. The transparency of the atmosphere. Very small suspended particles in the troposphere scatter visible spectrum both to the space and towards the earth surface.
5. The configuration of land in terms of its aspect.

3. **Heat budget of the Earth**
    1. The earth as a whole does not accumulate or loose heat.
    2. If the insolation received at the top of the atmosphere is 100 percent. Roughly 35 units are reflected back to space even before reaching the earth's surface due to reflection, scattering and absorption. Of these, 27 units are reflected back from the top of the clouds and 2 units from the snow and ice-covered areas of the earth.
    3. The remaining 65 units are absorbed, 14 units within the atmosphere and 51 units by the earth's surface. The earth radiates back 51 units in the form of terrestrial radiation. Of these, 17 units are radiated to space directly and the remaining 34 units are absorbed by the atmosphere.
    4. 48 units absorbed by the atmosphere are radiated back into space. This is termed the heat budget or heat balance of the earth.
4. **Factors controlling temperature distribution**
    1. **Latitude:** Insolation varies according to the latitude hence the temperature also varies accordingly.
    2. **Altitude:** The temperature generally decreases with a rate of 6.5C per km with increasing height.
    3. **Distance from the sea:** Compared to land, the sea gets heated slowly and loses heat slowly. Sea and land breezes moderate the temperature of coastal areas.
    4. **Air-mass and ocean currents:** Warm air-masses increase temperatures.

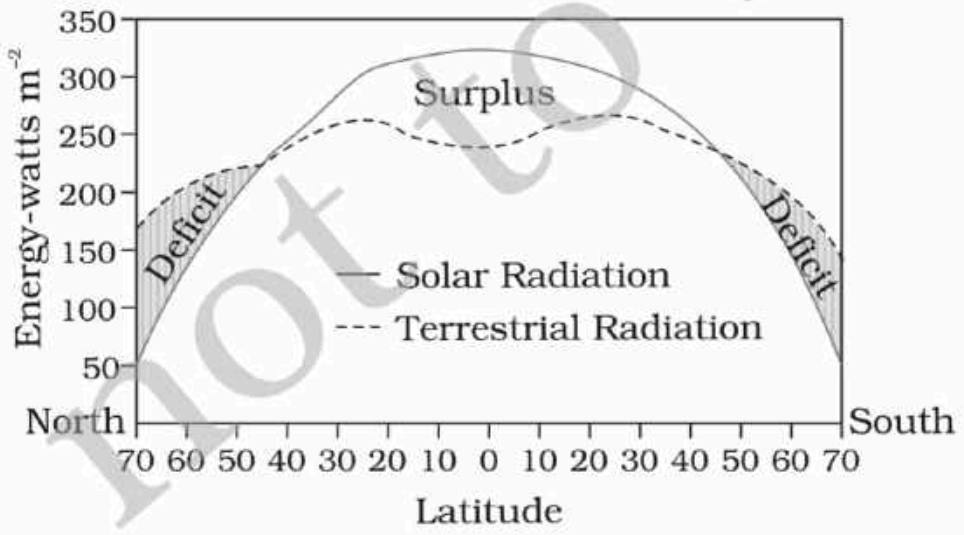


Figure 9.3 : Latitudinal variation in net radiation balance

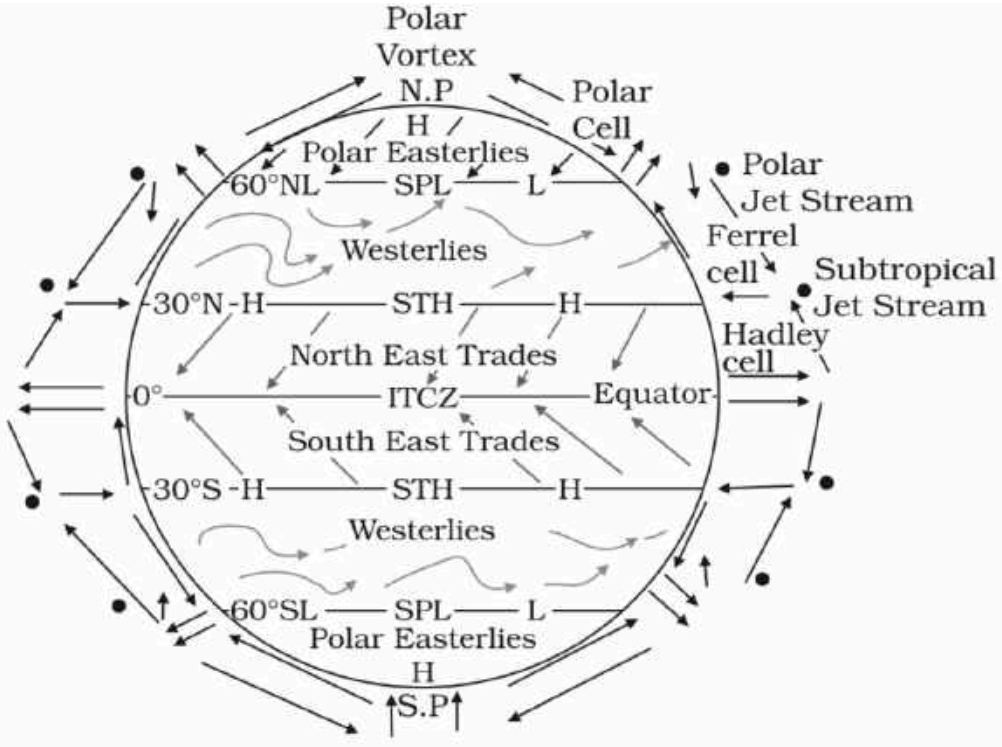


Figure 10. 6 : Simplified general circulation of the atmosphere

Temperature inversion

Ideal Conditions for Temperature Inversion:

- Long winter nights, so that the loss of heat by terrestrial radiation from the ground surface during night is greater than the incoming radiation.
- Clear skies, which allow unobstructed escape of radiation.
- Calm and stable air, so that there is no vertical mixing at lower levels.
- Slow movement of air, so that there is no transfer and mixing of heat in the lower layers of the atmosphere.
- Snow-covered ground surface, so that there is maximum reflection of incoming solar radiation.

Types of Temperature Inversion:

- **Ground Inversion (Surface Temperature Inversion):** A ground inversion develops when air is cooled by contact with a colder surface until it becomes cooler than the overlying atmosphere.
- **Subsidence Inversion (Upper Surface Temperature Inversion):** It develops when a widespread layer of air descends, gets compressed and heated by the resulting increase in atmospheric pressure, and as a result the lapse rate of temperature is reduced. Anti-cyclonic conditions
- **Frontal Inversion (Advectional type of Temperature Inversion):** Occurs when a cold air mass undercuts a warm air mass and lifts it.
- **Temperature Inversion in Intermontane Valley (Air Drainage Type of Inversion):** Sometimes along a sloping surface, the surface radiates heat back to space rapidly and cools down at a faster rate than the upper layers. The lower cold layers get condensed and become heavy and the sloping surface underneath makes them move towards the bottom while the upper layers are relatively warmer.

1. **Impact of temperature inversion on air quality**
    1. Absolute stability condition with low chances of rain.
    2. Hygroscopic nucleic cannot move vertically. This causes lower temperature which ultimately results into foggy conditions.
    3. Pollutants increase in air which makes air unhealthy for breathing like PM 2.5, PM10, CO2.
    4. Poor visibility increases road accident, delay in transportation and flights.

Weather and Climate

1. Weather indicates changes in temperature and humidity on a short term basis, usually hours, days. Whereas climate gives changes in average temperature and humidity levels over medium to long term basis. Ex: Season wise, Year wise.
2. **Salient features of Indian climate**

1. Moderate temperature and rainfall in majority parts of India. Unlike extremes in deserts or polar regions. Himalayas presence was the main reason for Northern India having moderate climate.
2. Seasonal reversal of winds (monsoons) due to upward and downward motion of the ITCZ and associated pressure changes.
3. Seasonal and variable rainfall owing to the variations in the wind pattern (NE-trade winds) with respect to the Pacific oscillation (ENSO).
4. High pressure vs low pressure over the Indian subcontinent owing to the differential heating of the land and oceans.
5. Huge variation and diversity along the entire E-W and N-S stretch. For example, highest rainfall in Mawsynram (Meghalaya) vs Thar desert (one of the hottest and driest regions of the world), tropical evergreen forests on the Andaman to conifers in the higher regions of Himalayas.
6. Prone to the natural calamities like cyclones along the eastern borders like Odisha and TN, earthquake in Gujarat and upper reaches of Himalayas, floods in the UK, HP states and others.

3. **Climatic regions around the world**
    1. **Equatorial rain forest:** Mostly between 5 N and 5 S of Equator. Found in the lowlands of the Amazon, the Congo, Malaysia and the East Indies. High temperature and abundant rainfall. Plantation crops -- Malaysia and Indonesia are the leading producers of rubber
    2. **Monsoon climate:** Occur within 5 to 30 N and S. Indian sub-continent, Burma, Thailand and Northern Australia. It has 3 distinct seasons.
    3. **Savannah:** It is confined within the tropics and is best developed in Sudan, hence its name the Sudan climate.
    4. **Steppe climate:** They lie in the interiors of the continents and in westerly belt. Climate is continental with extremes of temperature. In mid-latitudes or temperate region.
    5. **Mediterranean climate:** Entirely confined to the western portion of continental masses, between 30° and 45° north and south of the equator. The basic cause of this type of climate is the shifting of the wind belts. Central Chile, California (San Francisco), the south-western tip of Africa (cape town) and southern Australia.
    6. **China type:** Uniform distribution of rainfall throughout the year.

7. **British type:** They are regions of frontal cyclonic activity (temperate cyclones). This type of climate is typical to Britain. Rainfall occurs all the year round.
8. **Taiga:** Annual range of temperature of the Siberian climate is the greatest. Canada, Scandinavian Europe and Southern Russian.

Air Masses

1. It is defined as a large body of air having little horizontal variation in temperature and moisture. When the air remains over a homogenous area for a sufficiently longer time, it acquires the characteristics of the area. The homogenous regions can be the vast ocean surface or vast plains. The homogenous surfaces are called the source regions. The necessary conditions for development of an airmass are large scale subsidence of air over the source region. The subsiding air acquires the properties of the source region.
2. They are classified based on the source region and air mass modification. Thus there can be tropical maritime air mass, tropical continental air mass, polar maritime air mass, polar continental air mass. When the air mass is heated or cooled from the surface below, it is called a thermodynamic change.
3. **How it affects climate**
   - **Change in local weather:** An air mass on the move begins to transform as it passes over new landscapes, while at the same time retaining enough of its original conditions to alter local weather. For example, a cP air mass move south in winters and brings frigid temperatures to the central United States. While dry in its source region, such an air mass often picks up substantial moisture during an early-winter transit of the Great Lakes, allowing it to dump 'lake effect snow' on leeward coasts.
   - **Cyclones and Anti-cyclones:** collision of two air masses leads to formation of fronts. For instance, when polar and tropical air masses merge in the mid-latitudes, prevailing westerly winds funnel along alternating low- and high-pressure centers causing cyclones and anticyclones, respectively.
   - **Rainfall:** It also causes precipitation and temperature change in many regions. Maritime-tropical air sourced over warm waters of the Atlantic Ocean, Caribbean Sea and Gulf of Mexico is the main contributor of precipitation for much of North America east of the Rocky Mountains.
   - **Cooling effect:** Maritime air masses also contribute to a moderating climatic influence on coastal temperatures, as oceans heat up and cool down more slowly and less dramatically than landmasses.

   1. When a warm air moves over a cold surface, temperature inversion results which inhibits further vertical cooling. If a cold air mass moves over a warm surface, convectional currents are formed. This leads to formation of vertical clouds (cumulus) and air turbulence.

4. **Fronts**
    1. When two different air masses meet, the boundary zone between them is called a front. The process of formation of the fronts is known as frontogenesis. The fronts occur in middle latitudes and they do not occur in tropical latitudes.
    2. They are characterised by steep gradient in temperature and pressure. They bring abrupt changes in temperature and cause the air to rise to form clouds and cause precipitation.
    3. There can be four types of fronts such as Warm front, Cold front, Stationary front and Occluded. When warm air mass rises
    4. above a cold air mass it is warm front. When the cold air mass forces its way under the warm air mass it is the cold front.
    5. If an air mass is fully lifted above the land surface, it is called the occluded front. When the front remains stationary, it is called a stationary front.

5.

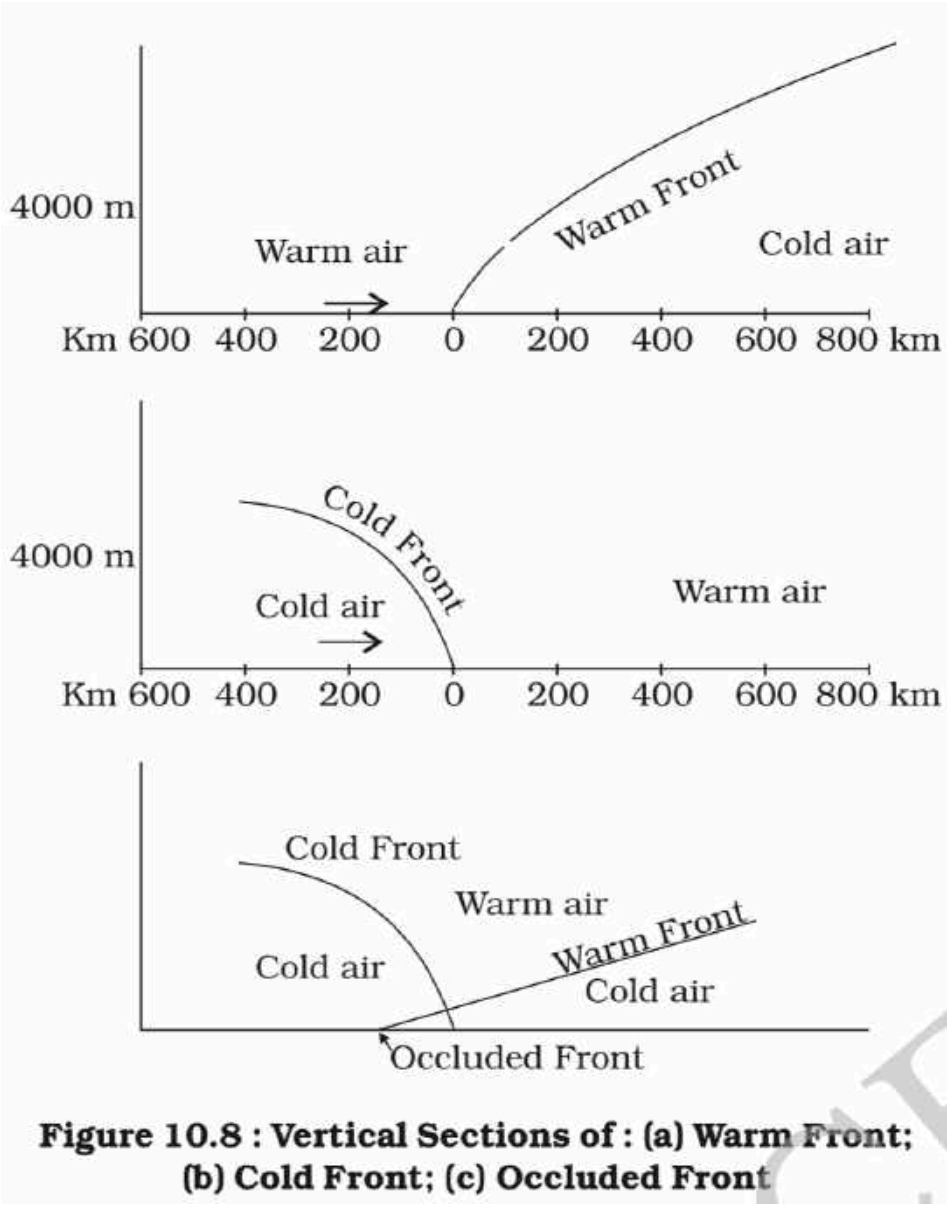


Figure 10.8 : Vertical Sections of : (a) Warm Front; (b) Cold Front; (c) Occluded Front

Jet streams

Answer: Jet streams are the swift and narrow westerly flowing winds in the upper troposphere, which help to complete the global circulation. They are found near the junction of the Ferrell, Hadley, and polar cells. They are having velocity in the range of 100km/hr to 900km/hr.

A jet stream develops where air masses of differing temperatures meet. Therefore, the surface temperatures determine where the jet stream will form. The greater the difference in temperature, the faster the wind velocity inside the jet stream.

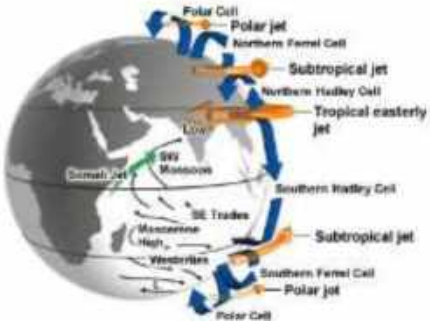
A variety of jet streams exist in the atmosphere, both permanent and temporary.

Permanent Jet Streams

- **Polar Jet Streams** -The polar front jet is produced by a temperature difference and is closely related to the polar front. It has a more variable position than the sub-tropical jet. In summer, its position shifts towards the poles and in winter towards the equator. The jet is strong and continuous in winter.
- **Subtropical Jet Streams** -The sub-tropical jet stream is produced by the earth's rotation (Coriolis force) and temperature contrast between tropical and sub – tropical regions.It exists all year in the southern hemisphere. However, it is intermittent in the northern hemisphere during summer when it migrates north.

Temporary Jet Streams

They are narrow winds with speeds more than 94 kph in the upper, middle and sometimes in lower troposphere. They are few. Important ones are Somali Jet and The African Easterly jet or Tropical Easterly Jet. These two jet streams play an important



role in the formation and progression of Indian Monsoons.

- **The African Easterly jet or Tropical Easterly Jet** - The Tropical Easterly Jet is a unique and dominant feature of the northern hemispheric summer over southern Asia and northern Africa. The TEJ is found near between 5° and 20°N. It is fairly persistent in its position, direction, and intensity from June through the beginning of October.

Monsoon

1. **Key players in Monsoon**
    1. The differential heating and cooling of land and water.
    2. Northward shifting of the ITCZ which subsequently leads to Northward shifting of the westerly jet.

3. The presence of the high pressure area, east of Madagascar, approximately at 20 S over the Indian ocean. The intensity and position of this high pressure area affects the Indian monsoon.
4. The Tibetan plateau gets intensely heated during summer, which results in strong vertical air currents.
5. Tropical Easterly Jet Stream which is associated closely with the burst of Monsoon.
6. El-Nino and La-Nina.

2. **Causes**
    1. **Northward shifting of ITCZ:** Such a shift in June causes low pressure at Tibetan plateau. Tropical easterly jets move towards the Mascarene high and push moist monsoon winds from Mascarene high to Tibetan plateau.
    2. **Somali Jet stream in summer:** Somali Jet streams appear in summer and intensify the Somali ocean current. This pushes monsoon winds towards India.
    3. **Absence of westerly Jet in summer:** In winters, Sub Tropical Westerly Jet (STWJ) gets bifurcated and its one strand causes high pressure in India. In summers, entire STWJ is beyond Himalayas and hence low pressure is maintained over India.
    4. **Indian Ocean dipole:** The Indian ocean dipole between Western Pacific Pool and Mascarene High pushes monsoon winds towards India. In an El Nino year, this push is weak whereas in La Nina year it is strong.
3. **Monsoon winds of the Arabian Sea**
    1. One branch is obstructed by western ghats.
    2. Second branch strikes coast of northern Mumbai and cause rainfall in central India as it moves. The chotanagpur plateau gets 15 cm rainfall from this part of the branch. Thereafter, they enter the Ganga plains and mingle with the Bay of Bengal branch.
    3. A third branch of this monsoon wind strikes the Saurashtra Peninsula and the Kachchh. It then passes over west Rajasthan causing only a scanty rainfall.
    4. In Punjab and Haryana, 3rd branch joins the Bay of Bengal branch. These two branches, reinforced by each other, cause rains in the western Himalayas.
4. **Monsoon winds of the Bay of Bengal**

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

5. **The retreating southwest monsoon**
    1. Season is marked by clear skies and rise in temperature. The land is still moist. Owing to the conditions of high temperature and humidity, the weather becomes rather oppressive. This is commonly known as the October heat.
    2. The weather in the retreating monsoon is dry in north India but it is associated with rain in the eastern part of the Peninsula. Here, October and November are the rainiest months of the year.
    3. The widespread rain in this season is associated with the passage of cyclonic depressions which originate over the Andaman Sea and manage to cross the eastern coast of the southern Peninsula.
    4. Northeast monsoon rains over Tamil Nadu, Kerala and adjoining areas of south Andhra Pradesh and Karnataka.
6. **For a normal monsoon season**
    1. The Peruvian coast has relatively high pressure than the areas near north Australia and South-East Asia.The Indian Ocean is slightly warmer than the adjoining oceans and thus the pressure is relatively low. This is why the moisture winds move from near the west pacific to the Indian Ocean and from there on to the lands.
    2. The pressure on heated Indian land is much lower than that on the Indian Ocean. This facilitates the movement of monsoon winds from the sea to the Indian land without any significant diversion.
7. **El Nino**
    1. Off the coast of Peru there is normally cool surface water because

of the cold Peruvian current. But El Nino makes it go warm. When the water becomes warm, the trade winds, which otherwise flow from East to west, either reverse their direction or get lost. This causes heavy rains in Peruvian desert during El Nino years.

2. On the other hand, the waters cool off in western pacific and Asia. This leads to rise in surface pressure over the Indian Ocean, Indonesia, and Australia. This robs the Indian subcontinent of its share in the Monsoon rains. The greater the temperature and pressure difference, the greater would be the shortage in the rainfall in India. The arid west coast of South America receives heavy rainfall, drought occurs in Australia and sometimes in India and floods in China.

8. **La-Nina**
    1. La Niña, anti-El Niño or simply a cold event is the cooling of water in the Eastern Pacific Ocean. The water in Eastern Pacific, which is otherwise cool gets colder than normal. This causes strengthening of monsoons in India.
    2. This has so far caused the following major effects such as Drought in Ecuador and Peru. Low temperature, high pressure in Eastern Pacific, heavy floods in Australia, high temperature in western Pacific, Indian ocean, off coast Somalia and good rains in India. Drought in East Africa.
9. **Spatial distribution of rainfall in India**
    1. **Areas of high rainfall (Over 200cm):** North-east, Wind ward side of Western Ghats and in some Himalayan regions.
    2. **Areas of medium rainfall (100-200 cm):** In the southern parts of Gujarat, east Tamil Nadu, north-eastern Peninsula covering Orissa, Jharkhand, Bihar, eastern Madhya Pradesh, northern Ganga plain along the sub-Himalayas and the Cachar Valley.
    3. **Areas of low Rainfall (50-100 cm):** Most of the regions having the effect of continentality like Western Uttar Pradesh, Delhi, Haryana, Punjab, Jammu and Kashmir, eastern Rajasthan, Gujarat and Deccan Plateau.
    4. **Areas of inadequate Rainfall (Less than 50 cm):** These are arid regions lying in the interior parts of the Peninsula, especially in Andhra Pradesh, Karnataka and Maharashtra, Ladakh and most of western Rajasthan.

10. **World distribution of rainfall**

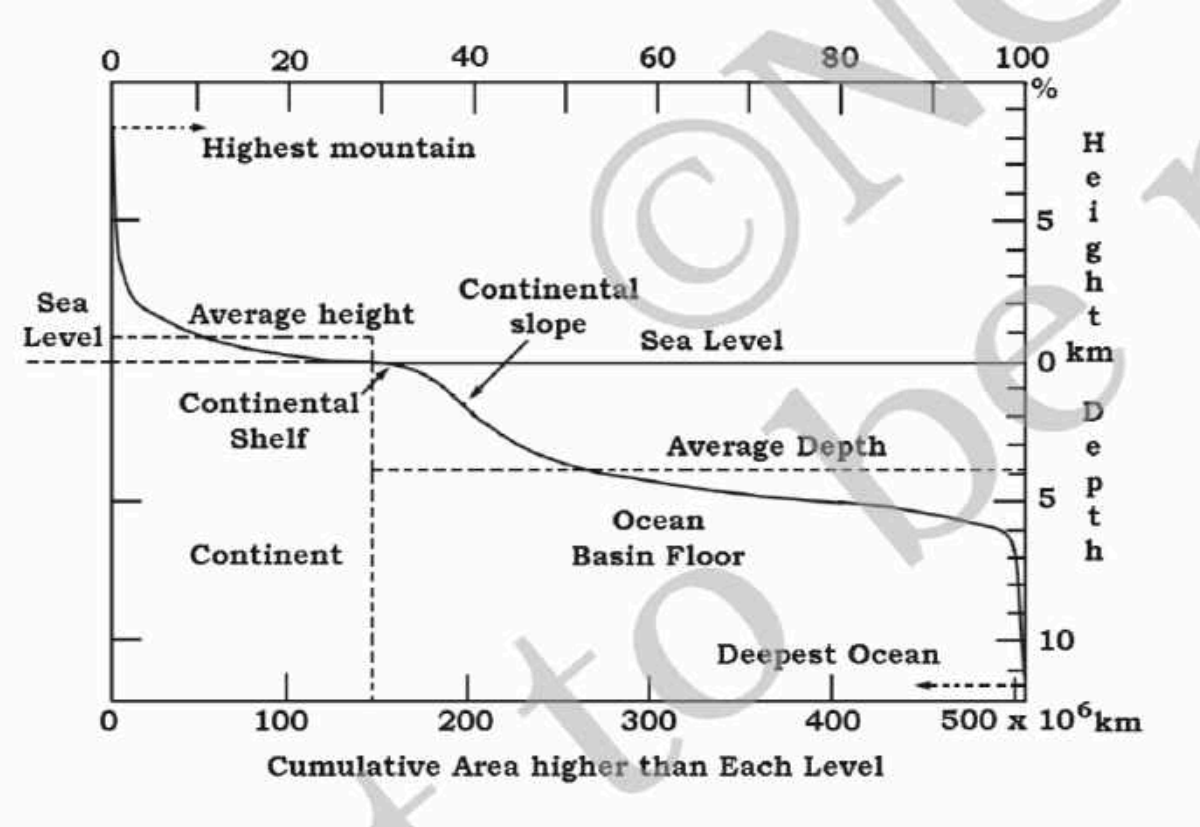
    1. In general, as we proceed from the equator towards the poles, rainfall goes on decreasing steadily.
    2. Between the latitudes 35 and 40 N and S of the equator, the rain is heavier on the eastern coasts and goes on decreasing towards the west. But, between 45 and 65 N and S of equator, due to westerlies, the rainfall is first received on the western margins of the continents and it goes on decreasing towards the east.
    3. The equatorial belt, the windward slopes of the mountains along the western coasts and the coastal areas of the monsoon land receive heavy rainfall of over 200 cm per annum. Interior continental areas receive moderate rainfall varying from 100-200 cm per annum. The coastal areas of the continents receive moderate amount of rainfall.
    4. The central parts of the tropical land and the eastern and interior parts of the temperate lands receive rainfall varying between 50-100 cm per annum. Areas lying in the rain shadow zone of the interior of the continents and high latitudes receive very low rainfall-less than 50 cm per annum.
    5. The coastal areas of the world receive greater amounts of rainfall than the interior of the continents. The rainfall is more over the oceans than on the landmasses of the world because of being great sources of water. Wherever mountains run parallel to the coast, the rain is greater on the coastal plain, on the windward side and it decreases towards the leeward side.
    6. Seasonal distribution of rainfall provides an important aspect to judge its effectiveness. In some regions rainfall is distributed evenly throughout the year such as in the equatorial belt and in the western parts of cool temperate regions.

Local winds

1. Local winds circulate in narrow areas, as compared to planetary winds, and develop due to local variations in temperature, pressure and humidity. Local terrain has a very strong influence. These can be regular or periodic and influence human health as well as socio-economic activities.

2. **Chinook:** These are dry winds in the interior west of North America. It can dry out soil and sublimate snow. They cause migraine headaches. They trap the pollutants in the cold air and causing inversion smog.
3. **Santa Ana:** They are strong, dry winds that affect coastal southern California. The winds are known especially for the dry weather, and are infamous for fanning regional wildfires and hence also called the devil winds.
4. **Khamsin:** They are sandy local winds in North Africa and the Arabian Peninsula. Carrying great quantities of sand and dust from the deserts it impacts health and day to day activities.
5. **Mistral:** It is a strong, cold and north-westerly wind that blows from southern France into the northern Mediterranean. It creates a climate of Provence in France. Brings good health, since the dry air dries stagnant water. It also blows away pollution.
6. **Kal-Baisakhi:** It is dry local wind of West Bengal, Assam, Bangladesh and parts of Orissa and Bihar during summer season. They cause destruction to life and property due to sudden rise in wind speed, lighting, thunder and hail. However, rain associated with the storm is extremely helpful for the pre-kharif crops like jute, paddy and vegetables and fruits. It is good for the tea crop in Assam and the jute and rice in West Bengal.
7. **Loo:** It is a hot, dry wind, that blows in Northern plains. It is very common in Bihar, western UP, Punjab and Haryana. The heat wave takes its toll and many people die because of it.
8. **Mango showers:** Occurs along the coast of Kerala. The showers prevent the mangoes from dropping prematurely from trees and are crucial for the mango cultivation in South India.
9. **Coffee showers:** It is a local wind that blows over the interior Karnataka during the hot weather season and is extremely helpful for coffee cultivation. These are also called as blossom showers.

Oceans



Ocean currents

1. An ocean current is any permanent or continuous, directed movement of ocean water that flows in oceans.
2. **Factors influencing ocean currents**
    1. **Heating by solar energy:** Heating by solar energy causes the water to expand. That is why, near the equator the ocean water is about 8 cm higher in level than in the middle latitudes. This causes a very slight gradient and water tends to flow down the slope.
    2. **Planetary winds:** Most dominating influence on the ocean currents. Ex: Ocean currents in the Indian ocean changes with the direction of Monsoon winds.
    3. **Gravity:** Gravity tends to pull the water down to pile and create gradient variation.
    4. **Salinity:** Water of high salinity sinks and water of low salinity flows on the surface.
    5. **Earth's rotation:** Because of rotation, every object on the Earth

comes under influence of Coriolis force, including ocean currents. In Northern Hemisphere, ocean currents are deflected towards right, so they sets in a Clock wise circulation.

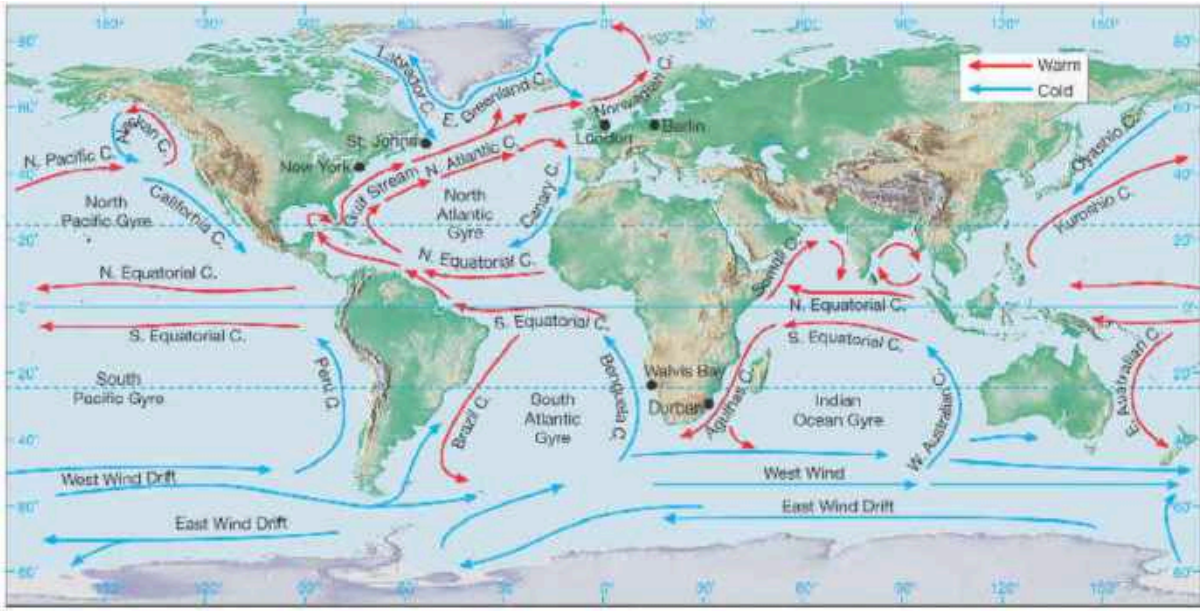
6. **Land:** A land mass always obstructs and diverts a current. For example, a tip of southern Chile diverts part of the West Wind Drift northwards as the Peruvian Current.
7. **Upwelling and downwelling:** Upward movement of cold water as near the Peruvian coast and downward drift of water where salinity or density is high influence the water circulation as a whole system.
8. **Ocean bottom topography:** Ocean bottom topography also affect the circulation of oceanic water. Such as huge mid-oceanic ridges in the Atlantic and Pacific ocean, seamounts and guyots.

3. **Types of ocean currents**
    1. The ocean currents may be classified based on their depth as surface currents and deep water currents : (i) surface currents constitute about 10 percent of all the water in the ocean, these waters are the upper 400 m of the ocean; (ii) deep water currents make up the other 90 percent of the ocean water. These waters move around the ocean basins due to variations in the density and gravity. Deep waters sink into the deep ocean basins at high latitudes.
    2. The ocean currents can also be classified based on temperature as cold currents and warm currents. Cold currents bring cold water into warm water areas. These currents are usually found on the west coast in the low and middle latitudes and on the east coast in the higher latitudes in the Northern Hemisphere. Warm currents are usually observed on the east coast of continents in the low and middle latitudes. In the northern hemisphere they are found on the west coasts of continents in high latitudes.
4. **Effects of ocean currents**
    1. Ocean currents transport warm water from the equator toward the poles and cold water from the poles back to the tropics. Thus, currents regulate global climate, helping to counteract the uneven distribution of solar radiation reaching Earth's surface.
    2. They give free navigation. The north eastern arm of Gulf Stream keeps ports and harbours of Russia & Scandinavia navigable

through out the year.

3. It distributes minerals and pollution added to it becomes highly diluted and later negligible. It helps in growth of juveniles of certain fish & its distribution to other countries.
4. West coasts of the continents in the middle and higher latitudes are bordered by warm waters which cause a distinct marine climate. They are characterised by cool summers and relatively mild winters with a narrow annual range of temperatures.
5. Warm currents flow parallel to the east coasts of the continents in tropical and subtropical latitudes. This results in warm and rainy climates.
6. The mixing of warm and cold currents help to replenish the oxygen and favour the growth of planktons, the primary food for fish population. The best fishing grounds of the world exist mainly in these mixing zones.

5. **Major Ocean Currents**



Temperature of ocean waters

1. Ocean waters get heated up by the solar energy just as land. The process of heating and cooling of the oceanic water is slower than land. The average annual temperatures for the northern and southern hemisphere are around 19° C and 16° C respectively.

2. **Factors affecting**
    1. **Latitude:** The temperature of surface water decreases from the equator towards the poles because the amount of insolation decreases poleward.
    2. **Unequal distribution of land and water:** The oceans in the northern hemisphere receive more heat due to their contact with larger extent of land than the oceans in the southern hemisphere.
    3. **Prevailing wind:** The winds blowing from the land towards the oceans drive warm surface water away form the coast resulting in the upwelling of cold water from below. It results into the longitudinal variation in the temperature. Contrary to this, the onshore winds pile up warm water near the coast and this raises the temperature.
    4. **Ocean Currents:** Gulf stream raises temperature near the east coast in North America.
3. **Horizontal and Vertical distribution of temperature**

    1. Maximum temperature of the oceans is always at their surfaces because they directly receive the heat from the sun and the heat is transmitted to the lower sections through the process of convection. The temperature falls very rapidly up to the depth of 200 m and thereafter, the rate of decrease of temperature is slowed down.
    2. The temperature structure of oceans over middle and low latitudes can be described as a three-layer system from surface to the bottom. The first layer represents the top layer of warm oceanic water and it is about 500m thick with temperatures ranging between 20° and 25° C.
    3. The second layer called the thermocline layer lies below the first layer and is characterised by rapid decrease in temperature with increasing depth. The thermocline is 500 -1,000 m thick. The third layer is very cold and extends upto the deep ocean floor. About 90 per cent of the total volume of water is found below the thermocline in the deep ocean. In this zone, temperatures approach 0° C.
    4. The average temperature of surface water of the oceans is about 27°C and it gradually decreases from the equator towards the poles. The rate of decrease of temperature with increasing latitude is generally 0.5°C per latitude. The oceans in the northern hemisphere

record relatively higher temperature than in the southern

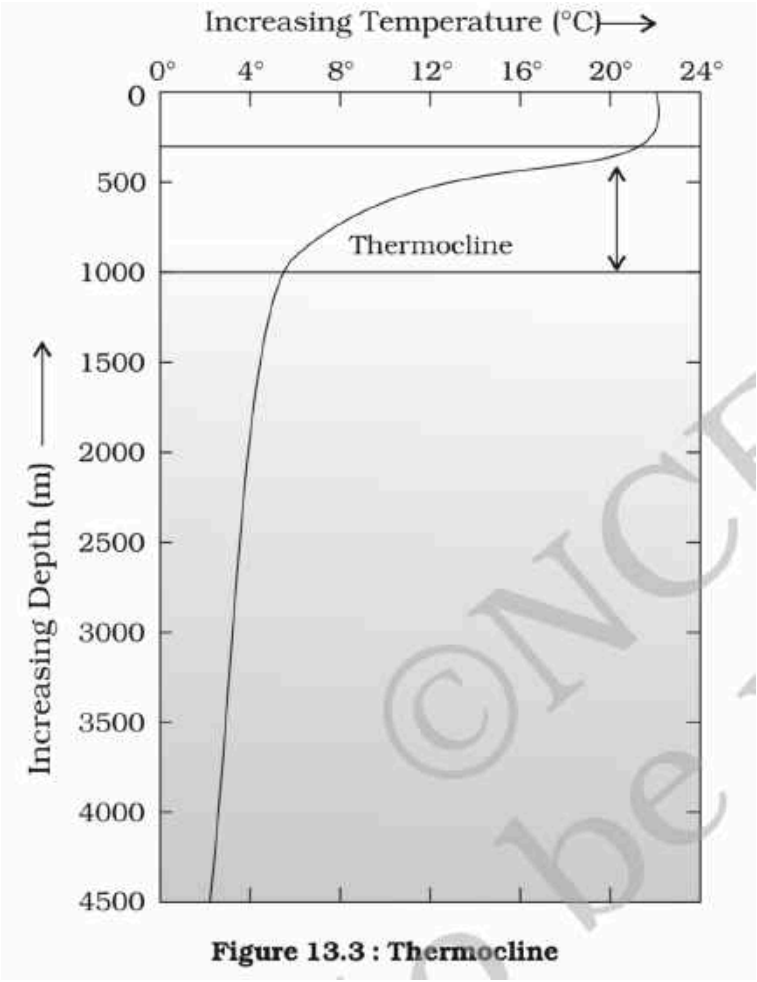


Figure 13.3 : Thermocline

hemisphere.

Rivers

1. **Peninsular vs Himalayan Rivers**
    1. Peninsular rivers are old, have broad channels, slow moving. Himalayan rivers are in late youth, shallow channels and fast moving.
    2. The Himalayan rivers are perennial in nature, whereas peninsular rivers are seasonal in nature and dry up in summers as they are dependent upon rainfall.
    3. Himalayan rivers cause much erosion and have great flow of water, compared to peninsular. So the peninsular rivers don't bring as much alluvium brought down by Himalayan rivers.
    4. Himalayan rivers are meandering, whereas peninsular rivers are straight.

5. Himalayan rivers create great plains suitable for agriculture, urbanisation and industrialisation. These are some of the most densely populated areas in the country.
6. Himalayan rivers flow in levelled Northern plains, so quite useful for navigation. While peninsular flow on uneven rocky surface, so not useful for navigation.
7. Canals can be dug to use waters of Himalayan rivers, but not possible in case of Peninsular rivers because of rocky terrain.
8. Himalayan rivers are antecedent and consequent leading to dendritic pattern in plains. While Peninsular rivers are super imposed, rejuvenated resulting in trellis, radial and rectangular pattern.

2. **Conditions favourable for deltas**
    1. Active vertical and lateral erosion in the upper course of river to provide extensive sediments to be eventually deposited as deltas.
    2. The coast should be sheltered, preferably tideless.
    3. The sea adjoining the delta should be shallow or else the load will disappear in the deep waters.
    4. There should be no large lakes in the river course to filter off the sediments.
    5. There should be no strong current running at right angles to the river mouth, washing away the sediments.
3. **Why no delta by west flowing rivers**
    1. Peninsular plateau has hard rock surface and lacks alluvial material. So west flowing rivers do not carry large amount of sediments.
    2. West flowing rivers flow at high speed through rift valleys because of higher gradient so no deposition of silt, while east flowing rivers are slow and deposit.
    3. Western coast is narrower which inhibits formation of deltas.
    4. Rivers arriving into a sea with high tidal range will not form deltas because the changes in the tidal area will wash away the sediments brought by the river.
4. **Delta vs Estuary**
    1. The triangular deposits made by the rivers at their mouth form Delta. The sharp edged mouth of rivers, devoid of any deposits is known as Estuary.

2. Deltas are formed in the regions of low tides and coastal plains. Regions of high tides and rift valleys witness Estuaries.
3. Deltas are fertile lands. Estuary does not have fertile lands.
4. East flowing rivers such as Ganga and Brahmaputra, Krishna, Kaveri and Mahanadi form delta. While west flowing rivers such as Narmada and Tapi rivers form Estuaries.
5. Estuary is a zone of mixing of fresh and saline water, but delta is made of fresh water's silt near a sea.

5. **Human aspects of Glaciers**

1. Most striking impact is felt in temperate regions of Europe and North America which were once under continental ice sheets. In hilly regions such as the mountain slopes of Scandinavia, ice sheets and Glaciers have removed most of the top soil, leaving them quite bear of vegetation.
2. Benches of alps which were not affected by glaciers have good pastures during summer. Cattle are driven up to graze on the grass and return to the bottom in winter.
3. Glaciers hallow out lakes, which greatly inconvenience large scale farming or land development. Large lakes formed by former glaciation, like great lakes of North America, make excellent waterways.
4. The Fluvio-Glacial deposits have economic significance.
5. The water that plunge down from hanging valleys are being harnessed to provide hydro-electric power.
6. Tourist attraction. Skiing, mountain climbing and sight-seeing are all popular with Alpine tourists.

Forests

The total forest cover in India is **21.54%**of the total area of the country. Forest is the second largest land use in India next to agriculture.

Forests add to the floral and faunal wealth of India, in addition to acting as important sources of livelihoods through agro-forestry, social forestry, farm forestry, forest produce, medicine, bio-diversity, carbon sinks and providers of fresh air.

Types of forests vis-a-vis their spatial distribution and their economic usage:

- **Tropical Evergreen and Semi Evergreen forests**
  - These forests are found in the western slope of the **Western Ghats,** hills of **the northeastern region and the Andaman and Nicobar Islands**.
  - Tropical evergreen forests are well stratified, with layers closer to the ground and are covered with shrubs and creepers, with short structured trees followed by tall variety of trees.
  - Example: rosewood, mahogony, aini, ebony, rubber, bamboos etc.
  - **Economic usage:** Fine grained, hard and durable timber used in Railways and construction work, rubber and associated industry etc.
- **Tropical Deciduous forests/ Monsoon Forests**
  - These are the most widespread forests in India. They are also called the monsoon forests. They spread over regions which receive rainfall between 70-200 cm. On the basis of the availability of water, these forests are further divided into moist and dry deciduous.
  - **Moist deciduous forests** are more pronounced in the regions which record rainfall between 100-200 cm. These forests are found in the **northeastern states along the foothills of Himalayas, eastern slopes of the Western Ghats and Odisha.** Examples: Teak, sal, shisham, hurra, mahua, amla, semul, kusum, and sandalwood etc.
  - **Dry deciduous forest** covers vast areas of the country, where rainfall ranges between 70 -100 cm. These forests are found in rainier areas of the **Peninsula and the plains of Uttar Pradesh and Bihar**. Examples: Tendu, palas, amaltas, bel, khair, axlewood, etc.
  - **Economic usage:** Source of timber, recreation and conserving wildlife, agro-forestry, medicine, bidi making, etc.
- **Tropical Thorn forests:**
  - Tropical thorn forests occur in areas which receive rainfall less than 50 cm **in semi-arid areas of south west Punjab, Haryana, Rajasthan, Gujarat, Madhya Pradesh and Uttar Pradesh.**
  - **Economic usage:** Trees like babool, ber, and wild date palm, khair, neem, khejri, palas and Tussocky grass are mostly used in agro-forestry, medicine, fruits, handicrafts and other sources of livelihoods to the poor and tribals.

- **Montane forests:**
  - Mountain forests can be classified into two types, **the northern mountain forests and southern mountain forests.**
  - The Himalayan ranges show a succession of vegetation **from the tropical to the tundra, which change with the altitude.**
  - Deciduous forests are found in the foothills of Himalayas. It is succeeded by wet temperate forests between an altitude of 1,000-2,000 m. In the higher **hill ranges of north-eastern India, hilly areas of West Bengal and Uttaranchal,** evergreen broad leaf trees such as oak and chestnut are predominant.
  - The **southern mountain forests** include forests found in three distinct areas of Peninsular India viz; **Western Ghats, Vindhyas** and **Nilgiris**. As they are closer to tropics, and only 1,500 m above sea level, vegetation is temperate in higher regions, and subtropical on the lower regions of **Western Ghats, especially in Kerala, Tamil Nadu and Karnataka**. **Temperate forests / Sholas** are found in in **Nilgiris, Anaimalai and Palani hills**. Such forests are also found in **Satpura and Maikal ranges**.
  - **Economic usage:** Deodar is used in construction activity. Chinar and walnut, sustain Kashmir handicrafts. Grasslands in this region provide important source of livelihoods to tribes such as Gujjars, Bakarwals, Bhotiyas and Gaddis.
- **Littoral and Swamp forests:** Also called as wetland forests, they are found along:
  - reservoirs of Deccan Plateau with the lagoons and other wetlands of the southern west coast;
  - saline expanses of Rajasthan, Gujarat and Gulf of Kachchh
  - freshwater lakes and reservoirs from Gujarat eastwards through Rajasthan (Keoladeo National Park) and Madhya Pradesh
  - delta wetlands and lagoons of India's east coast (Chilika Lake)
  - freshwater marshes of Gangetic Plain
  - floodplains of Brahmaputra; marshes and swamps in hills of northeast India and Himalayan foothills
  - lakes and rivers of the montane region of Kashmir and Ladakh
  - mangrove forest and other wetlands of the island arcs of Andaman and Nicobar Islands
  - **Economic usages:** Mangroves and wetlands are important sources of bio-diversity, wildlife species and tourism.

Himalayan Geography

1. **Boundaries:** North -- Tibetan Plateau; South -- Indo-gangetic plain; East -- Brahmaputra; West -- Nanga Parbat.
2. **Three parallel ranges**
    1. **Inner Himalayas:** Average height of 6,000 metres. Contains all the prominent Himalayan peaks. It is perennially snow bound.
    2. **Middle Himalayas:** Rugged mountains. This region is well known for its hill stations. Pir Panjal, Dhaula Dhar and Mahabharat ranges.
    3. **Outer Himalayas:** Un-consolidated sediments. The longitudinal valley lying between Himachal and the Shiwaliks are known as Duns.
3. **Five divisions**

1. **Kashmir Himalayas:** Zafran. Karakoram, Ladakh, Zaskar and Pir Panjal. Jhelum in youth state forms meanders.
2. **Himachal and Uttaranchal Himalayas:** Ladakh cold desert.
3. **Darjeeling and Sikkim Himalayas:** Shiwalik and Dun formations. Suitable for tea plantations
4. **Arunachal Himalayas**
5. **Eastern Hills:** Dissected by fast flowing rivers. ethnic tribals like Monpa, Daffla, Abor, Mishmi, Nishi and the Nagas.

4. **Difference between Fold and Block mountains**

1. Fold mountains are produced when tectonic plates move towards each other. The resulting compressive force cause folding along the lines of weakness. Block Mountains are produced when the fault develops in the Earth's crust either by compression or tension forces experienced by it, it uplifts a certain portion of the land leading to formation of the Block Mountain.
2. Fold mountains are very high in elevation. Block mountains have comparatively lower elevation.
3. Fold mountains contain many active volcanoes e.g. around circum-pacific fold mountain system. While block mountains have no such active volcanoes.
4. Fold mountains are rich in mineral resources.
5. Fold mountains are most widespread mountains found throughout the world. Himalayas in India, Rockies in America, Andes in South America and Alps in Europe are examples of it. Block mountains are found in black forest of Rhineland, Hunsruck mountains, East African Valley system, and the mountains surrounding the Narmada Rift Valley in India.

Peninsular plateau

1. The general elevation of the plateau is from the west to the east. It was formed due to the breaking and drifting of the Gondwana land. This has undergone recurrent phases of upliftment. Black soil area known as Deccan Trap.
2. Deccan plateau.

3. Central highlands.
4. Northeastern plateau.

Deserts

1. Desert refers to the regions having a little precipitation and consequently hostile conditions for survival of plant and animal life. Deserts can be hot, semi-arid, coastal and cold.
2. **Important factors**
    1. **Wind pattern:** Most of the deserts are located within 15° to 30° north and south of the equator. Here the trade winds blow offshore. The equatorial winds that rose upwards from equator and when they descend at the tropics, they have little moisture. Ex: Sahara desert.
    2. **Cold currents:** Most of the hot deserts are present along the west coast of continents as cold ocean currents along these coasts have desiccating effect on rainfall over interior areas. Ex: Atacama desert.
    3. Presence on the leeward side also causes little precipitation. It is also called as Rain Shadow desert. Ex: Gobi desert.
    4. Also absence of mountain to cause orographic rain is also a cause. For example Aravalli is not able to cause rainfall and consequently we have Thar.
    5. Polar areas have very cold air which does not cause precipitation frequently. So they are also considered as cold desert.
    6. The formation of deserts is caused also due to weathering process. Winds can blow freely in desert areas due to little vegetation and cause abrasion effects. Temperature variations of hot days and cool nights have an exfoliating effect on the outer surfaces. Occasional downpour also causes weathering as water expands on being frozen. All of these cause faster disintegration of rocks and particles are transported and deposited in sand dunes.

Corals

1. **What are they**
    1. Coral polyps are short lived microscopic organisms, which live in

colonies. They secrete hard rock like substance which form coral reefs. Barrier reef, fringing reef and atolls are three types of coral reefs. Atolls are circular or horse shoe shaped coral reefs.

2. In India, they are present in Gulf of Kutch, Andaman and Nicobar islands, Lakshadweep islands, Gulf of Mannar, etc. Coral reefs are not present on western coasts of continents, because of cold ocean currents. Presence of warm currents means that the corals are present far to the North. Pacific and Indian oceans have most of the corals.

2. **Conditions for survival**
    1. **Shallow water:** Corals need to grow in shallow water where sunlight can reach them. Algae, in corals, needs sunlight to survive. Corals rarely develop in water deeper than 165 feet (50 meters).
    2. **Mud-free water:** Sediment and plankton can cloud water, which decreases the amount of sunlight that reaches the zooxanthellae.
    3. **Warm water:** Reef-building corals require warm water conditions to survive. corals generally live in water temperatures of 20–32° C.
    4. **Salty water:** Fresh water inhibits coral formation.
    5. **No pollution:** Sediment can get deposited on corals, blocking out the sun and harming the polyps. Wastewater may contain too many nutrients that cause seaweeds to overgrow the reef.
    6. **Moving water:** As silts will be cleared up.
3. **How are corals formed**
    1. Coral reefs are result of symbiotic relationship between zooxanthellae & corals in an oceanic ecosystem. Corals give shelter to algae in exchange of nutrients which algae produce by photosynthesis process.
    2. These corals secrete calcium carbonates which become hardened after their death and new corals make this skeletons their home. Repetitive process of secretion of calcium carbonates resulting in beautiful creation of fringing reef, atolls etc.
4. **Importance of corals**
    1. Coral reefs are one of the prominent reason for thriving biodiversity in the ocean. They give shelter to various species who depend on corals for food.

2. They are the source of nitrogen and other essential nutrients for marine food chains. The fishing industry depends on coral reefs because many fish spawn there.
3. They are first level protection against floods, tsunami, which lessen the impact on coastal areas. These are barriers to surge, storms.
4. Corals prevent erosion of coastal areas.
5. They regulate the carbon dioxide content in the oceans by absorbing carbon dioxide to form calcium carbonate for their structures.
6. Coastal population depends on corals as these provide tourism and recreational activities thus diminishing economy.
7. Provides services like recycling and purification of water and air, the break down of pollutants, etc.
8. The study of coral reefs provide a clear, scientifically testable record of climatic events over the past million years or so. This includes records of recent major storms and human impacts that are recorded by the changes in coral growth patterns.

5. **Factors threatening Corals**
    1. **Temperature:** Corals survive in very narrow range of temperature and are adopted to live in warm waters. Slight change in temperature because of solar radiation variation cause coral bleaching.
    2. **Climate change:** Climate change problem, ENSO effect also cause variation in temperature causing death of coral bleach.
    3. **Human activities:** Human activities such as fishing, ocean pollution such as oil spills etc., are serious threat to their existence.
    4. **Fresh-water dilution:** Fresh water from runoffs cause dilution of fresh water. As corals are adapted to saline water, they react adversely in such circumstances.
    5. **Pollution:** Sediments, industrial garbage disposal in ocean have caused chemicals accumulation in ocean water, thus hampering the growth of corals.

Phytoplankton

Phytoplanktons are photosynthetic organisms that live suspended beneath the water's surface. For e.g. Microalgae and blue-green bacteria. The oceanic phytoplankton plays an important role in the biogeochemical cycle and modulating climate change. For e.g.,

- **Marine Food web**: Phytoplankton is the base of the oceanic food web, supplying organic matter for all other organisms in the marine environment.
- **Biological pump and fossil fuel:** They absorb and transform inorganic carbon into their cells, which upon death and decay, sink down to be de-posited as seafloor sediments becoming a source of fossil fuel. The process is known as the 'Biological pump'.
- **Global warming**: If the upper ocean biological pump stops pumping carbon down to the ocean interior, atmospheric levels of CO2 would in time rise thereby accelerating global warming

A **bloom** takes place due to eutrophication, where phytoplankton reproduces at a rapid rate. It is caused by the addition of nutrients such as nitrates, iron and phosphates naturally or artificially, fertilizing the marine ecosystem. For e.g. bloom in the Atlantic sea is ascribed to the availability of iron-rich dust from Patagonia desert. It increases with the availability of conducive environment such as optimum light condition, pH, salinity etc. The wind also controls the phytoplankton blooms by mixing the water column and inducing upwelling.

Blooms can impact the ecosystem in several ways such as it can cause:

- The death of submerged aquatic organisms due to reduction in the sunlight penetrating the sea.
- Loss of coral reefs due to increased turbidity
- Contamination of marine food resources due to its exposure to toxins released by the bloom. Consequent closure of fishery industry and reduction in seafood sales.
- Change in species composition due to species invasion by alien species.
- Reduction in tourism and related businesses and increased cost of conducting monitoring programs.

Thus, there is a clear need to understand phytoplankton boom phenomenon and to develop scientific sound management and mitigation technique.

Forest Fires

1. **Natural causes of forest fire**
    1. High atmospheric temperatures and dryness caused due to low humidity can cause a fire.
    2. Lightening due to thunderstorms.
    3. In dry seasons due to friction by rolling stones in the mountainous areas can cause spark.
    4. In bamboo areas, by the rubbing together of clumps of dry bamboos.
    5. Volcanic eruptions.
2. **Anthropogenic causes of forest fire**
    1. Shifting cultivation where farmers put fire to the field to clear of

vegetation and also to add organic matter to the soil.

2. Villagers reportedly burn leaves and grass in order to get better growth of grass the following year. They also burn the needles of the chir pine, which form a slippery carpet on the ground.
3. To facilitate collection of non-timber forest produce, collectors ignite fire which accidentally spread in the forest. For example, in the Terai region, honey collectors often start fires to drive away bees.
4. For concealing the illicit felling.
5. Careless throwing of bidi stubs, cigarettes, etc., by people working in the forests and villagers. Camp fires during winter.

3. **Policies and methods followed in India**
    1. In India there are no separate department for wildfires and the regular forest department staff carries out the activities of forest fire management.
    2. One-size-fits-all approach of fire protection is incompatible with the ecology of India's tropical dry forests.
    3. Forest management still suffers from a colonial hangover intent on keeping production forestry systems free from fire despite loss of stock.
    4. No-fire policy which leads to the spread of alien invasive species like Lantana Camara.
4. **How to manage forest fire**
    1. Construction of narrow lanes in the forest, at crucial junctions, to restrict forest fires.
    2. Planting of broad tree leaves in forests, and after a period of five years, systematic replacement of chir pine trees in forests by broad leaves.
    3. Procurement of sweeping machines to clear roadsides of chir pine needles and dry leaves in vulnerable areas. Advocated large scale incentives and programmes under MGNREGA to collect pines for use as fuel, and other incineration.
    4. A dedicated toll free number for reporting incidents of forest fire in each state. Use of corporate social responsibility funds for creating awareness campaigns on forest fires. Ex: Not carrying match boxes.
    5. More modern systems of fire monitoring alongside traditional

methods like maintaining fire lines, so there is a clearing between two forests to prevent the fire from spreading from one to the other.

6. Ministry should train fire brigade officers of all states and equip them with forest fire equipment so that in the event of forest fires they do not have to depend on outside agencies like NDRF.
7. Creation of ponds and other water harvesting structures within the forest area to not only reduce river bank erosion but also as a handy tool for supply of water to douse forest fires.
8. The method of counter fire too is being adopted with forest officials starting fires from the opposite end of a forest to check the flames at a defined boundary. Scientific waste management techniques to avoid fires due to methane gas evolution, like the one happened in Deonar, Mumbai

5. **Benefits of wildfire**
    1. Wildfires are sometimes a natural process, and help forests by promoting flowering, branching and seedling establishment. Fires that are limited to the surface may help in the natural regeneration of forests.
    2. The heating of the soil may result in helpful microbial activity, and hasten decaying processes that are useful for the vegetation.

Wetlands

1. They transitional lands between terrestrial and aquatic eco-systems where the water table is usually at or near the surface. About 70 percent of wetlands in India comprises areas under paddy cultivation.
2. **Wetlands in India have been grouped into eight categories**
    1. The reservoirs of the Deccan plateau in the south together with the lagoons and other wetlands of the southern west coast.
    2. The vast saline expanses of Rajasthan, Gujarat and the Gulf of Kachchh.
    3. Fresh water lakes and reservoirs from Gujarat eastwards through Rajasthan (Keoladeo) and MP.
    4. The delta wetlands and lagoons of India's east coast (Chilika Lake).

5. The fresh water marshes of the Gangetic plain.
6. The flood plains of the Brahmaputra, the marshes and swamps in the hills of northeast India and the Himalayan foothills.
7. The lakes and rivers of the montane region of Kashmir and Ladakh.
8. The mangrove forest and other wetlands of the island arcs of the Andaman and Nicobar Islands.

3. **Uses of wetlands**
    1. It has been estimated that freshwater wetlands hold more than 40% of all the world's species and 12% of all animal species. Individual wetlands can be extremely important in supporting high numbers of endemic species.
    2. The most significant social and economic benefit that wetlands provide is flood control. Wet lands acts like sponges. They absorb waters during floods and release water during droughts.
    3. Coastal wetlands such as coral reefs, mangroves and salt marshes act as frontline defences against potential devastation during disasters.
    4. Wetlands act as the Earth's filters, cleaning up water in a number of ways. Wetlands remove pollutants such as phosphorous, heavy metals and toxins which are trapped in the sediments of the wetlands.
    5. Wetlands also act as carbon sequestrator.
    6. Throughout history humans have gathered around wetlands and these areas have played an important part in human development and are of significant religious, historical or archaeological value to many cultures around the world.
4. **Causes for loss of wetlands**
    1. Natural phenomena like floods, storms, sea level rise and biotic effects like excessive sediment inflow has become greatest concern for the lake. It has potential to destroy the peculiar ecosystem.
    2. Agricultural activities and related discharge in the form of pollutants.
    3. Waste disposal, mining for minerals and dumping.
    4. Hydrological alteration by construction of dams, channellisation

for navigation and ground water abstraction.
5. Settlement and infrastructure development.

5. **Measures for protection**
    1. **International:** The Convention on Wetlands, called the Ramsar Convention, is an intergovernmental treaty. Wetlands international, a global non-profit organization for sustaining and restoring wetlands.
    2. **National:** National Wetlands Conservation Program (NWCP) is adopted by the Union in close collaboration with concerned States. National lake conservation plan (NLCP) was carved out to focus on lakes particularly in urban areas. Formulation of Management Action Plan by states to define objectives taking into consideration factors responsible for degradation of the wetland.
6. **Wetland management rules, 2016**
    1. The wetland rules 2016 follow the "wise use" philosophy of the Ramsar Convention and accord emphasis on maintaining ecological character and integrity.
    2. The Central Wetlands Regulatory Authority (CWRA) will be removed. The power of notification would rest with States.
    3. There is no time limit for notification as against the period of 12 months stipulated in 2010 rules.
    4. The number of restricted activities have been reduced.
    5. Earlier the decision taken by CWRA could have been challenged before NGT by a citizen. No provision of citizen check is present under the new rules.
7. **Issues**
    1. Firstly, the new rules have omitted some of the wetlands that were protected in the 2010 rules. For example, the 2010 rules explicitly mentioned the wetlands located in the UNESCO World Heritage Sites including Western Ghats, high altitude wetlands etc. New rules don't even mention them.
    2. The record of states in implementation of the rules has not been encouraging. It is observed that states are susceptible to yielding under local pressure.
    3. Scraping of central authority may prove disastrous as body has long experience and technical knowhow to apply the conservation methodology.

4. It has no ecological criteria for recognising wetlands such as biodiversity, reefs, mangroves, and wetland complexes in identification of wetlands. This may harm the identification process altogether.
5. It has deleted sections on interpretation of harmful activities which require regulation on various pollution criteria. This may increase pollution level due to various natural and manmade activities.
6. EIA has no mention in the draft rule which was previously compulsory before undertaking any activity in a wetland area. No role to local people and institutions have been given.

8. **Concerns with the decentralised approach**
    1. Trans-state wetland will be affected due to state wise conservation effort. Ex: Assam's rivers and wetlands which crisscross the state, may lose much needed holistic protection.
    2. States are also not fully competent with funding, research and ecological dynamics of wetlands and their conservation.
    3. Due to local political pulls and pressures, whole provisions of protection and conservation may end up in wrong direction. States have failed to secure perimeters and catchment areas or notify wetlands.
    4. For example, Asia's largest freshwater oxbow lake, the Kanwar lake in Bihar, has shrunk to one-third of its size due to encroachment, much like Jammu and Kashmir's Dal lake.
9. **Way forward**
    1. There is need for scientific criteria for identifying wetlands. An independent authority can help with respect to this. Various ecological criteria like genetic diversity, outstanding natural beauty, wildlife habitats, corals, coral reefs, mangroves, heritage areas must find place.
    2. Create a data bank on wetlands which is now only available for Ramsar sites. In absence of proper data bank, extent of wetland is not ascertained and encroachment becomes easier.
    3. Proper checks and balances, both on part of central government and citizens is required.
    4. The rules should be people centric and should involve town and country planning Board in identification of wetlands. More role to

locals like fishing community, farming and pastoral community in management. They have experience as well as interest in their protection.

5. Conservation of wetlands needs cooperative and decentralised efforts from local bodies to States to centre.

Western ghats

1. **Why Karnataka receive higher rainfall**
    1. Mountain topography of Ghats is broad in Karnataka and narrow in Maharashtra. So, rain bearing winds have to travel a longer distance and have more time for the drops to coalesce. In contrast, the narrow width of the Ghats in Maharashtra allows the rain-bearing wind to cross over to the leeward side rapidly before precipitation can occur.
    2. Ghats of Karnataka are gently sloped when compared to the steep slopes of the Ghats in Maharashtra and Kerala. Gentle slopes will make the air parcel retain its energy and speed for a longer time. This will provide sufficient vertical motion to cloud droplets to grow by collision coalescence process and hence form precipitation.
    3. Third, the gentle slope absorbs greater amount of sunlight and heating leading to greater convection when compared with an abrupt slope i.e. less Ghat area such as that of the Maharashtra and Kerala Ghats.
    4. Fourth, the continuous mountain presents a greater barrier to rain-bearing winds than a range comprising isolated mountains with gaps in between where the winds can easily pass to the leeward side. Unlike in the case of Kerala, the Ghats in Maharashtra and Karnataka are continuous.
2. **Issues in declaring western ghats as Ecologically sensitive area**
    1. **Difference in estimation of ECA:** Gadgil Committee recommended that entire western Ghats should be declared as ESA while Kasturirangan Panel recommending only 1/3rd should be made ESA
    2. **Opposition from states:** Mining in these areas is the important revenue source for states like Karnataka, Maharashtra. ESA

prohibits mining activity.

3. **Opposition from Industry:** Demanding for development is necessary to extract minerals, metal in the area.
4. **Rehabilitation:** No proper rehab and resettlement policy and no alternate employment opportunities due to lack of skills is also an issue.
5. **Perceptions:** ESA declaring is propagated as anti-developmental and non-declaration is propagated as pro-industry and anti-conservation strategy.

Tsunami

1. Tsunami originate because of rapid displacement of water from the lake, sea or ocean. The displaced ocean water rushes back in the form of large waves thus surging over land with great destructive power. Tsunamis are frequently observed along the Pacific ring of fire, particularly along the coast of Alaska, Japan, Philippines, and other islands of South east Asia, Indonesia, Malaysia, Myanmar, Sri Lanka, and India etc.
2. The speed of wave in the ocean depends upon the depth of water. It is more in the shallow water than in the ocean deep. So, the impact of tsunami is less over the ocean and more near the coast. Therefore, a ship at sea is not much affected by tsunami and it is difficult to detect a tsunami in the deeper parts of sea. Thus, these are also called Shallow water waves.
3. **Causes**
    1. Fault movements on the sea floor, accompanied by an earthquake. They release huge amount of energy and have the capacity to cross oceans.
    2. Landslide either occurring under water or originating above the sea and then plunging into the water. The largest tsunami ever produced by a landslide was in Lituya Bay, Alaska 1958.
    3. Volcanic activity. In 1883, the violent explosion of the famous volcano, Krakotoa in Indonesia, produced tsunami measuring 40 meters which crushed upon Java and Sumatra. Also, 80% Tsunamis in Pacific ocean are result of volcanism.
    4. Meteorites from the outer space also result in the Tsunami waves.

4. **Tsunami warning**
    1. **International Tsunami Warning Systems:** Shortly after the Hilo Tsunami (1946), the Pacific Tsunami Warning System (PTWS) was developed with its operational center near Honolulu, Hawaii. The PTWC is able to alert countries several hours before the tsunami strikes. The warning includes predicted arrival time at selected coastal communities where the tsunami could travel in few hours. A tsunami watch is issued with subsequent arrival time to other geographic areas.
    2. **Regional Warning Systems:** Usually use seismic data about nearby earthquakes to determine if there is a possible local threat of a tsunami. Such systems are capable enough to provide warnings to the general public in less than 15 minutes.
    3. Survey of India (SOI) maintains a tide gauge network along the coast of India. The gauges are located in major ports of India. The day-to-day maintenance of the gauge is carried with the assistance from authorities of the ports.
    4. Apart from the tide gauge, tsunami can be detected with the help of radars. But radars take long time to process information.
5. **Possible risk reduction measures**
    1. Japan has implemented an extensive programme of building tsunami walls of up to 4.5m (13.5 ft) high in front of populated coastal areas. Other localities have built flood gates and channels to redirect the water from incoming tsunamis.
    2. The designation and zoning of tsunami hazard areas for such open-space uses as agriculture, parks and recreation. This strategy is designed to keep development at a minimum in hazard areas.
    3. Development of Disaster Information Management System (DIMS) in all the coastal states.
    4. Mangrove forests and plating rows of tress on coasts act as an efficient barrier.
    5. Control of sea mining as Mining of sand and other minerals from the sea, as is done in Kanyakumari, makes the concerned area highly vulnerable to tsunamis. The sand deposited on the sea floor absorbs much energy of the waves.
    6. Most of the habitation of the fishing community is seen in the coastal areas. The houses constructed by them are mainly of light

weight materials without any engineering inputs. So, people should be educated about the good construction practices that they should adopt.

Floods

1. The inundation of an area by water is called a flood. Unlike other natural disasters, the causes of floods are well established. Floods are relatively slow in occurrences and often, occur in well identified regions and within expected time in a year. The most flood prone areas are the Brahmaputra, Ganga and Indus basins.
2. **Causes of floods**
    1. Heavy rain in the catchment area of a river causes water to over flow its banks, which results in the flooding of nearby areas.
    2. River beds become shallow due to sedimentation. The water carrying capacity of such river is reduced.
    3. Due to deforestation, the land becomes obstruction free and water flows with greater speed into the rivers and causes flood.
    4. Cyclone generated sea waves of abnormal height spreads the water in the adjoining coastal areas. Large coastal areas are flooded by rising sea water, when a tsunami strikes the coast.
    5. Drainage congestion caused by badly planned construction of bridges, roads, railway tracks, canals etc. hampers the flow of water and the result is flood.
    6. Urban flooding due to heavy rainfall in a short period of time, concretisation, indiscriminate encroachment of waterways, inadequate capacity of drains. Ex: Chennai floods.
3. **Consequences**
    1. Frequent inundation of agricultural land and human settlement has serious consequences on the national economy and society.
    2. Floods do not only destroy valuable crops every year but these also damage physical infrastructure such as roads, rails, bridges and human settlements.
    3. Millions of people are rendered homeless and are also washed down along with their cattle in the floods.
    4. Spread of diseases like cholera, gastro-enteritis, hepatitis and other

water-borne diseases spread in the flood-affected areas.

5. Floods also make a few positive contributions. Every year, floods deposit fertile silt over agricultural fields which is good for the crops.

4. **Impact of floods on soil**
    1. Soil degradation due to flooding is a serious concern. An estimated 14 million hectares of land suffer soil degradation due to flooding annually in India.
    2. After the 2009 floods in North Karnataka, 13 flood-hit districts lost lot of top soil.
5. **Flood control measures**
    1. Identification and marking of flood prone areas on maps, preparation of close contour and flood vulnerability maps by the Central Water Commission (CWC), etc.
    2. Implementation of the schemes for expansion and modernisation of the flood forecasting and warning network, execution of flood protection and drainage improvement schemes. The efforts of the CWC, IMD, NRSA and the state governments will be integrated.
    3. Implementation of activities, which include construction of dams and catchment area treatment (CAT) works in India as well as neighbouring countries. But, dams built to control floods of Damodar could not control the flood.
    4. By building flood protection embankments, flood water can be controlled from overflowing the banks and spreading in nearby areas. Building of embankments on Yamuna, near Delhi, has been successful in controlling the flood.
    5. Dredging the river basins and Inter-basin transfers of river water can reduce flood.
    6. The furry of flood could be minimised by planting trees in catchment areas of rivers.
    7. Drainage system is generally choked by the construction of roads, canals railway tracks etc. Floods could be checked if the original form of drainage system is restored.
    8. Flood education, emergency search and rescue and emergency relief.
    9. More consultative decision making process in operations of large and medium dams that have an impact across state boundaries.

This is important, the floods in Bihar can be attributed to release of waters from Bansagar dam, MP.

10. A nation wide silt management policy. This can prevent the future floods of those types which took place in Bihar.

6. **Flash floods**
    1. Flash floods are short-term events, occurring within 6 hours of the causative event. They are characterised by a rapid stream rise with depths of water that can reach well above the banks of the creek.
    2. Flash flood damage and most fatalities tend to occur in areas immediately adjacent to a stream. Additionally, heavy rain falling on steep terrain can weaken soil and cause mud slides, damaging homes, roads and property.
7. **Causes of flash floods**
    1. Encroachment on the flood plains lead to flash flood.
    2. Urban settlements on the areas through which water get back to the oceans of rivers or any other natural place.
    3. Polluting elements like poly bags are also the reason which hinder the drainage systems. Unplanned waste dumping reduces the capacity of aquifers to recharge.
    4. Building roads and concrete structures have left no place for water to get absorbed into soil.
8. **Measures to control flash floods**
    1. Wetlands, lakes which are lost in illegal construction must be reclaimed to be able function as water harvesting facilities.
    2. Migrants should be provided decent housing. In the absence of which, they tend to settle along floodplains.
    3. Vulnerable areas must be identified.
    4. Hydraulic modelling of stormwater drains and placing sophisticated water pumps to pump out excess water.
    5. Not allowing construction activity in ecologically fragile areas like floodplains etc. The recent issue of world cultural festival on the floodplains of Yamuna is a case in point.
    6. To prevent damage during floods, resilience of cities must be increased by retrofitting critical infrastructure like schools, hospitals, water, electricity etc. so that they function even during emergencies. Customers must be alerted regarding property in hazardous areas.

9. **Urban floods**
    1. Urban flooding is significantly different from rural flooding as urbanisation leads to developed catchments, which increases the flood peaks from 1.8 to 8 times and flood volumes by up to 6 times. Consequently, flooding occurs very quickly due to faster flow times.
    2. Urban areas are densely populated and people living in vulnerable areas suffer due to flooding, sometimes resulting in loss of life. It is not only the event of flooding but the secondary effect of exposure to infection also has its toll in terms of human suffering, loss of livelihood and, in extreme cases, loss of life.
    3. Urban areas are also centres of economic activities with vital infrastructure which needs to be protected 24x7. In most of the cities, damage to vital infrastructure has a bearing not only for the state and the country but it could even have global implications.
    4. Major cities in India have witnessed loss of life and property, disruption in transport and power and incidence of epidemics. Most city areas around rivers are flooded during monsoon period. Mumbai floods in 2006 caused havoc in the whole city. Therefore, management of urban flooding has to be accorded top priority.
    5. Increasing trend of urban flooding is a universal phenomenon and poses a great challenge to urban planners the world over. Problems associated with urban floods range from relatively localised incidents to major incidents, resulting in cities being inundated from hours to several days.
    6. Therefore, the impact can also be widespread, including temporary relocation of people, damage to civic amenities, deterioration of water quality and risk of epidemics.

Cloud burst

1. A cloudburst is a sudden downpour within a radius of few kilometres. It usually lasts no longer than few minutes but is capable of flooding the area. This leads to flash floods, house collapse, dislocation of traffic and human casualties on large scale.
2. **Conditions favourable**
    1. Hilly areas are more prone to cloud burst. The topographical

conditions like steep hills favour the formation of these clouds.
    2. And also the devastations, as water flowing down the steep slopes bring debris, boulders and uprooted trees with great velocity damaging any structure that comes in their way.
3. **Cause**
    1. Most essential condition to develop a cloudburst is when the saturated clouds are unable to produce raindrops. This happens when strong vertical convectional currents are formed and they move upwards quickly, not letting the already formed raindrops to fall below.
    2. This helps in the formation of new drops and the existing ones grow bigger in size. This continues till the clouds are unable to hold the rain drops and they drown altogether in a quick flash. This condition is facilitated in hilly areas when clouds get stuck in a narrow space between the hills and mountains.
4. **Impact**
    1. Flash floods leads to soil erosion and changes the structure of landform. They also wash away the houses, properties of the people.
    2. Landslides prominent in hilly areas blocks transportation routes like roads.
    3. Cloudbursts in plain areas leads to water logging and inundation thus damaging crops.
    4. Business activities are hampered when offices, restaurants and shops are washed away.

Droughts

1. Drought refers to a situation where the available water (through rainfall, surface water or groundwater) falls short of the demand for extended periods of time due to inadequate precipitation, excessive rate of evaporation and over utilisation of water from the reservoirs and other storages, including the ground water.
2. **Reasons for drought**
    1. India receives major portion of precipitation from Southwest monsoon, which gets affected by dynamics such as El Nino and climate change.

2. Overuse of surface and groundwater due to perverse incentives in favour of cash crops and overuse.
3. Lack of water harvesting technologies.
4. Lack of irrigation facilities. Almost 65% agricultural lands in India are not irrigated.

3. **Impact of drought**
    1. Droughts cause scarcity of food and water. People die of hunger, malnutrition and epidemics.
    2. People are forced to migrate from their area of residence.
    3. Scarcity of water compels people to consume contaminated water resulting in spread of many waterborne diseases like gastro-enteritis, cholera, hepatitis, etc.
    4. Cattle die because fodder and water are not easily available.
    5. Farmers are deprived of their employment.
    6. People leave their villages with their families for a long, unknown and uncertain journey in the pursuit of food, water, green fodder and employment.
4. **Short-term measures**
    1. Rationing of water, drinking water kiosks in Kerala, prioritisation of water use, water trains during Marathwada drought.
    2. Provision of funds under disaster management act to mitigate immediate losses and also mobilising district disaster committees.
    3. Provision of additional working days (increased from 100 to 150) in MNREGA scheme. This provision saw increased demand in drought-hit states.
    4. New farm insurance scheme Fasal Bima Yojana (PMFBY) has been launched by the Govt. Revising norms for crop loss as well as extension of interest subvention schemes for the farmers.
    5. Distribution of safe drinking water, medicines for the victims and availability of fodder and water for the cattle and shifting of the people and their livestock to safer places.
5. **Long-term measures**
    1. Better forecasting of drought by IMD through newer forecasting models using supercomputers (Coupled Forecast System v2, dynamical model).
    2. Water management is the most crucial long-term step for fighting

drought. Rejuvenation of local water bodies and construction of water tanks (Jalyukt Shivar in Maharashtra, Mission Kakatiya in Telangana respectively).

3. By making high bunds around the fields, adoption of terrace cultivation, planting trees on the bunds of fields, the use of rainwater can be maximised. Water can also be conserved by taming the irrigation canals with mortar and bricks.
4. Increasing the awareness regarding water intensive crops, soil health and the judicious use of groundwater. Advance drought warnings through m-Kisan portals.
5. Inter-linking of river basins to shift water from surplus basins to deficit basins (Polavaram project, Ken-Betwa link).
6. Collection of each and every drop of rain could help in coping with the drought.
7. Increasing research in drought-resistant Genetically Modified (GM) crops. Increasing the research focus towards cloud-seeding and other measures to augment precipitation.
8. Increasing the adoption of storm-water drains in cities, as well as increasing the green cover by properly implementing projects such as Green India Mission (GIM) and funds from the Compensatory Afforestation Fund.
9. Livelihood planning identifies those livelihoods which are affected by the drought. Some of such livelihoods include increased off-farm employment opportunities, collection of non-timber forest produce from the community forests, raising goats, carpentry etc.

6. Droughts occur due to natural causes but they are aggravated due to human actions. The initiatives taken by the government are good in intention but suffer from lack of proper implementation and focus. Earnest support to the aforementioned measures can help alleviate the ill-effects of droughts to a great extent.

Why Tank irrigation is famous in South India

1. Tank is an artificial reservoir of water. Tank use is critical in parts of South India.
2. **Reasons**

1. It is difficult to dig canals and wells due to undulating relief and hard rock structure in south India.
2. Low percolation of rain water due to hard rock structure. So, not suitable for well irrigation.
3. Also, most of the rivers of this region are seasonal and dry up in summer season. Therefore, they cannot supply water to canals throughout the year.
4. Most of the tanks are natural and do not involve heavy cost for their construction. Even an individual farmer can have his own tank.
5. Tanks are generally constructed on rocky bed and have longer life span. In many tanks, fishing is also carried on. This supplements both the food resources and income of the farmer.
6. Population and agricultural fields are scattered which makes canal irrigation economically unviable.