GEOGRAPHY

FOR APSC

WORLD, INDIA & ASSAM

ACS

Academy of Civil Services

GEOGRAPHY

Earth and Universe:

- **Big Bang took place 13.7 billion years ago.** The **Big Bang Theory was first suggested by Edwin Hubble in 1920.**
- 2 major evidences of Big Bang Theory: **Red Shift Phenomenon and Cosmic Microwave Background Radiation.**
- **The Gaseous Hypothesis of Immanuel Kant in 1755**
- **The Nebular Hypothesis of Marquis Laplace in 1796**
- **Alfven's Electromagnetic Theory of Hanes Alfven in 1942**
- **Planetesimal Hypothesis of Chamberlin & Moulton in 1904**
- **The Tidal theory of Sir James Jeans & Sir Harold Jeffreys in 1919 & 1926**
- **The Binary Star Hypothesis of H N Russell**
- **The Nova Hypothesis of F Hoyle in 1939**
- **The Interstellar Dust Hypothesis of Otto Schimdt**
- **The Protoplanet Hypothesis of Gerald Kuiper in 1951**
- **The String Theory**
- **The core-accretion theory of planet formation is the currently accepted theory of planet formation.**
- **The word "accretion" refers to the process of a "core" seed gathering more and more material to itself resulting in growth**

GALAXY AND STAR FORMATION

A **galaxy starts to form by accumulation of hydrogen gas in the form of a very large cloud called 'Nebula'**

- The James Webb Space Telescope (JWST), hurled into space by the Ariane 5 rocket will now be able to observe the farthest reaches of the universe without any atmospheric turbulence.
- At Lagrange points, the gravitational pull of two large masses precisely equals the centripetal force required for a small object to move with them. These points in space can be used by spacecraft to reduce the fuel consumption needed to remain in position.
- The Kepler space telescope was a space telescope launched by NASA to discover Earth-size planets orbiting other stars.

CLASSIFICATION OF GALAXIES

- Galaxies are classified by shape. There are **Regular and Irregular Galaxies.**
- Regular Galaxies are **Spiral and Elliptical.**

- **Spiral Galaxies** have a distinctive shape with spiral arms in a relatively flat disk and a central "bulge". The bulge has a large concentration of stars. The arms and bulge are surrounded by a faint halo of stars. The bulge and halo consist mainly of older stars, where spiral arms have more gas, dust and younger stars. **Our Milky Way Galaxy** is a spiral galaxy.
- **Elliptical Galaxies** are round or oval, with stars distributed uniformly throughout. They have a bulge and halo, like spiral galaxies, but don't have the flat disk of stars.
- **Irregular Galaxies** have no identifiable shape or structure to them. They are often chaotic in appearance, without a bulge or any trace of spiral arms.

PLANET FORMATION

- **small-rounded objects by the process of cohesion develop into what is called 'Planetesimals'.**
- Larger bodies start forming by collision, and gravitational attraction causes the material to stick together. **Planetesimals are a large number of smaller bodies.**
- These large number of **small planetesimals accrete to form a fewer large body in the form of planets.**

The Solar System

- Constituents of the solar system: **8 planets + Asteroid Belt + Kuiper Belt + Oort Cloud.**
- The 4 planets outside the orbit of Mars (Jupiter, Saturn, Uranus, Neptune) have low densities because they mostly composed of gases and are called the **Jovian Planets.**

Sl. No.	Planets	Distance from Sun (million kms)	Orbital Period (Earth Days)	Atmosphere	Moons
1	Mercury	58	88 Days		No Moon
2	Venus	108	225 Days	Carbon Dioxide	No Moon
3	Earth	150	365.25 Days	Nitrogen, Oxygen, and other gases (Argon, Carbon dioxide ,Neon etc).	1
4	Mars	228	687 Days	Carbon Dioxide, Nitrogen, and Argon gases	2
5	Jupiter	778	4,333 Days	Hydrogen and Helium gas	53
6	Saturn	1427	10,759 Days	Hydrogen and Helium gas with traces of other substances(Methane & Water ice)	53
7	Uranus	2870	30,687 Days	Hydrogen and Helium, with a small amount of Methane, traces of Water and Ammonia	27
8	Neptune	4497	60,190 Days	Hydrogen and Helium with just a little bit of Methane	14

Planetary Objects in News

- **Amalthea one of Jupiter's 53 named natural satellites.**
- Valles Marineris, or Mariner Valley, is **a vast canyon system that runs along the Martian equator(MARS) just east of the Tharsis region**.
- **A marsquake is a quake which, much like an earthquake, would be a shaking of the surface or interior of the planet Mars.**
- **Mars, however, does not have tectonic plates, and its crust is a giant plate.**
- According to NASA, '**marsquakes' are caused due to stresses that cause rock fractures or faults in its crust.**
- **Saturn's moon Titan holds liquid lakes, rivers and fields of sand dunes, much like Earth**, but the ingredients that make up the landscapes of the two worlds are different.
- For instance, **Titan's sand dunes, rounded piles of sand deposited by the wind, contain hydrocarbons, unlike sand on Earth.**
- Europa is **slightly smaller than Earth's moon** and its diameter is about one-quarter that of the Earth. It is the **sixth-closest to the planet of all the 80 known moons of Jupiter.**
- Europa probably **contains twice the amount of the water in all of the Earth's oceans.**
- Hope spacecraft has **captured images of glowing atmospheric lights in the Red Planet's night sky, known as discrete auroras.**

Eggshell planets

- Eggshell Planets are exoplanets, that **orbit distant stars** and, as their name suggests, these **rocky bodies have an ultra-thin and brittle outer shell.** This means that the new planets could not support plate tectonics.
- Since these eggshell planets are **unlikely to show plate tectonics, such worlds are unlikely to be habitable**.
- What these models predicted was that worlds that are small, old, or far from their star are likely to have thick, rigid layers. However, in some circumstances, the planets could have a brittle outer shell only a few kilometers thick, which are called "eggshells."
- A circumbinary planet is a planet that orbits two stars instead of one.

Major Space Missions Of The World

SOLAR PROBES

- **Parker Solar Probe:** Solar mission-NASA- study the **corona of the sun**. PSP will travel through the sun's atmosphere, closer to the surface than any spacecraft before it.
- **Solar Orbiter:** The Solar Orbiter is a planned Sun-observing satellite of **the European Space Agency and NASA** to study the inner heliosphere and nascent solar wind, and perform close observations of the polar regions of the Sun.

MERCURY MISSIONS

- **MESSENGER:** MESSENGER means (Mercury Surface, Space Environment, Geochemistry, and Ranging). It is **NASA's robotic spacecraft** (2011-2015) to study Mercury's **chemical composition, geology, and magnetic field.** The mission had come to its after running out of propellant.
- **Bepi Colombo:** A joint mission of the **European Space Agency (ESA) and the Japan Aerospace Exploration Agency (JAXA) to Mercury.**

  The mission comprises two satellites launched together:

  - Mercury Planetary Orbiter (MPO) of ESA
  - Mercury Magnetospheric Orbiter (MMO) or *Mio* of JAXA

  The mission will perform a comprehensive study of Mercury, including characterization of its **magnetic field, magnetosphere, and both interior and surface structure.** It was launched on an **Ariane 5 rocket.**

VENUS MISSIONS

- **Akatsuki :**Aka the **Venus Climate Orbiter (VCO), is a Japanese (JAXA)** space probe tasked to study the atmosphere of Venus.

MARS MISSIONS

- **MAVEN:** Mars Atmosphere and Volatile Evolution (MAVEN) is a spacecraft developed by **NASA to study Mars's atmosphere.**
  Objective: determining the history of the loss of atmospheric gases to space and providing answers about **Martian climate evolution.**
- **ExoMars:** It is a joint endeavour between ESA and Roscosmos. The programme comprises two missions:
  - **A Trace Gas Orbiter** (TGO) and an Entry, Descent and Landing Demonstrator Module, known as Schiaparelli – launched in 2016.
  - A **rover and surface platform –** planned for 2020.

  TGO objectives are to search for evidence of **methane and other trace atmospheric gases** that could be signatures of active biological or geological processes.

- **InSight Mission** (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport): It is a robotic lander of NASA to study the interior of Mars.
- **Hope Mars Mission:** Aka Emirates Mars Mission being conducted by **Mohammed Bin Rashid Space Centre of UAE**. It aims to draw a clear and comprehensive picture of the Martian climate. The Hope probe launched in 2020.

ASTEROID BELT MISSIONS

- **Dawn:** Dawn is a mission to the two most massive bodies in the main asteroid belt-**Vesta and Ceres**. It is part of **NASA's Discovery Program.**
- **Hayabusa-2:** It is an asteroid sample-return mission of JAXA. It will explore the near-earth **asteroid Ryugu.** Asteroid Ryugu is a primitive carbonaceous near-earth asteroid. Carbonaceous asteroids are expected to preserve the most pristine materials in the Solar System.
- **OSIRIS-Rex(**Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer): It is an **Asteroid study and sample-return mission of NASA.** Its aim is to study a near-earth carbonaceous asteroid named Bennu. The spacecraft was launched in 2016 and is expected to return by 2023.

JUPITER MISSIONS

- **Juno Mission:** It is NASA space probe orbiting the planet Jupiter. It is part of the New Frontiers Program of NASA. The mission will determine how much water is in Jupiter's atmosphere, look into **Jupiter's atmosphere and measure its properties, map Jupiter's magnetic and gravity fields, and explore and study Jupiter's magnetosphere** near the planet's poles.
- **JUICE:** The "Jupiter ICy moons Explorer" or JUICE is an interplanetary spacecraft of ESA. It will perform detailed investigations of Jupiter and its system along with the **three largest moons of Jupiter**, i.e. **Ganymede, Callisto, and Europa.**
- **Europa Clipper:** The Europa Clipper is an interplanetary mission of NASA to study **Jupiter's moon Europa.** It will investigate whether the icy moon could harbor conditions suitable for life.

SATURN MISSIONS

- **Cassini–Huygens:** The Cassini–Huygens is a collaboration between **NASA, ESA and the Italian Space Agency (ASI)** to send a probe to study the planet Saturn and its system, including its rings and natural satellites. The mission comprised of NASA's Cassini orbiter probe and ESA's Huygens lander, which landed on Saturn's largest moon, **Titan.** The mission had various objectives which included studying the planet's magnetosphere and its gravitational field, its various moons and rings.

  At the end of Cassini's life until September 2017, it was intentionally plunged into Saturn's atmosphere.

- **Dragonfly:** Dragonfly is a planned rotorcraft lander mission (dual quadcopter) to **explore Saturn's largest moon** Titan. It will sample materials and determine surface composition. Also search for chemical signatures that could indicate water-based or hydrocarbon-based life. The dense, calm atmosphere and low gravity make flying an ideal way to travel to different areas of the moon. Dragonfly will be launched in 2026.

URANUS, NEPTUNE, PLUTO & KUIPER BELT MISSIONS

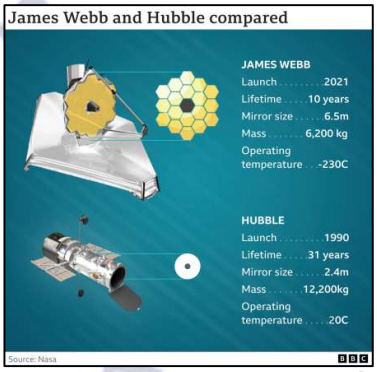
- **Voyager 1 & Voyager 2:** The Voyager program is a scientific program of **NASA** that employs **two robotic probes,** Voyager 1 and Voyager 2, to study the outer Solar System. Voyager 2 conducted flyby missions to **Uranus and Neptune.**

  Currently both the space probes have escaped the heliosphere and is in interstellar space.

- **New Horizons:** New Horizons is an interplanetary space probe that was launched as a part of **NASA's New Frontiers Program.** The goal of the mission is to understand the formation of the **Plutonian system, the Kuiper belt**, and the transformation of the early Solar System.
  It flew by Pluto in 2015, and in 2019 it explored a Kuiper Belt object "Arrokoth" (previously known as Ultima Thule).

The James Webb Space Telescope (JWST):

Hurled into space by the Ariane 5 rocket will now be able to observe the farthest reaches of the universe without any atmospheric turbulence.



About the James Webb Space Telescope

- ✓ The James Webb Space Telescope will find the first galaxies that formed in the early universe and peer through dusty clouds to see stars forming planetary systems.
- ✓ It is the joint project of the National Aeronautics and Space Administration (NASA), ESA (European Space Agency) and the Canadian Space Agency is billed as the next-generation telescope.
- ✓ This telescope is the successor of NASA's Hubble telescope.

Webb Vs Hubble

- ✓ Webb's primary goals are to look at the universe at infrared wavelengths, while Hubble primarily studies the cosmos at optical and ultraviolet wavelengths.
- ✓ Webb has a much bigger mirror than Hubble. Since Webb has a much larger light collecting area, it can peer further back in time than Hubble is capable of doing.
- ✓ Hubble Space Telescope orbits the Earth at an altitude of around 570 kilometres above the planet, according to NASA. Webb will not orbit Earth, but will orbit the Sun, and will sit at the Earth-Sun L2 Lagrange point, 1.5 million kilometres away.
- ✓ Hubble can see the equivalent of "toddler galaxies" or young galaxies, while Webb will be able to see "baby galaxies", or the newborn galaxies. Webb will be able to see the first galaxies because it is an infrared telescope. The telescope will also look back in time to observe the earliest stars.
- ✓ Webb is designed to look deeper into space to look deep into nearby dust clouds to study the formation of stars and planets. It has infrared instruments with longer wavelength coverage and greatly improved sensitivity than Hubble.
- ✓ Both Hubble and Webb can look back in time. Hubble has the ability to observe how the universe was 12.5 billion years ago. Webb is a powerful time machine with infrared vision that will look back in time, more than 13.5 billion years.

About the Black Hole

- The **term 'black hole' was coined in the mid-1960s by American Physicist John Archibald Wheeler.**
- Black holes were **theorized by Albert Einstein in 1915**
- The black hole is **located in the center of galaxy Messier 87,** in the constellation Virgo. It is located about 53 million light years away from earth.
- The black hole has a mass of 6.5 billion suns.
- The Black Hole image is possible by the Event Horizon Telescope (EHT).
- EHT picks up the radiation emitted by particles in the galaxy heated to billion degrees as they revolve around the black hole close to the speed of light.
- Developing an accurate record of **radiocarbon** in the atmosphere from 55,000 years ago is key to **understanding Earth's processes, climate change and our future.** In an article in Science, researchers described this. For example, radiocarbon holds fingerprints of solar storms, which can today destroy much of our communications network.
- The invisible matter that we can't detect is called "dark matter."
- The Swiss astronomer **Fritz Zwicky** first used the term "dark matter" in the 1930s.

SPACE TIME BINDING

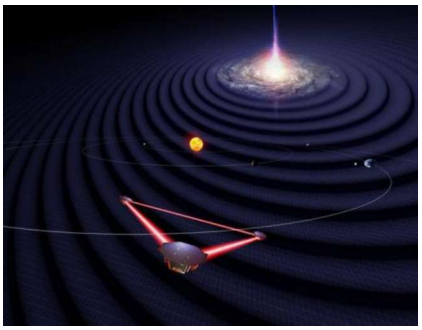
- The famous physicist **Albert Einstein** helped develop the idea of space-time as part of his theory of relativity.
- He describes it as **resembling a sheet of rubber.**
- His **theory of general relativity**that the force of gravity was due to curves in the fabric of space-time.
- Massive objects like the Earth, sun or blackholes create distortions in space-time that cause it to bend.
- These curves, in turn, constrict the ways in which everything in the universe moves, because **objects have to follow paths along this warped curvature.**
- Motion due to gravity is actually motion along **the twists and turns of space-time.**

GRAVITATIONAL WAVES

- Gravitational waves are **'ripples' in space-time** caused by some of the most violent and energetic processes in the Universe.
- Albert Einstein predicted the existence of **gravitational waves in 1916** in his general theory of relativity.
- Einstein's mathematics showed that massive accelerating objects (such as neutron stars or black holes orbiting each other) would disrupt space-time in such a way that **'waves' of undulating space-time** would propagate in all directions away from the source.
- These cosmic ripples would travel at the **speed of light,** carrying with them information about their origins, as well as clues to the nature of gravity itself.

e-LISA

- The evolved Laser Interfermoter Space Antenna (eLISA) is a mission aiming at **exploring the Gravitational Universe from space.**
- The eLISA mission consists of a "**Mother" and two "Daughter**" spacecrafts.
- These will orbit the Sun in a triangular configuration. The three satellites will form **a precision interferometer**. This interferometer will be capable of **detecting gravitational waves.**



LIGO - A Gravitational-Wave Interferometer

- LIGO is a **Gravitational-Wave Interferometer.**
- LIGO currently consists of **two interferometers**, each with two 4 km (2.5 mile) long arms arranged in the shape of an "L". These instruments **act as 'antennae' to detect gravitational waves.**

Gravitational lensing

- When light travels through space and passes near a massive or compact body – a star, a galaxy or a black hole, for example, the intense gravity of that body may attract the light towards it, bending it from its rectilinear (straight line) path.
- This phenomenon is known as gravitational lensing and was first observed by Arthur Eddington in 1919.
- Massive objects like galaxies can bend light significantly, producing multiple images, this is called **strong lensing**.
- Lighter objects like stars or black holes bend light less, and this is called **microlensing**.
- A similar lensing can happen to gravitational waves travelling towards the Earth, and this would leave signatures in the detected gravitational waves.
- This can be used to detect the presence, or the existence, of primordial black holes.

THE SUN

- The sun is comprised of many layers that work together to **produce energy.**
- This energy controls the Earth's climate and weather and provides life for all living things on earth. Because the Sun is mostly composed of **helium and hydrogen** and is not solid, it does not have an outer boundary that is clearly defined.
- The solar interior, from the inside out, is made up of the **core, radiative zone and the convective zone.**

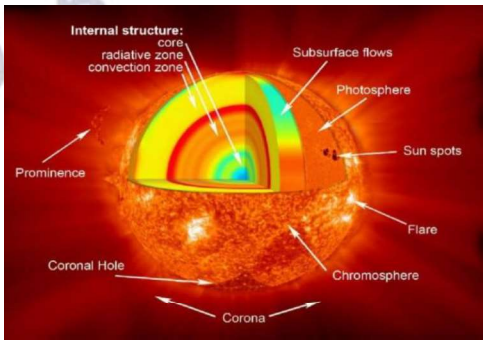
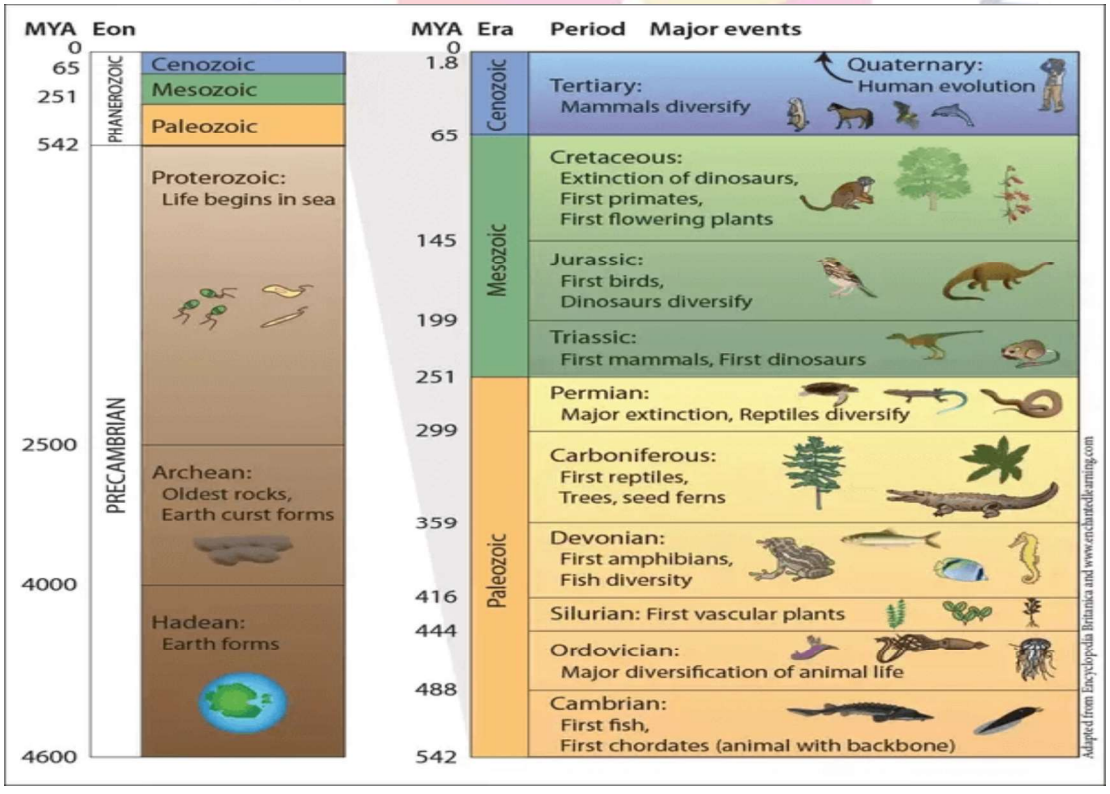


Fig : Different layers and features of the Sun

- The solar atmosphere above that consists of the **photosphere, chromosphere, and the corona** (solar wind is an outflow of gas from the corona).
- **Photosphere:**The photosphere is the **bright outer layer** of the Sun that emits most of the radiation.

- **Chromosphere:** Just above the photosphere is the chromosphere. It is relatively a **thin layer of burning gases.**
- **Sunspot:** A **dark patch** on the surface of the Sun is known as a sunspot. Each spot has a black centre **or umbra**, and a lighter region or **penumbra**, surrounding it. If more sunspots face the surface of the earth, then it eventually increases the temperature on the earth. Sunspot mainly occurs when **magnetic activity** takes place on the surface of the moon. Increase of the sunspot on the surface of the sun is known as **Solar Maximum.** Decrease of the sunspot on the surface of the sun is known as **Solar Minimum.** It takes nearly **11 years** for a sunspot to increase or decrease.
- **Solar Wind:** The solar wind is a stream of energised, charged **particles**, primarily electrons and protons, flowing outward from the Sun at speeds as high as 900 km/s and at a temperature of **1 million degrees (Celsius).**
- **Solar flares:** Solar flares are produced on the sun's surface due to magnetic anomalies. Solar Flares are mainly the charged particles from the sunspot.
- **Solar prominence:** An arc of gas that erupts from the surface of the Sun is called solar prominence.
- **Corona:** A corona is a distinctive **atmosphere of plasma** that surrounds the Sun and other celestial bodies. The Sun's corona extends millions of kilometers into space and is most easily seen during a total solar eclipse.

GEOLOGICAL TIME SCALE



POLE STAR

- The star above the North Pole is known as **Polaris** and it never changes its position.
- Southern Pole Star is known as **Sigma Octantis(Polaris Australis).**

SHAPE OF THE EARTH

- The earth has an **equatorial circumference of 24,897 miles** and its **polar circumference is less by 83 miles**.
- Its equatorial diameter is **longer by 26 miles.** This simply shows that the earth is not a perfect circle.

AXIAL TILT

- The axial tilt of the earth is **23.4º.**
- The equatorial tilt of the earth is **66.6º.**

SOLSTICES AND EQUINOXES

- Solstice means "sun stands still" in Latin.
- It is an astronomical event that occurs twice in a year, once in summer (June) and once in winter (December).
- Summer solstice refers to the **longest day and the shortest night of the year in the Northern Hemisphere**.
- The longest day does not necessarily mean that it brings the earliest sunrise or latest sunset and depends on the latitudinal location of the country.
- Technically, the solstice occurs when the **sun is directly over the imaginary Tropic of Cancer or 23.5°N latitude.**
- The **other names** of Summer Solstice are ***Estival solstice or midsummer.*** .
- The **Northern Hemisphere gets more direct sunlight** and heat from the Sun owing to the **earth's axis' maximum inclination towards the Sun** between March and September.
- During the solstice, the Earth's axis is tilted in a way that the **North Pole is tipped towards the sun and the South Pole is away from it.**
- According to NASA, the amount of incoming energy the Earth received from the sun on this day is 30 percent higher at the North Pole than at the Equator.
- In contrast, the **Southern Hemisphere receives most sunlight on December 21, 22 or 23** when the northern hemisphere has its longest nights– or the **winter solstice.**

LATITUDE

- Latitude is the angular distance of a point on the earth's surface, measured in degrees from the centre of the earth.
- It is **parallel to a line, the equator**, which lies midway between the poles.
- These lines are therefore called parallels of latitude, and on a globe are actually circles, becoming smaller pole wards.
- The **equator** represents **0º** and the **North and South poles are 90ºN and 90ºS**.
- Between these points, lines of latitude are drawn at intervals of 1º.

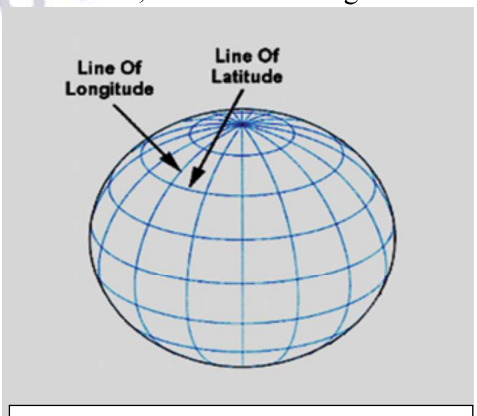


Fig: Latitude & Longitude

- For precise location on a map, **each degree is sub-divided into 60 minutes and each minute into 60 seconds.**
- The most important lines of latitude are the equator, **Tropic of Cancer ($23^1/_2{}^0$N)**, the **Tropic of Capricorn ($23^1/_2{}^0$S)**, **the Arctic circle ($66^1/_2{}^0$N)** and the **Antarctic circle ($66^1/_2{}^0$S)**.
- As the earth is slightly flattened at the poles, the linear distance of a degree of latitude at the pole is a little longer than that of the equator.

LONGITUDE

- Longitude is an angular distance measured in degrees along the equator east or west of the Prime Meridian.
- On the globe longitude is shown as a series of semi-circles that run from **pole to pole passing through the equator** which are called meridians.
- It was finally decided in 1884, by international agreement, to choose as the zero meridian the one which passes through the **Royal Astronomical Observatory at Greenwich**, near London.
- This is the **Prime Meridian (0^o)** from which all other meridians radiate **eastwards and westwards up to 180^o.**

LONGITUDE AND TIME

- Since the earth makes one complete revolution of **360^o in one day or 24 hours**, it passes through **15^o in one hour and 1^o in 4 minutes**.
- The earth rotates from **west to east**, so **every 15^o we go eastwards, local time is advanced by 1 hour**. Conversely, if we go **westwards**, **local time is retarded by 1 hour**.
- Places **east of Greenwich see the sun earlier and gain time**, whereas places **west of Greenwich see the sun later and lose time**.
- If we know G.M.T. to find local time, we merely have to add or subtract the difference in the number of hours from the given longitude.
- A simple memory aid for this will be East-Gain-Add (E.G.A) and West-Lose-Subtract (W.L.S).
- The rotation of the earth round the sun means that **at any point in time different places will experience a different time of day.**

Coordinated Universal Time

- Greenwich mean time was replaced by a universal time system in 1928 and this system was expanded in 1964 when coordinated universal time(UTC) was instituted.
- Today, UTC is the reference for official time in all countries.
- Although the Prime Meridian still runs through Greenwich, UTC is based on an **average time calculation** collected in Paris broadcast worldwide.
- Most countries adopt their standard time from the central meridian of their countries.
- In larger countries such as **Canada, U.S.A., China, and U.S.S.R**, it would be inconvenient to have single time zone. So these countries have multiple time zones.

- Both **Canada and U.S.A.** have **five time zones**—the Atlantic, Eastern, Central, Mountain and Pacific Time Zones. The difference between the local time of the Atlantic and Pacific coasts is nearly five hours.
- S.S.R had eleven time zones before its disintegration. **Russia** now has **nine time zones.**

GPS

- GPS consists of a network **of 24 active satellites** located nearly 20000 kilometers above the Earth's surface.

Sectors used in:

Internet of Things (IoT), Location based services, Emergency and security, Humanitarian services, Scientific research,

Weather and Climate, Transportation, Agriculture, Fisheries, Civil engineering, Communication, Banking, Energy

Types

- **GLONASS(Globalnaya Navigazionnaya Sputnikovaya Sistema)**
- **GALILEO(European Global Navigation Satellite System)**
- **INDIAN REGIONAL NAVIGATION SATELLITE SYSTEM (IRNSS)**
- **GAGAN(GPS Aided GEO Augmented Navigation)**

PREVIOUS YEAR QUESTION

1) How many kilometres are represented by 1º of latitude?

a) 321 km
b) 211 km
c) 111 km
d) 91 km

2. Which of the following is known as the Land of Midnight Sun?

A. Finland
B. Spain
C. Norway
D. Greenland

3. Which one of the following reflects more sunlight as compared to other three?

A. Sand Desert
B. Paddy cropland
C. Land Covered with fresh snow
D. Prairie land

4. Whichcountryon19th July,2020Launcheditsfirst mission to the Mars?

a. India
b. Malaysia
c. United Arab Emirates
d. Iran

5. **According to the most authentic geographical studies, when did life begin in the Earth?**
   (A) 4.2millionyears ago
   (B) 4.6billionyearsago
   (C) 3.8millionyearsago
   (D) 3.8billionyearsago
6. **Which of the following statements is not correct about the International Space Station? (1998)**
   a) It came into reality in December, 1998.
   b) The Russian-built Zarya Module and the USA-built Unity Module fitted together for the first time.
   c) It revolves around the earth at a height of about 1000 km.
   d) The Project seeks to join more than 100 space station components

INTERIOR OF THE EARTH

- There are **three layers of the interior of the earth**:
  - **Crust:** it is the thinnest layer of the earth's interior. It is found within 0-100 km and the pressure in the crustal region is least.
  - **Mantle:** it is found between 100-2900 km.
  - **Core:** there are two parts i.e. **inner core and outer core.** The inner core is in solid medium and the temperature here is above 6000^{o} Celsius. The outer core is in liquid medium.

SOURCES OF INFORMATION ABOUT THE INTERIOR

DIRECT SOURCES

- The most easily available solid earth material is surface rock or the rocks we get from **mining areas.** Gold mines in South Africa are as deep as 3 - 4 km. Going beyond this depth is not possible as it is very hot at this depth. 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". The deepest drill at Kola, in Arctic Ocean, has so far reached a depth of 12 km. This and many deep drilling projects have provided large volume of information through the analysis of materials collected at different depths.
- **Volcanic eruption** forms another source of obtaining direct information. As and when the molten material (magma) is thrown onto the surface of the earth, during volcanic eruption it becomes available for laboratory analysis. However, it is difficult to ascertain the depth of the source of such magma.

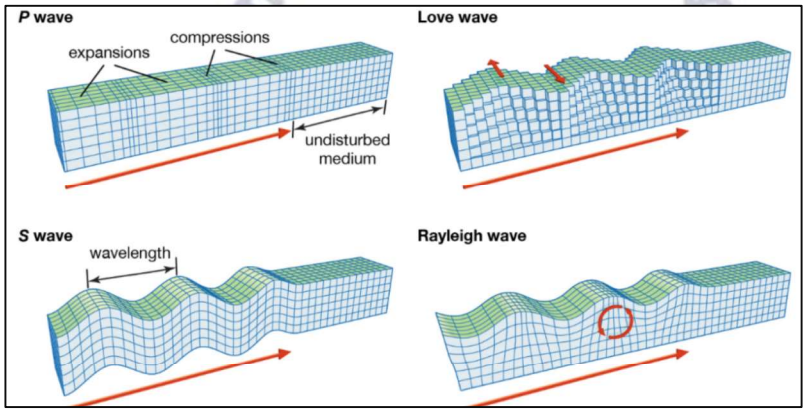
INDIRECT SOURCES

- Analysis of properties of matter indirectly provides information about the interior. We know through the mining activity that temperature and pressure increase with the increasing distance from the surface towards the interior in deeper depths. Moreover, it is also known that the density of the material also increases with depth.
- Knowing the total thickness of the earth, scientists have estimated the values of temperature, pressure and the density of materials at different depths.
- **Temperature** : Temperature goes on increasing with the increase in depth inside the Earth. This is clearly proved while going down a mine or deep wells. On an average, there is a rise of 1^0 C for every 32 meters depth.
- **Density**: In accordance with the Newton's laws of gravity the earth's density has been calculated to be 5.5 (gms per cubic centimetre).
- However, it is surprising that the rocks near the surface of the earth have an average density of 2.7 only (gms per cubic centimetre). This density is less than half the average density of the earth as a whole.
- The earth's internal part is composed of very dense rocks, their density must be in the range of 8-10 (gms per cubic centimetre). The density of the central part of the core is still more.
- Another source of information are the **meteors** that at times reach the earth. The material and the structure observed in the meteors are similar to that of the earth.
- **The Moon:** There are several ways of determining the moon's orbit around earth. Among these one of the important factors is earth's mass. There is close relationship between the mass and earth's gravitation. The movements of the moon and its distance from earth provide the basis for determining the mass of the earth by earth scientists.
- The other indirect sources include **gravitation, magnetic field**, and **seismic activity.** The gravitation force is not the same at different latitudes on the surface. It is greater near the poles and less at the equator.
- The gravity values also differ according to the mass of material. The uneven distribution of mass of material within the earth influences this value. These readings of gravity differ from the expected values. Such a difference is called **gravity anomaly.**
- Gravity anomalies give us information about the distribution of mass of the material in the crust of the earth.
- **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.
- **Seismic activity** is one of the most important sources of information about the interior of the earth.

EARTHQUAKE WAVES

- **Earthquake waves are generally divided into two types**: Body and Surface waves.

Body waves		Surface Waves	
P Waves	**S Waves**	**Love Waves**	**Rayleigh Waves**
I. These are 'Longitudinal Waves'. II. Under their influence particles are displaced in backward-forward direction.(compression waves.) III. Their velocity is the fastest. IV. Their average velocity is 6-15 kms/s. V. Different densities of rocks have different velocities. VI. They can travel through all mediums-solids, liquids and gases.	I. These are Transverse waves. II. Under their impact particles swing side by side (shear waves). III. Their velocity is lower than the primary waves. IV. These waves cannot pass through liquids. They travel through solids only.	I. These are Transverse waves. II. Their propagation is limited to the surface of the earth only. III. Their velocity through solid particles or rocks is about 3.5 kms/s. IV. They cause the greatest damage and destruction of property during the earthquake.	I. It produces the sudden shake in an elliptical motion, with no crosswise or perpendicular motion. II. It moves along the ground just like a wave moves across a lake or an ocean. III. The greater part of the shaking felt from an earthquake is because of the Rayleigh wave, which can be considerably bigger than other waves. IV. Because it rolls, it moves the ground up and down and side-to-side in the same direction that the wave is moving.



THE CRUST

- It is the outermost solid part of the earth.
- **Oceanic crust is thinner as compared to the continental crust.** The continental crust is thicker in the areas of major mountain systems.
- The predominant element seen on the crust of the earth is **Oxygen.**
- **The upper crust** is made up of **Sial (Silicon + Aluminium)**
- **The lower crust and upper mantle** are made up of **Sima (Silica + Magnesium).**
- **Sial is floating over Sima.**

Lithosphere

- ❖ rigid outer part of the earth with thickness varying between 10-200 km.
- ❖ **crust and the upper part of the mantle**.
- ❖ The lithosphere is broken into **tectonic plates (lithospheric plates)**

The Mantle

- ❑ **83 per cent of the earth's volume and holds 67% of the earth's mass**.
- ❑ composed of **silicate rocks that are rich in iron and magnesium**
- ❑ High-pressure conditions ought to inhibit seismicity in the mantle.
- ❑ Find the Elements

Asthenosphere

- ➢ upper portion of the mantle is called as asthenosphere (astheno means weak).
- ➢ **just below the lithosphere** extending up to **80-200 km**.
- ➢ **main source of magma, aid in plate tectonic movement and isostatic adjustments**

The Outer Core

- o **iron mixed with nickel** (**nife**) and trace amounts of lighter elements.
- o Dynamo theory suggests that **convection in the outer core, combined with the Coriolis effect**, gives rise to **Earth's magnetic field**.

The Inner Core

- ▪ composed primarily of **iron (80%) and some nickel** (**nife**).
- ▪ At 6000°C, this iron core is as hot as the Sun's surface, but the **crushing pressure caused by gravity prevents it from becoming liquid**.

SEISMIC DISCONTINUITIES

- These are the regions in the earth where seismic waves behave a lot different compared to the surrounding regions due to a marked change in physical or chemical properties.
- **Mohorovicic Discontinuity** (Moho): Separates the lower crust from the mantle.
- **Gutenberg Discontinuity**: Lies between the lower mantle and the outer core.
- **Repetti Discontinuity**: The discontinuity between the upper mantle and the lower mantle.
- **Lehmann Discontinuity**: The discontinuity between the outer core and the inner core.

MINERAL AND ROCKS

- About **98%** of the total crust of the earth is composed of eight elements like **oxygen, silicon, Aluminium, iron, calcium, sodium, potassium and magnesium,** and the rest is constituted by titanium, hydrogen, phosphorous, manganese, Sulphur, carbon, nickel and other elements.

WHOLE EARTH		EARTH'S CRUST	
Elements	Percentage	Elements	Percentage
1. Iron	35	1. Oxygen	46.6
2. Oxygen	30	2. Silicon	27.7
3. Silicon	15	3. Aluminium	8.1
4. Magnesium	13	4. Iron	5
5. Nickel	2.4	5. Calcium	3.6
6. Sulphur	1.9	6. Sodium	2.8
7. Calcium	1.1	7. Potassium	2.6
8. Aluminium	1.1	8. Magnesium	2.1
Others, less than	1.0	Others, less than	1.4

Fig: Composition of Earth

FORMATION OF ROCKS

- **Solidification:** It is the process of solidifying of molten magma from the Earth's surface. **Igneous rocks are** form due to solidification.
- **Sedimentation:** The existing rocks can disintegrate into fine particles, gravels or pebbles. These sediments combine to form **Sedimentary rocks.**
- **Metamorphism:** It generally means transformation. Due to this transformation, a new rock is formed known as **Metamorphic rock.**

SOME ROCK-FORMING MINERALS

- **Feldspar:** Half the crust is composed of feldspar. It has a light colour, and its main constituents are silicon, oxygen, sodium, potassium, calcium, aluminium. It is used for **ceramics and gloss making**.
- **Quartz:** It has two elements, silicon and oxygen. It has a hexagonal crystalline structure. It is uncleaved, white or colourless. It cracks like glass and is present in sand and granite. It is used in the manufacture of **radio and radar**.
- **Bauxite:** A hydrous oxide of aluminium, it is the **ore of aluminium**. It is non-crystalline and occurs in small pellets.
- **Cinnabar (mercury sulphide):** Mercury is derived from it. It has a brownish colour.
- **Dolomite:** A double carbonate of calcium and magnesium. It is used in cement and iron and steel industries. It is white.
- **Gypsum:** It is hydrous calcium sulphate and is used in cement, fertiliser and chemical industries.
- **Haematite:** It is a red ore of iron.
- **Magnetite:** It is the black ore (or iron oxide) of iron.
- **Amphibole:** It forms about 7 per cent of the earth's crust and consists mainly of aluminium, calcium, silica, iron, magnesium, etc. It is used in the **asbestos industry**.
- **Mica:** It consists of potassium, aluminium, magnesium, iron, silica, etc., and forms 4 % of the earth's crust. It is generally found in igneous and metamorphic rocks and is mainly used in **electrical instruments**.
- **Olivine:** The main elements of olivine are magnesium, iron and silica. It is normally a greenish crystal.

- **Pyroxene:** It consists of calcium, aluminium, magnesium, iron and silica. It is of green or black colour.
- Other minerals like chlorite, calcite, magnetite, hematite, bauxite, barite, etc., are also present in rocks.

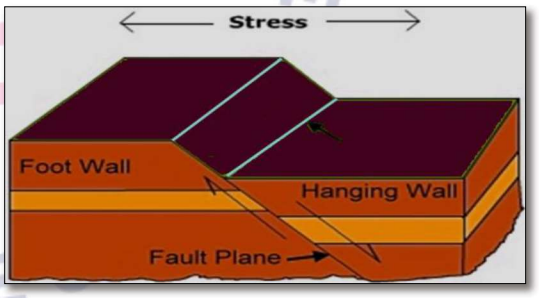
GEOLOGICAL MAP OF INDIA

- **Igneous rocks** can be found in parts of Maharashtra, Madhya Pradesh and Kathiawar region of Gujarat.
- **Sedimentary rocks** can be found in the Deccan region, northern plains and eastern coastal plains of the Himalayan region.
- **Metamorphic rocks** can be found in parts of Tamil Nadu, Karnataka and some other parts of South India.

FOLDING

- The depression created during the process of Folding is called **Syncline.**
- The ridges created during the process of Folding is called **Anticline.**
- The mountains created due to the process of Folding are called **Fold mountains**. E.g. Himalayas.
- The **Syncline** created during the process of folding will **act as the valleys** and the **Anticline will act as the mountains**.
- **Rockies, Andes and Alps** are other examples of Fold mountains.

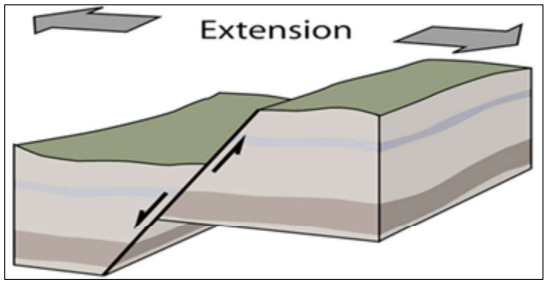
FAULTING



- The extension that takes place during the movement of the earth's plate boundaries is called **Faulting.**
- The cracks running on the surface of the earth is known as **Fault.** In a Normal Fault**,** the **hanging wall** occurs above the fault plane and the **footwall** occurs below it.
- The mountains created during the process of faulting is called **Block mountain.**
- The region where the fault takes place in the earth's surface is called **Fault scrap.Western Ghats** is an example of Fault scrap

Characteristics of Fold Mountains

- Fold mountains belong to the group of **youngest mountains of the earth**.



- The presence of fossils suggests that the **sedimentary rocks** of these folded mountains were formed after accumulation and consolidation of silts and sediments in a marine environment.
- Fold mountains extend for **great lengths** whereas their **width is considerably small**.
- Generally, fold mountains have a concave slope on one side and a convex slope on the other.
- Fold mountains are mostly found along continental margins facing oceans (C-O Convergence).
- Fold mountains are characterized by **granite intrusions** (formed when magma crystallises and solidifies underground to form intrusions) on a massive scale.
- **Recurrent seismicity** is a common feature in folded mountain belts.
- High heat flow often finds expression in **volcanic activity** (Himalayas is an exception, because of C-C convergence).
- These mountains are by far the most widespread and also the most important.
- They also contain rich mineral resources such as **tin, copper, gold** etc.

Block Mountains

- Block mountains are created because of faulting on a large scale (when large areas or blocks of earth are broken and **displaced vertically or horizontally**).
- The uplifted blocks are termed as **horsts,** and the lowered blocks are called **graben**.
- The **Great African Rift Valley (valley floor is graben)**, The **Rhine Valley (graben)** and the **Vosges mountain (horst)** in Europe are examples.
- Block mountains are also called **fault-block mountains** since they are formed due to faulting as a result of tensile and compressive forces.

There are two basic types of block mountains:

1. **Tilted block** mountains have one steep side contrasted by a gentle slope on the other side.
2. **Lifted block mountains** have a flat top and extremely steep slopes.

Longest Mountain Ranges

1. The Andes – 7,000 km
2. The Rockies – 4,830 km
3. The Great Dividing Range – 3,500 km
4. The Transantarctic Mountains – 3,500 km
5. The Ural Mountains – 2,500 km
6. The Atlas Mountains – 2,500 km
7. The Appalachian Mountains – 2,414 km

8. The Himalayas – 2,400 km
9. The Altai Mountains – 2,000 km (1,243 mi)
10. The Western Ghats – 1,600 km
11. The Alps – 1,200 km
12. Drakensberg – 1,125 km
13. The Aravalli Range – 800 km

CONTINENTAL DRIFT THEORY

- Alfred Wegener (German meteorologist)put forwarded "the continental drift theory" in 1912. This was regarding the distribution of the oceans and the continents
- The super continent was named **PANGAEA,** which meant all earth.
- The mega-ocean was called **PANTHALASSA**, meaning all water. He argued that, around 200 million years ago, the super continent, Pangaea, began to split. Pangaea 1st broke into two large continental masses as Laurasia and Gondwanaland forming the Northern and Southern components respectively.
- Subsequently, Laurasia and Gondwanaland continued to break into various smaller continents that exist today. A variety of evidence was offered in support of the continental drift. Some of these are given below.
- **Laurasia** becomes the Northern continents like **North America, Europe and Asia**.
- **Gondwana region** becomes the southern continents like **Australia, Antarctica, Africa and South America.**
- **Indian peninsular region and Madagascar** are the parts of Gondwana region.

EVIDENCES IN SUPPORT OF THE CONTINENTAL DRIFT

- **Jigsaw fit or geological matching, Polarwandering / Paleomagnetism, Paleo climatic unity, Tillite, Distribution of fossils**

SEA FLOOR SPREADING

- Rocks closer to the **mid-oceanic ridges have normal polarity** and are the youngest. The age of the rocks increases as **one moves away from the crest.**
- The **ocean crust rocks are much younger than the continental rocks**. The age of rocks in the oceanic crust is nowhere more than **200 million years** old. Some of the continental rock formations are as old **as 3,200 million years**

CONTINENTAL SHIELD

- Continental shield, any of the large stable areas of **low relief in the Earth's crust** that are composed of **Precambrian crystalline rocks.**
- The age of these rocks is in all cases greater than **540 million years,** and radiometric age dating has revealed some that are as old as **2-3 billion years.**

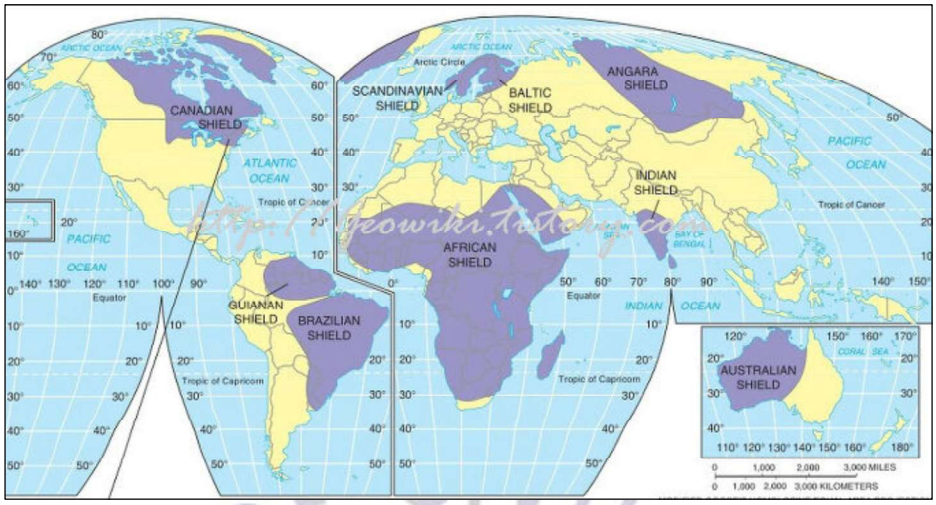


PLATE TECTONIC THEORY

- **Plate tectonics is an improvement over the Continental Drift Theory.**
- According to the **Plate Tectonic theory, it is the plates that are moving and not the continents.**
- **Oceanic crust and continental crust together are known as Plates.**

Major Plates of the World:

1. Eurasian plate
2. Indo-Australian plate
3. Pacific plate
4. North American plate
5. South American plate
6. African plate
7. Antarctica plate

Minor Plates of the World:

1. Philippines plate
2. Carolina plate
3. Cocos plate
4. Nazca plate
5. Caribbean plate
6. Arabian plate
7. Somali plate
8. Scotia plate
9. Burma plate
10. New Hebrides plate

- The plates share boundary with each other. There are **three types of boundaries**. They are:
  - I. Divergent plate boundary
  - II. Convergent plate boundary
  - III. Transform plate boundary

EROSIONAL LANDFORMS

- Valleys (V-shaped)
- Potholes and plunge pools
- Incised or entrenched meanders
- River terraces

DEPOSITIONAL LANDFORMS

- Alluvial fans: found in the western coastal region.
- Deltas: found in the eastern coastal region.
- Floodplains, Natural levees and Point bars
- Meanders
- Braided channels
- Ox Bow Lakes

GROUND WATER

EROSIONAL LANDFORMS

- Pools, Sinkholes, Lapis and Limestone pavements
- Caves

DEPOSITIONAL LANFORMS

- Stalactites, stalagmites and pillars

GLACIERS

DEPOSITIONAL LANDFORMS

- Moraines
- Eskers

EROSIONAL LANDFORMS

- Cirque
- Horns and serrated ridges

WAVES AND CURRENTS

- High rocky coasts
- Low sedimentary coasts

EROSIONAL LANDFORMS

- Cliffs, terraces, caves and stacks

DEPOSITIONAL LANDFORMS

- Bars, barriers and spits
- Beaches and dunes

WINDS

EROSIONAL LANDFORMS

- Pediments and Pedi plains
- Plays
- Deflation hollows and caves

DEPOSITIONAL LANDFORMS

- Sand dunes

List of Lakes in India

Lakes Name	River Name	Type	Surface area	Location	State Name
Kolleru Lake	Krishna and Godavari	Fresh water	245 km2	Vijayawada	Andhra Pradesh
Pulicat Lake	Arani River, Kalangi River and Swarnamukhi River	Brackish to salty	250-450 km2	Chennai, Sriharikota, Sullurpeta	Andhra Pradesh
Deepor Beel	Brahmaputra River	Fresh water	4,014 km2	Guwahati	Assam
Chandubi Lake	Kulsi River	N.A	100 ha	Guwhatai	Assam
Haflong Lake	N.A	High altitude lake	N.A	Silchar	Assam
Son Beel	Kakra River	Fresh water Tectonic lake	34.58 km2	Karimganj	Assam
Kanwar Lake	Gandak River	N.A	N.A	Begusarai	Bihar
Hamirsar Lake	N.A	Artificial lake	11 ha	Bhuj	Gujarat
Kankaria Lake	N.A	Artificial lake	N.A	Ahmedabad	Gujarat
Nal Sarovar	Bhogawo River	N.A	123 km2	Ahmedabad-West	Gujarat
Narayan Sarovar	N.A	Artificial lake	N.A	Bhuj	Gujarat
Thol Lake	N.A	Artificial lake	14 km2	Ahmedabad-West	Gujarat
Vastrapur Lake	Narmada River	Fresh waters	N.A	Ahmedabad-West	Gujarat
Lakhota Lake	N.A	N.A	N.A	Jamnagar	Gujarat

Sursagar Lake	**N.A**	**Artificial lake**	**22,800 m2 (approx.)**	**Vadodara**	**Gujarat**
Brighu Lake	**N.A**	**High altitude lake**	**N.A**	**Kullu**	**Himachal Pradesh**
Dashir Lake	**N.A**	**High altitude lake**	**N.A**	**Keylong**	**Himachal Pradesh**
Dhankar Lake	**N.A**	**High altitude lake**	**N.A**	**Kullu**	**Himachal Pradesh**
Kareri (Kumarwah) lake	**N.A**	**Freshwater, High altitude lake**	**2934 meters (sea level)**	**Dharamsala**	**Himachal Pradesh**
Khajjiar Lake	**Ravi River**	**Mid altitude lake**	**4180.64 m2**	**Chamba**	**Himachal Pradesh**
Macchial Lake	**N.A**	**Low altitude lake**	**N.A**	**Mandi**	**Himachal Pradesh**
Maharana Pratap Sagar	**Beas River**	**N.A**	**400 Km2 (approx.)**	**Kangra**	**Himachal Pradesh**
Manimahesh Lake	**N.A**	**High altitude lake**	**N.A**	**Chamba**	**Himachal Pradesh**
Nako Lake	**N.A**	**High altitude lake**	**N.A**	**Kinnaur**	**Himachal Pradesh**
Pandoh Lake	**Beas River**	**N.A**	**N.A**	**Mandi**	**Himachal Pradesh**
Prashar Lake	**N.A**	**Holomictic**	**N.A**	**Mandi**	**Himachal Pradesh**
Renuka Lake	**N.A**	**Low altitude lake**	**N.A**	**Sirmour**	**Himachal Pradesh**
Rewalsar Lake	**N.A**	**Mid altitude lake**	**N.A**	**Mandi**	**Himachal Pradesh**
Seruvalsar Lake	**N.A**	**High altitude lake**	**N.A**	**Chamba**	**Himachal Pradesh**
Manimahesh Lake	**N.A**	**High altitude lake**	**N.A**	**Chamba**	**Himachal Pradesh**
Suraj Taal	**Chandra River**	**High altitude lake**	**N.A**	**Lahaul and Spiti**	**Himachal Pradesh**

Chandra Taal	**N.A**	**Sweet Water lake**	**N.A**	**Lahaul and Spiti**	**Himachal Pradesh**
Badkhal Lake	**N.A**	**Natural Water ake**	**206 Acres**	**Faridabad**	**Haryana**
Brahma Sarovar	**Rajwaha River**	**Ancient Water Tank**	**430 meters**	**Thanesar**	**Haryana**
Karna Lake	**N.A**	**Landscaped**	**N.A**	**Uchana**	**Haryana**
Sannihit Sarovar	**Seven Sacred Sarasvatis of Rig Veda**	**Holy Water Tank**	**N.A**	**Thanesar**	**Haryana**
Surajkund Lake	**N.A**	**Ancient Reservoir**	**99 Acres**	**Sunam**	**Haryana**
Tilyar Lake	**N.A**	**N.A**	**132 Acres**	**Rohtak**	**Haryana**
Blue Bird Lake	**N.A**	**N.A**	**20 Acres**	**Hisar**	**Haryana**
Dal Lake	**Jhelum River**	**Warm monomictic**	**22 Km2**	**Srinagar**	**Jammu and Kashmir**
Pangong Tso	**N.A**	**Soda lake**	**700 Km2 (approx.)**	**Jammu**	**Jammu and Kashmir**
Tso Moriri	**N.A**	**Brackish**	**30,000 Acres**	**Jammu**	**Jammu and Kashmir**
Wular Lake	**Jhelum River**	**Fresh-Water lake**	**30 - 260 km2**	**Srinagar**	**Jammu and Kashmir**
Manasbal Lake	**Jhelum River**	**Mixing Monomictic**	**2.81 Km2**	**Srinagar**	**Jammu and Kashmir**
Mansar Lake	**N.A**	**Holocene mono-mictic, Oligotropic**	**0.59 Km2**	**Jammu**	**Jammu and Kashmir**
Sheshnag Lake	**Lidder River**	**Alpine high altitude, Oligotrophic lake**	**N.A**	**Anantnag**	**Jammu and Kashmir**
Bellandur Lake (Bangalore)	**Ponnaiyar River**	**N.A**	**3.61 Km2**	**Bengaluru**	**Karnataka**
Ulsoor Lake (Bangalore)	**N.A**	**Stalewater**	**123.6 Acres**	**Bengaluru**	**Karnataka**

Sankey Lake (Bangalore)	**N.A**	**Artificial lake or tank**	**37.1 Acres**	**Bengaluru**	**Karnataka**
Hebbal Lake (Bangalore)	**N.A**	**N.A**	**150 Acres**	**Bengaluru**	**Karnataka**
Lalbagh Lake (Bangalore)	**N.A**	**N.A**	**40 Acres**	**Bengaluru**	**Karnataka**
Puttenahalli Lake (Bangalore)	**N.A**	**N.A**	**13 Acres**	**Bengaluru**	**Karnataka**
Madiwala Lake (Bangalore)	**N.A**	**Artificial tropical lake**	**114.3 ha**	**Bengaluru**	**Karnataka**
Agara Lake (Bangalore)	**N.A**	**Artificial lake**	**0.24 km2**	**Bengaluru**	**Karnataka**
Karanji lake (Mysore)	**N.A**	**N.A**	**90 ha**	**Mysore**	**Karnataka**
Kukkarahalli lake (Mysore)	**N.A**	**Freshwater, Recreational and Fisheries**	**150 Acres**	**Mysore**	**Karnataka**
Lingambudhi Lake (Mysore)	**Kaveri River**	**Perennial freshwater**	**N.A**	**Mysore**	**Karnataka**
Pampa Sarovar	**Tungabhadra River**	**Sacred Pond (Holy Pond for Hindus epic)**	**N.A**	**Koppal**	**Karnataka**
Ashtamudi Lake	**Kallada River**	**Unique wetland ecosystem, a palm-shaped**	**61.42 km2**	**Kollam**	**Kerala**
Maanaanchira Lake	**N.A**	**Artificial, freshwater lake**	**3.49 Acres**	**Kozhikode**	**Kerala**
Padinjare chira Lake	**N.A**	**Artificial pond**	**N.A**	**Thrissur**	**Kerala**
Paravur Kayal	**Ithikkara River**	**Fresh and backwater**	**6.62 km2**	**Kollam**	**Kerala**
Punnamada Lake (Vembanad lake)	**Achenkovil, Manimala, Meenachil, Muvattupuzha, Pamba, Periyar Rivers**	**N.A**	**2033 km2**	**Alappuzha**	**Kerala**

Shasthamkotta lake	**Kallada River**	**Largest freshwater lake**	**920 Acres**	**Kollam**	**Kerala**
Vadakkechira	**N.A**	**Artificial pond**	**4 Acres**	**Thrissur**	**Kerala**
Vellayani Lake	**Karamana River**	**N.A**	**N.A**	**Thiruvananthapuram**	**Kerala**
Upper Lake (Bhopal)	**Kolans River**	**N.A**	**31 km 2**	**Bhopal**	**Madhya Pradesh**
Lower Lake, Bhopal	**N.A**	**N.A**	**1.29 km2**	**Bhopal**	**Madhya Pradesh**
Moti Jheel, Kanpur	**N.A**	**Artificial lake**	**N.A**	**Kanpur**	**Uttar Pradesh**
Gorewada Lake	**Pili River**	**Fresh water lake**	**N.A**	**Nagpur**	**Maharashtra**
Lonar Lake	**N.A**	**Impact crater lake, salt lake**	**1.13 Km2**	**Lonar**	**Maharashtra**
Pashan Lake	**Ram Nadi**	**Artificial lake**	**40 Km2**	**Pune**	**Maharashtra**
Powai Lake	**N.A**	**Artificial lake**	**520 Acres**	**Mumbai**	**Maharashtra**
Rankala Lake	**N.A**	**Picturesque lake**	**107 ha**	**Kolhapur**	**Maharashtra**
Shivajisagar lake	**Koyna River**	**Reservoir**	**891.78 km2**	**Satara**	**Maharashtra**
Talao Pali Lake	**N.A**	**N.A**	**N.A**	**Thane**	**Maharashtra**
Upvan Lake	**N.A**	**N.A**	**500 km2**	**Thane**	**Maharashtra**
Venna Lake	**N.A**	**N.A**	**28 Acres**	**Mahabaleshwar**	**Maharashtra**
Umiam Lake	**Umiam River**	**N.A**	**N.A**	**Shillong**	**Meghalaya**
Loktak Lake	**Manipur River**	**Fresh water (lentic)**	**287 Km2**	**Moirang**	**Manipur**
Palak Dil Lake	**N.A**	**Lentic Lake**	**1.5 Km2**	**Saiha**	**Mizoram**
Tam Dil Lake	**N.A**	**Reservoir**	**N.A**	**Aizawl**	**Mizoram**
Anshupa Lake	**Mahanadi River**	**Fresh water lake**	**141 ha**	**Cuttack**	**Odisha**
Chilka Lake	**Daya River**	**Brackish water**	**1,165 Km2**	**Puri**	**Odisha**

Kanjia lake	**Mahanadi River**	**Natural lake**	**190 Acres**	**Bhubaneswar**	**Odisha**
Kanjli Wetland	**Bien River**	**Freshwater lake**	**4.9 Km2**	**Kapurthala**	**Punjab**
Harike Wetland	**Beas River and Sutlej River**	**Freshwater lake**	**4100 ha**	**Tarn Taran Sahib**	**Punjab**
Ropar Wetland	**Sutlej River**	**Man-made freshwater**	**1,365 ha**	**Rupnagar**	**Punjab**
Dhebar Lake	**Gomati River**	**Reservoir**	**87 Km2**	**Udaipur**	**Rajasthan**
Kaylana Lake	**N.A**	**Artificial lake**	**84 Km2**	**Jodhpur**	**Rajasthan**
Nakki Lake	**N.A**	**Artificial lake**	**N.A**	**Sirohi**	**Rajasthan**
Pachpadra Lake	**N.A**	**Saline lake**	**N.A**	**Barmer**	**Rajasthan**
Pushkar Lake	**Luni River**	**Artificial lake**	**22 km2**	**Ajmer**	**Rajasthan**
Ana Sagar Lake	**N.A**	**Artificial lake**	**97 ha**	**Ajmer**	**Rajasthan**
Rajsamand Lake	**Gomati River**	**Reservoir**	**510 km2**	**Kankroli**	**Rajasthan**
Sambhar Salt Lake	**N.A**	**Salt Lake**	**230 km2**	**Jaipur**	**Rajasthan**
Ramgarh Lake	**N.A**	**Artificial lake**	**15.5 Km2**	**Jaipur**	**Rajasthan**
Siliserhlake, Alwar	**N.A**	**Beautiful artificial lake**	**7 Km2**	**Alwar**	**Rajasthan**
Man Sagar lake	**N.A**	**Freshwater - Recreational**	**300 Acres**	**Jaipur**	**Rajasthan**
Lake Salusagar					**Rajasthan**
Dudh Talai	**N.A**	**Small water tank**	**N.A**	**Udaipur**	**Rajasthan**
Fateh Sagar Lake	**Ayad River**	**Artificial, fresh water, polymictic lake**	**4 km2**	**Udaipur**	**Rajasthan**
Pichola lake	**N.A**	**Freshwater lake**	**1,720 Acres**	**Udaipur**	**Rajasthan**
Rangsagar lake	**N.A**	**Small artificial lake**	**N.A**	**Udaipur**	**Rajasthan**
Swaroopsagar lake	**Ayad River**	**Small artificial lake**	**4 km2**	**Udaipur**	**Rajasthan**

Gurudongmar Lake	**N.A**	**Fresh water lake**	**N.A**	**North Sikkim**	**Sikkim**
Khecheopalri Lake	**N.A**	**Sacred lake**	**9.4 Acres**	**Pelling, West Sikkim**	**Sikkim**
Lake Tsongmo	**N.A**	**Glacial lake**	**N.A**	**East Sikkim**	**Sikkim**
Lake Cholamu	**N.A**	**Glacial, fresh-water lake**	**N.A**	**North Sikkim**	**Sikkim**
Hussain Sagar	**Musi River**	**Artificial lake**	**4.4 Km2**	**Hyderabad**	**Telangana**
Osman Sagar	**Musi River**	**Artificial lake**	**46 km2**	**Hyderabad**	**Telangana**
Himayat Sagar	**Musi River**	**Artificial lake**	**N.A**	**Hyderabad**	**Telangana**
Shamirpet Lake	**N.A**	**Artificial lake**	**100 Acres**	**Hyderabad**	**Telangana**
Mir Alam Tank	**Musi River**	**Artificial lake**	**1.7 Km2**	**Hyderabad**	**Telangana**
Durgam Cheruvu (Secret Lake)	**N.A**	**Freshwater**	**83 Acres**	**Hyderabad**	**Telangana**
Saroornagar Lake	**N.A**	**Artificial lake**	**99 Acres**	**Hyderabad**	**Telangana**
Alwal Cheruvu Lake	**N.A**	**Artificial lake**	**N.A**	**Secunderabad**	**Telangana**
Berijam Lake	**N.A**	**Freshwater**	**59 Acres**	**Dindigul**	**Tamil Nadu**
Chembarambakkam Lake	**Adyar River**	**Artificial lake**	**3,800 Acres**	**Chennai**	**Tamil Nadu**
Kodaikanal Lake	**N.A**	**Fresh-water, Artificial lake**	**N.A**	**Kodaikanal**	**Tamil Nadu**
Ooty Lake	**N.A**	**Artificial lake**	**3.885 Km2**	**Udhagamandalam**	**Tamil Nadu**
Red Hills Lake (Puzhal lake)	**N.A**	**Artificial lake**	**18.21 Km2**	**Chennai**	**Tamil Nadu**
Singanallur Lake	**N.A**	**N.A**	**N.A**	**Coimbatore**	**Tamil Nadu**
Sholavaram Lake	**N.A**	**N.A**	**N.A**	**Thiruvallur**	**Tamil Nadu**
Veeranam Lake	**N.A**	**Artificial, intermittent lake**	**25 Km2**	**Cuddalore**	**Tamil Nadu**
Ramgarh Taal Lake	**N.A**	**N.A**	**1,790 Acres**	**Gorakhpur**	**Uttar Pradesh**
Keetham Lake	**N.A**	**Scenic lake**	**7.13 Km2**	**Agra**	**Uttar Pradesh**

Belasagar Lake	N.A	Artificial lake	16 km2	Kulpahar	Uttar Pradesh
Barua Sagar Tal	N.A	Artificial lake	N.A	Barua Sagar city	Uttar Pradesh
Sheikha Jheel	N.A	Fresh water perennial	30 ha	Aligarh	Uttar Pradesh
Bhimtal Lake	N.A	Largest natural lake	N.A	Bhimtal	Uttarakhand
Dodital	N.A	Freshwater lake	N.A	Dehradun	Uttarakhand
Nainital Lake	N.A	Natural Freshwater	120.5 Acres	Nainital	Uttarakhand
Naukuchiatal	N.A	N.A	N.A	Nainital	Uttarakhand
Sat Tal	N.A	Freshwater lake	4 ha		Uttarakhand
Rabindra Sarobar (Dhakuria Lake)	N.A	Artificial lake	73 Acres	Kolkata	West Bengal
Senchal Lake	N.A	Artificial lake	N.A	Darjeeling	West Bengal
East Calcutta Wetlands	N.A	Natural and human-made wetlands	125 Km2	Kolkata	West Bengal
Santragachhi Lake	N.A	N.A	32 Acres	Santragachhi	West Bengal

Some important drainage basins across the world

Basin	Continent	Drains to	Basin Area km^2
Amazon River	South America	Atlantic Ocean	6,144,727
Hudson Bay	North America	Atlantic Ocean	3,861,400
Congo River	Africa	Atlantic Ocean	3,730,474
Caspian Sea	Asia/Europe	Endorheic basin	3,626,000

Nile River	**Africa**	**Mediterranean Sea**	**3,254,555**
Mississippi-Missouri River	**North America**	**Gulf of Mexico**	**3,202,230**
Lake Chad	**Africa**	**Endorheic basin**	**2,497,918**
Black Sea	**multiple**	**Mediterranean Sea**	**2,400,000**
Niger River	**Africa**	**Atlantic Ocean**	**2,261,763**
Yangtze River (Chang Jiang)	**Asia**	**Pacific Ocean**	**1,722,155**
Baltic Sea	**Europe**	**Atlantic Ocean**	**1,700,000**
Ganges–Brahmaputra	**Asia**	**Bay of Bengal**	**1,621,000**
Indus River	**Asia**	**Arabian Sea**	**1,081,733**

#Identify in the World Physical Map

EARTHQUAKES

- The materials inside the earth's surface contains some energy and due to certain imbalances, these energies get release in certain places. This is called **Earthquake.**
- Wherever, the release of energy is taking place inside the earth's interior, it is called **Focus.**
- The region just above the focus, where the intensity of earthquake is maximum, this place is called **Epicenter.**
- Earthquake is more frequent in places with **Fold mountains because folding will create faulting.**
- Volcanic eruptions can also cause **Earthquake waves.**

EARTHQUAKE MEASUREMENT

- There are **two types of measurement of earthquake**:
    1. **Magnitude scale**
    2. **Intensity scale**

DISTRIBUTION OF EARTHQUAKES IN INDIA

- In the peninsular region of India, **the earthquake is comparatively less.**
- Since the Indian plate converged with the Eurasian plate, and the Himalayas are created, that's why this region has more earthquake occurrence due to the instability caused during the convergence.
- The **entire Himalayan region are above high damage risk zones** such as the entire North-east region, Sikkim, Nepal, Uttarakhand and Kashmir.
- **Bhuj in Gujarat** is also having very high damage risk because of the earthquakes caused.
- **Bhima, tributary of Krishna** has a Faultline nearby, where the damage caused by earthquake is very high; and another one is the **Malda fault**, near the **Rajmahal hills.**
- The Karnataka regions are more stable then Kerela because the intensity of the **earthquake increases towards the Kerela.**
- Also, Delhi is **closer to multiple faults** (Faults are the regions of seismic activities) such as:
- **Mahendragarh-Dehradun Fault (MDF),**
- **Sohna Fault (SF) &**
- **Mathura Fault (MF)**

WORLD DISTRIBUTION OF EARTHQUAKES

- The maximum intensity of earthquake is in the **circum-pacific belt,** which is followed by the **Himalayan-Alpine region.**

Some Important Earthquakes Of The World

Year	*Date*	*Location*	*Deaths*	*Magnitude*
1556	Jan.23	Shenshi, China	830,000	-
1737	Oct.11	Kolkata, India	300,000	-
1923	Sept.1	Kwanto, Japan	143,000	8.2
1939	Dec.27	Erzican, Turkey	40,000	8.6
1970	May 31	Northern Peru	66,000	7.8
1976	July 28	Tangshan, China	250,000	7.6
1978	Sept. 16	Iran	25,000	7.7
2004	Jan.26	Banda Aceh, Sumatra, Indonesia	> 200,000	8.5
2011	March, 11	Tohoku, Japan	>25,000	9.01976
2011	Sept. 18	Sikkim (India)	>500	6.8
2011	Oct. 23	Van (Turkey)	>1000	7.2
2015	April, 25	Gorkha Distt. (Nepal)	>1500	7.9
2016	April 16	Ecuador	1,339	7.8
2017	November 12	Iran-Iraq border, Iran	1,232	7.3
2018	September 28	Sulawesi, Indonesia	5,239	7.5
2019	September 25	Ambon, Indonesia	220	6.5

List of Major Earthquakes in India

DATE	LOCATIONLocation	MagniMAGNITUDEtude
June 16, 1819	Kutch, Gujarat	8
Jan 10, 1869	Near Cachar, Assam	7.5
May 30, 1885	Sopore, Jammu and Kashmir	7
June 12, 1897	Shillong Plateau, Meghalaya	8.7
April 4, 1905	Kangra, Himachal Pradesh	8
July 8, 1918	Srimangal, Assam	7.6
July 2, 1930	Dhubri, Assam	7.1
Jan 15, 1934	Bihar-Nepal Border	8.3
June 26, 1941	Andaman Islands	8.1
Oct 23, 1943	Assam	7.2
Aug 15, 1950	Arunachal Pradesh-China Border	8.5
July 21, 1956	Anjar, Gujarat	7
Dec 10, 1967	Koyna, Maharashtra	6.5
Jan 19, 1975	Kinnaur, Himachal Pradesh	6.2
Aug 06, 1988	Manipur-Myanmar Border	6.6
Aug 21, 1988	Bihar-Nepal Border	6.4
Oct 20, 1991	Uttarkashi, up hills	6.6
Sept 30, 1993	Latur-Osmanabad, Maharashtra	6.3
May 20, 1997	Jabalpur,Madhya Pradesh	6
Mar 29, 1999	Chamoli District, Uttar Pradesh	6.8
Jan 26, 2001	Bhuj, Gujarat	7.7

VOLCANOES

- Volcanoes are classified based on **nature of eruption and the form developed** at the surface.
- Volcanoes are caused, when there is a **magma chamber near the earth's crustal region** and from there the magma will rise upward. This process is called **Volcanocity.**
- The region from where the magma erupts is called **Volcano.**

- The exterior region inside the earth's crust from where the magma is erupting out is called **Vent.** And the region beneath the vent is called **Volcanic Pipe.**
- When the volcano starts to erupt, a depression is caused in the mouth and it is known as **Volcanic Crater.**
- The magma after reaching the earth's crust solidify and take the shape of a **volcanic cone**. And the mountains that will be created there will be of igneous and metamorphic rocks.
- The components of volcano are **Dyke, Sill, Lacolith and Batholith**.
- On the basis of periodicity, the volcanoes are divided into:

ACTIVE VOLCANO	DORMANT VOLCANO	EXTINCT VOLCANO
When the volcano erupts in regular intervals, it is known as **Active volcano**.	The volcano can erupt in future, has also erupted in the past but in the recent past there is no sign of eruption, is known as **Dormant volcano**.	Here, the volcano has very less chance for eruption in future but has erupted in the past, is known as **Extinct volcano.**

- **Barren Island in the Andaman and Nicobar Islands**, Anak Krakatoa are active volcanoes
- **Mount Kilimanjaro** (it has three volcanic cones), is a **dormant** stratovolcano in Tanzania.
- **Mount Kenya** is an extinct stratovolcano.
- The **Barren Island in the Andaman and Nicobar Islands** of India which was thought to be extinct erupted recently.
- **Before a volcano becomes extinct, it passes through a waning stage during which steam and other hot gases and vapours are exhaled. These are known as fumaroles or solfataras.**

Volcanism along the Pacific Ring of Fire

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

Regions with active volcanism along 'Pacific Ring of Fire'

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

The 5 countries with the most volcanoes

1. United States – 173 (most of them are in Alaska)
2. Russia – 166
3. Indonesia – 139
4. Iceland – 130

5. Japan – 112

Other regions

Along the Atlantic coast

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

Great Rift region

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

The West Indian islands

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

Mediterranean volcanism

- Volcanoes of the Mediterranean region are mainly associated with the Alpine folds, e.g. **Vesuvius**, **Stromboli (Light House of the Mediterranean)** and those of the Aegean islands.
- A few continue into Asia Minor (Mt. Ararat, Mt. Elbruz).
- The volcanism of this broad region is largely the result of convergence between the Eurasian Plate and the northward-moving African Plate.
- This type of volcanism is mainly due to **breaking up of the Mediterranean plate** into multiple plates due to the interaction of African and Eurasian plate

TSUNAMI

- A **tsunami** is a **series of waves** of extremely **long wavelength** and is usually caused by a **strong disturbance of the water column**. A tsunami is different from a wind generated surface wave on the ocean.
- It is **not generated by tides** but by certain lithospheric events which disturbs the water column. However, it may be influenced by tide level at the time of its impact on the coast.
- Tsunami may reach **enormous size** and have been known to **travel across the oceans.** The word tsunami is derived from Japanese words **'tsu'** meaning **Harbour** and **'nami'** meaning **wave.**

TSUNAMIS IN THE INDIAN OCEAN

- Even though Indian Ocean is not prone to tsunamis as much as Pacific Ocean, a number of times tsunami has been generated in the Indian Ocean.
- 2004, Sumatra Tsunami of Indian Ocean happened to be one of the most devastating tsunamis in recorded history.

SUMATRA TSUNAMI

- On **26 December 2004,** a powerful earthquake of the **magnitude of 9** on Richter Scale occurred, in the **Indian Ocean**. This earthquake had its **epicenter** off the coast of **Sumatra (Indonesia) at 3.5°N latitude and 95°E longitude**.
- This place happens to be at the **tri-junction** of the **Indian**, **Australian** and **Burmese** (Myanmar) **plates**. The deep oceanic earthquake was caused due to **sudden subduction** of **Indian plate** below **Burma plate** up to **20 meters** in a boundary line of **1000 km** or even more.
- This tectonic movement caused **10 m rise** in the **oceanic bed** which suddenly **displaced immense volume of water** causing killer tsunamis of **wavelength 160 km** and **speed of 960 km/hrs**. Towards inland it had a **height of 10m.**
- **Sumatra tsunami** is also called as the **Tragedy of International dimensions.**

COMPOSITION AND STRUCTURE OF ATMOSPHERE

- Atmosphere is a **mixture of different gases** and it **envelopes the earth** all round.
- The air is an integral part of the earth's mass and **99%** of the total mass of the atmosphere is confined to the **height of 32 km** from the earth's surface..
- Atmosphere mainly protects all the other regions like lithosphere, hydrosphere etc.
- Atmosphere is mainly attached to the earth's surface by gravitational force.
- **99% mass of the atmosphere is within the height of 32 km.**
- Atmosphere acts like a greenhouse by trapping the heat.

COMPOSITION OF THE ATMOSPHERE

- The Atmosphere is composed of **gases, water vapour and dust particles.**
- The proportion of the gas's changes in the higher layers of the atmosphere in such a way that **oxygen will be almost in negligible quantity at the height of 120 km.**
- Similarly, **carbon dioxide** and **water vapor** are found **only up to 90 km** from the surface of the earth.

GASES

CONSTITUENT	FORMULA	PERCENTAGE BY VOLUME
Nitrogen	N_2	78.08
Oxygen	O_2	20.95
Argon	Ar	0.93
Carbon dioxide	CO_2	0.036
Neon	Ne	0.002
Helium	He	0.0005
Krypton	Kr	0.001

Xenon	**Xe**	**0.00009**
Hydrogen	**H_2**	**0.00005**

- **Ozone** is another important component of the atmosphere found between **10 and 50 km** above the earth's surface and acts as a **filter and absorbs the ultra-violet rays' radiation** and prevent them from reaching the surface of the earth.

WATER VAPOUR

- Water vapour is also a **variable gas** in the atmosphere, which **decreases with altitude.**
- In the **warm and wet tropics**, it may account for **4%** of the air by volume, while in the **dry and cold areas** of desert and polar regions, it may be **less than 1%** of the air.
- Water vapor also **decreases from** the **equator towards the poles**.
- It also **absorbs** part of the **insolation** from the sun and **preserves the earth's radiated heat.**

DUST PARTICLES

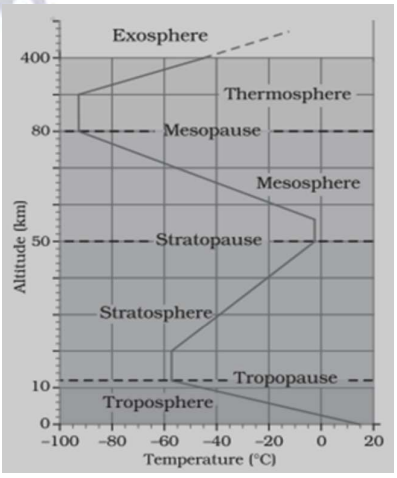
- Atmosphere has a sufficient capacity to keep small solid particles, which may originate from different sources and include **sea salt, fine soil, smoke-soot, ash, pollen, dust and disintegrated particles of meteors.**
- Dust particles are generally **concentrated in the lower layers of the atmosphere;** yet, **convectional air currents** may transport them to great heights.

STRUCTURE OF THE ATMOSPHERE

- The atmosphere consists of different layer with **varying density and temperature.**
- Density is highest near the surface of the earth and decreases with increasing altitude.
- The column of atmosphere is divided into 5 different layers depending upon the temperature condition. They are **Troposphere, Stratosphere, Mesosphere, Ionosphere** and **Exosphere.**

TROPOSPHERE

- **lowermost layer** of the atmosphere.
- Its average height is **13 km** and extends roughly to a height of **9 km near the poles** and about **18 km at the equator.**
- Thickness of the troposphere is the greatest at the equator because heat is transported to great heights by **strong convectional currents**. This layer contains **dust particles** and **water vapour**. All changes in **climate and weather** take place in this layer.
- The temperature in this layer decreases at the rate of **1° c/165 m of heights known as Normal Lapse Rate.**
- The zone separating the troposphere from stratosphere is known as the **tropopause.** The air temperature at the tropopause is about **minus 80° Cover the equator** and about



45°C over the poles. The temperature here is **nearly constant**, and hence, it is called the tropopause and extends up to a **height of 50 km.**

- Jet Aero planes often avoid flying in this layer of atmosphere because of the upward vertical movement of air. And airplanes need horizontal winds and not vertical winds.
- More clouds formation takes place in this layer of atmosphere.

STRATOSPHERE

- One important feature of the **stratosphere** is that it contains the **ozone layer**. This layer **absorbs ultra- violet radiation** and shields life on the earth from intense, harmful form of energy. The temperature increases with altitude in stratosphere.
- **Low vertical mixing**
- **Less clouds formation**
- This layer is suitable for **flying of jet planes** because of the less formation or no formation of clouds.
- The region from stratosphere to mesosphere is called **Stratopause.**

MESOSPHERE

- The **mesosphere** lies above the stratosphere which extends up to a **height of 80 km**. In this layer, once again, temperature **starts decreasing with the increase in altitude** and reaches up to **minus 100° C** at the heights of 80km.
- The upper limit of mesosphere is known as the **mesopause.**
- Mesosphere is **one of the coldest regions in the earth's atmosphere.**
- **Meteor showers** takes place in this layer of atmosphere. These meteors will bring more water vapour from outside the earth's atmosphere.

IONOSPHERE

- The **ionosphere** is located between **80 and 400 km** above the mesopause. It contains **electrically charged particles** known as **ions,** and hence it is known as ionosphere.
- **Radio waves** transmitted from the earth are reflected back to the earth by this layer.
- Temperature here starts **increasing with height**.
- Here, we can see the **formation of Aurora Borealis(**in Northern Hemisphere**) and Aurora Australis(**in Southern hemisphere**).**

EXOSPHERE

- The uppermost layer of the atmosphere above the ionosphere is known as the **exosphere.**

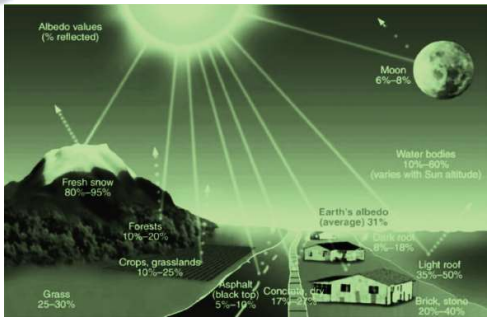
- This is the **highest layer** but very little is known about it. Whatever contents are there, these are **extremely rarefied** in this layer, and it gradually **merges with the outer space**.
- Although all layers of the atmosphere must be exercising influence on us, geographers are concerned with the first two layers of the atmosphere.
- Here, the **density of gases is extremely thin,** and it gradually merges with the outer space.
- **Magnetosphere** can be found in this layer of atmosphere.

INSOLATION

- The earth receives almost all of its energy from **the sun**. The earth in turn **radiates back to space** the energy received from the sun. As a result, the **earth neither warms up nor does it get cooled** over a period of time.
- Thus, the amount of **heat received** by different parts of the earth is **not the same**. This variation causes **pressure differences in the atmosphere.**
- This leads to **transfer of heat** from one region to the other **by winds.**
- Earth receives Sun's radiation (heat) in the form of **short waves (visible light + wavelengths below visible light – most of it is ultraviolet radiation)** which are of electromagnetic nature. The earth absorbs short wave radiation during daytime and reflects back the heat received into space as **long-wave radiation (mostly infrared radiation)** during night.

ALBEDO

- Albedo is the **radiation reflected back by the surface of the earth or any other planet in the solar system.**
- The amount of the light reflected back by the surface is determined by the albedo of that surface.
- The **visual brightness of any planet is determined by its Albedo** such as planet Venus has more visual brightness than planet Mercury among the inner planets of the solar system.
- **Earth's albedo is around 30-35%.** This means out of the total insolation received by the earth, more than 70% is absorbed by the earth's surface and the rest 30-35% is reflected back in the atmosphere.
- The planet **Venus has the highest albedo** among the Inner or Rocky planets.
- The albedo of outer planets or **Gas-giants ranges from 73% to 94%.**
- **Reduction of albedo results mainly in Global Warming.**
- Global warming results in the melting of the ice caps and this ice cap melting again results in the reduction of the albedo which in turn leads to more incoming solar radiation to the earth's surface and thus again causing global warming**.**



- **Light colour surface will have more albedo than the surface with dark colour.**

Earth's Distance form Sun

- During its revolution around the sun, the earth is farthest from the sun **(152 million km on 4th July)**. This position of the earth is called
- On **3rd January**, the earth is the nearest to the sun **(147 million km).** This position is called
- Therefore, the annual insolation received by the earth on 3rd January is slightly more than the amount received on 4th July.
- However, the effect of this variation in the solar output is masked by other factors like the distribution of land and sea and the atmospheric circulation.
- Hence, this variation in the solar output does not have great effect on daily weather changes on the surface of the earth.

HEATING AND COOLING OF ATMOSPHERE

The heat energy from the solar radiation is received by the earth through three mechanisms—

- Radiation == Heat transfer from one body to another **without actual contact or movement**. It is possible in relatively emptier space, for instance, from the sun to the earth through space.
- Conduction == Heat transfer through matter by **molecular activity**. Heat transfer in iron and other metals is by conduction. Generally, denser materials like water are good conductors and a lighter medium like air is a bad conductor of heat.
- Convection == Transfer of heat energy by **actual transfer of matter** or substance from one place to another. (heat transfer by convection cycles in atmosphere as well as oceans)

Seasonal Temperature Distribution

- The global distribution of temperature can well be understood by studying the temperature distribution in January and July.
- The temperature distribution is generally shown on the map with the help of isotherms. The Isotherms are lines joining places having equal temperature.
- In general the effect of the latitude on temperature is well pronounced on the map, as the isotherms are generally parallel to the latitude. The deviation from this general trend is more pronounced in January than in July, especially in the northern hemisphere.
- In the northern hemisphere the land surface area is much larger than in the southern hemisphere. Hence, the effects of land mass and the ocean currents are well pronounced.

Heat Budget:

- The earth receives a certain amount of Insolation **(short waves)** and gives back heat into space by terrestrial radiation **(longwave radiation).** Through this give and take, or the heat budget, the earth maintains a constant temperature.

Daily mean temperature:

- It is **calculated by adding the maximum and minimum temperature of the day and dividing the total by two**.

Monthly mean temperature:

- **It is calculated by adding the daily mean temperatures for the each day of the month and dividing the total by the number of days in a month.**

Annual mean temperature:

- **It is calculated by adding the mean monthly temperatures of all the twelve months and dividing the total by 12.**

Annual range of temperature:

- **It is calculated by subtracting the minimum monthly mean temperature from the maximum monthly mean temperature in a year.**

ANNUAL RANGE OF TEMPERATURE

- There is **high annual range of temperature in land than in Ocean.**
- Large oceans will have less annual range of temperature whereas small oceans will have more annual range of temperature.
- The annual range of temperature on land usually varies according to the seasonal changes whereas the oceans generally have uniform heating over the years.
- The **annual range of temperature is smaller if the size of the ocean is larger**.
- The **annual range of temperature is greater in Northern Hemisphere than in Southern Hemisphere.**
- **Diurnal range of temperature is very high in the desert regions** whereas the annual range of temperature is not so high in those areas throughout the year.

EFFECTS OF TEMPERATURE INVERSION

- **Frost formation:** It means forming of the ice crystals. Temperature inversion can reduce the temperature below 0^{o} C and that will cause the frost to form. It is not at all suitable for agriculture
- **Fog and Smog:** The region where warm and cold air meets up, causes for formations. Fog combines with smoke and gives rise to smog formation. It reduces the visibility which leads to more accidents.
- **Decreases rainfall:** During temperature inversion the cold air at the surface will never rise up due to which clouds formation does not take place. So, it causes less rainfall.
- **Valley floors are avoided for human settlements:** where cold air usually settles down in the valleys which makes the climate colder than other places.

ACADEMY OF CIVIL SERVICES
ESTD 2016

PREVIOUS YEAR QUESTIONS

1) **Which of the following devices is used to record humidity?**
   - **a) Hygrometer**
   - b) Psychrometer
   - c) Thermo-hygrograph
   - d) All of the above

2) **Which of the following is a warm current?**
   - a) South Pacific Current
   - **b) Kuroshio current**
   - c) Labrador current
   - d) Rip current

3) **The tropical cyclone of Phillipines is termed as**
   - a) Typhoon
   - b) Willy-Willy
   - c) Hurricane
   - **d) Baguio**

4) **Biodiversity forms the basis for human existence in which of the following ways?**
   - a) Soil formation
   - b) Prevention of soil erosion
   - c) Recycling of waste
   - **d) Pollination of crops**

5) **Which one of the following basins experiences the conventional rainfall?**
   - **a) Amazon**
   - b) Ganga
   - c) Hwang Ho
   - d) Mississippi

6) **The seasonal reversal of winds is the typical characteristic of**
   - a) Equatorial
   - b) Mediterranean climate
   - **c) Monsoon climate**
   - **d)** All of the above

7. **Raindropsaresphericalinshapebecauseofthephenomenoncalled**
   - a) Viscosity
   - b) Velocity
   - c) Residual pressure
   - **d) Surface tension**

8. **Punjab in winter gets precipitation from the view point(1998)**
   - a) Retreating monsoons
   - b) Cyclones coming from Mediterranean and Gulf of Iran
   - c) South West Monsoons
   - d) N E Trade Winds

PRESSURE BELTS

EQUATORIAL TROUGH OF LOW PRESSURE

- This belt is located on either side of the equator extending between **0º and 10ºN and S**. Its outer margins shift north and south of the **Tropic of Cancer** and the **Tropic of Capricorn** respectively, due to apparent movement of the sun.
- It is thermally produced low pressure belt. Here, the **pressure** is more **uniform** than other parts of the world. **Surface winds** are generally **absent** since winds approaching this region begin to rise vertically near its margin.

SUBTROPICAL HIGH PRESSURE (HORSE LATITUDE)

- The subtropical high pressure is located between the tropics (**25ºN and** S) and **35º north and south latitudes.** This belt is broken into a number of high-pressure cells.
- The high pressure is caused due to the subsidence and piling of the air. The descent of winds from above causes high pressure on the surface which in turn causes **anticyclonic conditions**. And, this zone **(30º-35º)** is characterized by calm conditions with **variable** and **feeble winds.**
- These regions are often referred to as '**horse latitudes'** because in the early days, the sailing vessels with the cargo of horse found it difficult to sail under such **calm conditions**. The sailors used to throw the horses in the sea to make the vessels lighter for smooth sailing and hence, the name.
- This region also aids **desert formations across the earth.**

SUBPOLAR LOW-PRESSURE BELT

- The sub-polar low-pressure belt is located between **45º N and S latitudes** and the **Arctic** and the **Antarctic circles** respectively.
- These low-pressure cells are well developed in the **North Atlantic** and **North Pacific regions**. The low pressure is caused by **converging and rising air**.
- Due to a great contrast between the temperature of the winds from subtropical polar source regions, **cyclonic storms** are produced.

POLAR HIGHS

- At the poles, there are well-developed high-pressure zones. These zones are the result of **persistent low temperature** that makes the air cold and heavy.
- This gives rise to a cap of high pressure in polar region. The **prevailing easterly winds** blow out of these caps of high pressure to sub-polar low-pressure areas.

WATER IN THE ATMOSPHERE

- The air contains water vapour. It varies from 0-4% by volume of the atmosphere and plays an important role in the weather phenomena.
- Water is present in the atmosphere in 3 forms viz., **Gaseous, Liquid and Solid**.

EVAPORATION AND CONDENSATION

- The amount of water vapour in the atmosphere is added or withdrawn due to evaporation and condensation respectively. **Evaporation** is a process by which water is transformed from **liquid to gaseous state**. Heat is the main cause for evaporation.
- The temperature at which the water starts evaporating is referred to as the **latent heat of vaporization**. Increase in temperature increases water absorption and retention capacity of the given parcel of air. Similarly, if the moisture content is low, air has a potentiality of absorbing and retaining moisture.
- Movement of air replaces the saturated layer with the unsaturated layer. Hence, the **greater the movement of air**, the greater is the evaporation.
- The transformation of water vapour into water is called **condensation**. Condensation is caused by the loss of heat.
- When moist air is cooled, it may reach a level when its capacity to hold water vapour ceases. Then, the excess water vapour condenses into liquid form. If it directly condenses into solid form, it is known as **sublimation**.

CLOUDS

- Cloud is a mass of minute water droplets or tiny crystals of ice formed by the condensation of the water vapour in free air at considerable **elevations**.
- As the clouds are formed at some height over the surface of the earth, they take various shapes. According to their height, expanse, density and transparency or opaqueness clouds are grouped under four types**: (i) Cirrus; (ii) Cumulus; (iii) Stratus; (iv) Nimbus.**
- **Cirrus**
  - Cirrus clouds are formed at **high altitudes** (8,000 - 12,000m). They are thin and detached clouds having a feathery appearance. They are always white in colour. They are formed of Ice crystals because here the dew point will be below the freezing point.
- **Cumulus**
  - Cumulus clouds look like **cotton wool**. They are generally formed at a height of 4,000 - 7,000 m. They exist in patches and can be seen scattered here and there. They have a **flat base**. They have a rising dome shape and these clouds mainly represent fair weather. Vertical movement of the air is needed for the cumulus clouds to form vertically.
- **Stratus**
  - As their name implies, these are **layered** clouds covering large portions of the sky. These clouds are generally formed either due to loss of heat or the mixing of air masses with different temperatures. These clouds don't have enough moisture and so no rainfall takes place.
- **Nimbus**

- Nimbus clouds are **black or dark grey**. They form at **middle levels** or very near to the surface of the earth. These are extremely **dense and opaque** to the rays of the sun.
- Sometimes, the clouds are so low that they seem to touch the ground. Nimbus clouds are shapeless **masses of thick vapour**. They are mainly low altitude clouds. These clouds give rise to more condensation and rainfall will take place.

A **combination of these four basic types** can give rise to the following types of clouds: high clouds -cirrus, cirrostratus, cirrocumulus; middle clouds – altostratus and altocumulus; low clouds - stratocumulus and nimbostratus and clouds with extensive vertical development - cumulus and cumulonimbus.

- **High Clouds**
  - **Cirrocumulus clouds:** These clouds are mainly globular in shape and causes less rainfall because of their high altitude.
  - **Cirrostratus:** These are high altitude thin clouds which covers the entire sky. They don't provide any rainfall or shadows.
- **Middle Clouds**
  - **Altostratus clouds:** These clouds mainly cover the sky like a sheet or layer.
  - **Altocumulus clouds:** These are flattened clouds which mainly appear in globular shape. They provide shadows and are much thicker in shape which sometimes can cause rainfall.
- **Low Clouds**

- **Stratocumulus clouds:** These are large globular masses of clouds which we can see in the sky. These are much thicker clouds and they provide more shadows.
- **Nimbostratus Clouds:** 'Nimbo' means having thick water-vapour. When the stratus clouds have more water vapour in it, then it will give more rainfall.
- **Cumulonimbus Clouds:** 'Cumulo' means rising dome shape and 'Nimbus' means having more water vapour. Their formation takes place from low to high altitude. They have great vertical development and mainly produce thunder and lightning. These clouds are associated with thunderstorms. Heavy downpour of rainfall takes place in these clouds. These clouds cannot go beyond the tropopause and so in the high altitude it generally has anvil shape.
  - **HALO FORMATION**

This phenomenon is mainly related with Cirrostratus clouds. Halo is generally a symmetric type shape taking place in the day and night sky.

- **CORONA FORMATION**

This formation is mainly associated with Stratus and Altostratus Clouds. The middle portion of corona will be brighter, and the surrounding portion will be little brighter. At the centre there will be sun or moon.

- **MACKEREL SKY**

These clouds are mainly formed out of cirrocumulus clods.

- **THUNDER CLOUDS**

These are associated with cumulonimbus clouds because they are associated with thunderstorms.

TYPES OF RAINFALL/PRECIPITATION

- On the basis of origin, rainfall may be classified into three main types **– the convectional, orographic or relief and the cyclonic or frontal.**
- **Convectional Rain**: The air on being heated becomes light and rises up in **convection currents**. As it rises, it expands and loses heat and consequently, condensation takes place and **cumulous clouds** are formed. With **thunder and lightning**, heavy rainfall takes place, but this does not last long. Such rain is common in the **summer** or in the **hotter part of the day**. It is very common in the equatorial regions and interior parts of the continents, particularly in the northern hemisphere.
- **Orographic Rain**: When the saturated **air mass comes across a mountain**, it is forced to ascend and as it rises, it expands; the temperature falls, and the moisture is condensed.
- The chief characteristic of orographic rain is the **windward slopes receive greater rainfall**. After giving rain on the windward side, when these winds reach the other slope, they descend, and their temperature rises. Then their capacity to take in moisture increases and the leeward slopes remain rainless and dry. The area situated on the leeward side gets less rainfall is known as the **rain-shadow area (relief rain)**.
- **Cyclonic or Frontal Rain**: It is independent of relief or convection. It is purely associated with **cyclonic activity** whether in the temperate regions (depressions) or tropical regions (cyclones). Basically, it is due to the **convergence** (meeting) of two different air masses with different temperature and other physical properties.
- As cold air is denser, it tends to remain close to the ground. In ascent, pressure decreases, the air expands and cools, condensation takes place and light showers called cyclonic or **frontal rain** occur.
- The heavier and colder air masses eventually push up the warmer and lighter air and the sky is clear again.
- **Convergent Precipitation**: When we have two winds converging near the surface, the air will be going upward creating low pressure in the surface. The rainfall taking place through this process is called Convergent precipitation.
- **Rainfall:** drop size more than 0.5 mm.
- **Virage:** raindrops evaporate before reaching the earth.
- **Drizzle:** light rainfall; drop size less than 0.5 mm.
- **Mist:** evaporation occurs before reaching the ground leading to foggy weather.
- **Snowfall:** fine flakes of snow fall when the temperature is less than 0°C.
- **Sleet:** frozen raindrops and refrozen melted snow; mixture of snow and rain or merely partially melted snow.
- **Hail:** precipitation in the form of hard rounded pellets is known as hail; 5 mm and 50 mm.

WORLD DISTRIBUTION OF RAINFALL

- Different places on the earth's surface receive different amounts of rainfall in a year and that too in different seasons. If we move from the **equator towards the poles, rainfall goes on decreasing steadily.**
- 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.
- Between the latitudes **35^0 and 40^0 N and S** of the equator, the rain is heavier on the eastern coasts and goes on decreasing towards the west. But, between **45^0 and 65^0 N and S** of equator, due to the westerlies, the rainfall is first received on the western margins of the continents and it goes on decreasing towards the east.
- 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.
- On the basis of the total amount of annual precipitation, major precipitation regimes of the world are identified as follows. The **equatorial belt**, the **windward slopes** of the mountains along the western coasts in the cool temperate zone 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. 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.
- **Seasonal distribution** of rainfall provides an important aspect to judge its effectiveness. In some region's rainfall is distributed evenly throughout the year such as in the equatorial belt and in the western parts of cool temperate regions.

FORMS OF CONDENSATION

DEW

- When the moisture is deposited in the form of water droplets on cooler surfaces of solid objects (rather than nuclei in air above the surface) such as stones, grass blades and plant leaves, it is known as **dew.**

FROST

- Frost forms on cold surfaces when condensation takes place below freezing point (0^0C), i.e. **the dew point is at or below the freezing point**.
- The excess moisture is deposited in the form of **minute ice crystals** instead of water droplets. The ideal conditions for the formation of white frost are the same as those for the formation of dew, except that the air temperature must be at or below the freezing point.

FOG AND MIST

- When the temperature of an air mass containing a large quantity of water vapour falls all of a sudden, condensation takes place within itself on fine dust particles. So, **the fog is a cloud with its base at or very near to the ground**. Because of the fog and mist, the **visibility becomes poor to zero**.
- In urban and industrial centers smoke provides plenty of nuclei which help the formation of fog and mist. Such a condition when fog is mixed with smoke, is described as **smog**
- The only difference between the mist and fog is that **mist contains more moisture than the fog**. In mist each nuclei contains a thicker layer of moisture. Mists are frequent over mountains as the rising warm air up the slopes meet a cold surface.
- **Fogs are drier than mist** and they are prevalent where warm currents of air come in contact with cold currents.
- **Fogs** are mini clouds in which condensation takes place around nuclei provided by the dust, smoke, and the salt particles.

CLOUD FORMATION

- Cloud formation mainly influences the weather.
- On a sunny day, the heat from the sun keeps on heating the ground continuously, which in turn makes the ground warm.
- The warm air from the ground rises up in the atmosphere which gradually becomes cooler. The cold air now has less moisture than before.
- The remaining moisture in the air will start to condense and this condensation gives rise to cloud formation.

AIR MASSES

- 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 air with distinctive characteristics in terms of **temperature and humidity** is called an **airmass.** It is defined as a large body of air having little horizontal variation in temperature and moisture.
- The homogenous surfaces, over which air masses form, are called the **source regions**. The air masses are classified according to the source regions.
- There are five major source regions. These are**:** (i) Warm tropical and subtropical oceans; (ii) The subtropical hot deserts; (iii) The relatively cold high latitude oceans; (iv) The very cold snow-covered continents in high latitudes; (v) Permanently ice-covered continents in the Arctic and Antarctica.
- Accordingly, following types of airmasses are recognized: (i) Maritime tropical (MT); (ii) Continental tropical (CT); (iii) Maritime polar (MP); (iv) Continental polar (cP); (v) Continental arctic (CA). Tropical air masses are warm and polar air masses are cold.

FRONTS

- 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.** There are four types of fronts: **(a) Cold; (b) Warm; (c) Stationary; (d) Occluded.**
- When the front remains stationary, it is called as **stationary front.**
- When the cold air moves towards the warm air mass, its contact zone is called the **cold front.**
- Whereas if the warm air mass moves towards the cold air mass, the contact zone is a **warm front.**
- If an air mass is **fully lifted above the land surface,** it is called the **occluded** front.
- The fronts occur in middle latitudes and are characterized 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.**

EXTRA TROPICAL CYCLONES/TEMPERATE CYCLONES

- The systems developing in the mid and high latitude, beyond the tropics are called the **middle latitude or extra tropical cyclones.** The passage of front causes abrupt changes in the weather conditions over the area in the middle and high latitudes.
- Extra tropical cyclones form along the **polar front.** Initially, the front is stationary.
- 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 towards, south setting in motion an **anticlockwise cyclonic circulation.**
- The cyclonic circulation leads to a well-developed extra tropical cyclone, with a warm front and a cold front. There are pockets of warm air or warm sector wedged between the forward and the rear cold air or cold sector.
- The warm air glides over the cold air and a sequence of clouds appear over the sky ahead of the warm front 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.
- 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.**
- The processes of wind circulation both at the surface and aloft are closely interlinked. The extra tropical cyclone differs from the tropical cyclone in number of ways.
- The **extra tropical cyclones** have a **clear frontal system** which is not present in the tropical cyclones. They cover a larger area and can originate over the land and sea. Whereas the tropical cyclones originate only over the seas and on reaching the land they dissipate.
- The **extra tropical cyclone** affects a much larger area as compared to the tropical cyclone. The wind velocity in a tropical cyclone is much higher and it is more destructive. The extra tropical cyclones move from west to east but tropical cyclones, move from east to west.

DISTRIBUTION OF TEMPERATE CYCLONES

- USA and Canada – extend over Sierra Nevada, Colorado, Eastern Canadian Rockies and the Great Lakes region,
- the belt extending from Iceland to Barents Sea and continuing over Russia and Siberia,
- winter storms over Baltic Sea,
- Mediterranean basin extending up to Russia and even up to India in winters (called western disturbances) and the Antarctic frontal zone.

TROPICAL CYCLONES

- They are known as **Cyclones in the Indian Ocean, Hurricanes in the Atlantic, Typhoons** in the **Western Pacific** and **South China Sea**, and **Willy-willies** in the **Western Australia.**
- The diameter of the storm over the Bay of Bengal, Arabian sea and Indian ocean is between 600 - 1200 km. The cyclone creates storm surges and they inundate the coastal lowlands.

FORMATION OF TROPICAL CYCLONE

- **The conditions favorable for the formation and intensification of tropical storms are:**
  I. Large sea surface with temperature higher than 27° C;
  II. Presence of the Coriolis force;
  III. Small variations in the vertical wind speed;
  IV. A pre-existing weak low-pressure area or low-level-cyclonic circulation;
  V. Upper divergence above the sea level system**.**
- **Tropical cyclone** generally occurs in the low-pressure area. From the low-pressure area, the air will be going up carrying moisture and the energy will be released. This released energy is used by the tropical cyclone to intensify the low-pressure at the centre.
- **Tropical cyclones** need **warm ocean waters or high sea surface temperature**. The temperature should be above 27^{o}C. Warm ocean waters have more atmospheric pressure, which is favorable for tropical cyclones.
- **Coriolis force** sustains the spinning movement of the tropical cyclone. The tropical cyclone is limited to 8-20^{o} North and South latitudes. Tropical cyclone cannot from near the equator, because here the Coriolis force is minimum.
- **Inter Tropical Convergence Zone** also helps in the formation of tropical cyclones because it provides low level convergence and high-level divergence. It also provides the initial low pressure for the tropical cyclone to form.
- **Low values of the vertical wind shear** is needed for the tropical cyclones to form. Wind shear means as the altitude of the wind increases, there is a change in the direction or speed of the wind. And this can also disturb the vertical transportation of moisture.
- **Pre-existing disturbances in the low-pressure area** is needed for the tropical cyclones to form.

DIFFERENCE BETWEEN EXTRA-TROPICAL CYCLONES AND TROPICAL CYCLONES

EXTRA TROPICAL CYCLONES	TROPICAL CYCLONES
1. Extra tropical cyclones mainly form due to the frontal system.	1. Tropical cyclones mainly form due to the condensation of atmospheric moisture.
2. Extra tropical cyclones can form both over land and sea because they are influenced by air masses and fronts.	2. Tropical cyclones form only over the oceans. It dissipates over the land region, and the process is known as Landfall.
3. Extra tropical cyclones usually travel from west to east direction.	3. Tropical cyclones travel from east to west direction.
4. The wind velocity of extra tropical cyclones is less.	4. The wind velocity of tropical cyclones is more.
5. Jet stream intensifies the speed of extra tropical cyclones.	5. Jet stream weakens the speed of tropical cyclones.
6. Extra tropical cyclones form due to the temperature contrast between different fronts.	
7. Extra tropical cyclones form over a large area compared to tropical cyclones.	

- More tropical cyclones form over the Bay of Bengal region as compared to Arabian Sea.
- Sea surface temperature is high in Bay of Bengal than the Arabian Sea and so tropical cyclones occur more in Bay of Bengal region.
- More pre-existing disturbances from South China Sea reaches the Bay of Bengal and less in the Arabian Sea.
- Storm Surge:
- Storm Surge is an abnormal rise of sea level as the cyclone crosses the coast.
- Sea water inundates the coastal strip causing loss of life, large scale destruction to property & crop.
- Increased salinity in the soil over affected area makes the land unfit for agricultural use for two or three seasons.
- Storm surge depends on intensity of the cyclone (Maximum winds and lowest pressure associated with it and Coastal bathymetry (shallower coastline generates surges of greater heights).

HOW ARE TROPICAL CYCLONES MONITORED BY IMD?

- A good network of meteorological observatories (both surface and upper air) is operated by IMD, covering the entire coastline and islands.
- The conventional observations are supplemented by observational data from automatic weather stations (AWS), radar and satellite systems.
- INSAT imagery obtained at hourly intervals during cyclone situations has proved to be immensely useful in monitoring the development and movement of cyclones.

THUNDERSTORMS

- **Thunderstorms** are caused by intense convection on moist hot days.
- A thunderstorm is a **well-grown cumulonimbus cloud** producing **thunder and lightning.**
- A thunderstorm is characterized by intense **updraft of rising warm air,** which causes the clouds to grow bigger and rise to greater height. This causes precipitation.
- When the clouds extend to heights where **sub-zero temperature prevails**, **hails** are formed, and they come down as hailstorm.
- The **thunder sound is mainly created due to the supersonic movement of air** and **lightning is caused due to charge separation.**
- **Two factors are needed for the thunderstorms to produce:**
  I. Warm Moist Air
  II. Uplifting Mechanism
- The thunderstorms in India are mainly caused due to **Western Disturbance and Norwesters.**
- The thunderstorm in **West Bengal** is known as **Kalbaisakhi.**
- The thunderstorm in **Assam** is known as **Bordoisila.**

JET STREAMS

Jet streams are

- Circumpolar (situated around or inhabiting around one of the earth's poles),
- narrow, concentrated bands of mean dering, upper tropospheric, high velocity, geostrophic streams, bounded by low speed winds and are a part of upper level westerlies.
- The meandering jet streams are called **Rossby Waves.**
- Rossby waves are formed when polar air moves toward the Equator while tropical air is moving poleward.
- The existence of these waves explains the low-pressure cells **(cyclones)** and high-pressure cells **(anticyclones).**

- Jet streams flow just below the Tropopause.
- Polar jet streams flow **6 – 9 km** above the ground and Sub-tropical jet streams flows **10 – 16 km** above the grounds

WESTERN DISTURBANCE

- Western Disturbance is a **low-pressure area** or a trough over surface or the upper air in the westerly wind's regime, north of **20°N**, causing changes in pressure, wind pattern and temperature fields.

- It is accompanied by **cloudiness**, with or without precipitation. The term Western Disturbance (WD) was coined by Indian meteorologists for describing the systems moving from the **west to east direction**.
- Western Disturbances originate in the **Caspian Sea** or the **Mediterranean Sea** as **extra-tropical cyclones**. They gradually travel across the middle east from **Iran**, **Afghanistan** and **Pakistan** to enter the Indian sub-continent.
- Though Western Disturbances move across the Indian region throughout the year, it is **peak** during **winter months** of **January** and **February**. Their **effect is minimal** during the **monsoon months in India**.
- **Induced systems** are secondary low-pressure areas or cyclonic circulations induced by the primary Western Disturbance. Generally, these are observed over central Pakistan and adjoining west Rajasthan region which gradually shift eastwards, **accentuating rain over Northwest India**.
- They also lead to **rise in temperatures**, **fall of surface pressure**, appearance of high, medium and low **clouds**. Normal pressure and wind patterns are restored with the moving away of the disturbance.

EFFECT

- Western Disturbances along with their induced systems are the principle **rain producing systems** during **non-monsoonal months** over Northwest India including Punjab, Haryana, Uttar Pradesh and Delhi.
- Their effect sometime extends up to Gangetic plains and Northeast India. They are also responsible for bringing **snowfall** in the higher reaches of Jammu & Kashmir, Himachal Pradesh and Uttarakhand.
- **Western Disturbance** brings **winter and pre-monsoon** rain and is important for the development of the **Rabi crop** in the Northern subcontinent. Considering that **wheat** is one of the most important Rabi crops, which is the staple diet of people in this region, winter showers contribute to meet India's food security.
- **Western Disturbances** also influence the **thunderstorms and dust storms**. If there is **insufficient moisture**, a thunderstorm can generate **dust storms.**

ANTI-CYCLONE

- Anti-cyclone is mainly formed over the high-pressure belts.
- During the formation of anti-cyclone, there is always high-pressure at the centre and from there the winds will be spiraling out in all directions. The spiraling winds will generally be cold.

- Anti-cyclone in the Northern Hemisphere generally blow in Clockwise direction and in the Southern Hemisphere in anti-clockwise direction.
- In India, anti-cyclone mainly forms during the winter season.
- **Anti-cyclone** mainly gives rise to Frost formation because of the spiraling cold winds from the high-pressure regions.
- **Anti-cyclone** is mainly caused under the influence of Western Disturbance.

TORNADO

- Severe thunderstorms sometimes spiraling wind descends like a trunk of an elephant with great force, with very low pressure at the centre, causing massive destruction on its way. Such a phenomenon is called a **tornado.**
- **Tornadoes** generally occur in **middle latitudes.**
- **Tornado** is a local storm and the wind velocity is very much high then the other prevailing winds.
- It is a very violent weather event and it mainly occurs in the parts of USA.
- The tornado over the sea is called **waterspouts.**

EL NINO AND LA NINA

- An **El Niño state** occurs when the **central and eastern equatorial Pacific** sea-surface temperatures are substantially **warmer** than usual.
- **La Niña conditions** occur when the central and eastern equatorial Pacific waters are substantially **cooler** than usual. A La Niña event usually, although not always, follows an El Niño event.
- **ENSO (*El Niño-Southern Oscillation*)**describes the natural year-to-year variations in the ocean and atmosphere in the tropical Pacific. It can lead to large-scale changes in sea-level pressures, sea-surface temperatures, precipitation and winds–not only in the tropics but across many other regions of the world. Sea-surface temperatures in the central and eastern equatorial Pacific cycle between above and below-average.
- ***El Niño*** refers to the **ocean component of ENSO**. The ***Southern Oscillation*** part of the term ENSO refers to the **atmospheric component**: the shifting of atmospheric pressure between the central/eastern Pacific and the western Pacific. As the conditions of the ocean change, the atmosphere responds, and vice versa. The main indicators of these changes are pressure and temperature.

NEUTRAL YEAR

- In order to understand the ENSO cycle, we must first understand what the Pacific is like in its neutral state.

AIR PRESSURE

- During neutral years' atmospheric pressure is low in the **warmer western tropical Pacific** (referenced at Darwin, Australia), and relatively higher in the **cooler central/eastern tropical Pacific** (referenced at Tahiti).
- Air naturally moves from areas of high pressure to low pressure, so this difference in pressure moves the **equatorial air**, known as the trade winds, from the coast of South America toward the western Pacific Ocean.

EL-NIÑO

- El Nino is an unusual warming of sea surface temperatures in **equatorial Pacific Ocean**, off the coast of **Peru** and **Ecuador** in South America. It was given its name by the fishermen of Peru, who called it "the Child" because they became aware of it around the Christmas season, as the fish catches failed. The shift of warm seas leaves the **western Pacific cooler** and both temperature shifts seem to play out in disruption of global weather patterns, including the Indian monsoon rainfall. The recent spell of El Nino was one of the **longest and strongest ever**, thus earning the name '**Godzilla'**.

FORMATION

- During El Niño, the **trade winds weaken** or even reverse sometimes, thus warming the ocean. Further, the warmer waters lower air pressure across the central and eastern Pacific, **weakening the pressure gradient** that would normally force the trade winds from Tahiti toward Darwin (east to west). The weaker trade winds reduce the amount of surface water pushed to the west and the surface water stays warm and reinforces the weakened pressure gradient.

EFFECTS

- The direct effects of the changes in temperature and pressure often include **increased rainfall** along the **western coast** of the **Americas**, and **decreased rainfall** around **Indonesia** and **Australia**.
- Much of Asia has been punished by **El-Nino inspired heat wave** marked by record-high temperatures, threatening the livelihoods of countless millions. **Vietnam**, one of the world's top rice exporters, has been particularly hard-hit by its worst drought in a century.
- In the economically vital **Mekong Delta**, breadbasket of Vietnam, the mighty river's vastly reduced flow has left up to 50% of arable land affected by salt-water intrusion that harms crop and can damage farmland. This has also caused food-related unrest in the **Philippines**.
- Neighboring **Thailand** and **Cambodia** also are suffering, with vast areas short of water and Thai rice output curbed. In **Malaysia**, the extreme weather has shrunk reservoirs, dried up agricultural lands, forced water rationing in some areas, and caused repeated school closures as a health precaution.

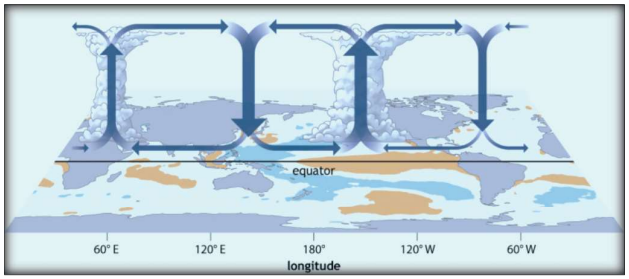


Fig: El-Nino Condition

- El-Nino has also been linked to **drought** and **harvest failures** on the **African continent**, devastating fires in the normally moist rainforests of the **Indonesian archipelago**, both drought and flood in **Australia**, damaging floods in the **Americas**, and unusually mild winters in **Europe**.
- Further, tens of thousands of people have been forced to flee their homes in the border areas of **Paraguay**, **Uruguay**, **Brazil** and **Argentina** due to severe flooding in the wake of **heavy summer rains** brought on by El Niño.
- Also, generally warm El Niño events are characterized by **more tropical storms** and **hurricanes** in the **eastern Pacific** and a **decrease** in the **Atlantic**, **Gulf of Mexico** and the **Caribbean Sea**. In El Niño years, the wind patterns are aligned in such a way that the **vertical wind shear** is increased over the Caribbean and Atlantic.
- The increased wind shear helps to prevent tropical disturbances from developing into hurricanes. In the eastern Pacific, the wind patterns are altered in such a way to reduce the wind shear in the atmosphere, contributing to more storms.

EL-NINO AND CLIMATE CHANGE

- The atmospheric carbon dioxide concentration is rising year-on-year due to human emissions, but now it is getting an extra boost due to the recent El Nino event.
- El Nino **warms** and **dries** tropical ecosystems, **reduces** their **up take of carbon** as well as exacerbates forest fires.

EFFECTS ON INDIA

- El-Nino's impact on weather worldwide has been so entrenched that the winter that ensued has proved to be a warm one with adverse implications for the **Rabi crop** in the North-West. **Western disturbances** that bring crucial precipitation to North-West India and **dense fog** in the region was less frequent and did not have the required amplitude to trigger the usual **thundershowers** over the Rabiland scape.
- Thus, northern Indian experienced a **dry winter**. El-Nino is also seen responsible for the **consecutive droughts of 2014 and 2015** which has affected food production and dampened **rural spending and consumption**.
- EI-Nino is used in India for forecasting long range **monsoon rainfall**. In 1990-91, there was a wild EI-Nino event and the onset of southwest monsoon was delayed over most parts of the country ranging from five to twelve days. Due to recent **Godzilla El-Nino** the **monsoon** ended up with a **deficit** of **14per cent in 2015**, the second consecutive drought year, and only the third such instance in the last 100 years.

LA-NIÑA

- During a La Nina, the equatorial and eastern basin of the Pacific cools below the critical threshold; the western stretches of the vast ocean (closer to Asia) becomes comparably warmer. La Niña occurs as an **enhanced version of the neutral state.**

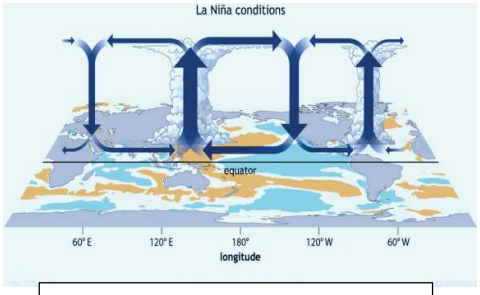


Fig: La-Nina Condition

- When air pressure is higher-than-average in Tahiti and lower-than-average in Australia, the easterly trade winds blow more intensely than usual. The colder-than-normal ocean water extends across the eastern and central equatorial Pacific, and the winds continue to push water westward, increasing the sea level around Indonesia.
- The water in the **western Pacific** thus **warms up** and this warmth brings **convection** (cloud-building), **storms** and **precipitation** to this region, and when coinciding with the **Indian monsoon**, it brings **good rains** into the subcontinent as well.
- La Nina is traditionally associated with a normal to above-normal Indian monsoon although there is no direct one-to-one relationship between the two. Based on **26 El Nino events** since **1900**, around **50%** have been followed by a **neutral** year, while **40%** have been followed by a **La Nina**.
- La-Nina could bring heavy rain to an already flood-prone region, exacerbating agricultural damage and leaving crops vulnerable to disease and pests.

CLOUD BURST

- Sudden heavy rainfall (100 mm per hour)
- Short duration
- Small geographical area
- Hilly areas

FORMATION

- Vertical winds
- Coalescing rain droplets
- Hilly terrain
- Monsoon clouds
- Vertical and high clouds

EFFECTS

- Flash floods
- Landslide and Mudslide

- Thunderstorms and hail formation

CLIMATIC REGIONS OF THE WORLD

THE HOT, WET EQUATORIAL CLIMATE

- **DISTRIBUTION :** The equatorial, hot, wet climate is found between **5° and 10° North and South** of the equator. Its greatest extent is found in the lowlands of the Amazon, the Congo, Malaysia and the East Indies.
- **CLIMATE**

➢ **Temperature:** It has great **uniformity of temperature** throughout the year. The mean monthly temperatures are always around **26°C** with very little variation. There is **no winter**. **Cloudiness** and **heavy precipitation** help to moderate the daily temperature. Regular **land and sea breeze** assist in maintaining a truly equable climate. The diurnal and annual range of temperature is small.

➢ **Precipitation:** Precipitation is heavy and **well distributed** throughout in the year. There is no month without rain and a distinct **dry season is absent**. There are two periods of maximum rainfall, in April and October which occur shortly after the equinoxes and least rain falls at the June and December solstices. The **double rainfall peaks** coinciding with the **equinoxes** are a characteristic feature of equatorial climates**.** Due to the great heat in the equatorial belt, mornings are **bright and sunny**. There is much evaporation and convectional air currents are set up, followed by heavy downpours of **convectional rain** in the **afternoons** from the towering **cumulonimbus clouds**.

THE TROPICAL MONSOON AND TROPICAL MARINE CLIMATES

- The tropical monsoon lands are characterized with **on-shore wet monsoons** in the summer and **off-shore dry monsoons** in the winter. Best developed in the Indian sub-continent,Burma, Thailand, Laos, Cambodia, parts of Vietnam and south China and northern Australia. Outside this zone, the climate is modified by the **influence of the on-shore Trade Winds** all the year round and has a more **evenly distributed rainfall**. Such a climate better termed the **Tropical Marine Climate**, is experienced in Central America. West Indies, north-eastern Australia, the Philippines, parts of East Africa, Madagascar, the Guinea Coast and eastern Brazil.

TROPICAL MONSOON LANDS

- The basic cause of monsoon climate is the difference between in the **rate of heating and cooling of land and sea**. In the **summer**, when the sun is overhead at the tropic of cancer, the great land masses of the northern hemisphere are heated. **Central Asia** will be hotter than its normal temperature and a region of **intense low pressure** is set up. At the same time, the southern hemisphere experiences winter, and a region of high pressure is set up in the continental interior of Australia. Wind blows outwards from this high pressure towards the low pressure in Central Asia, bringing rainfall to the landmasses. In the **winter**, conditions are reversed. The sun is overhead at the Tropic of Capricorn, central Asia is extremely cold, resulting in rapid cooling of the land. A region of high pressure is created without blowing winds – the **North-East monsoon**.

On crossing the equator, the winds are attracted to the low-pressure centre in Australia and arrive in northern Australia as the **North-West Monsoon.**

- In tropical monsoon climate regions three distinct seasons can be identified.
- The **Cool Dry Season (Oct-Feb)** with low temperature and little or no precipitation.
- The **Hot Dry Season (March-mid June)** with high temperature and low relative humidity.
- The **Rainy Season (mid June-Sep)** with torrential downpours. This **concentrated heavy rainfall in summer** is a characteristic feature of the tropical monsoon climate.

THE TROPICAL MARINE CLIMATE

➢ This type of climate is experienced along the **eastern coasts of tropical lands**, receiving **steady rainfall** from the Trade Winds all the time. The rainfall is both **orographic** where the moist trade winds meet upland masses as in **eastern Brazil**, and **convectional** due to intense heating during the day and in summer. Its tendency is towards a **summer maximum** as in monsoon lands, but **without any distinct dry period**. Approximately 70% of the rainfall is concentrated in the four summer months but there is **no month without any rainfall**. Due to the steady influence of trades, the Tropical Marine Climate is more favorable for habitation, but it is prone to severe **tropical cyclones, hurricanes or typhoons.**

THE SAVANNA OR SUDAN CLIMATE

- **DISTRIBUTION**

➢ The Savanna or Sudan Climate is a **transitional type of climate** found between **the equatorial forests** and the **trade wind hot deserts** as it gets **convectional rainfall** during the summer, whereas during **rest of the year** it remains **dry** under the dominating **influence of the trade winds**. This climatic type is bounded by tropical rainforest climate toward the equator and by dry climates towards the poles. Savanna climate-Sudan and Veld Plateau of Africa, the tropical grasslands of northern Australia, the Llanos of the Guiana highlands of South America and the Campos of Brazil. They are best developed in the Sudan where the **dry and wet seasons** are most distinct, hence its name the **Sudan Climate**.

- **CLIMATE**

➢ **Rainfall:** The Sudan type of climate is characterized by an **alternate wet summer with dry winters**. The annual rainfall is about 160cm. Floods and droughts are quite common. Duration of the rainy season and the average amount of annual rainfall decreases with the increasing distance from the equator.

- **TEMPERATURE**

➢ Temperature is **high throughout the year**, the annual average temperature being about 23^{o}C. The annual range of temperature is 5^{o} to 6^{o}C and it increases away from the equator. Here the tropical rainforest gives way to the savanna, a tropical grassland with **scattered deciduous trees**. Days are hot and when night falls the clear sky which promotes intense heating during day, also causes rapid radiation in the night. Temperatures drop and night frosts are not uncommon. This **extreme diurnal range of temperature** is another characteristic feature of the Sudan type of climate.

- **WINDS**

- The prevailing winds of the region are the **Trade Winds**, which bring rain to the coastal districts. They are strongest in the summer but are relatively dry by the time they reach the continental interiors or **western coasts** of the continents. In West Africa the North-East Trades, in fact, blow off-shore from the Sahara Desert and reach the Guinea coast as a dry, dust-laden wind, called locally the **Harmattan**, meaning **'the doctor'**. It is so dry that its relative humidity seldom exceeds **30%.** 'The doctor' provides a welcome relief from the damp air of the Guinea lands by increasing the rate of evaporation with resultant cooling effects, but it is such a dry dusty wind that, besides ruining the crops, it also stirs up a thick **dusty haze and impedes inland river navigation.**

THE HOT DESERT AND MID-LATITUDE DESERT CLIMATES

- **DISTRIBUTION**
  - The chief feature of any desert climate is the **scarcity of water**. This results where evaporation exceeds precipitation. Aridity or dryness is not simply a matter of low precipitation, but of the '**effective precipitation'**. The aridity of the hot deserts is mainly due to the effects of **off-shore Trade Winds**; hence they are also called
- **Trade Wind Deserts**.
  - The major hot deserts of the world are located on the **western coasts of continents** between latitudes **15º and 30ºN and S**. They include the **Sahara Desert**, the largest single stretch of desert. The next biggest desert is the **Great Australian Desert** which covers almost half of the continent. The other hot deserts are the **Arabian Desert, Iranian Desert, Thar Desert, Kalahari and Namib Deserts.** In North America, the desert extends from Mexico into U.S.A.
  - **Tropical deserts** located along the west coast of continents reveal marked **influence of cold ocean currents** on their climates. For example, Atacama in Peru and Chile, and the Namib in south-west Africa. These areas receive the lowest annual rainfall totals in the world despite their location adjacent to the oceans. In fact, the aridity in this part is intensified because of the **cold offshore waters** which chill the air and further stabilize it.
  - The **temperate deserts** are rainless because of their **interior location** in the temperate latitudes, well away from the **rain-bearing winds**. Amongst the mid-latitude deserts, many are found on plateau and are at a considerable distance from the sea. These are Gobi, Turkestan and Patagonian Deserts. The Patagonian Desert is more due to its rain-shadow position on the leeward side of the lofty Andes than to continentality.
- **CLIMATE**
  - **Rainfall:** The hot deserts lie astride the **Horse latitudes** where the air is descending, a condition least favorable for precipitation of any kind to take place. And the rain bearing **trade winds** blow offshore and the **westerlies** that are onshore blow outside the desert limits. Also, the desiccating effect of the **cold oceanic current** along the coast deserts is so pronounced that the mean annual rainfall is very less. Thus, precipitation is low, and rain normally occurs as violent **thunderstorms** of the convectional type. The thunderstorm is so violent and comes so suddenly that it has disastrous consequences on desert landforms.

- **TEMPERATURE:**
  - Deserts have high temperatures throughout the year. The reasons for the high temperatures are obvious – **a clear, cloudless sky, intense insolation, dry air and a rapid rate of evaporation.** There is **no cold season** in the hot deserts. Coastal deserts by virtue of their maritime influence and the cooling effect of the cold currents have much lower temperatures.
  - The desert interiors, however, experience much higher summer temperatures and the winter months are rather cold.
  - The **diurnal range of temperature** in the deserts is very great. Intense insolation by day in a region of dry air and no clouds causes the temperature to rise with the sun. But as soon as the sun sets, the land loses heat very quickly by radiation. **Frost** may occur at night in **winter**.
- **CLIMATIC CONDITIONS IN THE MID-LATITUDE DESERT**
  - **mountains** all around them. As a result, they are cut off from the rain bearing winds. Occasionally **depressions** may penetrate the Asiatic continental mass and bring light rainfall in winter, or unexpected **convectional storms** bring brief showers in summer.

THE WARM TEMPERATE WESTERN MARGIN (MEDITERRANEAN) CLIMATE

- **DISTRIBUTION**
  - The Warm Temperate Western Margin Climate is found in relatively few areas in the world. They are entirely confined to the western portion of continental masses between **30º and 45º north and south** of the equator. Areas around the Mediterranean Sea, Central California, Central Chile, southern part of South Africa and south-eastern and south-western parts of Australia experience this climate. The basic cause of this type of climate is the **shifting of the wind belts**. Though the area around the Mediterranean Sea has the greatest extent of this type of **'winter rain climate'** and gives rise to the more popular name Mediterranean Climate, the best developed form of this peculiar climatic type is in fact, found in central Chile.
- **CLIMATE**
  - **Rainfall**: Rainfall is **moderate** and varies between 40 and 60cms. Most of it occurs in the winter season due to the prevailing **onshore westerlies**. The rain comes in **heavy showers** and only on a few days with bright sunny periods between them.
  - **Temperature**: As there is seasonal shift of pressure belts with the annual movements of the sun, these areas come under the influence of **sub-tropical high-pressure** conditions during **summer** and **cyclonic low-pressure** conditions during **winter**. Summers are, therefore, warm and dry, temperature being in between 20º-27ºC. Winters are mild with temperature ranging between 1º-10ºC. The annual range of temperature is about 10º-17ºC.
  - Climatic characteristics of Mediterranean climate are, bright sunny weather with **hot dry summers and wet, mild winters**; and prominence of **local winds** (Sirocco, Mistral, Bora etc.) around the Mediterranean Sea.

THE TEMPERATE CONTINENTAL (STEPPE) CLIMATE

- **DISTRIBUTION**

- Bordering the deserts, away from the Mediterranean regions and in the interiors of continents are the **temperate grasslands**. Though they lie in the Westerly wind belt, they are so remote from maritime influence that the grasslands are **practically treeless**. In **Eurasia,** they are called the **Steppes** and in **North America**, the grasslands are also quite extensive and are called **Prairies.** In the southern hemisphere, due to the narrowness of the temperature portions of the southern continents, the grasslands are rather restricted and less continental.
- Unlike the low latitude deserts, the steppes are not controlled by the subsiding air masses of the sub-tropical anticyclones. Instead, these are dry lands principally because of their position in the **deep interiors of large land masses** away from the oceanic influences, in addition, presence of **mountain barriers** across the paths of the prevailing winds further restrict maritime influences. The middle latitude deserts having steppe climates are, therefore, most widespread in North America and Eurasia.

- **CLIMATE**
  - **Temperature:** The **annual means** (21°C) as well as **annual range** of temperatures (13°C) are comparatively **lower**. In **northern hemisphere**, their climate is continental with extremes of temperature. Summers are very warm, and winters are very cold, so that the Eurasian Steppes are snow covered for several months and the snow melts with the return of spring and by mid-summer temperatures are high. In contrast, the steppe climate region in **southern hemisphere** is never severe due to maritime influence.
  - **Precipitation**: This climatic type is characterized by **meagre and unreliable precipitation** like the tropical deserts. The annual rainfall is 30cm. Steppes located on the poleward side of the deserts receive maximum rainfall during the cool season, while those located towards the equator receive it during the warm season.

THE WARM TEMPERATURE EASTERN MARGIN (CHINA TYPE) CLIMATE

- This type of climate is found on the **eastern margins of continents** between **25°** and **45°** latitudes. It has comparatively **more rainfall than the Mediterranean climate** in the same latitudes, coming mainly in the **summer**. China type occurs in the south-eastern United States, Uruguay, Argentina, southern Brazil, eastern China, southern Japan and eastern coastal belt of Australia.

- **Summers are hot and humid. Winters are mild**. The average annual temperature is 20°C and the average annual range of temperature is about 17°C. Yearly precipitation totals are usually more than 100 centimeters. It is **well distributed throughout the year**. These areas experience dreaded **hurricanes and typhoons**, mostly in the late summer and autumn.

THE COOL TEMPERATE WESTERN MARGIN (BRITISH TYPE) CLIMATE

- The cool temperature **western margins** are under the permanent influence of the Westerlies all-round the year they are also regions of much **cyclonic activity**, typical of Britain, and are thus said to experience the British type of climate. From Britain, the climatic belt stretches far inland into the lowlands of North-West Europe, including such regions as northern and western France, Belgium, the Netherlands, Denmark, western Norway and also north-western Iberia**.** There is so much **oceanic influence** on both the temperature and the precipitation. **Summers** are, in fact never very warm and **winters** are abnormally mild. This is attributable to the warming effect of the **warm North Atlantic Drift** and the **prevalence of the south westerlies**. It has adequate rainfall throughout the year with a tendency towards a **slight winter or autumn maximum** from cyclonic sources. Since the rain-bearing winds come from the west, the western margins have the heaviest rainfall. The amount decreases eastwards with **increasing distance from the sea.** This climate is ideal for **maximum comfort** and **mental alertness**.

THE COOL TEMPERATE CONTINENTAL (SIBERIAN CLIMATE)

- **DISTRIBUTION**
  - The **Cool Temperate Continental (Siberian) Climate** is experienced only in the northern hemisphere where the **continents** within the **high latitudes** have a broad east-west spread. On its poleward side, it merges into the Arctic tundra of Canada and Eurasia at around the Arctic Circle. Southwards, the climate becomes less severe and fades into the temperate Steppe climate.
  - The predominant vegetation of this Siberian or "sub-Arctic" type of climate is **evergreen coniferous forest**. It stretches in a great, continuous belt across North America, Europe and Asia. The greatest single band of the coniferous forest is the **taiga** (a Russian word for **coniferous forest**) in Siberia. In Europe the countries that have a similar type of climate and forest are mainly in northern Europe, Sweden, and Finland.
  - The Siberian Climate is conspicuously **absent in the southern hemisphere** because of the narrowness of the southern continents in the high latitudes. The strong oceanic influence reduces the severity of the **winter and coniferous forests** are found only on the mountainous uplands of southern Chile, New Zealand, Tasmania and south-east Australia.
- **CLIMATE**
  - **Temperature:** The climate of the Siberian type is characterized by a **bitterly cold winter** of long duration, and a cool brief summer. The **summers are short,** and the temperature varies between **10^{o}C and 15^{o}C**. The **winters are long and very cold**. Minimum temperature may be as low as – 50^{o}C. The extremes of temperature are so great in Siberia that it is often referred to as the '**cold pole of the earth'**. In North America the extremes are less severe, because of the continent's lesser east-west stretch. With low temperatures in the cold season, heavy snowfall can be expected. **Frosts** occur as early as August and by September lakes and ponds are already ice-bound. All over Russia, nearly all the **rivers are frozen**.
  - **Precipitation:** The interiors of the Eurasian continent are so remote from maritime influence that annual precipitation cannot be high. The **precipitation is low** and is

concentrated in **warmer months**. Despite its small amount, it is sufficient for tree growth because evaporation is less. The vegetation associated with this climatic type is the **soft-wood coniferous forest**.

THE COOL TEMPERATE EASTERN MARGIN(LAURENTIAN)

- **DISTRIBUTION**
  - The cool Temperate Eastern Margin (Laurentian) Climate is an intermediate type of climate between the **British and the Siberian type of climate**. It has features of both the maritime and the continental climates. Laurentian type of climate is found only in two regions. One is **north-eastern North America, including eastern Canada, north-east U.S.A,** (i.e. Maritime Provinces and New England states), and Newfoundland. This may be referred to as the North American region. The other region is the eastern coastlands of Asia, including eastern **Siberia, North China, Manchuria, Korea and northern Japan.** It may be referred to as the **Asiatic region.** In the southern hemisphere, this climatic type is absent because only a small section of the southern continents extends south of the latitude of **40^0 S.**
- **CLIMATE**

➢ The **summers are long**, hot and humid under the influence of **tropical maritime air masses**. Average summer temperature is 25^0C. The winters are cold and the average winter temperature ranges between -4^0C and 0^0C. Precipitation is variable. Summer rainfall is characteristic and is convectional in nature. In winter, precipitation is usually less than in summer, and falls mostly in the form of snow.

THE ARCTIC OR POLAR CLIMATE

- **DISTRIBUTION**
  - Polar climates are those in which the mean temperature of the **warmest month is below 10°C**. These are thus characterized by the **absence of a warm period** and by long cold conditions. The polar type of climate and vegetation is found mainly **north of the Arctic Circle** in the northern hemisphere. The **icecaps** are confined to **Greenland** and to the **highlands** of these **high-latitude** regions, where the ground is permanently snow-covered. The lowlands, with a few months ice-free, have tundra vegetation. They include the coastal strip of Greenland, the barren grounds of northern **Canada and Alaska and the Arctic seaboard of Eurasia.**
- **TUNDRA CLIMATE**
  - It is found almost exclusively in the **Northern Hemisphere** occupying the **coastal fringes** of the Arctic Ocean and many Arctic Islands and the **ice-free shores** of Iceland and Greenland.
  - **Winters** are **severe** but **summers** are **cool**. **Annual temperature** ranges are **high**. **Precipitation** is **small**. Temperature of the warmest month does rise above 0°C, but never above 10°C. As such, the ground may be **free from snow**, but for a short period. The 10°C summer isotherm thus marks the equator ward limit of the tundra as well as the poleward limit of tree growth. Only sparse vegetation is possible which comprises **grasses, mosses and lichens**.

- **THE ICE-CAP CLIMATE**
  - The ice-cap climate does not have single monthly mean above 0^0C. consequently, the growth of **vegetation is prohibited,** and it is a region of permanent ice and snow.

INDIAN MONSOON

- The monsoon regime emphasizes the **unity of India** with the rest of southeast Asian region.
- The climate of India has many regional variations expressed in the **pattern of winds,temperature and rainfall, rhythm of seasons** and the **degree of wetness or dryness.** These regional diversities may be described as sub-types of monsoon climate. For example, the climate of Kerala and Tamil Nadu in the south are so different from that of Uttar Pradesh and Bihar in the north, and yet all of these have a monsoon type of climate.

FACTORS RELATED TO THE ORIGIN OF MONSOON

- **Inter Tropical Convergence Zone (ITCZ)**
  - ITCZ is the region where the trade winds converge, and it is a low-pressure region.
  - The position of the ITCZ is not constant; rather it shifts its position according to the sun's apparent position.
  - During the summer season, the ITCZ will be moving northward and during the winter season the ITCZ will be moving southward.
  - Due to the change of the position of ITCZ, we have the monsoon winds. As the ITCZ moves northward, India comes under the influence of Monsoon climate.
  - When the ITCZ will be over the Indian subcontinent, it will be attracting winds from the Indian ocean thereby providing rainfall to some parts of India. This season is known as the **South-West Monsoon.** It is mainly onshore in nature.
  - During winter season, the ITCZ shifts southward thereby giving rainfall to the other parts of India. This annual rainfall is known as the **North-East Monsoon or the Retreating Monsoon.** It is mainly offshore in nature.
- **Thermal Difference between Land and Sea**
  - During the summer season, the land surface will absorb more heat, which in turn will create low pressure over the surface of the land. This low pressure will attract the winds from the Indian ocean, thereby providing rainfall to the parts of India.
- **Madagascar High**
  - Madagascar High is a high-pressure region. This high-pressure region leads to the development of low-pressure over the Indian subcontinent.
  - When the winds from the high-pressure region moves towards the low-pressure it gets deflected towards right after crossing the equator.
  - This winds thereby reaches the Indian subcontinent and provides rainfall to most parts of India.

DISTRIBUTION OF MONSOON

- There are two types of Monsoons that occurs in India. They are:
  - **I. South-West Monsoon**
  - **II. North-East Monsoon or Retreating Monsoon.**

THE SOUTHWEST MONSOON SEASON

- As a result of rapid increase of **temperature in May** over the north western plains, the low-pressure conditions over there get further intensified. By early June, they are powerful enough to attract the trade winds of Southern Hemisphere coming from the Indian Ocean. These southeast trade winds cross the equator and enter the Bay of Bengal and the Arabian Sea, only to be caught up in the air circulation over India.
- Passing over the equatorial warm currents, they bring with them moisture in abundance. After crossing the equator, they follow a south westerly direction. That is why they are known as southwest monsoons.
- The rain in the southwest monsoon season begins rather abruptly. One result of the first rain is that it brings down the temperature substantially. This sudden onset of the moisture-laden winds associated with violent thunder and lightning, is often termed as the "break" or "burst" of the monsoons.
- The monsoon may burst in the 1st week of June in the coastal areas of Kerala, Karnataka, Goa and Maharashtra while in the interior parts of the country, it may be delayed to the 1st week of July. The day temperature registers a decline of 5°-8°C between mid-June to mid-July.
- As these winds approach the land, their southwesterly direction is modified by the relief and thermal low pressure over the northwest India. The monsoon approaches the landmass in two branches:
  I. The Arabian Sea Branch.
  II. The Bay of Bengal Branch.

MONSOON WINDS OF THE ARABIAN SEA

- The monsoon winds originating over the Arabian Sea further split into three branches:
  I. It's one branch is obstructed by the Western Ghats. These winds climb the slopes of the Western Ghats from 900-1200 m. Soon, they become cool, and as a result, the windward side of the Sahyadri's and Western Coastal Plain receive very heavy rainfall ranging between 250-400cm. After crossing the Western Ghats, these winds descend and get heated up. This reduces humidity in the winds. As a result, these winds cause little rainfall east of the Western Ghats. This region of low rainfall is known as the rain-shadow area.
  II. Another branch of the Arabian sea monsoon strikes the coast north of Mumbai. Moving along the Narmada and Tapi river valleys, these winds cause rainfall in extensive areas of central India. The Chotanagpur plateau gets 15 cm rainfall from this part of the branch. Thereafter, they enter the Ganga plains and mingle with the Bay of Bengal branch.
  III. A 3rd branch of this monsoon wind strikes the Saurashtra Peninsula and the Kachchh. It then passes over west Rajasthan and along the Aravalli's, causing only a scanty rainfall. In Punjab and Haryana, it too joins the Bay of Bengal branch. These two branches, reinforced by each other, cause rains in the western Himalayas.

MONSOON WINDS OF THE BAY OF BENGAL

- The Bay of Bengal branch strikes the coast of Myanmar and part of southeast Bangladesh. But the Arakan Hills along the coast of Myanmar deflect a big portion of this branch towards the Indian subcontinent.

- The monsoon, therefore, enters West Bengal and Bangladesh from south and southeast instead of from the south-westerly direction.
- This branch splits into two under the influence of the Himalayas and the thermal low is Northwest India. It's one branch moves westward along the Ganga plains reaching as far as the Punjab plains. The other branch moves up the Brahmaputra valley in the North and the Northeast, causing widespread rains.
- Its sub-branch strikes the Garo and Khasi hills of Meghalaya. Mawsynram, located on the crest of Khasi hills, receives the highest average annual rainfall in the world. The Tamil Nadu coast remains dry during this season due to:

I. The Tamil Nadu coast is situated parallel to the Bay of Bengal branch of southwest monsoon.
II. It lies in the rain shadow area of the Arabian Sea branch of the south-west monsoon.

SEASON OF RETREATING MONSOON

- The months of October and November are known for retreating monsoons. By the end of September, the southwest monsoon becomes weak as the low-pressure trough of the Ganga plain starts moving southward in response to the southward march of the sun.
- The monsoon retreats from the western Rajasthan by the 1st week of September. It withdraws from Rajasthan, Gujarat, Western Ganga plain and the Central Highlands by the end of the month. By the beginning of October, the low pressure covers northern parts of the Bay of Bengal and by early November, it moves over Karnataka and Tamil Nadu.
- By the middle of December, the centre of low pressure is completely removed from the Peninsula. The retreating southwest monsoon season is marked by clear skies and rise in temperature. The land is still moist. Owing to the conditions of high temperature and humidity, the weather becomes rather oppressive(known as '**October heat').** In the 2nd half of October, the mercury begins to fall rapidly, particularly in northern India. The weather in the retreating monsoon is dry in north India but it is associated with rain in the eastern part of the Peninsula. Here, October and November are the rainiest months of the year.
- The widespread rain in this season is associated with the passage of cyclonic depressions which originate over the Andaman Sea and manage to cross the eastern coast of the southern Peninsula. These tropical cyclones are very destructive. The thickly populated deltas of the Godavari, Krishna and Kaveri are their preferred targets. Every year cyclones bring disaster here. A few cyclonic storms also strike the coast of West Bengal, Bangladesh and Myanmar. A bulk of the rainfall of the Coromandel coast is derived from these depressions and cyclones. Such cyclonic storms are less frequent in the Arabian Sea.

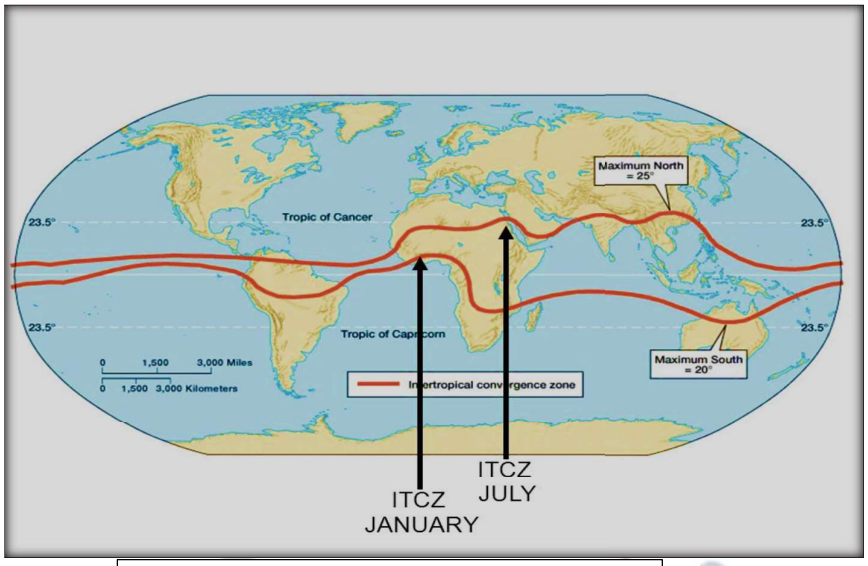
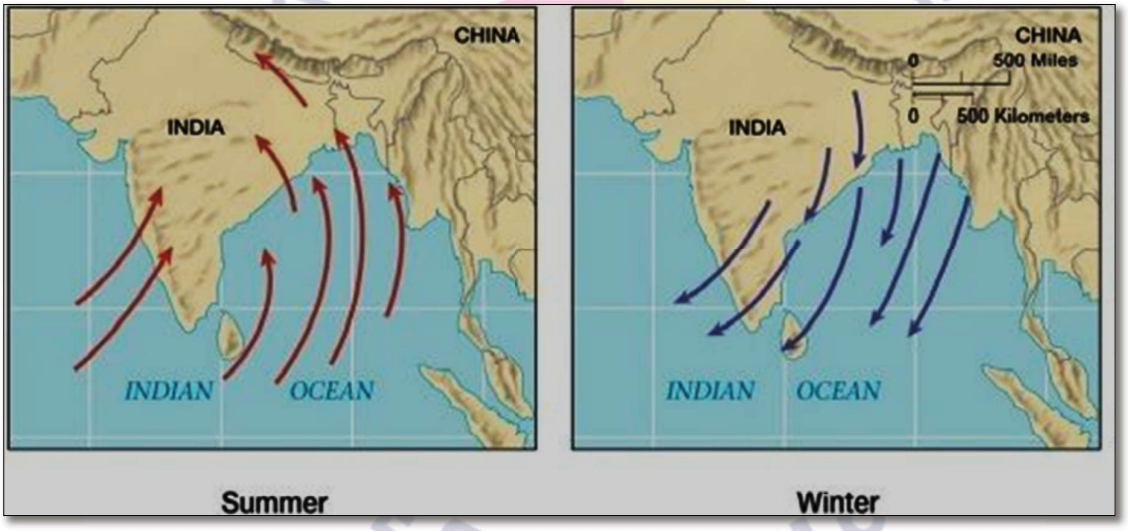


Fig: Inter Tropical Convergence Zone



ADVANCING MONSOON

- The South-west Monsoon advances from the Malabar region from 1st of June.
- On June 5th, it gradually reaches the Karnataka region.
- On June 10th, it reaches the Mumbai region.
- On June 15th, it reaches the Kathiawar peninsula of the Gujarat region.
- It then reaches the Rajasthan plains by 15th of July.
- During the Retreating monsoon, the Bay of Bengal branch gives rainfall to some parts of Mizoram and Tripura. The monsoon here will coincide with the rainfall in the Malabar region.

RETREATING MONSOON

- The monsoon starts retreating from September 1st from the Rajasthan plains.
- The Retreating monsoon last reaches the coasts of Tamil Nadu.

ONSET OF THE MONSOON

- The **shift in the position of the ITCZ** is also related to the phenomenon of the **withdrawal of the westerly jet stream** from its position over the north Indian plain, south of the Himalayas. The easterly jet stream sets in along 15°N latitude only after the western jet stream has withdrawn itself from the region. This easterly jet stream is held responsible for the burst of the monsoon in India.
- **Entry of Monsoon into India:** The southwest monsoon sets in over the Kerala coast by 1st June and moves swiftly to reach Mumbai and Kolkata between 10th -13th June. By mid-July, southwest monsoon engulfs the entire subcontinent **.**
- **The onset of monsoon** in simple terms means the beginning of the monsoon season.

RAIN-BEARING SYSTEMS AND RAINFALL DISTRIBUTION

- There seem to be two rain-bearing systems in India. First originate in the Bay of Bengal causing rainfall over the plains of north India. Second is the Arabian Sea current of the southwest monsoon which brings rain to the west coast of India. Much of the rainfall along the Western Ghats is orographic as the moist air is obstructed and forced to rise along the Ghats. The intensity of rainfall over the west coast of India is, however, related to two factors:
  I. The offshore meteorological conditions.
  II. The position of the equatorial jet stream along the eastern coast of Africa.
- The frequency of the **tropical depressions** originating from the Bay of Bengal varies from year to year. Their paths over India are mainly **determined by the position of ITCZ** which is generally termed as the **monsoon trough.**
- As the axis of the monsoon trough oscillates, there are fluctuations in the track and direction of these depressions, and the intensity and the amount of rainfall vary from year to year. The rain which comes in spells, displays a declining trend from west to east over the west coast, and from the southeast towards the northwest over the North Indian Plain and the northern part of the Peninsula.
- **Jet Stream and Upper Air Circulation:** The pattern of air circulation discussed above is witnessed only at the lower level of the atmosphere near the surface of the earth. Higher up in the lower troposphere, about three km above the surface of the earth, a different pattern of air circulation is observed. The variations in the atmospheric pressure closer to the surface of the earth have no role to play in the making of upper air circulation. All of Western and Central Asia remains under the influence of westerly winds along the altitude of 9-13 km from west to east. These winds blow across the Asian continent at latitudes north of the Himalayas roughly parallel to the Tibetan highlands. These are known as jet streams. Tibetan highlands act as a barrier in the path of these jet streams. As a result, jet streams get bifurcated. One of its branches blows to the north of the Tibetan highlands, while the southern branch blows in an eastward direction, south of the Himalayas. It has its mean position at

25°N in February at 200-300 mb level. It is believed that this southern branch of the jet stream exercises an important influence on the winter weather in India.

- **Easterly Jet Stream and Tropical Cyclones:** The easterly jet stream steers the tropical depressions into India. These depressions play a significant role in the distribution of monsoon rainfall over the Indian subcontinent. The tracks of these depressions are the areas of highest rainfall in India. The frequency at which these depressions visit India, their direction and intensity, all go a long way in determining the rainfall pattern during the southwest monsoon period.
- Tropical cyclones originate over the Bay of Bengal and the Indian ocean. These tropical cyclones have very high wind velocity and heavy rainfall and hit the Tamil Nadu, Andhra Pradesh and Orissa coast. Most of these cyclones are very destructive due to high wind velocity and torrential rain that accompanies it.

BREAK IN THE MONSOON

- During the south-west monsoon period after having rains for a few days, if rain fails to occur for one or more weeks, it is known as **break in the monsoon**. These dry spells are quite common during the rainy season. These breaks in the different regions are due to different reasons:
  I. In northern India rains are likely to fail if the rain-bearing storms are not very frequent along the monsoon trough or the ITCZ over this region.
  II. Over the west coast the dry spells are associated with days when **winds blow parallel to the coast.**

BURST OF MONSOON

- When the rainfall increases after the onset of monsoon, it is known as the **Burst of Monsoon.**
- **Bursting of monsoon** refers to the sudden change in weather conditions in India (typically from hot and dry weather to wet and humid weather during the southwest monsoon), characterized by an abrupt rise in the mean daily rainfall. The normal rainfall suddenly increases and continues constantly for several days. this is known as burst of monsoon.

NORMAL MONSOON

- Rainfall is termed **normal** when the quantum of rain is 96-104% of LPA. Millions of Indians depend on rains for agriculture, making the **monsoon** season crucial for India's economy. It provides over 75% of rainfall to the country and irrigates over half its farms.
- LPA is considered to be the '**normal' rainfall** in India. It is derived from the **average rainfall** from June to September across the country over a 50-year time period.
- Indian Meteorological Department brands the monsoon as 'normal' or 'deficient' based on how it fares against its benchmark **Long Period Average (LPA).**
- The country is said to have received **deficient rainfall if the actual rainfall falls below 90% of LPA.**

- Similarly, the country is said to have received **excess rainfall if the rainfall is greater than 110 per cent of LPA.**
- It is deemed '**normal' when the actual rainfall received falls between 96-104% of LPA.**

FACTORS AFFECTING INDIAN MONSOON

- **Seasons:** During the summer season there will be more rainfall whereas during the winter season the rainfall will be less because during summer season, low-pressure will be created over the land surface which will attract the wind from the Indian ocean, thereby giving rainfall to India.
- **Coriolis force:** It mainly influences the direction of the Indian monsoon. The Coriolis force generally deflects the direction of the wind after crossing the equator. It reaches the Indian subcontinent towards the south-west direction thereby, providing rainfall to most parts of India.
- **ENSO:** During El Nino phase of El Nino Southern Oscillation (ENSO), we will have less rainfall throughout the Indian subcontinent and during the La Nina phase we will have more rainfall.
- **Tropical depressions:** These are mainly the low-pressure systems similar to the rain bearing systems.
- **Indian Ocean Dipole:**
  - During Indian Ocean Dipole, the equatorial western Indian Ocean will become warmer during one of its phases.
  - The equatorial eastern Indian ocean will become warmer during another phase.
  - During the **positive phase of the Indian Ocean Dipole**, the western Indian Ocean will become warmer and at the same time the eastern Indian Ocean will be cooler.
  - During the **negative phase of the Indian Ocean Dipole**, the eastern Indian ocean will become warmer and at that time the western Indian ocean will be cooler. **Fig: Indian Ocean Dipole**
  - During the positive phase, rainfall will be more and during the negative phase the rainfall will be less.
- **Upper Air Circulation**
  - These are fast blowing winds in the narrow zone of the **upper atmosphere** called jet streams. During the summer seasons, the easterly jet streams pull tropical depressions to cause monsoon rainfall all over **India**. In this way, the **climate of India** is **governed by the upper air circulation**.
  - **Upper air circulation** refers to streams of air that flow at the higher altitudes of the atmosphere.
- **Landscape**
  - Monsoonal rainfall is largely governed by relief or topography. For instance, the windward side of the Western Ghats register a rainfall of over 250 cm. Again, the heavy rainfall in the north-eastern states can be attributed to their hill ranges and the Eastern Himalayas.
  - The lofty Himalayas in the north along with its extensions act as an effective climatic divide. The towering mountain chain provides an invincible **shield to protect** the **subcontinent from the cold northern winds.** These cold and chilly winds originate near the Arctic circle and blow across central and eastern Asia.
  - The Himalayas also trap the monsoon winds, forcing them to shed their moisture within the subcontinent.

- **ITCZ (Inter Tropical Convergence Zone**
  - Based on the position of ITCZ the monsoon in India advances and retreats.
  - By the middle of July, the low-pressure belt nearer the surface [termed as Inter Tropical Convergence Zone (ITCZ)] shifts northwards, roughly parallel to the Himalayas between 20° N and 25° N. By this time, the westerly jet stream withdraws from the Indian region. The ITCZ being a zone of low pressure, attracts inflow of winds from different directions thereby, providing rainfall to most parts of India.
  - During winter, the ITCZ shifts southward thereby giving rainfall to other parts of India including Mizoram, Tripura, Tamil Nadu, West Bengal.
- **Aerosols**
  - With rising pollution levels, small particles suspended in the air, such as dust, soot, and organic matter are also increasing. These particles, **called aerosols**, are known to affect the formation of clouds that bring rain, besides affecting our health.

ANNUAL RAINFALL IN INDIA

- The average annual rainfall in India is about 125 cm, but it has great spatial variations.
- **Areas of High Rainfall:** The highest rainfall occurs along the west coast, on the Western Ghats, as well as in the sub-Himalayan areas is the northeast and the hills of Meghalaya. Here the rainfall exceeds 200 cm. In some parts of Khasi and Jaintia hills, the rainfall exceeds 1,000 cm. In the Brahmaputra valley and the adjoining hills, the rainfall is less than 200 cm.
- **Areas of Medium Rainfall:** Rainfall between 100-200 cm is received in the southern parts of Gujarat, east Tamil Nadu, northeastern Peninsula covering Odisha, Jharkhand, Bihar, eastern Madhya Pradesh, northern Ganga plain along the sub-Himalayas and the Cachar Valley and Manipur.
- **Areas of Low Rainfall:** Western Uttar Pradesh, Delhi, Haryana, Punjab, Jammu and Kashmir, eastern Rajasthan, Gujarat and Deccan Plateau receive rainfall between 50-100 cm.
- **Areas of Inadequate Rainfall:** Parts of the Peninsula, especially in Andhra Pradesh, Karnataka and Maharashtra, Ladakh and most of western Rajasthan receive rainfall below 50 cm.
- Snowfall is restricted to the Himalayan region.
- The eastern coast of Tamil Nadu gets less rainfall during the South-west monsoon. Rainfall will be mainly from Retreating monsoon and Tropical cyclonic season.
- Jammu and Kashmir get more rainfall from the Western Disturbances and less rainfall from the South West monsoon.

CLIMATIC REGIONS IN INDIA

- The whole of India has a monsoon type of climate. But the combination of elements of the weather, however, reveal many regional variations. These variations represent the subtypes of the monsoon climate. It is on this basis that the climatic regions can be identified.
- A climatic region has a homogeneous climatic condition which is the result of a combination of factors. Temperature and rainfall are two important elements which are considered to be decisive in all the schemes of climatic classification.

Climatic regions in India

The various climatic regions of India are given below:

Name of climatic region	States or territories
Tropical Rainforest	Assam and parts of the Sahyadri Mountain Range
Tropical Savannah	Sahyadri Mountain Range and parts of Maharashtra
Tropical and subtropical steppe	Parts of Punjab and Gujarat
Tropical Desert	Most parts of Rajasthan
Moist subtropical with winter	Parts of Punjab, Assam, and Rajasthan
Mountain climate	Parts of Jammu and Kashmir, Himachal Pradesh, and Uttaranchal
Drought	Rajasthan, Gujarat, and Haryana
Tropical semi-arid steppe	Tamil Nadu, Maharashtra, and other parts of South India

Characteristics of rainfall in India

Type of Rainfall	Areas
Areas of very little rainfall (lower than 50 cm):	Western Rajasthan , northern part of Kashmir, the Deccan Plateau and Punjab.
Areas of low precipitation (50-100 cm):	Eastern Rajasthan, Upper Ganga basin, Southern plains of Karnataka, Punjab, Tamil Nadu, and Andhra Pradesh.
Areas of comparatively heavy rainfall (100-200 cm):	Southern areas of Gujarat, north-eastern Peninsular region, east Tamil Nadu, eastern Maharashtra, Western Ghats, Orissa, Madhya Pradesh, and the central Gangetic basin.
Areas of heavy rainfall (more than 200 cm):	The western seashores, the Western Ghats, Hills of Meghalaya, and the Sub-Himalayan range territories in North East. West Bengal, Assam, Western Coast, and southern part of east Himalayas.

WATER (OCEANOGRAPHY)

- There is more water in the **Southern Hemisphere(57%)** and less water in the **Northern Hemisphere(43%).**
- About 97% of water is in the oceans. The water is mainly saline. **Only 3% water on the surface of the land is fresh**.
- Out of the freshwater, 69% of water is in the Glaciers, 30% water is underground, and less than 1% water is located on the surface of the water.

Reservoir	*Volume (Million Cubic km)*	*Percentage of the Total*
Oceans	1,370	97.25
Ice Caps and Glaciers	29	2.05
Groundwater	9.5	0.68
Lakes	0.125	0.01
Soil Moisture	0.065	0.005
Atmosphere	0.013	0.001
Streams and Rivers	0.0017	0.0001
Biosphere	0.0006	0.00004

RELIEF OF THE OCEAN FLOOR

- The geographers have divided the oceanic part of the earth into five oceans, namely **the Pacific, the Atlantic, the Indian, Southern Ocean and the Arctic.** The various seas, bays, gulfs and other inlets are parts of these four large oceans.
- A major portion of the ocean floor is found between **3-6 km below the sea level.** The 'land' under the waters of the oceans, that is, the ocean floor exhibits complex and varied features as those observed over the land.
- The floors of the oceans are rugged with the world's largest mountain ranges, **deepest trenches and the largest plains.**

DIVISIONS OF THE OCEAN FLOORS

- The Ocean Floors can be divided into four major divisions:
  - **I. The Continental Shelf;**
  - **II. The Continental Slope;**
  - **III. The Deep-Sea Plain;**
  - **IV. The Oceanic Deeps.**
- Besides, these divisions there are also major and minor relief features in the ocean **floors like ridges, hills, sea mounts, guyots, trenches, canyons, etc.**

CONTINENTAL SHELF

- The continental shelf is the extended margin of each continent occupied by relatively shallow seas and gulfs. It is the shallowest part of the ocean showing an average gradient of **1° or even less.**
- The shelf typically ends at a very steep slope, called the **shelf break.**
- The width of the continental shelves varies from one ocean to another. The average width of **continental shelves is about 80 km.**
- The continental shelves are covered with variable thicknesses of sediments brought down by rivers, glaciers, wind, from the land and distributed by **waves and currents.**
- **Massive sedimentary deposits** received over a long time by the continental shelves, become the source of fossil fuels.

CONTINENTAL SLOPE

- The continental slope **connects the continental shelf and the ocean basins.**
- It begins where the bottom of the continental shelf sharply drops off into a steep slope.
- The gradient of the slope region varies **between 2-5°.** The depth of the slope region varies **between 200-3000 m.**
- The slope boundary indicates the end of the continents. **Canyons and trenches are found in this region.**

DEEP SEA PLAIN

- Deep sea plains are gently sloping areas of the ocean basins.
- These are **the flattest and smoothest regions** of the world.
- The depths vary between **3000-6000m.** These plains are covered with fine-grained sediments like clay and silt.

OCEANIC DEEPS OR TRENCHES

- These areas are the **deepest parts of the oceans.**
- The trenches are relatively **steep sided, narrow** basins.
- They are **3-5 km** deeper than the surrounding ocean floor.
- They occur at the bases of continental slopes and along island arcs and are associated with **active volcanoes and strong earthquakes.**
- As many as 57 deeps have been explored so far; of which 32 are in the Pacific Ocean; 19 in the Atlantic Ocean and 6 in the Indian Ocean.

MINOR RELIEF FEATURES

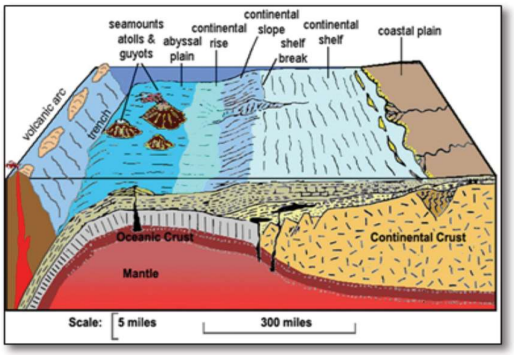
Apart from the major relief features of the ocean floor, some minor but significant features predominate in different parts of the oceans.

MID-OCEANIC RIDGES

- A mid-oceanic ridge is composed of two chains of mountains separated by a large depression.
- The mountain ranges can have peaks as **high as 2,500 m** and some even reach above the ocean's surface.
- **Iceland, a part of the mid-Atlantic Ridge, is an example.**

SEAMOUNT

- It is a mountain with pointed summits, rising from the seafloor that does not reach the surface of the ocean.
- Seamounts are **volcanic in origin.**
- These can be 3**000-4500 m tall.** The Emperor seamount, an extension of the Hawaiian Islands in the Pacific Ocean, is a good example.



SUBMARINE CANYONS

- These are deep valleys, some comparable to the **Grand Canyon of the Colorado river.**
- They are sometimes found cutting across the continental shelves and slopes, often extending from the mouths of large rivers.
- **The Hudson Canyon is the best-known submarine canyon in the world.**

GUYOTS

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

ATOLL

- These are low islands found in the tropical oceans consisting of **coral reefs surrounding a central depression.**
- It may be a part of the **sea (lagoon),** or sometimes form enclosing a body of **fresh, brackish, or highly saline water.**

HYPSOGRAPHIC CURVE OF THE EARTH SURFACE

- This is a graph of the area of the Earth's surface above and given elevation or depth above or below the sea level. It may be observed from the highest mountain peak (Mt. Everest) is 8848.86 m, while the **greatest ocean depth is 11,022m.**
- The average elevation of the exposed land is 840m and the average depth of the oceans is -3790m.

TEMPERATURE OF OCEAN WATERS

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.

FACTORS AFFECTING TEMPERATURE DISTRIBUTION

The **factors** which affect the distribution of temperature of ocean water are:

I. **Latitude:** The temperature of surface water decreases from the equator towards the poles because the amount of insolation decreases poleward.
II. **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.
III. **Prevailing wind:** The winds blowing from the land towards the oceans drive warm surface water away from 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.
IV. **Ocean currents**: Warm ocean currents raise the temperature in cold areas while the cold currents decrease the temperature in warm ocean areas. Gulf stream (warm current) raises the temperature near the eastern coast of North America and the West Coast of Europe while the Labrador current (cold current) lowers the temperature near the north-east coast of North America.

- All these **factors influence the temperature of the ocean currents locally.**
- The enclosed seas in the low latitudes record relatively higher temperature than the open seas; whereas the enclosed seas in the high latitudes have lower temperature than the open seas.

SALINITY OF OCEAN WATERS

- All waters in nature, whether rainwater or ocean water, contain dissolved mineral salts. Salinity is the term used to define the total content of dissolved salts in sea water. It is calculated as the amount of salt (in gm) dissolved in 1,000 gm (1 kg) of seawater. It is usually expressed as parts per thousand (o/oo) or ppt.
- Salinity is an important property of sea water. Salinity of 24.7 o/oo has been considered as the upper limit to demarcate 'brackish water'.
- **Factors affecting ocean salinity are mentioned below:**

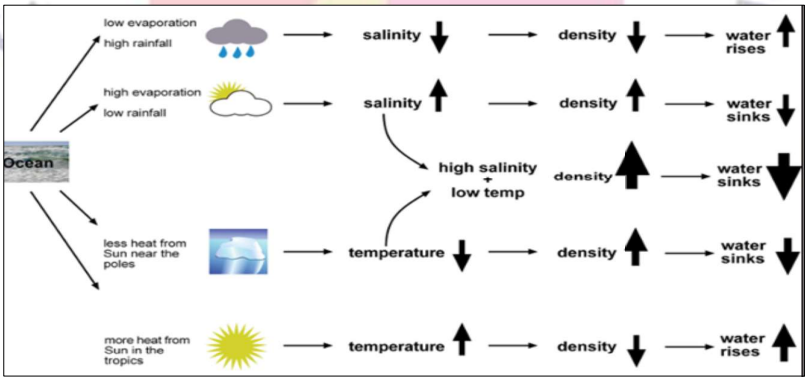
➢ The salinity of water in the surface layer of oceans depend mainly on **evaporation and precipitation:** places with high rainfall will have less salinity and places with more evaporation will have high salinity.
➢ Surface salinity is greatly influenced in coastal regions by the freshwater flow from rivers, and in polar regions by the processes of freezing and thawing of ice.
➢ Wind also influences salinity of an area by transferring water to other areas. Areas with on-shore winds will **have high salinity** and areas with off-shore winds will **have less salinity**.
➢ The ocean currents contribute to the salinity variations. Salinity, temperature and density of water are interrelated. Hence, any change in the temperature or density influences the salinity of water in an area.

Salt	Percentage
Sodium chloride	2.6
Magnesium chloride	0.3
Magnesium sulphate	0.2
Calcium sulphate	0.1
Potassium chloride	0.1
Potassium bromide	0.01
Other elements	0.01

Fig: Chemical Composition of Sea Water

HORIZONTAL DISTRIBUTION OF SALINITY

- The salinity for normal open ocean ranges between 33-37 o/oo. In the land locked Red Sea, it is as high as 41o/oo, while in the estuaries and the Arctic, the salinity fluctuates from 0 – 35$^{o}/_{oo}$, seasonally.
- In hot and dry regions, where evaporation is high, the salinity sometimes reaches to 70$^{o}/_{oo}$.
- The salinity variation in the Pacific Ocean is mainly due to its shape and larger areal extent.
- Salinity decreases **from 35-31 o/oo** on the western parts of the **Northern Hemisphere** because of the influx of melted water from the Arctic region. In the same way, after 15° - 20° south, it decreases to 33 o/oo.
- The average salinity of the **Atlantic Ocean is around 36 o/oo.** The highest salinity is recorded between 15°-20° latitudes.
- **Maximum salinity** (37 o/oo) is observed between 20° N -30° N and 20° W - 60° W. It gradually decreases towards the north.
- The North Sea, in spite of its location in higher latitudes, records higher salinity due to more saline water brought by the North Atlantic Drift.
- **Baltic Sea records low salinity** due to influx of river waters in large quantity.
- The **Mediterranean Sea records higher salinity** due to high evaporation.
- Salinity is, however, very low in Black Sea due to enormous freshwater influx by rivers. See the atlas to find out the rivers joining Black Sea.
- The average salinity of the Indian Ocean is 35 o/oo. The low salinity trend is observed in the Bay of Bengal due to influx of river water.
- On the contrary, **the Arabian Sea shows higher salinity** due to high evaporation and low influx of fresh water.



TIDES

- The periodical rise and fall of the sea level, once or twice a day, mainly due to the attraction of the sun and the moon, is called a **tide**.
- The study of tides is very complex, spatially and temporally, as it has great variations in frequency, magnitude and height. The **moon's gravitational pull to a great extent and to a lesser extent the sun's gravitational pull, are the major causes for the occurrence of tides.**
- The gravitational pull of the moon is more predominant then the gravitational pull of the sun. the moon can attract more water from the earth towards itself then the sun.
- Another **factor is centrifugal force**, which is the force that acts to counterbalance the gravity. Together, the gravitational pull and the centrifugal force are responsible for creating the two major tidal bulges on the earth.
- On the side of the earth facing the moon, **a tidal bulge occurs** while on the opposite side though the gravitational attraction of the moon is less as it is farther away, the centrifugal force causes tidal bulge on the other side. The 'tide-generating' force is the difference between these two forces; i.e. the gravitational attraction of the moon and the centrifugal force.
- On the surface of the earth, nearest the moon, pull or the attractive force of the moon is greater than the centrifugal force, and so there is a net force causing a bulge towards the moon. On the opposite side of the earth, the attractive force is less, as it is farther away from the moon, the centrifugal force is dominant.
- Hence, there is a **net force away from the moon.** It creates the second bulge away from the moon. On the surface of the earth, the horizontal tide generating forces are more important than the vertical forces in generating the tidal bulges. The tidal bulges on wide continental shelves, have greater height.
- When tidal bulges hit the mid-oceanic islands, they become low. The shape of bays and estuaries along a coastline can also magnify the intensity of tides. Funnel-shaped bays greatly change tidal magnitudes. When the tide is channeled between islands or into bays and estuaries, they are called **tidal currents.**
- **Distribution of Land and Ocean is another factor influencing the Tides.** The region that have more continental shelf will have shallow ocean water and therefore, the tidal bulge created from the **High Tides** will be less. Whereas, the **low tide** that will be receding back will be much greater in these regions because of the shallowness of the ocean water.
- . **The time difference between these two High Tides will be 12 hours 26 minutes.**

TIDAL CURRENT

- The **inward and outward movement of water is called Tidal current.**
- During the High Tide, the narrow channel of water connecting the Gulf will carry water inward and during the Low Tide, the water from the narrow channel will be carried backwards or outward.
- The **Gulf has two parts: Front and Rear End.**
- If the Front or the mouth of the Gulf is very narrow, then the water flowing from the ocean in the Gulf during High Tide will be less. And if the mouth of the Gulf is very wide then the water flowing from the ocean in the Gulf during the High Tide will be very High.

- In case of Rear end of the Gulf, if it is narrow then the height of the High Tide originating will be High. Whereas, if the rear end of the Gulf region is very wide, more water will be needed for the sea level to rise. Here, the height of the High Tide will be less.

TIDAL PORTS

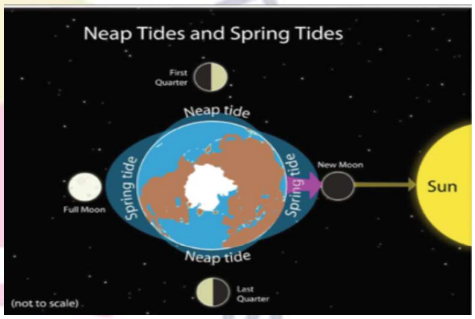
- The ports which work using the tidal nature of the ocean are called Tidal Ports.
- During the High Tide, the ship can sail and can come back to the Harbour. Whereas, during Low tide it is not possible.
- Diamond Harbour and Haldia port are two ports situated at the estuary of River Hugli.
- Kandla Port or Deendayal Port is another port situated in the Gujarat region.

TIDAL RANGE

- The difference between High Tide and Low Tide is called Tidal range.

TYPES OF TIDES

- **SPRING TIDE**
  - Spring Tide occurs when the moon, earth and sun are in a straight line. The gravitational pull of all the three are complementing each other.
  - During Spring Tide, the High Tide will be higher than usual and Low Tide will be lower than usual.
  - Spring Tide occurs two times a year: once during Full moon and another during New moon.



- **NEAP TIDE**
  - Neap Tide occurs when the moon, earth and sun are in a right-angle position.
  - The tidal bulge will be near the moon, but some amount of water will also go on the side of the sun.
  - During Neap Tide, the High Tide will be less than usual and Low Tides will be higher than usual.
- **PERIGEAN SPRING TIDE**
  - It is mainly associated with the Perigee and Apogee position of the moon.
  - When the moon is nearest to the earth it is called Perigee position. Whereas, when the moon is farthest from the earth it is called Apogee position.
  - When the Spring Tide coincides with the Perigee position of the moon during full moon and new moon night, then the High Tide related to Spring Tide will be more powerful than occurring during the normal Spring Tide. This is known as Perigean Spring Tide.

IMPORTANCE OF TIDES

- Tides helps in navigation.
- Tides helps in Fishing.
- Tides clears away the sediments.
- Tides are useful for generating electricity.

PREVIOUS YEAR QUESTIONS

1) **Which of the following rivers of India does not meet the Bay of Bengal?**
   A. North Pennar
   B. Subarnarekha
   C. Mahi
   D. Vaigai
2) **Which of the following Wildlife Sanctuaries is located in Udalguri district?**
   A. Chakrashila
   B. Bornadi
   C. Amchang
   D. Bura Chapori
3. **Which of the following rivers has the largest river basin in Indian sub continent"?**
   (A) The Brahmaputra
   (B) The Indus
   (C) The Ganga
   (D) The Krishna
4. **Which water resource project covers and extends the benefits to Madhya Pradesh, Maharashtra, Gujarat and Rajasthan?**
   (A) Hirakud Dam Project
   (B) Sardar Sarovar Dam Project
   (C) Bhakra-Nangal Dam Project
   (D) Tehri Dam Project
5. **The smallest state in India from the view point(1998)**
   a) Goa
   b) Sikkim
   c) Nagaland
   d) Tripura

OCEAN CURRENTS

The movement of ocean water in a particular direction is called **Ocean Current.**

FACTORS INFLUENCING OCEAN CURRENTS

- **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.
- **Wind:** Wind blowing on the surface of the ocean pushes the water to move. Friction between the wind and the water surface affects the movement of the water body in its course.
- **Gravity:** Gravity tends to pull the water down the pile and create gradient variation.
- **Coriolis force:** The Coriolis force intervenes and causes the water to move to the right in the northern hemisphere and to the left in the southern hemisphere. These large accumulations of water and the flow around them are called Gyres. These produce large circular currents in all the ocean basins.
- **Difference in water density:** Differences in water density affect vertical mobility of ocean currents. Denser water tends to sink, while relatively lighter water tends to rise. Cold-water ocean currents occur when the cold water at the poles sinks and slowly moves towards the equator. Warm-water currents travel out from the equator along the surface, flowing towards the poles to replace the sinking cold water.
- **Salinity:** Water with high salinity is denser than water with low salinity and in the same way cold water is denser than warm water.
- **Ocean relief features** also helps in influencing the ocean currents.

UPWELLING

- **Upwelling** is a process mainly associated with cold ocean currents. The area where the wind is offshore in nature, it will push away the warm surface water away from the coastal region. This warm surface water is on the top surface of the ocean. As it moves away, the water from the beneath of the ocean rises up. This rising up of cold ocean water to the top surface is called **Upwelling.**
- Currents moving away from the equator are **warm ocean currents** and currents coming near the equator are **cold ocean currents**.

TEMPERATURE AND SALINITY

- Low evaporation + High rainfall = Less salinity + Less density + Water rises
- High evaporation + Less rainfall = High salinity + High density + Water sinks
- High salinity + Low temperature = High density + Water sinks
- **Less heat from sun near the poles**
  Low temperature + High density + Water sinks
- **More heat from sun near the poles**
  High temperature + Low salinity + Water rises

THERMAL CONVEYER BELT

- The warm water from the equator moves towards the poles and the cold water from the poles come back to the equator. This mixing up of warm and cold ocean water is maintaining the heat balance of the earth. Therefore, the ocean currents perform as a **thermal conveyer belt** to the earth.

OCEAN CURRENTS

Ocean	Name Of The Current	Nature	Effect
North Atlantic Ocean	North Equatorial Current	**Warm**	Carries the warm water of the Gulf of Guinea towards South America.
	Antilles	**Warm**	Keeps the temperature of Antilles above 250C throughout the year.
	Gulf Stream	**Warm**	Its confluence with the Labrador current produces heavy fog along the coasts of New Foundland. It is one of the important fishing grounds of the world.
	North Atlantic Drift	**Warm**	It keeps the ports of Norwegian Sea and Barents Sea like Murmansk and Severodvinsk (Russia) situated at higher latitudes ice-free throughout the year.
	Labrador	**Cold**	The confluence of Labrador and Gulf Stream produces heavy fog in the region of New Foundland which create conducive conditions for fishing. The fog creates obstacles in navigation.
	Canaries	**Cold**	Leads to fog along the western coast Of North Africa. Helped in the genesis of Sahara Desert.
South Atlantic Ocean	South Equatorial Current	**Warm**	Carries warm water from the Gulf of Guinea towards Brazil.
	Brazilian Current	**Warm**	Keeps the eastern coast of South America warm.
	Benguela Current	**Cold**	Leads to foggy conditions along the coast Of Namibia. Helped in the development of Namibian and Kalahari deserts.
North Pacific Ocean	North Equatorial Current	**Warm**	Carries heat from the eastern Pacific towards the East Indies. Carries warm water towards Alaska.
	Oyashio/Kurile Current	**Cold**	The confluence of Oyashio with Kuroshio produces heavy fog around Hokkaido. This confluence is conducive for the development of fisheries.

	Alaska Current	**Warm**	Keeps the seaports of Alaska open throughout the year.
	California Current	**Cold**	Leads to foggy conditions along the coast of California. It helped in the development Of Arizona and Sonara deserts.
South Pacific Ocean	South Equatorial Current	**Warm**	Carries warm water from the eastern parts of the South Pacific towards New Guinea and eastern Australia.
	East Australian Current	**Warm**	Carries heat from the equatorial region towards the eastern coast of Australia.
	Peru /Humboldt Current	**Cold**	Helped in the desertification of the Atacama Desert. El-Nino effects the weather in western South America. It also affects the timely arrival of Indian Monsoon.
Indian Ocean	Mozambique Current	**Warm**	Carries heat from the equatorial region towards the eastern coast of Mozambique.
	Agulhas	**Warm**	Increases temperature along the eastern coast of South Africa.
	West Australian Current	**Cold**	Leads to foggy conditions along the western coast of Australia. It helped in the genesis of West Australian Desert.

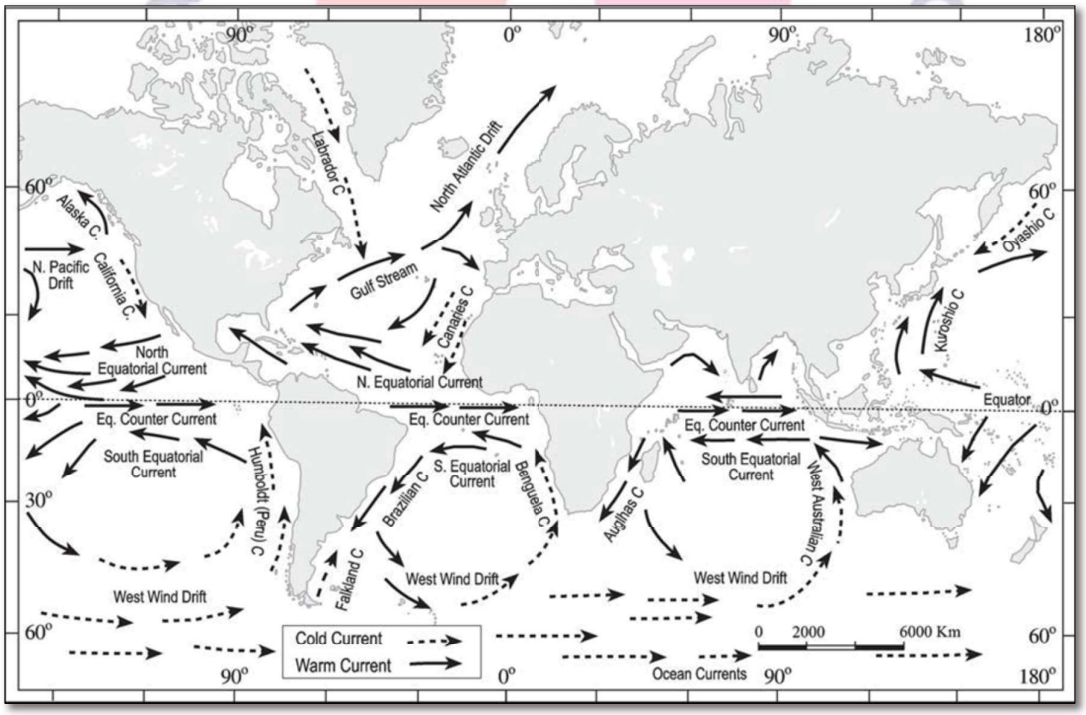


Fig: Ocean Currents

CORAL REEFS

- Coral reef is a linear mass of calcium carbonate (aragonite and calcite) assembled from coral organism, algae, mollusks, worms, etc.
- Coral may contribute less than half of the reef material.
- In most reefs, the predominant organisms are stony corals that secrete calcium carbonate (limestone).
- The coral reefs are also referred as the 'Rainforests Of the oceans' because of their tremendous biodiversity.
- The coral reefs may be **broadly classified in the following** categories:

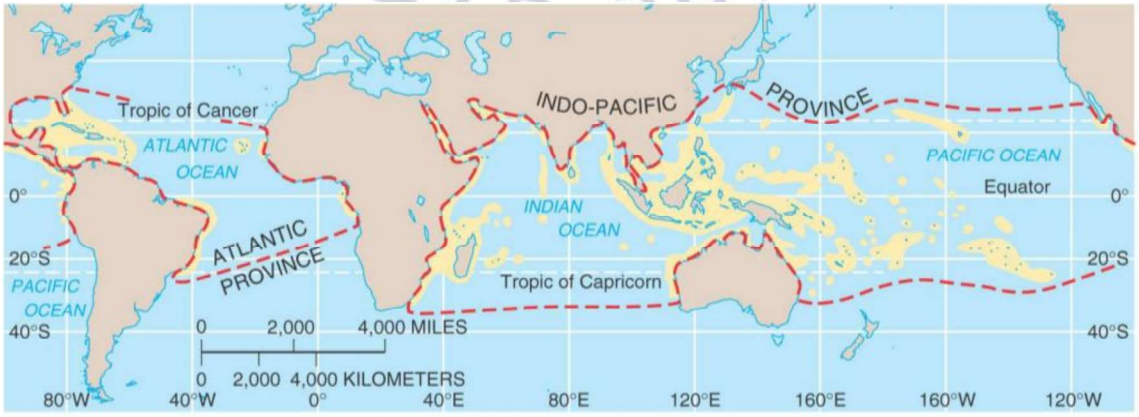
I. **Fringing Reef:** Reef that is directly attached to a shore or borders it with an intervening shallow channel or lagoon.

II. **Barrier Reef:** Reef separated from a mainland or island shore by a deep lagoon. The Great Barrier Reef lying to the east of Queensland is the largest living structure on the Earth. It extends for more than 2000 km.

III. **Atoll Reef:** A more or less circular or continuous barrier reef extending all the way around a lagoon without a central island.

Distribution of Coral Reefs in the World

- Most of the coral reefs are found between 300 N and 300 S, where the average temperature of the sea surface is about 21^0C.
- Coral reefs are almost absent from along the west coast of Americas and the west coast of Africa. Corals are also restricted from the coastline of South Asia from Pakistan to Bangladesh.
- They are also not found in the delta region of the Ganga-Brahmaputra river and the Amazon river due to the addition of vast quantities of fresh water.



FISHING GROUNDS

- The major fishing grounds can be found where the warm and cold ocean water are mixing with each other.
- Fishes depends generally on phytoplankton and various ocean-based nutrients. The cold ocean currents will bring nutrients from the deep ocean surface and the warm ocean currents will bring more oxygen supply into this region. Therefore, more phytoplankton can be found in this region.
- The **Regions famous for the fishing grounds** are:
  I. North East Atlantic Region
  II. North West Atlantic Region
  III. South East Pacific Region
  IV. North West Pacific Region
  V. West Central Pacific Region

EFFECTS OF OCEAN CURRENTS

- **Modification in the coastal climate:** the warm ocean currents are influenced by onshore winds and so precipitation will be high. Whereas, cold ocean currents are influenced by offshore winds and so rainfall will be less. So, rainfall and temperature are important for the modification of coastal climate.
- **Effects on Fishing:** areas where the warm and cold ocean currents mix, gives rise to the major fishing grounds of the world.
- **Effects on trade and navigation:** mixing of warm and cold ocean currents reduces the visibility and so it leads to the adverse effects on trade and navigation.

Marine (Ocean) Pollution

- With the increasing pressure of population and international trade, the sea-routes have become crowded.
- The excessive utilization of ocean resources can result in the accidental (or unintentional) release of harmful substances.
- The marine pollution changes the quality of the water or affect the physical and biological environment.
- **Chemical pollution**: It is the introduction of harmful contaminants into the ocean. Common man-made pollutants that reach the ocean include pesticides, herbicides, fertilizers, detergents, oil, industrial chemicals, and sewage.
- **Light pollution**: It penetrates under the water, creating a vastly different world for fish living in shallow reefs near urban environments. Light disrupts the normal cues associated with, circadian rhythms/ clock to which species have evolved timing of migration, reproducing, and feeding. Artificial light at night can make it easier for predators to find smaller fish prey and can affect breeding in reef fish.
- **Noise Pollution:** The increased presence of loud or persistent sounds from ships, Sonar devices, and oil rigs disrupts natural noises in the marine environment. Unnatural noises

disrupting migration, communication, hunting, and reproduction patterns for many marine animals.

- **Plastic pollution:** It **seeps into the ocean** through run-off and even purposeful dumping. A huge culprit is **single-use plastics.** These single-use items are accidentally consumed by many marine mammals. Plastic bags resemble jellyfish, a common food for sea turtles, while some seabirds eat plastic because it releases a chemical that makes it smell like its natural food. Discarded fishing nets drift for years, ensnaring fish and mammals.

  The major **causes of marine pollution** are:

  I. **Volcanic Eruption**
  II. **Oil Pollution Natural Seeps**
  III. **Offshore-Drilling, near Shore Refining and Accidents of Tankers**
  IV. **Spill Of Refined Oil**
  V. **Eutrophication**
  VI. **Acidification**
  VII. **Dumping Of Wastes etc.**

Preventive measures for Marine Pollution:

- Recycling and reuse can minimize plastic pollution. **Minimize the use of plastic** and littering garbage as they not only choke up the drains but also releases into the oceans.
- Chemicals should not be used anywhere near the **streams of water** and try cutting down on **the usage of such chemicals.**
- Farmers should switch from **chemical fertilizers and pesticides** to the usage of organic farming methods.
- Use of public transport and **minimize the carbon footprint** by taking small and substantial measures that will not only help in reducing the pollution from the environment but also will ensure a safe and healthy future for the future generations.

Environmental Change

- Environmental change is a continuous process that has been in operation since the **Earth came into existence about 4600 million years ago.**
- Earlier, there was a belief that man is the product of the Earth (Miss Semple), but now **human beings are affecting the environment significantly.**
- At present the **oil spill in the oceans and nuclear ration** (Fukushima) are causing great damage to the ecosystems.

PREVIOUS YEAR QUESTIONS

1) **Which of the following numericals stands as the extent of seawater/ocean water distance from the baseline in case of Exclusive Economic Zone (EEZ)?**
   - **A. 200 nautical miles**
   - B. 250 nautical miles
   - C. 300 nautical miles
   - D. 500 nautical miles

2) **The International Year of the Ocean is(1998)**
   - a) 1996
   - b) 1997
   - c) 1998
   - d) 1999

PHYSICAL STRUCTURE OF INDIA

- Based on the variations in its **geological structure and formations**, India can be divided into 3 geological divisions.
  - **I. The Peninsular Block**
  - **II. The Himalayas and other Peninsular Mountains**
  - **III. Indo-Ganga-Brahmaputra Plain.**

THE PENINSULAR BLOCK

- The Northern boundary of the Peninsular Block may be taken as an irregular line **running from Kachchh along the western flank of the Aravalli Range near Delhi** and then roughly parallel to the **Yamuna and the Ganga as far as the Rajmahal Hills and the Ganga delta.**
- Apart from these, the **Karbi Anglong and the Meghalaya Plateau in the northeast and Rajasthan in the west are also extensions of this block.**
- The North eastern parts are separated by the Malda fault in West Bengal from the Chotanagpur plateau. In Rajasthan, the desert and other desert–like features overlay this block.
- The **Peninsula is formed essentially by a great complex of very ancient gneisses and granites,** which constitutes a major part of it. Since the Cambrian period, the Peninsula has been standing like a rigid block with the exception of some of its western

coast which is submerged beneath the sea and some other parts changed due to tectonic activity without affecting the original basement.

- As a part of the Indo-Australian Plate, it has been subjected to various vertical movements and block faulting. **The rift valleys of the Narmada, the Tapi and the Mahanadi and the Satpura block mountains are some examples of it.**
- The Peninsula mostly consists of relict and residual mountains like the Aravalli hills, the Nallamalla hills, the Javadi hills, the Veliconda hills, the Palkonda range and the Mahendragiri hills, etc. The river valleys here are shallow with low gradients.
- Most of the **east flowing rivers form deltas before entering into the Bay of Bengal.** The deltas formed by the Mahanadi, the Krishna, the Kaveri and the Godavari are important examples.
- The Peninsular block is very **rigid and inflexible block**.
- **Recent uplifts of the Peninsular block**: Palani and Nilgiri hills
- **Palani hills** is near Annamalai hills and it is a **pilgrim hill station** in Tamil Nadu.
- **Recent subsidence of the Peninsular block**: Valleys of the Godavari, Mahanadi and the Damodar; and the faults of the Narmada and the Tapi valley and of the Malabar and Makran coasts.

HIMALAYAS

- The Himalayas along with other Peninsular mountains are young, **weak and flexible** in their geological structure unlike the rigid and stable Peninsular Block.
- Consequently, they are still subjected to the interplay of exogenic and endogenic forces, resulting in the development of **faults, folds and thrust plains.**
- The Himalayas are a series of parallel mountain ranges and are highly rugged in topography. The mountain ranges are mainly **Karakoram, Zaskar, Ladakh and Pir Panjal.**
- These mountains are tectonic in origin, dissected by fast-flowing rivers which are in their youthful stage. Various landforms like **gorges, V-shaped valleys, rapids, waterfalls,** etc. are indicative of this stage.
- The central axial range is 2500 km from east to west, and their width varies between 160-400 km from north to south. The rocks in the Himalayan mountains are mainly **Sedimentary Rocks.**

INDO-GANGA-BRAHMAPUTRA PLAIN

- The 3rd geological division of India comprises the plains formed by the **river Indus, the Ganga and the Brahmaputra.** Originally, it was a geo-synclinal depression which attained its maximum development during the 3rd phase (64 million years) of the Himalayan mountain formation. Since then, it has been gradually filled by the **sediments brought by the Himalayan and Peninsular rivers.**
- Average depth of **alluvial deposits in these plains' ranges from 1000-2000 m.**

- The relief and physiography of India has been greatly influenced by the geological and geomorphological processes active in the Indian subcontinent.

PHYSIOGRAPHY

- 'Physiography' of an area is the outcome of structure, process and the stage of development.
- The **Northern part** of India has a **vast expanse of rugged topography** consisting of a series of mountain ranges with varied **peaks, beautiful valleys and deep gorges.**
- The Southern part of India consists of **stable table land** with highly dissected **plateaus, denuded rocks and developed series of scarps**. In between these two lies the vast North Indian Plain.
- **Based on these macro variations, India can be divided into the following physiographic divisions:**
  I. The Northern and North-eastern Mountains
  II. The Northern Plain
  III. The Peninsular Plateau
  IV. The Indian Desert
  V. The Coastal Plains
  VI. The Island

THE NORTH AND NORTHEASTERN MOUNTAINS

- The North and Northeastern Mountains consist of the Himalayas and the Northeastern hills. The Himalayas consist of a series of parallel mountain ranges. Some of the important ranges are the Greater Himalayan range are the **Great Himalayas** and the **Shiwaliks**, **Lesser or Middle Himalayas and Outer Himalayas**.
- **Pir Panjal or Dhauladhar** lying in the south of the Great Himalayas, are parts of Lesser of Middle Himalayas.
- Shiwaliks ranges till Nepal but absent in **Sikkim and Arunachal Pradesh** are known as Outer Himalayas.
- The general orientation of Great Himalayan ranges is **from northwest to the southeast direction in the northwestern part of India**. Himalayas in the Darjeeling and Sikkim regions lie in an **east west direction,** while in Arunachal Pradesh they are from **southwest to the northwest direction.**
- In **Nagaland, Manipur and Mizoram,** they are in the **north south direction.** The approximate length of the **Great Himalayan range**, also known as the **central axial** range, is 2,500 km from east to west, and their width varies between 160-400 km from north to south.
- The Greater Himalayas has the **highest altitude** among all the other mountain ranges.
- The Himalayas almost stand like a strong, long wall between the Indian subcontinent and the **Central and East Asian countries.**
- There are large-scale regional variations within the Himalayas.

- On the basis of relief, alignment of ranges and other geomorphological features, the Himalayas can be divided into:
  I. **Kashmir** or Northwestern Himalayas
  II. **Himachal and Uttarakhand** Himalayas
  III. **Darjeeling and Sikkim** Himalayas
  IV. **Arunachal** Himalayas
  V. **Eastern** Hills and Mountains.
- The **Trans- Himalayan ranges are**:

  I. Karakoram
  II. Ladakh
  III. Zaskar
  IV. Kailash

- **Indus river is flowing between Ladakh and Zaskar ranges**.
- **Kanchenjunga, near Sikkim is one of the highest peaks in India**.

The important passes are:

- Burzil Pass (in Northern Pakistan)
- Pir Panjal Pass (in Pir Panjal range in Jammu & Kashmir)
- Banihal Pass (in the Pir Panjal range)
- Karakoram Pass (pass between India and China)
- Zojila Pass (in Himalayas in Ladakh)
- Bara Lacha Pass (in Zaskar range connecting Himachal Pradesh to Ladakh)
- Shipki la Pass (India-China border, Sutlej enters India through this pass)
- Niti Pass (pass connecting Uttarakhand to Tibet)
- Dharma Pass (in Uttarakhand)
- Rohtang Pass (in Pir Panjal range of Himalayas)
- Nathula Pass (in Himalayas in east Sikkim district)
- Jalepla Pass (a high mountain pass between East Sikkim District, Sikkim, India and Tibet Autonomous Region, China)
- Bomdila Pass (in Arunachal Pradesh)
- Thal Ghat (links Nasik to Mumbai)
- Bhor Ghat (links Mumbai to Pune)
- Pal Ghat (Kerela to Tamil Nadu)
- Senkota Pass (located between the Nagercoil and the Cardamom hills links Thiruvananthapuram and Madurai)
- Diphu Pass (in the tri-point borders of India, China, and Myanma

KASHMIR OR NORTHWESTERN HIMALYAS

- Kashmir or Northwestern Himalayas comprise a series of ranges such as the **Karakoram, Ladakh, Zaskar and Pir Panjal.** The northeastern part of the Kashmir Himalayas is a **cold desert**, which lies between the Greater Himalayas and the Karakoram ranges.

- Between the **Great Himalayas and the Pir Panjal range, lies the world-famous valley of Kashmir and the famous Dal Lake**. Important glaciers of South Asia such as the **Baltoro and Siachen** are also found in this region.
- The Kashmir Himalayas are also **famous for Karewas formations**, which are useful for the cultivation of Zafran, a local variety of saffron. Some of the important passes of the region are Zoji La on the Great Himalayas, Banihal on the Pir Panjal, Photu La on the Zaskar and Khardung La on the Ladakh range.
- Some of the important fresh lakes such as **Dal and Wular and saltwater lakes** such as Pangong Tso and Tso Moriri are also in this region. This region is drained by the river Indus, and its tributaries such as the Jhelum and the Chenab.
- The Kashmir and northwestern Himalayas are well-known for their scenic beauty and picturesque landscape. The landscape of Himalayas is a major source of attraction for adventure tourists.
- Some famous places of pilgrimage such as Vaishno Devi, Amarnath Cave, Charar -e-Sharif, etc. are also located here and large number of pilgrims visit these places every year. Srinagar, capital city of the state of Jammu and Kashmir is located on the banks of Jhelum river.
- Dal Lake in Srinagar presents an interesting physical feature. Jhelum in the valley of Kashmir is still in its youth stage and yet forms meanders – a typical feature associated with the mature stage in the evolution of fluvial landform. The southernmost part of this region consists of longitudinal valleys known as duns. **Jammu dun and Pathankot dun are important examples.**

HIMACHAL AND UTTARANCHAL HIMALAYAS

- The Himachal and Uttarakhand Himalayas lies approximately between the **Ravi in the west and the Kali (a tributary of Ghaghara) in the east**.
- It is drained by two major river systems of India, i.e. the Indus and the Ganga.
- Tributaries of the Indus include the **river Ravi, the Beas and the Sutlej, and the tributaries of Ganga flowing through this region include the Yamuna and the Ghaghara.**
- The Northernmost part of the Himachal Himalayas is an extension of the Ladakh cold desert, which lies in the Spiti subdivision of district Lahul and Spiti.
- All the three ranges of Himalayas are prominent in this section also. These are the **Great Himalayan range, the Lesser Himalayas** (which is locally known as Dhauladhar in Himachal Pradesh and Nagtibha in Uttarakhand) and the **Shiwaliks range from the North to the South.**
- The altitude of Lesser Himalayas lies between 1000-2000 m that specially attracted the British colonial administration, and subsequently, some of the important hill stations such as Dharamshala, Mussoorie, Shimla, Kaosani and the cantonment towns and health resorts such as Shimla, Mussoorie, Kasauli, Almora, Lansdowne and Ranikhet, etc. were developed in this region.
- The two distinguishing features of this region are the **'Shiwaliks' and 'Dun formations**. Some important duns located in this region are the Chandigarh-Kalka dun, Nalagarh dun, Dehra Dun, Harike dun and the Kota dun, etc.

- **Dehra Dun is the largest of all the duns** with an approximate length of 35-45 km and a width of 22-25 km.
- In the Great Himalayan range, the valleys are mostly inhabited by the **Bhotia's.** These are nomadic groups who migrate to **'Bugyals'** (the summer glass lands in the higher reaches) during summer months and return to the valleys during winters.
- The **famous 'Valley of flowers' is also situated in this region**.
- The places of pilgrimage such as the Gangotri, Yamunotri, Kedarnath, Badrinath and Hemkund Sahib are also situated in this part. The region is also known to have five **famous Prayags** (river confluences).

DARJEELING AND SIKKIM HIMALAYAS

- These are flanked by **Nepal Himalayas in the west and Bhutan Himalayas in the east.** It is known for its **fast-flowing rivers such as Tista**.
- It is a region of high **mountain peaks like Kanchenjunga** (Kanchengiri), and deep valleys.
- The higher reaches of this region are inhabited by **Lepcha tribes** while the southern part, particularly the Darjeeling Himalayas, has a mixed population of Nepalis, Bengalis and tribals from Central India.
- The British, taking advantage of the physical conditions such as moderate slope, thick soil cover with high organic content, well distributed rainfall throughout the year and mild winters, introduced tea plantations in this region.
- In comparison with other sections of the Himalayas, these along with the Arunachal Himalayas are conspicuous by the **absence of the Shiwaliks formations**.
- In place of the Shiwaliks, the **'duar formations'** are important, which have also been used for the development of tea gardens.
- Sikkim and Darjeeling Himalayas are also known for their scenic beauty and rich flora and fauna, particularly various types of orchids.

THE ARUNACHAL HIMALAYAS

- These extend from the east of the **Bhutan Himalayas up to the Diphu pass in the east**. The general direction of the **mountain range is from southwest to northeast**. Important mountain peaks are **Kangtu and Namcha Barwa.**
- These ranges are dissected by fast-flowing rivers from the north to the south, forming deep gorges. Brahmaputra flows through a deep gorge after crossing Namcha Barwa.
- Important rivers are **Kameng, Subansiri, Dihang, Dibang and Lohit.** They are perennial rivers with the high rate of fall, having the **highest hydro-electric power potential in the country.**
- An important aspect of the Arunachal Himalayas is the numerous ethnic tribal communities inhabiting in these areas.

- Some of the prominent ones from west to east are the **Monpa, Abor, Mishmi, Nyishi and the Nagas.** Most of these communities' practice **Jhumming**. It is also known as shifting or slash and burn cultivation.
- This region is rich in biodiversity which has been preserved by the indigenous communities. Due to rugged topography, the inter -valley transportation linkages are nominal. Hence, most of the interactions are carried through the duar region along the Arunachal-Assam border.

THE EASTERN HILLS AND MOUNTAINS

- These are part of the Himalayan mountain system having their general alignment from the **north to the south direction**. They are known by different local names.
- In the north, they are known as **Patkai Bum, Naga hills, the Manipur hills and in the south as Mizo or Lushai hills.** These are low hills, inhabited by numerous tribal groups practicing **Jhum cultivation**.
- Most of these ranges are separated from each other by numerous small rivers. The Barak is an important river in Manipur and Mizoram.
- The physiography of Manipur is unique by the presence of a large lake known as **'Loktak' lake** at the centre, surrounded by mountains from all sides. Mizoram which is also known as the 'Molassis basin' which is made up of soft unconsolidated deposits.
- Most of the rivers in Nagaland form the tributary of the Brahmaputra. While two rivers of Mizoram and Manipur are the tributaries of the Barak river, which in turn is the tributary of Meghna; the rivers in the eastern part of Manipur are the tributaries of Chindwin, which in turn is a tributary of the Irrawaddy of Myanmar.

List of Mountain Ranges and Hills in India

Following are the complete list of the Mountain ranges in India with their brief details in various columns:

Rank (India)	Rank (world)	List Of Mountains	Height (m)	Range	State
1	3	Kanchenjunga	8,598	Himalayas	Sikkim
2	23	Nanda Devi	7,816	Garhwal Himalaya	Uttarakhand
3	29	Kamet	7,756	Garhwal Himalaya	Uttarakhand
4	31	Saltoro Kangri / K10	7,742	Saltoro Karakoram	Ladakh
5	35	Saser Kangri I / K22	7,672	Saser Karakoram	Ladakh
6	48	Mamostong Kangri / K35	7,516	Rimo Karakoram	Ladakh

Rank (India)	Rank (world)	List Of Mountains	Height (m)	Range	State
7	49	Saser Kangri II E	7,513	Saser Karakoram	Ladakh
8	51	Saser Kangri III	7,495	Saser Karakoram	Ladakh
9	56	Teram Kangri I	7,462	Siachen Karakoram	Ladakh
10	57	Jongsong Peak	7,462	Kangchenjunga Himalaya	Sikkim
11	61	K12	7,428	Saltoro Karakoram	Ladakh
12	65	Kabru N	7,412	Kangchenjunga Himalaya	Sikkim
13	69	Ghent Kangri	7,401	Saltoro Karakoram	Ladakh
14	71	Rimo I	7,385	Rimo Karakoram	Ladakh
15	73	Teram Kangri III	7,382	Siachen Karakoram	Ladakh
16	76	Kirat Chuli	7,362	Kangchenjunga Himalaya	Sikkim
17	92	Mana Peak	7,272	Garhwal Himalaya	Uttarakhand
18	96	Apsarasas Kangri	7,245	Siachen Karakoram	Ladakh
19	97	Mukut Parbat	7,242	Garhwal Himalaya	Uttarakhand
20	98	Rimo III	7,233	Rimo Karakoram	Ladakh
21	108	Singhi Kangri	7,202	Siachen Karakoram	Ladakh
22		Hardeol	7,161	Kumaon Himalaya	Uttarakhand
23		Chaukhamba I / Badrinath Peak	7,138	Garhwal Himalaya	Uttarakhand
24		Nun-Kun	7,135	Zanskar Himalaya	Ladakh
25		Pauhunri	7,128	Sikkim Himalaya	Sikkim
26		Pathibhara / The Pyramid	7,123	Kangchenjunga Himalaya	Sikkim
27		Trisul I	7,120	Kumaon Himalaya	Uttarakhand
28		Satopanth	7,075[1]	Garhwal Himalaya	Uttarakhand
29		Tirsuli	7,074	Garhwal Himalaya	Uttarakhand
30		Chong Kumdang Ri	7,071[2]	Rimo Karakoram	Ladakh
31		Dunagiri	7,066	Garhwal Himalaya	Uttarakhand
32		Kangto	7,060	Assam Himalaya	Arunachal Pradesh

Rank (India)	Rank (world)	List Of Mountains	Height (m)	Range	State
33		Nyegyi Kansang	7,047	Assam Himalaya	Arunachal Pradesh
34		Padmanabh	7,030[2]	Rimo Karakoram	Ladakh
35		Shudu Tsempa	7,024[4]	Sikkim Himalaya	Sikkim
36		Chamshen Kangri / Tughmo Zarpo	7,017[5]	Saser Karakoram	Ladakh
37		Aq Tash	7,016[6]	Rimo Karakoram	Ladakh
38		Chong Kumdang Ri II	7,004[2]	Rimo Karakoram	Ladakh
39		Rishi Pahar	6,992	Kumaon Himalaya	Uttarakhand
40		Thalay Sagar	6,984	Garhwal Himalaya	Uttarakhand
41		Mount Lakshmi	6,983	Rimo Karakoram	Ladakh
42		Kedarnath Main	6,968	Garhwal Himalaya	Uttarakhand
43		Langpo	6,965[7]	Sikkim Himalaya	Sikkim
44		Saraswati Parvat I / Saraswati Peak	6,940[1]	Garhwal Himalaya	Uttarakhand
45		Shahi Kangri	6,934[8]	Central Tibetan Plateau	Ladakh
46		Sri Kailash	6,932	Garhwal Himalaya	Uttarakhand
47		Kalanka	6,931	Garhwal Himalaya	Uttarakhand
48		Chorten Nyima Ri	6,927[7]	Sikkim Himalaya	Sikkim
49		Saf Minal / P. 6911	6,911[9]	Garhwal Himalaya	Uttarakhand
50		Panchchuli II	6,904[10]	Kumaon Himalaya	Uttarakhand

THE NORTHERN PLAINS

- The Northern plains are formed by the **alluvial deposits brought by the rivers – the Indus, the Ganga and the Brahmaputra.** These plains extend approximately 3,200 km from the east to the west.
- The average width of these plains varies between 150-300 km.
- The maximum depth of alluvium deposits varies between 1,000-2,000 m.
- From the North to the South, these can be divided into 3 major zones: the **Bhabar, the Tarai and the Alluvial plains**.

- The alluvial plains can be further divided into the **Khadar and the Bhangar**.
- Bhabar is a narrow belt ranging between **8-10 km parallel to the Shiwaliks foothills** at the break-up of the slope.
- The streams and rivers coming from the mountains deposit heavy **materials of rocks and boulders, and at times, disappear in this zone.**
- South of the Bhabar is the Tarai belt, with an **approximate width of 10-20 km where most of the streams and rivers re-emerge** without having any properly demarcated channel, thereby, creating marshy and swampy conditions known as the Tarai. This has a **luxurious growth of natural vegetation** and houses a varied wildlife.
- The south of Tarai is a belt consisting of old and new alluvial deposits known as the **Bhangar (older alluvium) and Khadar (younger alluvium) respectively**. These plains have characteristic features of mature stage of fluvial erosional and depositional landforms such as **sand bars, meanders, oxbow lakes and braided channels.**
- The Brahmaputra plains are known for their riverine islands and sand bars. Most of these areas are subjected to periodic floods and shifting river courses forming braided streams.
- The mouths of these mighty rivers also form some of the largest deltas of the world, for example, the famous Sundarbans delta.
- The states of Haryana and Delhi form a water divide between the Indus and the Ganga river systems. As opposed to this, the Brahmaputra river flows from the northeast to the southwest direction before it takes an almost 90° southward turn at Dhubri before it enters into Bangladesh.
- These river valley plains have a fertile alluvial soil cover which supports a variety of crops like wheat, rice, sugarcane and jute, and hence, supports a large population.

THE PENINSULAR PLATEAU

- Rising from the height of 150 m above the river plains up to an elevation of 600-900 m is the irregular triangle known as the Peninsular plateau. Delhi ridge in the northwest, (extension of Aravalli's), the Rajmahal hills in the east, Gir range in the west and the Cardamom hills in the south constitute the outer extent of the Peninsular plateau. The **highest peak in the Aravalli range is Guru Sikhar.**
- **River Narmada flows between the Vindhyan and the Satpura ranges**. The south of the Satpura range is the **Satmala hills.**
- **River Tapi flows between Satpura and Satmala hills.**
- **Mountains from West to East:** Vindhyan – Satpura – Mahadeo – Maikala – Kaimur – Ramgarh – Rajmahal Hills.
- **Mountains from North to South:** Satmala – Ajanta – Balaghat – Harishchandra – Mahendragiri – Nallamala – Palkonda – Javadi – Nilgiri – Shevaroy – Annamalai – Cardamom.
- **Highest peak in the Eastern Ghats is –** Mahendragiri.

- **Highest peak in the Nilgiri Hills is –** Dodabetta
- **Highest peak in the entire Peninsular region is –** Anaimudi peak in Annamalai hills.

SLOPE OF PENINSULAR PLATEAU

- An extension of Peninsular plateau is also seen in the northeast, in the form of Shillong and Karbi-Anglong plateau.
- **Delhi ridge in the north-west** (extension of the Aravalli hills), the Rajmahal hills in the East, Gir range in the west and the Cardamom hills in the south; northeast- Shillong and the Karbi Anglong plateau.
- The Peninsular India is made up of a series of **plateaus viz. the Hazaribagh plateau, the Palamu plateau, the Ranchi plateau, the Malwa plateau, the Coimbatore plateau, the Karnataka plateau, etc.**
- This is **one of the oldest and the most stable landmass of India.** The general elevation of the plateau is from the west to the east, which is also proved by the pattern of the flow of rivers.
- Some of the important physiographic features of this region are **block mountains, rift valleys, spurs, bare rocky structures, series of hummocky hills and wall-like quartzite dykes** offering natural sites for water storage. The western and northwestern part of the plateau has an emphatic presence of black soil. Erosional surfaces of the Chotanagpur; Dissected gneissic country of Bundelkhand; trough valleys of the Damodar, the Narmada and the Tapi.
- This Peninsular plateau has undergone recurrent phases of **upliftment and submergence accompanied by crustal faulting and fractures.** (The Bhima fault needs special mention, because of its recurrent seismic activities). These spatial variations have brought in elements of diversity in the relief of the Peninsular plateau.
- The Northwestern part of the plateau has a complex relief of ravines and gorges. The ravines of Chambal, Bhind and Morena are some of the well-known examples.
- On the basis of prominent relief features, the Peninsular plateau can be divided into:

I. **The Deccan Plateau**
II. **The Central Highlands**
III. **The Northeastern Plateau.**

DECCAN PLATEAU

- This is **bordered by the Western Ghats in the west, Eastern Ghats in the east and the Satpura, Maikal range and Mahadeo hills in the north**.
- Western Ghats are locally known by different names: Sahyadri in Maharashtra, Nilgiri hills in Karnataka and Tamil Nadu and Annamalai hills, Cardamom hills in Kerala.
- **Western Ghats are comparatively higher in elevation and more continuous than the Eastern Ghats.** Their **average elevation is about 1,500 m with the height increasing from north to south.**

- **'Anaimudi'** (2,695 m), the **highest peak of Peninsular plateau is located on the Annamalai hills** of the Western Ghats followed by **Dodabetta (2,637 m) on the Nilgiri hills.**
- Most of the Peninsular rivers have their origin in the Western Ghats**. Eastern Ghats comprising the discontinuous and low hills** are highly eroded by the rivers such as the Mahanadi, the Godavari, the Krishna, the Kaveri, etc.
- Some of the important ranges include the Javadi hills, the Palkonda range, the Nallamalla hills, the Mahendragiri hills, etc.
- The **Eastern and the Western Ghats meet each other at the Nilgiri hills.**
- Deccan plateau is **famous for Regur soil** and is **built up by flat lying basalt lava.**

CENTRAL HIGHLANDS

- They are bounded to the **west by the Aravalli range.** The **Satpura range is formed by a series of scarped plateaus on the south**, generally at an elevation varying between 600-900 m above the mean sea level.
- This forms the northernmost boundary of the Deccan plateau.
- It is a classic example of relict mountains which are highly denuded and form discontinuous ranges.
- Extension of Peninsular plateau is upto **Jaisalmer in the West**, where it has been covered by longitudinal sand ridges and crescent-shaped sand dunes(barchans).
- This region has **undergone metamorphic processes in its geological history,** which can be corroborated by the presence of metamorphic rocks such as marble, slate, gneiss, etc.
- The general elevation of the **Central Highlands ranges between 700-1,000 m** above the mean sea level and it slopes towards the north and northeastern directions.
- Most of the tributaries of the river **Yamuna have their origin in the Vindhyan and Kaimur ranges.**
- Banas is the only significant **tributary of the river Chambal** that originates from the Aravalli in the west.
- An eastern extension of the Central Highland is formed by the **Rajmahal hills,** to the south of which lies a large reserve of mineral resources in the Chotanagpur plateau.
- The **Bundelkhand upland in the Central Highlands** is famous for gneissic and granitic rocks.

NORTHEASTERN PLATEAU

- It is an extension of the main Peninsular plateau. It is believed that due to the force exerted by the northeastward movement of the Indian plate at the time of the

Himalayan origin, a huge fault was created known as **Malda fault between the Rajmahal hills and the Meghalaya plateau.**

- Later, this depression got filled up by the deposition activity of the numerous rivers.
- Today, the Meghalaya and Karbi Anglong plateau stand detached from the main Peninsular Block. The **Meghalaya plateau is further sub-divided** into three:
  I. The Garo Hills;
  II. The Khasi Hills;
  III. The Jaintia Hills, named after the tribal groups inhabiting this region.
- An extension of this is also seen in the Karbi Anglong hills of Assam.
- Similar to the Chotanagpur plateau, the Meghalaya plateau is also rich in mineral resources like Coal, Iron Ore, Sillimanite, Limestone And Uranium.
- This area receives maximum rainfall from the South West Monsoon. As a result, the Meghalaya plateau has a highly eroded surface.
- Cherrapunji displays a bare rocky surface devoid of permanent vegetation cover.
- The **high seismicity regions in the Peninsular plateau** are:
  I. Malda fault
  II. Bhima fault
  III. Bhuj region in Gujarat

THE INDIAN DESERT

- To the **northwest of the Aravalli hills lies the Great Indian desert.**
- It is a land of undulating topography dotted with longitudinal dunes and barchans.
- This region receives low rainfall below 150 mm/year; hence, it has arid climate with low vegetation cover. It is because of these characteristic features that this is also known as **Marusthali.**
- It is believed that during the **Mesozoic era, this region was under the sea**. This can be corroborated by the evidence available at wood fossils park at Aakal and marine deposits around Brahmsar, near Jaisalmer (The approximate age of the wood fossils is estimated to be 180 million years).
- Though **the underlying rock structure of the desert is an extension of the Peninsular plateau,** yet, due to extreme arid conditions, its surface features have been carved by physical weathering and wind actions.
- Some of the well pronounced desert land features present here are **mushroom rocks, shifting dunes and oasis** (mostly in its southern part).
- On the basis of the orientation, the desert is divided into 2 parts: the Northern part is sloping towards Sindh and the southern towards the Rann of Kachchh. Most of the **rivers in this region are ephemeral.**
- The **Luni river flowing in the southern part of the desert is of some significance**. Low precipitation and high evaporation make it a water deficit region.

- There are some streams which disappear after flowing for some distance and present a typical case of inland drainage by joining a lake or playa. The lakes and the playas have brackish water which is the main source of obtaining salt.

- **Ladakh**, large area of the northern and eastern Kashmir region, north-western Indian subcontinent. Administratively, Ladakh is divided between Pakistan (northwest), as part of Gilgit-Baltistan, and India (southeast), as part of Ladakh union territory (until October 31, 2019, part of Jammu and Kashmir state); in addition, China administers portions of northeastern Ladakh.
- In south eastern Ladakh lies Rupshu, an area of large, brackish lakes with a uniform elevation of about 13,500 feet (4,100 metres)

THE COASTAL PLAINS

- On the basis of the location and active geomorphological processes, it can be broadly divided into two:
  - **I. The Western Coastal Plains;**
  - **II. The Eastern Coastal Plains**
- **The western coastal plains** are an example of **submerged coastal plain**.
- It is believed that the **city of Dwarka** which was once a part of the Indian mainland situated along the west coast **is submerged under water**. Because of this submergence it is a narrow belt and provides **natural conditions for the development of ports and harbors**.
- Kandla, Mazagaon, JLN port Navha Sheva, Marmagao, Mangalore, Cochin, etc. are some of the important natural ports located along the west coast.
- Extending from the Gujarat coast in the north to the Kerala coast in the south, the western coast may be divided into following divisions- **the Kachchh and Kathiawar coast in Gujarat, Konkan coast in Maharashtra, Malabar coast in Karnataka and Kerala respectively.**
- The western coastal plains are narrow in the middle and get broader towards north and south. The rivers flowing through this coastal plain **do not form any delta.**
- The Malabar coast has got certain distinguishing features in the form of '**Kayals' (backwaters),** which are used for fishing, inland navigation and also due to its special attraction for tourists.
- Every year the famous **Nehru Trophy** Vallamkali (boat race) is held in Punnamada Kayal in Kerala.
- **Vembanad lake** in Kerela is one of the **longest lakes in India**.

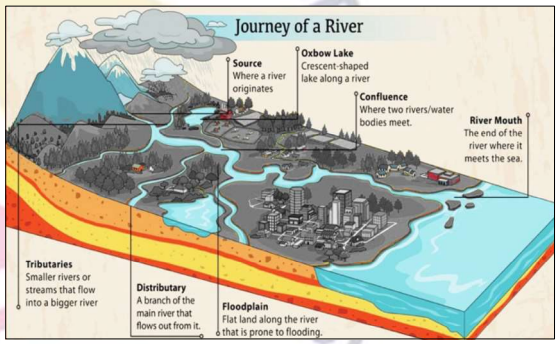
- As compared to the western coastal plain, the **eastern coastal plain is broader and is an example of an emergent coast.** There are **well-developed deltas here, formed by the rivers** flowing eastward into the Bay of Bengal.
- These include the deltas of the **Mahanadi, the Godavari, the Krishna and the Kaveri. Because of its emergent nature**, it has **lesser number of ports and harbors**.
- The continental shelf extends up to 500 km into the sea, which makes it difficult for the development of good ports and harbors.
- The **division of coasts in the Eastern coastal plains** are:
  I. Coromandel coast (Tamil Nadu)
  II. Andhra coast (Andhra Pradesh)
  III. Utkal coast (Odisha and West Bengal)
- The **states of India having the coastlines are** Gujarat, Maharashtra, Goa, Karnataka, Kerela, Tamil Nadu, Andhra Pradesh, Odisha and West Bengal.
- **Gujarat has the longest coastline among all the states in India**.

THE ISLANDS

- There are **two major island groups in India-one in the Bay of Bengal and the other in the Arabian Sea.**
- The **Bay of Bengal island groups consist of about 572 islands/islets**. These are situated roughly between **6°N-14°N and 92°E -94°E.** The two principal groups of islets include the **Ritchie's archipelago and the Labyrinth island.**
- The entire group of islands is divided into two broad categories - the **Andaman in the north** and the **Nicobar in the south.** They are separated by a waterbody which is called the **Ten-degree channel**.
- **Barren island,** the only active volcano in India is also situated in the Nicobar Islands and **Narcodam island**, the only dormant volcano is situated in North Andaman.
- The coastal line has some coral deposits, and beautiful beaches. These islands receive **convectional rainfall** and have an **equatorial type of vegetation.**
- The islands mainly have **elevated portion of submarine mountains** and the **smaller islands are mainly volcanic in origin.**
- **Duncan passage separate South Andaman from Little Andaman.**
- **Indira point is situated in Great Nicobar.**
- **Mountains of Andaman:**
  - **Saddle Peak** (North Andaman 738m)
  - **Mount Koyob** (South Andaman 642m)
  - **Mount Diavolo** (Middle Andaman 515m)
  - **Mount Thuiller** (Great Nicobar 642m)
- The **islands of the Arabian sea include Lakshadweep and Minicoy**. These are scattered between **8°N-12°N and 71°E -74°E longitude**.
- These islands are located at a distance of **280-480 km off the Kerala coast.** The entire island group is built of **coral deposits**.

- There are **approximately 36 islands of which 11 are inhabited**. **Minicoy is the largest** island with an area of 453 km^2.
- The entire group of islands is broadly divided by the **Ten-degree channel, north of which is the Amini Island and to the south of the Canannore Island.**
- The Islands of this archipelago have storm beaches consisting of unconsolidated pebbles, shingles, cobbles and boulders on the eastern seaboard.
- **Kavarati or Lakshadweep and Minicoy** islands are separated by a Nine-degree channel.
- **Amini/Aminidivi island and Canannore islands** are separated by an **Eleven-degree channel.**
- **Lakshadweep/Minicoy islands and Maldives** are separated by an **Eight-degree channel.**

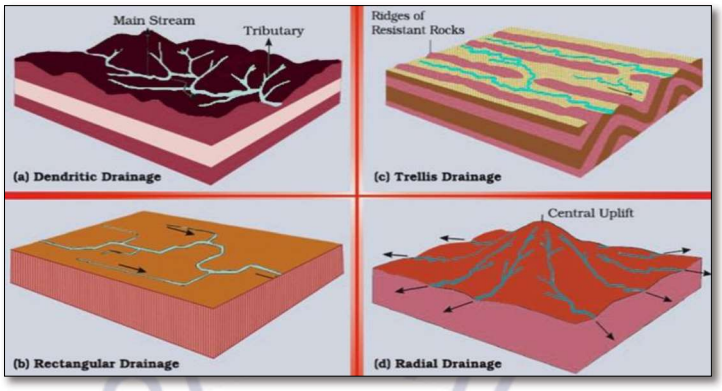
DRAINAGE SYSTEM



- A river drains the water collected from a specific area, which is called its **'catchment area'.**
- An area drained by a river and its tributaries
- is called a **drainage basin.**
- The boundary line separating one drainage basin from the other is known as the **watershed.**
- The catchments of large rivers are called river basins while those of small rivulets and rills are often referred to as watersheds.
- Watersheds are small in area while the basins cover larger areas.
- The connecting rivers to the main river are called **Tributary. Tributaries** mainly flow from the elevated region to the main river.
- **Distributaries** means splitting of the rivers.
- Tributaries, distributaries, main course of river, delta formations altogether are known as **Drainage system.**
- **Radial drainage:** here the river will flow from an uplifted region in different direction.
- **Dendritic drainage:** it can mostly be found in the northern plains. It may develop on homogeneous rock, which has a shape resembling the pattern made by the branches of a tree or the veins of a leaf such as rivers from Peninsular and Himalayan region are joining the Ganga river.
- **Trellis drainage:** it occurs where sub parallel streams erode a valley along the strike of less resistant formations. These beds are usually steeply dipping and may be part of

a fold system. The tributaries often intersect at right angles where a notch called a water gap cuts through a harder formation.

- **Rectangular drainage:** here mainly the rivers splits in different direction and then they again come back and join the previous path.



- On the basis of the mode of origin, nature and characteristics, the Indian drainage may also be classified into the **Himalayan drainage** and the **Peninsular drainage**.
- The Himalayan rivers are snow fed and rain fed rivers. They mainly get rainfall all throughout the year and hence known as **Perennial rivers.**
- The Himalayan drainage system has evolved through a long geological history. It mainly includes **the Ganga,** the **Indus** and the **Brahmaputra** river basins.

HIMALAYAN RIVERS

- These rivers pass through the **giant gorges carved out by the erosional activity** carried on simultaneously with the uplift of the Himalayas.
- These rivers also form **V-shaped valleys**, **rapids and waterfalls** in their mountainous course.
- While entering the **plains**, they form **depositional features** like **flat valleys**, **ox-bow lakes, flood plains, braided channels, and deltas** near the river mouth.
- In the Himalayan reaches, the course of these rivers is highly tortous, but in plains they display a strong meandering tendency and shift their courses frequently.
- River Kosi is also known as the **'sorrow of Bihar',** has been notorious for frequently changing its course. The Kosi brings huge quantity of sediments from its upper reaches and deposits it in the plains. The course gets blocked, and consequently, the river changes its course.

THE INDUS SYSTEM

- It is one of the largest river basins of the world, covering an area of 11,65,000 km^2 (in India it is 321, 289km^2 and a total length of 2,880 km (in India 1,114 km).
- The Indus also known as **the Sindhu,** is the **westernmost of the Himalayan rivers in India.** It originates from a glacier near Bokhar Chu (31°15' N latitude and 81°40'

E longitude) in the Tibetan region at an altitude of 4,164 m in the Kailash Mountain range.

- In Tibet, it is known as **'Singi Khamban; or Lion's mouth.** After flowing in the northwest direction **between the Ladakh and Zaskar ranges,** it passes through Ladakh and Baltistan. It cuts across the Ladakh range, forming a spectacular gorge near **Gilgit in Jammu and Kashmir**. It enters into Pakistan near **Chilas in the Dardistan region**.
- The Indus receives a number of Himalayan tributaries such as the **Shyok, the Gilgit, the Zaskar, the Hunza, the Nubra, the Shigar, the Gasting and the Dras.** It finally emerges out of the hills near Attock where it receives the **Kabul river** on its right bank.
- The other important tributaries joining the **right bank** of the Indus are **Khurram, Tochi, Gomal, Viboa and Sangar.** They all originate in the **Sulaiman ranges.** The river flows southward and receives **'Panjnad'** a little above Mithankot.
- The Panjnad is the name given to the 5 rivers of Punjab, viz. **Sutlej, Beas, Ravi, Chenab and Jhelum.** It finally discharges into the Arabian Sea, **east of Karachi. The Indus flows in India only through Jammu and Kashmir.**
- The Jhelum, an important tributary of the Indus, rises from **a spring at Verinag** situated at the foot of the **Pir Panjal** in the south-eastern part of the valley of Kashmir. It flows through **Srinagar** and the **Wular lake** before entering Pakistan through a deep narrow gorge. It joins the Chenab near Jhang in Pakistan.
- The Chenab is the largest tributary of the Indus. It is formed by 2 streams,Chandra and Bhaga, which join at Tandi near **Keylong in Himachal Pradesh**. Hence, it is also known as **Chandrabhaga.** The river flows for 1180 km before entering into Pakistan.
- The Ravi is a tributary of the Indus. It rises west of the **Rohtang pass** in the **Kullu hills of Himachal** Pradesh and flows through the Chamba valley of the state. Before entering Pakistan and joining the Chenab near Sarai Sidhu, it drains the area lying between the southeastern part of the **Pir Panjal and the Dhauladhar ranges.**
- The Beas is a tributary of the Indus, originating from the **Beas Kund** near the **Rohtang Pass** at an elevation of 4,000 m above the mean sea level. The river flows through the **Kullu valley** and forms gorges at Kati and Largi in the Dhauladhar range. It enters the Punjab plains where it meets the Sutlej near Harike.
- The Sutlej originates in the **'Raksas tal'** near **Man Sarovar** at an altitude of 4,555 m in Tibet where it is known as **Langchen Khambab.** It flows almost parallel to the Indus for about 400 km before entering India and comes out of a gorge at **Rupar.** It passes through the **Shipki La** on the Himalayan ranges and enters the Punjab plains. It is an **antecedent river.** It is a very important tributary as it feeds the canal system of the **Bhakra Nangal project.**

THE GANGA SYSTEM

- The Ganga is the most important river of India both from the point of view of its basin and cultural significance.
- It rises in the **Gangotri glacier near Gaumukh** (3,900 m) in the **Uttarkashi district of Uttarakhand.** Here, it is known as the **Bhagirathi.**
- It cuts through the Central and the Lesser Himalayas in narrow gorges.
- At **Devprayag,** the **Bhagirathi** meets the **Alaknanda;** hereafter, it is known as the **Ganga.**
- The **Alaknanda** has its source in the **Satopanth glacier** above Badrinath. The Alaknanda consists of the **Dhauli** and the **Vishnu Ganga** which meet at Joshimath or **Vishnu Prayag.**
- The other tributaries of Alaknanda such as the **Pindar** joins it at **Karna Prayag** while **Mandakini** or **Kali Ganga** meets it at **Rudra Prayag**.
- **The Ganga enters the plains at Haridwar.** From here, it flows first to the south, then to the south-east and east before splitting into 2 distributaries, viz. **Bhagirathi** and **Padma.**
- The river has a length of 2,525 km. It is shared by **Uttarakhand** (110 km) and **Uttar Pradesh (1,450 km),** Bihar (445 km) and **West Bengal** (520 km). The Ganga basin covers about 8.6 lakh km^2 area in India alone.
- The Ganga river system is the largest in India having a number of perennial and non-perennial rivers originating in the Himalayas in the north and the Peninsula in the south, respectively. The **Son** is its major right bank tributary.
- The important left bank tributaries are **Ramganga,Gomati,Ghaghara,Gandak, Kosi and Mahananda.** The river finally discharges itself into the Bay of Bengal near the **Sagar Island.**
- The **Yamuna,** the western most and the longest tributary of the Ganga, has its source in the **Yamunotri glacier** on the western slopes of Bander punch range (6,316 km). It joins the **Ganga at Prayag (Allahabad).** It is joined by the Chambal, the Sind, the Betwa and the Ken on its right bank which originates from the Peninsular plateau while the Hindan, the Rind, the Sengar, the Varuna, etc. join it on its left bank. Much of its water feeds the western and eastern Yamuna and the Agra canals for irrigation purposes.
- **The Chambal** rises near Mhow in the Malwa plateau of Madhya Pradesh and flows northwards through a gorge up wards of Kota in Rajasthan, where the Gandhisagar dam has been constructed. From Kota, it traverses down to Bundi, Sawai Madhopur and Dholpur, and finally joins the Yamuna. The Chambal is famous for its badland topography called the Chambal ravines.
- **The Gandak** comprises two streams, namely Kaligandak and Trishulganga. It rises in the Nepal Himalayas between the Dhaulagiri and Mount Everest and drains the central part of Nepal. It enters the Ganga plain in Champaran district of Bihar and joins the Ganga at Sonpur near Patna.
- T**he Ghaghara** originates in the glaciers of Mapchachungo. After collecting the waters of its tributaries – Tila, Seti and Beri, it comes out of the mountain, cutting a deep gorge at Shishapani. The river Sarda (Kali or Kali Ganga) joins it in the plain before it finally meets the Ganga at Chhapra.
- **The Kosi** is an antecedent river with its source to the north of Mount Everest in Tibet, where its mainstream Arun rises. After crossing the Central Himalayas in Nepal, it is joined by the Son Kosi from the West and the Tamur Kosi from the east. It forms Sapt Kosi after uniting with the river Arun.
- **The Ramganga** is comparatively a small river rising in the Garhwal hills near Gairsain. It changes its course to the southwest direction after crossing the Shiwaliks and enters

into the plains of Uttar Pradesh near Najibabad. Finally, it joins the Ganga near Kannauj.

- **The Damodar** occupies the eastern margins of the Chotanagpur Plateau where it flows through a rift valley and **finally joins the Hugli**. The **Barakar** is its main tributary. Once known as the **'sorrow of Bengal'**, the Damodar has been now tamed by the **Damodar Valley corporation**, a multipurpose project.
- **The Sarda or Saryu river rises** in the Milam glacier in the Nepal Himalayas where it is known as the **Goriganga.** Along the Indo-Nepal border, it is called Kali or Chauk, where it joins the Ghaghara.
- The **Mahananda** is another important tributary of the Ganga rising in the Darjeeling hills. It joins the Ganga as its last left bank tributary in West Bengal.
- The **Son** is a large south bank tributary of the Ganga, originating in the Amarkantak plateau. After forming a series of waterfalls at the edge of the plateau, it reaches Arrah, west of Patna, to join the Ganga.
- **Tehri dam –** on river Bhagirathi
- **Gandhi Nagar dam –** on river Chambal in Madhya Pradesh.

THE BRAHMAPUTRA SYSTEM

- The Brahmaputra, one of the largest rivers of the world, has its origin in the **Chemayungdung glacier** of the **Kailash range near the Mansarovar lake**. From here, it traverses eastward longitudinally for a distance of nearly 1,200 km in a dry and flat region of southern Tibet, where it is known as the **Tsangpo,** which means 'the purifier.'
- The Rango Tsangpo is the major right bank tributary of this river in Tibet. It emerges as a turbulent and dynamic river after carving out a deep gorge in the Central Himalayas **near Namcha Barwa** (7,755 m).
- The river emerges from the foothills under the name of **Siang or Dihang**. It enters India west of **Sadiya town in Arunachal Pradesh**. Flowing southwest, it receives its main left bank tributaries, viz., **Dibang or Sikang and Lohit**; thereafter, it is known as the **Brahmaputra.**

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

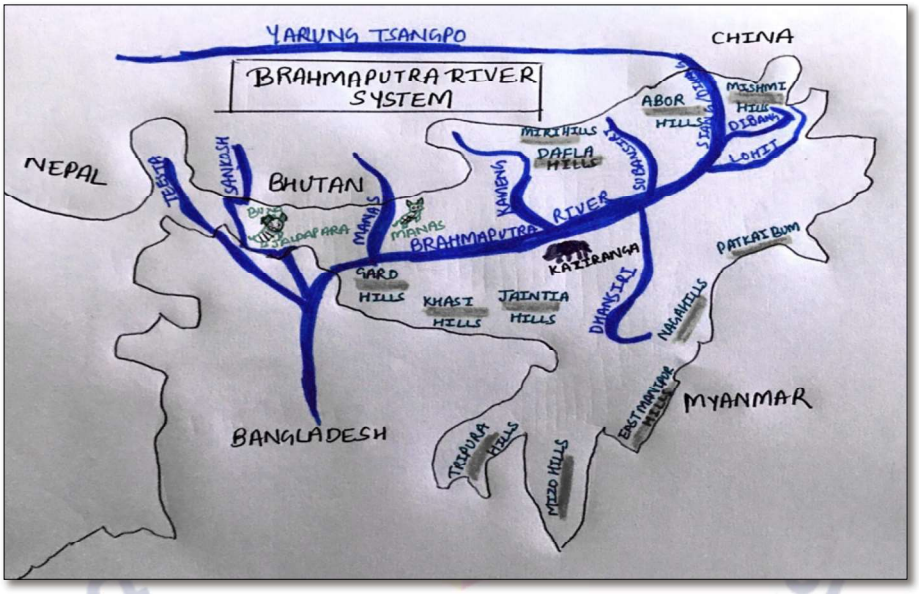


Fig: Brahmaputra River System

THE EVOLUTION OF PENINSULAR DRAINAGE SYSTEM

- The Peninsular drainage system is **older than the Himalayan one.** This is evident from the broad, largely graded shallow valleys, and the maturity of the rivers.
- The other major river systems of the Peninsular drainage are – the **Mahanadi the Godavari**, the **Krishna** and the **Kaveri.**
- Peninsular rivers are characterized by fixed course, absence of meanders and non-perennial flow of water. The **Narmada and the Tapi** which flow through the **rift valley** are, however, exceptions.
- **Narmada is the longest west-flowing river in India** and the **second longest in the Peninsular river drainage system**
- **Sardar Sarovar dam and Indira Sagar dam (MP) is on Narmada river**.
- **Ukai dam is on Tapi river**.

- Three major geological events in the distant past have shaped the present drainage systems of Peninsular India:
  I. **Subsidence of the western flank** of the Peninsula leading to its submergence below the sea during the early tertiary period. Generally, it has disturbed the symmetrical plan of the river on either side of the original watershed.
  II. **Upheaval of the Himalayas** when the northern flank of the Peninsular block was subjected to subsidence and the consequent trough faulting. The Narmada and The Tapi flow in trough faults and fill the original cracks with their detritus materials. Hence, there is a lack of alluvial and deltaic deposits in these rivers.
  III. **Slight tilting of the Peninsular block** from northwest to the southeastern direction gave orientation to the entire drainage system towards the Bay of Bengal during the same period.

RIVER SYSTEMS OF THE PENINSULAR DRAINAGE

- There are a large number of river systems in the **Peninsular drainage.**
- The **Mahanadi** rises near Sihawa in Raipur district of Chhattisgarh and runs through Odisha to discharge its water into the Bay of Bengal. It is 851 km long and its catchment area spreads over 1.42 lakh km^2. Some navigation is carried on in the lower course of this river. Fifty-three per cent of the drainage basin of this river lies in Madhya Pradesh and Chhattisgarh, while 47% lies in Odisha.
- The **Godavari** is the largest Peninsular river system. It is also called the Dakshin Ganga. It rises in the **Nasik district of Maharashtra** and discharges its water into the Bay of Bengal. Its tributaries run through the states of Maharashtra, Madhya Pradesh, Chhattisgarh, Odisha and Andhra Pradesh. It is 1,465 km long with a catchment area spreading over 3.13 lakh km^2 49 % of this, lies in Maharashtra, 20 % in Madhya Pradesh and Chhattisgarh, and the rest in Andhra Pradesh. **The Penganga, the Indravati, the Pranhita, and the Manjra are its principal tributaries.** The Godavari is subjected to heavy floods in its lower reaches to the south of Polavaram, where it forms a picturesque gorge. It is navigable only in the deltaic stretch. The river after **Rajahmundry** splits into several branches forming a large delta.

DAMS/ RESERVOIRS

Dam	**River (Basin)**	**State (Nearest city)**
Tehri Dam	Bhagirathi (Ganga)	Uttarakhand (Pratapnagar)
Lakhwar Dam	Yamuna (Ganga)	Uttarakhand (Dehradun)
Koteshwar Dam	Bhagirathi (Ganga)	Uttarakhand (Pratapnagar)

Ramganga Dam	Ramganga (Ganga)	Uttarakhand (Lansdowne)
Rihand Dam	Rihand (Ganga)	Uttar Pradesh (Dudhi)
Gandhi Nagar	Chambal	Madhya Pradesh
Bhakra Dam	Sutlej (Indus)	Himachal Pradesh (Bilaspur)
Nangal Dam	Sutlej (Indus)	Himachal Pradesh
Govind sagar reservoir	Sutlej	Himachal Pradesh
Ranjit Sagar Dam	Ravi (Indus)	Punjab (Pathankot)
Pong Dam	Beas (Indus)	Himachal Pradesh (Dera Gopipur)
Parbati II Dam	Parbati (Indus)	Himachal Pradesh (Kullu)
Baglihar Dam	Chenab (Indus)	Jammu & Kashmir (Ramban)
Chemera I Dam	Ravi (Indus)	Himachal Pradesh (Bhattiyat)
Subansiri Lower HE (Nhpc) Dam	Subansiri (Brahmaputra)	Arunachal Pradesh
Doyang Hep Dam	Doyang (Brahmaputra)	Nagaland (Wokha)
Teesta -V Dam	Teesta (Brahmaputra)	Sikkim
Tilaiya Dam	Barakar (Damodar)	Jharkhand
Panchet dam	Damodar	Jharkhand
Sardar Sarovar Dam	Narmada (Narmada)	Gujarat (Rajpipla)
Indira Sagar Dam	Narmada (Narmada)	Madhya Pradesh (Khandwa)
Ukai Dam	Tapi (Tapi)	Gujarat (Songadh)
Jakham Main Dam	Jakham (mahi)	Rajasthan (Pratapgarh)

Hirakud dam	Mahanadi	Orissa
Minamata (Hasdeo) Bango Dam	Hasdeo (Mahanadi)	Chhattisgarh (Katghora)
Podagada Dam	Podagada (Godavari)	Odisha (Nabarangapur)
Bandardhara Dam	Paravara (Godavari)	Maharashtra (Akola)
Nizam Sagar Dam	Manjira River (Godavari)	Telangana
Srisailam Dam	Krishna (Krishna)	Telangana (Nandikotkur)
Nagarjuna Sagar Dam	Krishna (Krishna)	Telangana (Guruzala)
Koyna Dam	Koyna (Krishna)	Maharashtra (Patan)
Warna Dam	Varna (Krishna)	Maharashtra (Shahuwadi)
Alamatti	Krishna	Karnataka
Tungabhadra	Tungabhadra (Krishna)	Karnataka
Supa Dam	Kali Nadi	Karnataka
Mettur Dam	Cauvery	Tamil Nadu
Pillur Dam	Bhavani (Cauvery)	Tamil Nadu (Mettuppalaiyam)
Idukki Arch Dam	Periyar	Kerala (Todupulai)
Idamalayar Dam	Idamalayar	Kerala
Cheruthoni Dam	Cheruthoni	Kerala (Todupulai)

Lakes in India – Part 1

Wular Lake

- Kashmir – India's largest freshwater lake
- Formed by tectonic forces
- Forms Delta with river Jhelum
- Tulbul project

Dal Lake

- Kashmir – freshwater lake
- Srinagar is located along its coast
- Contains char chinar & nami islands

Mansar Lake

- Jammu – katra highway – freshwater lake
- Natural lake used mainly for fishing

Naini Lake

- Uttarakhand – freshwater lake

Sambhar Lake

- Rajasthan – most saline lake of India
- Listed in Ramsar as a wetland of international importance

Pushkar Lake

- Ajmer (Rajasthan), a freshwater lake

Panchprada Lake

- Barmer (Rajasthan), a saline lake

Dhebar Lake

- Rajasthan – Largest artificial lake of India
- Also known as Jaisamand Lake
- Built in 17th century, a freshwater lake

Rajsamad Lake

- Rajsamad (Rajasthan) –freshwater lake
- Created in 17th century by damming the water of Gomti, Kelva & Tali rivers
- Home of two islands

Nakki Lake

- A bowl shape lake, located in Mt. Abu (Rajasthan)
- Probably volcanic

Nal Sarovar Lake

- Saline water lake located in Gujrat
- largest bird century of Gujrat

Nokrek Lake

- Fresh water lake located in Meghalaya, famous for its Biodiversity
- Nokrek National Park & Biosphere reserve

Loktak Lake

- Manipur – Largest freshwater lake located in NE India
- Floating island – Phundis

Lakes in India – Part 2

Bhoj Wetland

- A highly polluted lake surrounded by city of Bhopal
- Consists of 2 lakes viz. upper lake & lower lake

Kankaria

- Biggest artificial lake of Ahmedabad
- Built by Sultan Ahmed shah, whose name accounts for the name of the city Ahmedabad

Lonar

- Crater lake, located at Maharashtra

Chilka

- Largest Saline water lagoon located at Orissa
- Siberian bird migrates here in winters

Usman Sagar

- Artificial lake of Hyderabad, by creating a dam on river Musi
- Created by Nizam Usman Khan in 1920

Kolleru Lake

- Fresh water lake, Situated b/w deltas of Godavari & Krishna
- A bird sanctuary & a wetland under Ramsar list

Pullicat Lake

- Saltwater lagoon located at the coast of Andhra Pradesh
- Separated from the sea by Sriharikota island

Sholavaram

- A rainfed reservoir, located at Thanjavur in Chennai
- Due to scanty rainfall for last few years, lake looks like a pond

Vembanad

- Kerala, a lagoon, famous for boat competition and longest lake in India

Ashtamudi

- Kerala, a lagoon, under Ramsar convention

Lakes in India – Part 3

Pangong Lake

- Ladakh, b/w India & China (Tibet)
- Nearby Chnagla Pass

Tsomoriri Lake

- Largest high-altitude lake, located at Ladakh
- Tourists are not allowed boating in this lake

Chandra Tal

- A high-altitude lake, located at Lahaul & Spiti districts of Himachal nearby Kunzam Pass
- Chandra river, a major tributary of Chenab originated from Chandra Tal
- Declared as a wetland under Ramsar convention

Suraj Tal

- Located below Baralacha pass at Lahaul & Spiti districts of Himachal
- Remains frozen during the greater part of the year

Roop Kund

- Mystery lake of Uttarakhand
- Also known as Skeleton lake
- 672 Skeletons has been found in this shallow lake

Sukhna Lake

- Chandigarh

Sat Tal

- Quiet & calm group of 7 pristine lakes in lower Himalayan range situated near Bhimtal in Uttarakhand.

SOILS OF INDIA

SOIL FORMATION

- Biological activity is slowed or stopped if the soil becomes **too cold or too dry.** Organic matter increases when leaves fall, or grasses die.

PROCESS OF SOIL FORMATION

- Soil-forming Factors **Five basic factors** control the formation of soils:
  - **I. Parent Material;**
  - **II. Topography;**
  - **III. Climate;**
  - **IV. Biological Activity;**
  - **V. Time.**
- On the basis of genesis, colour, composition and location, the soils of India have been classified into:
  - I. **Alluvial soils**
  - II. **Black soils**
  - III. **Red and Yellow soils**
  - IV. **Laterite soils**
  - V. **Arid soils**
  - VI. **Saline soils**
  - VII. **Peaty soils**
  - VIII. **Forest soils.**

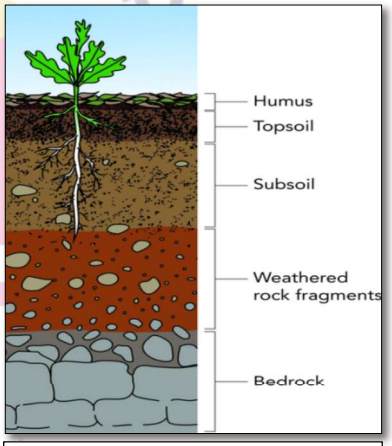
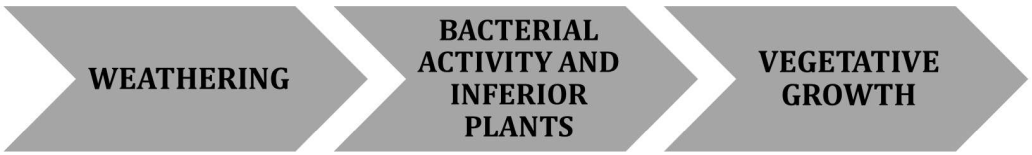


Fig: Soil Profile

Fig: Soil Formation



ALLUVIAL SOILS

- Alluvial soils are widespread in the **northern plains and the river valleys.**
- These soils cover **about 40 %** of the total area of the country.
- They are depositional soils, transported and deposited by **rivers and streams.** Through a narrow corridor in Rajasthan, they extend into the plains of Gujarat. In the Peninsular region, they are found in **deltas** of the east coast and in the **river valleys.**
- The alluvial soils vary in nature from **sandy loam to clay.**
- These soils **are loamier and more clayey in the lower and middle Ganga plain** and the **Brahmaputra valley.** The sand **content decreases from the west to east.**
- They are generally rich in **potash but poor in phosphorous.**
- In the Upper and Middle Ganga plain, two different types of alluvial soils have developed, viz. **Khadar and Bhangar.**
- **Khadar is the new alluvium** and is deposited by floods annually, which enriches the soil by depositing fine silts.
- **Bhangar** is **older alluvium,** deposited away from the flood plains.
- Both the **Khadar and Bhangar** soils contain calcareous concretions (Kankars).
- The colour of the alluvial soils varies from the light **grey to ash grey.**
- Its shades depend on the depth of the deposition, the texture of the materials, and the time taken for attaining maturity. **Alluvial soils are intensively cultivated.**

BLACK SOILS

- Black soil covers most of the **Deccan Plateau** which includes parts of Maharashtra, Madhya Pradesh, Gujarat, Andhra Pradesh and some parts of Tamil Nadu.
- In the upper reaches of the Godavari and the Krishna, and the north western part of the Deccan Plateau, the black soil is very deep.
- These soils are also known as the **'Regur Soil' or the 'Black Cotton Soil'.**
- The black soils are generally **clayey, deep and impermeable.**
- They swell and become **sticky when wet and shrink when dried.** So, during the dry season, these soils develop wide cracks. Thus, there occurs a kind of 'self-ploughing'.
- Chemically, the black soils are rich in **lime iron, magnesia and alumina.** They also **contain potash.** But they lack in phosphorous, nitrogen and organic matter.
- The colour of the soil ranges from deep black to grey.

RED AND YELLOW SOIL

- Red soil develops on **Crystalline Igneous Rocks** in areas of low rainfall in the Eastern and Southern part of the **Deccan Plateau.** Along the piedmont zone of the Western Ghat, long stretch of area is occupied by red loamy soil.
- Yellow and red soils are also found in parts of Odisha and Chhattisgarh and in the southern parts of the middle Ganga plain. The soil develops **a reddish colour due to a wide diffusion of iron in crystalline and metamorphic rocks.**
- It looks **yellow when it occurs in a hydrated form.** The fine-grained red and yellow soils are normally fertile, whereas coarse-grained soils found in dry upland areas are poor in fertility.
- They are generally **poor in nitrogen, phosphorous and humus.**

LATERITE SOIL

- Laterite has been derived from the Latin word 'Later' which means **brick.**
- The laterite soils develop in areas with **high temperature and high rainfall.** These are the result of intense leaching due to tropical rains.
- With rain, **lime and silica are leached away,** and soils rich in **iron oxide and Aluminium** compound are left behind.
- Humus content of the soil is removed fast by **bacteria that thrives well in high temperature.**
- These soils are **poor in organic matter, nitrogen, phosphate and calcium,** while **iron oxide and potash are in excess.**
- Hence, laterites are **not suitable for cultivation;** however, application of manures and fertilizers are required for making the soils fertile for cultivation.
- **Red laterite** soils in Tamil Nadu, Andhra Pradesh and Kerala are more suitable for tree crops like **cashew nut.**
- Laterite soils are widely cut as bricks for use in **house construction.** These soils have mainly developed in the higher areas of the **Peninsular plateau.** The laterite soils are commonly found in Karnataka, Kerala, Tamil Nadu, Madhya Pradesh and the hilly areas of Odisha and Assam.

ARID SOIL

- Arid soils range from **red to brown in colour.** They are generally sandy in structure and **saline in nature.** In some areas, the salt content is so high that common salt is obtained by evaporating the saline water. Due to the **dry climate, high temperature and accelerated evaporation, they lack moisture and humus.**
- **Nitrogen is insufficient and the phosphate content is normal.** Lower horizons of the soil are occupied by **'kankar'** layers because of the increasing calcium content downwards.

- The '**Kankar' layer formation in the bottom horizons** restricts the infiltration of water, and as such when irrigation is made available, the soil moisture is readily available for a sustainable plant growth.
- Arid soils are characteristically developed in western Rajasthan, which exhibit characteristic arid topography. These soils are **poor and contain little humus and organic matter.**

SALINE SOIL

- They are also known as **Usara soils.** Saline soils contain a larger proportion of **sodium, potassium and magnesium,** and thus, they are infertile, and do not support any vegetative growth.
- They have more salts, largely because of **dry climate and poor drainage.** They occur in **arid and semi-arid regions,** and in waterlogged and swampy areas. Their structure ranges from sandy to loamy. They lack in nitrogen and calcium.
- Saline soils are more widespread in western Gujarat, deltas of the eastern coast and in Sunderban areas of West Bengal. In the Rann of Kachchh, the Southwest Monsoon brings salt particles and deposits there as a crust.
- **Seawater intrusions in the deltas promote the occurrence of saline soils.** In the areas of intensive cultivation with excessive use of irrigation, especially in areas of green revolution, the fertile alluvial soils are becoming saline.
- Excessive **irrigation with dry climatic conditions promotes capillary action,** which results in the deposition of salt on the top layer of the soil. In such areas, especially in Punjab and Haryana, farmers are advised to add gypsum to solve the problem of salinity in the soil.

PEATY SOIL

- They are found in the areas of **heavy rainfall and high humidity,** where there is a good growth of vegetation. Thus, large quantity of **dead organic matter** accumulates in these areas, and this gives a rich humus and organic content to the soil.
- Organic matter in these soils may go even up to 40-50 %. These soils are normally **heavy and black in colour.** At many places, they are **alkaline** also. It occurs widely in the northern part of Bihar, southern part of Uttarakhand and the coastal areas of West Bengal, Odisha and Tamil Nadu.

FOREST SOIL

- As the name suggests, forest soils are formed in the forest areas where sufficient **rainfall is available.** The soils vary in structure and texture depending on the **mountain environment where they are formed.**
- They are **loamy and silty on valley sides and coarse-grained in the upper slopes.** In the snow-bound areas of the Himalayas, they experience denudation, and are **acidic with low humus content.** The soils found in the lower valleys are fertile.

SOIL EROSION

- The **destruction of the soil cover** is described as soil erosion. The soil forming processes and the erosional processes of running water and wind go on simultaneously. But generally, **there is a balance between these two processes.**
- The rate of removal of fine particles from the surface is the same as the rate of addition of particles to the soil layer.
- Sometimes, such a balance is disturbed by natural or human factors, leading to a **greater rate of removal of soil.** Human activities too are responsible for soil erosion to a great extent.
- **Wind and water are powerful agents of soil erosion** because of their ability to remove soil and transport it. **Wind erosion** is significant in arid and semi-arid regions. In regions with heavy rainfall and steep slopes, erosion by running water is more significant.
- **Water erosion** which is more serious and occurs extensively in different parts of India, takes place mainly in the form of **splash, rill,sheet and gully erosion**.
- **Splash erosion** is the first stage of the **erosion** process. It occurs when raindrops hit bare soil. The explosive impact breaks up soil aggregates so that individual soil particles are 'splashed' onto the soil surface.
- **Sheet erosion** takes place on level lands after a heavy shower and the soil removal is not easily noticeable. But it is harmful since it removes the finer and more fertile topsoil.
- **Rill erosion** is the removal of soil by concentrated water running through little streamlets, or head cuts. Detachment in a **rill** occurs if the sediment in the flow is below the amount the load can transport and if the flow exceeds the soil's resistance to detachment.
- **Gully erosion** is common on steep slopes. Gullies deepen with rainfall, cut the agricultural lands into small fragments and make them unfit for cultivation. A region with a large number of deep gullies or ravines is called a badland topography
- **Contour ploughing, Strip cropping, Terrace farming, Mulching (cover cropping), Sand Fence and Wind Break** are some of the remedial measures which are often adopted to reduce soil erosion.
- **Contour Ploughing:** it is done mainly in hilly areas. The cultivation is mainly done along the contour lines or across the slopes.

- **Strip cropping:** the strip of crops was cultivated across the slopes or along the contour lines to conserve soil erosion.
- **Terrace farming:** it is the practice of cutting flat areas out of a hilly or mountainous landscape in order to grow crops. It also helps to prevent soil erosion.
- **Mulching:**it is a practice of covering the topsoil surface with organic materials like straw, grass, stones inorganic materials like plastics, etc.
- **Sand fence:**A sand fence is a barrier used to force windblown, drifting sand to accumulate in a desired place. Sand fences are employed to control erosion.
- **Wind break:**A **windbreak** (shelter belt) is a planting usually made up of one or more rows of trees or shrubs planted in such a manner as to provide shelter from the **wind** and to protect soil from erosion.

PROBLEMS OF INDIAN SOILS

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

MAJOR CROPS AND CROPPING PATTERN

➢ India has **three major agricultural cropping seasons**:

I. **Kharif season** starts with the onset of monsoons and continues till the beginning of winter. Major crops of this season are rice, maize, jowar, bajra, cotton, sesamum, groundnut and pulses such as moong, urad, etc.

II. **Rabi season** starts at the beginning of winter and continues till the end of winter or beginning of summer. Major crops of this season are wheat, barley, jowar, gram and oil seeds such as linseed, rape and mustard.

III. **Zaid season** is summer cropping season in which crops like rice, maize, groundnut, vegetables and fruits are grown. Now some varieties of pulses have been evolved which can be successfully grown in summer.

TYPES OF FARMING:

➢ **Irrigated farming**: Farming with assured water supply from artificial sources of irrigation is known as **irrigated farming**.

➢ **Rainfed farming:** Rainfed agriculture is a type of farming that relies on rainfall for water. **Types of rainfed farming** are:

I. **Dryland farming –** this farming is practiced in those areas where **rainfall is very less.** E.g. millets.

II. **Wetland farming –** this farming is practiced in those areas where **rainfall is very heavy.**

- **Subsistence farming:** Subsistence agriculture occurs when farmers grow food crops to meet the needs of themselves and their families. In **subsistence agriculture**, farm output is targeted to survival and is mostly for local requirements with little or no surplus.
- **Commercial farming:**Commercial farming is a type of farming in which crops are grown for **commercial use only.** It is a modernized method of farming that is undertaken on a large scale. In this type of farming the large land, labour and machines are used.
- **Pastoral farming**: Pastoral farming (also known in some regions as ranching, livestock farming or grazing) is **aimed at producing livestock**, rather than growing crops. Examples include dairy farming, raising beef cattle, and raising sheep for wool.
- **Mixed farming:** Mixed farming is a type of farming which **involves both the growing of** crops **and the raising of** livestock**.**
- **Intensive farming:** Intensive farming or intensive agriculture is a kind of agriculture where a lot of **money and labour are used to increase the yield** that can be obtained per area of land. The use of large amounts of pesticides for crops, and of medication for animal stocks is common.
- **Extensive farming:** Extensive farming or extensive agriculture (as opposed to intensive farming) is an agricultural production system that **uses small inputs of labor, fertilizers, and capital, relative to the land area being farmed**.
- **Nomadic farming:**Nomadic farming is Farming adapted by peoples who are not permanent residence of an area and who **keep on moving**. It includes rearing of duck, goat, sheep, various cattle.
- **Shifting cultivation** also known as **'slash and burn'** cultivation. Shifting cultivation is an agricultural system in which a person uses a piece of land, only to abandon or alter the initial use a short time later. This system often involves clearing of a piece of land followed by several years of wood harvesting or farming until the soil loses fertility. It leads to **large scale deforestation, soil erosion** etc. This cultivation is more prevalent in **North-eastern region** of India.
- **Conservation agriculture:**This farming system that **maintains a permanent soil cover to assure its protection**, avoids soil tillage, and cultivates a diverse range of plant species to improve soil conditions, reduce land degradation and increase water and nutrient use efficiency.
- **Contract Farming**:It is one type of farming that can be described **as a contract or an agreement between a farmer and a buyer**. Due to this agreement or contract between two people, there would **be terms and conditions involved in production** as well as **marketing**. In this type of farming, the farmer will come to an agreement with the buyer. The followings are the objectives of contract farming:

  I. To produce a **given volume of product of specified quality.** The product will be purchased by the company on an agreed price. In other words, marketing enters into contract with production. The company after making the **purchase, freezes,**

dehydrates and starts canning operation. Sometimes the company enters into contracts with the **co-operative societies.**

II. In contract farming the main crops grown are vegetables, fruits, flowers and poultry.

NATIONAL WATER POLICIES

- National Water Policy is formulated by the **Ministry of Water Resources of the Government of India** to govern the planning and development of water resources and their optimum utilization. **The first National Water Policy was adopted in September 1987. It was reviewed and updated in 2002 and later in 2012.**
- **A Draft National Water Framework Bill 2016 was framed by a committee headed by Dr Mihir Shah.** The Committee was formed by the Ministry of Water Resources, River Development and Ganga Rejuvenation. The objective behind framing this bill was to conserve, manage, protect and regulate the use of water.
- The main emphasis of National Water Policy 2012 is to treat **water as economic good which the ministry claims to promote its conservation and efficient use.** This provision intended for the privatization of water-delivery services is being criticized from various quarters. The policy also does away with the priorities for water allocation mentioned in 1987 and 2002 versions of the policy. **The policy was adopted with a disapproval from many states.**

NATURAL HAZARDS

- A natural hazard is a **natural phenomenon** that might have a negative effect on humans and other animals, or the environment. It includes:
  - **Drought**
  - **Floods**
  - **Cyclones**
  - **Earthquakes**
  - **Tsunami**
  - **Cloudburst etc.**

MAJOR CROPS OF INDIA

CROPS

- **Food grains -** Food Grains in India are Bajra (Spiked Millet), Barley, Jowar (Great Millet), Maize, Pulses, Ragi (Small Millet), Rice, Wheat.
- **Commercial crops:** A commercial crop is an agricultural crop which is **grown for sale to return a profit**. It is typically purchased by parties separate from a farm.
- **Plantation crops:** it is a type of **mono agriculture**. Only **one type of crop is being cultivated** in a piece of land. Such crops include cotton, coffee, tobacco, sugar cane, sisal, and various oil seeds and rubber trees.

- **Horticulture:** Horticulture, the branch of plant **agriculture dealing with garden crops, generally fruits, vegetables, flowers and ornamental plants**. These plants need more temperature, but the growing season will be short.
- **Green manure crops:** The **plants that are grown for green manure** known as green manure crops. It basically **helps to maintain the organic matter status of the arable soil**. Examples of green manure crops include grass mixtures and legume plants.

CROPPING SEASONS OF INDIA:

- **Kharif season** (June to September)
  - **Rabi season** (October to March)
  - **Zaid season** (April to June)

Cropping season	Major crops cultivated	
	Northern States	Southern States
Kharif June-September	Rice, Cotton, Bajra, Maize, Jowar, Tur	Rice, Maize, Ragi, Jowar, Groundnut
Rabi October-March	Wheat, Gram, Rapeseeds and Mustard, Barley	Rice, Maize, Ragi Groundnut, Jowar
Zaid April-June	Vegetables, Fruits, Fodder	Rice, Vegetables, Fodder

CROPS						
FOOD GRAINS			COMMERCIAL /PLANTATION CROPS		HORTICULTURE	
CEREALS		PULSES	OILSEEDS	OTHERS	VEGETABLES	FRUITS
Rice, Wheat	**Coarse Cereals/ Millets** Jowar, Bajra, Ragi, Maize, Barley	Tur, Gram, Moong, Urad, Lentil	Groundnut, Caster seed, Niger seed, Sesamum, Rapeseed, Mustard, Linseed, Safflower, Sunflower, Soybean	Sugarcane, Cotton, Jute, Mesta, Coconut, Tapioca, Tobacco, Rubber, Coffee, Tea, Arecanut, Spices	Potato, Sweet potato, Onion, Chillies, Tomato, Cauliflower, Brinjal	Banana, Mango, Apple, Apricot, Grapes, Pineapple, Walnut

Agriculture Glossary

Agribusiness: Agriculture operated by business and involving all activities in the business of agricultural production.

Agriculture: The occupation of farming animals, plants and fungi needed for human life.

Agropoly: A term coined to describe when only a few companies control the majority of the food system.

Big food: Name given to large food corporations that dominate the food industry.

Biofuel: Fuel that is made from the energy source of living things or the waste that they produce. e.g. vegetable oil, algae and sugar cane.

Biodynamic: This is a spiritual-ethical-ecological approach to agriculture, food production and nutrition where the whole farm is viewed as a living organism, pioneered by Austrian scientist and philosopher Dr Rudolf Steiner. It is also a recognized certification for organic farms that meet higher biodynamic practice standards.

Co-operative: An organization which is owned and managed by the same people that use its services. Co-operatives are commonly used by farmers selling the same produce or buyers wanting to purchase produce as a group to achieve economies of scale.

Conventional farming: A method of farming practiced by industrial farmers which requires external high energy inputs in order to achieve high yields. Conventional farming often involves the use of fertilizers, pesticides and machinery.

Demeter: The largest certifier of biodynamic farms and their produce.

Developing country: A lowly-industrialised country usually with a poor performing economy that is usually primarily based on agriculture. The average income for an individual is often less than $2 a day.

Ecological: Practices that care for and/or work in harmony with the environment.

Erosion (soil): The weathering of the earth, often by wind, water or farming practices which often results in the loss of topsoil.

Extreme weather: Severe weather events that are unusual or unseasonal.

Factory farming: A method of intensive farming where animals are raised in confinement, often indoors, in order to maximize their growth rate for maximum profit. Also known as industrial animal farming.

Fair trade: A model of trade where the price for produce is raised and maintained to cover the costs of sustainable production, empower farmers and encourage environmental and sustainable farming practices.

Farm to Fork: A term used to describe the path of produce from where it is grown to where it is consumed.

Farmer: Someone who grows produce or animals for consumption.

Farm management software: Software that helps farmers to manage all farm activities, finances, inventory and analyze farm performance.

Farmer's market: A place where consumers can buy produce direct from farmers.

Food desert: Places where there is limited or no access for the community to fresh and healthy food.

Food fraud: Deceptive practices where food is manipulated and sold under false pretenses.

Food industry: The activities involved in growing, production and selling food locally and globally.

Food-like product: An item that is sold as food to be eaten but has little resemblance or nutritional value to the raw ingredients from which it was made. e.g. a **Twinkie**.

Food miles: The distance between where food is grown to where it is consumed.

Food security: A situation where the continual supply of food to feed a population is stable.

Food shortage: The lack of sufficient food to meet demand.
Food sovereignty: The right of people to control and define their own food systems and policies, without influence from corporations and governments.
Free-range: A method of farming which allows animals access to an outdoor area for a minimum time period.
GAP: Good Agricultural Practices. These are specific farming techniques that help to grow food that is safe and sustainable, whilst caring for the long term health of the land and environment.
GMO: Genetically Modified Organism. An organism whose DNA has been genetically engineered for select characteristics deemed favorable.
Hyper-local food: Food grown and eaten in the same place with extremely low food miles. e.g. restaurant roof-top farming.
Independent farmer: A farmer who owns and operates their farm with minimal influence from organizations.
Local food: Food which is consumed close to where it was grown.
Medicinal produce: Produce that is grown for alternative medicine and the pharmaceutical industry.
Multi-national food corporation: A company which makes and sells food and operates internationally.
Natural fiber produce: Animal or plant produce grown for the use in the textile industry. e.g. wool, cotton, bamboo, cane wicker.
Organic: A certification given to produce grown without the use of synthetic fertilizers or chemicals, are not GMO and in the case of meat – the animals are not given antibiotics or growth hormones.
Pasture-raised: To raise animals outside in their natural environment (but with access to shelter) where they are able to forage and behave according to their natural instincts.
Produce: Any raw or whole food, drink, medicinal plant or natural fiber grown by farmers.
Re-seller: A person who acts as an agent between farmer and buyers in the produce supply chain. They often add value through distribution.
Slow food: An international movement which values food that is prepared following local culinary traditions, using high quality, locally sourced ingredients.
Small-holder farmer: Farmers who farm land under two hectares.
Ugly fruit & vegetables: Produce that does not meet food presentation standards, often set by supermarkets.
Whole-food: Food in its most natural state, harvested but largely unprocessed.

IRRIGATION

- The **main features of Irrigation** are:
    I. Irrigation protects the crops from stagnant growth.
    II. Irrigation improves the yield of the crops.

III. Irrigation suppresses weed growth.

IV. Irrigation also prevents soil consolidation. **Consolidation** is the gradual reduction in the volume of a partly or fully saturated soil under sustained loading and is mainly due to the expulsion of water from the soil pores.

- The **main needs of Irrigation** are:
  - India is a big country with **large land area** and so irrigation facilities are needed to grow more food to feed our teaming millions.
  - The **distribution in rainfall is uneven** and uncertain which either causes famines or drought. By means of irrigation we can check both the problems.
  - **Different water requirements of different crops** can only be met through irrigation facilities.
  - India, being a tropical country, the **temperature is high and evaporation more rapid**, so, artificial irrigation is necessary for ample supply of water and also to prevent water scarcity in the long dry winter season.
  - Irrigation helps to cope up with areas having **less per capita water** for the cultivation of crops.
  - Irrigation can **increase average yields** for certain crops by more than 128%, compared to the average yield of the same no irrigated crop.
- The **main sources of Irrigation** are:
  - **Canals -**Canals are the main source of irrigation in India. **Canals are big water channels taken out from rivers to carry water to places far away from the river.**
  - **Tanks -** Tanks are commonly used in Deccan Plateau, Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra. **About 8% of total irrigated area is irrigated by tanks.**
  - **Wells and Tube wells -** It is more widespread in plains, coasts and some regions of peninsular India. It is less costly and more flexible as water can be drawn whenever needed and 'evaporation loss' is minimized and no fear of "over irrigation". Uttar Pradesh leads in well irrigation and is followed by Punjab, Haryana, Bihar, Gujarat and Andhra Pradesh.
- The **main modes of application** are:

- Flooding
- Furrows
- Sprinkler
- Sub-surface irrigation
- Localized or Drip irrigation

ROCK SYSTEM OF INDIA

THE ARCHAEAN ROCK SYSTEM(PRE-CAMBRIAN ERA) – VERY OLD PLUTONIC ROCKS

- The rocks of the Archaean system are found mainly in Karnataka, Tamil Nadu, Andhra Pradesh, Madhya Pradesh, Orissa, Chotanagpur plateau in Jharkhand and the southern-eastern part of Rajasthan.
- The rocks of this system are economically very important. All prominent metallic minerals (iron, gold, manganese etc.) are found in these rocks.
  - **Archaean gneisses and Schists: Gneiss** is formed because of the metamorphosis of the igneous rocks. The **Bundelkhand gneiss is the oldest one.**
  - **Dharwar system:**These rocks have been formed as a result of the erosion and sedimentation of the rocks of the Archaean system. The Aravali mountain range which is the oldest fold mountain of the world has been made with these rocks.

THE PURANA ROCK SYSTEM(PRE-CAMBRIAN ERA) – OLDEST METAMORPHOSED ROCKS

- **Cuddapah system**
  - These rocks have been formed as a **result of erosion and sedimentation of the rocks** of Dharwar system. These are also **sedimentary rocks.**
  - The rocks have been **named after the district of Cuddapah in Andhra Pradesh** where these are **semi-circular in expansion.**
  - These rocks contain ores of iron, manganese, copper, cobalt, nickel, etc.
- **Vindhyan system**
  - These have been formed after the Cuddapah rocks by the deposition of silt of river valleys and shallow oceans. Thus, these rocks are **also sedimentary rocks.**
  - The **evidences of fossils of micro-organisms** are found in this structure.
  - This structure is **famous for house-building rocks**. The Sanchi Stupa, the Red Fort, the Jama Masjid etc. are built with the red sandstone of this structure. Besides, limestone, china clay, dolomite etc. are also found in this structure.
  - The diamond mines of Golconda in Karnataka and Panna in Madhya Pradesh are found in this structure.

THE DRAVIDIAN ROCK SYSTEM(PALEOZOIC)

- Dravidian rocks are **mainly found in the Extra Peninsular region (Himalayas and Ganga plain)** and are very rare in Peninsular India.

  - **Carboniferous Rocks (European and North American Coal):** The Carboniferous rocks (350 million years) comprise mainly of limestone, shale and quartzite. **Coal formation** started in the Carboniferous age.

THE ARYAN ROCK SYSTEM(RECENT ROCKS)

- **Gondwana System (Indian Coal)**

➢ The word **Gondwana has originated from the Gond region** of Madhya Pradesh.
➢ These rocks have been formed **between the Carboniferous and Jurassic periods.**
➢ They are deposits laid down in **synclinal troughs** on ancient plateau surface.
➢ Fresh water and sediments accumulated in these trough and terrestrial plants and animals thrived.

- **Jurassic System**

➢ The marine transgression in the latter part of the Jurassic gave rise to thick series of **shallow water deposits** in Rajasthan and in Kuchchh.
➢ Coral limestone, sandstone, conglomerates and shales occur in Kuchchh.

- **Deccan Trap**

➢ The volcanic action in the peninsular India began in the last period (Cretaceous period) of the Mesozoic era. Thus, the **Deccan trap has been formed as a result of fissure eruption.**
➢ This structure is **made up of basalt and dolorite rocks.**
➢ These rocks are very hard, and their weathering has resulted in the formation of the black soil.
➢ Present Deccan Trap covers about **5 lakhkm^2** mainly in parts of Kuchchh, Saurashtra, Maharashtra, the Malwa plateau and northern Karnataka.

- **Tertiary System (Formation of Himalaya)**

➢ These rocks have been **formed between the Eocene and Pliocene periods**.
➢ The Himalayan mountain range has developed as discussed below:
  I. The **Great Himalayas** were formed during the **Oligocene period'**
  II. The **Lesser Himalayas** were formed during the **Miocene period**.
  III. **Shiwaliks** were formed during the **Pliocene and Upper Pliocene periods**.
➢ Mineral oil in Assam, Rajasthan and Gujarat is found in the structures of the Eocene and Oligocene period.

MINERALS

- **Metallic minerals:**Metallic minerals are the minerals that **contain one or more metals**. In general, they occur as mineral deposits and are a **good conductor of heat and electricity.** There are two types of metallic minerals:
  I. **Ferrous mineral:** These minerals contain iron. Minerals such as iron ore, haematite, Geothite etc. provide a strong base for the development of metallurgical industries.
  II. **Non-ferrous mineral**: These minerals does not contain iron. Important non-ferrous metals include Gold, Silver, Copper, Lead etc. and alloys such as brass.
- **Non-metallic minerals:** Non-metallic minerals **do not contain any metal substances** in them.
- These minerals are basically **good insulators of electricity and heat**. Limestone, sandstone. Marble, mica etc. are some examples of non-metallic minerals.
- **Energy minerals:**Energy minerals include coal, oil, natural gas and uranium.

- About 80% of the coal deposits in India is of bituminous type and is of non-cooking grade. **Jharia is the largest coal field followed by Raniganj.**
- **Iron Ore:** There are several grades of iron ore, based on purity and mineral content. Hematite is reddish in colour which has highest grade ore. Magnetite is black which has intermediate colour.

LEADING PRODUCERS OF IRON ORE IN INDIA(2017-2018):

Serial no	State	Production in 000 tonnes	% of the total production
1.	Odisha	102177	50.84
2.	Chhattisgarh	34546	20.54
3.	Jharkhand	21848	13.24
4.	Karnataka	28724	8.25
5.	goa	8040	7.77
6.	others	5620	2.92

IRON ORE DEPOSITS OF INDIA:

Serial no	State	Quality	Mining Centers
1.	Karnataka	Magnetite	Kemmangundi(Baba-BudanHills-ChikmagaIur District), Sandur and Hosepet (Bellary District), Chitradurga, Dharwar, Shimoga, Tumkur, Uttar Kannad.
2.	Odisha	Hematite	Cuttack, Kendujhar, Koraput, Barabil-Koira Valley, Badampahar (Mayurbhanj), Sambalpur, Kandadhar (Sundargarh), Daitri Hill along the boundary of Kendujhar and Cuttack.
3.	Chhattisgarh	Hematite	Bailadila, Dalli-Rajhara (Durg), Bilaspur, Jagdalpur, Raigarh, Surguja.
4.	Goa		Pima-Adolpale-Asnora (North Goa).
5.	Jharkhand		Singhbhum, Noamandi, Santhal Pargana, Hazaribagh.

6.	Others	Siderite, Limonite	Anantapur, Cuddapah, Guntur,Khammam, Kurnool, Nellore (Andhra Pradesh), Bhavnagar, Junagarh, Vadodra (Gujarat): Kangra, Mandi (Himachal Pradesh) Chandrapur, Ratnagiri, Sindhudurg (Maharashtra): Alwar, Bhilwara, Bundi, Jaipur, Udaipur (Rajasthan), Almora, Garhwal, Nainital (Uttarakhand), Mirzapur (Uttar Pradesh) Birbhum, Burdwan, Darjeeling (West Bengal).

- **Manganese (Mn):** Manganese is found as a free element or in combination with iron-ore or some other minerals. Manganese compounds were used by the Egyptian and Roman glass makers. **It forms only about 0.1% of the Earth's crust.** It is an important metal alloy particularly in **stainless steel.**

MANGANESE RESERVES- LEADING PRODUCING STATES OF INDIA 2017-2018:

Serial no	State	Qty in tonnes	% of the total production	Main Mining District
1.	Maharashtra	731418	28.24	Bhandara Nagpur, Ratnagiri
2.	Madhya Pradesh	831348	32.10	Balaghat, Chhindwara
3.	Odisha	516865	19.96	Bolangir, Kalahandi, Koraput, Sambalpur, Sundargarh
4.	Andhra Pradesh	166872	6.44	Cuddaph, Guntur, Srikakulam, Vijainagram, Vishakhapatnam
5.	Karnataka	294711	11.38	Gulbarga, Shimoga
6.	Gujarat	18,362	0.709	Panchmahal, Vadodra
7.	Jharkhand	4,785	0.01	Hazaribagh, Santhal Pargana
8.	Rajasthan	7,497	0.28	Udaipur

- **Copper(Cu):**The people of Turkey started the use of copper during the pre-historic period. It is used for making **electric wires, cooking utensils and military products.** The ratio of weight loss in copper refining is extremely small, scarcely one per cent of the weight of the refiner's raw material.

COPPER LEADING PRODUCING STATES:

Serial no	State	Production in 000 tonnes	% of the total production	Main Mining District
1.	Madhya Pradesh	2415330	62.79	Malanjkhand (Balaghat), Badgaon (Betul)
2.	Rajasthan	1117241	29.04	Ajmer, Bhilwara, Chittaurgarh, Dungarpur, Jaipur, Khetri (Jhunjnu), Pali, Sikar, Singhana, Sirohi
3.	Jharkhand	313856	8.15	Hazaribagh,Santhal Pargana

- **Bauxite:** It is the raw material for aluminum industry. Bauxite occurs **more frequently in tropical areas having clay-limestone rocks exposed to weathering.** Bauxite formation is attributed to **lateritic weathering.** It is the raw material for aluminium which is an important metal because it combines the strength of such metals as iron, with extreme lightness and also with great conductivity and malleability.

PRODUCTION OF BAUXITE 2017-2018:

Serial no	State	Production in 000 tonnes	% of the total production	Main Mining District
1.	Odisha	11447740	51.30	Balangir, Kalahandi, Koraput, Sundargarh and Sambalpur
2.	Gujarat	3101577	13.90	Amreli, Bhavnagar, Jamnagar, Junagarh and Khachh
3.	Jharkhand	2590720	11.61	Dumka, Lohardaga, Palamu, Ranchi
4.	Maharashtra	2028422	9.09	Kolaput, Pune, Ratnagiri, Satara, Thane
5.	Chhattisgarh	2558453	11.46	Amarkantak Mountain, Bilaspur, Durg, Raigarh and Surguja
6.	Madhya Pradesh	581391	2.60	Balaghat, Kotni, Jabalput, Maikala range, Mandla and Shahdol
7.	Goa	4378	2.05	
8.	Others	196486	0.91	

- **Mica:** Mica is a naturally occurring element. It is optically flat, translucent, elastic in nature. Its composition is silicate, aluminium, potassium, manganese, water and iron. It contains the highest amount of silica and so is the most preferred mineral in industries and in other personal applications.

MICA MINOR MINERAL 2017-2018:

Serial no	State	Production in 000 tonnes	Main Mining District
1.	Andhra Pradesh/ Telangana	15217	Khammam,Krishna, Nellore, Vishakhapatnam and West Godaveri
2.	Rajasthan	6459	Ajmer, Bhilwara, Dungarpur, Sikar, Tonk, Udaipur

- **Coal:** It is also called as black gold. Coals are found in sedimentary strata. It Contains carbon, volatile matter, moisture and ash. They are mostly used for power generation and metallurgy. Coal reserves are six times greater than oil and petroleum reserves.
- **Distribution of Gondwana Coal in India:** Chhattisgarh, Jharkhand, Odisha, Madhya Pradesh, Andhra Pradesh, Maharashtra, West Bengal, Uttar Pradesh.
- **Tertiary Coalfields of India:** Assam, Arunachal Pradesh, Meghalaya, Jammu and Kashmir, Himachal Pradesh. Tertiary Coal-Lignite in India: Tamil Nadu, Gujarat and Rajasthan.
- **Petroleum:** Petroleum is obtained from sedimentary rocks of the earth. Petroleum fuels on burning gives little smoke and leaves no ash. So, they are better than coal.

1 lakh km^2 or 42% of India covered with sedimentary rocks. 10 lakh km^2 form marine basins of Mesozoic and Tertiary times. Total continental shelf of probable oil bearing rocks amounts to 2 lakh km^2.The total sedimentary area including both on shore and offshore comprises 27 basins. **Mumbai High, the Khambhat Gulf and the Assam** are the most productive areas.

- **On-shore Oil Production In India:** Brahmaputra valley of north-east India, Barmer area of Rajasthan, Gujarat coast in western India, Cauvery on-shore basin in Tamil Nadu, Andhra Pradesh has both on-shore and offshore oil reserves.
- **Off-shore Oil Production In India:** Western Coast(Mumbai High, Bassein and Aliabet), Eastern Coast(The basin and delta regions of the Godawari, the Krishna and the Cauvery rivers).
- **Natural Gas:** Natural gas is naturally occurring hydrocarbon gas mixture consisting primarily of methane, but commonly includes varying amounts of other higher alkanes, and sometimes a small percentage of carbon dioxide, nitrogen, hydrogen sulfide or helium.
- **Liquefied petroleum gas (LPG)** is a mixture of **butane and propane.** They commonly occur in association with crude oil. Natural gas is often found dissolved in oil or as a gas cap above the oil. Natural gas is commonly used in Electric power generation, Industrial, domestic, and commercial usage, ingredient in dyes and inks, rubber compounding operations.

- Ammonia is manufactured using **hydrogen derived from methane.** Ammonia is used to produce chemicals such as hydrogen cyanide, nitric acid, urea, and a range of fertilizers.
- **Distribution of Natural Gas in India:** KG basin, Assam, Gulf of Khambhat, Cuddalore district of Tamil Nadu, Barmer in Rajasthan etc.

INDUSTRIES

- **Primary Industry**: An **industry** involved in the extraction and collection of natural resources, such as copper and timber, as well as by activities such as farming and fishing. A company in a **primary industry** can also be involved in turning natural resources into products.
- **Secondary Industry**: Secondary industries are those that take the raw materials produced by the primary sector and process them into manufactured goods and products. **Examples of secondary industries** include heavy manufacturing, light manufacturing, food processing, oil refining and energy production.
- **Tertiary Industry**:The **tertiary industry** is the segment of the economy that provides services to its consumers, including a wide range of businesses such as financial institutions, schools and restaurants.
- **Footloose Industry:Footloose industry** is a general term for an industry that can be placed and located at any location without effect from factors such as resources or transport. These industries often have spatially fixed costs, which means that the costs of the products do not change despite where the product is assembled.
- **Weight losing industry: Weight-losing industries** are industries where the raw materials are relatively bulky, but the resulting product is relatively smaller. Timber, furniture and agriculture industries are some of the areas where weight loosing raw materials are used.
- **Sunrise Industry:** A **sunrise industry** is a new industry that is **expanding rapidly** and is expected to be increasingly important in the future. The **IT sector** is referred to as the sunrise industry as it has grown rapidly over the past ten years. Some of the examples are for this industrial sector is Hydrogen fuel production, petrochemical industry and food processing industry.

IRON AND STEEL INDUSTRY

- These are feeder industries whose products are used as raw materials for other industries.
- The products produced from such industries are used as raw material by other industries.
- The inputs for the industry include raw materials such as iron ore, coal and limestone, along with labour, capital, site and other infrastructure. **The process of converting iron ore into steel involves smelting and refining.** The output obtained is steel which is a basic material needed in every other industry.
- All the important steel-producing centres such as **Bhilai, Durgapur, Burnpur, Jamshedpur, Rourkela, Bokaro** are situated in a region that spreads over four states that are **West Bengal, Jharkhand, Odisha and Chhattisgarh.**
- **Bhadravati and Vijay Nagar in Karnataka, Visakhapatnam in Andhra Pradesh, Salem in Tamil Nadu** are other important steel centres utilising local resources.

COTTON AND TEXTILE INDUSTRIES

- Fibres are the raw material of the textile industry and textile industries can be divided on the basis of raw materials used in them.
- After the industrial revolution, **the first successful mechanized textile mill was established in Mumbai in 1854.** The warm, moist climate, a port for importing machinery, availability of raw material and skilled labour resulted in rapid expansion of the industry in the region.
- **In Gujarat on the banks of the Sabarmati river the first cotton textile mill was established in 1859.** It soon became the second-largest textile city of India, after Mumbai. Ahmedabad was therefore often referred to as the 'Manchester of India'.
- Initially, this industry flourished in the states of **Maharashtra and Gujarat because of the favourable humid climate.** But today, Coimbatore, Kanpur, Chennai, Ahmedabad, Mumbai, Kolkata, Ludhiana, Puducherry and Panipat are some of the other important centres.

NATIONAL HIGHWAYS:

- Over a period of time, the numbering of National Highways in India has been renewed. The Ministry has released details of National Highways in the country on its official website.
- The total length of National Highways is 132499 Km(March 2019).

Serial no.	NH no	Route	Length(km)
1.	**44(Old NH7)**	Srinagar -Kanyakumari	3745
2.	**27**	Porbandar-Silchar	3507
3.	**48(Old NH8)**	Delhi-Chennai	2807
4.	**52**	Hisar, Jaipur, Kota, Indore mule. Aurangabaa Bijapur. Hubli	2317
5.	**30**	Sitarganj (Uttarakhand Ibrahimpamam in Andhra Pradesh	2010
6.	**6**	Jorabat (Meghalaya)-Selling (Mizoram)	1873
7.	**53**	Hajira (Gujarat) —Pradip Port (Odisha)	1781
8.	**16(Old NH5)**	Part of Golden Quadrilateral West Bengal-Andhra Pradesh	1659
9.	**66(Old NH17)**	Panvel-Kanyakumari	1593
10.	**19(Old NH2)**	Delhi-Kolkata (has historical part of Grand Trunk Road)	1435

11.	**34**	Gangotri Dam (Uttarakhand) —Lakhnadon (Jabalpur)	1426
12.	**2**	Dibrugarh ,Assam. Nagaland, Manipur, Mizoram (Second longest in North Eastern Region)	
13.	**13(Old NH229)**	Tawang (Arunachal Pradesh) to Pasighat (Assam)	
14.	**47**	Bambanbore (Gujarat)-Nagpur (Maharashtra)	
15.	**31**	Uttar Pradesh — West Bengal	

The lengths of the roadways are given as under:

National Highways/ Expressway	132499 km
State Highways	156694 km
Other Roads	5608477 km

Inland waterways of India

- India has a wide network of inland waterways which consist of rivers, backwaters, canals and creeks. The overall navigable length is 14500 km. Out of this around 5200 km of river and 4000 km of canals can be used by mechanized vessels. There are total five national waterways in India, these waterways provide means of public and freight transportation. Cargo transportation is only limited to a few waterways in Goa, West Bengal, Assam and Kerala in an organized manner.
  Inland Waterways Authority of India (IWAI) is the legal authority in-charge of the waterways in India and was created by the Govt. of India on 27 October 1986 .Its headquarters is located in Noida, Uttar Pradesh and regional offices are at Patna, Kolkata, Guwahati and Kochi and sub-offices at Allahabad, Varanasi, Bhagalpur, Farrakka and Kollam. The function of IWAI is to build necessary infrastructure in the waterways, survey the economic possibilities of new projects, administrate, develop and regulate the waterways for navigation and shipping.

National Waterway 1

- The National Waterway 1 lies on the Allahabad-Haldia stretch of the Ganges, Bhagirath and Hooghly river system. It was established in October 1986 and has a length of 1620 km.

National Waterway 2

- The National Waterway 2 lies on the Sadiya-Dhubri stretch of the Brahmaputra River. It was established in September 1982 and has a total length of 891 km.

National Waterway 3

- The National Waterway 3 lies on the Kottapuram-Kollam stretch of the West Coast Canal, Champakara Canal and Udyogmandal Canal. It was established in February 1993 and a length of 205 km.

National Waterway 4

- The National Waterway 4 lies on the Kakinada-Pondicherry stretch of Canals and the Kaluvelly Tank, Bhadrachalam-Rajahmundry stretch of River Godavari and Wazirabad-Vijayawada stretch of River Krishna. It was established in November 2008 and has a length of 1095 km,

National Waterway 5

- The National Waterway 5 lies on the Talcher-Dhamra stretch of the Brahmani River, the Geonkhali-Charbatia stretch of the East Coast Canal, the Charbatia-Dhamra stretch of Matai River and the Mangalgadi-Paradip stretch of the Mahanadi River Delta. It was established in November 2008 and has a length of 623 km.

National Waterway 6 (Proposed)

- The National Waterway 6 will be from Lakhipur to Bhanga on the River Barak with a total length of 121 km.

POWER RESOURCES

The socio-economic development of a country is largely controlled by availability of power and energy resources. Every sector of the national economy viz. **agriculture, industry, transport, commercial and domestic needs inputs of energy.**

ELECTRICITY

- Electricity is a clean source of energy. It is generated from **water, coal, mineral oil, natural gas, wind, sea-waves, tides, thermal springs, and atomic minerals.** Electricity is relatively **cheap, transportable, pollution free, and renewable.** Because of these advantages it is becoming increasingly popular.

Hydroelectricity:

- The end of the 19th century saw the development of power in India. **In 1897, electricity was commissioned in Darjeeling** and in 1902, a **Hydro Power** station at Sivasamudram in Karnataka was commissioned.
- At present there are **115 hydel power projects in operation in India.** Most of them are located in hilly regions of the country.
- **List of some of the important Hydroelectric Power Plants in India:**

States	River	Hydroelectric Power Plant
Andhra Pradesh	Krishna	Nagarjunasagar Hydro Electric Power plant
Andhra Pradesh	Krishna	Srisailam Hydro Electric Power plant
Gujarat	Narmada	Sardar Sarovar Hydro Electric Power plant
Himachal Pradesh	Sutlej	Bhakra Nangal Hydroelectric Power plant
Jammu and Kashmir	Jhelum	Uri Hydro Electric Power plant
Jharkhand	Subarnarekha	Subarnarekha Hydroelectric Power plant
Karnataka	Kaveri	Shivanasamudra Hydroelectric Power plant
Kerala	Periyar	Idukki Hydro Electric Power plant
Madhya Pradesh	Sone	Bansagar Hydroelectric Power plant
Madhya Pradesh	Narmada	Indira Sagar Hydro Electric Power plant
Maharashtra	Koyna	Koyna Hydroelectric Power plant
Manipur	Leimtak	Loktak Hydro Electric Power plant
Sikkim	Rangit	Rangit Hydroelectric Power plant
Sikkim	Teesta	Teesta Hydro Electric Power plant
Uttarakhand	Bhagirathi	Tehri Hydro Electric Power plant
Himachal Pradesh	Satluj	Nathpa Jhakri Hydro Electric Power Plant
Himachal Pradesh	Beas	Pong

Thermal Electricity:

- Thermal power plants generate electricity by using **heat from a fuel source.** The heat usually **generates steam in a boiler** which is then used **to run a steam turbine** connected to a generator.
- There are India mainly **three types of thermal power plants in India.** Viz. **Coal:** 206404.50 MW, **Gas:** 24956.51 MW, **Liquid Fuel(Diesel):** 509.71 MW
- The total capacity of thermal power plants as on January 31, 2021, all across India is 231870.72 MW.
- The electricity generated by these plants adds up to **71% of the total power generation** in the country.
- **List of some of the important Thermal electric Power Plants in India:**

State	Thermal Power Plant
Assam	Namrup Thermal Power Plant
Andhra Pradesh	Ramagundam Thermal Power plant
Bihar	Barauni Thermal Power Station
Chhattisgarh	Bhilai Thermal Power Plant
Jharkhand	Bokaro Thermal Power plant
Karnataka	Bellary Thermal Power station
Odisha	Talcher Thermal Power plant
Rajasthan	Kota Thermal Power plant
Tamil Nadu	Neyveli Thermal Power Station
Madhya Pradesh	Amarkantak Thermal Power Plant
Madhya Pradesh	Singrauli Super Thermal Power Station
Maharashtra	Chandrapur Thermal Power plant
Maharashtra	Amravati Thermal Power plant
Gujarat	Sabarmati Thermal Power Station
Gujarat	Gandhinagar Thermal Power plant
Uttar Pradesh	National Capital Thermal Power plant
West Bengal	Durgapur Thermal Power plant

NUCLEAR ENERGY

- The essential minerals used for the generation of nuclear energy are **Uranium and Thorium.** Geographically, Uranium ores are found at many different locations along the **Singbhum Copper Belt.** Thorium is mainly obtained from monazite and ilmenite, which is largely found along the coast of **Kerala and Tamil Nadu.**
- **Atomic Energy Commission was established in 1948** and the Atomic Energy Institute at Trombay was founded in 1954.
- However, the **Atomic Energy Institute at Trombay** was renamed as **Bhabha Atomic Research Centre in 1967.**
- The important nuclear power projects are located at Tarapur (Maharashtra); Rawatbhata near **Kota** (Rajasthan); **Kalpakkam** (Tamil Nadu); **Narora** (Uttar Pradesh); **Kaiga** (Karnataka); and **Kakarapara** (Gujarat).

SOLAR ENERGY

- Solar energy is one of the most important sources of **non-conventional sources of energy.** It is **7% more effective** than coal or oil based plants and **10% more effective** than nuclear plants.
- In many parts of India, **the solar energy programmes have been implemented.** One such example is Rural Energy Co-operative at Sagar Island in **Sundarban Delta** of West Bengal. Similar programmes have been implemented in other islands of the **Bay of Bengal**, the district of **Jodhpur** (Rajasthan), **Kalyanpur** (Aligarh) and **Coimbatore** (Tamil Nadu).

OTHER SOURCES OF ENERGY

- The Ministry of Non-conventional Sources of Energy is responsible for the development of wind energy in India as the **major source of renewable energy.**
- **Ocean currents are the store-house of infinite energy.** Hence, India has great potential for the development of tidal energy.
- Natural **hot springs and geysers** are being used since medieval period, but in the present world, these could be potential sources of renewable energy.
- **Manikaran, a hot spring in Himachal Pradesh** is a major renewable source of energy in India.
- Bio-energy is the energy derived usually from the **biological products,** such as agricultural residues and **other bio-waste.** Bio-energy can be converted into **electrical energy, heat energy, and gas for cooking.**

PREVIOUS YEAR QUESTIONS

1) **Which one of the following commercially important groups of trees belongs to cool temperate hardwood species?**
   a) Maple, mahogany and oak
   b) Mahogany, ebony and maple
   c) Oak, polar and maple
   d) Ebony, oak and polar

2) **Which one of the following covers the highest percentage of forest area in the world?**
   a) Temperate coniferous forest
   b) Temperate decidous forest
   c) Tropical monsoon forest
   d) Tropical rain forest

3) **Which of the following wildlife sanctuaries/ National Parks is located in the Assam –Arunachal Pradesh boarder?**
   (A) Sonai Rupai Wildlife sanctuary
   (B) Bornadi Wildlife sanctuary
   (C) Dibru-Saikhowa National Park
   (D) Namdapha National Park

4) **The National Bamboo Mission strives to**
   1. Increase the are a under bamboo plantation in non-forest areas.
   2. Rejuvenate the under developed bamboo industry in India.
   3. Take over the sick paper mills in India.
   4. Explore the export market for Bamboo.

   Choose the correct answer
   A. 1 and2
   B. 1and 3
   C. 1,2and 3.

5) **Which among the following is the State Tree Of Assam?**
   D. Titachapa
   E. Nahor
   F. Hollong
   G. Segum

6) **Most of the world's wheat producing regions have(1998)**
   a) More than 1500 mm of rainfall
   b) Less than 300 mm of rainfall
   c) Very high rainfall
   d) Less than 1000 mm of rainfall

7) **For which of the following items, Tirupur is well known as a huge exporter to many parts of the world?**

a) Gems and jewellery
b) Leather goods
c) Handicrafts
d) Knitted garments

8) **Identify the power project which is managed by NEEPCO.**

A. Bongaigaon Thermal Power Station
B. Lawka Gas Thermal Power Station
C. Namrup Thermal Power Station
D. Kathalguri Thermal Power Station

9) **Which of the following is the major contributor to national income of India within the primary sector?**

A. Agriculture
B. Fishery
C. Forestry
D. Mining

10) **The term "Black Revolution"in the present context of India is associated with**

A. Higher exportability of crude oil.
B. Self-dependence in the production of crude oil.
C. Improvement in the quality of black soil
D. Self-dependence in the milk production.

11) **he contribution of agriculture in India's Gross Domestic Product (GDP) is**

a) 14%
b) 24%
c) 34%
d) None of the above

12) **Which one of the following industries is known as 'Sunrise Industry'?**

a) Iron and Steel
b) Cotton and Textile
c) Information Technology
d) Tea and Coffee

13) **Which among the following cities is known as the tea city of India?**

(A) Darjeeling
(B) Dibrugarh
(C) Siliguri
(D) Nainital

14) **Which of the following statements is correct?(1998)**

a) Maharashtra produces iron ore
b) Uttar Pradesh has no cement factory
c) Punjab produces rice
d) Andaman Island have no indigenous population

15) Which of the following does not apply to Gujarat?(1998)

a) It is the largest producer of groundnut
b) It is the largest producer of tobacco
c) It is the largest producer of salt
d) It is the largest producer of milk product

16) India is self sufficient in all of the following minerals except(1998)

a) Coal
b) Copper
c) Manganese
d) Mica

ASSAM GEOGRAPHY

Physical Features and Major Physiographic Divisions

Location

- Two river valleys basically : Brahmaputra valley and Barak Valley
- Brahmaputra Valley is divided into 3 regions:
    1. The Uttarpar or Uttarkula
    2. The Dhakhinpar or Dakhinakula
    3. The Majuli and other river islands formed by the river Brahmaputra.
- **Length** of Brahmaputra **within** Assam is about **720 km** and it is on the average 8 to 10 km wide.
- **Boundaries : 2 foreign countries and 7 Indian states**
    1. **North-** Bhutan and Arunachal Pradesh
    2. **East-**Arunachal Pradesh, Nagaland and Manipur
    3. **South-** Mizoram, Meghalaya
    4. **West-**West Bengal, Bangladesh and Tripura.
- **Decending Order [Inter-state boundary]**
    1. Assam- Meghalaya -723.2 km
    2. Assam- Arunachal Pradesh- 704km
    3. Assam Nagaland- 434km
    4. Assam- Manipur- 132.8km
    5. Assam- Mizoram- 130km
    6. Assam- West Bengal- 128km
        a. Kokrajhar- Jalpaiguri
        b. Dhubri- Cooch Behar
    7. Assam- Tripura- 23.3km
- **Present Area of Assam=** 78,438 sq km
- It **covers** about 2.93 % of the total geographic area of India.

Geological structure

There are three physiographical divisions of Assam:

- The Plateau region
- The folded hill region
- The plains [Brahmaputra and Barak plain]

The plateau region

The Plateau Region of Assam is divided into two parts:

1. **The Central Karbi Plateau**

- The plateau is eroded and fairly subdued by age-old weathering and erosion under hot and humid tropical monsoon conditions.
- In spite of this, the hard crystalline rocks have resisted erosion in the central part of the plateau, which stands out as the **Rengma Range.**
- This range reaches a height of 1,363 m at **Dumbuksu** and 1360m **at Singhasan.**
  This is the highest area of the plateau.
- The Central Karbi plateau shows two important geomorphic features:
- There are a series of waterfalls and hot springs extending over a distance of about 80km. It includes **Garampani and Fatasil waterfalls** in the east and the **Champawati(Chapanala)falls** in the west.
- Besides this, there is another series of waterfalls along the eastern face of the highest part of the plateau. This part lying parallel to the Dhansiri River supports **coal and limestone deposits.**
- The waterfalls and hot springs contain **sulphur and phosphorus** in high proportion.
- The second geomorphic feature of the plateau is the presence of a relatively low lying east- west corridor in its middle part. This 90km long corridor is created by the age old erosion of the Jamuna river, a mojor tributary of the Kapili.
- It may be identified as the Davaka- Dimapur corridor. It divides he plateau into two unequal halves.

The Hamren plateau

- It is in continuity to Jaintia Hills. It rises in height from **Lanka, Hojai, Jogijan and Sahari** foothills of Nagoan district towards south to Jaintia hills.

The Folded hills

- The folded hilly region of Assam is confined to the North Cachar district of Barak Valley. It is popularly known as **Barail Range.**
- The folded mountainous region of Assam is a part of Patkai Hills which is a part of the great Himalayan Range.
- The Barail ranges support the highest peaks of Assam. These include **Theipibung (1866m) Mahadeo(1739m) and Kaukaha(1736m).**
- The North Cachar Hills are not denuded and subdued like the Karbi Plateau because these are made of **young tertiary folds**; the ranges are high and alternate with valleys.
- As this area is under hot and humid climatic condition, the processes of weathering and erosion are very active that has led to development of deep valleys, gorges and steep slopes.

The plains

- The plains are a result of alleviation of the master streams, tributaries and the sub-tributaries, some of which are rain fed and some snow fed.

The Brahmaputra Plain

- **Largest plain in North-East India.** It is extending from the **Lohit Plain** near **Sadiya** in the east to the **Sankosh Plain** in the West.
- The Brahmaputra Plain has the highest drainage frequency in the world.
- This fertile plain is formed by about 57 northern tributaries and 32tributaries from the south carrying boulders, pebbles, sand, silt and soil.

Geomorphologic Variations within the Brahmaputra plain. These include:

1. **Bhabhar Zone :** Narrow fertile belt composed of old alluvial fans basically in the foothills of Arunachal. This zone is densely forested and here the water generally percolates down the surface.
2. **Tarai Zone:** Lies in the Southern border of the Bhabhar zone and it is a strip of flat ground all along the north bank of the plain. The water that percolates down in the Bhabhar zone reappears in this zone. Hence this region is damp and swampy. It normally supports tall grass and lots of tall trees.

The Barak plain

- The southern part of Assam is occupied by the Barak Plain, which is relatively a small one.
- The horseshoe shaped basin lies with the Barail Range in the North, Manipur Hills in the East, Lushai hills in the south and generally merges with the Sylhet Plain of Bangladesh in West.
- It generally slopes down westwards to 73m, near Silchar and further to 51 m near Karimganj.
- There are large number of tributaries of Barak River; these include Jiri, Labak, Madhura, Dalu, Jatinga and Larang in the north bank and the Sonai, Katakhal, Dhaleswari, Singla and Langai in the South bank.

The Brahmaputra river

- Known as **Yarlung Tsangpo** in Tibet, The Brahmaputra, Lohit, Siang and Dihang in India and Jamuna in Bangladesh.
- The entire basin of the Brahmaputra inside and outside India is about 5, 80,000 sq Km.
- It has two islands- One **Majuli (largest)** and the other **Ummananda (smallest) in (Guwahati)** .
- **NorthTributaries**: Subansiri, Ronganadi, Dikrong, Buroi, Jiabharali, Dhansiri (North), Puthimari, Manas, Beki,Aie, Sankosh are the main tributaries on the North Bank of the river Brahmaputra.
- **South Tributaries**: The Nodihing, Birhidihing, Desang, Dikhow, Bhogdoi, Dhansir (south), Kopili, Kulsi, Krishnai, Dhudnoi, Jinjiran are the main tributaries on the south bank of the river Brahmaputra.

Notes:

- **Subansiri-** known as Gold river, and it is the largest tributary of the Brahmaputra.
- **Lohit :** It is also known as Zayu river in the Kangri Garpo range. It travels through the red laterite soils of the Lohit basin and therefore it is known as “the river of blood”.
- **Manas:** It is a transboundary river in the Himalayan foothills between southern Bhutan and India. It is the largest river system of Bhutan. It is met by three other major streams before it again debouches into India in western Assam.
- **The Manas** flows through the west of the Manas National Park further it splits into two separate rivers, the **Beki and Bholkaduba.**
- The river also acts as an **international border** dividing India and Bhutan.

Soils of Assam

Types of soil in Assam

1. **Alluvial (Old and New alluvial soil)**

Features:

- Contains both sand and silt.
- **Old alluvium**: Sandy but hard, highly acidic and less fertile, amount of Potash and Phosphate is less. Beneficial for the cultivation of **tea and sugarcane** because of their acidic character.
- **New alluvium:** These soils are formed of silt, sand and organic contents and are highly suitable for agriculture. In this soil the content of phosphate, potash, calcium and nitrogen are more and the acidity is less. It is free of salt.

Located: Floodplains of Brahmaputra and Barak, in the Island of Majuli, other char areas and central plains of the north bank and south bank. This soil is highly suitable for cultivation of rice, jute, wheat, banana, oilseeds, pulses, tobacco, maize, vegetables etc.

2. **Laterite Soil**

- Soil is having brick red colour because of high iron content. This soil is generally deficient in Nitrogenous materials, phosphorous, acid and lime. It is highly sticky when wet. Suitable for: Jackfruit, orange, potatoes, mangoes, radish, cabbage etc.

3. **Red Loamy or Hilly Red Soil**

- The hilly red soils are rich in humus, oxygen and acid content but deficient in phosphate and potash. This soil is loose and becomes sticky in presence of water but it develops cracks in the absence of water.

  The reddish colour of the soil is because of the oxidation of the iron present in the rock. (Precambrian metamorphic rocks)

  This soil on the hill slopes are favourable for production of rice, cotton, maize, millet, wheat, pulses, potatoes, vegetables and fruits especially orange, pineapple, pear, etc. This soil also supports luxuriant tropical deciduous and semi- evergreen vegetation.

Previous Years' Questions -APSC

1. The total area of Assam is (2009)
   a) 80,645 km2
   b) 78,438 km2
   c) 79,012 km2
   d) 77,901 km2

2. How much percent of the Indian landmass is covered by the State of Assam? (2013)
   a) 3.39 percent
   b) 2.39 percent
   c) 4.39 percent
   d) 2.93 percent

3. North Cachar Hill is known for(2014)
   a) Graphite
   b) Rock Salt
   c) Limestone

d) Coal

4. In Assam, Red Soil is the main feature of (2014)
   a) Bodoland Area
   b) **North Cachar Hill Area**
   c) Barak valley Region
   d) Brahmaputra Valley Region
5. Baksa district of Assam was created from the parts of which of the following districts?(2016)
   a) **Barpeta, Nalbari and Kamrup**
   b) Goalpara and Kokrajhar
   c) Bongaigaon and Kokrajhar
   d) Darrang, Barpeta and Nalbari
6. Which among the following is the State Tree of Assam?(2020)
   a) Titachapa
   b) Nahor
   c) **Hollong**
   d) Segun
7. Which among the following cities is known as the "Tea City of India"?(2020)
   a) Darjeeling
   b) **Dibrugarh**
   c) Siliguri
   d) Nainital
8. The four districts under the Bodoland Territorial Council (BTC) are(2020)

a) Kokrajhar, Barpeta, Chirang and Baksa
b) **Kokrajhar, Baksa, Chirang and Udalguri**
c) Kokrajhar, Baksa, Sonitpur and Udalguri
d) Baksa, Chirang,Udalguri and Nalbari

Climate of Assam

Assam falls within **the sub-tropical monsoon regime**.

- The special climate characteristics of Assam are heavy downpour with high temperature during summer and low rainfall associated with low temperature.
- In different districts of the state the mean annual maximum temperature, i.e. July-August, ranges from 30-33 °and the minimum temperature i.e. December- January ranges from 8-15° c.
- Assam experiences an average annual rainfall of 230 cm.
- The rainless months in the state generally are December, January and February.
- Assam may be divided into three distinct rainfall belts on the basis of nature of distribution of rainfall. These regions are as follows:

Heavy rainfall belt: Lakhimpur, Dhemaji, Dibrugarh, TInsukia, Sibsagar, Jorhat, Dhubri, Kokrajhar, Bongaigoan, Chirang, Goalpara, Cachar and Karimganj.

Medium Rainfall Belt: Barpeta, Nalbari, Baksa, Kamrup, Darrang, Udalguri, Sonitpur, Morigaon, Nagoan, Golaghat and Karbi Anglong.

Low rainfall belt:

- It includes the southern part of Nagoan district.
- It forms a distinct rain shadow area north of the Meghalaya Plateau.
- The belt runs from Guwahati eastward along the Meghalaya foothills through Hojai, Lanka and Lumding.

Agro-climatic region

- Based on the amount and characteristics of rainfall, temperatures, relative humidity, terrain conditions and soil characteristics Assam can be divided into 6 climatic regions.

1. **The Upper Brahmaputra Valley (North)**
2. **The Upper Brahmaputra Valley(South)**
3. **The central Brahmaputra Valley**
4. **The Lower Brahmaputra Valley**
5. **The Hills**
6. **The Barak Valley**

The upper Brahmaputra Valley (NORTH)

- Zone Comprises the districts of Dhemaji, Lakhimpur, Sonitpur, Udalguri and Darrang.
- It is a belt of rice, tea, jute, mustard and sugarcane. Rice occupies the first and tea the second position in respect of area covered.

The upper Brahmaputra Valley (SOUTH)

- Zone comprises the districts of Tinsukia, Dibrugarh, Sibsagar, Jorhat and Golaghat.
- Soils are generally acidic and have high sulphur and phosphrous content. Important crops: Rice, tea, mustard and sugarcane.

The central Brahmaputra Valley

- Zone comprises the districts of Nagoan and Morigoan. This zone is **bowl-shaped** and its middle and northern parts is **flood prone.**
- Main crops: Rice, jute, mustard, pulse and vegetables. [NO TEA]

The lower Brahmaputra Valley

- Zone comprises the districts of Kamrup, Nalbari, Barpeta, Bongaigaon, Kokrajhar, Chirang, Baksa, Dhubri and Goalpara.

The Hills

- Zone consists of hill districts of Karbi Anglong and North Cachar hills.
- The Karbi Plateau is in the rain shadow area and hence it has lesser average annual rainfall ranging between 100cm in its southern part to 200 cm in the northern part.'

- The soil of this zone is **Lateritic** and contains a high proportion of acidity providing congenial conditions for **citrus fruits.**

The Barak Valley

- Zone consists of the districts of Cachar, Hailakandi and Karimganj.
- The soil of this region is sandy loam and is most neutral so far the pH value is concerned.
- Cultivation: JUTE (major)

Previous Years' Questions-APSC

1. **Assam state enjoys(2009)**
   a) **Tropical climate**
   b) Hot climate
   c) Warm Climate
   d) Cold climate

Natural vegetation

According to the type of flora and the nature of vegetation found in Assam, the forests of Assam may broadly be divided into:

1. **Evergreen forests**
2. **Mixed deciduous forests**
3. **Riverine forests**
4. **Savanna forests**

Evergreen forests

- Are composed of broad-leafed species where rainfall is usually heavy.
- Common feature- tall trees, presence of thick undergrowth and many creepers and lianas at upper level.
- Both evergreen and semi-evergreen forests flourish in alluvial soil having capacity to retain water.
- Main species: Sal, Bonsum, Titasopa, Hollock, Khokan, Gameri, Hollong, Shishu, Ajhar, Sonaru and other species.

Economic importance

- These are used as timber, wood and as construction materials.
- Hollong and Makai are the most important trees found in this forest because they provide raw materials for plywood industry.
- Softwoods found are used to produce plywood and tea chests.

Mixed Deciduous forests

- The deciduous forests are grown in those areas of Assam where the average annual rainfall is 80 to 200cm.

- The major portions of the mixed deciduous forests are at stages of succession towards climax forests with the tendency towards turning to evergreen if left to nature without human interference or grazing.

Riverine forests

- The forest areas found in Kanamakra, Manas, beki, Pagladiya and Puthimari, Barnadi, Nanoi etc. are instances of riverine forests.
- In the Brahmaputra alluvium of the State, the principal species of the group of forests is **Simul or Simalu.**
- The Jamuna and the Kapili valley alluvium in central Assam contains the mixed type of forests and is composed of trees like Korai, Ajhar, Uriam, Simalu, Outenga etc.and also in the well- drained soils the better species like Sopa, Poma, Gandhsorai, Amari etc.

Savannah forests

- Grasses like **Ikara and Nal** are also found in his type of forests.
- The grass forests of savannah type gets burnt every year making the soil very dry and unfit for the invasion and establishment of other species towards the climax forests.

Previous Years' Questions-APSC

1. The National Park of Assam where the rare white- winged duck(Deohah) is found is (2009)
   a) Nameri
   b) Dibru Saikhowa
   c) Manas
   d) Orang

2. Of the total geographical area of Assam the total area under forest is (2009)
   a) 33 percent
   b) 22 percent
   c) 28 percent
   d) 19 percent

3. In which year, Kaziranga wildlife Sanctuary was elevated to a National Park?(2013)
   a) 1974
   b) 1975
   c) 1976
   d) 1977

4. Pani Dihing Birds Sanctuary is located in which of the following districts of Assam?(2013)
   a) Jorhat
   b) Golaghat
   c) Sibsagar
   d) Dhemaji

5. Arrange the National Parks of Assam correctly in the order of descending size: (2013)
   a) Kaziranga, Manas,Nameri, Dibru Saikhowa, Orang
   b) Manas, Kaziranga, Dibru Saikhowa, Nameri, Orang
   c) Kaziranga, Manas,Nameri, Orang, Dibru Saikhowa
   d) Manas, Dibru Saikhowa, Kaziranga, Orang, Nameri

NOTE:

- **Assam-** Land of Red river and Blue Hills
- **Arunachal Pradesh-** Land of Dawn Lit Mountains
- **Nagaland-** Land of Festivals/ Falcon Capital of the World.
- **Manipur-** Land of Jewels
- **Mizoram-** Land of Hills/Blue Mountain
- **Tripura- Tri(water) and Pra(near)** which in totality means "near water".
- **Meghalaya-** Abode of Clouds