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- Analysis of Controversial Topics & Tips to handle
- DAF Analysis
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- Mock Feedback
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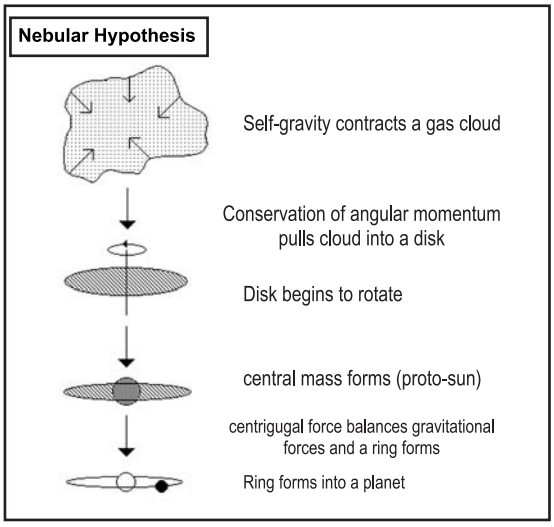
DAY - 16

UNIVERSE

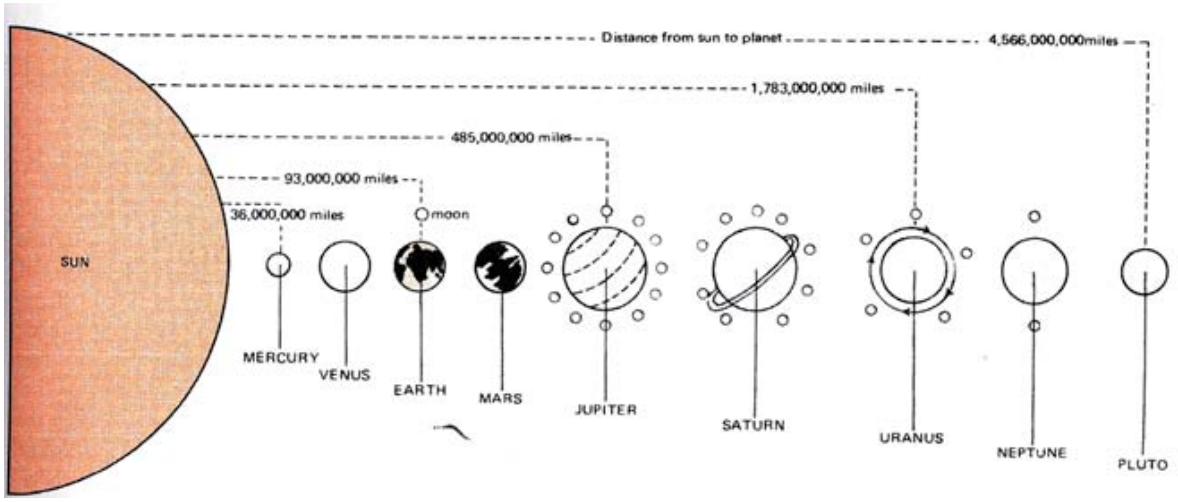
Theories on origin of the Universe

- **Nebular Hypothesis:** (Initial arguments were given by German philosopher Immanuel Kant Mathematician Laplace revised it in 1796). The hypothesis considered that the planets were formed out of a cloud of material associated with a youthful sun, which was slowly rotating.
- **Planetesmial Hypothesis:** In 1900, Chamberlain and Moulton considered that a wandering star approached the sun. Sir James Jeans and later Sir Harold Jeffrey supported the argument.
- At a later date, the arguments considered of a companion to the sun to have been coexisting. These arguments are called binary theories.
- In 1950, **Otto Schmidt in Russia** and **Carl Weizascar in Germany** somewhat revised the '**nebular hypothesis'**.



- **Big Bang Theory/ Expanding Universe Hypothesis**: It was given by **Edwin Hubble**. According to "**Big Bang Theory**" everything in the universe emerged from a point known as '**Singularity**' 15 billion years ago. Later on, this point expanded and inside it galaxies move apart due to which empty space between them expanded. All matter in the universe was created at one instant in fixed moment of time. A single fire ball existed along with wispy clouds of matter. When it exploded, it formed cluster of galaxies which exploded to form stars and then stars exploded to form planets.

■ Solar System



- The solar system comprises the Sun and its eight planets which are believed to have been developed from the condensation of gases and other lesser bodies.
- All the planets revolve round the Sun in *elliptical orbits.*
- Alternatively, the first four are called **Terrestrial**, meaning earth-like as they are made up of rock and metals, and have relatively high densities. The rest four are called **Jovian** or Gas Giant planets**. Jovian means Jupiter-like**. Most of them are much larger than the terrestrial planets and have thick atmosphere, mostly of helium and hydrogen.
- Till recently (August 2006), Pluto was also considered a planet. However, in a meeting of the **International Astronomical Union**, a decision was taken that Pluto like other celestial objects (2003 UB313) discovered in recent past may be called **'dwarf planet'**.
- The eight bodies officially categorized as planets are often further classified in several ways:
  - **By composition**:
    - **Terrestrial or rocky planets**: Mercury, Venus, Earth, and Mars.
    - The terrestrial planets are composed primarily of rock and metal and have relatively high densities, slow rotation, solid surfaces, no rings and few satellites.
    - **Jovian or gas planets** : Jupiter, Saturn, Uranus, and Neptune:
    - The gas planets are composed primarily of hydrogen and helium and generally have low densities, rapid rotation, deep atmospheres and lots of satellites.
  - **By size:**
    - **Small planets:** Mercury, Venus, Earth, Mars. (The small planets have diameters less than 13000 km.)
    - **Giant planets:** Jupiter, Saturn, Uranus and Neptune. (The giant planets have diameters greater than 48000 km.The giant planets are sometimes also referred to as gas giants.)
  - **By position relative to the Sun:**
    - **Inner planets:** Mercury, Venus, Earth and Mars.
    - **Outer planets:** Jupiter, Saturn, Uranus, Neptune. The asteroid belt between Mars and Jupiter forms the boundary between the inner solar system and the outer solar system.
  - **Kuiper Belt:** The Kuiper Belt (sometimes referred to as the Kuiper-Edgeworth Belt) is an area of the outer solar system that is estimated to stretch across 20 astronomical units (AU) of space.
- It contains small solar system bodies made mostly of ices.
- The ices are frozen volatiles (gases) such as methane, ammonia, nitrogen and water.
- It also is home to the known dwarf planets Pluto, Haumea and Makemake.
- The Kuiper-Edgeworth Belt is named for the astronomers Gerard Kuiper.
- The Kuiper Belt extends from roughly the orbit of Neptune (at 30 AU out to about 55 astronomical units) from the Sun.
- **Oort cloud:** The Oort cloud is an extended shell of icy objects that exist in the outermost reaches of the solar system.
- It is named after astronomer Jan Oort, who first theorized its existence.
- The Oort cloud is roughly spherical, and is thought to be the origin of most of the long-period comets that have been observed.
- Objects in the Oort cloud are also referred to as Trans-Neptunian objects. This name also applies to objects in the Kuiper Belt.

Korolev Crater

About:

- European Space Agency's (ESA) Mars Express mission has discovered an icy crater on Mars which has been named as Korolev Crater.

- Korolev Crater has been located by Mars Express Mission near the north pole of the Red Planet It is filled with a mound of water ice 60 kilometers across and nearly 2 kilometers thick.
- The water ice is a permanent feature.
- It has been anticipated that the crater traps a layer of cold air that prevents the ice melting even during the six-month-long northern summer on Mars, making this a yearlong winter wonderland.
- **Significance:**
- Water on Mars has long been debated as the sign of existence of life on Mars, further existence of this huge reservoir of water will give thrust to it.
- To date, no proof has been found of past or present life on Mars but Cumulative evidence shows that during the ancient Noachian time period, the surface environment of Mars had liquid water and may have been habitable for microorganisms.
- Although, the existence of habitable conditions does not necessarily indicate the presence of life.

THE EARTH

- Earth is the third planet from the Sun and is **the largest** of the terrestrial planets.
- The Earth is the **only planet** in our solar system not to be named after a Greek or Roman deity.
- In size, it is the **fifth largest planet**. It is slightly flattened at the poles. That is why its shape is described as a **Geoid.**
- The Moon (or Luna) is the Earth's **only natural satellite**. The Moon is in synchronous rotation with Earth meaning the same side is always facing the Earth.

Evidence of the Earth's Sphericity

- **Ship's visibility:** When a ship appears over the distant horizon, top of the mast is seen before the hull & vice a versa.
- **Sunrise & Sunset:** Sun rises & sets at different times in different places. As earth rotates from west to east, places in east see sun earlier than those in the west.
- **Lunar eclipse:**Shadow cast by earth on the moon during the lunar eclipse is always circular.
- **Driving poles on level ground on curved earth:** Engineers while driving poles of equal length at regular intervals on the ground have found that they do not give a perfect horizontal level. Centre pole normally projects slightly above the poles at either end because of curvature of the Earth. Hence they have to make certain corrections for this inevitable curvature i.e. 8" to a mile.
- **Aerial Photographs:** Pictures taken from high altitudes by rockets & satellites show clearly the curved edge of the earth. This is perhaps the most convincing & up to date proof of earth's sphericity.

Latitudes and Longitudes

Latitudes:

- The Equator is an imaginary line around the middle of the Earth. It is halfway between the North and South Poles, and divides the Earth into the Northern and Southern Hemispheres.
- The Earth is widest at its Equator. The distance around the Earth at the Equator, its circumference, is 40,075 kilometers (24,901 miles).
- Orbital plane is the plane formed by the orbit. The axis of the Earth is an imaginary line that makes an angle of 66½° with its orbital plane.
- Latitudes and Longitudes are imaginary lines used to determine the location of a place on earth. Parallels of Latitudes are the angular distance of a point on the earth's surface, measured in degrees from the center of the Earth.
- 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 at the equator.
- Besides the equator (0°), the north pole (90°N) and the south pole (90°S), there are four important

parallels of latitudes–

- Tropic of Cancer (23½° N) in the Northern Hemisphere.
- Tropic of Capricorn (23½° S) in the Southern Hemisphere.
- Arctic Circle at 66½° North of the Equator.
- Antarctic Circle at 66½° South of the Equator.

Latitudinal Heat zones of the Earth

- The mid-day sun is exactly overhead at least once a year on all latitudes in between the Tropic of Cancer and the Tropic of Capricorn. This area, therefore, receives the maximum heat and is called the **Torrid Zone**.
- The mid-day sun never shines overhead on any latitude beyond the Tropic of Cancer and the Tropic of Capricorn. The angle of the sun's rays goes on decreasing towards the poles. As such, the areas bounded by the Tropic of Cancer and the Arctic circle in the northern hemisphere, and the Tropic of Capricorn and the Antarctic circle in the southern hemisphere, have moderate temperatures. These are, therefore, called **Temperate Zone**.
- Areas lying between the Arctic circle and the north pole in the northern hemisphere and the Antarctic circle and the south pole in the southern hemisphereare very cold. It is because here the sun does not raise much above the horizon. Therefore, its rays are always slanting. These are, therefore, called **Frigid Zone**.

Longitudes:

- Longitude is the angle east or west of a reference meridian between the two geographical poles to another meridian that passes through an arbitrary point.
- All meridians are halves of great circles, and are not parallel to each other.
- They converge only at the north and south poles. A line passing to the rear of the Royal Observatory, Greenwich (near London in the UK) has been chosen as the international zero-longitude reference line and is known as the **Prime Meridian.**
- Places to the East are in the Eastern Hemisphere, and places to the West are in the Western Hemisphere.
- The antipodal meridian of Greenwich serves as **both 180°W and 180°E**. There are 360° of the meridians and the longitude of prime meridian is 0°.
- Length of all meridians is equal. The distance between two meridians is **farthest at the equator** and it decreases as we move towards poles and becomes zero at poles.
- They determine local time in relation to G.M.T. or Greenwich Mean Time, which is sometimes referred to as World Time.

Longitude and Time:

- Since the earth makes one complete revolution of 360° in one day or 24 hours, it passes through 15° in one hour or 1° in 4 minutes.
- The earth rotates from west to east, so every 15° we go eastwards, local time is advanced by 1 hour. Conversely, if we go westwards, local time is retarded by 1 hour.

International Date Line (IDL):

- The International Date Line (IDL) is an imaginary line on earth's surface defining the boundary between one day and the next.
- The International Date Line is located halfway around the world from the prime meridian (0° longitude) or about 180° east (or west) of Greenwich, London, UK, the reference point of time zones. It is also known as the line of demarcation.
- A traveler **going eastwards gains time**from Greenwich until he reaches the meridian 180°E, when he will be 12 hours ahead of G.M.T.

- Similarly in **going westwards, he loses** 12 hours when he reaches 180°W. There is thus a total difference of 24 hours or a whole day between the two sides of the 180° meridian.

Circle of Illumination

- The circle of illumination is the circle that divides the day from night on the globe.
- Earth goes around the sun in an elliptical orbit. Note that throughout its orbit, the earth is inclined in the same direction.

Interior of the Earth

To understand the various endogenetic activities and their effects on the exogenetic landforms, it becomes very important to know about the interior of the Earth. The information regarding the earth's interior can be known through various sources. Some of them are discussed below:

Direct Sources

- The most easily available solid earth material is surface rock or the rocks we get from mining areas.
- Volcanic eruption forms another source of direct information. As and when the molten material (magma) is thrown onto the surface of the earth, 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 provides indirect information about the interior of the Earth.
- Another source of information is the meteors that at times reach the earth.
- The other indirect sources include:
  - **The gravitation force** (g) is not the same at different latitudes on the surface. It is greater near the poles and less at the equator. This is because of the distance from the center at the equator being greater than that at the poles. The gravity values also differ according to the mass of material. The uneven distribution of mass of material within the earth influences this value. The reading of the gravity at different places is influenced by many others factors.

- **Seismic Activity:**Some of the indirect evidences of seismic activity are:
  - Study of ancient rocks and parts of interior now exposed to surface due to erosive activity.
  - Study of lava erupted from volcanism from the interiors of the earth.

Seismological Evidences

The most authenticate source of knowledge about earth's interior is through detailed study of earthquake waves. The seismic waves can be classified into two categories:

- **Surface waves:**These waves travel through the surface of the earth. Due to their amplitude, they are most destructive waves causing extensive damage on the surface of the earth.
  - **Types of Surface Waves:**
    - **Love waves (L-waves)**- its fastest surface waves and move on ground side to side. It is confined to surface of the crust.
    - **Rayleigh waves-** Rayleigh waves rolls along the ground just like a wave roll across a lake or an ocean.
- **Body waves:** These waves travel through the interiors of the earth. While travelling through interiors, their characteristics such as velocity and wavelength changes according to the density of the medium in which they are travelling. The body waves are recorded at different seismograph stations located at different places throughout the surface of earth. Body waves can be further categorized into

- **Primary Waves:**Also known as P-waves. These are longitudinal or compressive in nature. These waves can pass through solid as well as liquid medium. The velocity of these waves increases with increasing density and rigidity of the medium. (They travel faster in solid than in liquids)
- **Secondary waves:**Also known as S-waves. These are transverse or distortional in nature. These waves cannot pass through liquid medium. Their velocity also increases with increasing rigidity of the medium.

- **Nature of Body Waves:**
  - These waves (both P and S waves) travel faster in rigid medium.
  - Among P and S waves the velocity of P waves is more.
  - These waves while passing from one medium to another medium of different density experiences refraction (bending from original path) similar to the light waves.
- **Observations from the study of body waves:**
  - The velocity of body waves initially increases continuously denoting the increasing density of material with increasing depth in the part of outer layer of earth known as core.
  - After around 100 km of depth, the velocity of both the waves shows a drastic decrease which denotes the less rigidity of the layer. This layer was named as asthenosphere and is made of plastic material.
  - The body waves velocity increases, again denoting the increasing density with depth in mantle.
  - After certain depth, the S-waves disappear and again re-emerge at surface of earth at an angle of 105°.The area where S-waves are not received is known as S-waves shadow region and lies between 105° on both sides. This concludes the presence of a liquid layer which forms outer core.
  - The P-waves continue its journey and its velocity increases drastically representing very dense material in inner core. Due to high degree of refraction the P-waves are not recorded between **140° and 105°**, and hence the region is known as **P-waves shadow region.**
  - The velocity and wavelength of waves in different regions give a concrete evidence of composition of different layers of interior of earth.

Earth's Interior

Based on all the evidences from Seismic data and their analysis, the earth's interior has been divided into **three layers.**

Crust:

- This is the outermost layer of the earth. Its depth varies from 16 km – 40 km.
- It is thicker at continents (30 - 40 km) and its thickness underneath the ocean basin varies from 5-10 kms.
- At continental crust, the uppermost part is mainly sedimentary rocks followed by granite and gneisses rocks which overlie the basaltic rocks. The oceanic crust however is devoid of sedimentary or granitic cover and mainly consists of basaltic rocks.
- Thus, continental and oceanic crusts differ in nature where continental crust is mainly granitic while oceanic crust is mainly basaltic in composition.

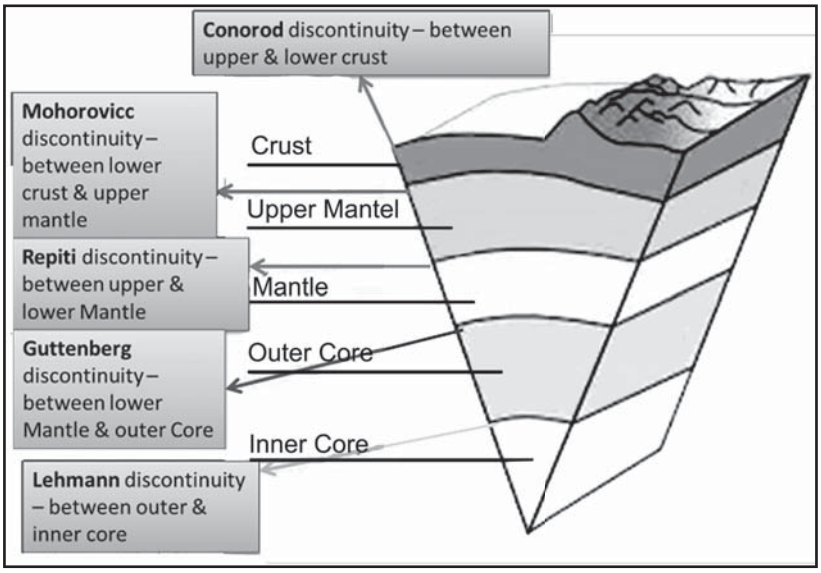
Mantle:

- This is the intermediate layer below crust. It extends upto 2900 km depth.
- It is composed of denseand rigid rocks having predominance of minerals like magnesium and iron. These rocks are similar to peridotite.

Core:

- It is the innermost layer of earth. It is divided into outer core and inner core.

- **Outer Core:**It extends from 2900 km to 5100 km depth from sea level. This is primarily made of iron with a small proportion of nickel, which is in liquid condition. At this depth, the S-waves suddenly disappear. Also, the velocity of P-waves abruptlydecreases.Despite such a high pressure, outer core is in liquid form because of the presence of silicon which decreases the melting point of iron



- **Inner Core:** It lies beyond 5100 km depth. The average density increases to 13. This is mainly composed of pure iron and nickel in solid state. The outer liquid core moving around solid inner core of iron acts as a giant self-exciting dynamo which is responsible for magnetic field of earth.

■ Discontinuities within the Earth's Interior

Conrad discontinuity: The Conrad discontinuity corresponds to the sub-horizontal boundary in continental crust at which the seismic wave velocity increases in a discontinuous way. This boundary is observed in various continental regions at a depth of 15 to 20 km, between **outer and inner crust** however it is not found in oceanic regions.

Mohorovicic discontinuity: The Mohorovicic Discontinuity, or "Moho," is the boundary between the **crust and the mantle**.

Repetti discontinuity: This discontinuity is found between upper and lower Mantle. This is marked by general decrease in velocity of seismic waves between **upper and lower mantle.**

Gutenberg discontinuity: The Gutenberg discontinuity occurs within Earth's interior at a depth of about 1,800 mi (2,900 km) below the surface, generally between **mantle and core** ,where there is an abrupt change in the seismic waves (generated by earthquakes or explosions) that travel through Earth.

Lehmann discontinuity: The Lehmann discontinuity is an abrupt increase of P-wave and S-wave velocities at the depth of 220±30 km, discovered by seismologist Inge Lehmann. It appears beneath continents, but not usually beneath oceans, and does not readily appear in globally averaged studies. It is generally found between **outer and inner core.**

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DAY - 17

ROCKS AND MINERALS

Rocks

- The Earth's crust is composed of rocks.
- A rock is an aggregate of one or more minerals.
- Rock may be hard or soft and in varied colors. For example, granite is hard, soapstone is soft. Gabbro is black and quartzite can be milky white.
- Rocks do not have deflnite composition of mineral constituents.
- Feldspar and quartz are the most common minerals found in rocks.
- Petrology is science of rocks.
- A petrologist studies rocks in all their aspects viz., mineral composition, texture, structure, origin, occurrence, alteration and relationship with other rocks.

Type of Rocks

- There are many different kinds of rocks which are grouped under three families on the basis of their mode of formation. They are:
  - Igneous Rocks — solidifled from magma and lava;
  - Sedimentary Rocks — the result of deposition of fragments of rocks by exogenous processes;
  - Metamorphic Rocks — formed out of existing rocks undergoing recrystallization.

Igneous Rocks

- As igneous rocks form out of magma and lava from the interior of the earth, they are known as primary rocks.
- The igneous rocks (Ignis – in Latin means 'Fire') are formed when magma cools and solidifles when magma in its upward movement cools and turns into solid form it is called igneous rock.
- The process of cooling and solidiflcation can happen in the earth's crust or on the surface of the earth. Igneous rocks are classifled based on texture. Texture depends upon size and arrangement of grains or other physical conditions of the materials.
- If molten material is cooled slowly at great depths, mineral grains may be very large. Sudden cooling (at the surface) results in small and smooth grains. Intermediate conditions of cooling would result in intermediate sizes of grains making up igneous rocks.
- Granite, gabbro, pegmatite, basalt, volcanic breccia and tuff are some of the examples of igneous rocks.

Types of Igneous Rocks:

- **Based on place and time** taken in cooling of the molten matter, igneous rocks can be divided into Plutonic and Volcanic rocks.

Plutonic Rocks or intrusive rocks:

- Sometimes, the molten matter is not able to reach the surface and instead cools down very slowly at great depths.
- Slow cooling allows big-sized crystals (large grains) to be formed.
- Granite is a typical example. These rocks appear on the surface only after being uplifted and denuded.

Lava or Volcanic Rocks or Extrusive rocks:

- These are formed by rapid cooling of the lava thrown out during volcanic eruptions.
- Rapid cooling prevents crystallization; as a result such rocks are fl ne-grained. Basalt is a typical example.
- The Deccan traps in the peninsular region are of basaltic origin.
- Basic rocks contain a greater proportion of basic oxides, e.g. of iron, aluminum or magnesium, and are thus denser and darker in color.
- **Based on the presence of acid forming radical, silicon,** igneous rocks are divided into Acid Rocks and Basic Rocks.

Acid Rocks:

- These are characterized by high content of silica—up to 80 per cent, while the rest is divided among aluminum, alkalis, magnesium, iron oxide, lime etc.
- These rocks constitute theSial portion of the crust.
- Due to the excess of silicon, acidic magma cools fast and it does not flow and spread far away.
- High mountains are formed of this type of rock.
- These rocks have a lesser content of heavier minerals like iron and magnesium and normally contain quartz and feldspar.
- Add rocks are hard, compact, massive and resistant to weathering.

Basic Rocks:

- These rocks are poor in silica (about 40 per cent); magnesia content is up to 40 per cent and the remaining 40 per cent is spread over iron oxide, lime, aluminum, alkalis, potassium etc.
- Due to low silica content, the parent material of such rocks cools slowly and thus, flows and spreads far away.
- This flow and cooling gives rise to plateaus. Presence of heavy elements imparts to these rocks a dark color.
- Basalt is a typical example, others being gabbro and dolerite. Not being very hard, these rocks are weathered relatively easily.

Sedimentary Rocks

- The word ‘sedimentary’ is derived from the Latin word sedimentum, which means settling. Rocks (igneous, sedimentary and metamorphic) of the earth’s surface are exposed to denudational agents, and are broken up into various sizes of fragments. Such fragments are transported by different exogenous agencies and deposited. These deposits through compaction turn into rocks. This process is called lithiflcation. In many sedimentary rocks, the layers of deposits retain their characteristics even after lithiflcation. Hence, we see a number of layers of varying thickness in sedimentary rocks like sandstone, shale etc.
- Depending upon the mode of formation, sedimentary rocks are classifled into three major groups:
  - **Mechanically formed**— sandstone, conglomerate, limestone, shale, loess etc. are examples;
  - **Organically formed**— geyserite, chalk, limestone, coal etc. are some examples;
  - **Chemically formed**— chert, limestone, halite, potash etc. are some examples.

Metamorphic Rocks

- The word metamorphic means 'change of form'. These rocks form under the action of pressure, volume and temperature (PVT) changes.
- Metamorphism occurs when rocks are forced down to lower levels by tectonic processes or when molten magma rising through the crust comes in contact with the crustal rocks or the underlying rocks are subjected to great amounts of pressure by overlying rocks.
- Metamorphism is a process by which already consolidated rocks undergo recrystallization and reorganization of materials within original rocks.
- Mechanical disruption and reorganization of the original minerals within rocks due to breaking and crushing without any appreciable chemical changes is called **dynamic metamorphism**.
- The materials of rocks chemically alter and recrystallize due to thermal metamorphism. There are two types of thermal metamorphism — contact metamorphism and regional metamorphism.
- In contact metamorphism the rocks come in contact with hot intruding magma and lava and the rock materialsrecrystallize under high temperatures. Quite often new materials form out of magma or lava are added to the rocks. In regional metamorphism, rocks undergo recrystallization due to deformation caused by tectonic shearing together with high temperature or pressure or both.
- In the process of metamorphism in some rocks grains or minerals get arranged in layers or lines.
- Such an arrangement of minerals or grains in metamorphic rocks is called **foliation or lineation**.
- Sometimes minerals or materials of different groups are arranged into alternating thin to thick layers appearing in light and dark shades. Such a structure in metamorphic rocks is called banding and rocks displaying banding are **called banded rocks**.
- Types of metamorphic rocks depend upon original rocks that were subjected to metamorphism. Metamorphic rocks are classifled into two major groups — foliated rocks and non-foliated rocks. Gneissoid, granite, syenite, slate, schist, marble, quartzite etc. are some examples of metamorphic rocks.

Types of Metamorphic Rocks:

- **Gneiss**is foliated metamorphic rock that has a banded appearance and is made up of granular mineral grains. It typically contains abundant quartz or feldspar minerals.
- **Quartzite**is a non-foliated metamorphic rock that is produced by the metamorphism of sandstone. It is composed primarily of quartz.
- **Schist** is metamorphic rock with well-developed foliation. It often contains signiflcant amounts of mica which allow the rock to split into thin pieces.
- **Marble**is a non-foliated metamorphic rock that is produced from the metamorphism of limestone. It is composed primarily of calcium carbonate.
- **Slate**is a foliated metamorphic rock that is formed through the metamorphism of shale. It is a low grade metamorphic rock that splits into thin pieces.
- **Soapstone**is a metamorphic rock that consists primarily of talc with varying amounts of other minerals such as micas, chlorite, amphiboles, pyroxenes and carbonates. It is a soft, dense, heat-resistant rock that has a high speciflc heat capacity. These properties make it useful for a wide variety of architectural, practical and artistic uses.

Minerals

- The earth is composed of various kinds of elements.
- These elements are in solid form in the outer layer of the earth and in hot and molten form in the interior.
- About 98 per cent of the total crust of the earth is composed of eight elements like oxygen, silicon, aluminum, iron, calcium, sodium, potassium and magnesium
- The rest is constituted by titanium, hydrogen, phosphorous, manganese, sulphur, carbon, nickel and other elements.

What is a mineral?

- A mineral is a naturally occurring organic or inorganic substance, having an orderly atomic structure and a deflnite chemical composition and physical properties.
- A mineral is composed of two or more elements. But, sometimes single element minerals like sulphur, copper, silver, gold, graphite, etc. are also found.
- The basic source of all minerals is the hot magma in the interior of the earth.
- When magma cools, crystals of the minerals appear and a systematic series of minerals are formed in sequence to solidify so as to form rocks.
- The minerals which contain metals are called as metallic minerals (eg: Haematite) and the metallic minerals which are profltably mined are called as the ores.
- The crust of the earth is made up of more than 2000 minerals, but out of these, only six are the most abundant and contribute the maximum.
- These six most abundant minerals are feldspar, quartz, pyroxenes, amphiboles, mica and olivine.

Types of Mineral

Metallic Minerals

These minerals contain metal content and can be sub-divided into three types:

Precious metals:gold, silver, platinum etc.

Ferrous metals:iron and other metals often mixed with iron to form various kinds of steel.

Non-ferrous metals:include metals like copper, lead, zinc, tin, aluminum etc.

Non-Metallic Minerals

These minerals do not contain metal content. Sulphur, phosphates and nitrates are examples of non-metallic minerals. Cement is a mixture of non-metallic minerals.

Physical Characteristics of Minerals

- **External crystal form**— determined by internal arrangement of the molecules — cubes, octahedrons, hexagonal prisms, etc.
- **Cleavage** — tendency to break in given directions producing relatively plane surfaces — result of internal arrangement of the molecules — may cleave in one or more directions and at any angle to each other.
- **Fracture**— internal molecular arrangement so complex there are no planes of molecules; the crystal will break in an irregular manner, not along planes of cleavage.
- **Lustre**— appearance of a material without regard to color; each mineral has a distinctive lustre like metallic, silky, glossy etc.
- **Color**— some minerals have characteristic color determined by their molecular structure — malachite, azurite, chalcopyrite etc., and some minerals are colored by impurities. For example, because of impurities quartz may be white, green, red, yellow etc.
- **Streak** — color of the ground powder of any mineral. It may be of the same color as the mineral or may differ — malachite is green and gives green streak, fluorite is purple or green but gives a white streak.
- **Transparency** — transparent: light rays pass through so that objects can be seen plainly; translucent — light rays pass through but will get diffused so that objects cannot be seen; opaque — light will not pass at all.
- **Structure**— particular arrangement of the individual crystals; fine, medium or coarse grained; fibrous — separable, divergent, radiating.
- **Hardness** — relative resistance being scratched; ten minerals are selected to measure the degree of hardness from 1-10. They are:

- Talc;
- Gypsum;
- Calcite;
- Fluorite;
- Apatite;
- Feldspar;
- Quartz;
- Topaz;
- Corundum; and
- Diamond. Compared to this for example, a fingernail is 2.5 and glass or knife blade is 5.5.

- **Specific gravity**— the ratio between the weight of a given object and the weight of an equal volume of water; object weighed in air and then weighed in water and divide weight in air by the difference of the two weights.

Soil

- Soil can be deflned as the solid material on the Earth's surface that results from the interaction of weathering and biological activity on the parent material or underlying hard rock.
- The naturally occurring soil is influenced by parent material, climate, relief, and the physical, chemical and biological agents (micro-organisms) in it.
- A soil is made up of four elements: inorganic fraction (derived from the parent material), organic material, air and water. The abundance of each component and its importance in the functioning of the soil system vary from horizon to horizon and from one soil to another.

Soil Characteristics

Soil Texture

- Soil texture is a term used to describe the distribution of the different sizes of mineral particles in a soil.
- Textures range from clay, sand, and silt at the extremes, to a loam which has all three sized fractions present.
- The main influence of texture is on permeability which generally decreases with decreasing particle size.
- A clayey soil may thus be described as flne, a sandy soil as course, while a silty soil is intermediate.

Soil Air

- The air content of a soil is vital, both to itself and to organic life within it. A certain amount of air is contained between the individual particles except for the waterlogged soils.
- The air in the soil helps in the process of oxidation which converts part of the organic material into nitrogen in a form readily available to the plants.

Soil water

- Depending on the texture of the soil, water moves downward by percolation. The amount of water in the soil varies from almost nil in arid climates which makes life virtually impossible for organisms, to a state of complete water logging which excludes all air, causes a reduction of bacteriological activity, and limits decomposition.
- In damp climates, especially in high latitudes where the evaporation rate is low, water tends to move predominantly downward, particularly in coarse-grained sandy soils. This dissolves the soluble

minerals in the soil, together with soluble humus material and carries both downward, a process called leaching or eluviations.

- A typical leached soil is known as podzol, a Russian word meaning ash because the surface layer is often grayish or ash-coloured. In a hot, arid climate, evaporation exceeds precipitation for greater part of the year, so the water tends to move upward and the soil dries out. Consequently, in some areas, a thin salty layer is formed on the surface. This process of **Salinization.**

Soil color

- Generally, soil color is determined by the amount of organic matter and the state of the iron. Soil color is also related to soil drainage, with free draining, well AERATED soils (with pore space dominated by oxygen) having rich brown colors.
- In contrast, poorly draining soils often referred to as gleys, develop under ANAEROBIC conditions (the pore space dominated by water) and have grey or blue-grey colors.
- Such colors are the result of oxidation-reduction; iron is the main substance affected by these processes. If the iron is released in an anaerobic environment, then it stays in the reduced state giving it the grey blue color of waterlogged soils.

Factors Responsible for Soil Formation

Soil formation is the combined effect of physical, chemical, biological, and anthropogenic processes on soil parent material.

Parent material

- This is the material from which the soil has developed and can vary from solid rock to deposits like alluvium and boulder clay. It has been defined as 'the initial state of the soil system'.
- The parent material cans influence the soil in a number of ways: color; texture; structure; mineral composition and permeability/drainage.
- Soil may form directly by the weathering of consolidated rock in situ (a residual soil), saprolite (weathered rock), or it may develop on superficial deposits, which may have been transported by ice, water, wind or gravity. These deposits originated ultimately from the denudation and geologic erosion of consolidated rock. Consolidated material is not strictly parent material, but serves as a source of parent material after some physical and /or chemical weathering has taken place.
- Soils may form also on organic sediments (peat, muck) or salts (evaporates). The chemical and mineralogical compositions of parent material determine the effectiveness of the weathering forces.

Climate

- Temperature varies with latitude and altitude, and the extent of absorption and reflection of solar radiation by the atmosphere. Solar radiation (direct radiation and diffuse radiation) increases with elevation, differs seasonally, and is influenced by cloud cover or other atmospheric disturbance (e.g. air) pollution). The absorption of the solar radiation at the soil surface is affected by many variables such as soil color, vegetation cover, and aspect. In general, the darker the soil color, the more radiation is absorbed and the lower the albedo. The effect of vegetative cover on absorption varies with density, height, and color of the vegetation. Hence the absorption differs in areas with decidious trees (soil surface is shaded by trees most of the year) and arable land (soil surface is not shaded throughout the year). Light, or whitish-colored, soil surfaces tend to reflect more radiation. When incoming solar radiation is reflected, there is less net radiation to be absorbed and heat the soil. Snow is especially effective in reflecting the incoming solar radiation.
- Temperature affects the rate of mineral weathering and synthesis, and the biological processes of growth and decomposition. Weathering is intensified by high temperatures, hence weathering is stronger in the tropics than in humid regions.
- Biological processes are intensified by rising temperatures. Reaction rates are roughly doubled for each 10°C rise in temperature, although enzyme-catalyzed reactions are sensitive to high temperatures and usually attain a maximum between 30° and 35°C.

Biological Factors

The soil and the organisms living on and in it comprise an ecosystem. The active components of the soil ecosystem are the vegetation, fauna, including microorganisms, and man.

- **Vegetation**
  - The primary succession of plants that colonize a weathering rock culminates in the development of a climax community, the species composition of which depends on the climate and parent material, but which, in turn, has a profound influence on the soil that is formed.
  - Deciduous forest seems to accelerate soil formation compared to grassland on the same parent material under similar climatic conditions.
- **Meso-/Macrofauna**
  - Earthworms are the most important of the soil forming fauna in temperate regions, being supported to a variable extent by the small arthropods and the larger burrowing animals (rabbits, moles).
  - Earthworms are also important in tropical soils, but in general the activities of termites, ants, and beetles are of greater significance, particularly in the sub humid to semiarid savanna of Africa and Asia.
- **Micro-organisms**
  - The organic matter of the soil is colonized by a variety of soil organisms, most importantly the micro-organisms, which derive energy for growth from the oxidative decomposition of complex organic molecules.
  - During decomposition, essential elements are converted form organic combination to simple inorganic forms (mineralization).
  - Types of micro-organisms comprise bacteria, actinomycetes, fungi, algae, protozoa, and soil enzymes.
- **Man**
  - Man is perhaps now the most influential of all organisms. He affects the soil by such activities as: ploughing, irrigating, mining, clearing, disposing and leveling.
- **Time**
  - Time is a factor in the interactions of all the above factors as they develop soil. Over time, soils evolve features dependent on the other forming factors, and soil formation is a time-responsive process dependent on how the other factors interplay with each other.
- **Relief**
  - Relief is not static; it is a dynamic system (its study is called geomorphology). Relief influences soil formation in several ways:
    - It influences soil profile thickness i.e. as angle of slope increases so does the erosion hazard. Gradient affects run-off, percolation and mass movement.
    - It influences aspect which creates microclimatic conditions

Stages of Soil Formation

Soil formation is a long slow process. It's estimated that an inch of soil takes 500 to 1000 years to form. Soil is constantly being formed.

- **Stage One**
  - This is the rock pulverizing stage. Here the forces of wind, rain, freezing and thawing water, earthquakes, volcanos all work to slowly pulverize rocks into smaller particles that can make up a soil. At the end of this stage a combination of sand, silt and clay sized particles forms. These form a mineral soil like substance but are unable to support life.
  - They are missing nitrogen. It may seem nitrogen should be the least of a being's worries. After all the air we breathe is made up of about 78% nitrogen gas. The problem is that plants cannot use nitrogen in this form. For them it needs to be converted to either ammonia which is a combination of nitrogen and hydrogen or nitrates - a combination of nitrogen and oxygen.

- **Stage Two**
  - This is the early stage of soil formation. Here life is added specifically by lichens.
  - Lichens are a symbiotic relationship of algae and fungus. The algae have the very important role of fixing the nitrogen, changing it from nitrogen gas to a form, the plant can use. It also captures the sunlight and creates sugars and oxygen. The fungus provides a place for the algae to live, along with water and the mineral nutrients it needs.
- **Stage Three**
  - At this time the little pockets of soil have formed to the extent that some larger plants, plants with roots can have a go at growing.
  - The first pioneers will be short lived but as their bodies are added to the layers of soil forming, the soil becomes more capable of supporting life. Humus builds and soil horizons begin to form.
- **Stage Four**
  - The soils are developed enough to support thick vegetation.

Soil Forming Processes

The four major processes that change parent material into soil are additions, losses, translocations, and transformations.

- **Additions**
  - The most obvious addition is organic matter. As soon as plant life begins to grow in fresh parent material, organic matter begins to accumulate. Organic matter gives a black or dark brown color to surface layer.
  - Other additions may come with rainfall or deposition by wind, such as the wind-blown or eolian material. By causing rivers to flood, rainfall is indirectly responsible for the addition of new sediment to the soil on a flood plain.
- **Losses**
  - Most losses occur by leaching. Water moving through the soil dissolves certain minerals and transports them into deeper layers. Some materials, especially sodium salts, gypsum, and calcium carbonate, are relatively soluble. They are removed early in the soil's formation. As a result, soil in humid regions generally does not have carbonates in the upper horizons.
  - Fertilizers are relatively soluble, and many, such as nitrogen and potassium, are readily lost by leaching, either by natural rainfall or by irrigation water.
  - Solid mineral and organic particles are lost by erosion. Such losses can be serious because the material lost is usually the most productive part of the soil profile.
- **Translocations**
  - Translocation means movement from one place to another. In low rainfall areas, leaching often is incomplete. Water starts moving down through the soil, dissolving soluble minerals as it goes. There isn't enough water, however, to move all the way through the soil. When the water stops moving, then evaporates, salts are left behind. Soil layers with calcium carbonate or other salt accumulations form this way. If this cycle occurs enough times, a calcareous hardpan can form.
  - Translocation upward and lateral movement is also possible. Even in dry areas, low-lying soils can have a high water table. Evaporation at the surface causes water to move upward. Salts that are dissolved in solution will move upward with the water and deposit on the surface as the water evaporates.
- **Transformations**
  - Transformations are changes that take place in the soil. Microorganisms that live in the soil feed on fresh organic matter and change it into humus. Chemical weathering changes parent material. Some minerals are destroyed completely. Others are changed into new minerals. Many of the clay-sized particles in soil are actually new minerals that form during soil development.

- Other transformations can change the form of certain materials. Iron oxides (ferric form) usually give soils a yellowish or reddish color. In waterlogged soils, however, iron oxides loose some of their oxygen and are referred to as being reduced. The reduced form of iron (ferrous) is quite easily removed from the soil by leaching. After the iron is gone, generally the leached area has a greyish or whitish color.

Soil Classification

- Soil Classification concerns the grouping of soils with a similar range of properties (chemical, physical and biological) into units that can be geo-referenced and mapped.
- Soils are divided into: (i) zonal, (ii) intrazonal, (iii) azonal categories.

Zonal

- A soil whose characteristics are dominated by the influence of climate and vegetation is known as a zonal soil. These soils occur on gently undulating land where drainage is free and where the parent material is of neither extreme texture nor chemical composition. They occur in latitudinal zones.

There are seven main types of zonal soils:

- **Tundra Soils:**
  - These soils extend over the tundra region, covering northern parts of North America, southern fringes of Greenland and northern Eurasia. The exact character of these soils depends on the ground ice position, slope and the vegetation. If the slope is stable, peaty soils are formed due to slow organic and chemical action. In case of steep slopes, thin soils result.
- **Podzols:**
  - These soils occur south of the tundra region in North America, northern Europe and Siberia and are associated with conifers and heath plants. In these soils, the horizon-A is colloidal and humus rich, horizon-E is bleached and ash- grey, horizon-B is brown clayey. Depending on the composition of horizon-B, the soils could be humus- podzol, iron-podzol or gleypodzol. These soils are generally infertile and require lime and fertilisers if put to agricultural use.
- **Brown Forest Soils:**
  - These soils occur south of the podzol region in milder climates of eastern to USA, northern Europe and England. These soils are associated with deciduous forests and derive their brown appearance from the equitable distribution of humus and sesquioxides.
  - There is less leaching, because there is no downward movement of sesquioxides. The brown forest soils are generally less acidic.
- **Lateritic Soils/Latosols/Ferralsols:**
  - These soils cover large areas of Asia, Africa, South and Central America and Australia. These soils are generally associated with tropical and sub-tropical climates with a short wet and long dry season and thick vegetation.
  - During the dry season, in these areas, there is intense physical and chemical weathering and organic activity. During the wet season, an intense leaching causes washing down of humus, organic and mineral colloids, clay and other soluble material.
  - The upper horizons are, as a result, acidic with minimum organic content. The insoluble oxides of iron and aluminum give the upper layers a characteristic red color. The lower horizons are clayey. The lateritic soils are generally poorly differentiated but have deep horizons and are suitable for mining. These soils are generally infertile due to low base status.
- **Chernozem/Prairie/Steppe:**
  - These soils are associated with grasslands receiving moderate rainfall in northern USA, the Commonwealth of Independent States (former USSR), Argentina, Manchuria and Australia.
  - The chernozems are characterised by high mineral content and low organic content. Calcium carbonate is quite high in the proflle. The upper horizons are dark, mineral-matrix-base rich. The humus content is around 10%. The parent material of chernozems may be ‘loess’ (wind eroded sediments). The soft, crumb structure imparts fertility to these soils.

- The chestnut soils occur on the arid side of chernozems, and are associated with low-grass steppe. The lime content is still higher in these soils compared to the chernozems.
- The prairies represent the transitional soils between chernozems and the brown forest soils and reflect the element of increasing wetness. These soils are characterized by less leaching, no calcium content and taller, coarser grasses. In the corn regions of the USA, prairie soils are quite fertile.

- **Grumusols/Reddish Brown Soils:**
  - These are dark clayey soils of savanna grasslands which occur on the drier margins of the laterites. These regions experience warm climate with wet-dry seasons.
  - There are no eluviated and alluvial horizons but the wholesolum is base-rich which gives these soils a dark appearance. These soils support scattered trees, low scrubs and grasses. During the dry season, these soils show cracks.
- **Desert (Seirozems and Red Desert) Soils:**
  - Seirozems or grey desert soils occur in mid-latitude deserts of Colorado and Utah states of USA, in Turkmenistan, Mongolia and Sinkiang. These soils occur on the extreme sides of chestnut soils and have a low organic content. Lime and gypsum are closer to the surface. Being rich in bases, the seirozems are good for irrigation.
  - The red desert soils occur in the tropical deserts of the Sahara, West Asia, Pakistan, South Africa and Australia. These soils are characterized by lack of vegetation and lack of leaching. The insoluble oxides of iron and aluminum give these soils a red color. The red desert soils are generally base rich, sandy and gravelly.
- **Intrazonal Soils**
  - Intrazonal soils is a soil which has been influenced in its development less by climate and vegetation than by other local factors, such as defective drainage, excessive evaporation or an unusual parent material (such as lime stone), terrain or age.
  - They can be sub-divided into:
    - Hydromorphic: Bog soils are formed under cool, temperate, continental climates. In these soils the upper layer is peaty while the lower layer is gleyey
    - **Calcimorphic:**Wherever the limestone is exposed, rendzinas are formed which are dark, organic rich and good for cultivation in humid regions.
    - **Halomorphic:**These soils occur mostly in deserts.

Azonal Soils

- A soil which has not been sufficiently subjected to soil –forming processes for the development of a mature profile and so is little changed from the parent rock material.
- Azonal soils do not have B horizon because it is too immature. Thus, the A horizon lies immediately above the C horizon.
- Examples are soil forming on scress, recently deposited alluvium, sand dunes, and newly deposited glacial draft, wind-blown sand, marine mud flats and volcanic soils.

Soils of India

- Since Independence, scientific surveys of soils have been conducted by various agencies.
- Soil Survey of India, established in 1956, made comprehensive studies of soils in selected areas like in the Damodar Valley.
- The National Bureau of Soil Survey and the Land Use Planning an Institute under the control of the Indian Council of Agricultural Research (ICAR) did a lot of studies on Indian soils. In their effort to study soil and to make it comparable at the international level, the ICAR has classified the Indian soils on the basis of their nature and character as per the United States Department of Agriculture (USDA) Soil Taxonomy.
- On the basis of genesis, colour,composition and location, the soils of Indiahave been classified into:

- Alluvial soils
- Black soils
- Red and Yellow soils
- Laterite soils
- Arid soils
- Saline soils
- Peaty soils
- Forest soils.

Alluvial Soils

- Alluvial soils are widespread in the northern plains and the river valleys.
- These soils coverabout 40 per cent 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.
- 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** represents a system of older alluvium, deposited away from the flood plains. Both the Khadar and Bhangar soils contain calcareous concretions (Kankars).
- These soils are **more loamy and clayey in the lower and middle Ganga plain** and the **Brahamaputra valley**.
- The **sand content decreases from the west to east**.

Black Soil

- 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 northwestern 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.
- 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.
- 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 aluminum compound are left behind.
- Humus content of the soil is removed fast by bacteria that thrive 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.
- Laterite soils are widely cut as bricks for use in house construction.

Arid Soils

- 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 phosphatecontent is normal.
- Lower horizons of the soilare occupied by 'kankar' layers because of the increasing calcium content downwards.

Saline Soils

- 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**.

Peaty Soils

- 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 per cent.

Forest Soils

- 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.

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DAY - 18

CONCEPTS OF GEOMORPHOLOGY

Evolution of Oceans and Continents

The Theory of Continental

- German meteorologist Alfred Wegener observed similarities among the continents that suggested the landmasses might have once been connected.
- **Coastal fit**: The "jig-saw" fit of opposing coasts of continents across Atlantic Ocean. The eastern coast of South America fits into western coast of Africa. Similar case is with eastern coast of North America fitting into western coast of Europe.
- **Fossil evidences:** There is a similarity in the fossils found in distant lands across oceans and sometimes at places where it should not be. Glaciation evidences found in landmasses such as Brazil, South Africa and peninsular India indicates that once these landmasses were in polar or subpolar region which is consistent with Wegner's hypothesis of Pangea located somewhere near South pole.

The distribution of glacial features can be best explained if the continents were part of Pangaea.

- **Geological evidences:** The rocks and minerals found in distant lands were found to be having similarity in their structure and age. The coal deposits found in Alps region were similar to those found in North America.
- Later, other evidences also came out which supported Wegner's Continental Drift Theory. Those evidences are:
- **Paleomagnetism:** These form the most reliable proof of the continental drift. The rocks found at any place preserve the magnetic properties like magnetic declination, inclination and polarity of that place during their time of cooling and rock formation. The socks of similar paleomagnatic evidence found at different location.
- These observations led Alfred Wegner to formulate his "Theory of Continental Drift", through which he tried to explain these anomalies.

Hypothesis

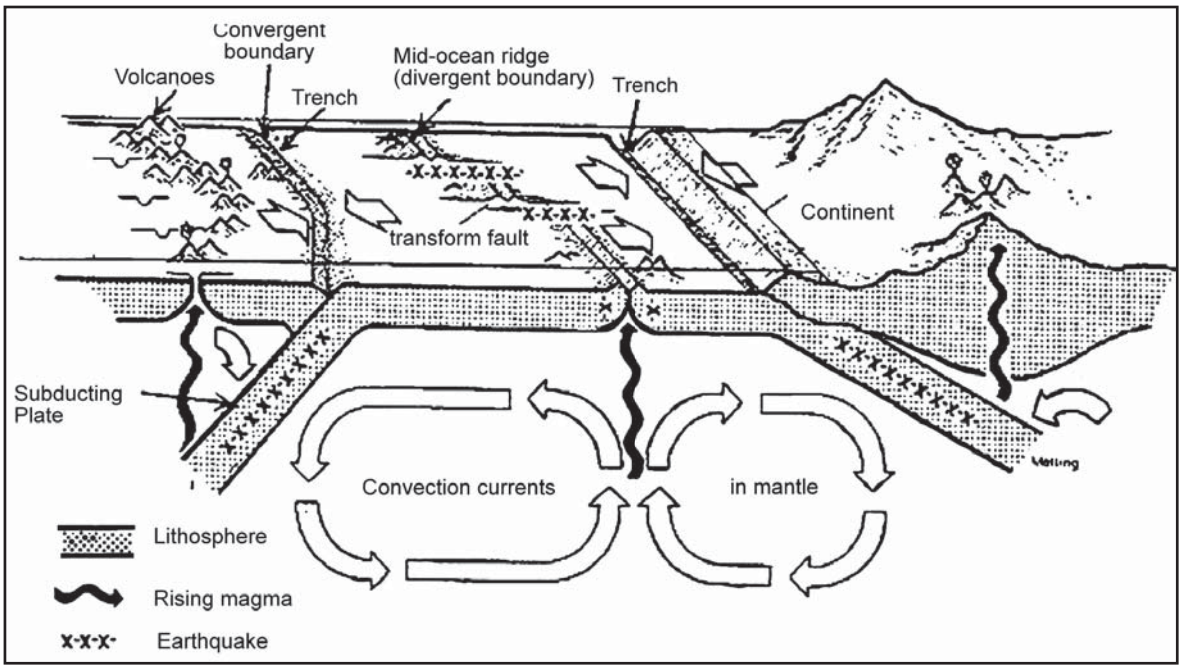
- All the continents were once combined as a single landmass called Pangea, which means "all lands" in Greek, during Carboniferous period.
- Pangea was surrounded by a vast water body which he called Panthalassa.

- Pangaea broke into two landmasses namely northern part which became Lauratia and the southern part namely Gondwanaland. A water body developed between these two landmasses known as Tethys Sea. The two landmasses drifted northward and westward.
- The northward movement was due to the gravitational attraction force exerted by the earth's equatorial bulge. Wegner called this "pole fleeing". The westward movement of landmasses was attributed to the tidal force exerted by moon and the sun.
- During the drifting of both the landmasses, they again broke due to differential dragging force into different continents.

Criticism of Wegner's Continental Drift Theory

- The driving force that Wegner suggested for the drift of landmasses was questioned. It has been argued that the tidal force of Moon and Sun cannot be of the magnitude to move such huge landmasses. If it were of so large magnitude then the rotation of earth would have been stopped due to effect of these forces.
- The assumption of Wegner that Sial floated over Sima and the formation of fold mountains which according to him were due to scrapping off of Sima and their folding was contradicted on the basis that it was not possible for a lighter Sial to scrap Sima and if any scrapping had been there, it would be of Sial not Sima.
- Another assumption of Wegner based on Suess theory that ocean floors are exposed part of Sima (or mantle) does not hold ground now, as it is now evidently proved that they are part of crust only, not the exposed part of mantle.
- The fossil evidence given by Wegner was countered by another "Theory of Parallel evolution", according to which it was possible for particular specie to evolve at two different places at the same period of time.

Sea - Floor Spreading



- According to Harry Hess, the hot magma rises from mantle to the surface by convection currents at the site of Mid Oceanic Ridges (MOR) and then diverges along two limbs on either side of MOR. This diverging limb drags the crust lying above it, causing them to diverge too. The diverging limb descends inside the crust at the boundary of continental crust dragging again the oceanic crust causing ocean crust to melt and destroyed at the site of trenches.
- Since a new crust is formed at the site of MORs, it is considered as constructive zone while at trenches, the oceanic crust is destroyed and hence the site is a destructive zone. This means that

oceanic crust is continuously being destroyed and new crust being formed. This explains why rocks of continental crust are much older than those found at oceanic crust although oceanic crust was the basis of all. In other way, "Oceanic crust is destructible while continents are forever".

Plate Tectonics Theory

By combining the sea floor spreading theory with continental drift and information on global seismicity, the new theory of Plate Tectonics became a coherent theory to explain crustal movements. According to the theory, plates are composed of lithosphere, about 100 km thick that "float" on the ductile asthenosphere. As of now there are six major plates and six minor plate's identified.

Major Plates

- Indian plate or Indo-Australian plate
- Pacific plate
- American plate (divided into North American plate and South American plate)
- African plate
- Eurasian plate
- Antartica plate

While the continents do indeed appear to drift, they do so only because they are part of larger plates that float and move horizontally on the upper mantle asthenosphere. The plates behave as rigid bodies with some ability to flex, but deformation occurs mainly along the boundaries between plates. The plate boundaries can be identified because they are zones along which earthquakes occur. Plate interiors have much fewer earthquakes.

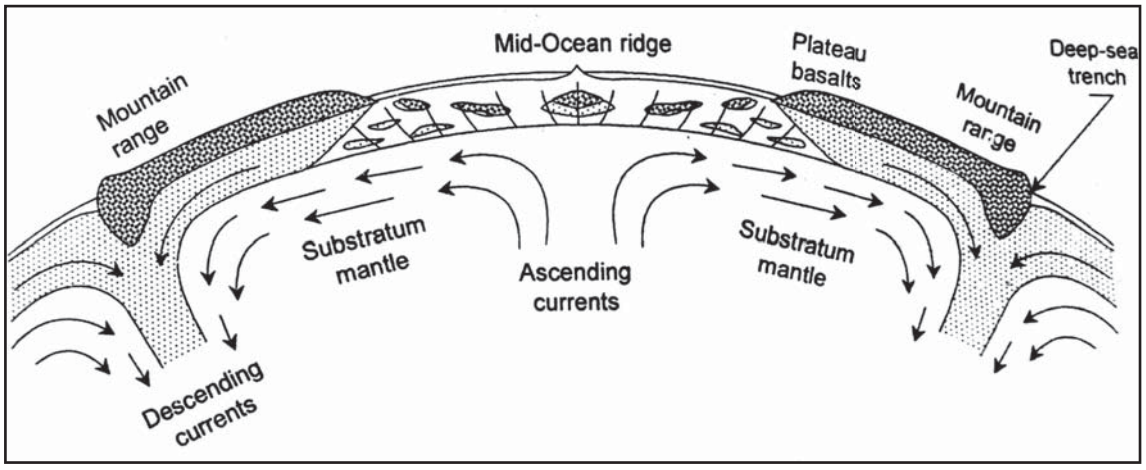


Plate Boundaries

There are three types of plate boundaries:

Divergent Plate boundaries:

These are areas where plates move away from each other, forming either mid-oceanic ridges or rift valleys. These are also known as constructive boundaries.

- **Regions of Divergent Boundaries**
  - East African Rift (Great Rift Valley) in eastern Africa
  - Mid-Atlantic Ridge system separates the North American Plate and South American Plate in the west from the Eurasian Plate and African Plate in the east
  - Gakkel Ridge is a slow spreading ridge located in the Arctic Ocean
  - East Pacific Rise, extending from the South Pacific to the Gulf of California

- Baikal Rift Zone in eastern Russia
- Red Sea Rift
- Aden Ridge along the southern shore of the Arabian Peninsula
- Carlsberg Ridge in the eastern Indian Ocean
- Gorda Ridge off the northwest coast of North America
- Explorer Ridge off the northwest coast of North America
- Juan de Fuca Ridge off the northwest coast of North America
- Chile Rise off the southeast Pacific

Convergent Plate Boundaries:

- Convergent boundaries are areas where plates move toward each other and collide. These are also known as compressional or destructive boundaries.
- **Subduction zones** occur where an oceanic plate meets a continental plate and is pushed underneath it. Subduction zones are marked by oceanic trenches. The descending end of the oceanic plate melts and creates pressure in the mantle, causing volcanoes to form.
- **Obduction** occurs when the continental plate is pushed under the oceanic plate, but this is unusual as the relative densities of the tectonic plate's favours subduction of the oceanic plate. This causes the oceanic plate to buckle and usually results in a new mid ocean ridge forming and turning the obduction into subduction.
- **Orogenic belts** occur where two continental plates collide and push upwards to form large mountain ranges. These are also known as collision boundaries
- **Regions of Convergent Boundaries**-Few of the regions are mentioned below:
  - The oceanic Nazca Plate subductsbeneath the continental South American Plate at the Peru–Chile Trench.
  - Just north of the Nazca Plate, the oceanic Cocos Plate subducts under the Caribbean Plate and forms the Middle America Trench.
  - Cascadia subduction zone is where the oceanic Juan de Fuca, Gorda and Explorer Plates subduct under the continental North American plate.
  - Oceanic Pacific Plate subducts under the North American Plate (composed of both continental and oceanic sections) forming the Aleutian Trench.

Transform Plate Boundaries

Occur when two plates grind past each other with only limited convergent or divergent activity.

Regions of Transform Boundaries

- The San Andreas Fault in California is an active transform boundary. The Pacific Plate (carrying the city of Los Angeles) is moving northwards with respect to the North American Plate.
- The Queen Charlotte Fault on the Pacific Northwest coast of North America.
- The Motagua Fault, which crosses through Guatemala, is a transform boundary between the southern edge of the North American Plate and the northern edge of the Caribbean Plate.
- New Zealand's Alpine Fault is another active transform boundary.
- The Dead Sea Transform (DST) fault which runs through the Jordan River Valley in the Middle East.
- The Owen Fracture Zone along the southeastern boundary of the Arabian Plate

Mountains:

- A portion of land rising considerably above the surrounding country either as a single eminence (Kilimanjaro) or in range (Himalayas, Rockies, Andes), is known as 'mountain'.
- Orogeny (Orogenesis): A period of mountain building involving the process of intense upward displacement of the earth's crust, usually associated with folding, thrust faulting and other compressional processes.

Fold Mountains

- Fold Mountains are formed at convergent boundaries at the meeting point of two tectonic plates.
- Fold Mountains are formed as a result of the compression of tectonic plates, which leads to the formation of large fold-like structures on the earth's crust.
- Fold Mountains primarily exist as mountain ranges, and the majority of the earth's well-known mountain ranges are examples of Fold Mountains.

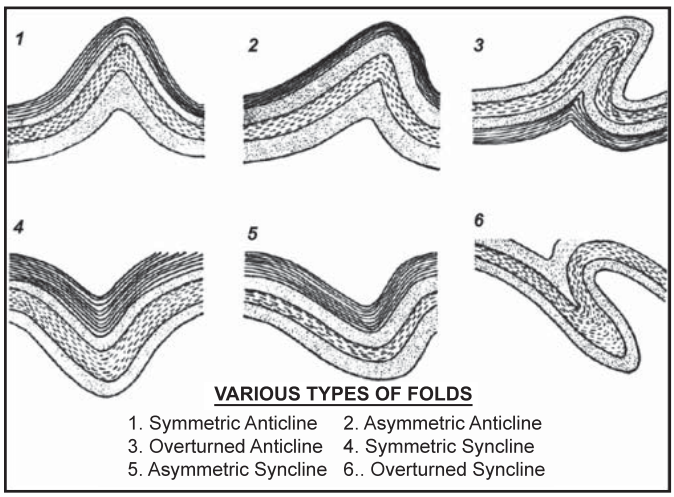
Characteristics of Fold Mountains

- 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 found along continental margins facing oceans.
- Fold Mountains are characterized by granite intrusions on a massive scale.
- Recurrent seismicity is a common feature in folded mountain belts.
- High heat flow often finds expression in volcanic activity.
- These mountains are by far the most widespread and also the most important.
- They also contain rich mineral resources such as tin, copper, gold.

Types of Folds

According to the shape, the folds are of many types:

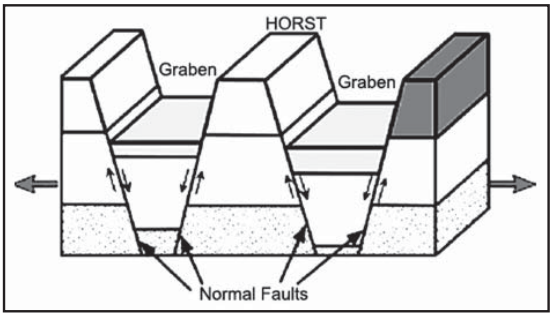
- **Symmetrical Folds:**These are ordinary folds. The limbs of the folds are equally inclined on either side.
- **Asymmetrical Fold:**One of the limbs is more inclined than the other.
- **Monoclinal Fold:** In this fold, one limb makes a right angle with the surface but the other limb is ordinarily inclined.
- **Isoclinal Fold:**The two limbs are so much inclined in such a way that they appear equally inclined and parallel to each other.



VARIOUS TYPES OF FOLDS
1. Symmetric Anticline 2. Asymmetric Anticline
3. Overturned Anticline 4. Symmetric Syncline
5. Asymmetric Syncline 6.. Overturned Syncline

- **Recumbent Fold:**In this fold the two limbs are so much inclined that they become horizontal.
- **Overturned Fold:**In this fold one limb is overturned over the other limb. The difference between the overturned and recumbent folds is that the overturned limbs are not horizontal like those of recumbent fold.
- **Plunging Fold:** If the axis of the fold is not parallel to the horizontal but makes an angle with it, it is known as Plunging Fold.
- **Fan Fold:** It is a great anticline which has many small anticlines and synclines. It is also known as Anticlinorium. A great syncline having many small anticlines and synclines is called Synclinorium.
- **Open Fold:** If the angle between the limbs of a fold is obtuse, the fold is called Open Fold.
- **Closed Fold:** If the angle between the limbs of a fold is acute, it is called Closed Fold.

Block Mountains



- Block Mountains are formed when two tectonic plates move away from each other causing cracks on the surface of the Earth. When parallel cracks or faults occur, the strip of land or the block of land between them may be raised resulting in the formation of Block Mountains. The upward block is called a horst. Examples, Black forest and the Vosges of Rhineland.
- Block Mountains are also formed when the crust of the Earth sinks on both sides of two parallel faults. Therefore, a block mountain can be found between two rift valleys. The land which sinks is known as graben. Examples, East African rift valleys.

Residual Mountains

- These are mountains evolved by denudation.
- Where the general level of the land has been lowered by the agents of denudation some very resistant areas may remain and these form residual mountains, e.g. Mt. Manodnock in U.S.A.
- Residual Mountains may also evolve from plateaus which have been dissected by rivers into hills and valleys. Examples of dissected plateaux, where the down-cutting streams have eroded the uplands into mountains of denudation, are the Highlands of Scotland, Scandinavia and the Deccan Plateau.

Volcanism

- A volcano is an opening in the earth's crust through which gases, molten rocks materials (lava), ash, steam etc. are emitted outward in the course of an eruption.
- Such vents or openings occur in those parts of the earth's crust where the rock strata are relatively weak.
- Volcanic activity is an example of endogenic process. Depending upon the explosive nature of the volcano, different land forms can be formed such as a plateau (if the volcano is not explosive) or a mountain (if the volcano is explosive in nature).

Types of Lava

- **Basic lavas:** There are highly fluid. They are dark coloured like basalt, rich in iron and magnesium but poor in silica. They are affect extensive areas, spreading out as thin sheets. The resultant volcano is gently sloping with a wide diameter and form a flattened shield or dome.
- **Acidic lavas:** There lavas are highly viscous with a melting point. They are light-coloured, of low density, and have a high percentage of silica. They flow slowly and seldom travel far. The resultant cone is therefore steep sided.

Types of Volcanoes

- Classification of Volcanoes **according to shape**
  - **Cinder cones**-are circular or oval cones made up of small fragments of lava from a single vent that has been blown up.
  - Cinder cones result from eruptions of mostly small pieces of scoria and pyroclasticthat builds up around the vent. Most cinder cones erupt only once.
  - Cinder cones may form as flank vents on larger volcanoes, or occur on their own.
  - **Composite Volcanoes**: These are steep-sided volcanoes composed of many layers of volcanic rocks, usually made from high-viscosity lava, ash and rock debris.
  - These types of volcanoes are tall conical mountains composed of lava flows and other ejected in alternate layers, the strata that give rise to the name.

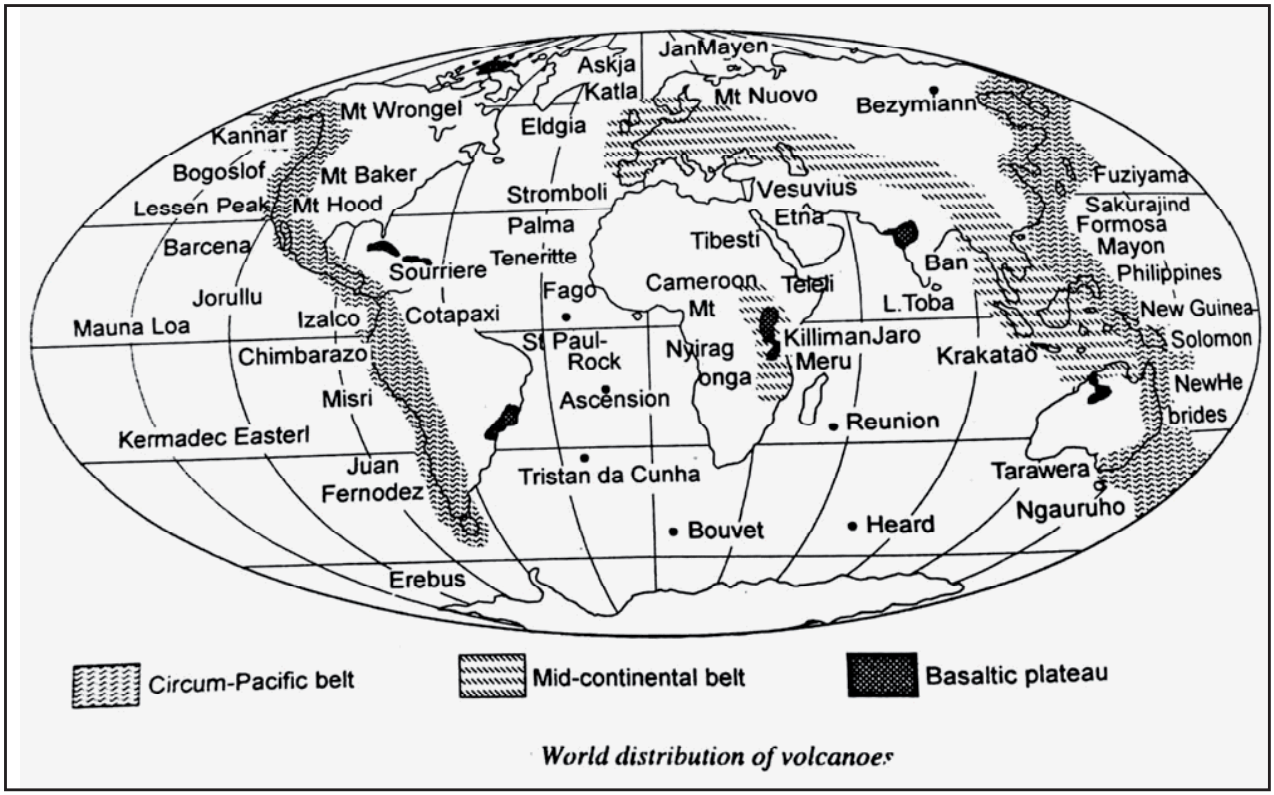
- Composite volcanoes are made of cinders, ash, and lava. Cinders and ash pile on top of each other, lava flows on top of the ash, where it cools and hardens, and then the process repeats.
- **Shield volcanoes**are volcanoes shaped like a bowl or shield in the middle with long gentle slopes made by basaltic lava flows.
- These are formed by the eruption of low-viscosity lava that can flow a great distance from a vent.
- They generally do not explode catastrophically.
- Since low-viscosity magma is typically low in silica, shield volcanoes are more common in oceanic than continental settings.
- The Hawaiian volcanic chain is a series of shield cones, and they are common in Iceland, as well.
- **Lava domes**are formed when erupting lava is too thick to flow and makes a steep-sided mound as the lava piles up near the volcanic vent.
- They are built by slow eruptions of highly viscous lava.
- They are sometimes formed within the crater of a previous volcanic eruption.
- Like composite volcano, they can produce violent, explosive eruptions, but their lava generally does not flow far from the originating vent.

- According to **flow of magma and its place of cooling**, volcanism may be categorized into:
  - **Extrusive volcanism:**Magma is expelled onto surface.
  - **Intrusive Volcanism:** Magma solidifies in the shallow crust near the surface. It can be exposed after weathering.
  - **Plutonic Volcanism:** Magma solidifies deep inside the earth's crust
- Classification of Volcanoes on the **basis of Periodicity:**
  - **Active Volcanoes:** When volcanic materials like lava, gases, ash, cinder, pumice etc. are ejected constantly from the vent. Most of the active volcanoes are found in the Circum-Pacifi c Belt which is known as the 'Ring of Fire'. A few examples of active volcanoes are: Etna and Visuvius, Mount Pelee (Martinique), Mount Karmai(Alaska), Mount Saint Helens, Nevado Del Ru'z (Columbia), Mount Unzen (Japan), Mount Pinatubo (Philippines), Mount Redoubt (Alaska) and Mount Mayon (Philippines). The Stromboli volcano emits so much fire and incandescent gases that it is known as 'the Light House of the Mediterranean Sea'.
  - **Dormant Volcanoes:**Those that have been known to erupt and show signs of possible eruption in the future. These are not extinct. For example: The Vesuvius erupted in 79 AD, 1631, 1803, 1872, 1906, 1927, 1928 and 1929. Violent eruptions of dormant volcanoes are generally preceded and accompanied by earthquakes, some of which have been very destructive. Example Mt. Kilimanjaro.
  - **Extinct Volcanoes:**A volcano that was active in the geological past and no longer has any active vulcanicity. The Crater is filled with water. For example: St. Arthur's Sea (Edinburgh) and the numerous Crater Lakes in the Andes and Rockies Mountains. Some of the volcanoes that are today dormant may become active. For example: Monte Sommawhich erupted 700 years back are now considered extinct by the inhabitants.

World distribution of Volcanoes

The CircumPacific Belt:

- Due to subduction of the Pacific plate below the Asiatic plate, the large number of volcanic eruptions are found circling Pacific Ocean known as Ring of Fire, which extends through the Andes of South America, Central America, Mexico, the Cascade Mountains of Western United States, the Aleutian Islands, Kamchatka, the Kuril Isles, Japan, the Philippines, Celebes, New Guinea, the Solomon Islands, New Caledonia and New Zealand where about 80 active volcanoes are found.



World distribution of volcanoes

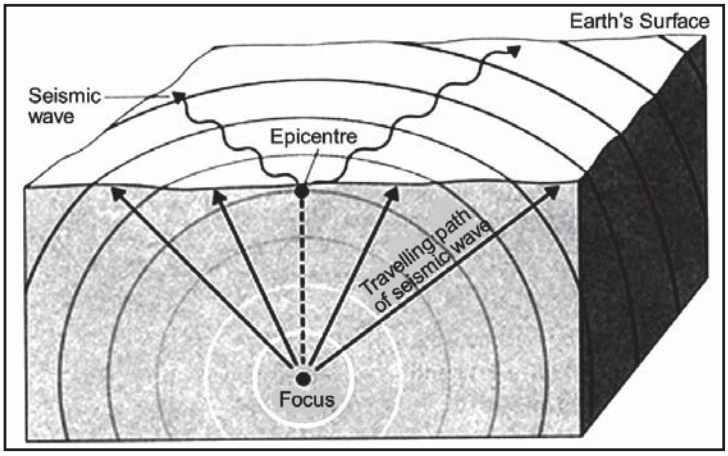
- The Circum-Pacific belt meets the mid- continental belt in the East Indies. This belt is characterised by high volcanic cones and volcanic mountains.
- The volcanoes of the Aleutian Island, Hawaii Island and Japan are found in Chains.
- Cotapaxi is the highest volcanic mountain (6035m) in the world.
- Other important volcanoes found in this belt are Fuziyama, Shasta, Rainer and Hood.
- Volcanic eruptions occur in this belt because of the subduction of the Pacific plate below the Asiatic plate.

The Mid-Continental Belt:

- Having various volcanoes of the Alpine Mountain Chain, Mediterranean Sea (Stromboli, Vesuvius, Etnaetc.), volcanoes of the Aegean Sea, Mt. Ararat, Elburz and Hindukush. There are several volcanic free zones found along the Alps and the Himalayas, come under this belt. Kilimanjaro, Elgon, Birunga and Rungwe etc. are the volcanoes found in the Rift Valleys of Africa.
- In the region where the boundaries of Persia, Afghanistan, and Baluchistan meet, there are several volcanic cones of large size, and one or two of them emit steam and other gases. This region has also a few extinct volcanoes.
- **The Mid Atlantic Belt:**
  - It includes the volcanoes of the Mid-Atlantic Ridge which are associated with the Atlantic Ocean and are located either on swells or ridges rising from the sea floor or on or near the edge of the continent where it slopes abruptly into the deep oceanic basins.
  - The volcanoes formed along the Mid-Atlantic Ridge actually represent the splitting zone of the American plate moving towards west and the Eurasian plate moving towards east representing the zones of crystal movement.
  - In the splitting zone there is constant upwelling of Magma hence known as crustal weakness.
  - Volcanoes in this belt are generally of fissure-eruption type such as Volcanoes of Lesser Antilles, Azores, and St. Helens etc.

Earthquakes

- An earthquake is the shaking or trembling of the earth's surface, caused by the sudden movement of a part of the earth's crust.
- They result from the sudden release of energy in the Earth's crust that creates seismic waves or earthquake waves.



Causes of Earthquakes

- **Volcanic Eruptions:** Volcanic eruptions are the main cause of earthquake caused by gas explosions or the upcoming and fissuring of volcanic structures. For example: Karakota (1883), Cotopaxi, Chimborazo, Kilimanjaro, Fujiyama etc.
- **Faulting (Displacement of Rocks):** Earthquakes occur when movement of earth takes place along a line of fracture (FAULT). Examples: San Andres Fault of California (Los Angeles) and earthquakes of 1994 at Northridge, California.
- **Plate Tectonics:** The 6 major and 9 minor plates of the earth crust are constantly moving at different rates. The boundaries of these plates are the primary location of earthquakes, example: the Ring of Fire. Shallow focus earthquakes occur on the Oceanic Ridges and in the Oceanic Trenches, deep focus earthquakes occur.
- **Anthropogenic Factors (Human's over Integration with Nature):** Extraction of minerals and the dams built on time to time disturbing the earth's balance – Marathon Dam (Greece) – 1929, Koyna (Maharashtra 1962), Hoover Dam (1935), Mangla Dam (Pakistan), Kariba Dam (Zambia), Manic Dam (Canada), Kurobe Dam (Japan).

Seismic Waves or Earthquake Waves

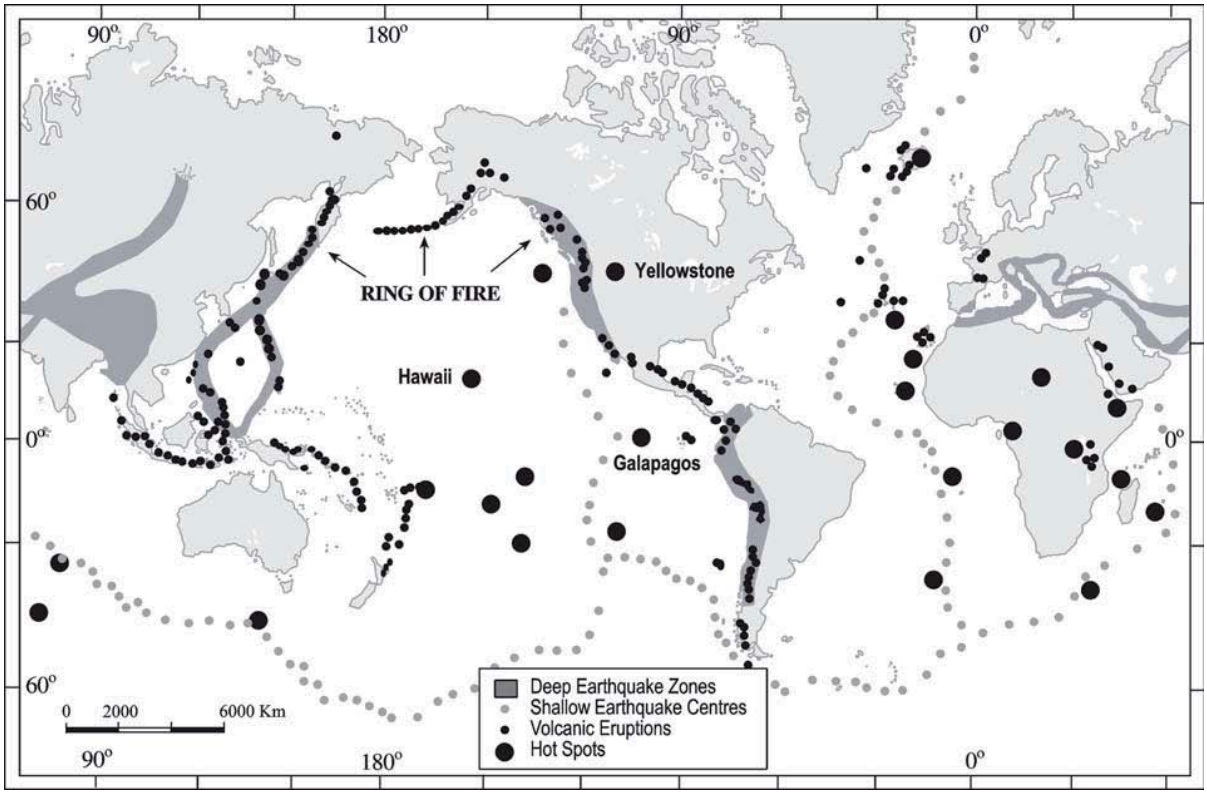
The seismic waves can be classified into two categories:

- **Surface Waves:** These waves travel through the surface of the earth. Due to their amplitude, they are most destructive waves causing extensive damage on the surface of earth.
  - **Types of Surface Wave**
    - **Love waves (L-waves):** It is fastest surface waves and move on ground side to side. It is confined to surface of the crust love wave is wounded by Seismograph.
    - **Rayleigh waves:** Rayleigh waves rolls along the ground just like a wave roll across a lake or an ocean.
    - **Stoneley waves:** Stone waves propagate along a solid - fluid boundary and also along solid - solid boundary.
    - **Standing waves:** Standing waves are the result of free oscillation of earth. When two waves moving opposite to each other interfere standing waves are produced.
- **Body waves:** These waves travel through the interiors of the earth. While travelling through interiors, their characteristics such as velocity and wavelength changes according to the density of the medium in which they are travelling. Body Waves can be further categorized into:
  - **Primary Waves:** Also known as P-waves. These are longitudinal or compressive in nature. These waves can pass through solid as well as liquid medium. The velocity of these waves increases with increasing density and rigidity of the medium. (They travel faster in solid than in liquids)
  - **Secondary waves:** Also known as S-waves. These are transverse or distortional in nature. These waves cannot pass through liquid medium. Their velocity also increases with increasing rigidity of the medium.

Measuring Earthquakes

- Seismometers are the instruments which are used to measure the motion of the ground, which including those of seismic waves generated by earthquakes, volcanic eruptions, and other seismic sources.
- A Seismograph is also another term used to mean seismometer though it is more applicable to the older instruments.
- The recorded graphical output from a seismometer/seismograph is called as a seismogram. (Note: Do not confuse seismograph with seismogram. Seismograph is an instrument while seismogram is the recorded output)
- There are two main scales used in the seismometers:
  - **Mercalli Scale:** The scale represents the intensity of earthquake by analyzing the after effects like how many people felt it, how much destruction occurred etc. The range of intensity is from 1-12.
  - **Richter Scale:** The scale represents the magnitude of the earthquake. The magnitude is expressed in absolute numbers from 1-10. Each whole number increase in Richter scale represents a ten times increase in power of an earthquake.

Earthquake Zones in the World



Distribution of earthquakes and volcanoes

Circum-Pacific Zone: This zone is mainly distributed along the subsidence zone along trenches, where oceanic plate subducts under continental plate. Enormous amount of energy is released in earthquakes which occur in this zone. The depth of focus may vary greatly in accordance with Benioff zones which can result in focus as deep as 300 to 700 km below sea level.

The Mediterranean and Trans-Asiatic zone: This zone runs along the fold mountain chains from Alpine system of Europe through Asia, Iran and Himalayan mountain system. These earthquakes owe their origin to collision of continental plates and resulting buckling of plates. These earthquakes have generally shallow to intermediate focus.

The Mid-Oceanic Ridges and the African Rift System: This runs along the mid-oceanic ridges through the oceans. These have generally shallow focus.

Earthquake Zones in India

Bureau of Indian Standardsbased on the past seismic history, grouped the country into four seismic zones, viz. Zone-II, -III, -IV and –V. Of these, Zone V is the most seismically active region, while zone II is the least.The Modified Mercalli (MM) intensity, which measures the impact of the earthquakes on the surface of the earth, broadly associated with various zones, is as follows: Seismic Zone Intensity on MM scale:

- **Zone-V comprises**of entire northeastern India, parts of Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Rann of Kutch in Gujarat, parts of North Bihar and Andaman & Nicobar Islands.
- **Zone-IV covers**remaining parts of Jammu & Kashmir and Himachal Pradesh, Union Territory of Delhi, Sikkim, northern parts of Uttar Pradesh, Bihar and West Bengal, parts of Gujarat and small portions of Maharashtra near the west coast and Rajasthan.
- **Zone-III comprises**of Kerala, Goa, Lakshadweep islands, and remaining parts of Uttar Pradesh, Gujarat and West Bengal, parts of Punjab, Rajasthan, Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh, Maharashtra, Odisha, Andhra Pradesh, Tamil Nadu and Karnataka.
- **Zone-II covers**remaining parts of the country. Further, as part of pre-disaster preparedness measure, Government of India has also completed seismic micro-zonation studies of some of the major cities in the country such as, Jabalpur, Guwahati, Bengaluru, greater Bharuch in Gujarat, Jammu in J&K, Shillong in Meghalaya, Chennai in Tamil Nadu and Sikkim state.

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DAY - 19

LANDFORMS AND ITS EVOLUTION

As the geomorphic agents are capable of erosion and deposition, two sets - erosional or destructional and depositional or constructional - of landforms are produced by them.

Many varieties of landforms develop by the action of each of the geomorphic agents depending upon especially the type and structure i.e. folds, faults, joints, fractures, hardness and softness, permeability and impermeability, etc.

There are some other independent controls like stability of sea level; tectonic stability of landmasses; climate, which influence the evolution of landforms.

Landforms Made by Running Water

- In humid regions, which receive heavy rainfall, running water is considered the most important of the geomorphic agents in bringing about the degradation of the land surface.
- Most of the erosional landforms made by running water are associated with vigorous and youthful rivers flowing over steep gradients.

The Course of a River

Youth

- Streams are few during this stage with poor integration and flow over original slopes showing shallow V-shaped valleys with no floodplains or with very narrow floodplains along trunk streams. Streams divides are broad and flat with marshes, swamp and lakes. Meanders if present develop over these broad upland surfaces. These meanders may eventually entrench themselves into the uplands. Waterfalls and rapids may exist where local hard rock bodies are exposed.

Mature

- During this stage streams are plenty with good integration. The valleys are still V-shaped but deep; trunk streams are broad enough to have wider floodplains within which streams may flow in meanders confined within the valley. The flat and broad inter stream areas and swamps and marshes of youth disappear and the stream divides turn sharp. Waterfalls and rapids disappear.

Old

- Smaller tributaries during old age are few with gentle gradients. Streams meander freely over vast floodplains showing natural levees, oxbow lakes, etc. Divides are broad and flat with lakes, swamps and marshes. Most of the landscape is at or slightly above sea level.

Erosional Landforms

Valleys:

- Valleys start as small and narrow rills; the rills will gradually develop into long and wide gullies; the gullies will further deepen, widen and lengthen to give rise to valleys.

- Depending upon dimensions and shape, many types of valleys like V-shaped valley, gorge, canyon, etc. can be recognized.
- A gorge is a deep valley with very steep to straight sides and a canyon ischaracterised by steep step-like side slopes and may be as deep as a gorge.
- A gorge is almost equal in width at its top as well as its bottom. In contrast, a canyon is wider at its top than at its bottom. In fact, a canyon is a variant of gorge.
- Valley types depend upon the type and structure of rocks in which they form. For example, canyons commonly form in horizontal bedded sedimentary rocks and gorges form in hard rocks.

Potholes and Plunge Pools:

- Over the rocky beds of hill-streams more or less circular depressions called potholes form because of stream erosion aided by the abrasion of rock fragments.
- Once a small and shallow depression forms, pebbles and boulders get collected in those depressions and get rotated by flowing water and consequently the depressions grow in dimensions.
- A series of such depressions eventually join and the stream valley gets deepened. At the foot of waterfalls also, large potholes, quite deep and wide, form because of the sheer impact of water and rotation of boulders.
- Such large and deep holes at the base of waterfalls are called plunge pools. These pools also help in the deepening of valleys.
- Waterfalls are also transitory like any other landform and will recede gradually and bring the floor of the valley above waterfalls to the level below.

Incised or Entrenched Meanders

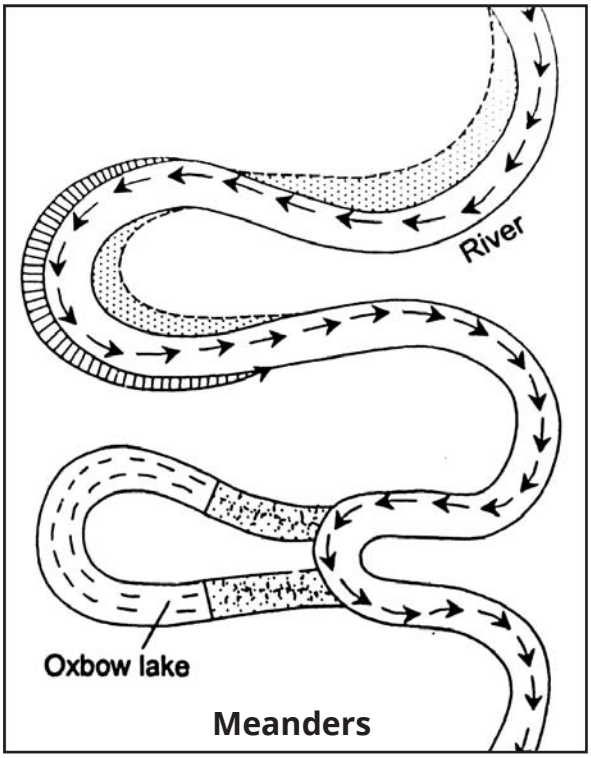
- In streams that flow rapidly over steep gradients, normally erosion is concentrated on the bottom of the stream channel.
- Also, in the case of steep gradient streams, lateral erosion on the sides of the valleys is not much when compared to the streams fl owing on low and gentle slopes.
- Because of active lateral erosion, streams fl owing over gentle slopes develop sinuous or meandering courses.
- It is common to find meandering courses over floodplains and delta plains where stream gradients are very gentle.
- But very deep and wide meanders can also be found cut in hard rocks. Such meanders are called incised or entrenched meanders.
- Meander loops develop over original gentle surfaces in the initial stages of development of streams and the same loops get entrenched into the rocks normally due to erosion or slow, continued uplift of the land over which they start.
- They widen and deepen over time and can be found as deep gorges and canyons in hard rock areas.
- They give an indication on the status of original land surfaces over which streams have developed.

River Terraces

- River terraces are surfaces marking old valley floor or floodplain levels.
- They may be bedrock surfaces without any alluvial cover or alluvial terraces consisting of stream deposits. River terraces are basically products of erosion as they result due to vertical erosion by the stream into its own depositional floodplain.
- There can be a number of such terraces at different heights indicating former river bed levels.
- The river terraces may occur at the same elevation on either side of the rivers in which case they are called paired terraces.

Depositional Landforms

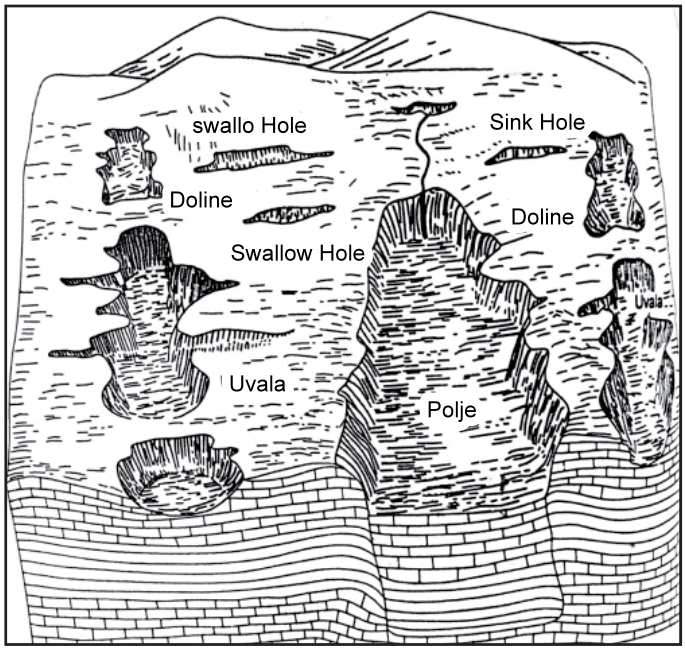
- **Alluvial fans**
  - Alluvial fans are formed when streams flowing from higher levels break into foot slope plains of low gradient.
  - Normally very coarse load is carried by streams flowing over mountain slopes.
  - This load becomes too heavy for the streams to be carried over gentler gradients and gets dumped and spread as a broad low to highcone shaped deposit called alluvial fan.
  - Usually, the streams which flow over fans are not confined to their original channels for long and shift their position across the fan forming many channels called distributaries.
  - Alluvial fans in humid areas show normally low cones with gentle slope from head to toe and they appear as high cones with steep slope in arid and semi-arid climates.
- **Deltas**
  - Deltas are like alluvial fans but develop at a different location.
  - The load carried by the rivers is dumped and spread into the sea. If this load is not carried away far into the sea or distributed along the coast, it spreads and accumulates as a low cone.
  - Unlike in alluvial fans, the deposits making up deltas are very well sorted with clear stratification.
  - The coarsest materials settle out first and the finer fractions like silts and clays are carried out into the sea.
  - As the delta grows, the river distributaries continue to increase in length and delta continues to build up into the sea
- **Floodplains**
  - Deposition develops a floodplain just as erosion makes valleys.
  - **Floodplain** is a major landform of river deposition. Large sized materials are deposited first when stream channel breaks into a gentle slope.
  - Thus, normally, fine sized materials like sand, silt and clay are carried by relatively slow moving waters in gentler channels usually found in the plains and deposited over the bed and when the waters spill over the banks during flooding above the bed.
  - A river bed made of river deposits is the active floodplain. The floodplain above the bank is inactive floodplain.
  - Inactive floodplain above the banks basically contain two types of deposits — flood deposits and channel deposits.
  - In plains, channels shift laterally and change their courses occasionally leaving cut-off courses which get filled up gradually.
  - Such areas over flood plains built up by abandoned or cut-off channels contain coarse deposits.
  - The flood deposits of spilled waters carry relatively finer materials like silt and clay.
  - The flood plains in a delta are called **delta plains.**
- **Meanders**
  - In large flood and delta plains, rivers rarely flow in straight courses.
  - Loop-like channel patterns called meanders develop over flood and delta plains.



Meanders

- Meander is not a landform but is only a type of channel pattern.
- This is because of (i) propensity of water flowing over very gentle gradients to work laterally on the banks; (ii) unconsolidated nature of alluvial deposits making up the banks with many irregularities which can be used by water exerting pressure laterally; (iii)coriolis force acting on the fluid water deflecting it like it deflects the wind.
- When the gradient of the channel becomes extremely low, water flows leisurely and starts working laterally.
- Slight irregularities along the banks slowly get transformed into a small curvature in the banks; the curvature deepens due to deposition on the inside of the curve and erosion along the bank on the outside.
- If there is no deposition and no erosion or undercutting, the tendency to meander is reduced. Normally, in meanders of large rivers, there is active deposition along the concave bank and undercutting along the convex bank.
- The concave bank is known as cut-off bank which shows up as a steep scarp and the convex bank presents a long, gentle profile. As meanders grow into deep loops, the same may get cut-off due to erosion at the inflection points and are left as ox-bow lakes.

Landform Made by Groundwater



- The surface water percolates well when the rocks are permeable, thinly bedded and highly jointed and cracked.
- After vertically going down to some depth, the water under the ground flows horizontally through the bedding planes, joints or through the materials themselves.
- It is this downward and horizontal movementof water which causes the rocks to erode.
- Physical or mechanical removal of materials by moving groundwater is insignificant in developing landforms. That is why; the results of the work of groundwater cannot be seen in all types of rocks. But in rocks like limestone's or dolomites rich in calcium carbonate, the surface water as well as groundwater through the chemical process of solution and precipitation deposition develops varieties of landforms.
- Any limestone or dolomitic region showing typical landforms produced by the action of groundwater through the processes of solution and deposition is called Karst topography after the typical topography developed in limestone rocks of Karst region in the Balkans adjacent to Adriatic Sea.
- The karst topography is also characterised by erosional and depositional landforms.

Erosional Landforms

Pools, Sinkholes, Lapies and Limestone Pavements

- Small to medium sized round to sub-rounded shallow depressions called swallow holes form on the surface of limestones through solution.
- Sinkholes are very common in limestone/karst areas. A sinkhole is an opening more or less circular at the top and funnel-shaped towards the bottom with sizes varying in area from a few sq. m to a hectare and with depth from a less than half a meter to thirty meters or more.

- Some of these form solely through solution action (solution sinks) and others might start as solution forms first and if the bottom of a sinkhole forms the roof of a void or cave underground, it might collapse leaving a large hole opening into a cave or a void below (collapse sinks). Quite often, sinkholes are covered up with soil mantle and appear as shallow water pools. Anybody stepping over such pools would go down like it happens in quick sands in deserts.
- The term doline is sometimes used to refer the collapse sinks. Solution sinks are more common than collapse sinks. Quite often the surface run-off simply goes down swallow and sink holes and flow as underground streams and re-emerge at a distance downstream through a cave opening.
- When sink holes and dolines join together because of slumping of materials along their margins or due to roof collapse of caves, long, narrow to wide trenches called valley sinks or Uvalas form.
- Gradually, most of the surface of the limestone is eaten away by these pits and trenches, leaving it extremely irregular with a maze of points, grooves and ridges or lapies. Especially, these ridges or lapies form due to differential solution activity along parallel to subparallel joints. The lapie field may eventually turn into somewhat smooth limestone pavements.

Caves

- In areas where there are alternating beds of rocks (shales, sandstones, quartzites) with limestones or dolomites in between or in areas where limestones are dense, massive and occurring as thick beds, cave formation is prominent. Water percolates down either through the materials or through cracks and joints and moves horizontally along bedding planes. It is along these bedding planes that the limestone dissolves and long and narrow to wide gaps called caves result. There can be a maze of caves at different elevations depending upon the limestone beds and intervening rocks. Caves normally have an opening through which cave streams are discharged. Caves having openings at both the ends are called tunnels.

Depositional Landforms

- Many depositional forms develop within the limestone caves. The chief chemical in limestone is calcium carbonate which is easily soluble in carbonated water (carbon dioxide absorbed rainwater). This calcium carbonate is deposited when the water carrying it in solution evaporates or loses its carbon dioxide as it trickles over rough rock surfaces.

Stalactites, Stalagmites and Pillars

- Stalactites hang as icicles of different diameters. Normally they are broad at their bases and taper towards the free ends showing up in a variety of forms.
- Stalagmites rise up from the floor of the caves. In fact, stalagmites form due to dripping water from the surface or through the thin pipe, of the stalactite, immediately below it.
- Stalagmites may take the shape of a column, a disc, with either a smooth, rounded bulging end or a miniature crater like depression.
- The stalagmite and stalactites eventually fuse to give rise to columns and pillars of different diameters.

Landform Made by Wind

- Wind is a geomorphic agent in all terrestrial environments. It is a potent agent only in dry areas with fi ne-grained soils and sediments and little or no vegetation. It is limited by a protective cover of vegetation and moist soil, which helps to bind soil particles together. Winds may erode, transport, and deposit materials, and are effective agents in regions with sparse vegetation and a large supply of unconsolidated sediments. Although water is a much more powerful eroding force than wind, Aeolian processes are important in arid environments such as deserts.
- Wind can erode desert rocks in two ways:
- Deflation: the removal of fi ne, loose particles from the surface of rocks.
- Abrasion: small particles being carried by the wind scrape off particles from the rock surface. It then transports the eroded material by three processes:

- Suspension: very small particles (<0.15mm) are picked up and carried by the wind.
- Saltation: small particles (0.15-0.25mm) are temporarily lifted from the ground and bounce along the surface.
- Surface Creep: larger particles (>0.25mm) are hit and pushed along the ground by particles being moved by saltation.

Erosional Landforms

Yardangs:

Yardangs are narrow, streamlined ridges that are usually three to four times longer than they are wide. They are made up of long ridges of hard resistant rocks alternating with narrow furrows of soft rocks. Here, both the bands of hard and soft rocks aligned vertically to the direction of the blowing prevailing winds. The process of abrasion is accelerated in the course of the blowing prevailing winds, assisting in wearing the soft bands of rocks into narrow corridors between the hard layers. Eventually, the bands of hard rocks remain standing high above the soft bands that have been worn into narrow corridors.

Zeugen:

A zeugenis a tabular mass of resistant rock, standing prominently in the desert. It is usually composed of alternating layers of hard and soft rocks. These alternating bands of rock usually lie horizontal on top of one and another. The softer rock layer usually lies beneath a surface layer of more resistant rock. The sculpturing effects of wind abrasion wear them into a furrow and ridge looking landscape. Insolation weathering enhances this activity.

Playas:

Playas are by far the most prominent landforms in the deserts. In basins with mountains and hills around and along, the drainage is towards the centre of the basin and due to gradual deposition of sediment from basin margins, a nearly level plain forms at the centre of the basin. In times of sufficient water, this plain is covered up by a shallow water body. Such types of shallow lakes are called as playas where water is retained only for short duration due to evaporation and quite often the playas contain good deposition of salts. The playa plain covered up by salts is called alkali flats.

Deflation Hollows and Caves:

Weathered mantle from over the rocks or bare soil, gets blown out by persistent movement of wind currents in one direction. This process may create shallow depressions called **deflation hollows.** Deflation also creates numerous small pits or cavities over rock surfaces. The rock faces suffer impact and abrasion of wind-borne sand and first shallow depressions called blow outs are created, and some of the blow outs become deeper and wider fi t to be called caves.

Mushroom, Table and Pedestal Rocks: Many rock-outcrops in the deserts easily susceptible to wind deflation and abrasion are worn out quickly leaving some remnants of resistant rocks polished beautifully in the shape of mushroom with a slender stalk and a broad and rounded pear shaped cap above. Sometimes, the top surface is broad like a table top and quite often, the remnants stand out like pedestals.

Depositional Landforms

Wind is a good sorting agent. Depending upon the velocity of wind, different sizes of grains are moved along the floors by rolling or Saltation and carried in suspension and in this process of transportation itself, the materials get sorted. When the wind slows or begins to die down, depending upon sizes of grains and their critical velocities, the grains will begin to settle. So, in depositional landforms made by wind, good sorting of grains can be found. Sand accumulations come in a range of sizes and forms. Deposition may occur as sheets of sand (dune fields and sand seas) or loess or as characteristic dunes.

Ripples: Wind ripples are the smallest Aeolian bed form. They are regular, wave like undulations lying at right-angles to the prevailing wind direction.

Loess: Loess is terrestrial sediment composed largely of windblown silt particles made of quartz. It covers some 5-10 per cent of the Earth's land surface, much of it forming a blanket over pre-existing topography that may be up to 400 m thick. Loess requires three things:

- a source of silt;
- wind to transport the silt; and
- a suitable site for deposition and accumulation

Dunes: Dunes are collections of loose sand built piece meal by the wind. They usually range from a few metres across and a few centimetres high to 2 km across and 400m high. Sand dunes form where there is a source of sand. Dune sand is usually composed of quartz, which is extremely hard and doesn't easily decay. Dune sand grains are beautifully rounded by abrasion.

Crescent shaped dunes called barchanswith the points or wings directed away from wind direction i.e., downwind, form where the wind direction is constant and moderate and where the original surface over which sand is moving is almost uniform. Parabolic dunes form when sandy surfaces are partially covered with vegetation. That means parabolic dunes are reversed barchans with wind direction being the same.

Seifalso called linear dunesis similar to barchans with a small difference. Seif has only one wing or point. This happens when there is shift in wind conditions. The lone wings of seifs can grow very long and high. Longitudinal dunes form when supply of sand is poor and wind direction is constant. They appear as long ridges of considerable length but low in height.

Transverse dunesare aligned perpendicular to wind direction. These dunes form when the wind direction is constant and the source of sand is an elongated feature at right angles to the wind direction. They may be very long and low in height. When sand is plenty, quite often, the regular shaped dunes coalesce and lose their individual characteristics. Most of the dunes in the deserts shift and a few of them will get stabilised especially near human

Coastal Landforms

Coastal processes are among the most dynamic geologic processes; change in the morphology of many coasts can be observed on annual (or shorter) time scales. The ever-pounding waves generated by winds at sea release tremendous quantities of energy along continental margins, constantly shaping coasts. Other than the action of waves, the coastal landforms depend upon (i) the configuration of land and sea floor; (ii) whether the coast is advancing (emerging) seaward or retreating (submerging) landward.

Coastlines of Emergence

- These are formed either by an uplift of the land or by the lowering of the sea level.
- Bars, spits, lagoons, salt marshes, beaches, sea cliff s and arches are the typical features.
- The east coast of India, especially its south-eastern part (Tamil Nadu coast), appears to be a coast of emergence.
- The west coast of India, on the other hand, is both emergent and submergent.
- The northern portion of the coast is submerged as a result of faulting and the southern portion, that is the Kerala coast, is an example of an emergent coast.

Coastlines of Submergence

- A submerged coast is produced either by subsidence of land or by a rise in sea level.
- Ria, fjord, Dalmatian and drowned lowlands are its typical features.
- **Erosional Coastal Landforms**
- **Cliff s, Terraces, Caves and Stacks**
  - A sea cliff is a vertical precipice created by waves crashing directly on a steeply inclined slope. Hydraulic action, abrasion, and chemical solution all work to cut a notch at the high water level near the base of the cliff. Constant undercutting and erosion causes the cliff s to retreat landward.

- Sea caves form along lines of weakness in cohesive but well-jointed bedrock. Sea caves are prominent headlands where wave refraction attacks the shore.
- A sea arch forms when sea caves merge from opposite sides of a headland. If the arch collapses, a pillar of rock remains behind as a sea stack.
- Seaward of the retreating cliff s, wave erosion forms a broad erosional platform called a wave-cut bench or wave-cut platform. After the constant grinding and battering, eroded material is transported to adjacent bays to become beaches or seaward coming to rest as a wave-built terrace. If tectonic forces raise the bench above the water level a marine terrace forms. Some shorelines have several marine terraces creating during various episodes of uplift.

Depositional Coastal Landforms

Beaches

- **A beach** is a deposit of loose sediment adjacent to a body of water. Though sand is common to most beaches, a remarkable diversity of sediment size, from boulders to fine silt is found on beaches around the world. Larger particles and steeper slopes are found where wave action is high. Fine particles and gentle slopes are characteristic of beaches exposed to low wave action.
- Most mid latitude beaches undergo a cycle of erosion and deposition following the seasonal changes in wave action. During the winter, mid latitude storms are more vigorous producing more wave action and erosion. Hence, beaches tend to narrow during the winter. Wave action subsides during the summer as storms weaken somewhat favoring deposition over erosion and producing broader beaches.

Spits and Bars

- **Sand spit**is one of the most common coastal landforms. A sand spit is a linear accumulation of sediment that is attached to land at one end. Sand carried parallel to shore by long shore drift may eventually extend across a bay or between headlands especially where water is relatively calm. Spits are typically elongate, narrow features built to several dozen feet by wind and waves.
- Spits often form when wave energy decreases as a result of wave refraction in a bay. When a coastline turns abruptly, wave energy is dissipated by divergence of wave trajectories, causing sediment to accumulate as the water loses its ability to transport.
- Spits can extend across the mouth of a bay, but wave action is usually strong enough to wash sand out to sea or be deposited in the embayment. They may curve into the bay or stretch across connecting to the other side as a bay mouth bar. When the bay is closed off by a bar it becomes a **lagoon**. Wave energy also dissipates in the lee of **large sea stacks or islets**. Wave refraction sweeps sediment behind the obstruction from two directions, depositing it as a slender finger called a **tombolo.**

Landform Made by Glaciers

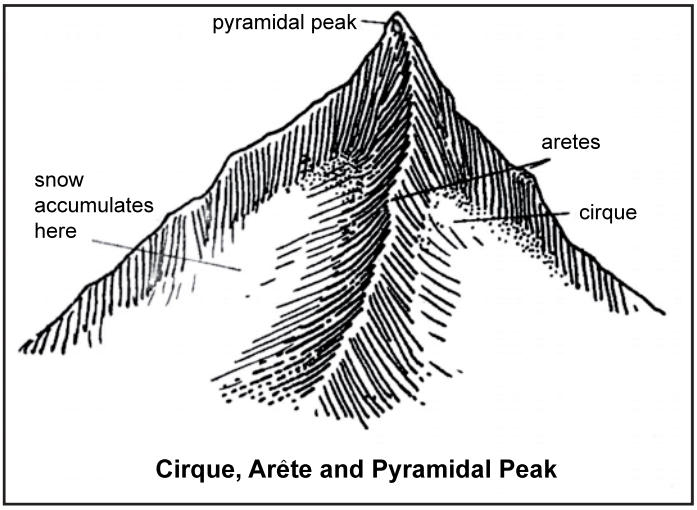
Masses of ice moving as sheets over the land (continental glacier or piedmont glacier if a vast sheet of ice is spread over the plains at the foot of mountains) or as linear flows down the slopes of mountains in broad trough-like valleys (mountain and valley glaciers) are called glaciers. Glaciers have played an important role in the shaping of landscapes in the middle and high latitudes and in alpine environments. Their ability to erode soil and rock, transport sediment, and deposit sediment is extraordinary. During the last glacial period more than 50 million square kilometers of land surface were geomorphically influenced by the presence of glaciers.

Erosional Landforms

- **Cirques** are bowl shaped features at the head of a glacial valley. They have steep headwalls and a low threshold of rock or moraine. A tarn (lake) may fi ll a cirque after the glacier is gone. Cirques may begin in nivation basins where freeze thaw beneath a snow bank breaks up rock which is then removed by creep, solifluction, and rill wash, thereby hollowing out a depression. Bergschrund are large, very deep glacial crevasses near the headwall of a cirque- between the ice and headwall.

Cirques are more common on north and east facing slopes in northern hemisphere because these sides remain cooler with less afternoon sunlight to melt the snow.

- **Horns**are steep faceted mountain peaks, sculpted and surrounded by three or more cirques and their steep headwalls.
- **Arêtes**are high, pinnacled ridges formed by cirques eroding each side of the ridge.
- **Cols** are low areas between higher stretches of a ridge (arête) where opposing cirques have started to cut through the ridge.



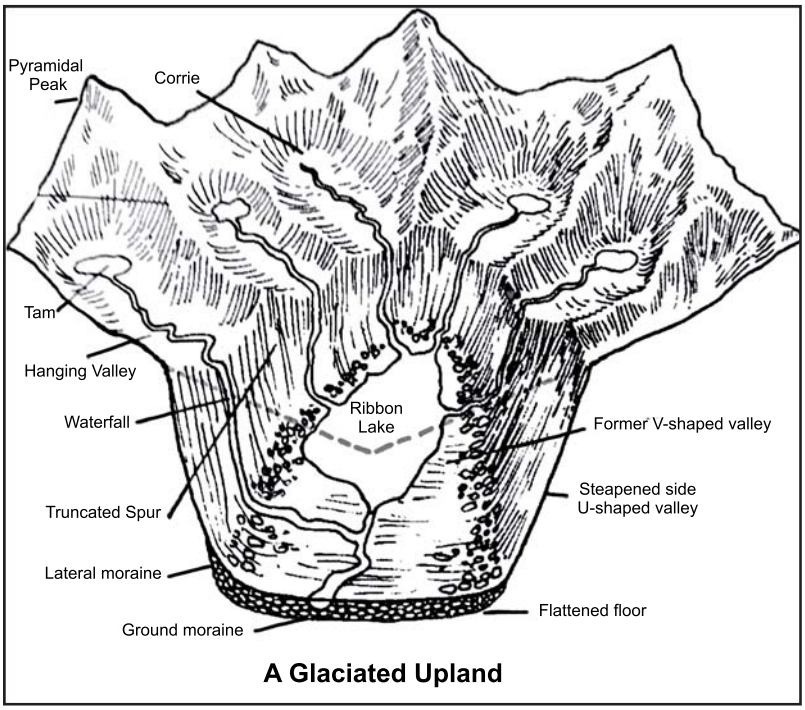
Cirque, Arête and Pyramidal Peak

- **Glacial Valleys** have a characteristic parabolic shape, which vary from the prototypical deep, steep-sided, flatbottomed, U-shape valley, which forms in resistant bedrock, to wide shallow troughs, which form in less resistant bedrock.

Depositional Landforms

The unassortedcoarse and fi ne debris dropped by the melting glaciers is called glacial till. Most of the rock fragments in till are angular to sub angularin form. Streams form by melting ice at the bottom, sides or lower ends of glaciers. Some amount of rock debris small enough to be carried by such melt water streams is washed down and deposited. Such Glaciofluvial deposits are called outwash deposits.

Unlike till deposits, the outwash deposits are roughly stratified and assorted. The rock fragments in outwash deposits are somewhat rounded at their edges. Some of the depositional landforms are discussed below:



A Glaciated Upland

Moraines

- They are long ridges of deposits of glacial till. Terminal moraines are long ridges of debris deposited at the end (toe) of the glaciers.
- Lateral moraines form along the sides parallel to the glacial valleys. The lateral moraines may join a terminal moraine forming a horse-shoe shaped ridge.
- There can be many lateral moraines on either side in a glacial valley.
- These moraines partly or fully owe their origin to glaciofluvial waters pushing up materials to the sides of glaciers.
- Many valley glaciers retreating rapidly leave an irregular sheet of till over their valley floors. Such deposits varying greatly in thickness and in surface topography are called ground moraines.

- The moraine in the centre of the glacial valley flanked by lateral moraines is called medial moraine. They are imperfectly formed as compared to lateral moraines. Sometimes medial moraines are indistinguishable from ground moraines.

Drumlins

- These are elongate hills of lodgement till that are typically wider and higher in the direction from which the glaciers fl owed. The elongation direction is parallel to the glacial flow direction.

Eskers

- When glaciers melt in summer, the water flows on the surface of the ice or seeps down along the margins or even moves through holes in the ice.
- These waters accumulate beneath the glacier and flow like streams in a channel beneath the ice. Such streams flow over the ground (not in a valley cut in the ground) with ice forming its banks.
- Very coarse materials like boulders and blocks along with some minor fractions of rock debris carried into this stream settle in the valley of ice beneath the glacier and after the ice melts can be found as a sinuous ridge called esker.

Outwash Plains

- The plains at the foot of the glacial mountains or beyond the limits of continental ice sheets are covered with glacio-fluvial deposits in the form of broad flat alluvial fans which may join to form outwash plains of gravel, silt, sand and clay.

Kettle

- When glaciers are rapidly retreating, numerous blocks of ice can become detached from the main body of the glacier. If glacial drift is then placed around the ice, a depression on the surface called a kettle hole can be created when the ice melts.
- Kettle holes are commonly found on moraine and outwash plain deposits. Large kettle holes that reach below the water table can form into lakes.

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DAY - 20

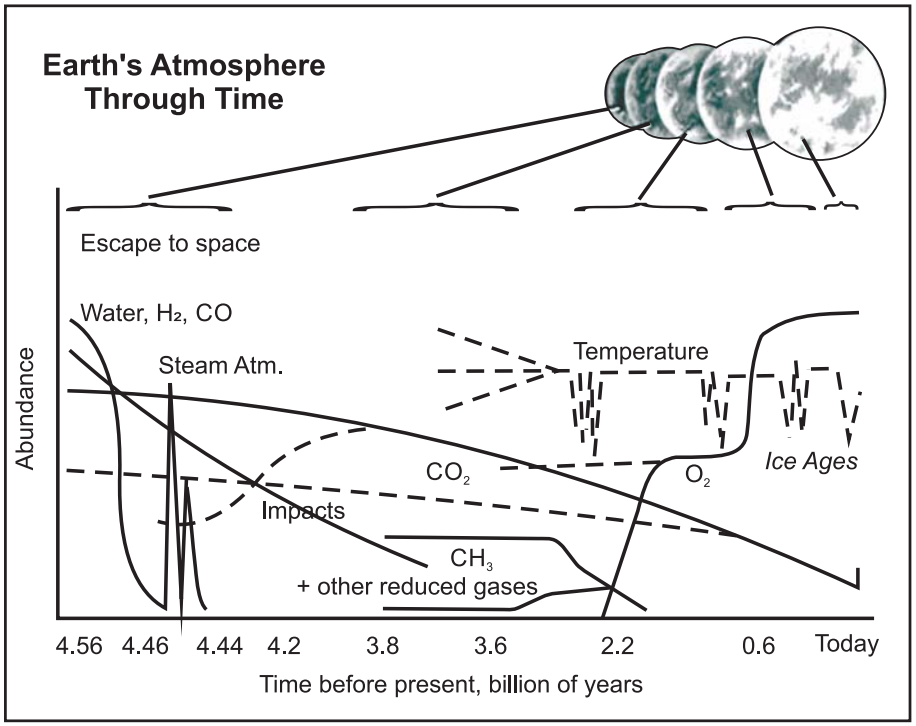
CLIMATOLOGY

Earth's Atmosphere

- Earth's atmosphere is a critical system for life on our planet. Atmosphere is a gaseous envelope extending thousands of kilometers above the earth's surface. Much of the life on the earth exists at the bottom of the atmosphere where it meets the lithosphere and the hydrosphere.
- The atmosphere is held to the earth by its gravitational force and is energized by the sun. But Earth's climate is not static.
- Many atmospheric processes take place in a state of dynamic balance —for example; there is an average balance between the heat input to, and output from, the atmosphere.

Evolution of Earth's Atmosphere

- In the first 500 million years, a dense atmosphere emerged from the vapor and gases that were expelled during degassing of the planet's interior. These gases may have consisted of Hydrogen (H_2), water vapor, Methane (CH_4), and Carbon Oxides.
- The hydrosphere was formed 4 billion years ago from the condensation of water vapor, resulting in oceans of water in which sedimentation occurred.



- The most important feature of the ancient environment was the absence of free oxygen. One billion years ago, early aquatic organisms called blue-green algae began using energy from the Sun to split

molecules of H_2O and CO_2 and recombine them into organic compounds and molecular oxygen (O_2). This solar energy conversion process is known as photosynthesis.

- Some of the photosynthetically created oxygen combined with organic carbon to recreate CO_2molecules. The remaining oxygen accumulated in the atmosphere, touching off a massive ecological disaster with respect to early existing anaerobic organisms. As oxygen in the atmosphere increased, CO_2 decreased.

Composition of the Atmosphere

- The atmosphere is a mixture of many gases, water vapour and dust particles. It also contains huge amount of solid and liquid particles collectively known as "aerosols". Pure dry air consists mainly of Nitrogen, Oxygen, Argon, and Carbon dioxide, Hydrogen, Helium and Ozone. Besides, water vapour, dust particles, smoke, salts are also present in air in varying quantities. The composition of atmosphere upto an altitude of about 90 km is uniform in terms of three major gases - Nitrogen, Oxygen and Argon. This layer is generally, called homosphere. Above 90 km, the composition begins to change with progressive increase in the lighter gases. This layer is known as heterosphere.

Gases

- Nitrogen and Oxygen comprise 99% of the total volume of the atmosphere. But they are climatically of little consequences. Nitrogen doesn't easily enter into chemical union with other substances but gets fixed into the soil. It serves mainly as diluents and regulates combustion.
- It is available to the organisms through plants. Plants convert the nitrogen into various usable forms through the process of nitrogen fixation. Various industries like fertilizer industries, explosive industries, etc. use the nitrogen available in atmosphere as raw material. So, it is of great biological and economical importance.
- Oxygen combines with all the elements and is most combustible.
- Carbon dioxide constitutes a small percentage of the atmosphere. It is transparent to the incoming shortwave but is capable of trapping long wave solar radiation. It can absorb heat and allow the lower atmosphere to be warmed up by heat radiation coming from the sun and from the earth's surface. It is largely responsible for the greenhouse effect.
- However increase in its concentration culminates to rise in temperature thus global warming.
- It is equally important in supporting the life as well as deterring it. CO2 is found in the atmosphere as free gas as well as in the dissolved from.
- Water Vapour
- Water vapor is a variable factor which ranges from 0 to 4% depending on various factors of the region like, atmospheric circulation of wind, temperature, supply of moisture, vegetation, concentration of population, and human activities, etc. Water vapour controls to a great extent the climatic condition of the area. Temperature is the primary factor which controls the presence of water vapour. So, it goes on decreasing towards the pole from equator. It's concentration is in the lower strata of the atmosphere upto the height of 5 km. The moisture content of the atmosphere creates several forms of condensation and precipitation e.g. clouds, fogs, dew, rainfall, frost, hailstorm, ice, snowfall, etc.

Particulate Matter

- The particulate matters present in the atmosphere includes dust particles, salt particles, pollen, smoke and soot, volcanic ashes, etc. They are kept in suspension in the atmosphere. When the smoke is mixed with the fog it forms smog. It persists in the atmosphere for longer time than the fog and reduces the visibility of the region to a great extent, sometimes even to few metres bringing the traffics to a standstill and is responsible for fatal accidents. They are the main cause of haze formation.

Structure of the Atmosphere

- About 50% of the atmosphere is confined to 5.6 km and 97% upto 29km. The upper limit of atmosphere is considered to be 10,000 km from sea level. On the basis of characteristic of temperature and pressure there are layers of atmosphere.

Troposphere

- It is lower most layer of the atmosphere. Temperature decreases with the increase in height at the rate of 6.5°C per 1000 m in this layer, called as normal lapse rate.
- The upper limit of the troposphere decreases from equator towards the pole.
- The average height of the troposphere is about 16 km over the equator and 6 km over the Poles. The upper limit is called as "tropopause", which is about 1.5 km thick.
- Troposphere is the most important layer of the atmosphere as all the weather phenomena like fog, cloud, dew, frost, rainfall, hailstorm, cloud thunder, etc occurs in this layer. It is apparent from this that the troposphere is the life supporting layer of the atmosphere which circulates various cycles like, hydrological cycle, oxygen cycle, carbon cycle, etc.

Stratosphere

- This layer is just above the troposphere; on an average stratosphere is 50 km high. The temperature in this layer gradually rises upward and is about 0°C at the stratopause, the upper limit of stratosphere. In the lower part of stratosphere there is ozone layer between the heights of 15 to 30 km. This part is called as ozonosphere. Ozone (O3) is a 3 atom isotope of oxygen. It is very important for the life forms on the earth as it absorbs high energy ultra violet radiations from the sun. If the U-V rays reach the earth's surface it will increase the temperature of the earth unexpectedly because of the high energy it has. It then causes the skin cancers in the fair complex human being and various other dermatological diseases in the living organisms. It is because of the absorption of this high energy radiation that the stratosphere is hotter than the layer above and below it.

Mesosphere

- This layer extends between 50 km and 80 km. Temperature again starts decreasing with increase in height in this layer. This is because this layer is being heated from below. The ozonosphere present in the stratosphere provides the heat. The upper most limit of mesosphere is 80 km where the temperature becomes - 80°C, and is called as mesopause. This is the height from where the air in the atmosphere starts inducing some frictional resistance on any moving object. When the meteors, which are also known as shooting stars enters the mesosphere, they get heated due tothe frictional resistance experienced by them due to air.

Thermosphere

- In this layer the temperature increases rapidly with increase in height. It is divided in two different layers. Ionosphere extends from 80 km to 640 km. Here the elements are found in the form of free ions that is why it is called as ionosphere. Now days, it has become an important source of income for government, which taxes and auctions it for exploitation. It has revolutionized the modes of communication because it is less costly and more efficient than the fixed lines.

Exosphere

- It represents the upper most layer of the atmosphere. It extends beyond 640 km and gradually merges with the outer space. We know very little about it.

Solar Radiation Temperature & Heat Balance

Weather & Climate

Temperature, pressure, wind, humidity and precipitation, interact with each other. They influence the atmospheric conditions like the direction and velocity of wind, amount of insolation, cloud-cover and the amount of precipitation. These are known as the elements of both weather and climate.

- Weather is the atmospheric condition of a place for a short duration with respect to its one or more elements.
- Whereas the average weather conditions, prevalent from one season to another in the course of a year, over a large area is known as climate.

Factors Affecting Climate

- **Latitude or Distance from the Equator:** The places near the equator are warmer than the places which are far away from it. This is because the rays of the sun fall vertical on the equator and slanting in the temperate and polar regions. Therefore, lower the latitude higher is the temperature and vice versa.
- **Altitude or the Height from the mean sea level:** The temperature decreases with increase in height as atmosphere is heated from below.
- **Continentality or the Distance from the Sea:** The water is a bad conductor of heat i.e. It takes longer time to heat and longer time to cool. Due to this moderating effect of the sea, places near the coast have low range of temperature and high humidity. The places in the interior of the continent do not experience moderating effect of the sea. These places have extreme temperatures. Mumbai has relatively lower temperature and higher rainfall than Nagpur, although both are almost situated on the same latitude.
- **Nature of the Prevailing Winds:** The on-shore winds bring the moisture from the sea and cause rainfall on the area through which they pass. The off -shore winds coming from the land are dry and help in evaporation. In India, the on-shore summer monsoon winds bring rains while off -shore winter monsoon winds are generally dry.
- **Cloud Cover:** In areas generally of cloudless sky as in deserts, temperature even under shade is very high because of the hot day time sunshine. At night this heat radiates back from the ground very rapidly. It results in a large diurnal range in temperature. On the other hand under cloudy sky and heavy rainfall at Thiruvananthapuram the range of temperature is very small.
- **Ocean Currents:** Ocean waters move from one place to another partly as an attempt to equalize temperature and density of water. The warm ocean currents raise the temperature of the coast and sometimes bring rainfall, while the cold currents lower the temperature and create fog near the coast. Port Bergen in Norway is free from ice even in winter due to warm North Atlantic Drift while Port Quebec in Canada remains frozen during winter months due to chilling effect of the Cold Labrador Current in spite of the fact that Port Quebec is situated in much lower latitude than Port Bergen.
- **Direction of Mountain Chains:** The mountain chains act as natural barrier for the wind. The on-shore moisture laden winds are forced to rise after striking against the mountain; and give heavy rainfall on the windward side. These winds descending on the leeward side cause very low rainfall. The great Himalayas check the moisture laden monsoon winds from crossing over to Tibet. This mountain chain also checks biting polar cold winds from entering into India. This is the reason for which northern plains of India get rains while Tibet remains a perpetual rain shadow area with lesser amount of rainfall.
- **Slope:** The concentration of heat being more on the gentler slope raises the temperature of air above them. Its lesser concentration along steeper slopes lowers the temperature. At the same time, mountain slopes facing the sun are warmer than the slopes which are away from the sun's rays. The southern slopes of Himalaya are warmer than the northern slopes.
- **The Nature of the Soil and Vegetation Cover:** The nature of soil depends upon its texture, structure and composition. These, qualities vary from soil to soil.

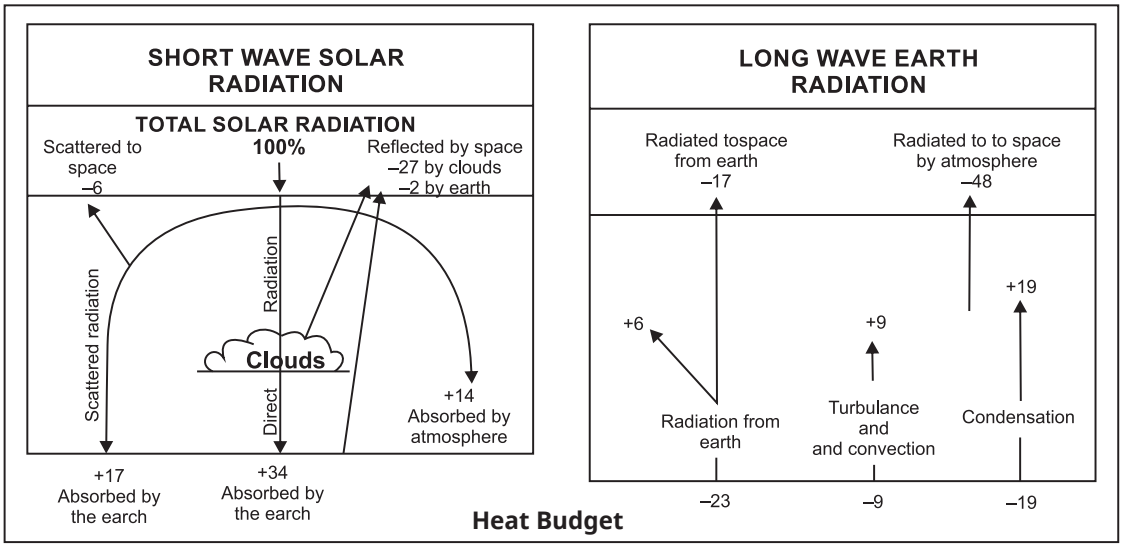
Solar Radiation

- The earth's surface receives most of its energy in short wavelengths. The energy received by the earth is known as incoming solar radiation which in short is termed as insolation.
- As the earth is a geoid resembling a sphere, the sun's rays fall obliquely at the top of the atmosphere and the earth intercepts a very small portion of the sun's energy.
- On an average the earth receives 1.94 calories per sq. cm per minute at the top of its atmosphere.
- The solar output received at the top of the atmosphere varies slightly in a year due to the variations in the distance between the earth and the 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 aphelion. On 3rd January, the earth is the nearest to the sun (147 million km). This position is called perihelion. 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.

Heat Budget

- The Earth's climate is a solar powered system. The earth as a whole does not accumulate or loose heat. It maintains its temperature. This can happen only if the amount of heat received in the form of insolation equals the amount lost by the earth through terrestrial radiation.
- Although the earth and its atmosphere as a whole have a radiation balance, there are latitudinal variations. The heat/energy is transferred from the lower latitudes to the higher latitudes through winds and ocean currents. In the low latitudes (between 40°N and 40°S) heat gained by short wave radiation is far more than the heat loss by long waves through the earth's radiation.
- In contrast in the higher latitudes more heat is lost by outgoing long wave than it is received in short waves. In view of the imbalances at high and low latitudes, there is large- scale transfer of heat from tropics to high latitudes by atmospheric and oceanic circulation.
- The absorption of outgoing thermal infrared by carbon dioxide means that Earth still absorbs about 70 per cent of the incoming solar energy, but an equivalent amount of heat is no longer leaving. The exact amount of the energy imbalance is very hard to measure, but it appears to be a little over 0.8 watts per square meter.



Heat Budget

Inversion of Temperature

Normally, temperature decreases with increase in elevation. It is called normal lapse rate. At times, the situation is reversed and the normal lapse rate is inverted. It is called Inversion of temperature. Inversion is usually of short duration but quite common nonetheless.

Types of Temperature Inversion

Ground Surface Inversion

- Ground surface inversion also called as radiation inversion occurs near the earth's surface due to radiation mechanisms. This is also called as non advection inversion because it occurs in states atmospheric condition characterized by no movement of air whether horizontal or vertical. The ground surface inversion occurs under the following conditions:
  - Long winter nights so that the loss of heat by terrestrial radiation from the ground surface during night may exceed the amount of insolation received.
  - Cloudless and clear sky so that the loss of heat through terrestrial radiation proceeds more rapidly without any obstruction. Clouds absorb terrestrial radiation and hence loss of heat from the earth's surface.

- Presence of dry air near the ground surface, so that it may not absorb much heart radiated from the earth's surface as moist air is capable of absorbing much of the radiant heat from the earth's surface.
- Slow movement of air, so that there is no transfer and mixing of heat in the lower layers of the atmosphere. Snow covered ground surface, so that there is maximum reflection of incoming solar radiation.
- Snow, being bad conductor of heat regards the flow of heat from the ground surface lying below the snow layers to the lower atmosphere.

- This inversion promotes stability in the lower portion of the atmosphere and causes dense fogs.

Upper Air Inversion

- Upper air inversion is of two type's viz. (i) thermal upper air inversion and (ii) mechanical upper air inversion.
- The thermal upper air inversion is caused by the presence of ozone layer lying between the heights of 15 to 35 km (even up to 80 km) in the stratosphere.
- The mechanical inversion of temperature is caused at higher heights in the atmosphere due to subsidence of air and turbulence and convertible mechanisms. Mechanical inversion caused by the subsidence of air currents is generally associated with the anticyclones conditions. This type of inversion of temperature is very common in the middle latitude where high pressures are characterized by sinking air.
- The pole wards regions of the winds are also characterized by high pressure caused by the subsidence of air resulting into mechanical inversion of temperature.
- The temperature inversion causes stability in the atmosphere. This is the reason that the polewardparts of trade winds are characterized by arid conditions.

Advection Inversion of Temperature

- Advection Inversion of Temperature is associated with the dynamism of the atmosphere. Strong wind movement and unstable conditions of the atmosphere are prerequisite conditions for advection inversion of temperature.

Frontal or Cyclonic Inversion

- Frontal or Cyclonic inversion is caused in the temperate zones due to temperate cyclones which are formed due to the convergence of warm western lies and cold polar winds in the northern hemisphere. The existence of warm air above and cold air below reverse the normal lapse rate and inversion of temperature occurs.

Surface Inversion

- Surface inversion of temperature is caused horizontal movement of air. It is caused when warm air invades the area of cold air or cold air moves into the area of warm. Cold air being denser settles down in both the case resulting into temperature inversion. The convergence of cold and warm ocean currents also causes surface inversion of temperature.

Valley Inversion

- Valley inversion generally occurs in the mountainous valleys due to radiation and vertical movement of air.
- The temperature of the upper parts of the valleys in mountainous areas becomes exceedingly low during winter nights because of rapid rate of loss of heat from the surface through terrestrial radiation. Consequently, the air coming in contact, which the cool surface also becomes cool .
- On the other hand, the temperature of the valley floor does not fall considerably because of comparatively low rate of loss of heat through terrestrial radiation. Thus, there is warm air aloft and cold air in the valley floor and inversion of temperature is caused.

- This situation is responsible for severe frost in the valley floors causing great damage to fruit orchards and vegetables and agricultural crops whereas the upper parts of the valleys are free from front. This is why the valley floors are avoided for human settlements while the upper parts inhabited in the mountainous valleys of middle latitudes.

Significance of Inversion of Temperature

Some of the most significant consequences of temperature inversions are the extreme weather conditions they can sometimes create. One example of these is freezing rain. This phenomenon develops with a temperature inversion in a cold area because snow melts as it moves through the warm inversion layer.

- Intense thunderstorms and tornadoes are also associated with inversions because of the intense energy that is released after an inversion blocks an area's normal convection patterns.
- Although freezing rain, thunderstorms, and tornadoes are significant weather events, one of the most important things impacted by an inversion layer is smog. Smog is impacted by the inversion layer because it is in essence, capped, when the warm air mass moves over an area.
- Inversion of temperature causes frost when the condensation of warm air due to its cooling by cold air below occurs at temperature below freezing point. Frost is definitely economically unfavorable weather phenomenon mainly for crops because fruit orchards and several agricultural crops such as potatoes, tomatoes peas etc. are totally damaged overnight.
- Inversion of temperature causes atmosphere stability which stops upward (ascent) and downward (descent) movements of air. The atmosphere stability discourages rainfall and favors dry condition.
- The inversion of temperature caused by the subsidence of air resulting into anticyclones conditions increases aridity . This is why the western parts of the continents situated between 200-300 latitudes and characterized by anticyclones condition represent most widespread tropical deserts of the world.

■ Atmospheric Humidity & Rainfall

Condensation

- Condensation is the process by which atmospheric water vapour changes into water or ice crystals. It is just reverse of the process of evaporation. When the temperature of saturated air falls below dew point, the air cannot hold the amount of humidity which it was holding earlier at a higher temperature. This extra amount of humidity changes into water droplets or crystals of ice depending upon the temperature at which condensation takes place.
- The temperature of the air falls in two ways. Firstly, cooling occurs around very small particles of freely floating air when it comes in contact with some colder object. Secondly, loss in air temperature takes place on a massive scale due to rising of air to higher altitudes.
- The condensation takes place around the smoke, salt and dust particles which attract water vapourto condense around them. They are called hygroscopic nuclei. When the relative humidity of an air is high, a slight cooling is required to bring the temperature down below dew point.
- But when the relative humidity is low and the temperature of the air is high, a lot of cooling of the air will be necessary to bring the temperature down below dew point. Thus, condensation is directly related to the relative humidity and the rate of cooling.
- Condensation takes place in two situations, firstly, when dew point is below freezing point or below 0°C and secondly, when it is above freezing point. In this way, the forms of condensation may be classified into two groups:
  - Frost, snow and some clouds are formed when dew point is below freezing point.
  - Dew, mist, fog, smog and some clouds are formed when dew point is above freezing point
- The forms of condensation may also be classified on the basis of place where it is occurring, for example, on the ground or natural objects such as grass blades and leaves of the plants or trees, in the air close to the earth's surface or at some height in the troposphere.

- **Dew:**When the atmospheric moisture is condensed and deposited in the form of water droplets on cooler surface of solid objects such as grass blades, leaves of plants and trees and stones, it is termed as dew. Condensation in dew form occurs when there is clear sky, little or no wind, high relative humidity and cold long nights. These conditions lead to greater terrestrial radiation and the solid objects become cold enough to bring the temperature of air downbelow dew point. In this process the extra moisture of the air gets deposited on these objects. Dew is formed when dew point is above freezing point.
- **Frost:**When the dew point is below freezing point, under above mentioned conditions, the condensation of extra moisture takes place in the form of very minute particles of ice crystals. It is called frost. In this process, the air moisture condenses directly in the form of tiny crystal of ice. This form of condensation is disastrous for standing crops such as potato, peas, pulses, grams, etc. It also creates problems for road transport system.
- **Mist and Fog:**When condensation takes place in the air near the earth's surface in the form of tiny droplets of water hanging and floating in the air, it is called mist. In mist the visibility is more than one kilometer and less than two kilometers. But when the visibility is reduced to less than one kilometer, it is called fog. Ideal conditions for the formation of mist and fog are clear sky, calm and cold winter nights.
- **Smog:**Smog is a fog that has been polluted and discoloured by smoke, dust, carbon monoxide, sulphur dioxide and other fumes. Smog frequently occurs in large cities and industrial centres. It causes respiratory illness.
- **Clouds:**Clouds are visible aggregates of water droplets, ice particles, or a mixture of both along with varying amounts of dust particles. A typical cloud contains billions of droplets having diameters on the order 0.01 to 0.02 mm; yet liquid or solid water accounts for less than 10 parts per million of the cloud volume. Clouds are generally classified on the basis of their general form or appearance and altitude.

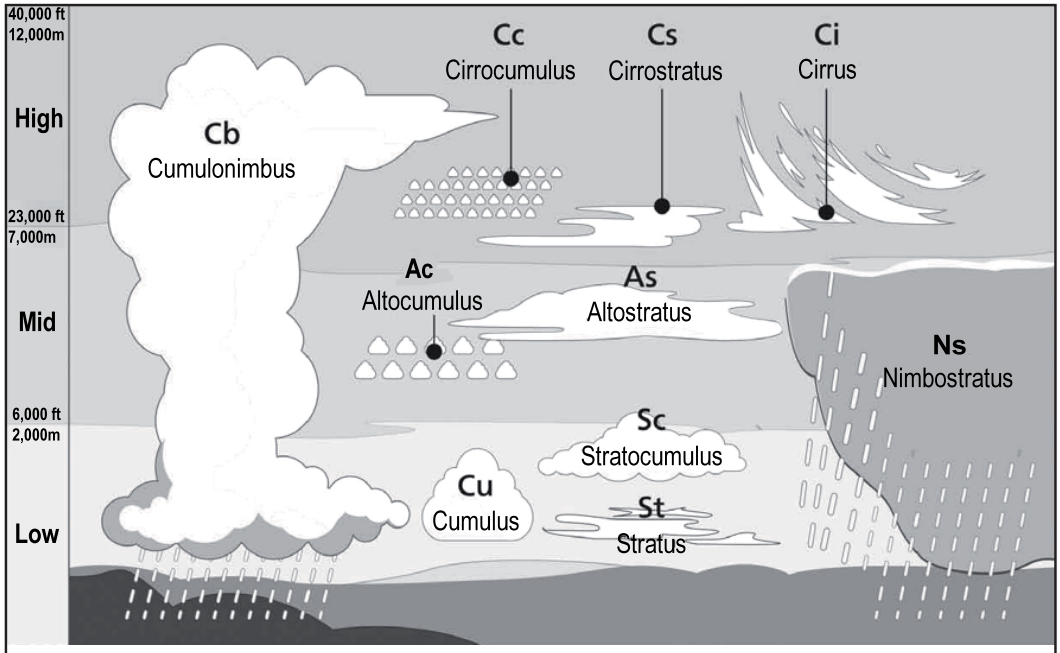
Clouds are very significant because:

- They cause all forms of precipitation.
- They play a major role in the heat budget of the earth.
- They reflect, absorb some part of incoming solar radiation as well as some part of long-wave terrestrial radiation re-radiated by the earth.

Types of Clouds

- **Cirrus clouds:** These clouds form above 20,000 feet (6,000 meters) and since the temperatures are extremely low at such high elevations, these clouds are primarily composed of ice crystals. High-level clouds are typically thin and white in appearance, but can appear in a magnificent array of colors when the sun is low on the horizon.
- **Cirro-cumulus:** These clouds appear as small, rounded white puff s. The small ripples in the cirrocumulus sometimes resemble the scales of a fish. A sky with cirrocumulus clouds is sometimes referred to as a "mackerel sky."
- **Cirro-stratus:** These clouds are thin, sheet-like high clouds that often cover the entire sky. They are so thin that the sun and the moon can be seen through them.
- **Altocumulus clouds:** These are middle level clouds that are made up of water droplets and appear as gray, puff y masses, sometimes rolled out in parallel waves or bands.
- **Altostratus clouds:** These are gray or blue- gray middle level clouds composed of ice crystals and water droplets. These clouds usually cover the entire sky. In the thinner areas of the cloud, the sun may be dimly visible as a round disk. Altostratus clouds often forms ahead of storms that produces continuous precipitation.
- **Stratus clouds:** These are uniform grayish clouds that often cover the entire sky. They resemble fog that does not reach the ground. Usually no precipitation falls from stratus clouds, but sometimes they may drizzle. When a thick fog "lifts," the resulting clouds are low stratus.
- **Nimbostratus clouds:** These form a dark gray, "wet" looking cloudy layer associated with continuously falling rain or snow. They often produce precipitation that is usually light to moderate.

- **Cumulonimbus clouds:** These are thunderstorm clouds that form if cumulus clouds continue to grow vertically. Their dark bases may be no more than 300 m (1000 ft) above the Earth's surface. Their tops may extend upward to over 12,000 m (39,000 ft). Tremendous amount of energy is released by the condensation of water vapour within a cumulonimbus. Lightning, thunder, and even violent tornadoes are associated with the cumulonimbus.
- **Cumulus Clouds:** These are puffy clouds that sometimes look like pieces of floating cotton. The base of each cloud is often fl at and may be only 1000 m (330 ft) above the ground. The top of the cloud has rounded towers. When the top of the cumulus resembles the head of a cauliflower, it is called cumulus congestus or towering cumulus. These clouds grow upward, and they can develop into a giant cumulonimbus, which is a thunderstorm cloud.



Types of clouds

Precipitation

- Precipitation is water released from clouds in the form of rain, freezing rain, sleet, snow, or hail on the Earth's surface.
- When air is lifted in the atmosphere, it expands and cools and leads to the formation of clouds.
- The clouds floating overhead contain water vapor and cloud droplets, which are small drops of condensed water.
- For precipitation to happen, first tiny water droplets must condense on even tinier dust, salt, or smoke particles, which act as a nucleus.
- Some vapor freezes into tiny ice crystals which attract cooled water drops. The drops freeze to the ice crystals, forming larger crystals known as snowflakes.
- When the snowflakes become heavy, they fall as it exceeds the cloud updraft speed.
- When the snowflakes meet warmer air on the way down, they melt into raindrops.

Conditions of Occurrence of Precipitation

- Precipitation is the result of a complex series of micro-physical processes within a cloud.
- Precipitation may form as a result of collision and coalescence within a cloud.
- Precipitation may form where ice crystals and water droplets coexist within a cloud; this precipitation mechanism is known as the Bergeron-Findeisen process.
- Precipitation-size droplets do not form instantly. It takes time for the droplets to grow in size. Only if the conditions favorable to droplet growth last for a sufficient length of time then only precipitation will reach the ground.

There are three major types of Rainfall

- **Conventional Rainfall:** It occurs when moist air, having been warmed by Conduction from a heated surface, expands, rises and is adiabatically cooled to the dew point. Cumulus clouds develop and may fall accompanied by thunder. Convectional rainfall occurs commonly during the afternoon near the equator due to high temperature and high humidity.
- **Orographic Rainfall:** This type of rainfall occurs when air is forced to ascend the side of a mountain range. When land barriers such as mountain ranges, hilly regions or even escarpments of plateaus lie in the path of prevailing winds, large portion of the atmospheric air is forced to rise above these barriers. This resultant precipitation is termed as orographic. Because the air has deposited on the windward side of the mountain, there will be normally less rainfall on the leeward side which is known as **RAIN SHADOW AREA.**
- **Frontal Rainfall:** Cyclonic or Frontal precipitation results when the warm, moist air mass (warm front) meets a cool and dry air mass (cold front). The molecules in the cold air are more tightly packed together (i.e., more dense), and thus, the cold air is heavier than the warm air. The warmer air mass is forced up over the cool air. As it rises, the warm air cools, the water vapour in the air condenses, and forms clouds and results in precipitation.

Factors Affecting Rainfall Distribution

- **Moisture supply** to the atmosphere is the main factor in determining the amount of rainfall in any region. Equatorial and rest of the tropical region have highest evaporation and hence highest supply of moisture. Coastal areas have more moisture than interior parts of continents. Frigid regions have very low evaporation hence very scanty precipitation.
- **Wind direction** in the belts of trades and westerlies winds is very important. Winds blowing from sea to land cause rainfall. Land bearing winds are dry. Winds blowing from higher to lower latitudes will get heated and give no rain while those blowing from lower to higher latitudes will get cooled and cause rainfall. Sub-tropical deserts have very little rainfall because they have off -shore winds.
- **Ocean currents** Warm current are associated with warm moist winds which cause rainfal1,cold current have cold dry wind and hence no rainfall.
- **Presence of mountain** across the direction of wind causes more rainfall on the windward side and creates rain shadow on the leeward side.
- **Pressure belts** are closely related with wind direction and rainfall. Areas of low pressure attract rain bearing winds while areas of high pressure do not.

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DAY - 21

ATMOSPHERIC CIRCULATION & WEATHER SYSTEMS

Atmospheric Pressure

The weight of a column of air contained in a unit area from the mean sea level to the top of the atmosphere is called the atmospheric pressure. The atmospheric pressure is expressed in units of milibar. At sea level the average atmospheric pressure is 1,013.2 milibar. Due to gravity the air at the surface is denser and hence has higher pressure.

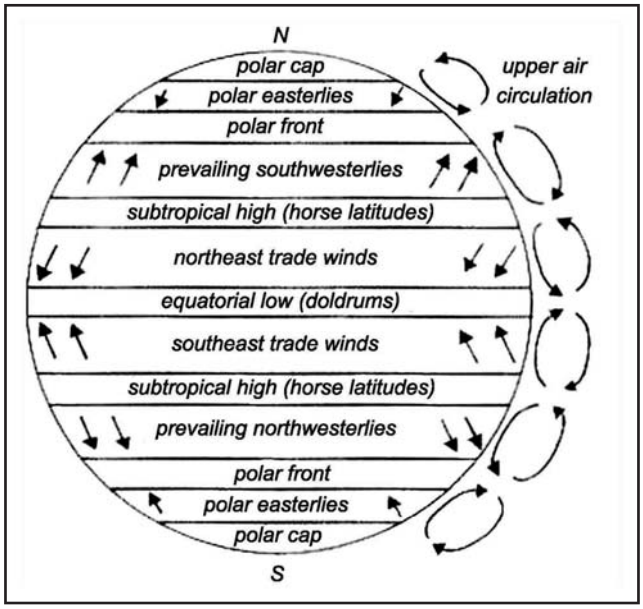
The distribution of atmospheric pressure over the globe is known as horizontal distribution of pressure. It is shown on maps with the help of isobars. The horizontal distribution of atmospheric pressure is not uniform in the world. It varies from time to time at a given place; it varies from place to place over short distances.

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

- **Air Temperature:** The earth is not heated uniformly because of unequal distribution of insolation, differential heating and cooling of land and water surfaces. Generally there is an inverse relationship between air temperature and air pressure. The higher the air temperature, the lower is the air pressure. In polar region, cold air is very dense hence it descends and pressure increases. From this we might expect, a gradual increase in average temperature towards equator.
- **The Earth's Rotation:** The earth's rotation generates centrifugal force. This results in the deflection of air from its original place, causing decrease of pressure. It is believed that the low pressure belts of the sub Polar Regions and the high pressure belts of the sub-tropical regions are created as a result of the earth's rotation. The earth's rotation also causes convergence and divergence of moving air.
- **Pressure of Water Vapour**: In winter the continents are relatively cool and tend to develop high pressure centres; in summer they stay warmer than the oceans and tend to be dominated by low pressure, conversely, the oceans are associated with low pressure in winter and high pressure in summer.

Pressure Belts of the World

- **Equatorial Low Pressure Belt:** At the Equator heated air rises leaving a low-pressure area at the surface. This low pressure area is known as equatorial low pressure. This area extends between 50N and 50S latitudes. The zone shifts along with the northward or southward movement of sun during summer solstice and winter solstice respectively. The pressure belt is thermally induced because the ground surface gets heated during the day. Thus warm air expands, rises up and creates low pressure.
- **Sub-tropical High Pressure Belts:** The warm air risen up at the equator due to heating reaches the troposphere and bend



towards the pole. Due to Coriolis force the air descends at 30-35° latitude thus creates the belt of sub-tropical high pressure. The pressure belt is dynamically induced as it owes its origin to the rotation of the earth and sinking and settling of winds. This zone is characterized by anti-cyclonic conditions which cause atmospheric stability and aridity. Thus, the hot deserts of the world are present in this region extending between 25-35 degree in both the hemisphere.

- **Sub-Polar Low Pressure Belt:** This belt is located between 60-65 degree latitudes in both the hemisphere. This pressure belt is also dynamically induced. As shown in the fi gure the surface air spreads outward from this zone due to rotation of the earth thus produces low pressure. The belt is more developed and regular in the southern hemisphere than the northern due to over dominance of water in the former.
- **Polar High Pressure Belt:** High pressure persists at the pole due to low temperature. Thus the Polar High Pressure Belt is thermally induced as well as dynamically induced as the rotation of earth also plays a minor role.

Winds

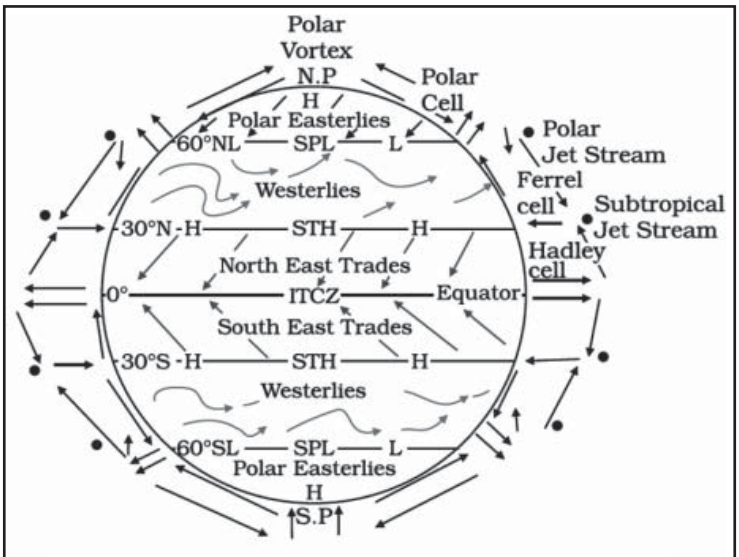
- The air is set in motion due to the differences in atmospheric pressure.
- The air in motion is called wind. The wind blows from high pressure to low pressure.
- The wind at the surface experiences friction.
- In addition, rotation of the earth also affects the wind movement.
- The force exerted by the rotation of the earth is known as the Coriolis force.
- Thus, the horizontal winds near the earth surface respond to the combined effect of three forces – the pressure gradient force, the frictional force and the Coriolis force. In addition, the gravitational force acts downward.

Planetary Winds

Planetary winds are major component of the general global circulation of air. These are known as planetary winds because of their prevalence in the global scale throughout the year. Planetary winds occur due to temperature and pressure variance throughout the world.

Trade Wind

- Winds blowing from the subtropical high pressure belt or horse latitudes towards the equatorial low pressure belt of the ITCZ are the trade winds. In the Northern Hemisphere, the trade winds blow from the northeast and are known as the Northeast Trade Winds; in the Southern Hemisphere, the winds blow from the southeast and are called the Southeast Trade Winds.
- The weather conditions throughout the tropical zone remain more or less uniform. This belt is subjected to seasonal variation due to northward and southward movement of sun.
- The equator ward part of the trade wind is humid because they are characterized by atmospheric instability thus causing heavy precipitation.



Simplified general circulation of the atmosphere

Westerly Wind

- The Westerlies are the prevailing winds in the middle latitudes between 35° and 65° blowing from the high pressure area in the sub tropical high pressure belt, i.e., horse latitudes towards the sub polar low pressure belt.

- The winds are predominantly from the south-west to north-east in the Northern Hemisphere and from the north- west to southeast in the Southern Hemisphere.
- The Westerlies are strongest in the winter season at times when the pressure is lower over the poles, while they are weakest in the summer season when pressures are higher over the poles.
- TheWesterlies are particularly strong, especially in the southern hemisphere, as there is less land in the middle latitudes to obstruct the flow.

Polar Wind

- The winds blowing in the Arctic and the Antarctic latitudes are known as the Polar Winds.
- They have been termed as the 'Polar Easterlies', as they blow from the Polar High Pressure belt towards the SubPolar Low- Pressure Belts.
- In the Northern Hemisphere, they blow in general from the north-east, and are called the North-East Polar Winds; and in the Southern Hemisphere, they blow from the southeast and are called the South-East Polar Winds.
- As these winds blow from the ice- capped landmass, they are extremely cold. They are more regular in the Southern Hemisphere than in the Northern Hemisphere.

Periodic/Seasonal Winds

- The pattern of wind circulation is modified indifferent seasons due to the shifting of regions of maximum heating, pressure and wind belts. This results in seasonal winds. The most pronounced effect of such a shift is noticed in the monsoons, especially over Southeast Asia.
- The word 'Monsoon' has been derived from the Arabic word 'Mausim' meaning season. The winds that reverse their direction with the change of seasons are called monsoon winds. During summer the monsoon winds blow from sea towards land and during winter from land towards sea.
- Traditionally these winds were explained as land and sea breezes on a large scale. But this explanation does not hold good now. Now a day the monsoon is generally accepted as seasonal modification of the general planetary wind system.
- The Asiatic monsoon is the result of interaction of both planetary wind system and regional factors, both at the surface and in the upper troposphere. India, Pakistan, Bangladesh, Myanmar (Burma), Sri Lanka, the Arabian Sea, the Bay of Bengal, South-east Asia, North Australia, China and Japan are important regions where monsoon winds are prevalent.

Summer Monsoon

During the summer, monsoon winds blow from the cooler ocean surfaces onto the warmer continents. In the summer, the continents become much warmer than the oceans because of a number of factors. These factors include:

- Specific heat differences between land and water.
- Greater evaporation over water surfaces .
- Sub-surface mixing in ocean basins, which redistributes heat energy through a deeper layer.
- Precipitation is normally associated with the summer monsoons. Onshore winds blowing inland from the warm ocean are very high in humidity, and slight cooling of these air masses causes condensation and rain. In some cases, this precipitation can be greatly intensified by orographic uplift. Some highland areas in Asia receive more than 10 meters of rain during the summer months.

Winter Monsoon

- In the winter, the wind patterns reverses, as the ocean surfaces are now warmer. With little solar energy available, the continents begin cooling rapidly as longwave radiation is emitted to space. The ocean surface retains its heat energy longer because of water's high specific heat and sub-surface mixing. The winter monsoonsbring clear dry weather and winds that flow from land to sea.

World Monsoonal Climate

- The Asiatic monsoon is the result of a complex climatic interaction between the distribution of land and water, topography, and tropical and mid- latitudinal circulation. In the summer, a low-pressure center forms over northern India and northern Southeast Asia because of higher levels of received solar insolation.
- Warm moist air is drawn into the thermal lows from air masses over the Indian Ocean. Summer heating also causes the development of a strong latitudinal pressure gradient and the development of an easterlyjet stream at an altitude of about 15 kilometers at the latitude of 25° north. The jet stream enhances rainfall in Southeast Asia, in the Arabian Sea, and in South Africa. When autumn returns to Asia the thermal extremes between land and ocean decrease and the westerlies of the mid-latitudes move in.
- The easterly jet stream is replaced with strong westerly winds in the upper atmosphere. Subsidence from an upper atmosphere cold layer above the Himalayas produces outflow that creates a surface highpressure system that dominates the weather in India and Southeast Asia.
- Besides, Asian continent, monsoon wind systems also exist in Australia, Africa, South America, and North America.

Local Winds

Local winds occur on a small spatial scale, their horizontal dimensions typically several tens to a few hundreds of kilometres. They also tend to beshort-lived lasting typically several hours to a day. There are many such winds around the world, some of them cold, some warm, some wet, some dry. There are many hazards associated with the winds.

Land and Sea Breezes

- A land breeze is created when the land is cooler than the water such as at night and the surface winds have to be very light. When this happens the air over the water slowly begins to rise, as the air begins to rise, the air over the surface of the ocean has to be replaced; this is done by drawing the air from the land over the water, thus creating a sea breeze.
- A sea breeze is created when the surface of the land is heated sufficiently to start air rising. As air rises, it is replaced by air from the sea and creates a sea breeze. Sea breezes tend to be much stronger and can produce gusty winds as the sun can heat the land to very warm temperatures, thereby creating a significant temperature contrast to the water.

Mountain and Valley Winds

- Mountain-valley breezes are formed by the daily difference of the thermo effects between peaks and valleys. In daytime, the mountainside is directly heated by the sun, the temperature is higher, air expands, air pressure reduces, and therefore air will rise up the mountainside from the valley and generate a valley breeze.
- The valley breeze reaches its maximum force in day time (mostly in afternoon). After this time, the breeze decreases in power and come to a complete stop by sunset. By Sunset, the mountain side region is able to dissipate heat more quickly, due to its higher altitude and therefore temperature drops rapidly. Cold air will then travel down the mountain side from the top and flow into the valley, forming a mountain breeze.
- In daytime, valley breezes carry water vapor to the peak, which will often condense into clouds; these are the commonly seen peak and flag clouds. When the mountain breeze travels down and gathers in the valleys, water vapor will condense. Therefore in valley or basin regions, there are usually clouds and fog before sunrise. During late spring or early autumn, the cold air trapped in the valley and basin will often generate frost.

Regional winds

- Hot winds - Loo, Foehn and Chinook are important hot winds of local category.

- The Foehn is a warm, dry, gusty wind which occurs over the lower slopes on the lee side (the side which is not directly exposed to wind and weather) of a mountain barrier. It is a result of forcing stable air over a mountain barrier. The onset of a Foehn is generally sudden. For example, the temperature may rise more than 10°C in five minutes and the wind strength increase from almost calm to gale force just as quickly. Foehn winds occur quite often in the Alps (where the name foehn originated) and in the Rockies (where the name Chinook is used).
- The local cold winds originate in the snow-capped mountains during winter and move down from the slopes towards the valleys. They are known by different names in different areas.

Air Mass

- An air mass is an extensive portion of the atmosphere having uniform characteristics of temperature, pressure and moisture which are relatively homogeneous horizontally.
- Air masses form over large surfaces with uniform temperatures and humidity, called source regions. Low wind speeds let air remain stationary long enough to take on the features of the source region, such as heat or cold. When winds move air masses, they carry their weather conditions (heat or cold, dry or moist) from the source region to a new region. When the air mass reaches a new region, it might clash with another air mass that has a different temperature and humidity.
- The major source regions of the air masses are the high latitude polar or low latitude tropical regions having such homogeneous conditions. Air masses, therefore, are of two kinds-polar and tropical air masses. Polar air mass is cold and tropical air mass is warm.
- When cold air mass and warm air mass blow against each other, the boundary line of convergence separating the two air masses is termed as front. When the warm air mass, moves upward over the cold air mass the front formed in such a situation is called warm front. On the contrary, when the cold air mass advances faster and undercuts the warm air mass and forces the warm air upwards, the front so formed is called cold front.
- The frontal surface of cold front is steeper than that of a warm front. A prevailing air mass in any region - polar, tropical, maritime or continental largely controls the regions general weather.
- Air masses are named according to their source region. Polar (P) air masses form at high latitudes toward Earth's poles. Air masses that form at low latitudes are Tropical (T) air masses. The terms Polar and tropical describe the temperature characteristics of an air mass. Polar air masses are cold, while tropical air masses are warm. In addition to their overall temperature, air masses are classified according to the surface over which they form.
- Continental (c) air masses form over land. Maritime (m) air masses form over water. The terms continental and maritime describe the moisture characteristics of the air mass. Continental air masses are likely to be dry. Maritime air masses are humid. Using this classification scheme, there are four basic types of air masses. A Continental Polar (cP) air mass is dry and cool. A Continental Tropical (cT) air mass is dry and warm or hot. Maritime Polar (mP) and Maritime Tropical (mT) air masses both form over water. But a Maritime Polar air mass is much colder than a Maritime Tropical air mass.

Fronts

- When cold air mass and warm air mass blow against each other, the boundary line of convergence separating the two air masses is termed as front. At the boundary, or front, there is a marked drop in temperature, increase in humidity, sudden wind change and a marked pressure rise. This marked discontinuity lends support to the theory of two separate air masses with the front being the boundary between the two.
- When the warm air mass, moves upward over the cold air mass the front formed in such a situation is called warm front. On the contrary, when the cold air mass advances faster and undercuts the warm air mass and forces the warm air upwards, the front so formed is called cold front. The frontal surface of cold front is steeper than that of a warm front.

High Pressure and Low Pressure Systems

The pressure differences cause air to move in ways that may make a high or low become the centre of a whole system of weather. At a high-pressure centre, air sinks slowly down. As the air nears the ground, it spreads out toward areas of lower pressure.

- In the Northern Hemisphere, the Coriolis effect makes the air turn clockwise as it moves outward. Most high-pressure systems are large and change slowly. When a high-pressure system stays in one location for a long time, an air mass may form. The air-and resulting air mass-can be warm or cold, moist or dry.
- A high-pressure system generally brings clear skies and calm air or gentle breezes. This is because as air sinks to lower altitudes, it warms up a little bit. Water droplets evaporate, so clouds often disappear.
- A small area of low pressure can also develop into a larger system. It begins as air moves around and inward toward the lowest pressure and then up to higher altitudes. The upward motion of the air lowers the air pressure further, and so the air moves faster.
- The pattern of motion strengthens into a low- pressure weather system. The rising air produces stormy weather. In the Northern Hemisphere, the air in a low-pressure system circles in a counter clockwise direction.
- A low-pressure system can develop wherever there is a centre of low pressure. One place this often happens is along a boundary between a warm air mass and a cold air mass.

Cyclones

Typically, cyclones are elliptical arrangement of isobars having low pressure at the centre with a convergence of winds within them. The wind direction in the cyclones is anti-clockwise in the northern hemisphere and clockwise in the southern hemisphere. Cyclones are of two types - the temperate or mid latitude cyclones and the tropical or low latitude cyclones.

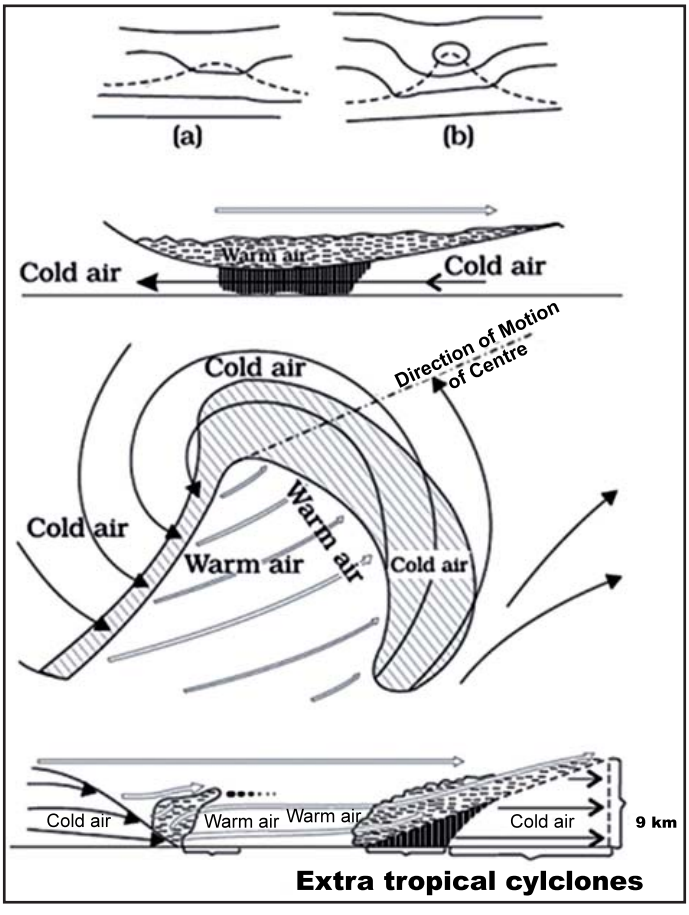
Temperate Cyclones

Temperate cyclones are formed along a front in mid-latitudes between 35°and 65° N and S. They blow from west to east and are more pronounced in winter season.

Polar Front Theory

Development and Evolution of a Wave Cyclone, the wave cyclone (often called a frontal wave) develops along the polar front- when a large temperature gradient exists across the polar front - the atmosphere contains a large amount of Available Potential Energy. Instability (kink) forms in the polar front. This instability is the incipient cyclone. A fully-developed “wave cyclone” is seen 1224 hours from its inception. It consists of:

- A warm front moving to the northeast.
- A cold front moving to the southeast.
- Region between warm and cold fronts is the “warm sector”.
- The central low pressure (low, which is deepening with time).



- Overrunning of warm air over the warm front.
- Cold air surging southward behind the cold front.
- Wide-spread of precipitation ahead of the warm front.
- Narrow band of precipitation along the cold front.
- Wind speeds continue to get stronger as the low deepens - the Available Potential Energy (APE) is being converted to Kinetic Energy (KE).
- The production of clouds and precipitation also generates energy for the storm as Latent Heat is released.
- As the cold front moves swiftly eastward,
  - The systems start to occlude.
  - Storm is most intense at this stage.
  - Have an occluded front trailing out from the surface low.
  - Triple point/occlusion - is where the cold, warm and occluded fronts all intersect.
  - The warm sector diminishes in size as the systems further occlude.
  - The storm has used most all of its energy and dissipates.
  - The entire APE has been utilized and the KE has dissipated into turbulence- cloud/ precipitation production has diminished.
  - The warm sector air has been lifted upward.
  - The cold air is at the surface-stable situation

Seasonal Occurrence of Temperate Cyclones

- The temperate cyclones occur mostly in winter, late autumn and spring. They are generally associated with rainstorms and cloudy weather.
- During summer, all the paths of temperate cyclones shift northwards and there are only few temperate cyclones over sub-tropics and the warm temperate zone, although a high concentration of storms occurs over Bering Strait, USA and Russian Arctic and sub-Arctic zone.

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.

Associated Weather

- The approach of a temperate cyclone is marked by fall in temperature, fall in the mercury level, wind shifts and a halo around the sun and the moon, and a thin veil of cirrus clouds.
- A light drizzle follows which turns into a heavy downpour.
- These conditions change with the arrival of the warm front which halts the fall in mercury level and the rising temperature.
- Rainfall stops and clear weather prevails until the cold front of an anticyclonic character arrives which causes a fall in temperature, brings cloudiness and rainfall with thunder.
- After this, once again clear weather is established. The temperate cyclones experience more rainfall when there is slower movement and a marked difference in rainfall and temperature between the front and rear of the cyclone. These cyclones are generally accompanied by anticyclones.

Tropical Cyclones

Tropical cyclones are intense cyclonic storms that develop over the warm oceans of the tropics. Surface atmospheric pressure in the centre of tropical cyclones tends to be extremely low. Most storms have an average pressure of 950millibars. To be classified as Tropical cyclones, sustained wind speeds must be greater than 118 kilometers per hour at the storm's centre.

The main characteristics of tropical cyclones are:

- Have winds that exceed 34 knots (39 mi/hr),
- Blow clockwise in the Southern Hemisphere, and
- Counter-clockwise about their centres in the Northern Hemisphere

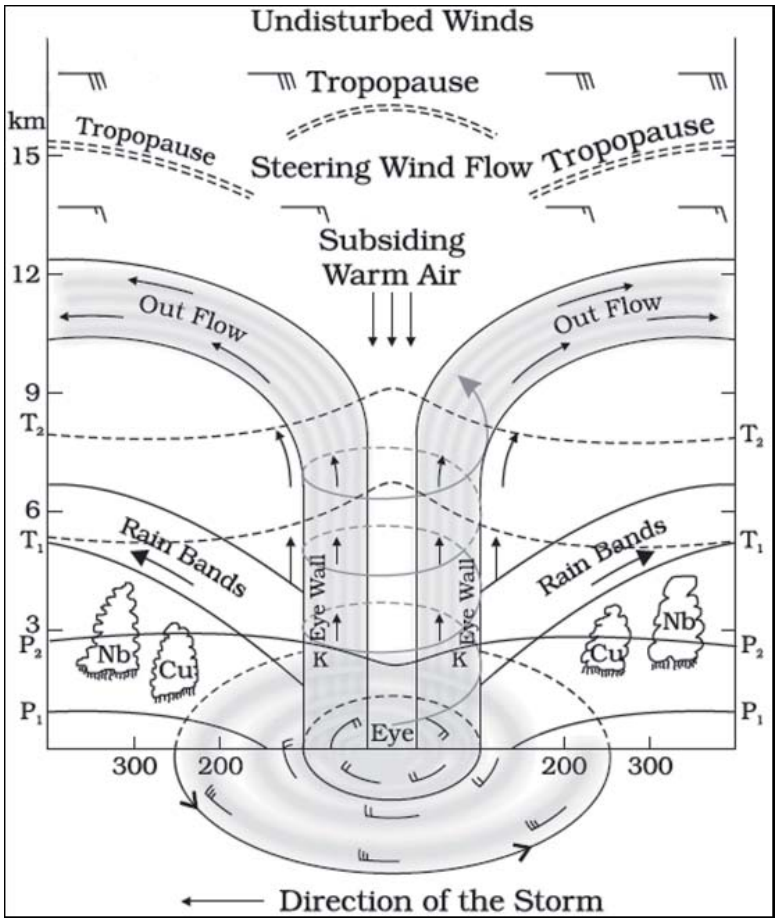
Condition for formation of Tropical Cyclones:

- For a cyclone to form several preconditions must be met:
- Warm ocean waters (of at least 26.5°C) throughout a sufficient depth (unknown how deep, but at least on the order of 50 m). Warm waters are necessary to fuel the heat engine of the tropical cyclone.
- An atmosphere which cools fast enough with height (is "unstable" enough) such that it encourages thunderstorm activity. It is the thunderstorm activity which allows the heat stored in the ocean waters to be liberated for the tropical cyclone development.
- Relatively moist layers near the mid- troposphere (5 km). Dry mid levels are not conducive for allowing the continuing development of widespread thunderstorm activity.
- A minimum distance of around 500 km from the equator. Some of the earth's spin (Coriolis force) is needed to maintain the low pressure of the system. (Systems can form closer to the equator but it's a rare event)
- A pre-existing disturbance near the surface with sufficient spin (vorticity) andinflow (convergence). Tropical cyclones cannot be generated spontaneously. To develop, they require a weakly organised system with sizeable spin and low level inflow.
- Little change in the wind with height (low vertical wind shear, i.e. less than 40 km/h from surface to tropopause). Large values of wind shear tend to disrupt the organization of the thunderstorms that are important to the inner part of a cyclone.
- Connection between tropical cyclones and wind speed.

Depending on the maximum sustained wind speed, tropical cyclones will be designated as follows:

- It is a tropical depression when the maximum sustained wind speed is less than 63 km/h.
- It is a tropical storm when the maximum sustained wind speed is more than 63 km/h. It is then also given a name.
- Depending on the ocean basins, it is designated either as a hurricane, typhoon, severe tropical cyclone, severe cyclonic storm or tropical cyclone when the maximum sustained wind speed is more than 119 km/h.
- Tropical cyclones can be hundreds of kilometers wide and can bring destructive high winds, torrential rain, storm surge and occasionally tornadoes.
- The impact of a tropical cyclone and the expected damage depend not just on wind speed, but also on factors such as the moving speed, duration of strong wind and accumulated rainfall during and after landfall, sudden change of moving direction and intensity, the structure (e.g. size and intensity) of the tropical cyclone, as well as human response to tropical cyclone disasters.

Structure of the Tropical Cyclone



- Tropical cyclones have no fronts associated with them like the mid-latitude cyclones of the polar front. They are also smaller than the mid-latitude cyclone, measuring on average 550 kilometers in diameter. Mature tropical cyclones usually develop a cloud-free eye at their centre.
- In the eye, air is descending creating clear skies. The eye of the tropical cyclones may be 20 to 50 kilometers in diameter. Surrounding the eye are bands of organized thunderstorm clouds formed as warm air move in and up into the storm. The strongest winds and heaviest precipitation are found in the area next to the eye where a vertical wall of thunderstorm clouds develops from the Earth's surface to the top of the troposphere.
- The circular eye or centre of a tropical cyclone is an area characterised by light winds, fine weather and often clear skies. The eye is the region of lowest surface pressure.
- The eye is surrounded by a dense ring of cloud known as the eye wall. This marks the most dangerous part of the cyclone having the strongest winds and heaviest rainfall.
- Radar and satellite imagery often show that the eye wall clouds are the inner-most coil of a series of spiral rain-band cloudsthat extend hundreds of kilometres from the centre and typically produce very strong wind squalls. The eye-wall is not always symmetrical, in fact at any one time it is common for the strongest convection and surface winds to be in one part of the eye wall.

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DAY - 22

OCEANOGRAPHY

Around 70% of the Earth's surface is covered by oceans. The average depth of the world's oceans is 12,200 feet. About 70% of the oxygen we breathe is produced by the oceans. Around 97 percent of the planets water is in the oceans. Around 80 percent of the world's population lives within 60 miles of the ocean coast. The largest ocean on Earth is the Pacific Ocean, covering around 30% of the Earth's surface. The deepest known area of the Earth's oceans is known as the Mariana Trench. It's deepest point measures 11km. The longest mountain range in the world is found under water. Stretching over 56,000km, the Mid-Oceanic Ridge is a mountain chain that runs along the centre of the ocean basins. The mountain Mauna Kea in Hawaii rises 33,474 feet from its base. This would make it the tallest mountain in the world if its base wasn't below sea level. The sea is home to the world's largest living structure – the Great Barrier Reef. Measuring around 2,600km, it can even be seen from the Moon!

Major Division of Ocean Hour

- Four major divisions can easily be identified on the ocean floor-
  - The Continental Shelf
  - The Continental Slope
  - The Continental Rise
  - The Abyssal Plain.
- Besides these, there are many associated features-ridges, hills, seamounts, guyots, trenches, canyons, sleeps, fracture zones, island arcs, atolls, coral reefs, submerged volcanoes and sea-scarps.
- This great variety of relief is largely due to interaction of tectonic, volcanic, erosional and depositional processes.
- At greater depths, the tectonic and volcanic phenomena are more significant processes.

Continental Shelf

- This is a gentle seaward sloping surface extending from the coasts towards the open sea. In all, about 7.5% of the total area of the oceans is covered by the continental shelves. The shelf is formed by the drowning of a part of a continent with a relative rise in sea level or marine deposition beneath the water.
- The average width of the continental shelf is about 70 km and mean slope is less than one degree, but the width shows great variety from location to location. For instance, it is almost absent in the eastern Pacific, especially off South America and is upto 120 km wide along the eastern coast of USA. The seaward edge of the shelf is usually 150-200 metres deep.
- The continental shelves are mostly covered by sediments of terrestrial origin. There are various types of shelves-glaciated shelf, coral reef shelf, and shelf of a large river, shelf with dendritic valleys and the shelf along young mountain ranges.

Continental Slope

- Marking the seaward edge of the continental shelf is the Continental Slope. This slope is steeper than the shelf, and it marks the boundary between continental crust and oceanic crust. Although the

steepness of the continental slope varies greatly from place to place, it averages about 5 degrees. In some places the slope may exceed 25 degrees. The continental slope is a relatively narrow feature, averaging only about 20 kilometers in width.

- Deep, steep-sided valleys known as submarine canyons are cut into the continental slope. These canyons may extend to the ocean basin floor. Submarine canyons have been eroded, at least in part, by turbidity currents.
- Turbidity currents are occasional movements of dense, sediment-rich water down the continental slope.
- They are created when sand and mud on the continental shelf and slope are disturbed-perhaps by an earthquake-and become suspended in the water. Because such muddy water is denser than normal seawater, it flows down the slope. As it flows down, it erodes and accumulates more sediment. Erosion from these muddy torrents is believed to be the major force in the formation of most submarine canyons. Narrow continental margins, such as the one located along the California coast, are marked with numerous submarine canyons.
- Turbidity currents are known to be an important mechanism of sediment transport in the ocean. Turbidity currents erode submarine canyons and deposit sediments on the deep-ocean floor.

Continental Rise

- Continental rise, a major depositional regime in oceans made up of thick sequences of continental material that accumulate between the continental slope and the abyssal plain. Continental Rises form as a result of three sedimentary processes: mass wasting, the deposition from contour currents, and the vertical settling of clastic and biogenic particles.
- The continental slope gradually loses its steepness with depth. When the slope reaches a level of between 0.5° and 1°, it is referred to as the continental rise. With increasing depth the rise becomes virtually flat and merges with the abyssal plain.

Abyssal Plains

- Beyond the continental rise, at depths from 3,000 m to 6,000 m, lie the deep sea plains, called abyssal plains or abyssal floors. Covering nearly 40% of the ocean floor, the abyssal plains are present in all major oceans and several seas of the world. They are uniquely fl at with a gradient of less than 10,000. The large supply of terrigenous and shallow water sediments buries the irregular topography to form a generally flat relief.

Other Features

Submarine Ridges

- Submarine ridges are mountain ranges, a few hundred kilometres wide and hundreds and often thousands of kilometres in length on the floors of oceans. Running for a total length of 75,000 km, these ridges form the largest mountain systems on earth.
- These ridges are either broad, like a plateau, gently sloped or in the form of steep-sided narrow mountains. These oceanic ridge systems are of tectonic origin and provide evidence in support of the theory of Plate Tectonics.

Abyssal Hills

- These are elevated features of volcanic origin. A submarine mountain or peak rising more than 1,000 metres above the ocean floor is known as a seamount. The fl at topped mountains are known as guyots.
- Seamounts and guyots are very common in the Pacific Ocean, where they are estimated to number around 10,000.

Submarine Trenches or Deeps

- These are the deepest parts of the oceans with their bottoms far below the average level of the ocean floors. A trench is a long, narrow and steep-sided depression on the ocean bottom, which is usually 5,500 metres in depth. The trenches lie along the fringes of the deep-sea plain and run parallel to the bordering fold mountains or the island chains.

- They are believed to have resulted from down faulting or down folding of the earth's crust and are, therefore, of tectonic origin. The trenches are very common in the Pacific Ocean and form an almost continuous ring along the western and eastern margins of the Pacific. The Mariana Trench off the Guam Islands in the Pacific Ocean is the deepest trench with a depth of more than 11 kilometers.
- These are steep valleys, forming deep gorges on the ocean floor. They are mainly restricted to the continental shelf, slope and rise.

Submarine Canyons

- Small gorges which begin at the edge of the continental shelf and extend down the slope to very great depths, e.g. Oceanographer Canyons near New England.
- Those which begin at the mouth of a river and extend over the shelf, such as the Zaire, the Mississippi and the Indus canyons.
- Those which have a dendritic appearance and are deeply cut into the edge of the shelf and the slope, like the canyons off the coast of southern California. The Hudson Canyon is the best known canyon in the world. The largest canyons in the world occur in the Bering Sea off Alaska. They are the Bering, Pribilof and Zhemchung canyons.

Temperature and Salinity of Ocean Waters

With increasing depth the temperature of the ocean water decreases. At great depths the temperature goes well beyond 0ºC. The top part of the ocean water is called the surface layer. Then there is a boundary layer called the thermocline layer. The thermocline layer separates the surface layers and the deep water of the ocean.

Temperature and Density of Ocean Water

- The temperature of the world's ocean is highly variable over the surface of the oceans, ranging from less than 0°C (32°F) near the poles to more than 29°C (84°F) in the tropics. It is heated from the surface downward by sunlight, but at depth most of the ocean is very cold. Seventy five percent of the water in the ocean falls within the temperature range of +1 to +6°C (30 to 43°F) and the salinity range of 34% to 35%.
- Variations in total salinity and in temperature cause variations in the density of sea water. Several factors can cause the salinity to deviate from 35%. Addition of river water or rainwater decreases salinity; excess evaporation or formation of pack ice causes salinity to increase (because ice crystals themselves do not contain salt- the salt is expelled to cracks and pores between the crystals).
- The density of a water sample is a measure of the total mass in a given unit volume. Salinity increases the density because the dissolved salts are contained in the same volume as the water. Water molecules cluster more closely around positive and negative ions in solution in a process called electrostriction, which also serves to increase sea water density.
- At depth, pressure from the overlying ocean water becomes very high (pressure at 4,000 meters is about 400 atmospheric pressure), but water is only slightly compressible, so that there is only a minor pressure effect on density. At a depth of 4,000 meters, water decreases in volume only by 1.8 percent. Although the high pressure at depth has only a slight effect on the water, it has a much greater effect on easily compressible materials.

Distribution of Ocean Water Temperature

- The horizontal distribution of the temperature of ocean water depends upon the following factors: **Latitudinal Distance:** Temperature of the ocean water decreases as we move away from the equator. The average temperature of ocean water is 26°C in open seas at equator but the temperature decreases to 23°C at 20° North and South latitudes. Temperature further decreases to 14°C at 40° latitudes and to 1°C at 60° latitudes.
- **Change of Season:** The effect of season is far more pronounced in air than in water. Ocean water records a seasonal range of only 1.2° between 20° and 30° latitudes. The range is still 1.2°C beyond 50° latitudes. The greatest range is found near New Foundland (4.5°C).

- **Enclosed Seas:** The highest temperature of ocean water is found in enclosed or partially enclosed seas in tropical areas. For example a temperature of 38°C has been recorded in Red Sea though the average temperature in summer is only 29°C.
- **The Effect of Ocean Currents:** The temperature of warm current is higher than that of the surrounding areas. The warm currents keep the coastal lands warmer. For example, the Gulf Stream does not allow the Norway Coast to freeze even in winter and thus helps the development of trade and commerce in that country. The temperature between Davis Strait and New Found land drops down because of cold Labrador Current washing the coasts.
- **Prevailing Winds:** The prevailing winds deflect the warm and cold currents and causes change in temperature of ocean water. For example, the currents on the east coast in the Trade Wind Belt shift away from the coast. Hence, the warm currents fl owing along the coast moves away from it which leads to the upwelling of cold water from below near the coast. Hence the temperature remains low in spite of the passage of warm currents. This is why the temperature remains lower on the eastern than on western parts of the oceans.
- **The effect of Land Masses:** The small seas are affected by the adjacent land masses. The temperature rises in summer and falls in winter because of the influence of the land masses.
- **Iceberg:** Icebergs are found near polar areas and can be seen to be floating up to 50° latitudes. One part of iceberg is above sea and eight parts remain submerged under sea water. Many icebergs have a height of hundreds of metres above sea level. Thousands of icebergs can be seen moving away from North Atlantic. The Falkland and Beneguela currents carry them too far off places. It lowers the temperature of the water at great depth.

Vertical Distribution of Temperature

When the sun's rays fall over the ocean water, they penetrate into it and hence their strength is reduced by scattering, reflection and diffusion. There is decrease in temperature with increase in depth. But, the rate of decrease in the temperature is not uniform at all depths. Up to a depth of about 10 metres, the temperature of water is about the same as that of the surface, while it falls from about 15°C to about 2°C between the surface and a depth of 1800 metres, and the decrease between 1800 to 4000 metres is from 2°C to about 1.6°C. The rate of decrease is greater at the equator than at the poles.

The factors affecting vertical distributions of temperature are:

- Upwelling of cold water.
- Sinking of dense surface water.
- Cold and warm currents.
- Regional Insolation.
- Submarine topography.
- Open and enclosed seas.

Salinity of Ocean Waters

The salinity of water is usually expressed in parts per thousand by weight (%) and is due to the presence of compounds of sodium, potassium, magnesium, calcium and other elements including a high proportion of sodium chloride (common salt). Rivers derive minerals from rocks and carry them to the sea. The salinity varies with the amounts of salts contributed, addition of fresh water by rainfall, rivers, and melting ice, and also with the rate of evaporation: rapid evaporation can cause relatively high surface salinity in open oceans.

- The average salinity of sea water is 35% (thirty five part per thousand).
- The lines on maps joining places of equal salinity at surface are known as Isohalines.

Lakes with highest salinity

- Great Salt Lake: 220%
- Dead Sea : 240%
- Lake Van (Turkey): 330%

Composition of Sea Water

- Sodium Chlorate - 77.5%
- Magnesium Chloride - 10.9%
- Magnesium Sulphate - 4.7%
- Calcium Sulphate - 3.6%
- Potassium Sulphate - 2.5%
- Calcium Carbonate - 0.3%
- Magnesium Bromide - 0.2%

Reasons for the Varying Salinity of the Sea Water

Evaporation and Precipitation

- Evaporation causes concentration of salt. Highest salinity is found near the tropics, because of active evaporation owing to clear sky, high temperature and steady trade winds. Salinity decreases towards the equator because of heavier rainfall. In the Atlantic Ocean the salinity near the tropics is 37% and near the equator it is only 35%.

Stream run off

- The areas which receive fresh water by rivers have low salinity, e.g., huge amount of fresh water brought by the Danube, the Dnieper and the Don into the Black Sea reduces its salinity to 17%.

Freezing and Melting of Ice

- In the polar areas, there is very little evaporation and this coupled with the melting of ice, yielding fresh water, leads to a decrease in salinity, usually between 20% and 32%.

Atmospheric Pressure and Wind Direction

- Salinity changes slightly due to winds resulting from differences in atmospheric pressure. Of the Californian coast, North East Trade winds carry the warm saline water far off the coast and consequently colder and less saline water start upwelling from below.

Ocean Currents

- The currents, stirred by wind, sweep away saline water from the eastern coast of the high latitudes to the western coasts, whereas cold water penetrates into the low latitudes. Thus there is a tendency for salinity to increase from east to west. Salinity is higher in enclosed seas as compared to open seas. The salinity of the Red Sea is 40% and that of the Dead Sea is 2.28%. This is because of high rate of evaporation, lack of supply of fresh water in enclosed seas.
- The Baltic Sea receives many fresh water rivers from the neighboring shield areas, and, with a low rate of evaporation the salinity is only 2% at the head of the Gulf of Bothnia. The Mediterranean waters do not mix freely with the open ocean. In the hot, dry summers there is very rapid evaporation. The Nile is the only large river entering the eastern parts and brings down much salt, so that the salinity of the eastern Mediterranean in summer is about 40%. Further east, in the inland Dead Sea, the salinity is almost 240%, and there is salt accumulation along the shores.
- The movement of ocean waters takes place in three different forms, viz., waves, currents and tides. Ocean water moves horizontally as well as vertically.
- These movements are due to variation in density from one part to another which results from the differences in salinity and temperatures. Winds also provide a motive force for the horizontal movement of surface water. The movement of surface water in which the rise and fall of water surface is more predominant than the actual forward motion of the water particles is called waves. When the movement of a mass of water in a fairly definite direction over great distances takes place is called current. Currents are caused by the differences in salinity, drag of winds, shape and position of coasts and variation in temperature.

- Currents are of two types: Warm currents and Cold currents. Currents exert an influence on the climate of the bordering coastal regions. They provide plankton, a food for the fish. Important ocean routes follow the favorable currents. There are important currents in Pacific Ocean, the Atlantic Ocean and the Indian Ocean.

Oceanic Movements: Waves, Tides & Currents

The ocean water is dynamic. Its physical characteristics like temperature, salinity, density and the external forces like of the sun, moon and the winds influence the movement of ocean water. The horizontal and vertical motions are common in ocean water bodies. The horizontal motion refers to the ocean currents and waves. The vertical motion refers to tides.

Waves

- Waves are actually the energy, not the water as such, which moves across the ocean surface. Water particles only travel in a small circle as a wave passes. Wind provides energy to the waves. Wind causes waves to travel in the ocean and the energy is released on shorelines.
- As a wave approaches the beach, it slows down. This is due to the friction occurring between the dynamic water and the sea floor. And, when the depth of water is less than half the wavelength of the wave, the wave breaks. The largest waves are found in the open oceans.
- Waves continue to grow larger as they move and absorb energy from the wind. Most of the waves are caused by the wind driving against water. When a breeze of two knots or less blows over calm water, small ripples form and grow as the wind speed increases until white caps appear in the breaking waves. Waves may travel thousands of km before rolling ashore, breaking and dissolving as surf.
- A wave's size and shape reveal its origin. Steep waves are fairly young ones and are probably formed by local wind. Slow and steady waves originate from far away places, possibly from another hemisphere. The maximum wave height is determined by the strength of the wind, i.e. how long it blows and the area over which it blows in a single direction.
- Waves travel because wind pushes the water body in its course while gravity pulls the crests of the waves downward. The falling water pushes the former troughs upward, and the wave moves to a new position. The actual motion of the water beneath the waves is circular. It indicates that things are carried up and forward as the wave approaches, and down and back as it passes.

Tides

Tides are the periodic motion of the waters of the sea due to changes in the attractive forces of the Moon and Sun upon the rotating Earth. Basically, tides are very long-period waves that move through the oceans in response to the forces exerted by the moon and sun.

- Tides originate in the oceans and progress toward the coastlines where they appear as the regular rise and fall of the sea surface. When the highest part or crest of the wave reaches a particular location, high tide occurs; low tide corresponds to the lowest part of the wave, or its trough.
- The difference in height between the high tide and the low tide is called the tidal range. A horizontal movement of water often accompanies the rising and falling of the tide. This is called the tidal current.
- Tides can either help or hinder a mariner. A high tide may provide enough depth to clear a harbour, while a low tide may prevent entering or leaving a harbour. Tidal current may help progress or hinder it, may set the ship toward dangers or away from them.

Causes of Tides

- The principal tidal forces are generated by the Moon and Sun. The Moon is the main tide-generating body. Due to its greater distance, the Sun's effect is only 46 percent of the Moon's. Observed tides will differ considerably from the tides predicted by equilibrium theory since size, depth, and configuration of the basin or waterway, friction, land masses, inertia of water masses, Coriolis acceleration, and other factors are neglected in this theory. Nevertheless, equilibrium theory is sufficient to describe the magnitude and distribution of the main tide-generating forces across the surface of the Earth.

- Newton's universal law of gravitation governs both the orbits of celestial bodies and the tide-generating forces which occur on them. The force of gravitational attraction between any two masses, m1 and m2, is given by: where d is the distance between the two masses, and G is a constant which depends upon the units employed. This law assumes that m1 and m2 are point masses. Newton was able to show that homogeneous spheres could be treated as point masses when determining their orbits.

Features of Tides

- At most places the tidal change occurs twice daily. The tide rises until it reaches a maximum height, called high tide or high water, and then falls to a minimum level called low tide or low water.
- The rate of rise and fall is not uniform. From low water, the tide begins to rise slowly at first, but at an increasing rate until it is about halfway to high water. The rate of rise then decreases until high water is reached, and the rise ceases.
- The falling tide behaves in a similar manner. The period at high or low water during which there is no apparent change of level

Types of Tides

Tides vary in their frequency, direction and movement from place to place and also from time to time. Tides may be grouped into various types based on their frequency of occurrence in one day or 24 hours or based on their height.

Tides based on Frequency

- **Semi-diurnal tide:** The most common tidal pattern, featuring two high tides and two low tides each day. The successive high or low tides are approximately of the same height.
- **Diurnal tide:**There is only one high tide and one low tide during each day. The successive high and low tides are approximately of the same height.
- **Mixed tide:** Tides having variations in height are known as mixed tides. These tides generally occur along the west coast of North America and on many islands of the Pacific Ocean.
- **Tides based on the Sun, Moon and the Earth Positions:**
- The height of rising water (high tide) varies appreciably depending upon the position of sun and moon with respect to the earth. Spring tides and neap tides come under this category.
- **Spring tides:** The position of both the sun and the moon in relation to the earth has direct bearing on tide height. When the sun, the moon and the earth are in a straight line, the height of the tide will be higher. These are called spring tides and they occur twice a month, one on full moon period and another during new moon period.
- **Neap tides:** Normally, there is a seven day interval between the spring tides and neap tides. At this time the sun and moon are at right angles to each other and the forces of the sun and moon tend to counteract one another. The Moon's attraction, though more than twice as strong as the sun's, is diminished by the counteracting force of the sun's gravitational pull. Once in a month, when the moon's orbit is closest to the earth (perigee), unusually high and low tides occur. During this time the tidal range is greater than normal. Two weeks later, when the moon is farthest from earth (apogee), the moon's gravitational force is limited and the tidal ranges are less than their average heights. When the earth is closest to the sun (perihelion), around 3rd January each year, tidal ranges are also much greater, with unusually high and unusually low tides. When the earth is farthest from the sun (aphelion), around 4th July each year, tidal ranges are much less than average. The time between the high tide and low tide, when the water level is falling, is called the ebb. The time between the low tide and high tide, when the tide is rising, is called the flow or flood.

Ocean Currents

Ocean currents are like river flow in oceans. They represent a regular volume of water in a definite path and direction. Ocean currents are influenced by two types of forces namely: primary forces that initiate the movement of water; secondary forces that influence the currents to flow.

The primary forces that influence the currents are:

- **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. Differences in water density affect vertical mobility of ocean currents.

- Water with high salinity is denser than water with low salinity and in the same way cold water is denser than warm water. 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.

Types of Ocean Currents

The ocean currents may be classified

- **Based on their depth as surface currents and deep water currents:**
  - Surface currents constitute about 10 per cent of all the water in the ocean; these waters are the upper 400 m of the ocean;
  - Deep water currents make up the other 90 per cent of the ocean water. These waters move around the ocean basins due to variations in the density and gravity. Deep waters sink into the deep ocean basins at high latitudes, where the temperatures are cold enough to cause the density to increase.
- **Based on temperature: As cold currents and warm currents:**
  - Cold currents bring cold water into warm water areas. These currents are usually found on the west coast of the continents in the low and middle latitudes (true in both hemispheres) and on the east coast in the higher latitudes in the Northern Hemisphere;
  - Warm currents bring warm: water into cold water areas and are usually observed on the east coast of continents in the low and middle latitudes (true in both hemispheres). In the northern hemisphere they are found on the west coasts of continents in high latitudes

The Circulation of the Atlantic Ocean

- The steady Trade Winds constantly drift two streams of water from east to west. At the 'shoulder' of north-east Brazil, the protruding land mass splits the South Equatorial Current into the Cayenne Current which flows along the Guiana coast, and the Brazilian Current which flows southwards along the east coast of Brazil.
- In the North Atlantic Ocean, the Cayenne Current is joined and reinforced by the North Equatorial Current and heads north-westwards as a large mass of equatorial water into the Caribbean Sea. Part of the current enters the Gulf of Mexico and emerges from the Florida Strait between Florida and Cuba as the Florida Current. The rest of the equatorial water flows northwards east of the Antilles to join the Gulf Stream off the south-eastern U.S.A. The Gulf Stream Drift is one of the strongest ocean currents, 35 to 100 miles wide, 2,000 feet deep and with a velocity of three miles an hour. The current hugs the coast of America as far as Cape Hatteras (latitude 35°N.), where it is *deflected eastwards* under the combined influence of the *Westerlies* and the *rotation* of the earth. It reaches Europe as the North Atlantic Drift. This current, flowing at 10 miles per day, carries the warm equatorial water for over a thousand miles to the coasts of Europe. From the North Atlantic, it fans out in three directions, eastwards to Britain, northwards to the Arctic and southwards along the

Iberian coast, as the cool Canaries Current. Oceanographic researches show that almost two- thirds of the water brought by the Gulf Stream to the Arctic regions is returned annually to the tropical latitudes by dense, cold polar water that creeps southwards in the ocean depths. The Canaries Current flowing southwards eventually merges with the North Equatorial Current, completing the clockwise circuit in the North Atlantic Ocean. Within this ring of currents, an area in the middle of the Atlantic has no perceptible current. A large amount of floating sea-weed gathers and the area is called the Sargasso Sea.

- Apart from the clockwise circulation of the currents, there are also currents that enter the North Atlantic from the Arctic regions. These cold waters are blown south by the out-flowing polar winds. The Irminger Current or East Greenland Current flows between Iceland and Greenland and cools the North Atlantic Drift at the point of convergence. The cold Labrador Current drifts south-eastwards between West Greenland and Baffin Island to meet the warm Gulf Stream off Newfoundland, as far south as 50°N. where the icebergs carried south by the Labrador Current melt.
- The South Atlantic Ocean follows the same pattern of circulation as the North Atlantic Ocean. The major differences are that the circuit is anti-clockwise and the collection of sea-weed in the still waters of the mid-South Atlantic is not so distinctive.
- Where the South Equatorial Current is split at Cape Sao Roque, one branch turns south as the warm Brazilian Current. Its deep blue waters are easily distinguishable from the yellow, muddy waters carried hundreds of miles out to sea by the Amazon further north. At about 40°S.
- The influence of the prevailing Westerlies and the rotation of the earth propel the current eastwards to merge with the cold West Wind Drift as the South Atlantic Current. On reaching the west coast of Africa the current is diverted northwards as the cold Benguela Current (the counterpart of the Canaries Current).
- It brings the cold polar waters of the West Wind Drift into tropical latitudes. Driven by the regular South-East Trade Winds, the Benguela Current surges equatorwards in a north-westerly direction to join the South Equatorial Current.
- This completes the circulation of the currents in the South Atlantic. Between the North and South Equatorial Currents is the east- flowing Equatorial Counter Current.

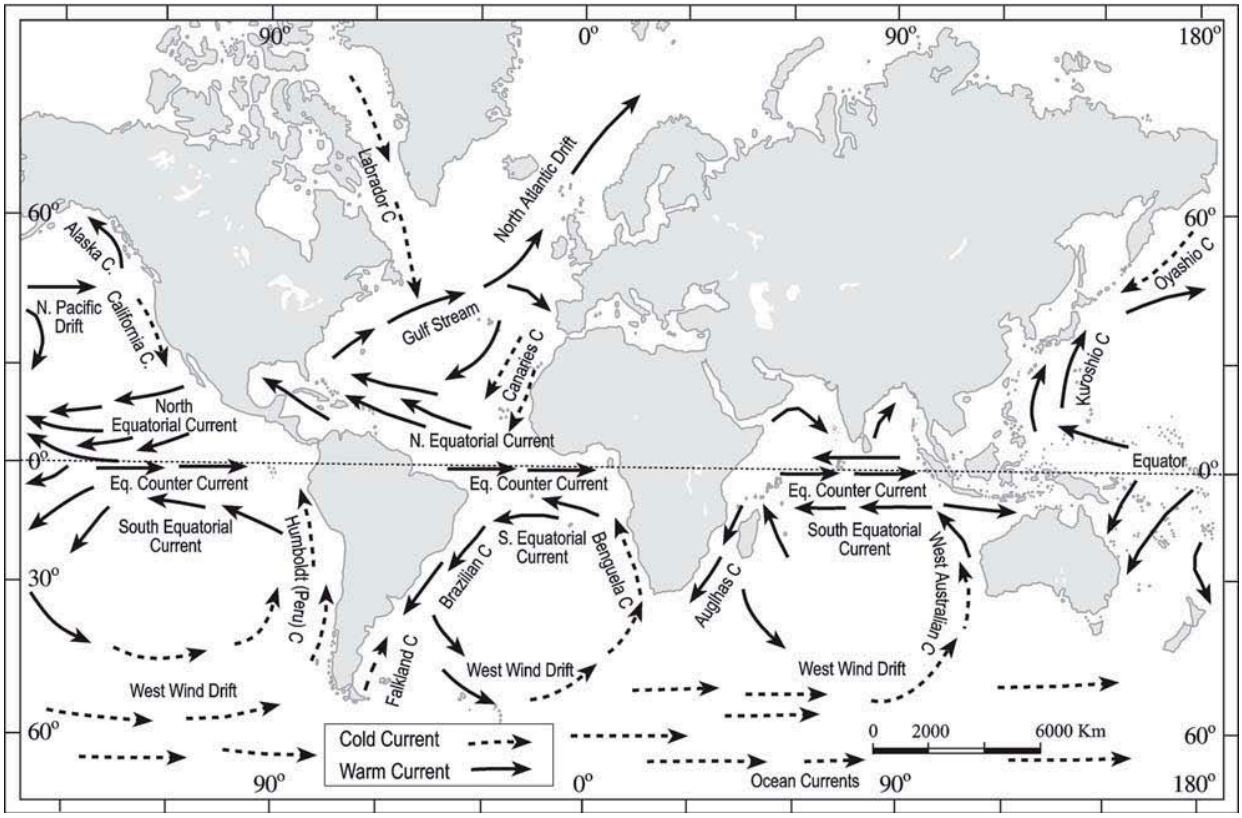
The Circulation of the Pacific Ocean

- The pattern of circulation in the Pacific is similar to that of the Atlantic except in modifications which can be expected from the greater size and the more open nature of the Pacific.The North Equatorial Current flows westwards with a compensating Equatorial Counter Current running in the opposite direction. Due to the greater expanse of the Pacific and the absence of an obstructing land mass the volume of water is very much greater than that of the Atlantic equatorial current. The North-East Trade Winds blow the North Equatorial Current off the coasts of the Philippines and Formosa into the East China Sea as the Kuroshio or KuroSiwo or Japan Current.
- Its warm waters are carried polewards as the North Pacific Drift keeping the ports of the Alaskan coast ice-free in winter. The cold Bering Current or Alaskan Current creeps southwards from the narrow Bering Strait and is joined by the Okhotsk Current to meet the warm Japan Current as the Oyashio, off Hokkaido.
- The cold water eventually sinks beneath the warmer waters of the North Pacific Drift. Part of it drifts eastwards as the cool Californian Current along the coasts of the western U.S.A. and coalesces with the North Equatorial Current to complete the clockwise circulation.
- The current system of the South Pacific is the same as that of the South Atlantic. The South Equatorial Current, driven by the South-East Trade winds, flows southwards along the coast of Queensland as the East Australian Current, bringing warm equatorial waters into temperate waters. The current turns eastwards towards New Zealand under the full force of the Westerlies in the Tasman Sea and merges with part of the cold West Wind Drift as the South Pacific Current.
- Obstructed by the tip of southern Chile, the current turns northwards along the western coast of South America as the cold Humboldt or Peruvian Current.
- The cold water chills any wind that blows on-shore so that the Chilean and Peruvian coasts are practically rainless. The region is rich in microscopic marine plants and animals that attract huge shoals of fish.

- Consequently, millions of seabirds gather here to feed on the fish. Their droppings completely whiten the coastal cliffs and islands forming thick deposits of gucmo, a valuable source of fertilizer. The Peruvian Current eventually links up with the South Equatorial Current and completes the cycle of currents in the South Pacific.

The Indian Ocean Circulation

- The Equatorial Current, turning southwards past Madagascar as the Agulhas or Mozambique Current merges with the West Wind Drift, flowing eastwards and turns equator-wards as the West Australian Current.
- In the North Indian Ocean, there is a complete reversal of the direction of currents between summer and winter, due to the changes of monsoon winds. In summer from June to October, when the dominant wind is the South-West Monsoon, the currents are blown from a south-westerly direction as the South- West Monsoon Drift.
- This is reversed in winter, beginning from December, when the North-East Monsoon blows the currents from the north-east as the North-East Monsoon Drift.
- The currents of the North Indian Ocean, demonstrate most convincingly the dominant effects of winds on the circulation of ocean currents.



Major currents in the Pacific, Atlantic and Indian oceans

The Oceanic Deposits of the Ocean Floor

Materials eroded from the earth which are not deposited by rivers or at the coast are eventually dropped on the ocean floor. The dominant process is slow sedimentation where the eroded particles very slowly filter through the ocean water and settle upon one another in layers. The thickness of the layer of sediments is still unknown. Its rate of accumulation is equally uncertain. Generally speaking, we may classify all the oceanic deposits as either muds, oozes or clays.

- **The muds-**These are terrigenous deposits because they are derived from land and are mainly deposited on the continental shelves. The muds are referred to as blue, green or red muds; their colouring depends upon their chemical content.

- **The oozes-**These are pelagic deposits because they are derived from the oceans. They are made of the shelly and skeletal remains of marine micro¬organisms with calcareous or siliceous parts. Oozes have a very fine; flour-like texture and either occur as accumulated deposits or float about in suspension.
- **The clays**-These occur mainly as red clays in the deeper parts of the ocean basins, and arc particularly abundant in the Pacific Ocean. Red clay is believed to be an accumulation of VOLCANIC DUST blown out from volcanoes during volcanic eruptions.

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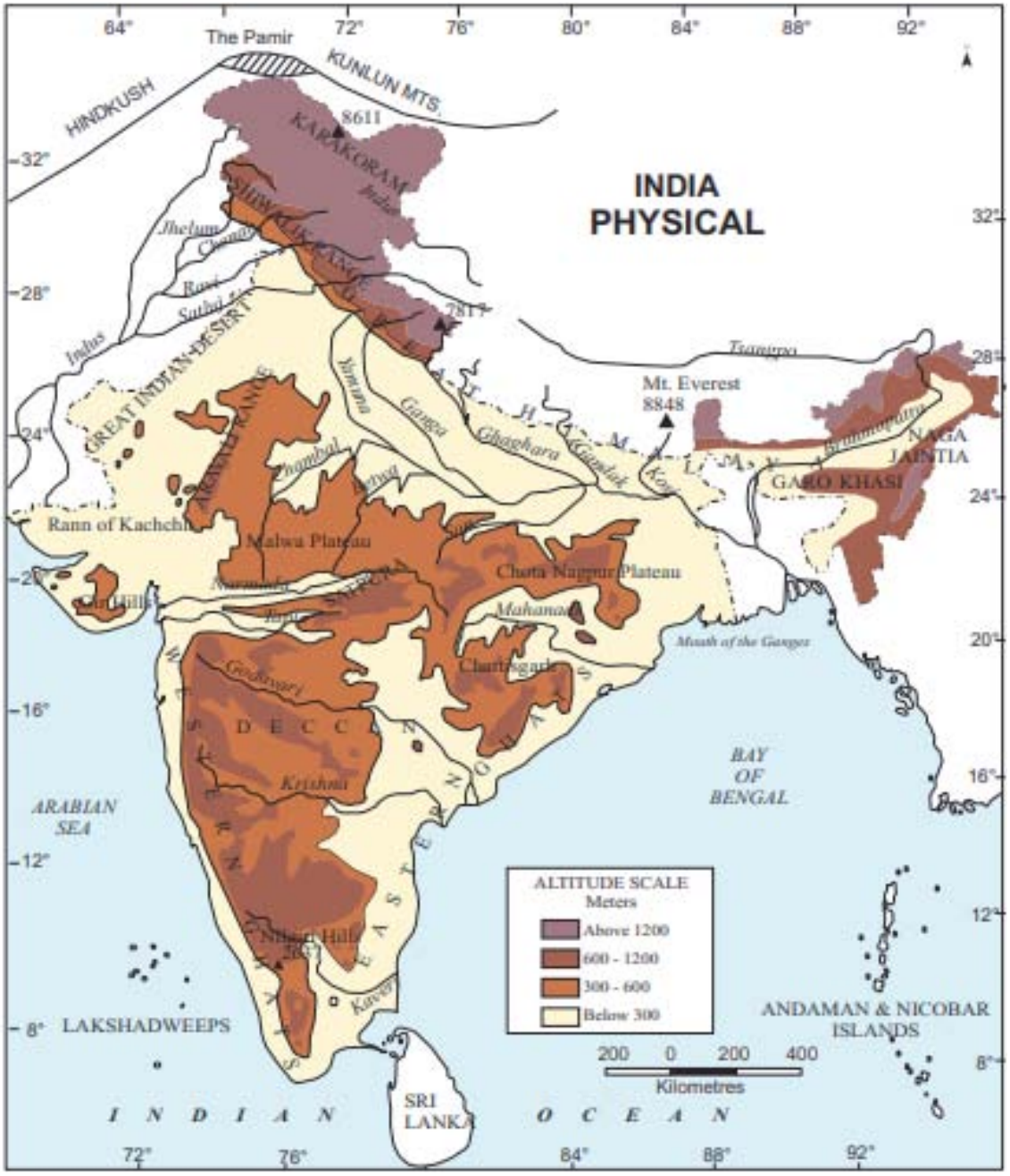
DAY - 23

PHYSIOGRAPHY OF INDIA

India is the seventh largest country in the world. It has land boundaries of 15,200 km and 6100km long coast line. India's landmass covers 3.28 million square kilometer of area. This accounts for nearly 2.42 percent of the total geographical area of the world. India is the largest country in terms of area and population in South-Asia. It is surrounded by ocean.



India is strategically located in Indian Ocean. It commands sea routes between Europe and Africa, SouthEast Asia, far East Asia and Oceania. It is because of this that India shares good trade relation between many countries since ancient times. India has a good location in terms of sea and also well connected by land. Various passes like Nathu-La (Sikkim), Shipki-La (Himachal Pradesh), Zoji-La and Burji la pass (Jammu & Kashmir) have their own importance.

The main India-Tibet trade route that connects Kalimpong near Darjeeling with Lhasa in Tibet passes through Jelepa La. Several passes have provided a passage to many ancient travelers. These routes are not only important for trade but also to exchange ideas and culture.

India has the topographical diversity .The reasons for variation in the topography could be:

- Differences in the rock formations. These landmasses have been formed in different geological periods.
- Number of processes such as weathering, erosion and deposition has modified these features to their present forms.
- India is a country of physical diversity. There are high mountain peaks in some areas while in others, lie the flat plains formed by rivers. On the basis of physical features, India can be divided into following six divisions:
  1. The Northern mountains
  2. The Northern Plains
  3. The Peninsular Plateau
  4. The Indian Desert
  5. The Coastal Plains
  6. The Islands.

The Northern Mountain:

- It is divided into three groups. They are:
  - The Himalayas
  - The Trans Himalayas
  - The Purvanchal hills

The Himalayan Mountains

- Himalayas are the young fold mountains. This is the highest mountain range of the world. Himalayas act as natural barrier. The extreme cold, snow and rugged topography discourage theneighbors to enter India through Himalayas. They run from west-east direction from Indus to Brahmaputra along the northern boundary of Indiacovering a distance of 2500 km. Their width varies from 400 km in the west and 150 km in the East. The Himalayas may be divided into three parallel ranges:
  1. Greater Himalayas or Himadari
  2. Lesser Himalayas or Himachal
  3. Outer Himalayas or Siwaliks.

  1. **The Greater Himalayas or Himadari:** The Greater Himalayas comprises of the northern most ranges and peaks. It has an average height of 6000 metres and width lies between 120 to 190 Kms.It is the most continuous range. It is snow bound and many glaciers descend from this range. It has high peaks like Mt. Everest, Kanchenjunga, Makalu, Dhaulagiri, Nanga Parbat etc. having a height of more than 8000 metres. Mt. Everest (8848 m) is the highest peak of the world and Kanchenjunga is the highest peak of Himalaya in India. High Mountain passes also exist in this range, namely, Bara Lacha-La, Shipki-La, Nathu-La, Zoji-La, Bomidi-La etc. The Ganga and Yamuna rivers originate from this Himalayas.
  2. **The Lesser Himalayas or Himachal:** The altitude of this range lies between 1000 and 4500 metres and the average width is 50 km. The Prominent ranges in this are PirPanjal, DhaulaDhar and Mahabharata ranges.It compresses of many famous hill stations like Shimla, Dalhousie

Darjeeling, Chakrata, Mussoorie, Nanital etc. It also comprises of famous valleys like Kashmir, Kullu, Kangra etc.

3. **The Outer Himalayas or the Siwaliks:** It is the outer most range of the Himalayas. The altitude varies between 900-1100 meters and the width lies between10km-50 km. They have low hills like Jammu Hills, etc.The valleys lying between Siwalik and Lesser Himalayas (Himachal) are called 'Duns' like Dehra Dun, Kotli Dun and Patli Dun.

The Trans-Himalayan ranges

- It extends north of greater Himalaya and parallel to it is called Zaskar range. North of Zaskar range liesLadakh range. The Indus River flows between Zaskar and Ladakh range. The Karakoram Rangelie extreme north of the country. K2 is the second highest peak of the world.

The Purvanchal hills

- It comprises Mishami, Patkoi, Naga, Mizo hills which are located in eastern side. The Meghalaya plateau is also part of these hills which includes the hills of Garo, Khasi and Jaintia.

The Northern Plains

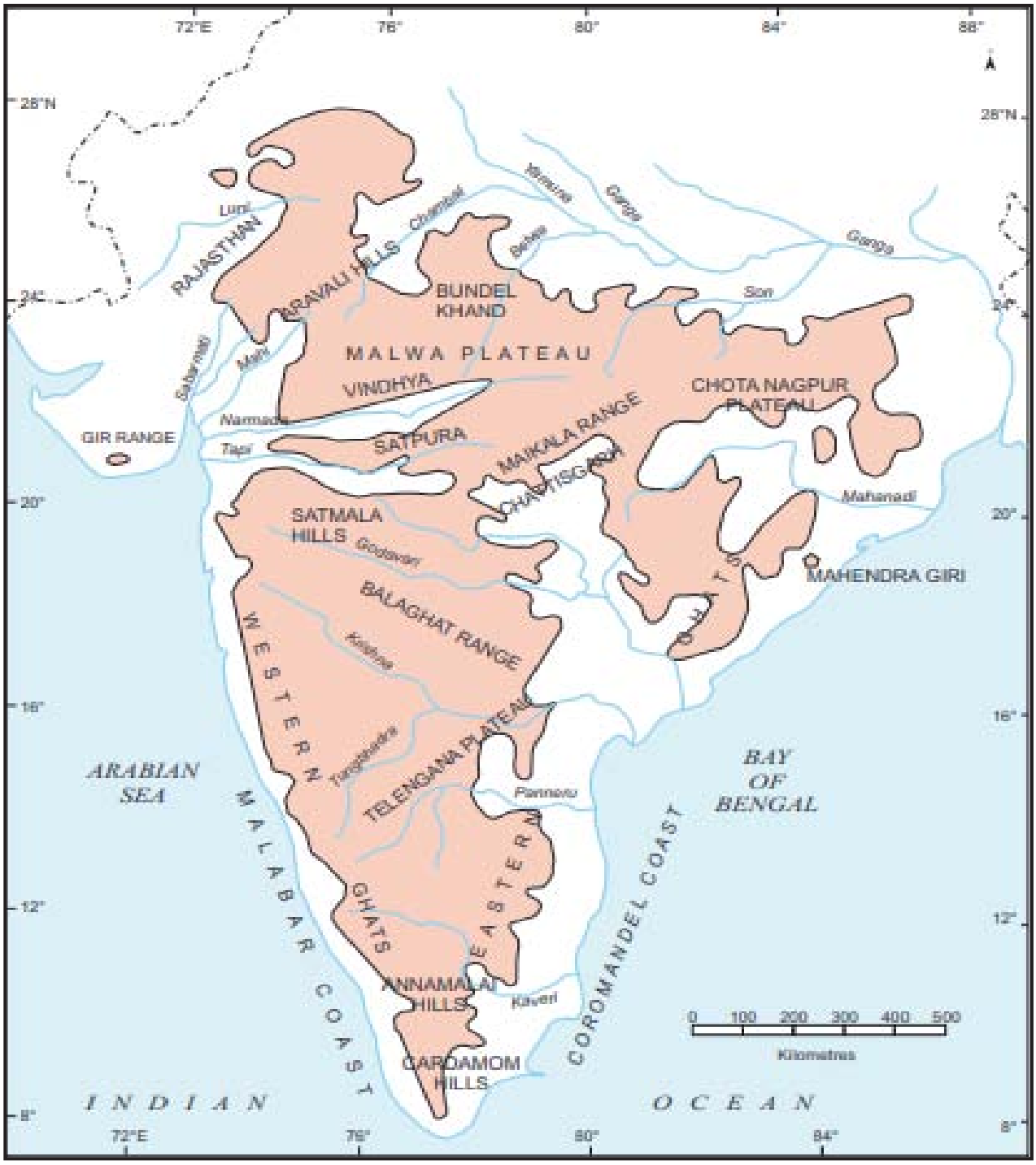
- The Northern Plains are located between south of the Himalayas and north of the Peninsular plateau. It is formed by the deposition of the sediments brought by three main river systems namely: the Indus, the Ganga and the Brahmaputra. From Punjab in the west to Assam in the east, this plain is about 2400 km long. Its width varies from about 300 km in the west to about 150 km in the east. It mainly includes the states of Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal and Assam. This plain is very fertile due to alluvial sediments brought by the rivers from the Himalayas. This plain is one of the largest and most fertile plains of the world. Major crops such as wheat, rice, sugarcane, pulses, oil seeds and jute are grown here. Due to proper irrigation, the plain makes significant contribution in the production of food grains. The Northern plain is broadly divided into two parts:
  1. The Western plain
  2. The Ganga-Brahmaputra plain

  - **The Western Plain**
    - This plain is formed by the river system of the Indus. It lies to the west of Aravallis.This plain is formed due to deposits brought by the rivers like the Satluj, the Beasand the Ravi. This part of the plain has doabs.
  - **The Ganga-Brahmaputra plain**
    - It is also formed by the deposition of the sediments brought by two main river systems, the Ganga and the Brahmaputra. The early civilizations like Mohenjo-Daro andHarappa also called river valley civilizations were spread over plain areas. This is because of the availability of fertile land and water through the river networks.

The Peninsular Plateau

- Peninsular plateau is a triangular shaped table land. It is part of ancient land mass called Gondwana level. It covers an area of nearly 5 lakh sq.km. It is spread over the states of Gujarat, Maharashtra, Bihar, Karnataka and Andhra Pradesh River Narmada divides the peninsular plateau into two parts: The central highlands and Deccan Plateau.
- **The central Highlands:** It extends from Narmada river and the northern plains. Aravallis is the important mountain which extends from Gujrat through Rajasthan to Delhi. The highest peak of the Aravallis hills is Gurushikhar (1722m) near Mt. Abu. The Malwa Plateau and Chhota Nagpur plateau are parts of the central highlands. River Betwa, chambal and Ken are the important river of Malwa plateau while Mahadeo, Kaimur and Maikal are the important hills of chhota Nagpur plateau. The valley of Narmada is lies between the Vindhyas and the Satpura which flows east to west and joins the Arabian sea.
- **The Deccan Plateau:** The Deccan plateau is separated by a fault (A fracture in the rock along which rocks have been relatively replaced), from Chota Nagpur plateau. The black soil area in the Deccan

plateau is known as Deccan trap. It is formed due to volcanic eruptions. This soil is good for cotton & sugarcane cultivation. The Deccan plateau is broadly divided into:



- The Western Ghats
- The Eastern Ghats
  - **The Western Ghats:** Western Ghats or Sahyadris lie on the Western edge of the Deccan plateau. It runs parallel to the western coast for about 1600 km. The average elevation of the Western Ghats is 1000 metres. The famous peaks in this area are DodaBetta, AnaimudiamdMakurti. The highest peak in this region is Anaimudi (2695m.). Western ghats are continuous and can be crossed through passes like Pal Ghat, ThalGhot and BhorGhat. The rivers like Godavari, Bhima and Krishna flow eastward while the river Tapti flows westward. The streams form rapids & water falls before entering the Arabian Sea. The famous water falls are Jogfalls on Sharavati, Shiva Samudram falls on Kaveri etc.

- **The Eastern Ghats:** The Eastern Ghats are discontinuous low belt. Their average elevation is 600m. They run parallel to the east coast from south of Mahanadi valley to the Nilgiri hills. The highest peak in this region is Mahendragiri (1501 m). The famous hills are Mahendragiri hills, Nimaigiri hills in Orissa, Nallamallai hills in Southern Andhra Pradesh, Kollimalai and Pachaimalai in Tamilnadu. The area is drained by the Mahanadi, Godawari, Krishna and Kaveri river systems. TheNilgiri hills join Western & Eastern Ghats in the south.

The Indian Desert

- The Indian Desert lies towards the western margin of Aravali Hills. It is also called Thar Desert. It is the ninth largest desert in the world. It spreads over the states of Gujarat and Rajasthan. This region has semi-arid and arid weather conditions. It receives less than 150 mm of rainfall per year. The vegetation cover is low with thorny bushes. Luni is the main river in this area. All other streams appear only at the time of rainfall otherwise they disappear into the sand.

The Coastal Plains

- The coastal plains in India run parallel to the Arabian Sea & Bay of Bengal along the Peninsular Plateau.The western coastal plain is a narrow belt along the Arabian sea of about 10-20km wide. It stretches from Rann of Kachchh to KanyaKumari.
- Western coastal plains comprises of three sectors
  - Konkan Coast (Mumbai to Goa),
  - Karnataka coast from Goa to Mangalore
  - Malabar Coast (Mangalore to KanyaKumari).
- The eastern coast runs along Bay of Bengal. It is wider than the western coastal plain. Its average width is about 120kms. The northern part of the coast is called Northern Circar and the southern part is called Coromandal Coast.
- Eastern coastal plain is marked by Deltas made by the rivers Mahanadi, Godavari, Krishna and Kaveri. The Chilka largest salt water lake in India in Odisha is located to the south of Mahanadi Delta. The coastal plains are belts for growing spices, rice, coconut, pepper etc. They are centres of trade & commerce.
- The coastal areas are known for fishing activities, therefore large number of fishing villages have developed along the coasts. Vembanad is famous lagoon which is located at Malabar Coast.

The Islands

- India has two main groups of Islands. There are 204 islands in Bay of Bengal called as Andaman and Nicobar Islands and 43 islands in Arabian Sea called as Lakshadweep islands
- The Andaman & Nicobar Island extend from north to south in Bay of Bengal.
- They are bigger in size. An active volcano is located on the Barren Island in Andaman & Nicobar group of islands. Lakshadweep islands are located near Malabar Coast of Kerala in the Arabian Sea.
- They cover an area of 32 sq km. Kavarati is the capital of Lakshdweep.
- These islands are formed by corals and endowed with variety of flora and fauna. These islands are important tourist attraction under water activities like snokling, such diving, deep sea diving and other sports make these island more popular.

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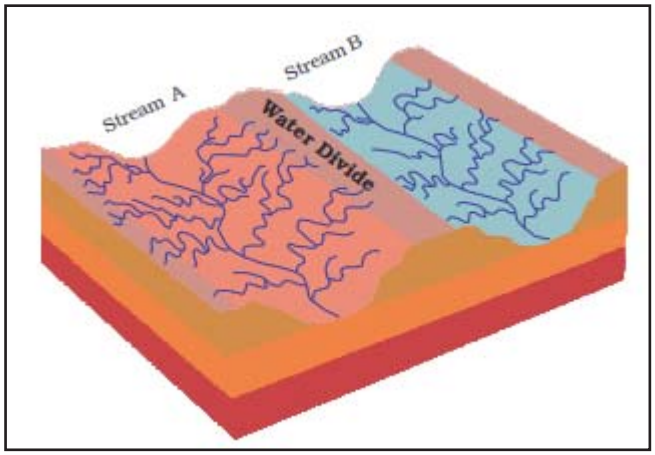
DAY - 24

DRAINAGE SYSTEM OF INDIA

The term drainage describes the river system of an area. The area drained by a single river system is called a drainage basin. A closer observation on a map will indicate that any elevated area, such as a mountain or upland, separates two drainage basins. Such an upland is known as a water divide.

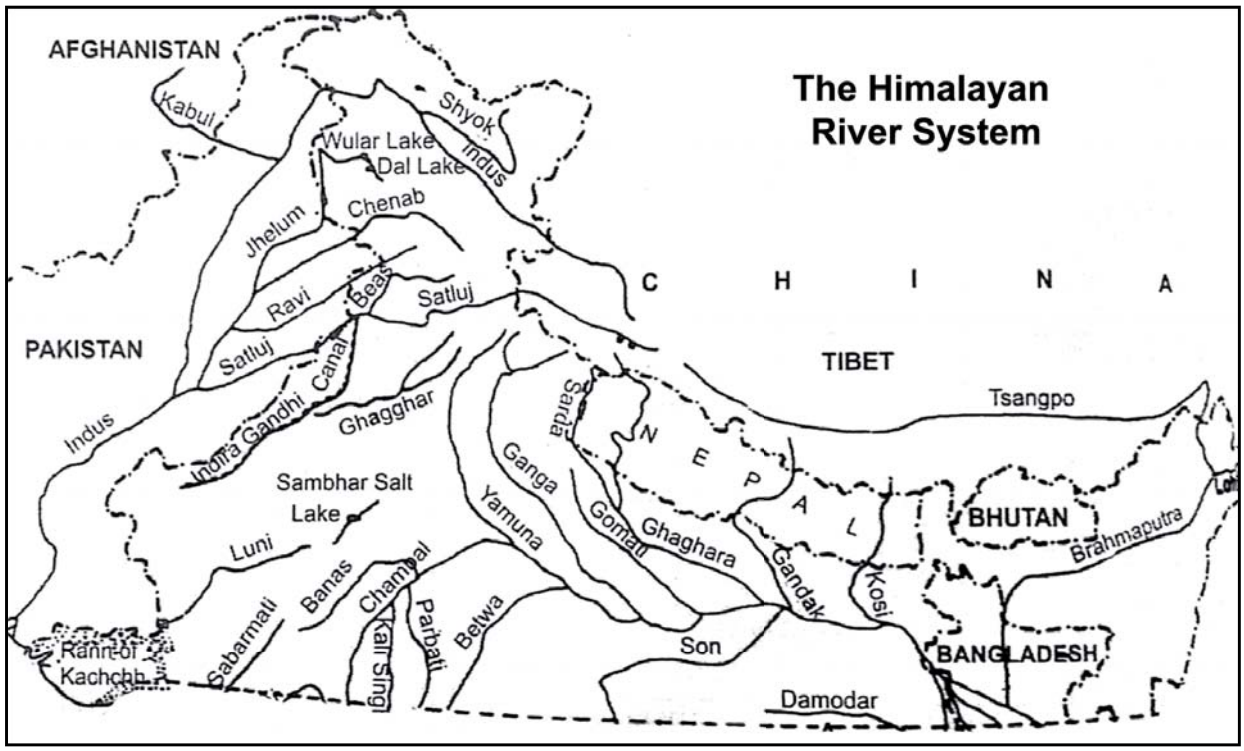


The drainage systems of India are mainly controlled by the broad relief features of thesubcontinent. Accordingly, the Indian rivers are divided into two major groups:

- The Himalayan rivers; and
- The Peninsular rivers.

Apart from originating from the two major physiographic regions of India, the Himalayan and the Peninsular Rivers are different from each other in many ways. Most of the Himalayan Rivers are perennial. It means that they have water throughout the year. These rivers receive water from rain as well as from melted snow from the lofty mountains. The two major Himalayan Rivers, the Indus and the Brahmaputra originate from the north of the mountain ranges. They have cut through the mountains making gorges. The Himalayan Rivers have long courses from their source to the sea. They perform intensive erosional activity in their upper courses and carry huge loads of silt and sand. In the middle and the lower courses, these rivers form meanders, oxbow lakes, and many other depositional features in theirfloodplains. They also have well-developed deltas. A large number of the Peninsular Rivers are seasonal, as their flow is dependent on rainfall. During the dry season, even the large rivers have reduced flow of water in their channels. The Peninsular Rivers have shorter andshallower courses as compared to their Himalayan counterparts. However, some of them originate in the central highlands and flow towards the west. Most of the rivers of peninsular India originate in the Western Ghats and flow towards the Bay of Bengal.

Himalayan Drainage System



Indus River System

- Indus River is great trans-Himalayan river of South Asia. It is one of the longest rivers in the world, with a length of some 1,800 miles (2,900 km). Its total drainage area is about 450,000 square miles (1,165,000 square km), of which 175,000 square miles (453,000 square km) lie in the Himalayan ranges and foothills and the rest in the semiarid plains of Pakistan.
- The Indus originates in the Kailash range in Tibet near Lake Manasarovar. It follows a north-westerly course through Tibet. It enters Indian Territory in Jammu and Kashmir. It forms a picturesque gorge in this part. Several tributaries - the Zaskar, the Shyok, the Nubra and the Hunza join it in the Kashmir region. It flows through the regions of Ladakh, Baltistan and Gilgit and runs between the Ladakh Range and the Zaskar Range. It crosses the Himalayas through a 5181 m deep gorge near Attock, lying north of the Nanga Parbat and later takes a bend to the south west direction before entering Pakistan. It has a large number of tributaries in both India and Pakistan and has a total length of about 2880 km from the source to the point near Karachi where it falls into the Arabian Sea. The main tributaries of the Indus in India are Jhelum, Chenab, Ravi, Beas and Sutlej.
- The principal rivers of the Indus River system are snow-fed. Their flow varies greatly at different times of the year: the discharge is at a minimum during the winter months (December to February); there is a rise of water in spring and early summer (March to June); and floods occur in the rainy season (July to September). Occasionally there are devastating flash floods. The Indus and its tributaries receive all their waters in the hilly upper parts of their catchments. Therefore, their flow is at a maximum where they emerge out of the foothills, and little surface flow is added in the plains, where evaporation and seepage considerably reduce the flow volume. On the other hand, some water is added by seepage in the period after the monsoon months. In the main stream of the Indus, the water level is at its lowest from midDecember to mid-February. After this the river starts rising, slowly at first and then more rapidly at the end of March. The high-water level usually occurs between mid-July and mid-August. The river then falls rapidly until the beginning of October, when the water level subsides more gradually.

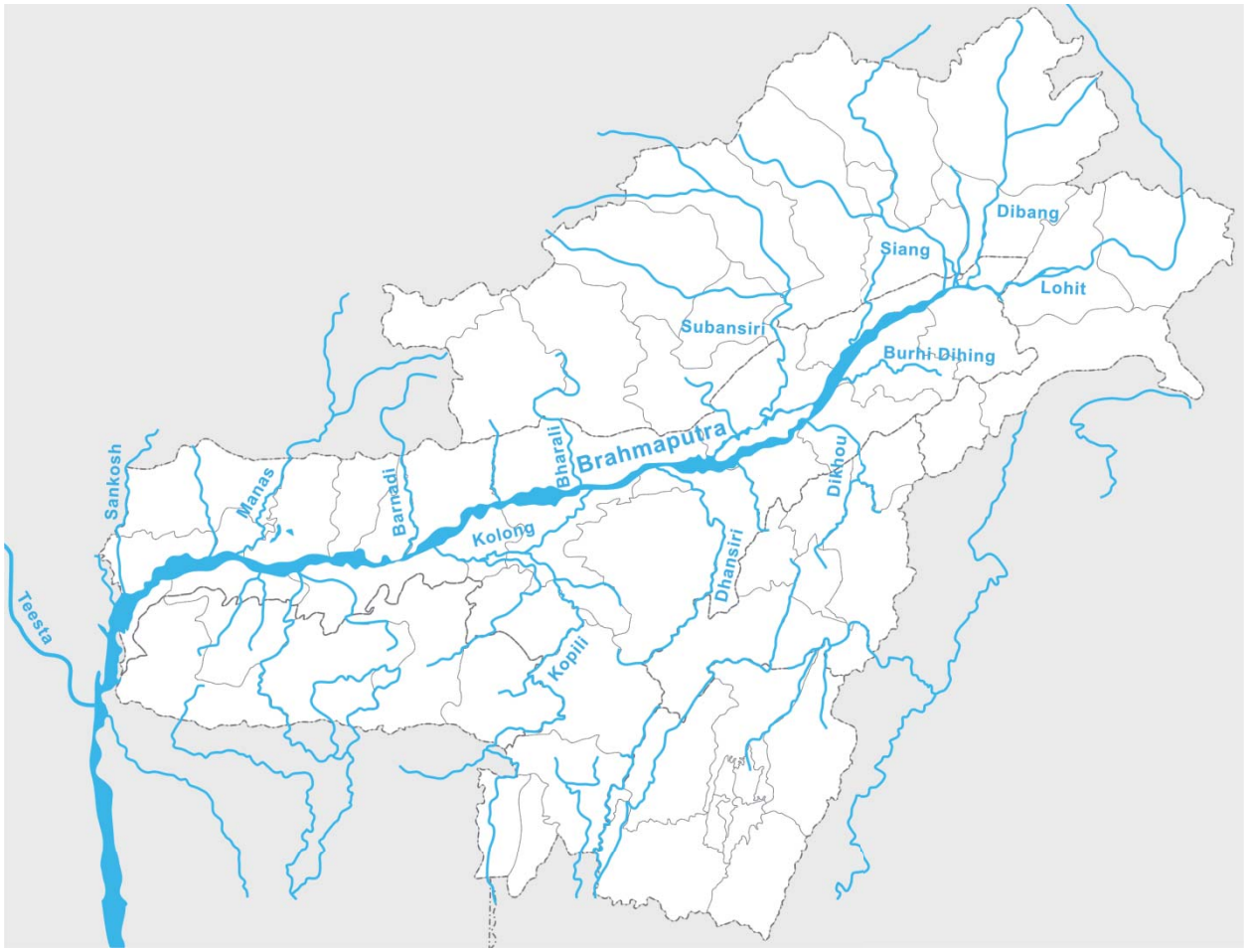
The Ganga River System

- The Ganga river system consists of the River Ganga and a large number of its tributaries. This system drains a very large area comprising the middle part of the Himalayas in the north, the northern part of the Indian Plateau in the south and the Ganga Plain in-between. The total area of the Ganga basin in India is 861,404 sq. km which accounts for 26.3 per cent of the geographical area of the country. This basin is shared by ten states. These states are Uttaranchal and Uttar Pradesh (34.2%), Madhya Pradesh and Chhattisgarh (23.1%), Bihar and Jharkhand (16.7%), Rajasthan (13.0%), West Bengal (8.3%), Haryana (4.0%) and Himachal Pradesh (0.5%). The Union Territory of Delhi accounts for 0.2% of the total area of the Ganga Basin.
- The Ganga originates as Bhagirathi from the Gangotri glacier in Uttar Kashi District of Uttaranchal at an elevation of 7,010 m. Alakhnanda joins it at Devaprayag. But before Devaprayag, the Pindar, the Mandakini, the Dhauliganga and the Bishenganga rivers pour into the Alaknanda and the Bheling fl

ows into the Bhagirathi. The total length of the Ganga River from its source to its mouth (measured along the Hugli) is 2525 km, of which 310 km in Uttaranchal, 1140 km in Uttar Pradesh, 445 km in Bihar and 520 km in West Bengal. The remaining 110 km stretch of the Ganga forms the boundary between Uttar Pradesh and Bihar.

- Before entering the Bay of Bengal, the Ganga, along with Brahmaputra, forms the largest delta of the world between two arms: the Bhagirathi Hugli and the Padma/Meghna covering an area of 58,752 sq km. The delta front of the Ganga is a highly indented area of about 400 km length extending from the mouth of the Hugli to the mouth of the Meghna. The delta is made of a web of distributaries and islands and is covered by dense forests called the Sunderbans. A major part of the delta is a low- lying swamp which is flooded by marine water during high tide.

Brahmaputra River System



- The river Brahmaputra covers a catchment area of about 5,80,000 Sq.km. right from its origin in Himalayan Lake Manasarover at an elevation of about 5,150 m in Tibet to the outfall in the Bay of Bengal. It flows eastward in Tibet and south, south-west in India and traverses a distance of about 2900 km out of which 1,700 km is in Tibet, 900 km is in India and 300 km is in Bangladesh. In the upper reaches, the river is fed by the glaciers and in the lower reaches, it is joined by a number of tributaries which originates at different elevation in the hills encircling the catchment, forming watershed. Among the tributaries Subansiri, Manas, Jiabharali, Pagladiya, Puthimari and Sankosh, etcare snow fed.
- The Tibetan name of river is “TSANGPO” and Chinese name is “YALUZANGBU”. The watershed area is mostly on the northern side of the river in this region. After traversing a distance of about 1700 km eastwardly, the river changes its course from east to south and then enters the Arunachal Pradesh in Indian Territory. Its name also changes from “TSANGPO” to Siang and Dehang in Arunachal Pradesh. The river then flows almost in Southern direction for another distance of about 200 km uptoPassighat. Before touching plains it is joined by two major Himalayan tributaries viz. Lohit and Debang. The combined flow of these rivers is known as the Brahmaputra and passes through the plains of Assam and Bangladesh before falling into the Bay of Bengal. From Passighat to Dhubri

where it travels in plains of Assam is well known as Brahmaputra valley.

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

DRAINAGE SYSTEM OF PENINSULAR INDIA

Origin of Peninsular Drainage

- Subsidence of western flank of peninsula during early tertiary period. It his disturbed the symmetry of peninsular block's river watershed.
- Upheaval of the Himalayas when the northern flank of peninsular block was subjected to subsidence and consequent trough faulting. The Narmada and Tapi flow in trough faults and fill the original cracks with detritus materials. Hence there is lack of alluvial and deltaic deposits in these rivers.
- Slight tilting of peninsular block from North-West to South-East has caused entire drainage system to flow towards Bay of Bengal.
- Types of Peninsular River System (On the basis of direction of flow)
  - West flowing rivers
  - East flowing Rivers

West flowing Rivers

Narmada

- **Origin** – Amarkantak plateau (1,057m) (Shahdol district, Madhya Pradesh)

- **Total Length**– 1,310 km (largest west fl owing river) Only 112 km navigable from mouth.
- Flows 1,078 km in Madhya Pradesh Forms 32 km long boundary between M.P and Maharashtra.
- Forms 40 km long boundary between Maharashtra & Gujarat Flows 160 km in Gujarat
- Makes an estuary before entering into Gulf of Khambhat.
- There are several islands in estuary formed by Narmada. Aliabet is an important estuary island.
- **States** – M.P. Maharashtra, Gujarat
- **Landmarks** – DhuanDhar falls also called cloud of mist (30m) located in Jabalpur district, Madhya Pradesh. This fall is located in a Gorge of marble.
- **Other falls**- Mandhar falls (12m)Dardi fall (12m) Sahasradhara falls (8m)

The Tapi (orTapti)

- **Origin** – Betul plateau (M.P) in Satpura Range
- **Total length** – 730 km (32 km from sea)
- **State** – M.P, Maharastra&Gujrat
- **Meets**- Arabian Sea at Gulf of Khambhat

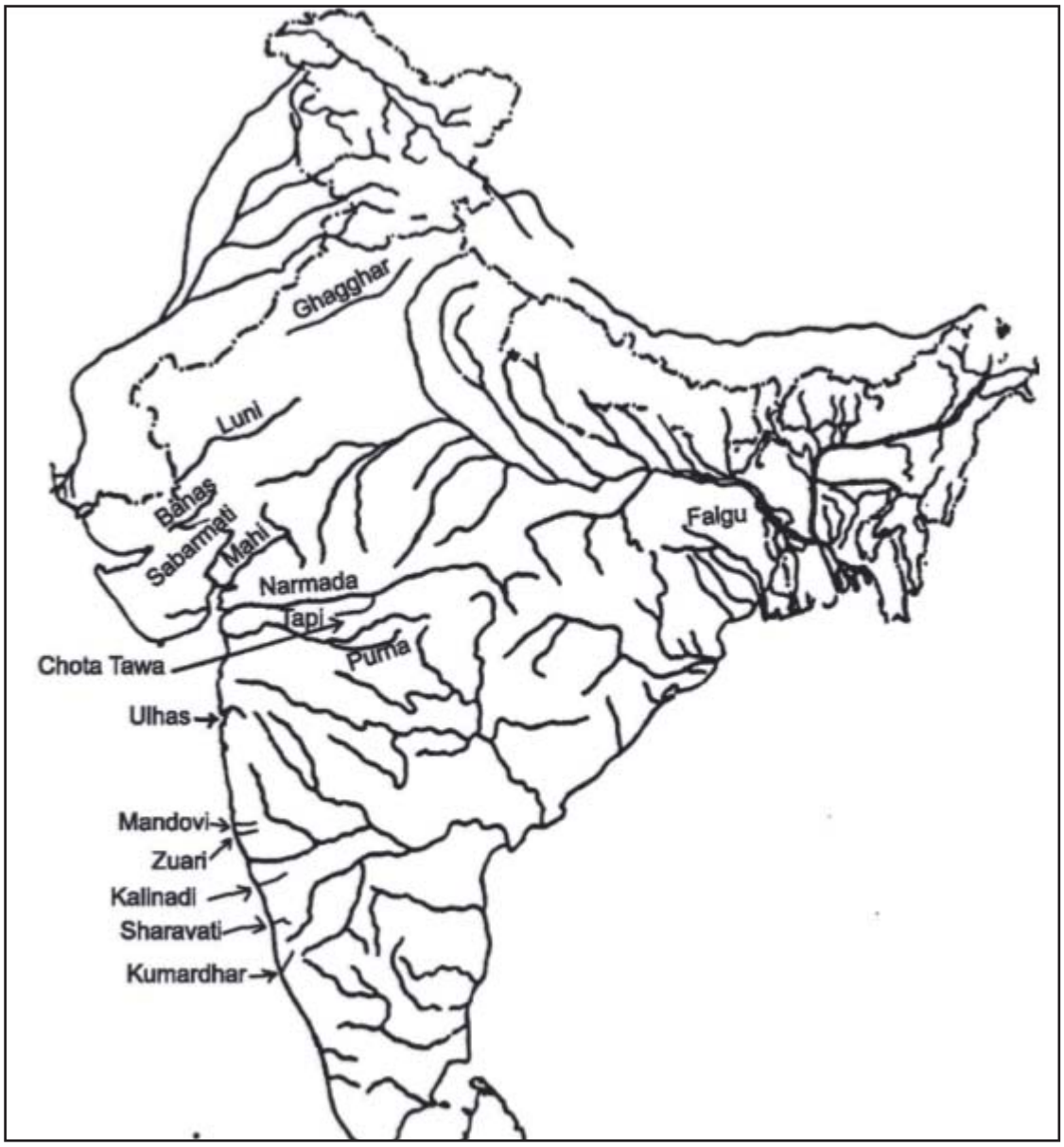
The Sabarmati

- Sabarmati River is formed by confluence of Sabar and Hathmati streams
- **Origin** – Mewar hills (Aravali range) (Rajasthan)
- **Length** – 320 km
- **Mouth** – Gulf of Khambhat
- **States** – Rajasthan & Gujarat
- **Tributaries** – The Sedhi, The Harnav, the Vartak, the Wakul, The Meshwa

The Mahi

- **Origin** – Vindhyas (500 m)
- **Meeting point** – Gulf of Khambat
- **States** – Madhya Pradesh, Maharastra&Gujrat
- **Length** – 533 km
- **Tributaries** – Som, Anas and Panam

Luni



- Also known as **'Sagarmati'**
- It flows through **'Thar Desert'**
- It has an **Inland Drainage** as it disappears into Marshy land of **Rann of Kutch**
- **Origin** – Aravalli (west of Ajmer, Rajasthan)
- **Length** – 482 km
- **Meeting point**– Lost into Marshy land of Rann of Kutch (Inland drainage)

East Flowing Rivers

Damodar

- **Origin –**Chhotanagpur plateau
- **Length** – 541 km
- Its joins the Bhagirathi – Hooghly in West Bengal
- Also known as **'Sorrow of Bengal'**

Suvarnrekha

- **Origin –**Ranchi plateau
- **Length** – 474 km
- **Tributaries** –Baitarni&Brahmani
- It flows in States of Jharkhand and Orissa

Mahanadi

- **Origin** – Dandakaranya (near Sihawa, Raipur, Chhattisgarh)
- **Length** – 857 km States –
- It flows in Chhattisgarh and Odisha.
- It forms delta of about 9,500 km sq.

Rushikulya River

- **Origin** – Nayagarh hills (Odhisha)
- **Length** – 165 km
- **States** – Its fl ows in Odisha
- It flows near Chilka lake (largest brackish water lake of Asia)
- Mouth of Rushikulya River is known for mass hatching of olive ridley turtles. This is smallest and most abundant of all sea turtles found in the world.
- Olive Ridley turtles are only found in tropical waters of Pacific, Altantic and Indian Ocean.

Godavari River

- **Origin – Trimbak** plateau (Nashik, Maharashtra
- **Length** – 1,465 km States – Maharashtra, Andhra Pradesh, Telangana
- It is second largest river of India and largest river system of Peninsular India
- It is also called Gautami or Virdhha Ganga

Krishna River

- **Origin –**Western Ghats just north of Mahabaleshwar (Maharashtra)
- **Length** – 1400 km
- **State** – Maharashtra, Telangana, Karanatka, Andhra Pradesh

Penneru

- **Origin** – Nandidurg Peak (Karnatka)
- **Length** – 597 km
- **State** – Karnatka and Andhra Pradesh
- **Tributaries-**Kundur, Charavati, Papagni, Punchu

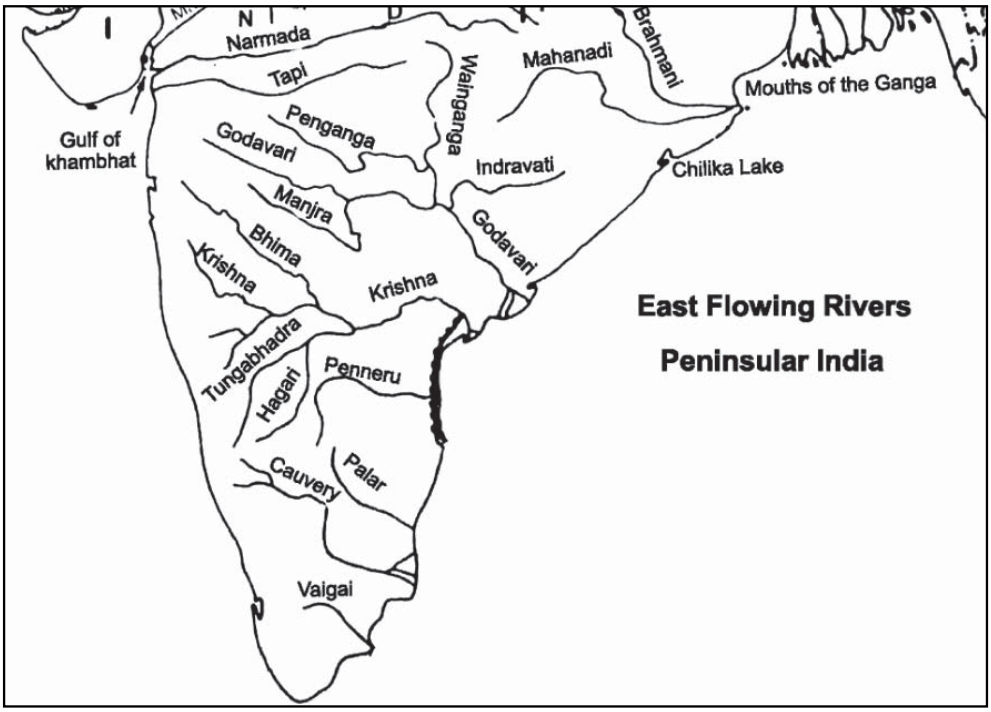
Kaveri

- **Origin –**TaalKaveri (Bramhagiri Range, Western Ghat, near Bengaluru, Karntaka)
- **Length –**800 km
- **States –**Karnatka, Tamil Nadu
- It receives rainfall from both South-West monsoon as well as retreating north-east monsoon due to which it causes flood in its lower course during winter.
- One of the most well utilized rivers having 90-95% capacity utilized.

- Forms delta before merging into Bay of Bengal.
- Sivasamudram waterfalls (101 m high) are situated on it.

Vaigai River

- **Origin –**Varushand hills (near Annamalai hills &Palni hills)
- **Length –**258 km
- **State –**Tamil Nadu
- It is a dry channel which reappears and disappears frequently.
- Madurai is located on Vaigai river



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DAY - 25

CLIMATE OF INDIA

Weather is the momentary state of the atmosphere while climate refers to the average of the weather conditions over a longer period of time. India has hot monsoonal climate which is the prevalent climate in south and Southeast Asia. The monsoon regime emphasizes the unity of India with the rest of Southeast Asian region.

Factors determining the climate of India

India's climate is controlled by a number of factors which are explained below**:**

Factors related to Location and Relief

- **Latitude:**The Tropic of Cancer passes through the central part of India in east-west direction. Thus, northern part of the India lies in sub-tropical and temperate zone and the part lying south of the Tropic of Cancer falls in the tropical zone. The tropical zone being nearer to the equator, experiences high temperatures throughout the year with small daily and annual range. Area north of the Tropic of Cancer being away from the equator, experiences extreme climate with high daily and annual range of temperature.
- **The Himalayan Mountains:** The 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.
- **Distribution of Land and Water:** India is flanked by the Indian Ocean on three sides in the south and girdled by a high and continuous mountain-wall in the north. As compared to the landmass, water heats up or cools down slowly. This differential heating of land and sea creates different air pressure zones in different seasons in and around the Indian subcontinent. Difference in air pressure causes reversal in the direction of monsoon winds.
- **Distance from the Sea:** With a long coastline, large coastal areas have an equable climate. Areas in the interior of India are far away from the moderating influence of the sea. Such areas have extremes of climate. That is why; the people of Mumbai and the Konkan coast have hardly any idea of extremes of temperature and the seasonal rhythm of weather. On the other hand, the seasonal contrasts in weather at places in the interior of the country such as Delhi, Kanpur and Amritsar affect the entire sphere of life.
- **Altitude: Temperature** decreases with height. Due to thin air, places in the mountains are cooler than places on the plains. For example, Agra and Darjeeling are located on the same latitude, but temperature of January in Agra is 16°C whereas it is only 4°C in Darjeeling.
- **Relief:** The physiography or relief of India also affects the temperature, air pressure, direction and speed of wind and the amount and distribution of rainfall. The windward sides of Western Ghats and Assam receive high rainfallduring June-September whereas the southern plateau remains dry due to its leeward situation along the Western Ghats.

Himalayan Climate System

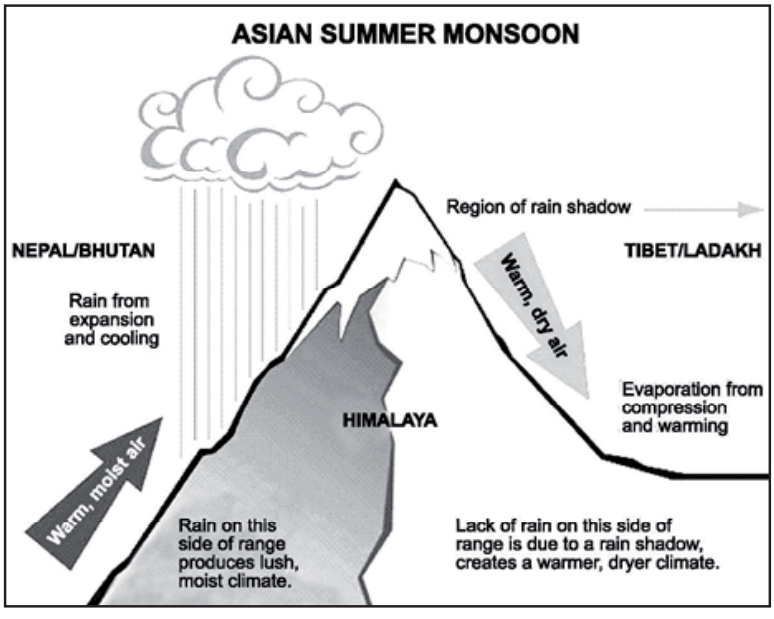
- India is separated from rest of the Asia by the wall of Himalayan mountain ranges. It restricts the cold and dry winds of Central Asia to the North of Himalayas. These mountain ranges also act as an effective physical barrier for rain bearing southwest monsoon winds and force them to shed their moisture within the country. Thus, it acts as an effective climatic divide between the Indian subcontinent and the central Asia.
- Within the Himalayas, Climate varies depending upon elevation and location. Climate ranges from subtropical in the southern foothills to warm temperate conditions in the middle Himalayas to cold temperate conditions in the higher parts of middle Himalayas to a cold alpine climate at higher elevations.

Seasonal Rhythm

- **Winter Season:** The temperature in the winter season falls progressively with the increase in altitude from sea level. At the foothill, the temperature in winter is about 18°C in the day time, at the middle Himalayas it is about 6 to 12°C and above this, the temperature is below freezing point. The higher elevations above 5000 meter are permafrost and Tundra type of climate. Dras valley in Kashmir is the coldest place in India. The minimum temperature recorded here on 28th December 1908 was –45°C.
- During the winter season, the westerly jet streams sets in on the south of the Himalayas due to the shift of the ITCZ (Inter Tropical Convergence Zone) southward. These jet streams often bring the low pressure depression created over the Mediterranean Sea to Himalayan region while its journey from Mediterranean Sea to Himalayas, the moisture content gets augmented by Caspian Sea and Persian Gulf. They even reach up to Arunachal Pradesh. Due to orographic upliftment, they cause precipitation in the form of snowfall. After the passage of the disturbance, widespread fog and cold waves set in the region thus lowering the minimum temperature by 5°C to 10°C below the normal average. The range of diurnal temperature increases and winters become more severe. Haze is common in morning and evening. These situations cause great problems to day to day activities. The roads get blocked, commercial setups cannot work due to snow cover creating difficulty, flights are affected and the people struggle to get everyday requirements and groceries.
- The frequencies of western disturbances vary from year to year but on an average 3 to 5 disturbance per month are experienced. The average precipitation during the three months of winter seasoni. e. from December to February is about 60cm in the Himalayan region. The eastern Himalayan region also gets rainfall from the north east monsoon. Although it is not so significant as the north east monsoon winds are coming from land and do not have sufficient moisture content due to lack of source, but the combined effect of western disturbances and north east monsoon causes an average precipitation of about 50 cm in Sikkim**,** Arunachal Pradesh and Assam.

Summer Season

- The period from March to June in India is the summer season. This season is mostly dry and hot. At the foothills of Himalayas, the maximum average temperature is about 30°C. Due to the effect of the lapse rate (6.5°C per 1000m of elevation) with altitude, the maximum temperature in the middle Himalayas ranges from 15°C to 25°C, varying in accordance with the altitude, latitude, and other governing factors of temperature. Above the elevation of 5000 m, the temperature is almost below freezing point throughout the year.



- Due to heating of land surface in the area of Chota Nagpur plateau region, a low pressure is created locally which leads to convectional movement of the air. This low pressure depression is carried to the eastern Himalayan region by the westerly jet streams. These air mass further gets cooled adiabatically due to orographic upliftment and causes precipitation in the eastern Himalayan region in the sates of Arunachal Pradesh, Assam, Nagaland, etc. The western disturbances still persist, although, their frequency is reduced. It brings precipitation in the upper reaches of the Himalayas. The weather condition changes abruptly with the arrival of western disturbances. The sky is overcast with clouds. The precipitation is in the form of snowfall and sleet. This condition persists till early April but can be experienced in May also in the upper reaches. These disturbances move eastward and can cause snowfall and thunderstorms in central and eastern Himalayas also till the end of April.
- The diurnal temperature range gradually reduces and is in the range of 11°C to 16°C varying with altitude, distance from sea, wind direction and other governing factors.

Rainy Season

- This season is also called as monsoon season as it starts with the onset of northwest monsoon in India. The monsoon season in India generally starts in last week of May and first week of June varying year to year. The weather conditions change. The relative humidity of the atmosphere increases, sky is over cast with clouds, atmospheric temperature increases before the outbreak of monsoon and there may be some spells of pre monsoon showers.
- As the monsoon comes, there is significant fall in the atmospheric temperature ranging from 3°C to 6°C lower than the month of June in the Himalayan region. After this sudden fall in temperature, there is no further fall in temperature throughout the season. However in the month of September, as the monsoon starts to retreat there is an increase in temperature for a short time period. The night temperature is more or less constant while the day temperature fluctuates on day to day basis. The diurnal temperature range is less and varies between 4°C to 6°C due to the greenhouse effect created by the clouds.
- The eastern Himalayas get the monsoonal rain earlier than the western Himalayas due to nearness to the sea and the direction of movement of the Bay of Bengal branch of monsoon wind. Around June 5, the monsoon breaks in eastern Himalayas. From here, due to the barrier effect of the Himalayas and the orientation of the Himalayas, the Bay of Bengal branch moves westerly along the foothills of Himalayas into the Ganga plains.
- The Arabian Sea branch moving on the eastern side of the Aravalis after being deflected due to the orientation of Western Ghats meets Bay of Bengal branch at Agra and moves towards Kashmir. The monsoon breaks in the western Himalayan region around 1st of July.
- But in the western Himalayan region, the precipitation is not as intensive as in the eastern region because most of the moisture is lost during journey of the monsoon winds up till here due to precipitation.
- However the Arabian Sea branchbrings more precipitation due to its shorter length of journey uptill western Himalayas. Heavy rainfall is caused in the eastern Himalayas, sub Himalayan regions and the southern slopes of Himalayas. This leads to high flooding of the rivers having their catchment areas in Himalayas.
- For eg.: Brahmaputra receives the water of the eastern Himalayas causing floods in the Assam plains, Kosi River receives the water of eastern Nepal Himalayas by Saptakosi catchment area causing floods in Bihar plains, etc. The western Himalayan region receives around 65 cm of average rainfall in the monsoon season, while the eastern Himalayas, as explained earlier, experience the precipitation around 200 cm to 410 cm on an average, while on some places, it reaches to as high as 600 cm also.

Cold Season

- The beginning of withdrawal of southwest monsoon marks the start of cold season which continues uptillNovember after which the winter season starts.
- In the Himalayan region, the monsoon in the western Himalayas reaches the last i.e. in the first week of July and withdraws from their first i.e. in the second week of September, which gives only two and a half month for the monsoonal activity in the western Himalayas. While in the eastern

Himalayan region the monsoon strikes in the first week of June and withdraws in second week of October giving a period of four and a quarter of month for monsoonal activity. Added to this, the eastern Himalayas get a good amount of precipitation from north east monsoon also. This is why there is a great regional disparity in the amount of total rainfall and precipitation received among the different regions of the Himalayas.

- In the season with the cession of the monsoon initially the temperature rises in the range of 3°C to 5°C but within a week or two, the temperature starts falling steeply. Within a month and half i.e. from second week of December, the minimum temperature in the Himalayan region falls below the freezing point. The diurnal temperature range increases steeply due to lack of clouds and absorption of latent heat of melting by the ice sheets.
- During this season from the last week of October the western disturbances start to appear and their frequency increase on the monthly basis as the westerly jet stream gets stronger progressively with the southward movement of Sun and the ITCZ. These western disturbances bring snow fall in the upper reaches.
- This season draws huge amount of tourists in the Himalayan region because of the snow cover. It provides them a perfect place for the skiing and other winter sports.

Annual Rainfall

- The areas receiving an annual rainfall of 200 cm and above are termed as areas of very high rainfall.
- The eastern Himalayas receive an annual rainfall of about 200 cm to 400 cm and even up to 400 to 800 cm in few pockets. Almost the whole of Arunachal Pradesh, Sikkim, Assam & Nagaland come under the area of heavy rainfall.
- The areas receiving a rainfall of 100cm to 200cm annually come under the zone of high rainfall. The southern parts of Jammu and Kashmir, Himachal Pradesh and Uttarakhand in Western Himalayas and other regions on the southern slopes of western Himalayas come under the zone of high rainfall.
- The areas receiving 50 cm to 100 cm of rainfall comes under the region of low rainfall. The leeward side of the southern Himalayas in Jammu and Kashmir and the valley areas of western Himalayas come under the zone of low rainfall.
- The areas receiving a rainfall of less than 50 cm comes under the zone of very low rainfall. The only area which is receiving less than 50 cm of rainfall in the Himalayan region is the Ladakh region of the state of Jammu and Kashmir. This area does not have the temperature as high as that of tropical and subtropical region that is why Ladakh region is also called as cold desert.

Indian Monsoon

- Monsoon is a seasonal prevailing wind that lasts for several months. The term was first used in English in India, to refer to the big seasonal winds blowing from the Indian Ocean and Arabian Sea in the Southwest bringing heavy rainfall to the area.
- The unique monsoon circulation in the Indian Ocean and associated rainfall over India has a fundamental impact on socio-economic and agricultural development in this densely populated country. The monsoon accounts for 80 per cent of the rainfall in the country.

Factors Affecting Indian Monsoon

1. Tibet Plateau (TP)

- It is the most mountainous in the world, with a mean height that exceeds 4000 m above sea level. The mechanical effect of the plateau has determinative roles upon the formation of a regional climate system in Asia.
- The thermal effect of the plateau may profoundly affect the atmospheric circulation as well because the sensible and latent heat fluxes from TP reach a higher altitude than its surroundings. The atmosphere above TP is heated more strongly than the surrounding atmosphere at the same level.

- The roles of the Tibetan Plateau (TP) upon the transition of precipitation in the South Asian summer monsoon are investigated using a simplified regional climate model. Before the onset of the south Asian monsoon, descending flow in the mid-troposphere, which can be considered as a suppressor against precipitation, prevails over northern India.
- The descending motion gradually weakens and retreats from this region before July, consistent with the northwestward migration of the monsoon rainfall. To examine a hypothesis that the dynamical and thermal effects of TP cause the mid-tropospheric subsidence and its seasonal variation, a series of numerical experiments are conducted using a simplified regional climate model. The mechanical effect of the TP generates robust descending flow over northern India during winter and spring when the zonal westerly flow is relatively strong, but the effect becomes weaker after April as the westerly flow tends to be weaker.
- The thermal effect of the TP, contrastingly, enhances the descending flow over north India in the pre-monsoonal season. The descending flow enhanced by the thermal effect of the TP has a seasonal cycle because the global-scale upper-level westerly changes the energy propagation of the thermal forcing response.
- The subsidence formed by the mechanical and thermal effects of the TP disappears over northern India after the subtropical westerly shifts north of the plateau, the seasonal change of which is in good agreement with that in the re-analysis data. The retreat of the descending flow can be regarded as the withdrawal of the pre-monsoon season and the commencement of the South Asian monsoon. After that, the deep convection, indicating the onset of the Indian summer monsoon, is able to develop over north India in relation to the ocean- atmosphere and land-atmosphere interaction processes. Northwest India is known to be the latest region of summer monsoon onset in south Asia. Thus, the thermal and mechanical forcing of the TP has great impact on the transition of the Indian monsoon rainfall by changing the mid-troposphere circulation.
- Recently it has been found that there is a positive correlation between Tibetan snow cover and Indian summer monsoon rainfall (IMR). The seasonal monsoon wind shift and weather associated with the heating and cooling of the Tibetan plateau is the strongest such monsoon on earth.

2. Jet Stream Theory

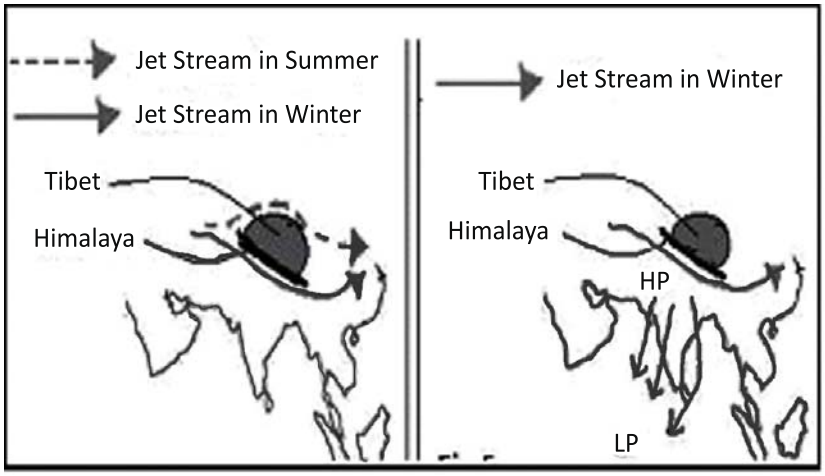
- This theory tries to explain the establishment of both the NE and SW Monsoons as well their unique features like bursting and variability. The jet streams are a system of upper-air westerlies. It gives rise to slowly moving upper-air waves, with 250 knots winds in some air streams.
- Over India, a subtropical westerly jet develops in the winter season which is replaced by the tropical easterly jet in the summer season. The high temperature over the Tibetan Plateau, as well as over Central Asia in general, during the summer is believed to be the critical factor leading to the formation of the tropical easterly jet over India in summer. The mechanism affecting monsoon is that the westerly jet causes high pressure over northern parts of the subcontinent during the winter. This results in the north to south flow of the winds in the form of the NE Monsoon. With the northwards shift of the vertical sun, this jet shifts northwards too. The intense heat over the Tibetan Plateau, coupled with associated terrain features of high altitude of the plateau, etc. generate the tropical easterly jet over Central India. This jet creates a low pressure zone over the northern Indian plains influencing the wind flow towards these plains, assisting the establishment of the SW Monsoon.

3. Tropical easterly jet

- Due to low pressure over Tibetan plateau, high pressure exists in upper troposphere. Due to high pressure, tropical easterly jet stream blow from Tibetan plateau to Mascrene high (low pressure at troposphere) near Madagascar. This helps in sudden onset of monsoon.

4. Subtropical westerly jet stream

- Subtropical westerly jet stream flows entirely south of Himalayas over north India. (during winter). They form depressions and high pressure over northern India.



5. Somali current and Somali jet stream (Phinlander jet)

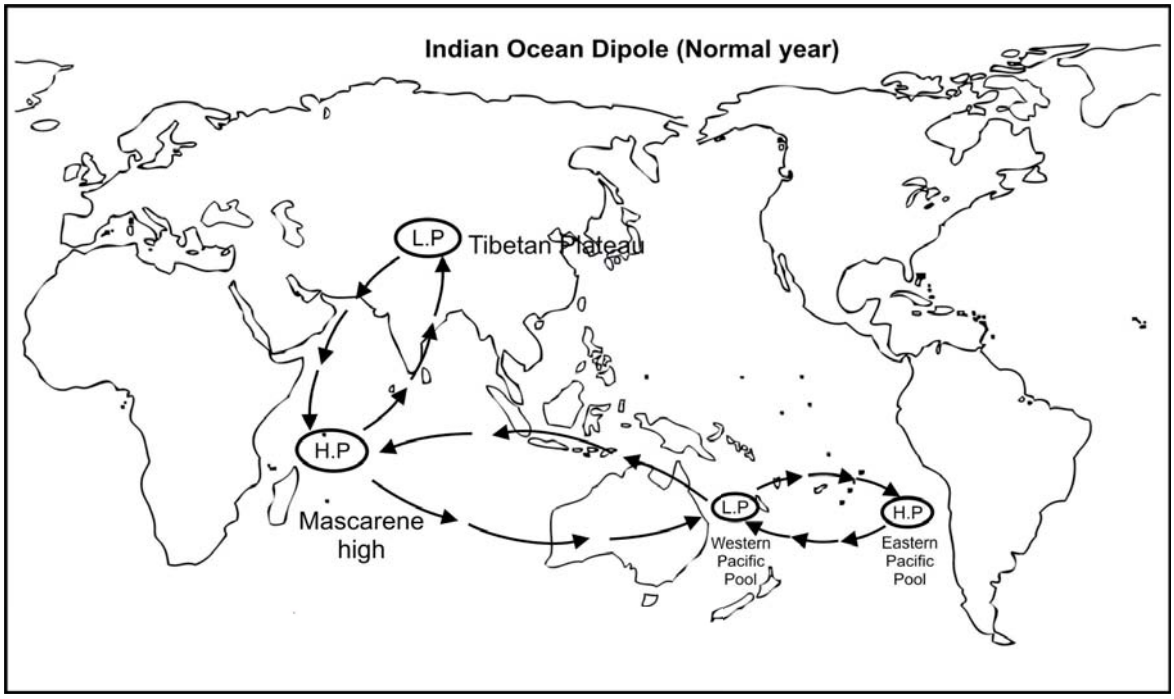
- During June-July-August due to creation of high pressure at Mascrene high basin, air diverges due to which it goes towards horn of Africa. Here it is divided into two parts - one goes towards Africa and another goes towards Indian subcontinent.]
  - It is a low level jet stream (appear only in summer)
  - Its occurrence predicts good monsoon in India.
  - Somali jet Stream is a low level jet stream which flows from Somalia to Indian mainland

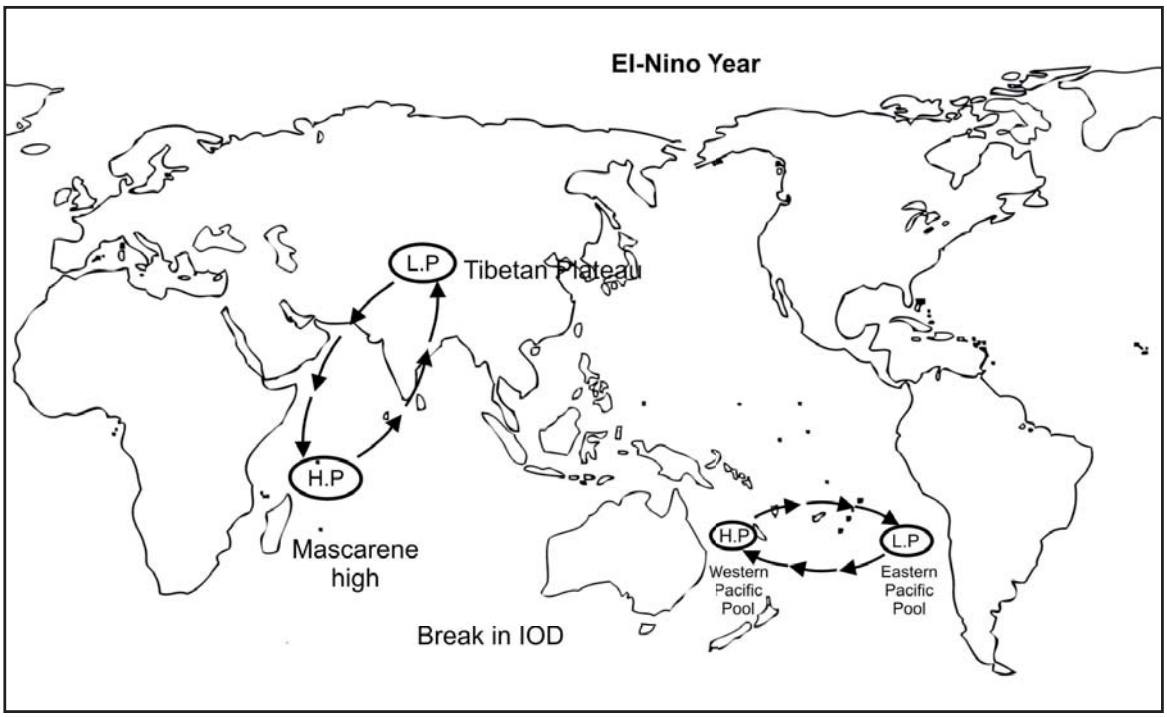
6. Shifting of ITCZ to Tibetan Plateau

- Inter Tropical Covergence Zone (ITCZ) is a zone of low-pressure system which lies at equator normally. But during summer in Northern hemisphere, due to intense heating of Tibetan Plateau, a low pressure system is developed and ITCZ shifts to Tibet Plateau. This causes a thermally induced condition to attract southwest monsoon towards Indian sub-continent.

7. Indian Ocean dipole

- Two poles are formed as :
  - Mascrence high basin & Tibetan plateau
  - Mascrene high basin & Western pacific pool
  - When strong low pressure is created over western pacific pool then more winds will flow towards Mascrene high basin and more will be the flow of winds towards low pressure Tibetan plateau. (Sign of good monsoon) this dipole like situation in Indian ocean is called IOD (Indian Ocean Dipole)
  - EI-Nino - Due to impact of EI-Nino, western pacific pool becomes high pressure (due to reversal of walker cell) and low pressure system develops at Peruvian coast dipole system is destroyed and hence no wind blow from western pacific pool towards Mascrene high and hence Indian monsoon is impacted.
  - Due to unusual heating of Peruvian current at western margin L.P system does not develop in east Australian coast which causes break in dipole. Instead, a new system is emerged by H.P at west Pacific Ocean.



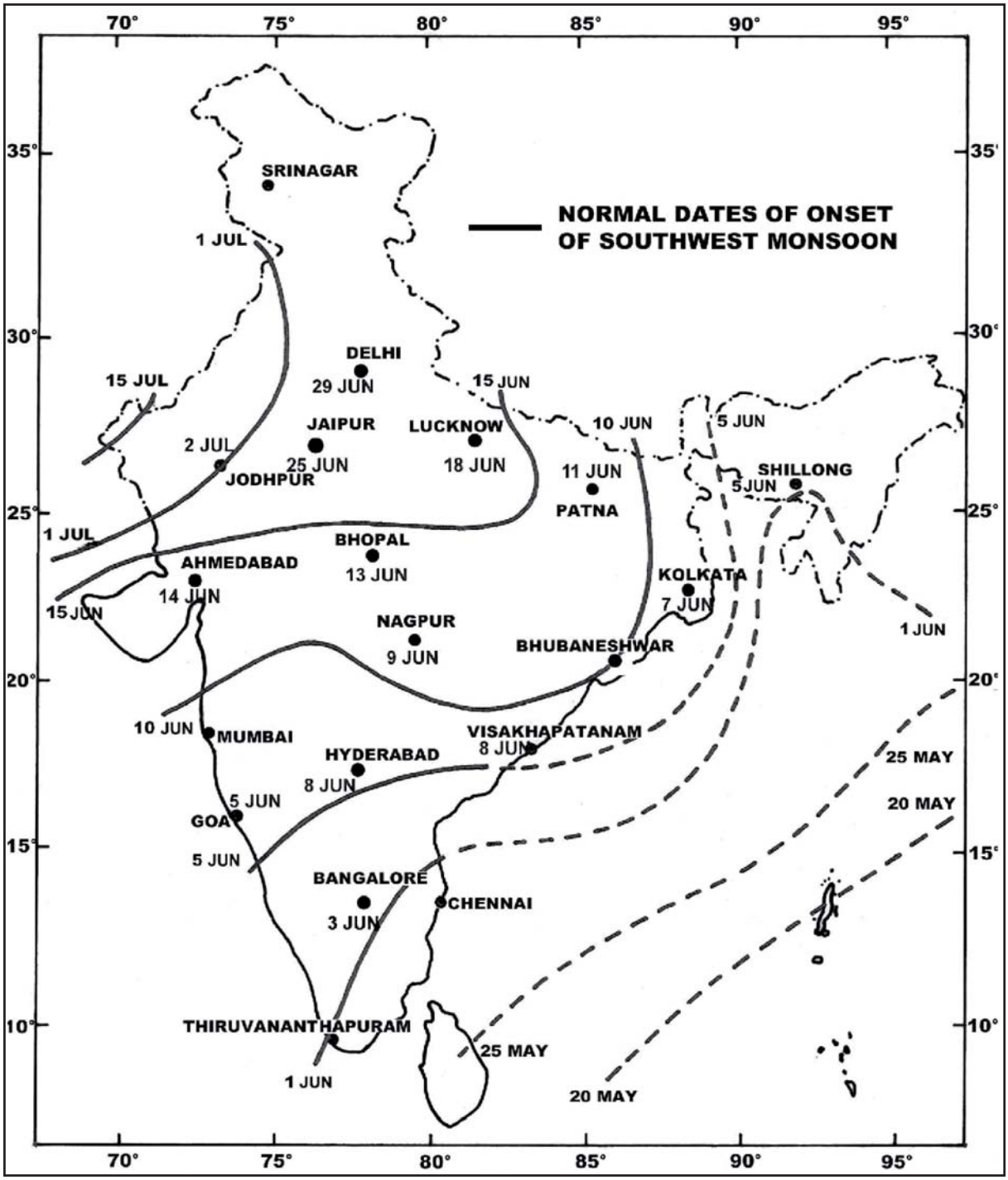


Theory of Bursting Monsoon

The unique feature of bursting of the Monsoon is primarily explained by the Jet Stream theory and the Dynamic Theory.

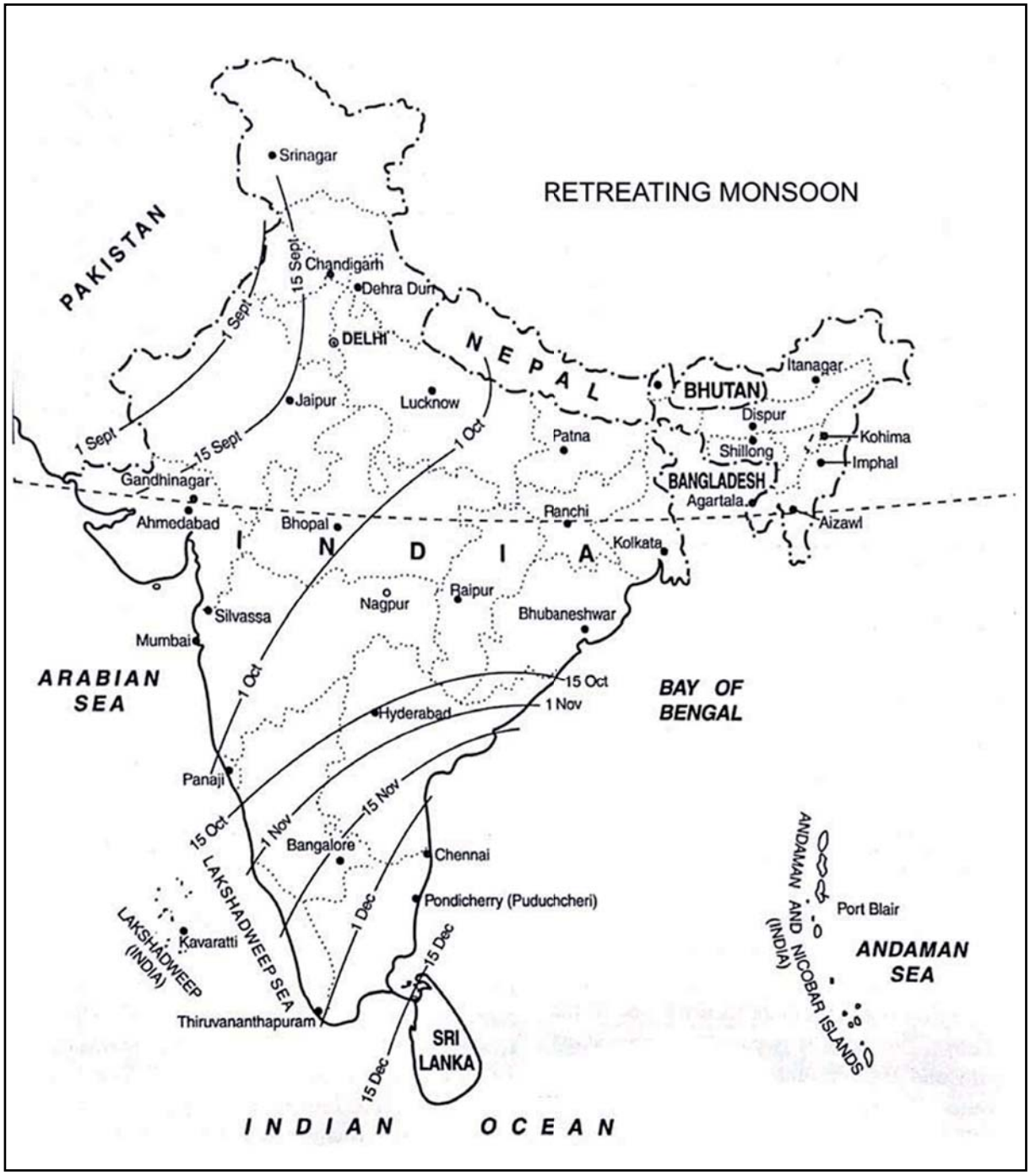
Dynamic Theory

- According to this theory, during the summer months of Northern Hemisphere, the ITCZ shifts northwards pulling the SW Monsoon winds onto the land from the sea. However the huge landmass of the Himalayas continues to restrict the low pressure zone onto the Himalayas itself. It is only when the Tibetan Plateauheats up a lot more than the Himalayas does the ITCZ abruptly and swiftly shift northwards leading to burst of Monsoon showers over the Indian subcontinent. The reverse shift takes place for the NE Monsoon winds leading to a second minor burst during the Northern Hemisphere winter Months of NE Monsoon rainfall over Eastern Indian peninsula.



Jet Stream Theory

- According to the theory the onset of SW Monsoon over Indian subcontinent is driven by the shift of the subtropical westerly jet northwards from over the plains of India towards the Tibetan Plateau. This shift is due to the intense heating of the Plateau during the summermonths. This shift of the westerly jet to the north of the Himalayas is not a slow and gradual process, as expected for most changesin weather pattern. The primary cause of these is believed to be the height of the Himalayas. As the Tibetan Plateau heats up the low pressure created over it pulls the westerly jet northwards. Due to lofty Himalayas, the westerly jet is inhibited from moving northwards. However, with continuous dropping pressure, sufficient force is created for the movement of the westerly jet across the Himalayas after a significant period. As such, the shift of the jet is sudden and abrupt causing the bursting of SW Monsoon rains onto the Indian plains. The reverse shift happens for the NE Monsoon.



Retreating Monsoon

- This season starts, when monsoon after drenching all of India, begins to retreat. By late September and early October the circulation pattern near the Himalayas returns to its winter regime. The low pressure centre in the northwestern part of India appears to be broken up. Now, the low pressure centre becomes weaker and weaker, and ultimately shifts to the equatorial region. The monsoons begin to retreat.
- Rainfall is the criterion adopted by the Meteorological Department of India for fixing the dates of onset and withdrawal of southwest monsoon over different parts of India. The Department chooses the middle dates of the five-day periods during which the characteristic rise or fall occurs in average rainfall.
- By the end of September the rainfall starts decreasing in the northern plain of India until it ceases by the month of October. However, in the southern part of Indian Peninsula it continues to rain until the middle of December. It may be pointed out that, unlike the sudden burst of monsoon, the retreat

of monsoon is gradual. Now, the anti-cyclonic conditions take the place of cyclonic conditions in the northern plain. The monsoon retreats to the south giving place to cold and dry winds of winter monsoon. By about September 15, the monsoon withdraws from the Punjab. The approximate dates of the retreat of monsoon from Uttar Pradesh and Bengal are October 1 and October 15 respectively. The earlier retreat of southwest monsoon is always viewed with great concern, for it dries up the standing crops which need a continuance of rainfall.

- It is well to remember that the retreating southwest monsoons give rainfall to Karnataka in the months of October and November. Madras receives about 55 cm of rainfall in the months of October and November by these winds coming from the northern margin of cyclonic circulation. At this period some depressions develop over the Bay of Bengal and the Arabian Sea. Sometimes they attain the hurricane intensity and produce occasional heavy rain and strong winds. Thus, winter precipitation of Southern India is due to the retreating southwest monsoon.

■ Seasonal Rhythm of Monsoon in Peninsular India

The Cold Weather Season or Winter Season

- The southern peninsula has rather warm condition and does not have distinctly defined winter weather. The isotherm of 20ºC runs in east-west direction roughly parallel to the tropic of cancer and divides India climatically in the northern and southern parts. In the peninsula temperatures are invariably above 20ºC. In the extreme south the temperature may be well above 25ºC.
- The pressure is comparatively lower in south India. The isobar of 1013mb touches the southern tip of India. The wind starts blowing in the direction of North West to south east. However the wind velocity is low due to low pressure gradient.
- The retreating winter monsoon picks moisture while crossing Bay of Bengal and causes Winter rainfall in Tamil Nadu and south Andhra Pradesh, south east Karnataka and south- east Kerala. The highest seasonal rainfall of about 75cm between October and December occurs along the south-eastern coast of Tamil Nadu and adjoining parts of south Andhra Pradesh

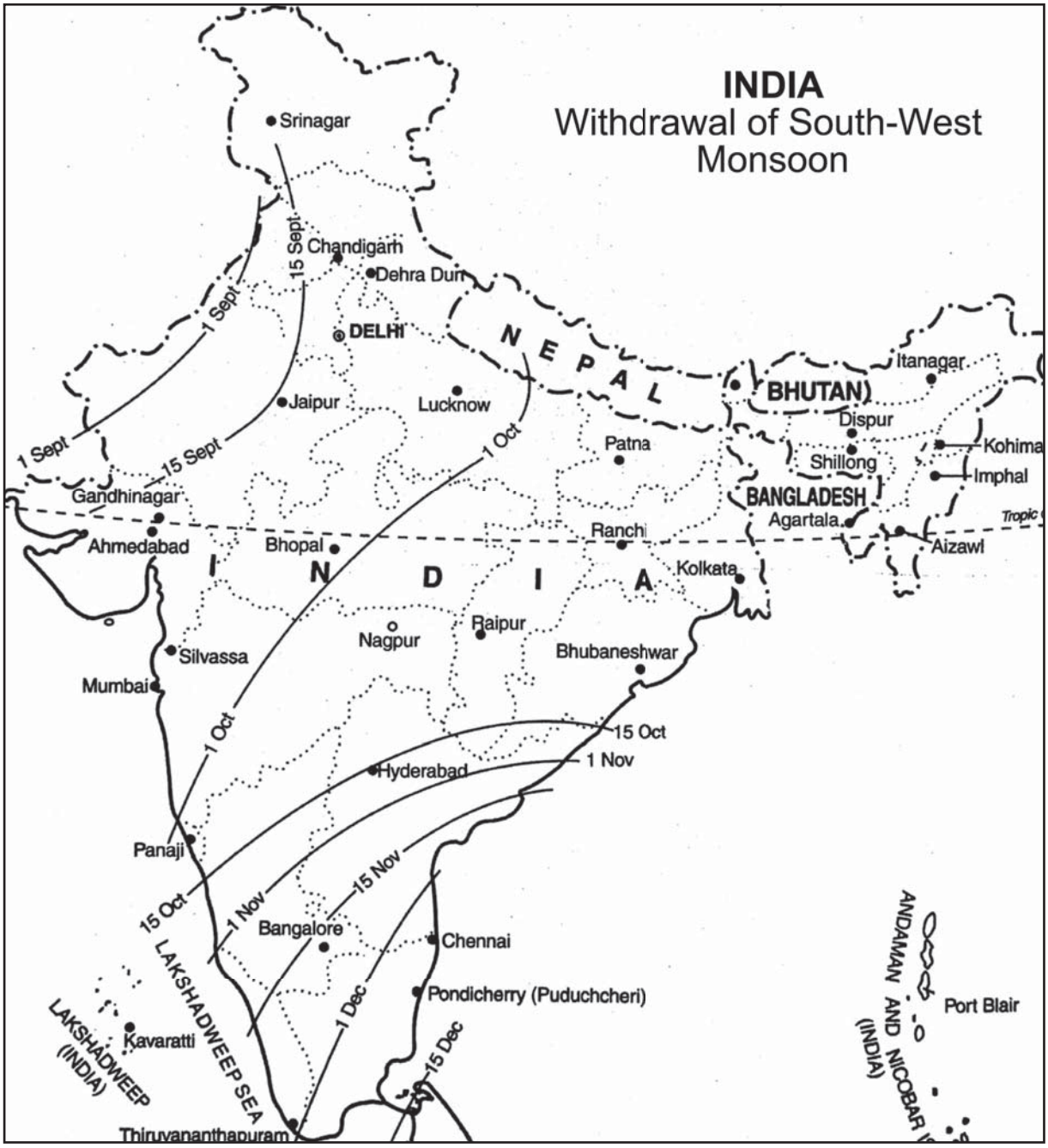
The Summer Season

- The period from March to June is called the summer season.Sometimes also referred to as pre monsoon period. As the season advances, sun's vertical rays move northwards and large parts of the country including south of Satpura range are heated up. The southern parts are distinctly warmer in March and April. In March, the highest temperatures are nearly 40ºC in the southern parts of the Deccan plateau. Even the night temperature ranges between 20ºC to 25ºC and even 27ºC in the Deccan region.
- However, the maximum summer temperatures are comparatively lower in the southern parts of the country due to moderating effect of sea. The mean maximum temperature at most places is about 26ºC to 30ºC. The temperatures along the West coast are comparatively lower than those prevailing on the east coast due to prevailing westerly winds.
- The pressure difference from north does exceed 3 to 4 MB. The isobar runs more or less parallel to the coast indicating differences in pressure over land and sea. There is marked change in the direction of winds from the winter conditions. The thunderstorms occur in Kerala and adjoining parts of Karnataka and Tamil Nadu, particularly during evening and nights.
- Coastal areas of Kerala and Karnataka receive about 25 cm of rainfall from thunderstorms. These thunderstorms also cause about 10cm of rainfall in the interior of south India. In Tamil Nadu and Andhra Pradesh they are very beneficial to mango crop. In Karnataka they are called cherry blossoms due to their salutary effects on the coffee plantation.

Rainy Season

- The June temperature in south India is 3ºC to 6ºC lower than the May temperature. The temperatures are quite low over the Western Ghats due to high elevation and also due to heavy rainfall, but the rain shadow area is comparatively warmer on account of low elevation and scanty rainfall. The coastal areas of Tamil Nadu and adjoining parts of Andhra Pradesh have temperatures above 30ºC because they receive little rainfall during this season.

- The atmospheric pressure steadily increases southwards where it ranges between 1008mb and 1010mb. The isobar of 1009mb crosses parts of Kerala and Tamil Nadu. Besides Arabian Sea and the Bay of Bengal the winds blow in a South West to Northeast direction from Arabian Sea and Bay of Bengal. They maintain this direction throughout the peninsular India. The normal date of the arrival of the monsoon is 20th may in Andaman and Nicobar islands.
- The normal date of onset of the South West monsoon over Kerala i.e. the fi rst place of mainland of India is 1st June. The monsoon advances with startling suddenness accompanied with a lot of thunder, lighting and heavy downpour. This sudden onset of rain is termed as monsoon burst. The date of arrival of monsoon on the southern tip is 1st June. Beyond Kerala, the monsoon progresses in two branches viz the Arabian Sea branch and the Bay of Bengal branch. The Arabian Sea branch gradually advances northwards after hitting Malabar Coast and reaches Mumbai by 10th June. While the Bay of Bengal branch hits Meghalaya by 5th of June.



The Season of Retreating Monsoon

- The monsoons withdraw from the peninsula by October and from the extreme South Eastern tip by December. Due to retreat of the monsoon, this season is also called as the Season of retreating

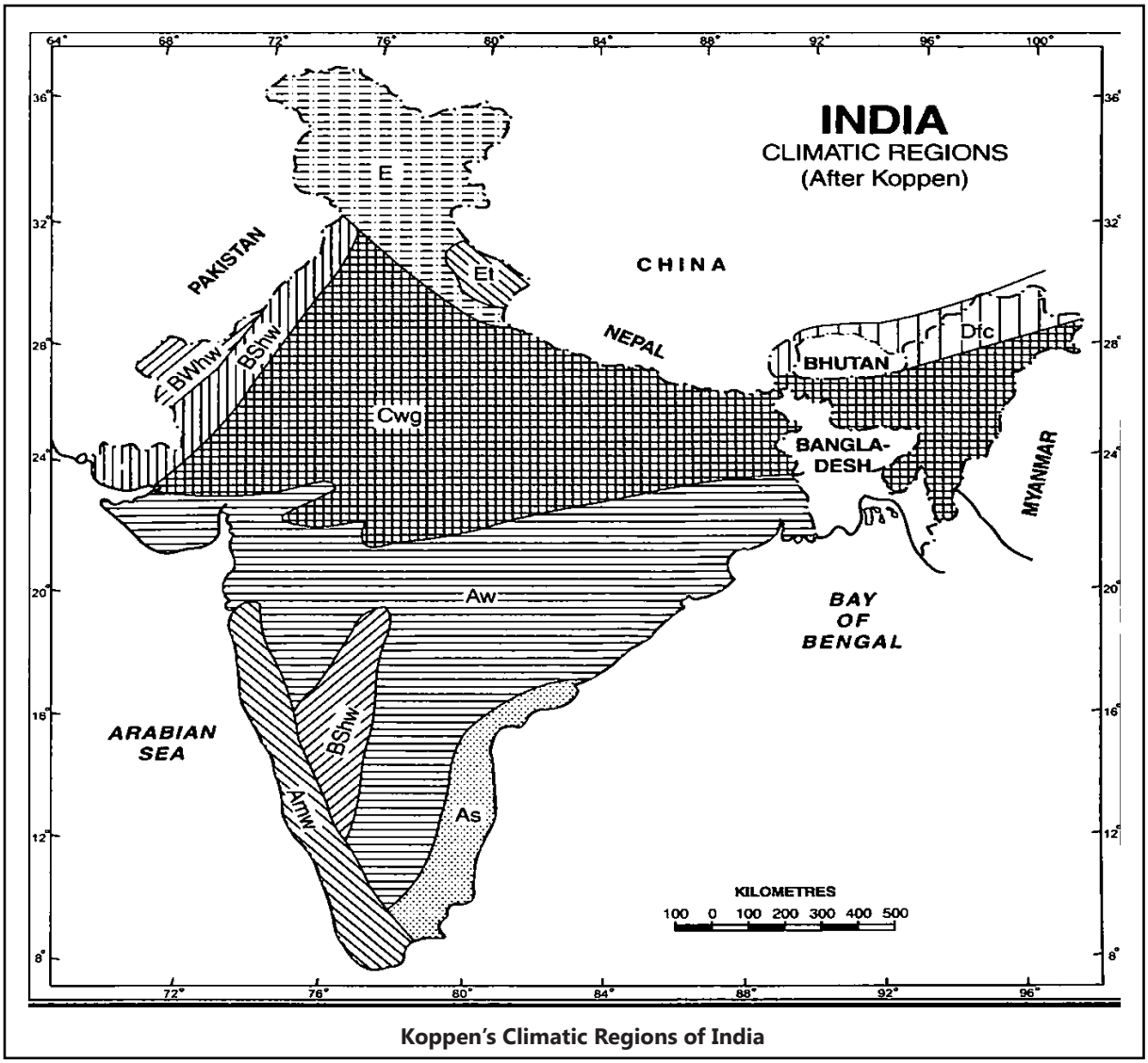
monsoon. Unlike the sudden burst of the advancing monsoons, the withdrawal is rather gradual and takes about three months. The temperature decreases to 33ºC in the peninsular and to 30ºC in the Meghalaya Plateau.

- The surface atmospheric pressure is mostly between 1010-1012mb. Consequently the pressure gradient is low.
- This is the season of the most severe and devastating tropical cyclones originating in the Indian seas especially in the Bay of Bengal. The highest frequency of the cyclones is in the month of October and the first half of November.
- Initially they move in a West or North Westerly direction, but many of them later recurve and move towards the Northeast direction. The area that is most vulnerable to these storms includes the coastal belts of Tamil Nadu, Andhra Pradesh and Orissa. They cross the peninsula and enter the Arabian Sea. Some of them again recurve northeast and strike Maharashtra and Gujarat coast.
- October and November is the main rainy season in Tamil Nadu and adjoining areas of Andhra Pradesh to the south of Krishna river delta as well as secondary rainy period for Kerala. The retreating monsoon absorbs moisture while passing over the Bay of Bengal and causes this rainfall.

Climatic Regions of India

- The two most significant factors in defining different climates are temperature and precipitation. A place's location on a continent, its topography, and its elevation may also have an impact on the climate. Although India has tropical monsoon climate as a whole, there are large regional variations in important climatic elements such as rainfall and temperature. Because of these variations India can be divided in to various climatic regions.
- Koppen's Classification of Climatic Regions
  - Dr. WladimirKoppen gave classification of climate based upon annual and monthly means of temperature and precipitation. It accepts the native vegetation as the best expression of the totality of a climate, so that many of the climatic boundaries are based upon vegetation.
  - Koppen has expressed the view that the effectiveness of precipitation in vegetation growth depends not only upon the amount of precipitation, but also upon the intensity of evaporation and transpiration. Much of the water obtained from precipitation is lost from the soil and plants by evaporation and transpiration and is not available for vegetation growth. Thus a certain amount of rain falling in hot and dry climate may not be as useful to vegetation as the same amount of rain falling in a cool and humid climate. Koppen has suggested five major types of climate which correspond with five principal vegetation groups. Each climatic type is represented by a capital letter explained below:
- **A:** Tropical rainy climate with no cool season. Temperature of the coolest month above 18°C.
- **B:** Dry climate in which there is an excess of evaporation over precipitation.
- **C:** Middle-Iatitude rainy climate with mild winters. Average temperature of coldest month below 18°C but above -3°C. Average temperature of warmest month over 10°C.
- **D:** Middle-latitude rainy climate with severe winters. Average temperature of coldest month below -3°C and that of warmest month above 10°C.
- **E:** Polar climate with no warm season. Average temperature of the warmest month below 10°C.
- The above mentioned major climatic types are further subdivided depending upon the seasonal distribution of rainfall or degree of dryness or cold. They are designated by small letters a,c,f,h,m,g,s and w each having a specific meaning as per details given below :
- **a**: hot summer, average temperature of the warmest month over 22°C.
- **c:** cool summer, average temperature of the warmest month under 22°C.
- **f:** no dry season.
- **w**: dry season in winter.
- **s**: dry season in summer.
- **g**: Ganges type of annual march of temperature; hottest month comes before the solstice and the summer rainy season.

- **h** (heiss): average annual temperature under 18°C.
- **m** (monsoon): short dry season.
  - The capital letters S and W are employed to designate the two subdivisions of dry climate: semiarid or Steppe (S) and arid or desert (W). Capital letters T and F are similarly used to designate the two subdivisions of polar climate: tundra (T) and icecap (F).
  - Koppen divided India into nine climatic regions making use of the above scheme (Fig.)
- **Amw** (Monsoon type with short dry winter season). This climate is found in the western coastal region, south of Mumbai. This area receives over 300 cm of annual rainfall in summer from the south-west monsoons.
- **As** (Monsoon type with dry season in high sun period). This is the region in which rainfall occurs in winter and summer is dry. Coromandel Coast experiences this type of climate. Coastal Tamil Nadu and adjoining areas of Andhra Pradesh are included in it. The amount of rainfall mostly in winter is 75-100 cm and is received from the retreating monsoons.
- **Aw** (Tropical Savanah type). This climate is found in most parts of the peninsular plateau barring Coromandel and Malabar coastal strips. The northern boundary of this climatic region roughly coincides with the Tropic of Cancer. The average annual rainfall is about 75 cm which is received in summer season from the south west monsoons. Winter season remains dry.



Koppen's Climatic Regions of India

- **BShw** (Semi-arid Steppe type). Some rain shadow areas of Western Ghats, large part of Rajasthan and contiguous areas of Haryana and Gujarat have this type of climate. Rainfall varies from 12 to25 cm and most of it occurs in summer. Winter is completely dry. Some arid steppe vegetation is found here.

- **BWhw**(Hot desert type). Most of western Rajasthan has hot desert type of climate where the amount of annual rainfall is less than 12 cm. Temperatures are very high in summer. Natural vegetation is almost absent.
- **Cwg** (Monsoon type with dry winters).This type of climate is found in most parts of the Ganga Plain, eastern Rajasthan, Assam and in Malwa Plateau. The summer temperature rises to 40°C which falls to 27 °C in winter. Most of rainfall occurs in summer and winter is dry.
- **Dfc** (Cold, Humid winters type with shorter summer). Some of the north-eastern states such as Sikkim, Arunachal Pradesh and parts of Assam have this type of climate. Winters are cold, humid and of longer duration. The winter temperatures are about 10°C. Summers are short but humid.
- **Et** (Tundra Type). This climate is found in the mountain areas of Uttarakhand. The average temperature varies from 0 to 10°C. There is fall in temperature with altitude.
- **E** (Polar Type). The higher areas of Jammu & Kashmir and Himachal Pradesh experience polar climate in which the temperature of the warmest month varies from 0° to 10°C. These areas are covered with snow for most part of the year.

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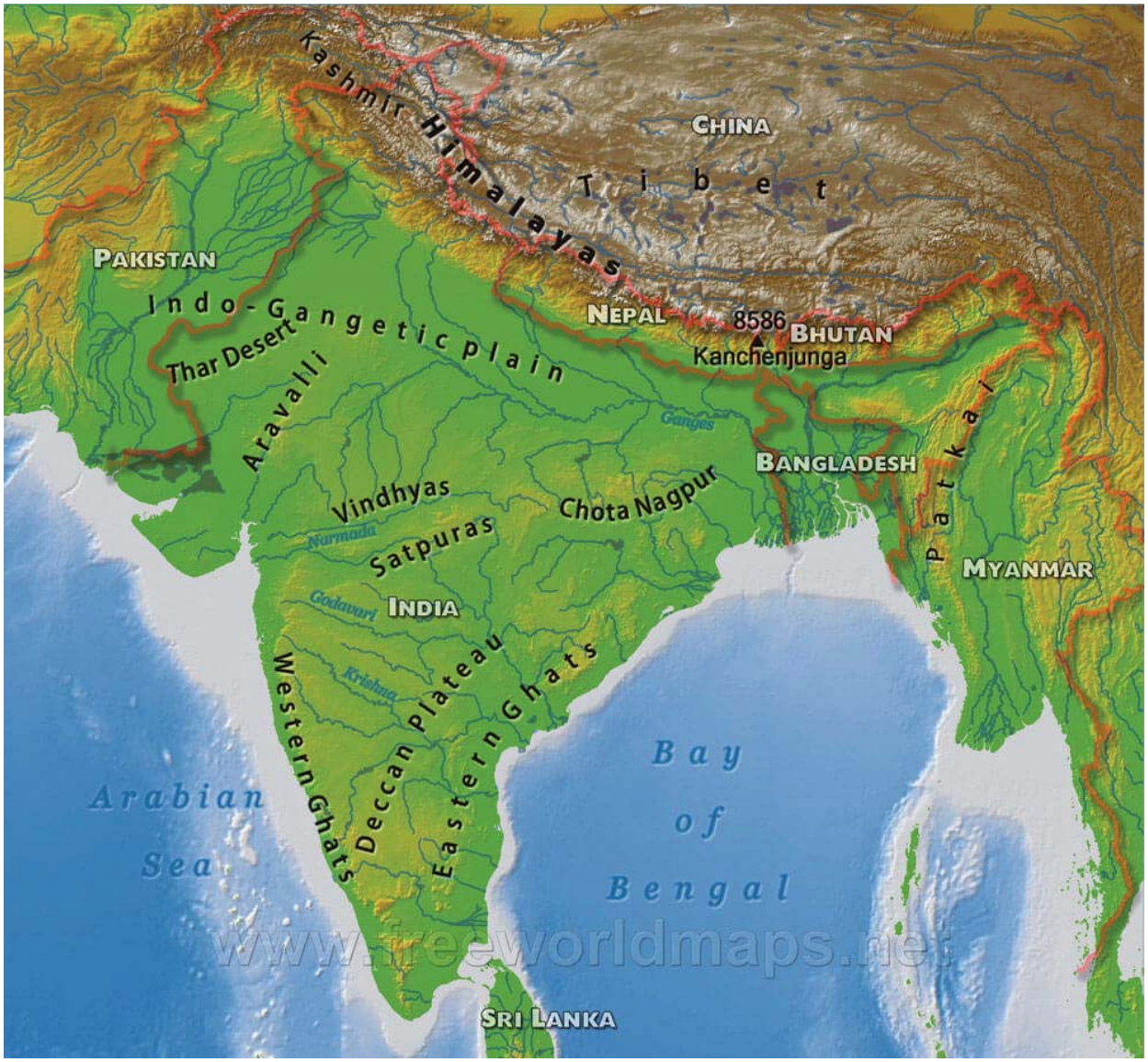
DAY - 26

MAPS OF INDIA AND WORLD

■ India



Important Facts about India

- India, officially the Republic of India is a country in South Asia.
- It is the seventh-largest country by area, the **second-most** populous country, and the **most populous democracy in the world.**
- Bounded by the Indian Ocean on the south, the Arabian Sea on the southwest, and the Bay of

Bengal on the southeast, **it shares land borders with Pakistan to the west; China, Nepal, and Bhutan to the north; and Bangladesh and Myanmar to the east.**

- **The longest boundary is shared by Bangladesh**
- In the Indian Ocean, India is in the vicinity of Sri Lanka and the Maldives; **it's Andaman and Nicobar Islands share a maritime border with Thailand and Indonesia.**
- The Tropic of Cancer passes through 8 states**. States being Gujarat, Rajasthan, Chhattisgarh, Madhya Pradesh, Jharkhand, West Bengal, Mizoram and Tripura.**
- 82° 30' East is the Indian Standard Meridian**, it passes through Mirzapur in Uttar Pradesh and touches five states of India. The states it passes through are Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Orissa and Andhra Pradesh.**
- **Kanchenjunga is the third highest mountain in the world (after Mount Everest and K2) and the tallest peak in India, with an elevation of 8,586 metres (28,169 ft.).**
- Kanchenjunga" which lies in the Himalayas means **"The Five Treasures of Snows" translated, as it contains five peaks, four of them over 8,450 metres.**
- The Ganges and its tributaries drain a 1,000,000-square-kilometer (390,000 sq mi) fertile basin **that supports one of the world's highest density of humans.**
- The Ganges River's long held reputation as a purifying river appears to have a basis in science**. The river water has a unique and extraordinary ability to retain oxygen.**
- **Siachen Glacier is the largest glacier in India. At 75.6 km long and 2.8 km wide, it is the longest glacier in the Karakoram and second-longest in the world's non-polar areas.**
- **Drass in western Ladakh is the coldest place in India. It is also the second coldest inhabited place in the world after Siberia.**
- **Varanasi, also known as Benaras, was called "the Ancient City" when Lord Buddha visited it in 500 B.C., and is the oldest, continuously inhabited city in the world today.**

Geographical Facts Continent Wise

Asia

- Asia is **the largest of the world's continents**, covering approximately 30 percent of the Earth's land area. Asia is made up of **48 countries, as well as 6 non-UN states, and 6 dependent territories.**
- Most geographers define Asia's western border as an indirect line that follows the **Ural Mountains, the Caucasus Mountains, and the Caspian and Black Seas.**
- Asia is bordered by the **Arctic, Pacific, and Indian Oceans.**

Mountain Systems

- The Himalaya Mountains extend for about 2,500 kilometers (1,550 miles), separating the Indian subcontinent from the rest of Asia.
- The Indian subcontinent is still crashing northward into Asia, and the Himalayas are growing about 5 centimeters (2 inches) every year.
- **The Tien Shan** mountain system stretches for about 2,400 kilometers (1,500 miles), straddling the border **between Kyrgyzstan and China**. The name Tien Shan means **"Celestial Mountains**" in Chinese.
- The two highest peaks in the Tien Shan are **Victory Peak,** which stands at 7,439 meters (24,406 feet), and Khan **Tängiri Peak**, which stands at 6,995 meters (22,949 feet).
- **The Ural Mountains** run for approximately 2,500 kilometers (1,550 miles) in an indirect north-south line from **Russia to Kazakhstan**.

Plateaus

- Asia is home to many plateaus, areas of relatively level high ground. The Iranian plateau covers more than 3.6 million square kilometers (1.4 million square miles), **encompassing most of Iran, Afghanistan, and Pakistan.**
- **The Deccan Plateau** makes up most of the southern part of India. It **is bordered by three mountain ranges: the Satpura Range in the north, and the Eastern and Western Ghats on either side.**
- **The Tibetan Plateau** is usually considered the largest and highest area ever to exist in the history of Earth. Known as **the "Rooftop of the World,"** the plateau covers an area about half the size of the contiguous United States and averages more than 5,000 meters (16,400 feet) above sea level.
- Tibetan Plateau is extremely important to the world's water cycle because of its tremendous number of glaciers.

Plains, Steppes, and Deserts

- **The West Siberian Plain**, located in central Russia, is considered one of the world's largest areas of continuous flatland.
- Central Asia is dominated by a steppe landscape, a large area of flat, unforested grassland.
- **The Rub' al Khali desert**, considered **the world's largest sand sea**, covers an area larger than France across Saudi Arabia, Oman, the United Arab Emirates, and Yemen.
- **It holds roughly half as much sand as Africa's Sahara desert, even though it is 15 times smaller in size**.
- The desert is known as the **Empty Quarter** because **it is virtually inhospitable to humans except for Bedouin tribes that live on its edges.**

Freshwater

- **Lake Baikal**, located in southern Russia, is the **deepest lake** in the world
- The lake contains 20 percent of the world's unfrozen freshwater, making it the largest reservoir on Earth.
- **It is also the world's oldest lake**, at 25 million years old.
- **The Yangtze is the longest river in Asia and the third longest in the world**.
- The **Tigris and Euphrates Rivers** begin in the highlands of eastern Turkey and **flow through Syria and Iraq**, joining in the city of Qurna, Iraq, before emptying into the Persian Gulf.

Saltwater

- The **Persian Gulf** has an area of more than 234,000 square kilometers (90,000 square miles). It **borders Iran, Oman, United Arab Emirates, Saudi Arabia, Qatar, Bahrain, Kuwait, and Iraq**.
- The seabed beneath the Persian Gulf contains an estimated 50 percent of the world's oil reserves.
- **The Sea of Okhotsk** covers 1.5 million square kilometers (611,000 square miles) between the **Russian mainland and the Kamchatka Peninsula.**
- **The Bay of Bengal is the largest bay in the world**, covering almost 2.2 million square kilometers (839,000 square miles) and **bordering Bangladesh, India, Sri Lanka, and Burma**.
- Many large rivers, including the Ganges and Brahmaputra, empty into the bay. The briny wetland formed by the Ganges-Brahmaputra on the **Bay of Bengal is the largest delta in the world.**

Africa

- Africa, the **second largest continent** (after Asia), covering about **one-fifth** of the total land surface of Earth.
- The **continent is bounded on the west by the Atlantic Ocean, on the north by the Mediterranean Sea, on the east by the Red Sea and the Indian Ocean, and on the south by the mingling waters of the Atlantic and Indian oceans.**
- There are **54 countries** and **one "non-self-governing territory**", **the Western Sahara**, in Africa.
- All of Africa was colonized by foreign powers during the "scramble for Africa", **except Ethiopia and Liberia.**
- African continent is the **world's oldest populated area**.
- Its northern extremity is **Al-Ghīrān Point, near Al-Abyaḍ Point (Cape Blanc), Tunisia; its southern extremity is Cape Agulhas, South Africa; its farthest point east is Xaafuun (Hafun) Point, near Cape Gwardafuy (Guardafui), Somalia; and its western extremity is Almadi Point (Pointe des Almadies), on Cape Verde (Cap Vert), Senegal.**
- In the northeast, Africa was joined to Asia by **the Sinai Peninsula until the construction of the Suez Canal.**
- Paradoxically, the coastline of Africa—18,950 miles (30,500 km) in length—**is shorter than that of Europe, because there are few inlets and few large bays or gulfs.**
- Off the coasts of Africa a number of islands are associated with the continent. Of these **Madagascar, one of the largest islands in the world is the most significant.**
- Other, smaller islands include the Seychelles, Socotra, and other islands to the east; the Comoros, Mauritius, Réunion, and other islands to the southeast; Ascension, St. Helena, and Tristan da Cunha to the southwest; Cape Verde, the Bijagós Islands, Bioko, and São Tomé and Príncipe to the west; and the Azores and the Madeira and Canary islands to the northwest.
- **The continent is cut almost equally in two by the Equator, so that most of Africa lies within the tropical region bounded on the north by the Tropic of Cancer and on the south by the Tropic of Capricorn. Because of the bulge formed by western Africa, the greater part of Africa's territory lies north of the Equator.**
- **Africa is crossed from north to south by the prime meridian (0° longitude), which passes a short distance to the east of Accra, Ghana.**

- The whole of Africa can be considered as a vast plateau rising steeply from narrow coastal strips and consisting of ancient crystalline rocks.
- **The plateau's surface is higher in the southeast and tilts downward toward the northeast.**
- **The northwestern part, which includes the Sahara (desert) and that part of North Africa known as the Maghrib, has two mountainous regions—the Atlas Mountains in northwestern Africa, which are believed to be part of a system that extends into southern Europe, and the Ahaggar (Hoggar) Mountains in the Sahara.**
- The southeastern part of the plateau includes the Ethiopian Plateau, the East African Plateau, and—in eastern South Africa, where the plateau edge falls downward in a scarp—the Drakensberg range.
- **One of the most remarkable features in the geologic structure of Africa is the East African Rift System, which lies between 30° and 40° E.**
- **The rift itself begins northeast of the continent's limits and extends southward from the Ethiopian Red Sea coast to the Zambezi River basin**.
- The East African Rift System constitutes the most striking and distinctive relief feature of the continent. Associated with its formation was the volcanic activity responsible for most of the higher peaks of East Africa, including Kilimanjaro. Seismic and volcanic disturbances are still recorded in the western portions of the rift valley system.
- In the Virunga Mountains, northeast of Lake Kivu, there are periodic outbursts (about every 10 or 12 years) that have created a series of lava flows.

- One of these volcanoes dammed the rift valley and converted a large area, formerly drained by a tributary of the Nile, into Lake Kivu.

- **Kilimanjaro (19,340 feet [5,895 metres]) is the highest point on the continent; the lowest is Lake Assal (515 feet [157 metres] below sea level) in Djibouti.**

North America

- North America, **the third-largest continent**, extends from the **tiny Aleutian Islands in the northwest to the Isthmus of Panama in the south.**

- The continent includes the **enormous island of Greenland in the northeast and the small island countries and territories that dot the Caribbean Sea and western North Atlantic Ocean.**
- In the far north, the continent stretches halfway around the world, from Greenland to the Aleutians.
- But at Panama's narrowest part, the continent is just 50 kilometers (31 miles) across.

Western Region

- **Young mountains rise in the west. The most familiar of these mountains are probably the Rockies, North America's largest chain. The Rockies stretch from the province of British Columbia, Canada, to the U.S. state of New Mexico.**
- The Rocky Mountains are part of a system of parallel mountain ranges known as the **Cordilleras**. A cordillera is a long series of mountain ranges. Although cordilleras exist all over the world, in North America, "the Cordilleras" indicate the massive mountain ranges in the western part of the continent. **The Cordilleras extend from Canada all the way to the Isthmus of Panama.**
- The **Sierra Madre mountain system is part of the Cordilleras**. The Sierra Madre **stretch from the southwestern United States to Honduras.** The Sierra Madre include many high volcanoes (up to 5,636 meters, or 18,500 feet) that stretch across Mexico south of the cities of Guadalajara and Mexico City.
- **Volcanic mountain ranges in Guatemala, Honduras, Nicaragua, Costa Rica, and Panama are also considered part of the Cordilleras**.
- Some of the **Earth's youngest mountains are in the Cascade Range of the U.S. states of Washington, Oregon, and California**.
- The three major desert regions of North America—**the Sonoran, Mojave, and Chihuahuan**—are all in the American southwest and northern Mexico. These large deserts are located in the rain shadows of nearby mountains. The mountains block precipitation and accelerate the movement of hot, dry wind over these regions.
- **The Sonoran is in the rain shadow of the Coast Ranges, the Mojave is in the shadow of the Sierra Nevada, and the Chihuahuan is in the shadow of the Sierra Madre**.

Great Plains

- The Great Plains lie in the middle of the continent.
- Deep, rich soil blankets large areas of the plains in Canada and the United States.
- **Grain grown in this region, called the "Breadbasket of North America," feeds a large part of the world. The Great Plains are also home to rich deposits of oil and natural gas.**
- The grassland or prairie regions of the Great Plains make up the largest biome in North America.

Canadian Shield

- **The Canadian Shield is a raised but relatively flat plateau. It extends over eastern, central, and northwestern Canada. The Canadian Shield is characterized by a rocky landscape pocked by an astounding number of lakes.**
- The tundra, stretching along the northern borders of Alaska and Canada to the Hudson Bay area, is a biome common to the Canadian Shield.
- **The Eastern region includes the Appalachian Mountains and the Atlantic coastal plain.**
- North America's older mountain ranges, including the Appalachians, rise near the east coast of the United States and Canada. These areas have been mined for rich deposits of coal and other minerals for hundreds of years.

Caribbean Region

- The Caribbean Region includes more than 7,000 islands, islets, reefs, and cays. The region's islands and smaller islets are varied in their topography; some have relatively flat and sandy terrain while others are rugged, mountainous, and volcanic.

- **The coral reefs and cays of the Caribbean Sea are among the most spectacular biomes in North America.**

South America

- South America, **the fourth-largest continent**, extends from the **Gulf of Darién in the northwest to the archipelago of Tierra del Fuego in the south.**
- South America's extreme geographic variation contributes to the continent's large number of biomes.

Mountains & Highlands

- South America's primary mountain system, **the Andes, is also the world's longest**. The range covers about 8,850 kilometers (5,500 miles). **Situated on the far western edge of the continent, the Andes stretch from the southern tip to the northernmost coast of South America**. There

are hundreds of peaks more than 4,500 meters (15,000 feet) tall, many of which are volcanic.

- The **highest peak in the Andes, Aconcagua, stands at 6,962 meters (22,841 feet) and straddles the Argentina-Chile border.**
- **Aconcagua is the tallest mountain outside Asia**.
- **The largest herb in the world, *Puya raimondii*, is known as the Queen of the Andes.**
- A *Puya raimondii* can live for 100 years and can grow to more than 9 meters (30 feet) tall.
- **The leaves of this endangered species all grow from one woody stem, allowing moisture to run down the leaves to the base of the plant**.
- Outside the Andes, South America has two principal highland areas: **the Brazilian Highlands and the Guiana Highlands.**
- **Located south of the Amazon River in Brazil, the Brazilian Highlands are made up of low mountains and plateaus that rise to an average elevation of 1,006 meters (3,300 feet).**
- **The Guiana Highlands are located between the Amazon and Orinoco Rivers**. The heavily forested plateau of the Guiana Highlands covers southern Venezuela, French Guiana, Guyana, northern Brazil, and a portion of southeastern Colombia.

River Basins

- South America has three important river basins: **the Amazon, Orinoco, and Paraguay/Paraná**.
- **The Amazon River basin** has an area of almost 7 million square kilometers (2.7 million square miles), making it the **largest watershed in the world**.
- The basin, which covers most of northern South America, is fed by tributaries from the glaciers of the Andes. Every second, the Amazon River empties 209,000 cubic meters (7,381,000 cubic feet) of freshwater into the Atlantic Ocean.
- The Amazon River is the life force of the equally vast Amazon rain forest, which makes up about half of the rain forest of the entire planet.
- **The Orinoco River flows north of the Amazon**. The Orinoco flows in a giant arc for more than 2,736 kilometers (1,700 miles), originating in the Guiana Highlands of northern Brazil and discharging in the Atlantic Ocean in Venezuela.
- **A vast savanna or grassland region, known as the Llanos, is the primary biome of the Orinoco River basin.**
- The Llanos is primarily made up of grasses. Swamp grasses, sedges, and bunchgrass are found in wet, low-lying areas. Carpet grass is found in the higher and drier elevations.
- **The Paraguay/Paraná River basin covers almost 2.8 million square kilometers (1,081,000 square miles), which is much of southeastern Brazil and Bolivia, Paraguay, and northern Argentina.** The Paraná River includes Iguazu Falls, a massive series of waterfalls that extend for 2.7 kilometers (1.7 miles).

Coastal Plains

- South American coastal plains are found on the northeastern coast of Brazil, on the Atlantic Ocean, and the western, Pacific coast of Peru and Chile.
- The coastal plains of northeastern Brazil are extremely dry. The Brazilian Highlands act as a wedge that pushes moist sea winds away from the coastal plains.
- **The Atacama Desert is part of the western coastal plain. The Atacama is considered the driest region in the world.**
- The average rainfall is about 1 millimeter (0.04 inches) a year, and some parts of the Atacama have never had rain in recorded history.

Europe

- Europe is the **second-smallest continent.**
- Europe extends from the **island nation of Iceland in the west to the Ural Mountains of Russia in the east.**
- Europe's northernmost point is the Svalbard archipelago of Norway, and it reaches as far south as the islands of Greece and Malta.
- **Europe is sometimes described as a peninsula of peninsulas.**
- **Europe is a peninsula of the Eurasian supercontinent** and is **bordered by the Arctic Ocean to the north, the Atlantic Ocean to the west, and the Mediterranean, Black, and Caspian Seas to the south.**
- **Europe's main peninsulas are the Iberian, Italian, and Balkan, located in southern Europe, and the Scandinavian and Jutland, located in northern Europe**.

Western Uplands

- **The Western Uplands, also known as the Northern Highlands**, curve up the western edge of Europe and define the physical landscape of Scandinavia (Norway, Sweden, and Denmark), Finland, Iceland, Scotland, Ireland, the Brittany region of France, Spain, and Portugal.
- The Western Uplands is defined by **hard, ancient rock that was shaped by glaciation**.

North European Plain

- The North European Plain **extends from the southern United Kingdom east to Russia**.
- **It includes parts of France, Belgium, the Netherlands, Germany, Denmark, Poland, the Baltic states (Estonia, Latvia, and Lithuania), and Belarus**.
- It is home to many navigable rivers, including the **Rhine, Weser, Elbe, Oder, and Vistula**.
- The North European Plain remains the most densely populated region of Europe.

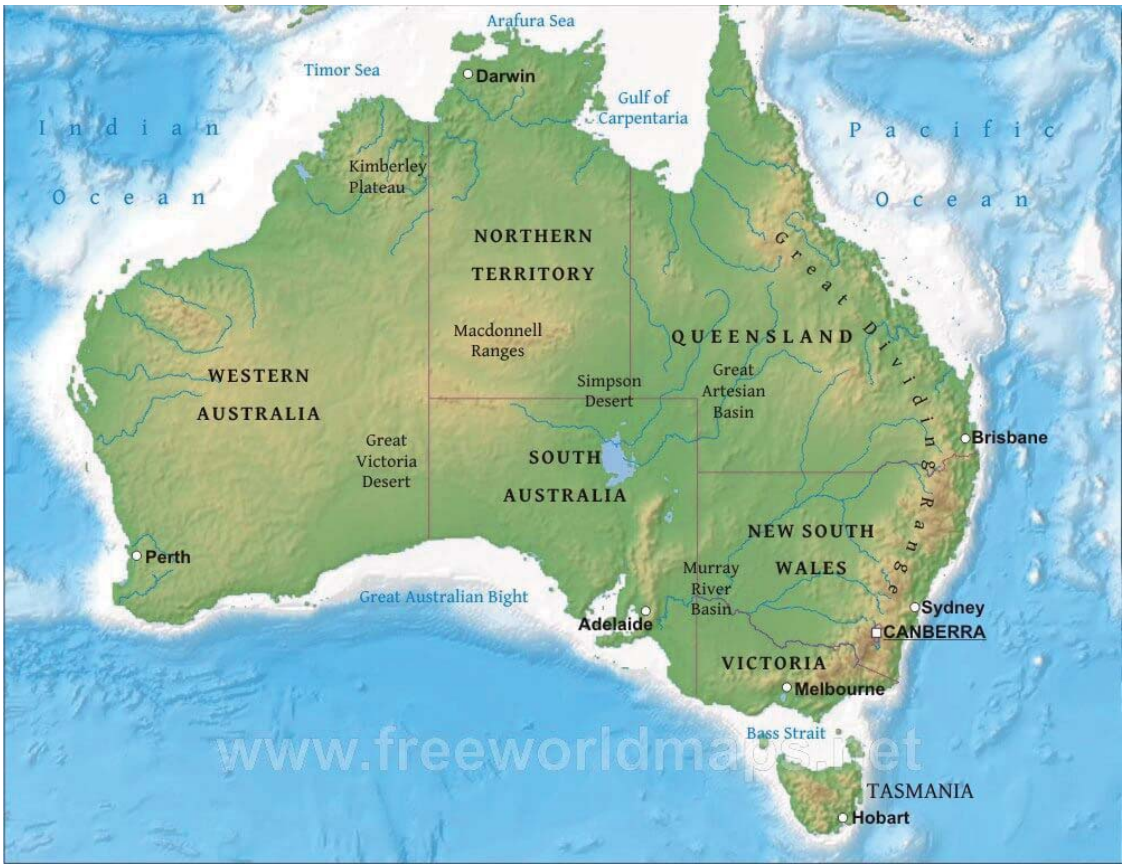
Central Uplands

- The Central Uplands extend east-west across central Europe and include western France and Belgium, southern Germany, the Czech Republic, and parts of northern Switzerland and Austria.
- Important highlands in this region include the Massif Central and the Vosges in France, the Ardennes of Belgium, the Black Forest and the Taunus in Germany, and the Ore and Sudeten in the Czech Republic.
- This region is sparsely populated except in the Rhine, Rhne, Elbe, and Danube river valleys.

Alpine Mountains

- The **Alpine Mountains include ranges in the Italian and Balkan peninsulas, northern Spain, and southern France**.
- The region **includes the mountains of the Alps, Pyrenees, Apennines, Dinaric Alps, Balkans, and Carpathians.**
- **Europe's highest peak, Mount Elbrus (5,642 meters/18,510 feet), is in the Caucasus Mountains of Russia.**
- **The Alpine region also includes active volcanoes, such as Mount Etna and Mount Vesuvius in Italy.**

Australia



- Australia, the smallest continent and one of the largest countries on Earth, lying between the Pacific and Indian oceans in the Southern Hemisphere.
- Australia's capital is Canberra, located in the southeast between the larger and more important economic and cultural centres of Sydney and Melbourne.
- Australia is both the flattest continent and, except for Antarctica, the driest.
- Australia has been called "the Oldest Continent," "the Last of Lands," and "the Last Frontier."
- The red and black soil plains of Queensland and New South Wales have long supported the world's greatest wool industry, and some of the most arid and forbidding areas of Australia conceal great mineral wealth.
- In particular the east coast, where European settlement began and where the majority of Australians now live, is topographically quite diverse and is comparatively well watered and fertile.
- Inland from the coast runs a chain of highlands, known as the Great Dividing Range, from Cape York in northern Queensland to the southern seaboard of Tasmania.

Overall characteristics

- Australia is a land of vast plains. Only 6 percent of the island continent is above 2,000 feet (600 metres) in elevation. Its highest peak, Mount Kosciuszko, rises to only 7,310 feet (2,228 metres).
- Australia is an arid continent; fully one-third of its area is occupied by desert, another third is steppe or semidesert, and only in the north, east, southeast, and southwest is precipitation adequate to support vegetation that significantly protects the land surface from weathering.
- Permanently flowing rivers are found only in the eastern and southwestern regions and in Tasmania.
- The major exception is the Murray River, a stream that rises in the Mount Kosciuszko area in the Eastern Uplands and is fed by melting snows.
- All other rivers in Australia are seasonal or intermittent in their flow, and those of the arid interior are episodic.
- The western half of Australia consists of the Western Plateau, which rises to mountain heights near the west coast and falls to lower elevations near the continental centre.
- The Western Plateau region is generally flat, though broken by various mountain ranges such as the Hamersley Range, the MacDonnell Ranges, and the Musgrave Range. Surface water is generally lacking in the Western Plateau, although there are several larger rivers in the west and north, such as the Murchison, Ashburton, and Victoria Rivers.
- Off the eastern coast of Australia is the world's largest coral reef complex, the Great Barrier Reef.
- The large and mountainous island of Tasmania, also a State of Australia, lies south of the south-eastern corner of the Australian mainland. It receives abundant rainfall, and has highly fertile soils particularly in comparison to the mainland.

Antarctica

- The continent of Antarctica makes up most of the Antarctic region.
- The Antarctic is a cold, remote area in the Southern Hemisphere encompassed by the Antarctic Convergence.
- The Antarctic Convergence is an uneven line of latitude where cold, northward-flowing Antarctic waters meet the warmer waters of the world's oceans.
- The Antarctic covers approximately 20 percent of the Southern Hemisphere.
- Antarctica is the fifth-largest continent in terms of total area. (It is larger than both Oceania and Europe.)
- Antarctica is a unique continent in that it does not have a native population.
- There are no countries in Antarctica, although seven nations claim different parts of it: New Zealand, Australia, France, Norway, the United Kingdom, Chile, and Argentina

Physical Geography

- The Antarctic Ice Sheet dominates the region.
- It is the largest single piece of ice on Earth.
- This ice sheet even extends beyond the continent when snow and ice are at their most extreme.
- Antarctica has a number of mountain summits, including the Transantarctic Mountains, which divide the continent into eastern and western regions.
- Without any ice, Antarctica would emerge as a giant peninsula and archipelago of mountainous islands, known as Lesser Antarctica, and a single large landmass about the size of Australia, known as Greater Antarctica.

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DAY - 27

AGRICULTURE

- According to Food and Agriculture organisation (FAO), at present some 11 percent (1.5 billion ha) of the globe's land surface (13.4 billion ha) is used in crop production (arable land and land under permanent crops).
- This area represents slightly over a third (36 percent) of the land estimated to be to some degree suitable for crop production.
- The fact that there remain some 2.7 billion ha with crop production potential suggests that there is still scope for further expansion of agricultural land.
- 40% of today's global population works in agriculture sector making it the single largest employer in the world. Nearly 80% of world cultivated area is rainfed.

Classification

- The framework of the agricultural systems of the world, except collective farming as outlined by Whittlesey can be presented as under —

Ecological or Near-Ecological Systems

- Nomadic herding
- Shifting cultivation/Simple Subsistence Farming

Subsistence Systems

- Rudimentary Sedentary Tillage
- Intensive Subsistence Tillage (with paddy dominance)
- Intensive Subsistence Tillage (without paddy dominance)
- Subsistence Crop and Livestock Farming
- Mediterranean Agriculture (near subsistence in the occidental world)

Commercial Systems

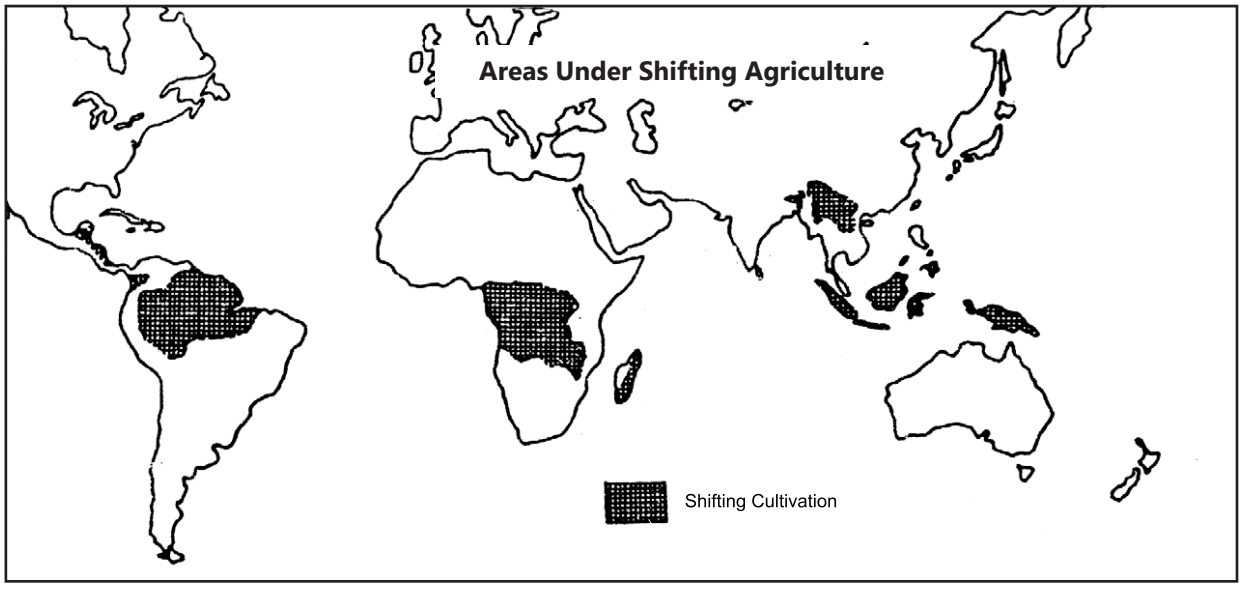
- Mediterranean Agriculture (commercial)
- Livestock Ranching
- Commercial Grain Farming
- Commercial Livestock and Crop Farming
- Commercial Dairy Farming
- Specialised Horticulture and Olericulture (fruit & vegetable culture)

Cash-Cropping System

- Commercial Plantation Tillage

Shifting cultivation/Simple Subsistence Farming

- It is the oldest form of 'agriculture' having its origin in 7000/8000 B.C.
- Shifting cultivation is the primitive form of soil utilisation, usually of tropical rainforests and bush areas of Central Africa, Central America and Southeast Asia. Farming is on a self-sufficient basis and farmers grow food only for themselves and their families. Shifting cultivation has two particularly important characteristics— **First , farmers usually clear the land for planting in part by slashing the vegetation and burning the debris. Second, farmers grow crops on a cleared field for only a few years and then leave it fallow for many years.**
  - It has **significant negative environment** impacts which include: deforestation inadequate land management practices soil erosion, flooding and siltation in lower reaches.
  - Shifting cultivation **can support only a low level of population**.
  - Shifting cultivation is carried on **chiefly in regions with a tropical forest climate**. It is widely spread in and along its borders. The tropical **regions of Americas, Central Africa, and Southeast Asia (including Indonesia)** may be identified as the home of shifting cultivation.
  - In these regions, agriculture is known as migratory, primitive, cut-and-burn, slash-and-burn and bush fallow agriculture.



Rudimentary Sedentary Tillage

- This form of agriculture is practiced at one place by a settled farmer, in which fields are not rotated and very primitive methods of cultivation is practiced. Nevertheless, the agricultural system is more reliable.
- Rudimentary sedentary tillage is mostly confined to the tropical lands of Central and South America, Africa and Southeast Asia.
- Crop rotation, rather than field rotation, is practiced and greater attention is paid to the land and the crop sown.
- Tilling methods are more intensive; however, all the work is done by hand. Ploughing and hoeing of the soil is done with crude hand implements. There is more employment of manpower in the field.
- Most of the crops grown under rudimentary sedentary tillage belong to the tuber and cereal family, such as potatoes, sweet potatoes, maize and sorghum, cassava, banana etc are also grown.

Subsistence Crop and Livestock Farming

In this type of farming, farmers produce crops and raise livestock mainly for their own subsistence and sell nothing in the local market. The returns are so low that they are sometimes unable to save the best seeds from their produce to resow them for obtaining the best harvests.

- This type of agriculture is practiced in some parts of south Mexico, Turkey, Iran, Iraq, etc. but the agricultural activities are increasingly becoming more commercial in organisation and practice in these countries. Thus, at present, subsistence crop and livestock farming covers a very limited part of the global arable land.
- The most important crops grown are barley and wheat in cereals. Rye and maize are the chief food grains for the people, and potatoes and barley are other staples.

Mediterranean Agriculture

It derives its name from the Mediterranean region of Europe where the agricultural characteristics are representative.

- It exists primarily in the lands that border the Mediterranean Sea in southern Europe, northern Africa and western Asia.
- Farmers in California, central Chile and the southwestern part of South Africa and Australia practice Mediterranean agriculture as well.
- The most common feature of Mediterranean agriculture is that both subsistence and cash crops figure in the economy of each of its regions.
- Two-thirds of the world's wine is produced in countries that border the Mediterranean Sea, especially Italy, France and Spain. Greece specializes in producing raisins and wine and Spain in oranges, olive oil and wine. Mediterranean regions elsewhere produce the remaining one-third.
- California specializes in growing citrus fruits and deciduous fruits. Horticulture is practiced in other Mediterranean climates but not to the extent found in California.
- Farmers derive a smaller percentage of income from animal products in the Mediterranean region. Livestock production is hindered by the lack of water and good grazing land during the summer. Small livestock herding, particularly of sheep, goats, pigs, is practiced in the region.

Mediterranean and Monsoon Agriculture

The Mediterranean agriculture and Monsoon agriculture have many similarities and dissimilarities.

Similarities

- There is a marked dry and rainy season.
- The agriculture is largely of intensive type.
- Dry farming and wet farming both are practiced.

Differences

- Monsoon region is associated with higher rainfall than Mediterranean region.
- In Mediterranean, the rainfall is received in the winters while it is summers in the monsoonal region.
- The farming in monsoonal region is largely subsistence while in the Mediterranean, it is largely near subsistence.
- The Monsoonal agriculture is largely concerned with grain farming while the Mediterranean is concerned with Horticulture and Olericulture.
- Rice is the dominant crop in the Monsoonal regions. However, in the Mediterranean region, there is dominance of horticultural crops.
- The arable area in the Monsoon region is very large while it is restricted in the Mediterranean lands.
- Farming in monsoonal region is done on alluvial plains, delta, loess and lava soil region covering large areas while in the Mediterranean, it is confined to small valleys, narrows floodplains deltas, piedmont plains and lower slopes of the mountains.

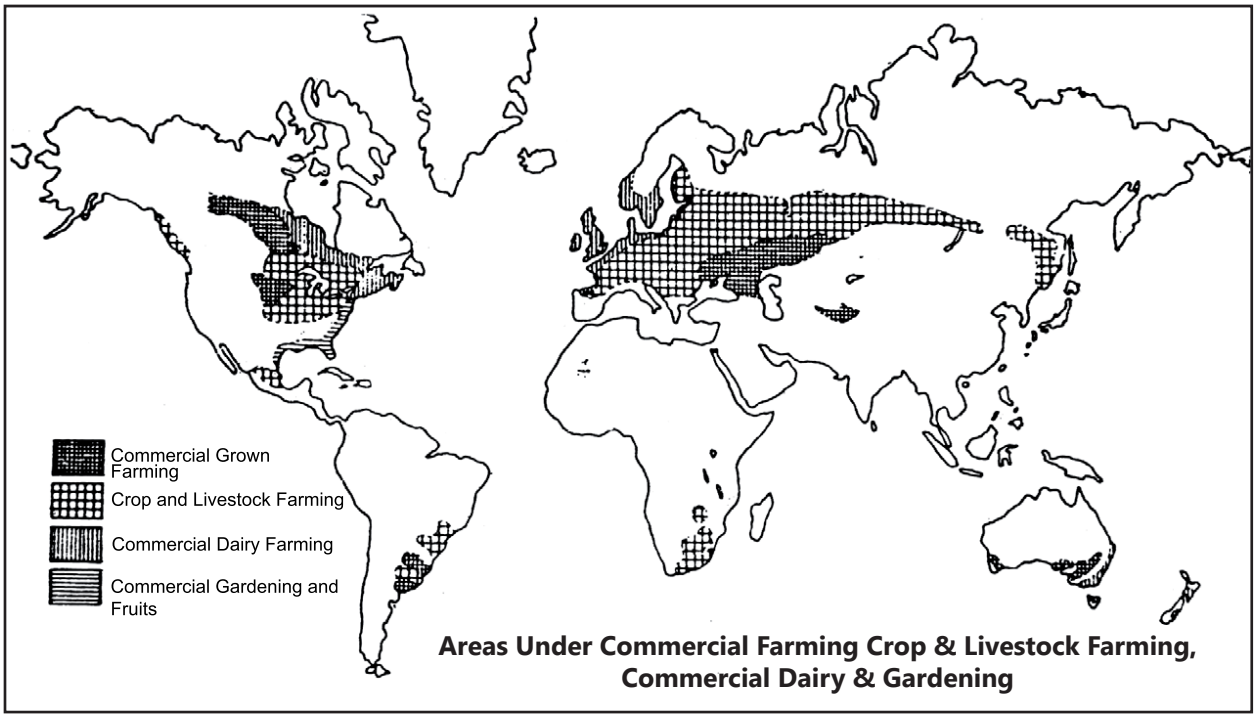
Livestock Ranching

- Livestock ranching is the **commercial grazing of livestock over an extensive area**. It is a form of agriculture adapted to semi-arid or arid land.
- The major livestock ranching areas are:
  - The western United States and the adjacent parts of Canada and Mexico;
  - The Llanos of Venezuela;
  - The Sertao of Brazil, the Pampa of Uruguay, the southeastern part Argentinean Pampa, the Chaco and Patagonia;
  - The Karroo of South Africa;
  - The arid interiors of Australia; and
  - The high country of South Island in New Zealand
- The livestock ranchers specialize in animal husbanding to the exclusion of crop raising even though both live in arid or semi-arid region.
- The livestock ranchers have fixed place of residence and operate as individuals rather than with in a tribal organization.
- Livestock ranching differs from nomadic herding in some important aspects
  - The vegetation cover is continuous.
  - There is little or no migration.
  - Ranches are scientifically managed.
  - Commercial grazing supports the development of town's communication.
- Livestock ranching is an extensive form of land use, which is associated with a very large land requirement and modest input of capital and human resources, labour and management.
- The major types of livestock are sheep, cattle, goats and horses. They were mostly introduced from the European stock, and at the same time are greatly improved by the adoption of scientific methods of breeding.

Extensive Commercial Grain Farming

- Commercial grain farming is the outcome of great economic and technological, changes that took place in the wake of the Industrial Revolution of the nineteenth century. It is found in the continental lands of the mid-latitudes, far away from marine influence.
- Large scale commercial grain cultivation is found in only five countries—the United States, Canada, the Commonwealth of Independent States (CIS), Argentina and Australia and is best developed in the, Eurasian Steppes in region of chernozem soil, east of the Volga River in northern Kazakastan and the southern part of western Siberia; the Canadian and Amerlegn Prairies; the Pampas of Argentina popularly known as wheat crescent from Rosario to Bahia Blanca; the Veldt of South Africa; the Australian Downs; and the Canterbury Plain of New Zealand.
- The commercial grain fanning is basically extensive. The main characteristics of these systems are
  - Big farm size
  - Comprehensive use of heavy machines
  - Low use of irrigation fertilizer
  - Low production rate
  - Long distance between farm and market.
- Widespread use of machinery enables commercial grain farmer to operate on this large scale.
- Wheat is the main crop; Maize, Barley, Oat ore another important crops. The wheat production regions are divided into two belts:
  - **Winter wheat belt**
  - **Spring wheat belt**

- Winter wheat (planted in autumn (fall) and harvested in mid-summer) is grown in the warmer south, where winters are sufficiently mild to enable the seeds to survive the winter. In the United States, the winter wheat belt extends through Kansas, Colorado and Oklahoma. The spring wheat is planted in the spring and harvested in the late summer. It is grown in the colder north. In North America, the spring wheat belt runs through Dakota, Montana and southern Saskatchewan.
- Although wheat is the main crop of commercial grain farming in semi-arid regions; barley, flax and corn are also grown with wheat as subsidiary crops. In Argentina and the Russian steppes, flax for oil seed is often grown and other oil seeds such as soya beans are also very important crops. Oats, rye, hay, etc. are grown chiefly to feed draught and non-draught animals; although the draught animals have been largely replaced by tractors.
- In the Prairies and the Steppes, irrigation is not very much significant, Grains are raised on un-irrigated lands since wheat or barley requires a little-inch of annual precipitation. Irrigation is required only in unfavorable locations.
- Complexes of farm buildings are located on farms. They include large machinery sheds and temporary storage facilities for grain. At such places, Railroad silos or elevators for wheat storage prior to shipment are most common.



Areas Under Commercial Farming Crop & Livestock Farming, Commercial Dairy & Gardening

Specialized Horticulture and Floriculture (Flower Culture)

- Specialized horticulture and floriculture involves production of fruits, flowers and, vegetables in orchards and kitchen gardens solely for the urban market.
- Market gardening is well developed in the densely populated industrial districts of northwestern Europe— in Britain, Denmark, Belgium, Germany and the Netherlands, and in the northeastern U.S.A., where the demands are very high.
- In the southeast U.S.A., this type of farming is called truck farming because trucks are used to transport the fruits and vegetables from the farm to the buyers. In tropical region, truck farming may be established for climatic regions. Upland areas may produce temperate fruits and vegetables, which are in great demand in urban areas.
- The market gardens are located just outside the city in suburban areas or in areas where climatic and soil conditions are particularly favorable.
- The scale of farming is small and intensive Attention is paid to individual plants. Labour, capital and organization are intensively applied to land. During peak periods, farmers and their family members have to work almost round the clock.

- The methods employed to grow crops are generally traditional and since most of the work is done by hand the farming is labour intensive. Where soil is good and favouring early harvest, intensive labour and consummate human skill devoted to the growing of a large number of crops on minimum hectares.

Plantation Agriculture

- Plantation is a form of commercial agriculture found in the tropics and the subtropics of Latin America, Africa and Asia. It refers to the large scale, capitalised and often highly centralised cultivation in the plantations of cash crops for export. It is, therefore, one of the best examples of an export-oriented system.
- Among the most important crops found on plantations are cotton, sugarcane, coffee, rubber and tobacco. Latin American plantations are most likely to grow coffee, sugarcane and bananas while Asian plantations may provide rubber and palm oil.
- Most estates have foreign ownership but the labour employed is local. The largest estates are owned by the Europeans. For example, the Malaysian rubber plantations are owned by Europeans while the tapping and processing of the rubber is done entirely by local people or by immigrant labourers from southern India.
- The British established large tea gardens in India and Sri Lanka and banana and sugarcane plantations in West Indies. The French have established cocoa and coffee plantations in West Africa, e.g. in -Cameroon and Ivory Coast.
- The Dutch once monopolised the sugarcane plantations in Indonesia, especially in Java; Spanish and American capitalists invested in coconut, abaca and sugar plantations in the Philippines; the Portuguese still own fazendas in Brazil. Sugarcane plantations in Queensland, Australia are an exception in the sense that they employ white labour.

Indian Agriculture

- Agriculture plays a vital role in Indian economy.
- 54.6% of the population is engaged in agriculture and allied activities (census 2011) and it contributes 17.1% to the country's Gross Value Added for the year 2017-18 (at current prices).
- India is the second largest fruit producer in the world. Production of horticulture crops is estimated at record 314.7 million tonnes (mt) in 2018-19 as per third advance estimates. India is also the largest producer, consumer and exporter of spices and spice products.
- India ranks second in agricultural output and India is in top fi ve positions for about 80 percent of products produced from farm.
- The major research institute for agricultural research is Indian Council of Agricultural Research (ICAR).
- The main food grain of India is Rice. India ranks second worldwide in rice production.
- West Bengal is the top state in rice production followed by Uttar Pradesh, Andhra Pradesh, Punjab, and Bihar.
- Yield wise, Tamil Nadu ranks first in rice production.
- Central rice research institute is located in Cuttack, Odisha.
- India ranks second in wheat production.
- Uttar Pradesh is the highest wheat producing state of India followed by Punjab, Madhya Pradesh, and Haryana.
- India is the second most tea producing country and in India, Assam is the most tea producing state.
- Karnataka is the highest coffee producing state.
- Sugarcane is one of the main crops produced by India. Uttar Pradesh is the key state in producing sugarcane.
- Indian Institute of Sugarcane Research is located in Lucknow.

- Cotton and Jute are the main fiber crops produced in India. Maharashtra is the largest producer of cotton and West Bengal is the largest producer of Jute in India.

Salient Features of Indian Agriculture

Agriculture is the primary source of livelihood for about 58 per cent of India's population. India has the 10thlargest arable land resources in the world. With 20 Agro-climatic regions, all 15 major climates in the world exist in India. The country also possesses 46 of the 60 soil types in the world.

- **Subsistence agriculture:** Most parts of India have subsistence agriculture. The farmer owns a small piece of land, grows crops with the help of his family members and consumes almost the entire farm produce with little surplus to sell in the market.
- **Pressure of population on agriculture:** The population in India is increasing at a rapid pace and exerts heavy pressure on agriculture. While looking into the present need of food grains, we require an additional 12-15 million hectares of land to cope with the increasing demands.
- **Importance of animals:** Animal force has always played a significant role in agricultural operations such as ploughing, irrigation, threshing and transporting the agricultural produce.
- **Dependent upon monsoon:** Indian agriculture is mainly dependent upon monsoon which is uncertain, unreliable and irregular. Nearly 60% area is rainfed.
- **Variety of crops:** India is a vast country with varied types of relief, climate and soil conditions. Therefore, there is a large variety of crops grown in India. Both the tropical and temperate crops are successfully grown in India.
- **Predominance of food crops:** Since Indian agriculture has to feed a large population, production of food crops is the first priority of the farmers almost everywhere in the country. More than two-thirds of the total cropped area is devoted to the cultivation of food crops. More than 85 per cent of the net sown area is already under foodgrains.
- **Insignificant place given to fodder crops:** Although India has the largest population of livestock in the world; fodder crops are given a very insignificant place in our cropping pattern. Only four per cent of the reporting area is devoted to permanent pastures and other grazing lands.
- **Mixed Cropping:** Mixed cropping is one of the chief characteristics of Indian agriculture particularly in the rain-fed areas. The popular crops are millets, maize and pulses in the kharif season and wheat, gram and barley in the Rabi season.
- **High percentage of reporting area under cultivation:** In the year 2013-14, 141.43 million hectares was the net sown area out of total reporting area of 307.8 million hectares. Thus nearly 46 per cent of the total reporting area is under cultivation. This is a very high percentage when compared to some of the advanced countries like 16.3% in U.S.A., 14.9% in Japan, 11.8% in China, and only 4.3% in Canada.
- **Labour intensive:** In large part of India, agriculture is labour intensive as most of agricultural operations like ploughing, levelling, sowing, weeding, pruning, sprinkling, spraying, harvesting, threshing, etc. are done by the farmers and their animals.

Food grains

- The importance of foodgrains in Indian agricultural economy may be gauged from the fact these crops occupy about two-third of total cropped area in the country.
- Foodgrains are dominant crops in all parts of the country whether they have subsistence or commercial agricultural economy.

Cereals

- The cereals occupy more than half of the total cropped area in India.
- The country produces about 11 per cent cereals of the world and ranks third in production after China and U.S.A.
- India produces a variety of cereals, which are classified as fi ne grains (rice, wheat), and coarse grains (jowar, bajra, maize, ragi), etc. Account of important cereals has been given in the following paragraphs:

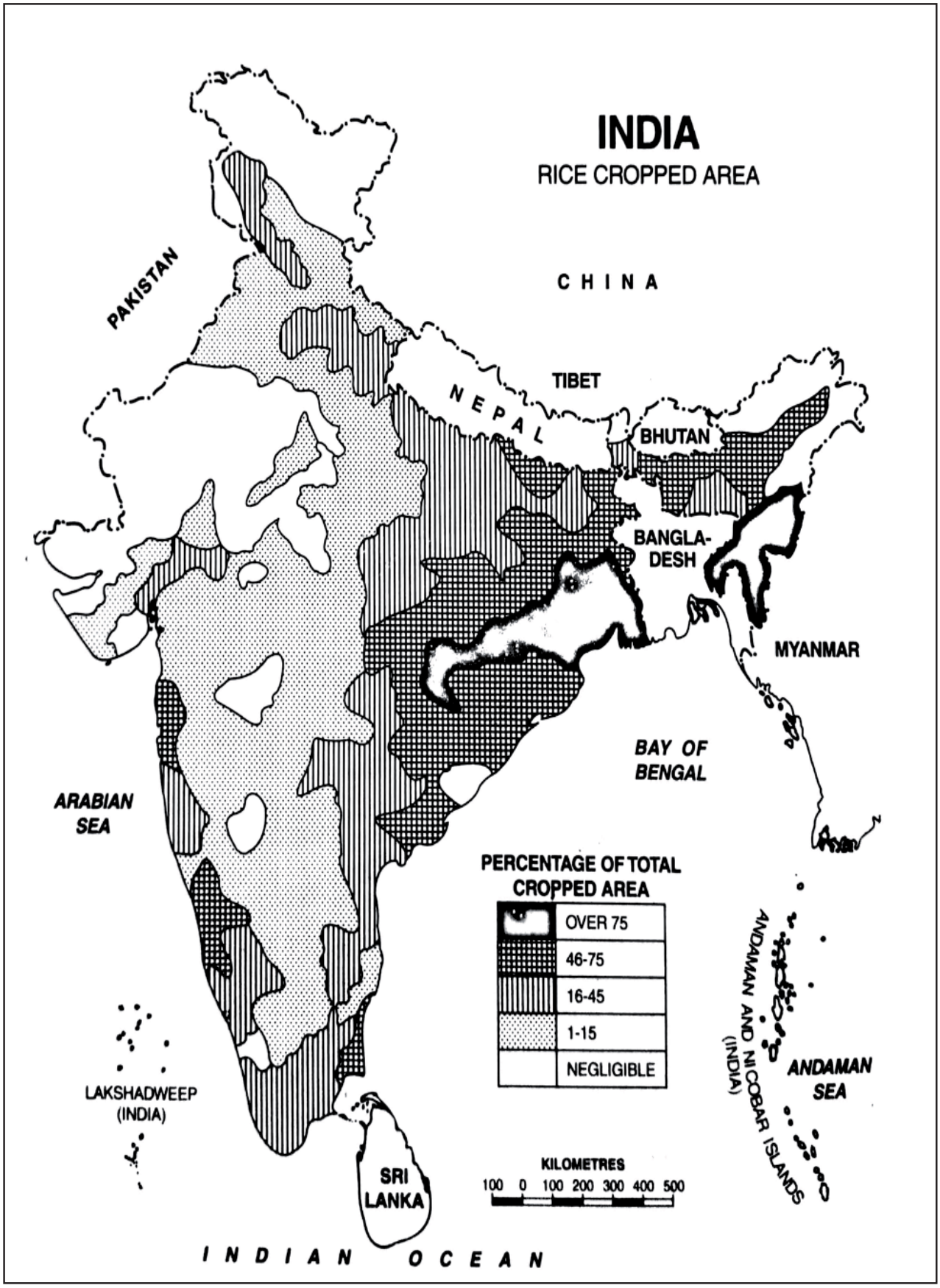
Major Crops	Temperature	Rainfall	Soil	Area	Other
Rice	22 -30 degree Celsius	150-300 cm	Deep clayey and loamy soil	West Bengal, Punjab, Uttar Pradesh, Tamil Nadu, Haryana, Andhra Pradesh, Telangana and Kerala	India contributes 21.6 per cent of rice production in the world and ranked second after China
Wheat	10-15 degree Celsius (Sowing time); 21-26 degree Celsius (Ripening & Harvesting)	75-100 cm	Well-drained fertile loamy and clayey loamy	About 85 per cent of total area under this crop is concentrated in north and central regions of the country i.e. Indo-Gangetic Plain, Malwa Plateau and Himalayas up to 2,700 m altitude Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, & Rajasthan.	Wheat is the second most important cereal crop in India after Rice. India produces about 12 per cent of total wheat production of world. It is primarily a crop of temperate zone.
Jowar	25-32 degree Celsius	30-100 cm	Can be grown in inferior alluvial or loamy soil	Semi-arid areas of central and southern India, Maharashtra, Karnataka, Andhra Pradesh and Madhya Pradesh	Jowar is the third most important food crop with respect to area and production. It is a rainfed crop mostly grown in the moist areas which hardly needs irrigation.
Bajra	25-30 degree Celsius	40-60 cm	Grows well on sandy soil and shallow black soil	Hot and dry climatic conditions in northwestern and western parts of the country Rajasthan, Uttar Pradesh, Gujarat & Haryana.	It is a hardy crop which resists frequent dry spells and drought in this region. It is cultivated alone as well as part of mixed cropping.
Maize	22-27 degree Celsius	50-100 cm	Can be grown in inferior alluvial or loamy soil	Grown under semi-arid climatic conditions, Chambal Region, southern states Karnataka, Madhya Pradesh, Bihar & Tamil Nadu.	Maize is a food as well as fodder crop
Pulses	Both in Kharif and Rabi season	50-75 cm	Can be grown in inferior alluvial or loamy soil	Largely concentrated in the dry lands of Deccan and central plateaus and northwestern parts of the country	India is the largest producer (about one fifth of world) as well as the consumer of pulses in the world, Pulses occupy about 11 per cent of the total cropped area in the country.
Millets	27-32 degree Celsius	50-75 cm	Can be grown in inferior alluvial or loamy soil	Rain fed and dry region	Drought resistant crop, high in nutrients

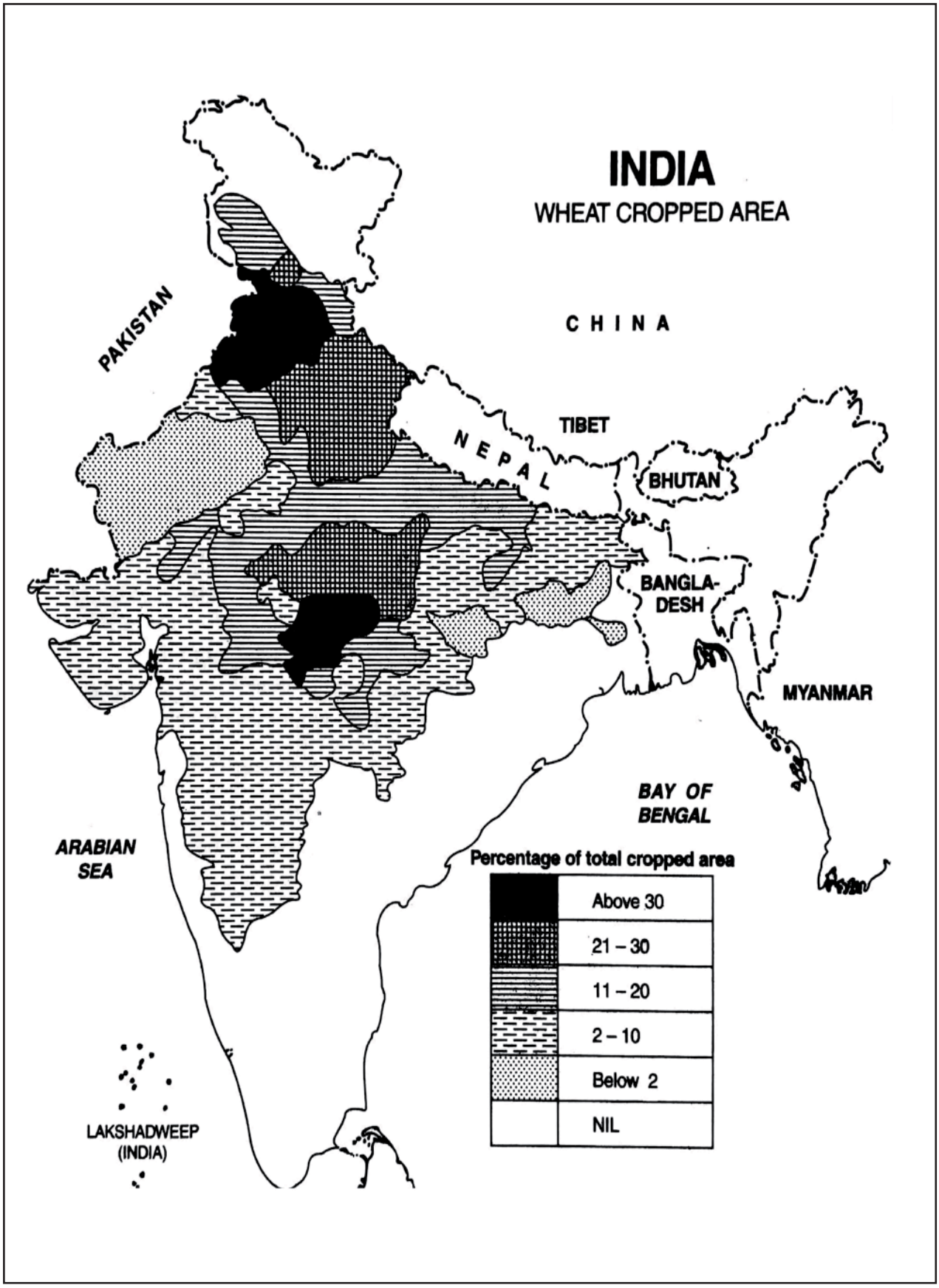
Gram	20-25 degree Celsius (Mild cool & Dry Climate)	40-45 cm	Loamy Soil	Rain fed and dry region, Rajasthan, Madhya Pradesh, Uttar Pradesh.	
Cotton	21-30 degree Celsius	50-100 cm	Black soil of Deccan and Malwa Plateau	Deccan and Malwa Plateau, Maharashtra, Tamil Nadu, Gujarat, Madhya Pradesh, Karnataka.	India grows both short staple (Indian) cotton as well as long staple (American) cotton called 'narma' in north western parts of the country. Cotton requires clear sky during flowering stage.
Oilseeds	20-30 degree Celsius	50-75 cm	Well drained light sandy loams, red, yellow and black soils	Dry lands of Malwa plateau, Marathwada, Gujarat, Rajasthan, Telangana and Rayalseema region of Andhra Pradesh and Karnataka plateau	Groundnut, rapeseed and mustard soyabean and sunflower are the main oilseed crops grown in India.
Tea	20-30 degree Celsius	150-300 cm	Undulating	Sub-Himalayan region of West Bengal (Darjeeling, Jalpaiguri and Cooch Bihar districts). Lower slopes of Nilgiri and Cardamom hills in Western, Brahmaputra valley of Assam	India is ranked fourth in terms of tea exports, Assam produces almost 50% of country's production
Coffee	15-28 degree Celsius	150-250 cm	Well drained, deep friable loamy soil	Highlands of Western Ghats in Karnataka, Kerala and Tamil Nadu	Karnataka alone accounts for more than two third of total production of coffee in the country. Indian coffee is known in the world for its good quality
Jute	24 -35 degree Celsius	150-200 cm	Grows well on well-drained fertile soils in the flood plains	West Bengal and adjoining eastern parts of the country	India produces about three-fifth of jute production of the world. West Bengal accounts for about three-fourth of the production in the country. Bihar and Assam are other jute growing areas.
Sugarcane	22 -28 degree Celsius	75-150 cm	Indo-Gangetic plain	Its cultivation is largely concentrated in Uttar Prades and Maharashtra, Tamil Nadu, Karnataka, Andhra Pradesh.	India is the second largest producer of sugarcane after Brazil

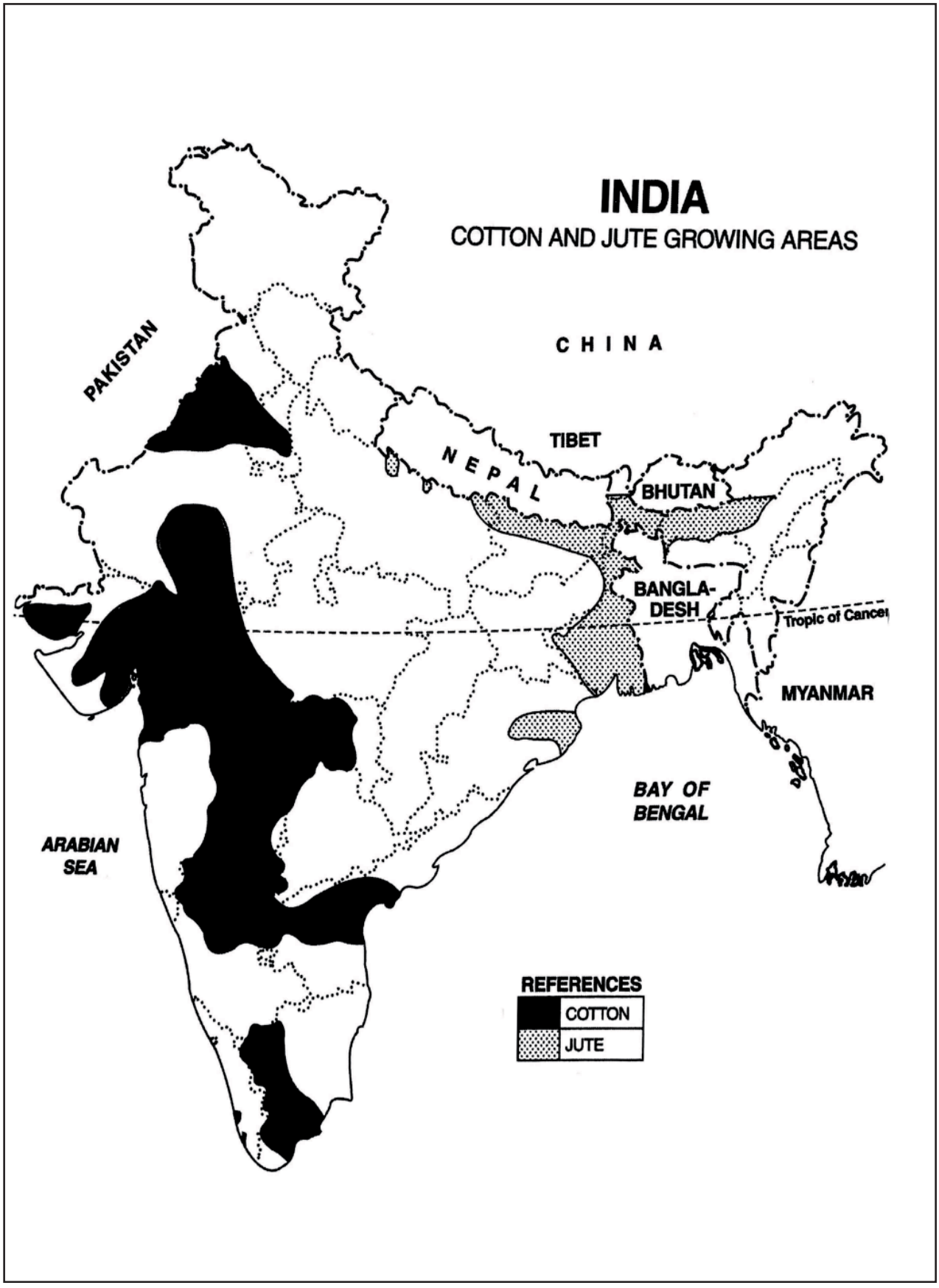
Suitability of different soils for different crops	
Soils	**Crops**
1. Alluvial soils	Wheat, maize, barley, gram, oilseeds, pulses, sugarcane.
2. Clayey loams, fine and heavy soils	Rice, jute
3. Volcanic black soils or regur	Cotton, wheat, oilseeds
4. Sandy loams and sandy soils	Jawar, bajra, groundnut, guar, pulses (green gram, red gram, black gram etc.)
5. Red and yellow soils	Jawar, groundnut, sugarcane.

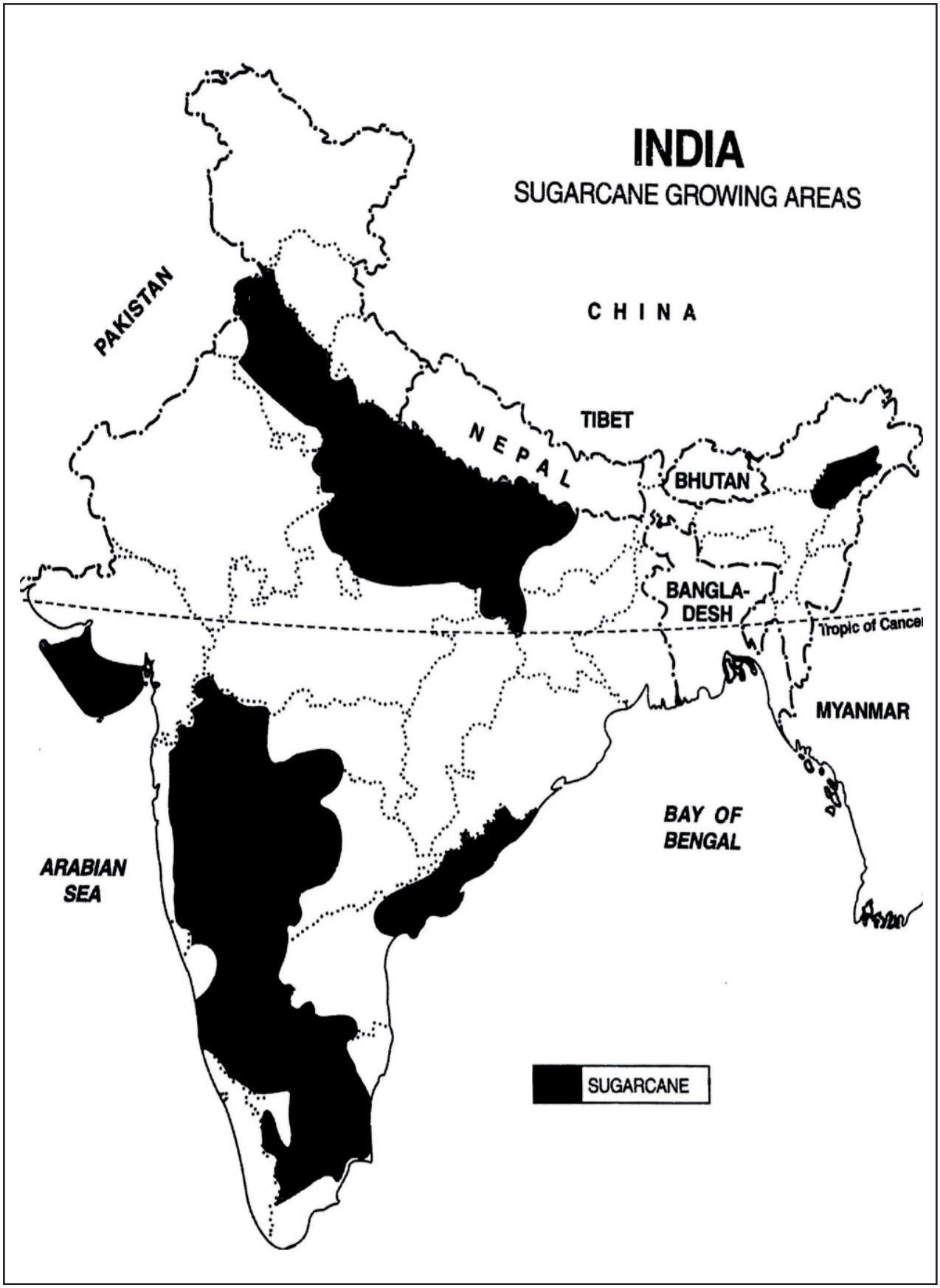
Major Crops Producing States of India

Crops	States
Rice	West Bengal, Uttar Pradesh, Tamil Nadu, Andhra Pradesh, Punjab
Wheat	Uttar Pradesh, Haryana, Punjab, Madhya Pradesh
Sugarcane	Uttar Pradesh, Maharashtra, Karnataka
Jowar	Maharashtra, Karnataka, Madhya Pradesh, Telangana, Gujarat
Bajra	Rajasthan, Maharashtra, Gujarat
Ragi	Andhra Pradesh, Karnataka, Tamil Nadu
Tea	Assam, West Bengal, Himachal Pradesh
Coffee	Karnataka, Kerala, Tamil Nadu
Cotton	Maharashtra, Gujarat
Jute	West Bengal, Bihar, Assam
Rubber	Kerala, North East States
Silk	Karnataka, Kerala
Maize	Uttar Pradesh, Rajasthan, Madhya Pradesh, Bihar
Gram	Rajasthan
Millets	Madhya Pradesh
Pulse	Madhya Pradesh, Maharashtra, Uttar Pradesh, Rajasthan
Tobacco	Andhra Pradesh, Maharashtra
Onion	Maharashtra,
Groundnut	Gujarat
Banana	Tamil Nadu,
Potato	Uttar Pradesh


INDIA
RICE CROPPED AREA
PAKISTAN
CHINA
TIBET
NEPAL
BHUTAN
BANGLA-
DESH
MYANMAR
BAY OF
BENGAL
ARABIAN
SEA
PERCENTAGE OF TOTAL
CROPPED AREA
OVER 75
46-75
16-45
1-15
NEGLIGIBLE
ANDAMAN AND NICOBAR ISLANDS
(INDIA)
ANDAMAN
SEA
LAKSHADWEEP
(INDIA)
SRI
LANKA
KILOMETRES
100 0 100 200 300 400 500
INDIAN OCEAN


INDIA
WHEAT CROPPED AREA
PAKISTAN
CHINA
TIBET
NEPAL
BHUTAN
BANGLA-
DESH
MYANMAR
BAY OF
BENGAL
ARABIAN
SEA
Percentage of total cropped area
Above 30
21 – 30
11 – 20
2 – 10
Below 2
NIL
LAKSHADWEEP
(INDIA)


INDIA
COTTON AND JUTE GROWING AREAS
CHINA
PAKISTAN
TIBET
NEPAL
BHUTAN
BANGLA-
DESH
Tropic of Cancer
MYANMAR
BAY OF
BENGAL
ARABIAN
SEA
REFERENCES
COTTON
JUTE


INDIA
SUGARCANE GROWING AREAS
PAKISTAN
CHINA
TIBET
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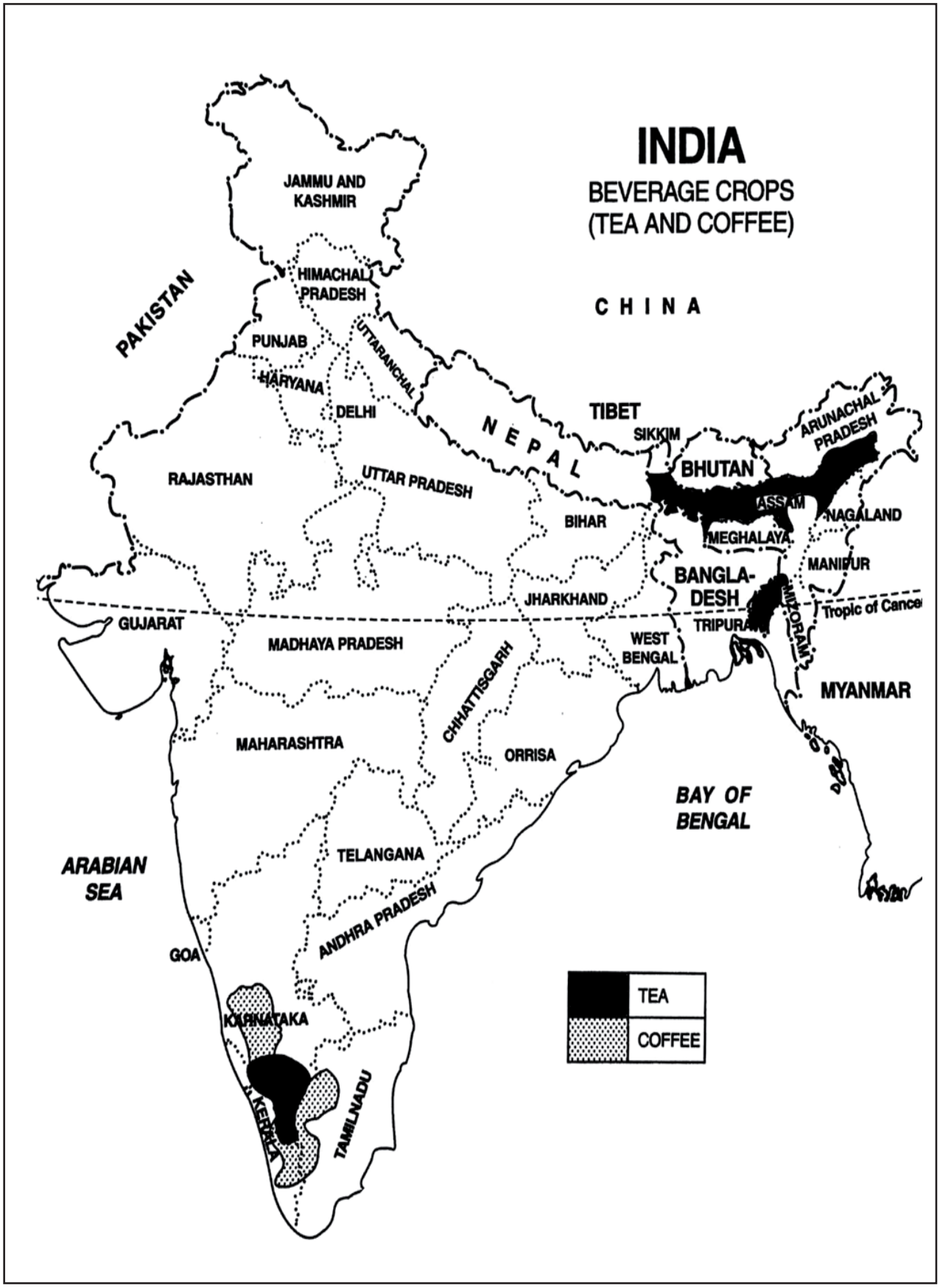
Tropic of Cancer
MYANMAR
BAY OF
BENGAL
ARABIAN
SEA
SUGARCANE



Agro-Climatic Regions

- Climate plays an important role in evolving crop ecology of a region and is responsible for regional variations in agriculture. Such variations are more prominent in a large country like India, where

there are large variations in climatic elements. Effects of climatic elements are reflected in crop calendars, crop productivity and cropping patterns in different parts of the country.

- The Planning Commission divided India into 15 major agro-climatic regions in 1989. These regions are :
  - The Western Himalayas
  - The Eastern Himalayas
  - The Lower Gangetic Plains
  - The Middle Gangetic Plains
  - The Upper Gangetic Plains
  - The Trans-Gangetic Plain
  - The Eastern Plateaus and Hills
  - The Central Plateaus and Hills
  - The Western Plateaus and Hills
  - The Southern Plateaus and Hills
  - The East Coastal Plains and Hills
  - The West Coastal Plains and Western Ghats
  - The Gujarat Plains and Hills
  - The Western Dry Region
  - The Islands Region.

Problems of Indian Agriculture

- **Dependence on Erratic Monsoon**: Irrigation covers only about 33 per cent of the cultivated area in India. The crop production in rest of the cultivated land directly depends on rainfall.
- **Low productivity:** The yield of the crops in the country is low in comparison to the international level. Per hectare output of most of the crops such as rice, wheat, cotton and oilseeds in India is much lower than that of U.S.A., Russia and Japan.
- **Constraints of Financial Resources and Indebtedness:** The inputs of modern agriculture are very expensive. This resource intensive approach has become unmanageable for marginal and small farmers as they have very meagre or no saving to invest in agriculture.
- **Lack of Land Reforms:** Indian peasantry had been exploited for a long time as there had been unequal distribution of land. After independence, land reforms were accorded priority, but these reforms were not implemented effectively due to lack of strong political will.
- **Small Farm Size and Fragmentation of Landholdings:** There are a large number of marginal and small farmers in the country. More than 60 per cent of the ownership holdings have a size smaller than one hectare. Furthermore, about 40 per cent of the farmers have Operational holding size smaller than 0.5 hectare. The average size of land holding is shrinking further under increasing population pressure. Furthermore, in India, the land holdings are mostly fragmented.
- **Lack of Commercialization:** A large number of farmers produce crops for self-consumption. These farmers do not have enough land resources to produce more than their requirement. Most of the small and marginal farmers grow foodgrains, which are meant for their own family consumption. Modernization and commercialization of agriculture have, however, taken place in the irrigated areas.
- **Vast Under-employment:** There is a massive under-employment in the agricultural sector in India, particularly in the un-irrigated tracts. In these areas, there is a seasonal unemployment ranging from 4 to 8 months. People engaged in agriculture do not have the opportunity to work round the year.

ENERGY RESOURCES

- Energy is the name given to the ability to do work.

- In order that anything may be done energy is required. All human life depends on energy in the universe.
- Most of the energy on the earth comes from the sun.
- It is the sun, which is the source of all forms of energy on the earth and related to the formation of energy fuels either directly or indirectly.
- It is the sun only, which makes all the motions on earth possible be it wind, wave or anything.

Types of Energy Resources

Commercial Energy Sources

Solid Fuels

- **Hard coal:** Coals with a gross calorific value (moist, ash-free basis) which is not less than 24 MJ/kg or which is less than 24 MJ/kg provided that the coal has a vitrinite mean random reflectance rather than or equal to 0.6 per cent. Hard coal comprises anthracite and bituminous coals.
- **Lignite:** Brown coal with a gross calorific value (moist, ash-free basis) less than 20 MJ/kg.
- **Coke:** Products derived directly or indirectly from the various classes of coal by carbonisation or pyrolysis processes, or by the aggregation of finely divided coal or by chemical reactions with oxidising agents, including water

Liquid Fuels

- **Crude petroleum:** A mineral oil of fossil origin extracted by conventional means from underground reservoirs, and comprises liquid or near-liquid hydrocarbons and associated impurities such as sulphur and metals.
- **Liquefied Petroleum Gas:** LPG refers to liquefied propane (C_3H_8) and butane (C_4H_{10}) or mixtures of both. Commercial grades are usually mixtures of the gases with small amounts of propylene, butylene, isobutene and isobutylene stored under pressure in containers.
- **Motor gasoline:** A mixture of some aromatics (e.g., benzene and toluene) and aliphatic hydrocarbons in the C5 to C12 range. The distillation range is 25°C to 220°C.
- **Naphtha's Light or medium oils** distilling between 30°C and 210°C, which do not meet the specification for motor gasoline.
- **Kerosene:** Mixtures of hydrocarbons in the range C9 to C16 and distilling over the temperature interval 145°C to 300°C, but not usually above 250°C and with a fl ash point above 38°C.
- **Gasoline type Jet fuels:** Light hydrocarbons for use in aviation turbine power units, distilling between 100°C and 250°C. They are obtained by blending kerosene and gasoline or naphtha in such a way that the aromatic content does not exceed 25 per cent in volume and the vapour pressure is between 13.7 kPa and 20.6 kPa.
- **Gas oil/Diesel oil:** Gas oils are middle distillation; predominantly of carbon number range C11 to C25 and with a distillation range of 160°C to 420°C.
- **Fuel oil:** Comprises residual fuel oil and heavy fuel oil. Residual fuel oils have a distillation range of 350°C to 650°C and a kinematic viscosity in the range 6 to 55 cSt at 100°C. Their fl ash point is always above 60°C and their specific gravity is above 0.95. Heavy fuel oil is a general term describing a blended product based on the residues from various refinery processes.

Gaseous Fuels

- **Natural Gas:** It is mixture of gaseous hydrocarbons, primarily methane, but generally also including ethane, propane and higher hydrocarbons in much smaller amounts and some non-combustible gases such as nitrogen and carbon dioxide.
- **Coke-oven gas:** A gas produced from coke ovens during the manufacture of coke.
- **Biogases:** Gases arising from the anaerobic fermentation of biomass and the gasification of solid biomass (including biomass in wastes).

- The gases are divided into two groups according to their production: biogases from anaerobic fermentation and biogases from thermal processes. They are used mainly as a fuel but can be used as a chemical feedstock.

Non-commercial Energy Sources

- **Fuelwood, wood residues and by-products:** Fuelwood or firewood (in log, brushwood, pellet or chip form) obtained from natural or managed forests or isolated trees. Also included are wood residues used as fuel and in which the original composition of wood is retained.
- **Remark:** Charcoal and black liquor is excluded.
- **Charcoal**: The solid residue from the carbonization of wood or other vegetal matter through slow pyrolysis.
- **Bagasse:** The fuel obtained from the fibre, which remains after juice extracts in sugar cane processing.

Based on the availability in near future and replenishments, energy resources can be classified as:

- **Non-renewable resources,** which when exhausted are exhausted forever, and
- **Renewable resources,** which can also be called inexhaustible.

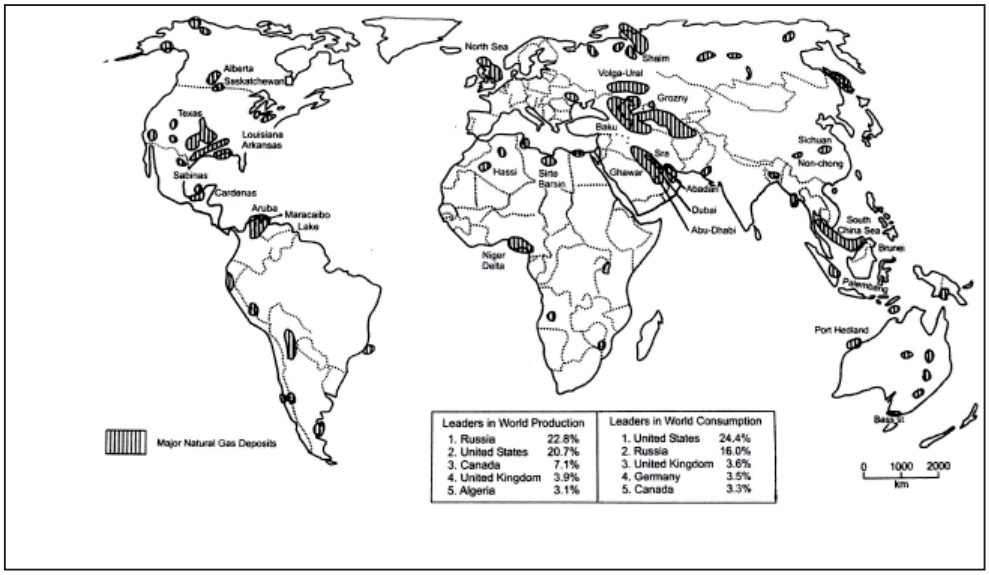
Other classification can be made between:

- **Conventional,** which has been in use by mankind for quite some time and which are more or less, direct form of energy.
- **Non-conventional** such as biogas, biomass in which one has to perform some processes before getting energy.

Natural Gas

- Natural gas is a naturally occurring hydrocarbon gas mixture consisting primarily of methane, but commonly includes varying amounts of other higher alkanes and even a lesser percentage of carbon dioxide, nitrogen, and hydrogen sulphide. Natural gas is an energy source often used for heating, cooking, and electricity generation. It is also used as fuel for vehicles and as a chemical feedstock in the manufacture of plastics and other commercially important organic chemicals.
- Natural gas is often informally referred to simply as gas, especially when compared to other energy sources such as oil or coal. However, it is not the same as gasoline, especially in North America, where the term gasoline is often shortened in colloquial usage to gas.

Major Natural Gas Deposits of the World



■ Natural gas as an energy source has certain merits and limitations.

Merits

- Burns clean compared to other energy resources.
- 70% loss carbon dioxide emission compared to other fossil fuel
- Helps improve quality of air and water (not a pollutant)
- Does not produce ashes after energy release
- Has high heating value of 24,000 Btu per pound
- Inexpensive compared to coal
- No odour until added

Limitations

- Natural gas is not a renewable source it is a finite resource trapped in the earth.
- Inability to recover all in-place gas from a producible deposit because of unfavorable economics and lack of technology (it costs more to recover the remaining natural gas because of flow, access, etc.)

Coal

- Coal is a sedimentary deposit formed by the slow action of heat and pressure on forests buried in the long past. It is a mechanical mixture of carbon, hydrogen, nitrogen, sulphur, etc. And it is the content of carbon which determines the quality of coal.
- In terms of fixed carbon, coals are classified into
  - **Anthracite (>95%)**-As gas coal it is used for the manufacture of city gas with coke as a by-product.
  - **Bituminous (42-83%)-**80% world's coal output
  - As coking coal it is used in coke ovens for the manufacture of metallurgical coke, with gas as a by- product.
- As household coal it is used for domestic heating purposes.
  - Lignite or Brown' coal (38%) - about 15% world's coal output is from lignite.
  - Having low heating capacity, it is sometimes used in steel plants.
  - Sometime used as fuel in power plants and mainly it is used, as a soil conditioner.

- Peat (<38%).

Distribution of Coal

North America

U.S.A.

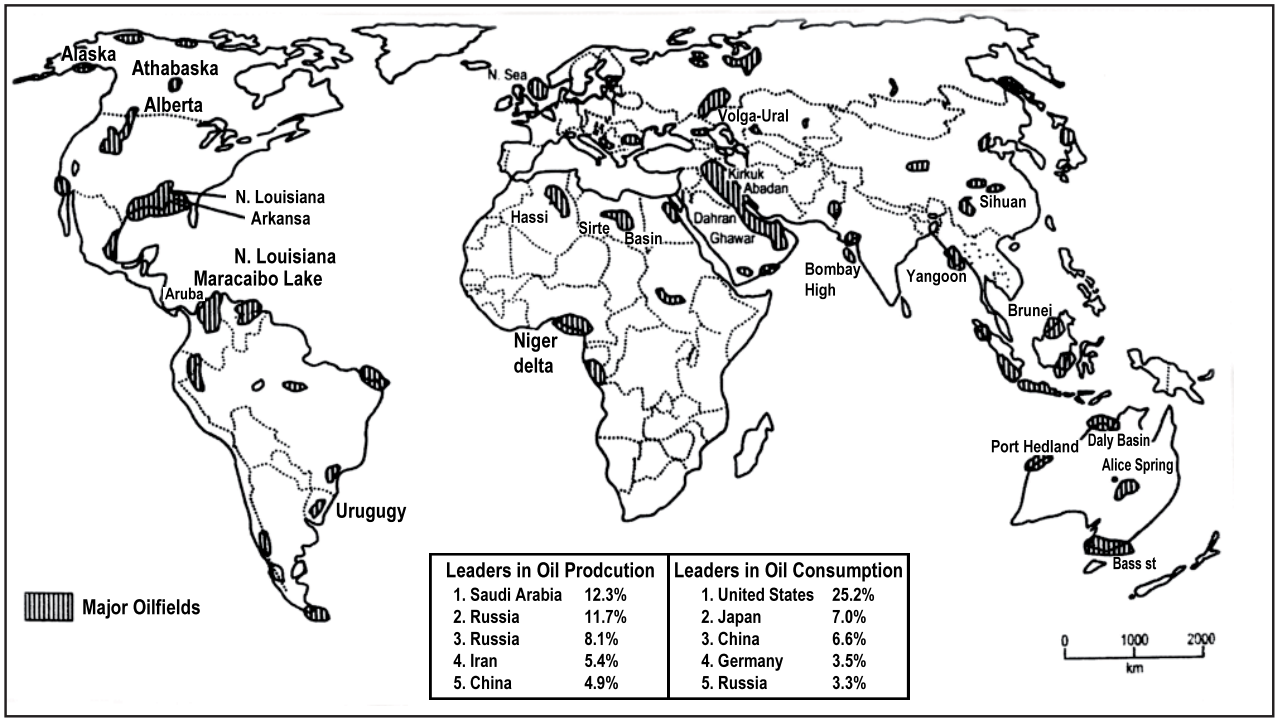
- Eastern province (a) Pennsylvania anthracite field—Scranton, Carbondale and Wilkes Barre; (b) Appalachian bituminous field—Pittsburgh, Kentucky and West Virginia, Alabama and Tennessee
- The interior province (Bituminous)—(a) Eastern interior field—Illinois, Indiana and Kentucky (b) Western interior field—Iowa, Missouri, Oklahoma and Arkansas, (c) Northern interior field—Michigan (d) Southwestern fields— Texas.
- Gulf Province (lignite) Texas, Alabama and Arkansas
- Rocky Mountain Province (lignite and low-grade bituminous)—Utah, Colorado, Wyoming, Montana, New Mexico and North Dakota.
- Pacific Province—Washington, Oregon, California and Alaska

Canada

- Prairie Province—Alberta (bituminous & lignite); British Columbia Coalfields—Vancouver Islands; Nova Scotia Coal fields—Cape Breton Island

Asia

- **China—** Shansi, Shensi, Inner Mongolia, Kansu, Hopei and Manchurian coalfields—Fushun (the world's longest strip mines and have thickest seam recorded anywhere), Fushin, Kailan and Hegang.
- **Japan—** Chikugo coalfield in the northwestern Kyushu, Ishikari fields of Hokkaido and Joban and Ube in Honshu
- **India—** Damodar valley in the states of Bengal, Jharkhand, Orissa and important mines are Raniganj, Bokaro, Jharia. Smaller deposits are at Chanda, Singareni, Tundur and Pench.
- **Pakistan—** Quetta and Kalabagh;
- **Iran**—Kermanshah.



Leaders in Oil Prodcution		Leaders in Oil Consumption	
1. Saudi Arabia	12.3%	1. United States	25.2%
2. Russia	11.7%	2. Japan	7.0%
3. Russia	8.1%	3. China	6.6%
4. Iran	5.4%	4. Germany	3.5%
5. China	4.9%	5. Russia	3.3%

Energy Resources: India

Energy is now a major input in sectors such as industry. Commerce , transport and telecommunications, besides the wide range of services required in the household sector.

Conventional Sources of Energy

- Coal, petroleum, natural gas and electricity are conventional sources of energy.

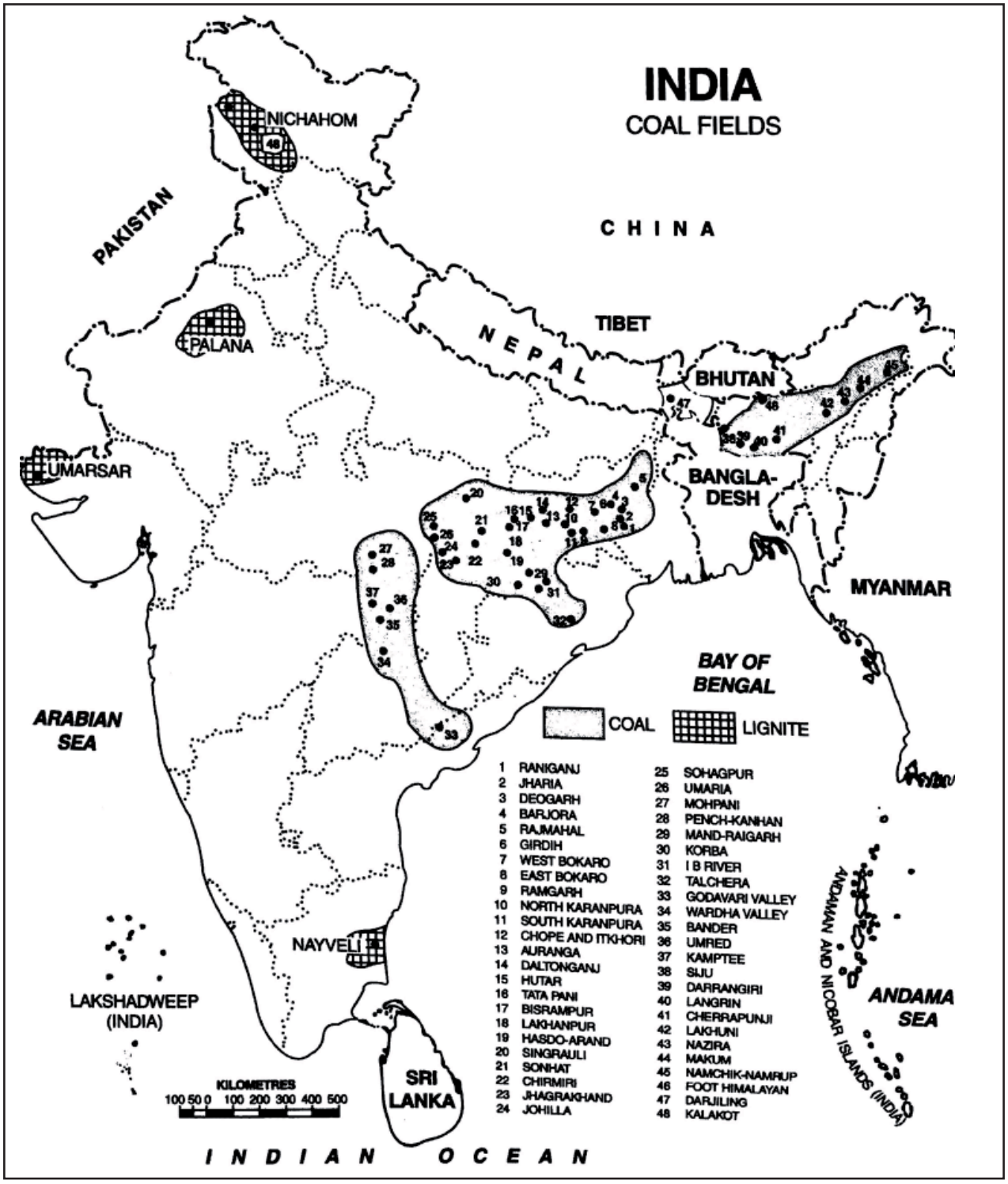
Occurrence of Coal in India:

The coal bearing strata of India are geologically classified into two main categories viz. the Gondwana coal fields and the Tertiary coal fields.

- **Gondwana Coal**- Gondwana coal contributes overwhelmingly large proportion of both the reserves and production of coal, accounting for 98 per cent of the total reserves and 99 per cent of the production of coal in India. It is the store house of India's metallurgical as well as superior quality coal. Of the 113 major coal fields found all over India, 80 are located in the rock systems of the lower Gondwana Age.
- **Tertiary Coal** -The tertiary rock systems bears coals of younger age; from 15 to 60 million years and are mainly confined to the extra-Peninsula. This coal generally has low carbon and high percentage of moisture and Sulphur. Important areas of Tertiary coal include parts of Assam, Meghalaya, Arunachal Pradesh, Nagaland, Himalayan foothills of Darjeeling in West Bengal, Jammu and Kashmir, Uttar Pradesh. Rajasthan, Kerala, Tamil Nadu and the union territory of Puducherry.

Distribution of Coal in India

- Majority of the coal-fields are found in the eastern part of India particularly to the east of 78° E longitude. Maximum concentration of coal fields is in the north-eastern pan of the peninsular plateau of India comprising pans of Jharkhand and Chhattisgarh.
- Odisha and eastern Madhya Pradesh and western part of West Bengal adjoining Jharkhand.



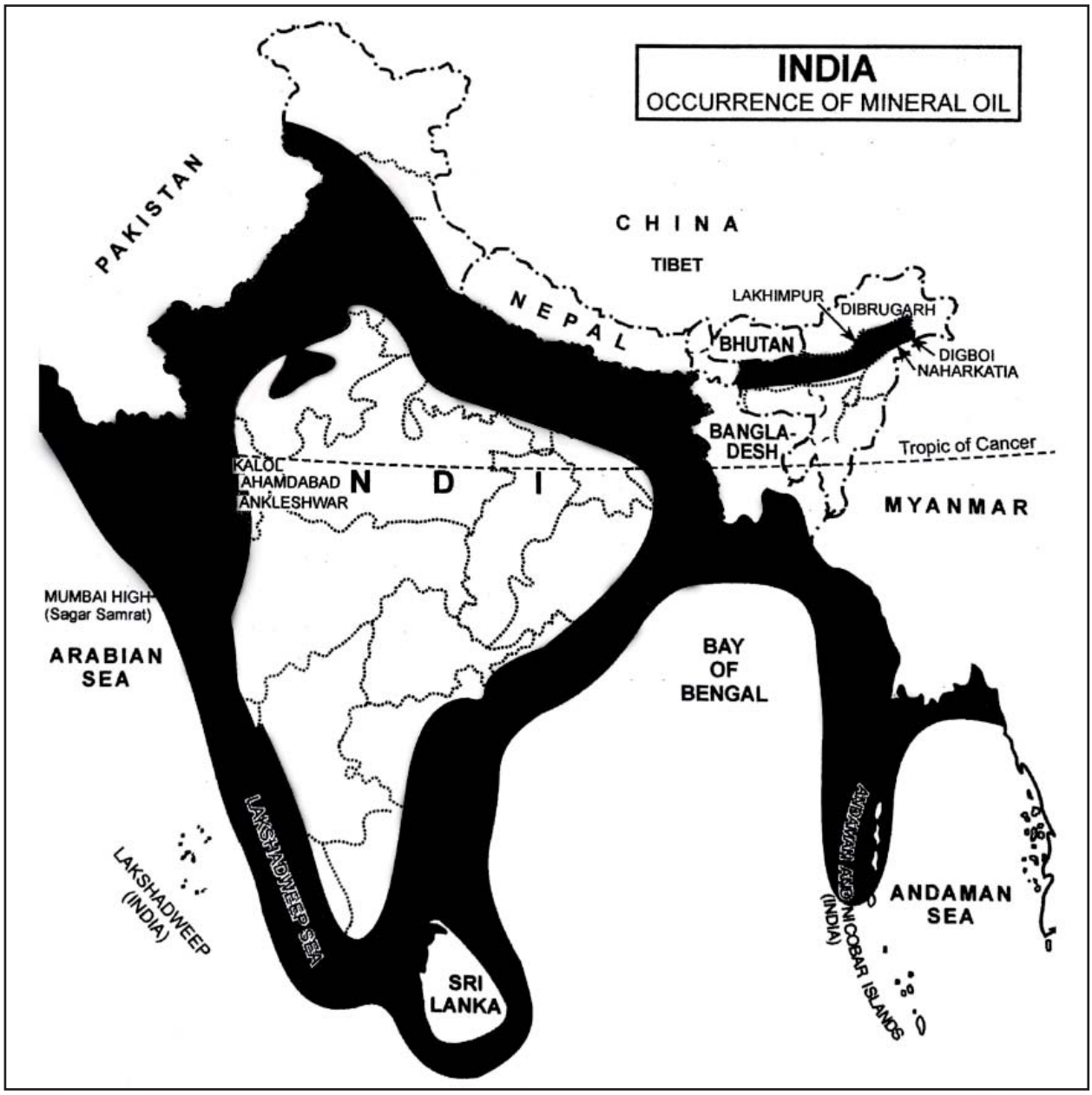
- Southern part of Madhya Pradesh, eastern part of Andhra Pradesh and eastern coast also have large deposits.
- About three-fourth of India's coal is produced by four states of Chhattisgarh, Jharkhand, Odisha and Madhya Pradesh.
- More than 40 per cent of India's total coal production comes from just two states of Chhattisgarh and Jharkhand.
- About one-third of the total coal of the country is obtained from Andhra Pradesh, Maharashtra, West Bengal, Uttar Pradesh and Meghalaya.

Petroleum & Mineral Oil

- Oil in India is obtained both from on-shore and off-shore areas, but off-shore areas made a major contribution.

On-shore Oil Production:

- On-shore oil fields are located in the Brahmaputra valley of north-cast India, Barmer area of Rajasthan, Gujarat coast in western India and Cauvery on-shore basin in Tamil Nadu. Besides Andhra Pradesh has both on-shore and off-shore oil reserves.



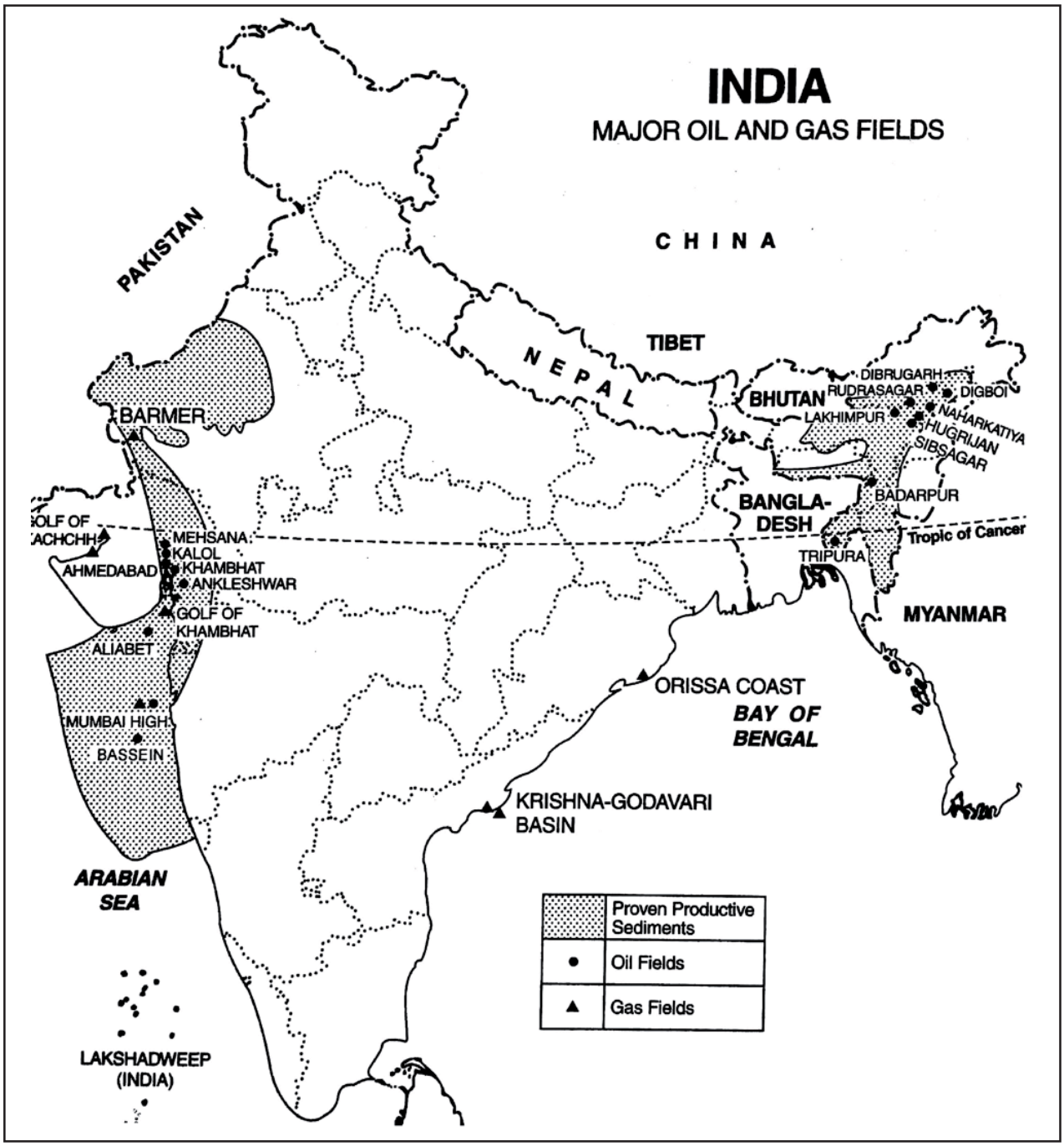
- **One of the largest inland oil** discoveries was made in **Barmer district of Rajasthan** in 2004. The oil block covers an area of approximately 5,000 sq km. State-of-the-art technology with innovative geological modelling was used in discovering this oil field.

Western Coast Off-Shore Oil fields

- Extensive surveys have been conducted by ONGC in the offshore areas of Kachchh, Khambhat, Konkan, Malabar and Coromandal coasts, Krishna-Godavari delta and Sunderbans.
- Success on commercial scale has been achieved at Mumbai High, Bassein and Aliabet.
  - **Mumbai High:** The greatest success achieved by the ONGC with respect to offshore surveys for oil was that of Mumbai High in 1974. It is located on the continental shelf off the coast of

Maharashtra about 176 km north-west of Mumbai.

- **Bassein:** Located to the south of Mumbai High, this is a recent discovery endowed with reserves which may prove to be higher than those of the Mumbai High. Huge reserves have been found at a depth of 1,900 metre. Production has started and has picked up fast.



- **Aliabet:** It is located at Aliabet Island in the Gulf of Khambhat about 45 km off Bhavnagar. Huge reserves have been found in this field. Commercial production is expected to start soon.

Natural Gas

- Natural gas usually accompanies petroleum accumulations. Whenever a well for oil is drilled, it is natural gas which is available before oil is struck. Natural gas is fast becoming an important source of energy in India. The recoverable reserves of natural gas as on 1 April 2003 were around 700 BCM (billion cubic meter).
- The estimated production of natural gas was 118 million metric standard cubic metres per day in 2012-13 the major part of which came from off-shore areas. Assam, Gujarat, Andhra Pradesh and

Tamil Nadu are the major on-shore producing states.

- Discovery of gas made rapid strides after 1985. Oil strikes at Cauvery off-shore and at Nanda in Khambhat basin as also gas found at Talot in Jaisalmer Basin in Rajasthan were major discoveries during 1988-89. Production from South Bassein Gas Field started in September 1988.
- During 1989-90 oil gas structures had been discovered in AdIyakkamanglam in Tamil Nadu, Andada in Gujarat, Khovaghat in Assam, Lingla in Andhra Pradesh.
- Mumbai off-shore and Kachchh offshore reserve. Another survey conducted in 1997 in the Andamans has revealed 1.700 billion cubic feet of gas reserves which can meet the country's requirements for the next 30 years.

Nuclear Energy

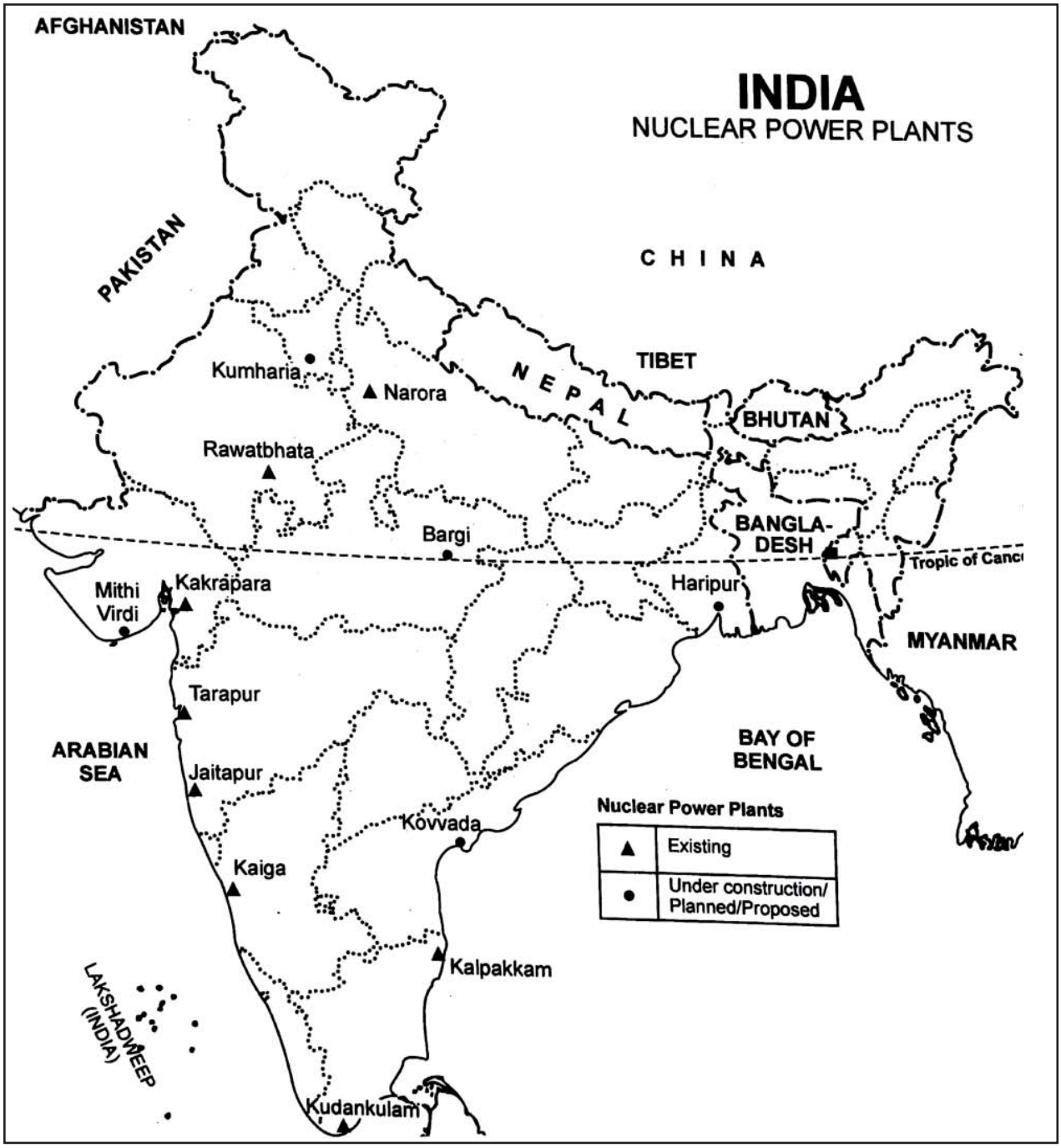
- Nuclear energy is obtained from uranium and thorium. India has vast untapped uranium resources and there is urgent need to make use of these resources if India really wants to get out of the Present scenario of power shortages and energy crisis.
- Although nuclear power contributes only a little over 3 Percent of our total power generation at present, it has vast potential for future development.
- It requires quite higher technology to develop nuclear which India has fortunately attained now. India is one of the few countries which have developed the capability of designing, constructing, commissioning and operating a nuclear power station without any help from outside.
- Most of the nuclear power stations in India have been constructed near sources of water required in great quantity for cooling purposes.

Non-Conventional Energy Sources

- With increasing demand for energy and with fast depleting conventional sources of energy such as coal, petroleum, natural gas. Etc. the non-conventional sources of energy such as energy from sun, wind, biomass, tidal energy, geo-thermal energy and even energy from waste material are gaining importance.
- This energy is abundant, renewable, pollution free and eco-friendly. It can be more conveniently supplied to urban, rural and even remote areas. Thus it is capable of solving the twin problems of energy supply in a decentralized manner and helping in sustaining cleaner environment. It is the energy of the future.

Solar Energy

- The radiation from the Sun is capable of producing heat, causing chemical reactions, or generating electricity.
- The total amount of solar energy incident on Earth is vastly in excess of the world's current and anticipated energy requirements.
- If suitably harnessed, this highly diffused source has the potential to satisfy all future energy needs.
- In the 21st century solar energy is expected to become increasingly attractive as a renewable energy source because of its inexhaustible supply and its nonpolluting character, in stark contrast to the finite fossil fuels coal, petroleum, and natural gas.



- It is an important source of renewable energy and its technologies are broadly characterized as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power.
- **Active solar techniques** include the use of photovoltaic systems, concentrated solar power and solar water heating to harness the energy.
- **Passive solar techniques** include orienting a building to the Sun, selecting materials with favorable thermal mass or light-dispersing properties, and designing spaces that naturally circulate air.

Wind Energy

- Wind is another important source of non-conventional energy. The cost inputs are only at the initial

DAY - 28

MINERAL RESOURCES

We live during an age of high consumption rates of matter and energy resources.

Modern industrial nations depend on aluminium, chromium, iron, copper, lead, mercury, zinc, tin and other metals; on materials such as sand, gravel, stone and clay; and on coal, oil, natural gas, uranium and other energy resources.

The exploitation of mineral resources depends on their occurrence as concentrations, which render them economically viable.

Such concentrations reflect both crustal and denudation processes that promote the segregation (fractionation) of materials involved in geochemical cycles.

Mineral resources are formed via different processes.

Ores

- An ore is a rock containing a sufficient proportion of metal to make its extraction an economic proposition.
- For an ore to be mined, it must be economically profitable to do so.
- However, it is important to note that a metalliferous rock that is valueless as a source of a metal at one time may be worthwhile mining some other time.

Origin of Mineral Deposits

In order for a deposit to form, some process or combination of processes must bring about a localized enrichment of one or more minerals. A convenient way to classify mineral deposits is through the principal concentrating process. Minerals become concentrated in five ways:

- Concentration by magmatic processes within a body of igneous rock to form magmatic mineral deposits.
- Concentration by hot, aqueous solutions fl owing through fractures and pore spaces in crustal rock to form hydrothermal mineral deposits.
- Concentration by precipitation from lake water or seawater to form sedimentary mineral deposits.
- Concentration by fl owing surface water in streams or along the shore to form placer or detrital mineral deposits.
- Concentration by weathering processes from residual mineral deposits.

Types of Minerals

Normally two types of minerals are recognised:

- **Metallic Minerals-**These minerals contain metal. Iron ore, copper, manganese, nickel, etc. are important examples of metallic minerals. Metallic minerals are further sub-divided into ferrous and non-ferrous minerals.
  - **Ferrous Minerals-**These minerals have iron content. Iron-ore, manganese, chromite, pyrites, tungsten, nickel, cobalt, etc. are important examples of ferrous minerals.

- **Non-ferrous Minerals-**These minerals do not have iron content. Gold, silver, copper, lead, bauxite, tin, magnesium, etc. are important examples of non-ferrous minerals.

- **Non-metallic Minerals -**These minerals do not contain metal. Limestone, nitrate, potash, dolomite, mica, gypsum, etc. are important examples of non-metallic minerals. Coal and petroleum are also non-metallic minerals. They are used as fuel and are also known as mineral fuels.

Other Classification of Minerals

- The wide varieties of minerals that have been explored by man for general and commercial purposes to satisfy his needs are classified in to the following groups:
  - **Industrial metallic minerals:** Iron Ore
  - **Ferroalloy metallic minerals:** Manganese, Chromium, Cobalt, Molybdenum Vanadium, Nickel.
  - **Precious metallic minerals:** Gold (Au), Silver (Ag) and Platinum (Pt).
  - **Non-metallic minerals:** Salt, and Tin, Potash, Asbestos, and Sulphur.
  - **Power Minerals (Mineral fuels):** Coal, Petroleum and Natural Gas which arenon-metallic minerals derived from vegetable remains
  - **Other:** Uranium

Mineralized Regions

- The injection of metalliferous and other minerals into the earth's crust is intimately associated with the movement of the plates or slabs of continental rock of which the crust is composed.
- Many of the concentrations of metalliferous ores are thus found in close association either with areas of ancient rock or with areas of recent tectonic movement in the course of which magma rose to the Surface.

Continental Europe

- Continental Europe was formerly endowed with many deposits of the metalliferous minerals, but many are now exhausted and abandoned. Most lay in the belt of ancient rock, which extends from the Meseta (plateau) of Spain, through France and Germany to Czechoslovakia and Poland.
- Lead, zinc and copper remain of some importance. A second highly mineralized region is the 'shield' of very old rock, which makes up much of Finland and northern Sweden. Many metalliferous ores are obtained here, but the most important is the high- grade Swedish iron ore.
- Europe also contains extensive deposits of low-grade bedded iron ores. The most extensive and important are those of Lorraine in eastern France and of the Harz region in West Germany.

CIS

- The Ukrainian plateau Ural Mountains and the rocks of the Siberian 'shield' are highly mineralized and the CIS has very large reserves of iron ore and of some non-ferrous metals.

Asia

- Metalliferous resources in Asia, outside the Soviet Union, do not appear to be very extensive. China has large reserves of tin and tungsten, Malaya of tin and India of iron ore, but Japan, the most industrialized Asian country, is also one of the least well endowed.

Africa and Australia

- These two landmasses are both made up largely of massifs or shields of hard, ancient rocks, intruded by numerous lodes or ore bodies. Africa, especially south of the Sahara Desert, is richly endowed.
- Among its most important resources are the copper of Zambia and Zaire, the gold and diamonds of South Africa and the tin of Nigeria. But there are also important reserves of chrome, zinc, manganese, cobalt, the radioactive minerals and of bauxite-the ore of aluminium.

- Australia has a number of rich sources of lead-zinc-silver. Its gold mines are no longer of great importance, but Australia is now one of the world's leading sources of iron ore, much of which is mined in Western Australia and shipped to Japan.

North America

- This is probably the most richly endowed of all the continents, and in none have mineral resources been exploited more actively during the past century. There is today very little active mining in the eastern half of the United States, but there are large reserves of copper, lead, zinc and the alloy metals in the mountainous west.
- In Canada copper, nickel and iron are being worked in the old rocks of the Laurentian Shield,

Latin America

- Gold and silver, which attracted the early explorers, are today of little Importance except in Mexico. Far more important are the copper of Chile, the tin of Bolivia, the bauxite of Guyana, Surinam and some of the West Indian islands, and the iron ores of Venezuela and Brazil.

Industrial Metallic Mineral

Iron Ores (Fe)

Magnetite (Fe_3O_4):

- Iron content up to 72.4%.
- It is a black mineral formed in igneous or metamorphic rocks in veins or lodes.
- It has excellent magnetic qualities.
- Uses: Magnetite iron is used as natural magnets and in electrical industry.

Haematite (Fe_2O_3):

- Iron content is 70%
- It is most important iron ore.
- They are red ores derived from sedimentary rocks and occur in crystalline or in powdery forms.
- Uses: Iron is most important for the purpose of industrial use.

Limonite ($2Fe_2O_3H_2O$):

- Iron content is 60%
- This is brown ore occurring in thick beds in sedimentary rock sequence or in swamps or lakes, (lake or bog iron).

Siderite ($Fe\ Co_3$):

- Iron content up to 48%
- This is ash-grey in colour and is found interbedded with other sedimentary rocks.
- It is basically used for making steel

Distribution

- **USA**
  - Lake Superior Region—(Mainly haematite ores) Mesabi Range, Vermilion, Cuyuna, Gogebic, Menominee and Marquette Ranges.
  - North-eastern Region—(Mainly Magnetite ores) Adirondacks region of New York and Cornwall area of Pennsylvania.

- South-western Region—(Both haematite and limonite ores) Birmingham and Alabama.
- Western Region— Utah (magnetite), Nevada, Wyoming (haematite) and California.

- **Canada**— Lake Superior Region, Labrador and Quebec (Haematite), the main centres being Schefferville and Wabush city. Newfoundland, British Columbia.
- **CIS** — Near Moscow and at Krivoi Rog in the Ukraine (haematite ore); Siberia and the Urals region near Magnitogorsk; Kuzbas at Kustanay. Kursk Magnetic Anomaly—Lipetsk and Donbass.
- **Sweden**— Kiruna and Gallivare (Magnetite ores);
- **Central Sweden**—Dannemora and Grangeborg;
- **Southern Sweden**—Kopparberg.
- **France**— Lorraine (Siderite ores); Normandy in Pyrenees; and central Massif.
- **Britain—** Scunthorpe (Siderite ores) and Frodingham.
- **Germany**— Siegerland.
- **Spain**— Bilbao, Santander and Oviedo (haematite).
- **Norway**— Kirkenes.
- **Finland**— Jussaro in the Ekenas Archipelago.
- **Austria—** Erzberg (siderite) and Huttenburg in Karnten.
- **ErstwhileYugoslavia**— North of Sarajevo and Zagreb and Banjalanka.
- **China—** Manchurian deposits at Anshan, Yangtze valley and in Hopei.
- **India—** Jharkhand and Orissa.
- **South Africa—** Postmasburg in Griqualand and Thabazimbi in the Transvaal (haematite).
- **Liberia—** BomiHtlls and Mt. Nimba.
- **Mauritania— Zouerate.**
- **Australia—** Western -Australia at Mt. Goldsworthy, Mt. Whaleback, Mt. Bruce, Mt. Tom Price and Yampi Sound; South Australia at Iron Knob.

- **Brazil—** Itabira and near Belo Horizonte in Minas Gerais.
- **Venezuela—** Guiana Highlands at Cerro Bolivar and El Pau.
- **Chile—** Algarrobo in Central Chile.
- **Peru—** Nazca-Marcona area.

Chromium (Cr)

Characteristics

Nature: It is a hard, silvery metal with a bluish tinge and a metallic lustre.

Uses:

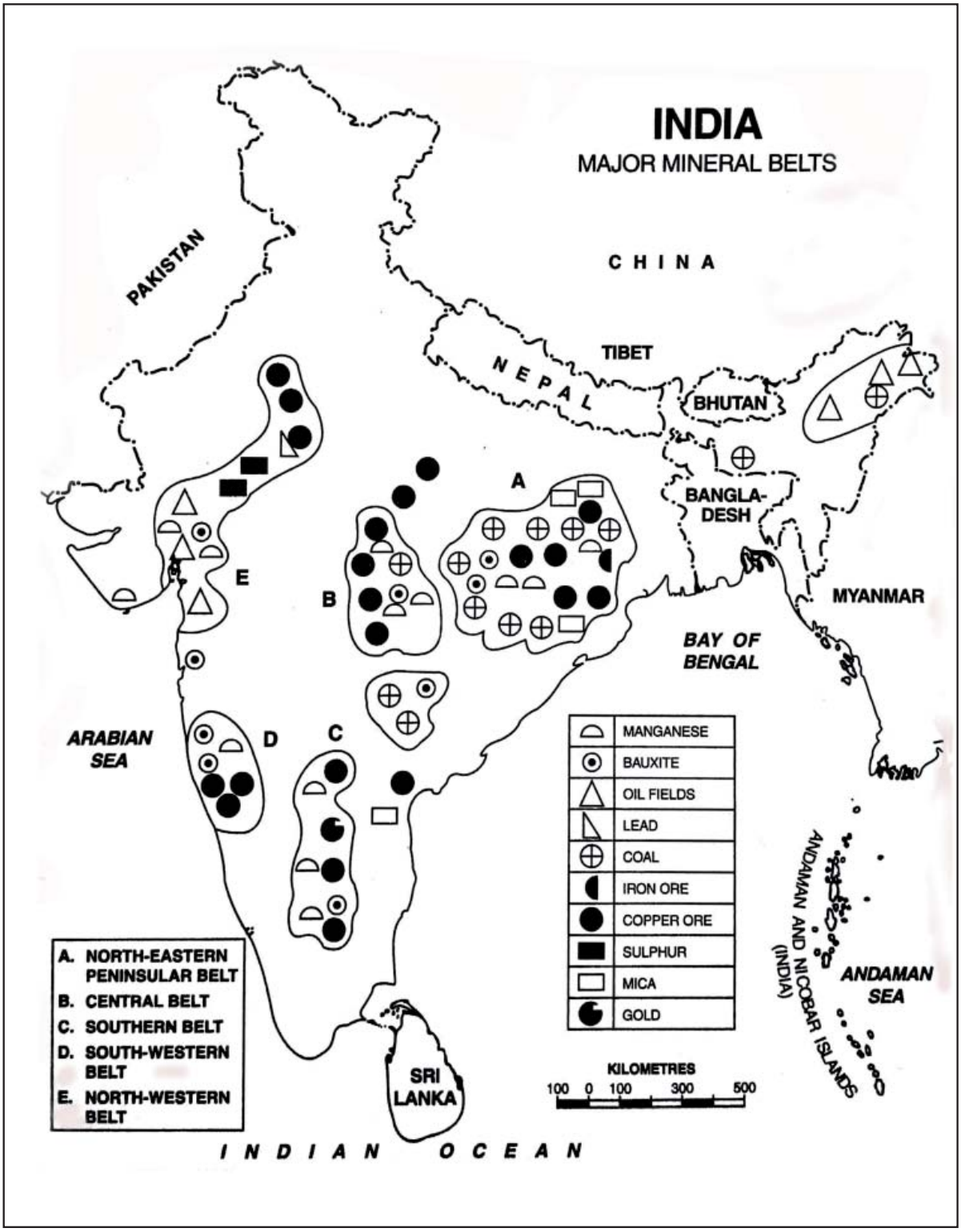
- Increases the hardenability of steel if mixed along with nickel.
- It is used for making stainless steel which is widely used in manufacture of machinery where steam, water, moist air or acids would corrode ordinary steels quickly.
- Larger amounts, 12-15% increase high temperature strength and corrosion resistance, as well as resistance to wear. Therefore, kitchen utensils, cutlery, oil burner components and bearings are made.
- Chromite ore is also used as a refractory material in basic brick linings of various metallurgical furnaces—chromite or chrome magnesite brick.
- Chromium, used in making nickel-chromium alloys (nichrome), is highly resistant to electric current and is thus used as a safety measure in electric wires, toasters and other electrical appliances.
- Chromium salts and compounds (chromates) are used in the manufacture of paint pigments, chemical industry, for leather tanning, metal and Wood to prevent rotting.

Distribution

- **Common Wealth of Independent States (CIS**)— Sarany, north of Sverdlovsk and Chromtay in Urals; **Balkan countries**—Kukas in Albania;
- **Philippines**—Zambales in northern Luzon;
- **Turkey**— Fethiye and Guleman; ;
- **S. Africa**—Selukwe;
- **Zimbabwe**—Kildonan; Brazil
- **India**

Mineral Resources: India

- India is endowed with a rich variety of minerals. It has been estimated that nearly 100 minerals are known to be produced or worked in India, of which nearly 30 may be considered more important including several which although comparatively unimportant in quantity today are capable of material development in future with expansion of industries.
- The country has fairly abundant reserves of coal, iron and mica, adequate supplies of manganese ore, titanium and Aluminum, raw materials for refractories and limestone; but there is a deficiency in ores of copper, lead and zinc.
- There are workable deposits of tin and nickel." India earns a lot of foreign exchange by exporting a large variety of minerals such as iron ore, titanium, manganese, bauxite, granite and a host of other minerals.
- At the same time India has to depend upon imports to meet her requirements of some other minerals such as copper, silver, nickel, cobalt, zinc, lead, tin, mercury, limestone, platinum, graphite and so many other minerals.



Metallic Minerals

- Metallic minerals form an important section of mining activity in India and provide solid base to metallurgical industries in the country.

Iron Ore

Iron is a metal of universal use. It is the backbone of modem civilization. It is the foundation of our basic industry and is used all over the world. The standard of living of the people of a country is judged by the consumption of iron. Following four varieties of iron ore are generally recognized:

Haematite:

- This is the best quality of iron ore with about 70 per cent metallic content and occurs as massive, hard compact and bumpy ore having reddish or coral red colour.
- Most of the haematite ores are found in Dharwad and Cuddapah rock systems of the peninsular India.
- Over 80 per cent of the hematite ores are concentrated in eastern parts of India comprising of important iron ore producing states of Odisha, Jharkhand, Chhattisgarh and Andhra Pradesh. In the western section, the major concentration is in Karnataka, Maharashtra and Goa.

Magnetite

- Also known as 'black ore', due to blackish colour, this is the second best ore, next only to haematite with metallic content varying from 60 to 70 per cent.
- Like hematite, magnetite ores occur in the Dharward and Cuddapah systems of the peninsular India.
- Magnetite ores have magnetic quality as a result of which they are known as magnetite ores. Most of the reserves are found in Karnataka, Andhra Pradesh, Rajasthan, Tamil Nadu and Kerala.

Limonite

- Limonites are inferior ores, yellowish in colour, which contain 40 to 60 per cent iron metal.
- These are found in Damuda series in Raniganj coal field, Garhwal in Uttarakhand, Mirzapur in Uttar Pradesh and Kangra valley of Himachal Pradesh.
- Though poor in quality, these have the advantage of easy and cheap mining.

Siderite:

- Also known as 'iron carbonate' this type of iron ore is of inferior quality and contains less than 40 per cent iron.
- It also contains many impurities and its mining is not economically viable.
- However, it is self-fluxing due to presence of lime.

Important Producers

Odisha

- Odisha produces over 40 per cent iron ore of India.
- The most important deposits occur in Sundargarh, Mayurbhanj, Cuttack, Sambalpur, Keonjhar and Koraput districts.
- India's richest haematite deposits are located in Barabil-Koira valley.

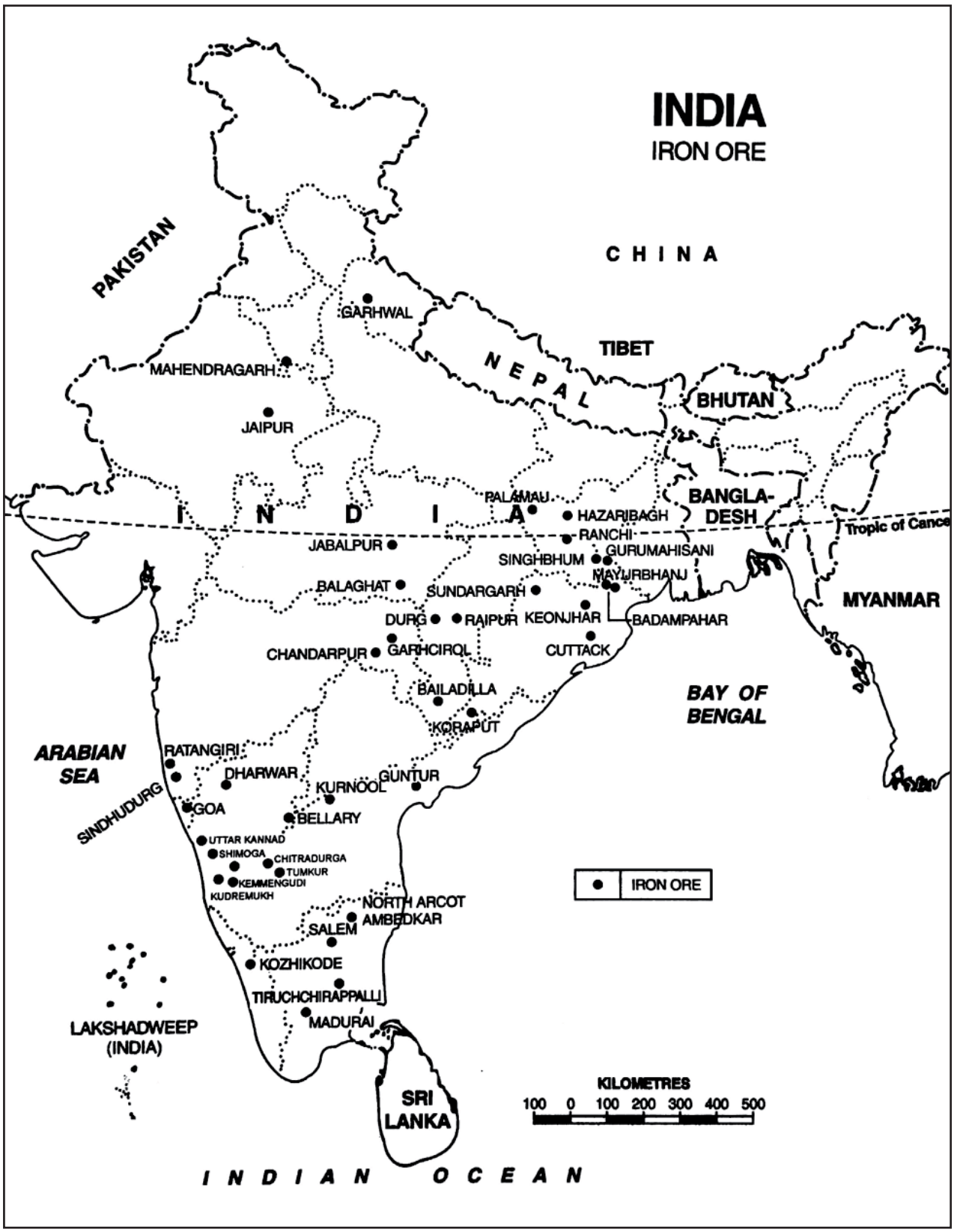
Chhattisgarh

- Chhattisgarh has about 18 per cent of the total iron ore reserves of India.
- This state produced about 18 per cent of the total iron ore production of the country in 201 1-12.
- The iron ores are widely distributed, the prominent deposits being those of Bastar and Durg districts.
- These reserves are of high grade ore, containing over 65 per cent iron.Bailadila in Dakshin Bastar, Dantewada and Bijapur district, and Dalli Rajhara in Durg district are important producers.

Karnataka

- Karnataka is the fifth largest producer and accounts for nearly 8 per cent of the total iron ore produced in India.

- Iron ores are widely distributed in the state, but high grade ore deposits are those of Kemmangundi in Bababudan hills of Chikmagalur district and Sandur and Hospet in Bellary district.
- Most of the ores are high grade haematite and magnetite.
- The other important producing districts are Chitradurga, Uttar Kannad, Shimoga, Dharwar and Tumkur.



Manganese

- It is an important mineral which is used for making iron and steel and it acts as a basic raw material for manufacturing alloy.
- Nearly 6 kilograms of manganese is required for manufacturing one tonnes of steel.
- It is also used for the manufacture of bleaching powder, insecticides, paints, and batteries

Production and Distribution

- India has the second largest manganese ore reserves in the world after Zimbabwe.
- The total reserves of manganese ore as in 2015 are 496 million tonnes.
- The main concentration is in Odisha (44%), Karnataka (22%), Madhya Pradesh (12%), Goa and Maharashtra (7% each), Andhra Pradesh (4%), Jharkhand (2%).
- Rajasthan,Gujarat and West Bengal together share the remaining 2 per cent resources
- India is the world's fi fth largest producer of manganese ore after Brazil, Gabon, South Africa and Australia.
- **Maharashtra -** The main belt is in Nagpur and Bhandara districts. High grade ore is found in Ratnagiri district also.
- **Madhya Pradesh-**Maharashtra is closely followed by Madhya Pradesh. The state produced only 11 per cent of India's manganese ore just two decades ago. The main belt extends in Balaghat and Chhindwara districts. It is just an extension of the Nagpur- Bhandara belt of Maharashtra.
- **Odisha**-It is obtained from Gondite deposits in Sundargarh district and Kodurite and Khondolite deposits in Kalahandi and Koraput Districts. Manganese is also mined from the lateritic deposits in Bolangir and Sambalpur districts.
- **Andhra Pradesh** - The main belt is found between Srikakulam and Vishakhapatnam districts. Srikakulam district has the distinction of being the earliest producer (1892) of manganese ore in India. Cuddapah, Vijayanagaram and Guntur are other producing districts.
- **Karnataka-**The main deposits occur in Uttara Kannada, Shimoga, Bellary, Chitradurg and Tumkur districts
- **Other producers-** Jharkhand, Rajasthan, Goa, Panchmahals and Vadodara in Gujarat, Udaipur and Banswara in Rajasthan and Singhbhum and Dhanbad districts in Jharkhand are other producers of manganese.

Bauxite

- Bauxite is an important ore which is used for making aluminium. It is an oxide of aluminium.
- It is not a specific mineral but a rock consisting mainly of hydrated aluminium oxides.
- It is a clay-like substance which is pinkish, whitish or reddish in colour depending on the amount of iron content.

Production and Distribution

Odisha

- Odisha is the largest bauxite producing state accounting for more than one-third of the total production of India.
- The main bauxite belt is in Kalahandi and Koraput districts and extends further into Andhra Pradesh. This 300 km long. 40 to 100 km wide and 950 to 1300 metre thick belt is the largest bauxite bearing region of the country.
- The main deposits occur in Kalahandi, Koraput, Sundargarh, Bolangir and Sambalpur districts.
- The important mining areas include Chandgiri, Baphalimoli Parbat, Kathakal, Manjimali, Pasenmali, Kunnumali, Kodingandi**,** Pottangi and Karalput in Kalahandi and Koraput districts

Chhattisgarh

- Chhattisgarh is the second largest producer of bauxite in India and produces more than 18 per cent bauxite of India.
- The Maikala range in Bilaspur, Durg districts and the Amarkantak plateau regions of Surguja, Raigarh and Bilaspur are some of the areas having rich deposits of bauxite.

Maharashtra

- Maharashtra accounts for over 15 percent of the total bauxite produced in India.
- The total recoverable reserves in the state have been estimated to be of the order of 87.7 million tonnes.

- The largest deposits occur in Kolhapur district capping the plateau basalts.
- Udgeri, Dhangarwadi, ! Radhanagari and Inderganj in Kolhapur district contain rich deposits with alumina content 52 to 89 percent.
- The other districts with considerable deposits are Thane, Ratnagiri, Satara and Pune.

Jharkhand

- Jharkhand is an important bauxite producing state of India accounting for over 14 per cent of the total production. The reserves of this state are found in extensive areas of Ranchi, Lohardaga, Palamu and Gumla districts. Some bauxite is also found in Dumka and Munger districts. High grade ore occurs in Lohardaga and adjoining areas.

Non-Metallic Minerals

- India also produces a large number of non-metallic minerals although only a few of them have assumed as much industrial and economic importance as is done by the metallic minerals.
- However, they are used in a large variety of industries; the major industries being cement, fertilizers, electricals, etc.

Mica

- Most important mica-bearing pegmatites occur in Andhra Pradesh, Bihar, Jharkhand, Maharashtra and Rajasthan. Occurrences of mica pegmatites are also reported from Gujarat, Haryana, Karnataka, Kerala, Odisha, Tamil Nadu and West Bengal. The total resources of mica in the country are estimated at 5, 32,237 tonnes out of which 1, 90,741 tonnes are placed under reserves category and 3, 41,496 tonnes under remaining resources category. Andhra Pradesh leads with 41 per cent share in country's total resources followed by Rajasthan (21 per cent), Odisha (20 per cent), Maharashtra (15 per cent), Bihar (2 per cent) and balance (less than 1 per cent) in Jharkhand.
- India has a near monopoly in the production of mica, producing about 60 per cent of world's total production.
- About 95 per cent of India's mica is found in just three states of Andhra Pradesh, Rajasthan and Jharkhand. Some mica is produced in Bihar also.

Limestone

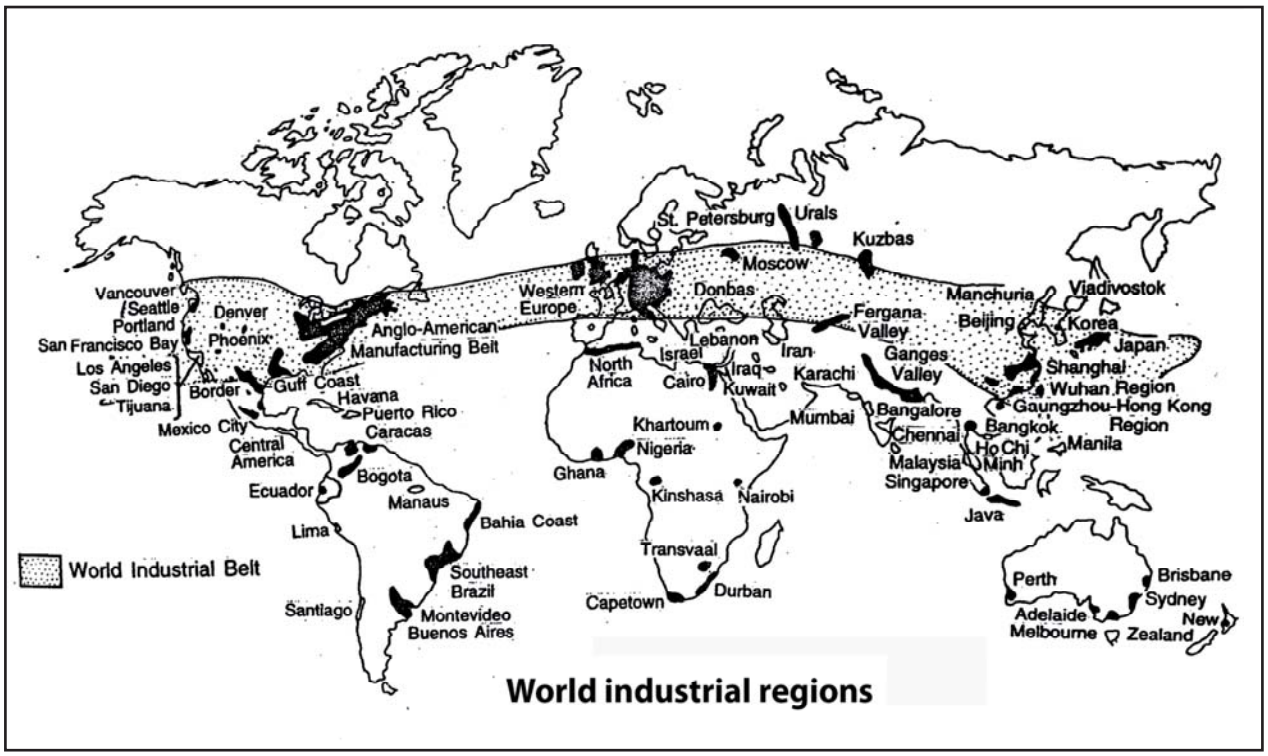
- Limestone is associated with rocks composed of either calcium carbonate, the double carbonate of calcium and magnesium, or mixture of these two constituents. In addition to the main constituents of calcium and magnesium carbonates, limestone also contains small quantities of silica, alumina, iron oxides, phosphorus and sulphur. Limestone deposits are of sedimentary origin and exist in almost all the geological sequences from pre-cambrian to recent except in Gondwana.
- The total resources of limestone of all categories and grades are estimated at 2, 03,225 million tonnes in 2015. Karnataka is the leading state having 27 per cent of total resources followed by Andhra Pradesh and Rajasthan (12 per cent each), Gujarat (10 per cent), Meghalaya (9 per cent), Telangana (8 per cent) and Chhattisgarh (5 per cent). The total production of limestone was 293 million tonnes in 2014-15, an increase by 4% as compared to that of the previous year. As much as 87.22% of the total output in 201415 was contributed by eight principal states, viz., Rajasthan (21.02%), Madhya Pradesh (13.31%), Andhra Pradesh (12.10%), Gujarat (8.79%), Karnataka (8.21%), Telangana (8.18%), Chhattisgarh (8.03%) and Tamil Nadu (7.58%). The remaining 12.78% of the total production was shared by other limestone producing states.
- Limestone is used for a large variety of purposes. Of the total consumption, 75 per cent is used in cement industry, 16 per cent in iron and steel industry and 4 per cent in the chemical industries. Rest of the limestone is used in paper, sugar, fertilizers, glass, rubber and ferromanganese industries.

Diamonds

- Diamonds have been highly valued and cherished throughout the ages because of their brilliance, adamantine, lustre, transparency and hardness. They are widely used for ornaments and for polishing the surface metals, minerals and gem cutting.

- The most important industrial use of diamonds is in cutting- edges of drills used for exploration and mining of minerals. The production of diamonds had increased from 1,674 carats valued at 5.34 lakh in 1950 to 18,489 carats valued at 19.8 crore in 2011-12. The main diamond bearing areas are Panna belt in Madhya Pradesh; Wajrakarur Kimberlite pipe in Anantapur district and the gravels of the Krishna river basin in Andhra Pradesh.
- Reserves have been estimated only in Panna belt and Krishna Gravels in Andhra Pradesh. The total in situ reserves are about 26, 43,824 carats. There are conditional resources of 19, 36,512 carat. The new kimberlite fields are discovered recently in Raichur-Gulbarga districts of Karnataka.
- Further investigations for diamonds are being carried out in Andhra Pradesh, Madhya Pradesh and Karnataka. Reserves of diamonds in India are not yet exhausted and modern methods are being applied for intensive prospecting and mining in Panna, Kumool, Bellary and some other selected places in central India. Indian diamonds are in great demand in the international market, especially for jewellery.
- Cutting and polishing of diamonds is done by modern techniques at important centres like Surat, Navasari, and Ahmedabad. Palanpur, Bhavnagar and Mumbai. Khambhat, Jaipur, Trichur and Goa are comparatively new centres

INDUSTRIAL REGIONS OF THE WORLD



North American Region

About four-fifth of the industrial output in this region is contributed from United States of America. Another major industrial country is Canada.

United States of America

- USA is the most dominant industrial super-power in the world.
- The total contribution of industry in the national Gross Domestic Product (GDP) in 1995 was 31 per cent of the total i.e. $ 6,952,020 million. The value of Merchandise import and export in 1996 was $ 814,888 and $ 575,477, respectively.

- At least 26% of the population is directly or indirectly involved in manufacturing activities. The manufacturing activities are available almost in all states, though some regions have wider concentration of industries, particularly in the north-eastern states.
- It is, however, very difficult to delineate the boundaries of different industrial regions, because most of the regions are geographically inseparable.
- The industrial regions in USA may broadly fall into following regions:
  - The New England Regions
  - The New York-Mid-Atlantic Region
  - The Mid-lake Region
  - The North-Eastern Region
  - The Southern industrial Region
  - The Western Region
  - The Pacific Region

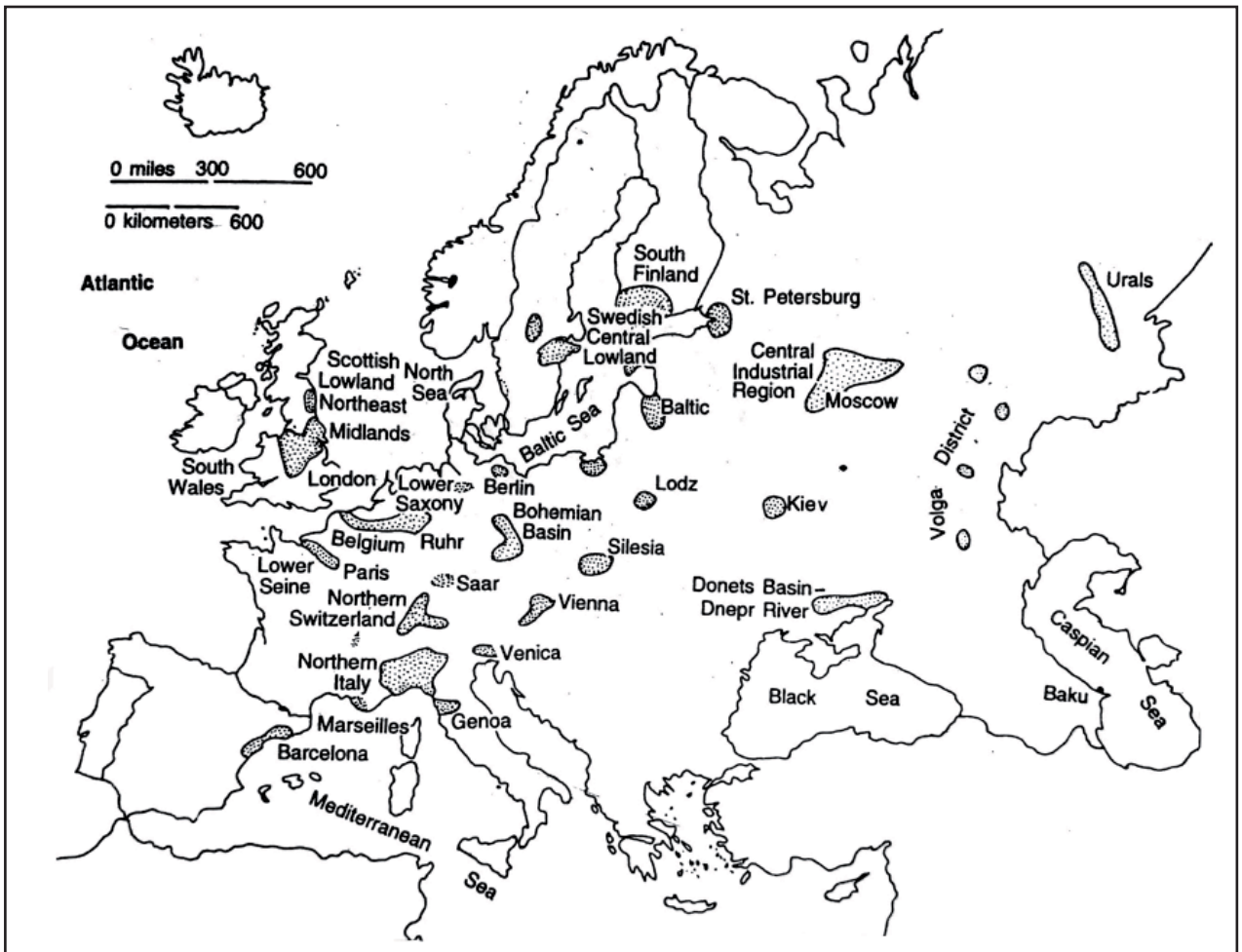
North American manufacturing districts

European Region

In Europe, particularly in Western Europe, most of the countries are highly industrialized. Some of the countries are leading manufacturing countries in the world. These are Germany, United Kingdom, Italy, France, Spain etc

United Kingdom

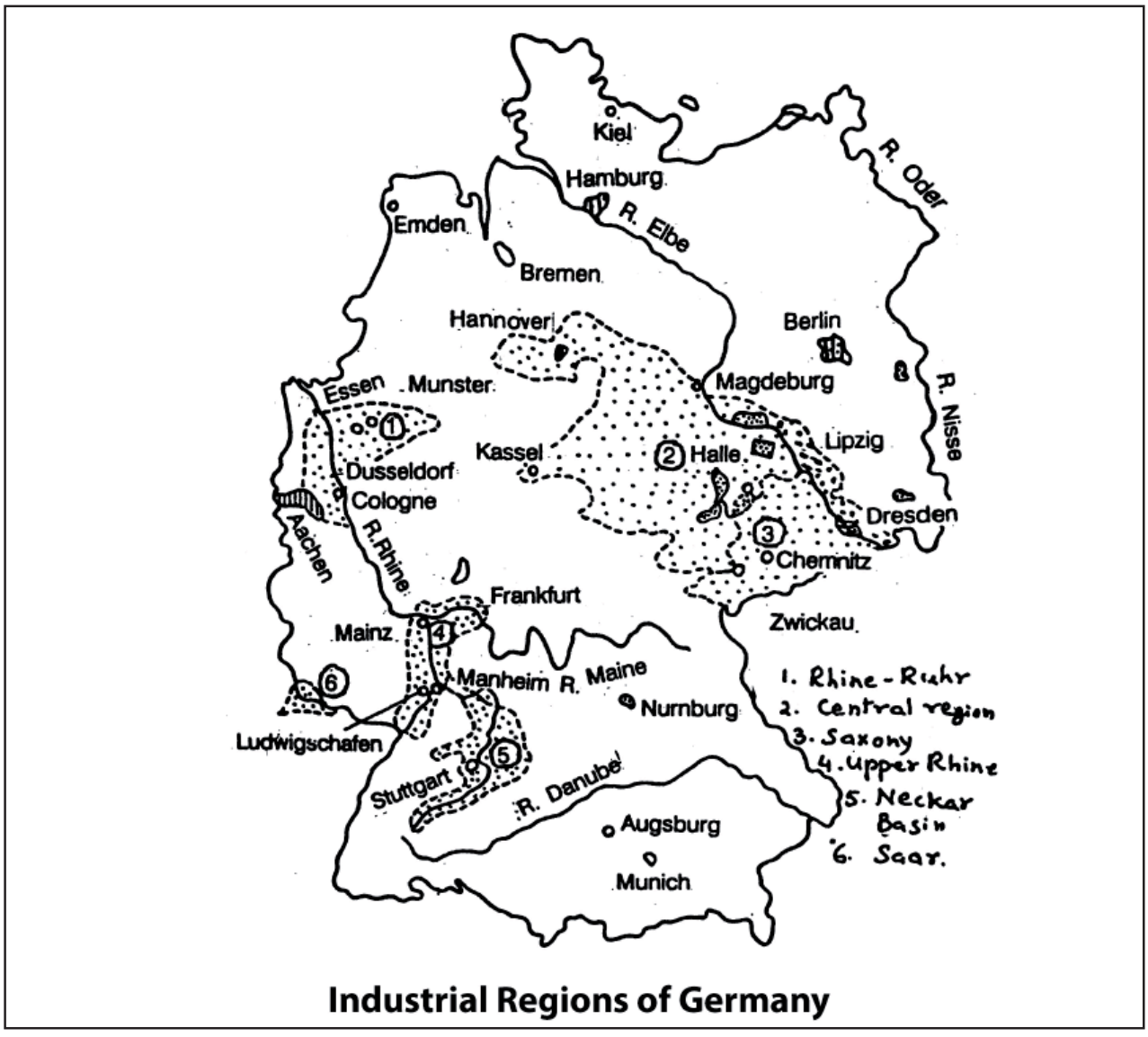
- United Kingdom is one of the most industrialized countries of the world. In fact, modern industrialization largely took its birth in British soil. In 1995, total industrial output in Britain was 32 per cent of the GDP.
- 29 per cent of the labour force is directly engaged in industry. Great Britain is having almost all types of manufacturing industries.
- The major manufacturing items are engineering, ferrous, chemical, textile, ceramic, electrical, leather, food and beverages and even electronics.
- The manufacturing region of Britain may be sub-divided into following groups:
  - The Midland
  - The Lower Scotland
  - The North-East Coast
  - The South Wales
  - The Lancashire
  - The London Basin



The industrial regions of Europe

Germany

- The United Germany is one of the most dominant industrial powers in Europe. Even before unification, West Germany was considered as a great industrial power.
- In 1996, industry contributed 38.2 per cent of the total GDP About 38% people were engaged in manufacturing activities.
- The major manufacturing regions in Germany are:
  - The Rhine Industrial Region
  - The Saar and Middle Rhine Industrial Region
  - The Hamburg Industrial Region
  - The Berlin Industrial Region
  - The Leipzig Industrial Region

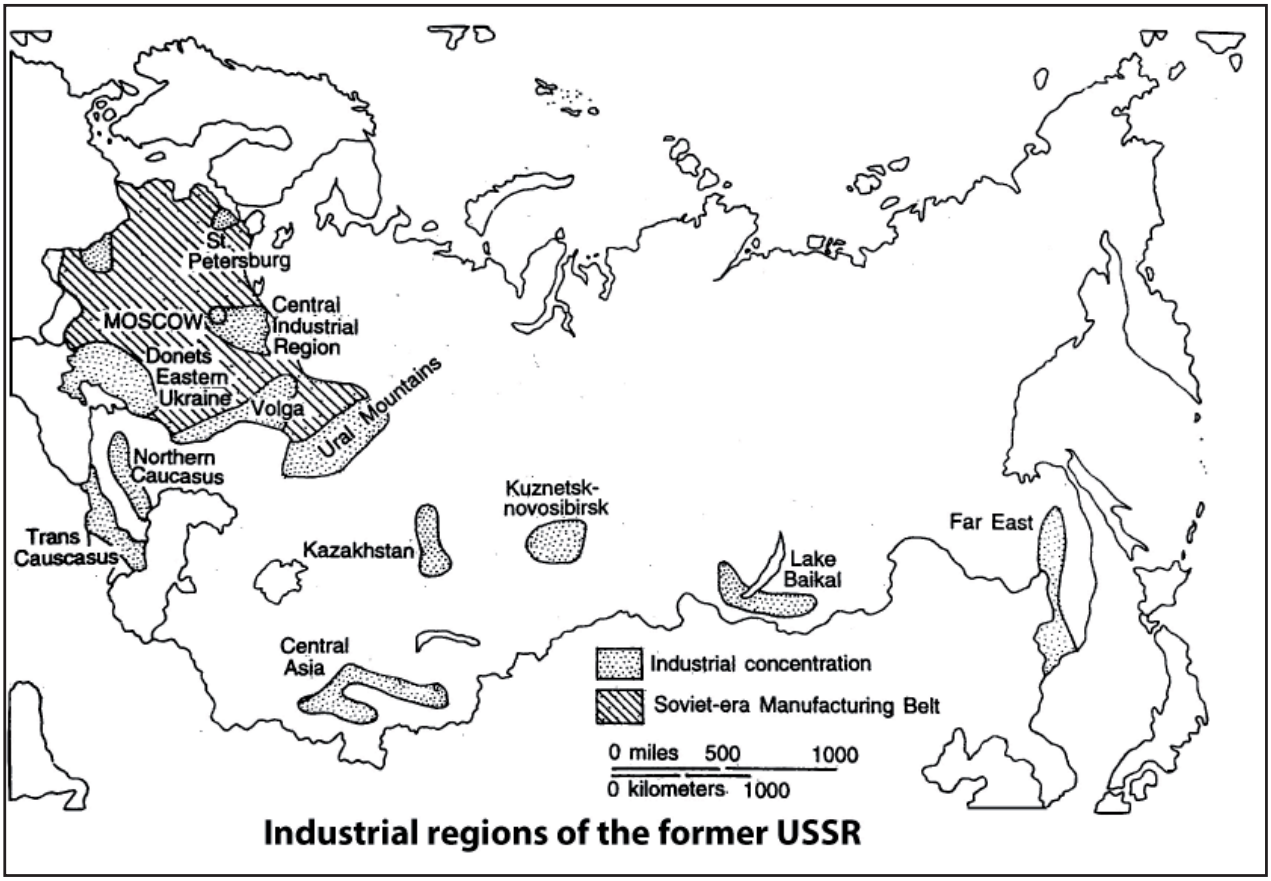


Industrial Regions of Germany

CIS: Commonwealth of Independent States

- The CIS is one of the mighty industrial powers of the world. In 1995, industry contributed nearly 40 per cent of the gross national product in Russian Federation.
- Nearly 47 per cent of work forces in 1991 were engaged in manufacturing industry.
- Soviet industrial regions may be sub-divided into following regions:

- The Moscow-Tula Industrial Region
- The Southern Industrial Region
- The Caucasus Industrial Region
- The Ural Industrial Region
- The Volga Industrial Region
- The Kuznetsk Industrial Region
- The Central Asia Industrial Region



Industrial regions of the former USSR

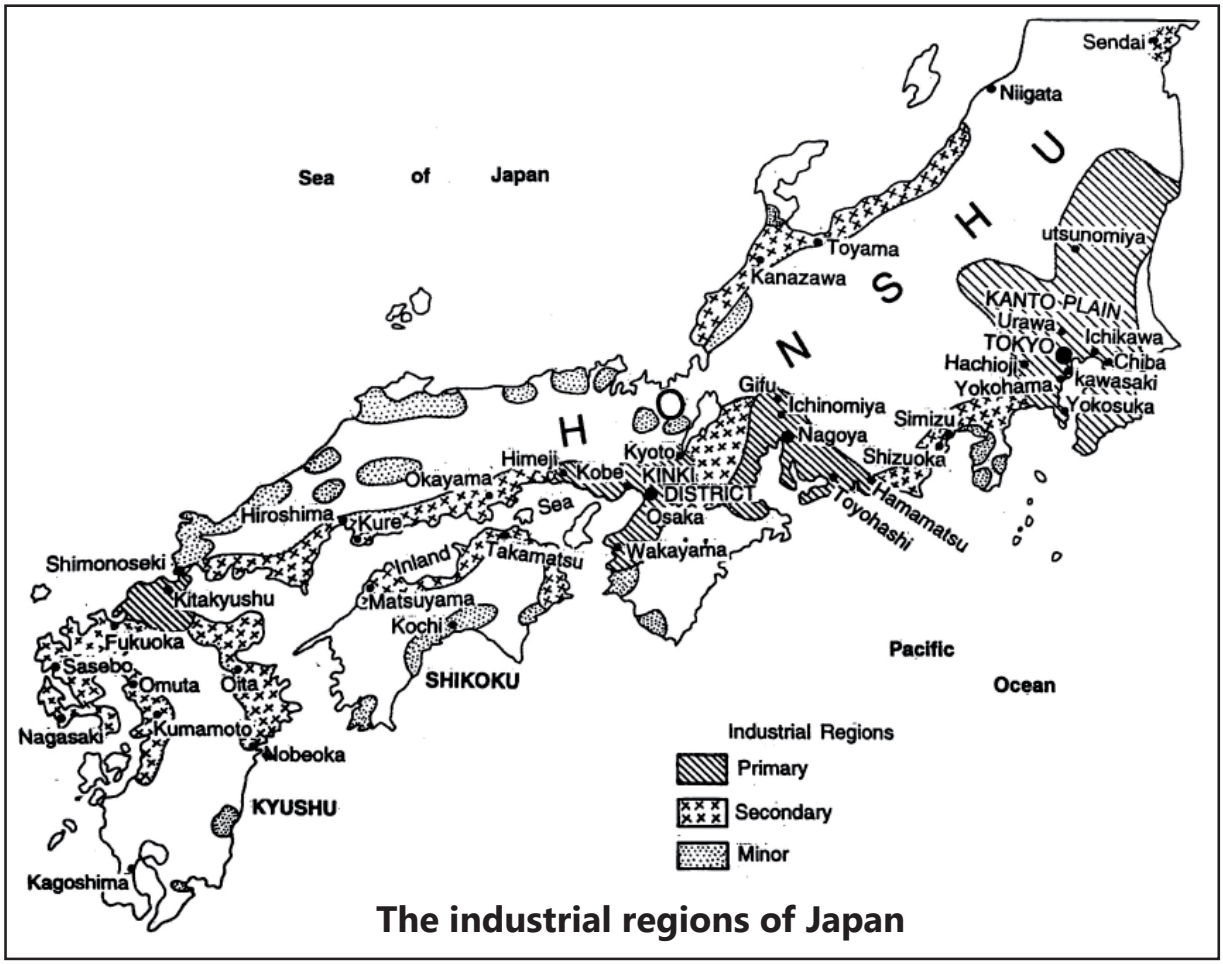
Asian Region

Until very recent period, no country in Asia had a sound industrial base. But, with the emergence of some countries like Japan, China, India, Korea, Taiwan in industrial sector, this region is now posing grave threat to the traditionally developed nations. In fact, regarding future industrialization of the world, Asia is frequently regarded as the dark horse.

Japan

- The meteoric rise of Japan in the industrial scenario has shattered the long-established domination of European and North American countries. The output and efficiency of Japanese industry is now comparable with any other industrialized country in the world.
- Japan now dominates almost all key industries, ranging from heavy chemical, iron-steel, petro-chemical to Ferro-alloy, electrical, electronics, motor vehicles and other consumer products.
- At present, 35 per cent of the working people in Japan are engaged in manufacturing activities. In 1995, manufacturing in Japan contributed 38 per cent of the country's GNP.
- Though Japanese industry had undergone a massive transformation, the spatial distribution pattern of industries remained unchanged. The intricate relationship between import of raw materials and export of finished products forced the industries to locate near coastal areas.

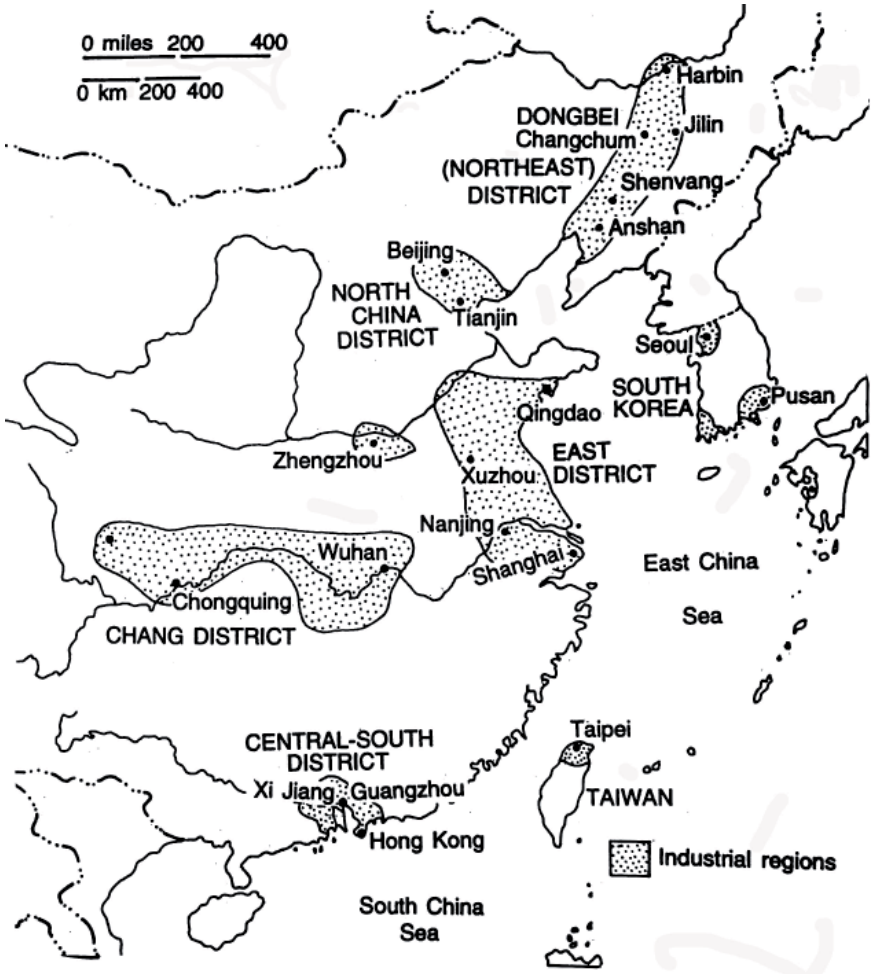
- The major industrial regions in Japan may be sub-divided into the following zones:
  - The Tokyo-Yokohama Region
  - The Osaka-Kobe Region
  - The Chukyo Region
  - The North Kyushu Region



The industrial regions of Japan

China

- China is gradually becoming one of the most dominant industrial powers in the world. In the year 1995, China produced 48 per cent of her GDP. from industrial sector. During this year, China handled the trade of merchandise product worth $ 138,833 million import and $ 151,047 million of export.
- The real development of industry in China began only after the installation of Communist rule in 1949.
- Chinese industrial system had gone through a complete transformation in last 50 years of Communist Rules. Old industrial policies were discarded and new policies were adopted. States power is supervising industrial development of the country in a planned manner. Eradication of regional imbalance and dispersion of the industries were encouraged. Basic industries like iron-steel, chemicals, textiles were given priority. On the basis of concentration of industries and their output, Chinese industrial regions may be sub-divided into following regions:
  - The Manchuria Region
  - The Yantze Valley Region
  - The North China Region
  - The South China Region
  - Other Regions



Industrial Regions of China and Its neighbour

India

- Since independence (1947), India has gradually emerged as a moderately industrialized nation. In some fields of manufacturing activity, Indian advancement is really spectacular. It is now considered as one of the leading industrialized country in the world. In 1995, industry contributed 29 per cent of the Gross Domestic Product.
- Spatially, Indian manufacturing establishments are mal-distributed. Some states are having very high concentration, while other regions are devoid of industries. It has been observed that regions situated in the plain, fertile lands and colonial heritage are historically having sound industrial base.
- Due to the failure of new centres to compete with old traditional centres, almost a status quo is maintained even today. Of late, some new industrial centres were evolved, specially around the steel cities.
- Among the states, Maharashtra contributes largest amount of industrial products, followed by Gujarat, Tamil Nadu, West Bengal, Uttar Pradesh, Bihar, Karnataka etc. According to the regional concentration of industries, Indian manufacturing regions may be sub-divided into six broad regions.
  - India Industrial Regions
  - The Calcutta Conurbation
  - The Bombay-Poona Megalopolis
  - The Ahmedabad-Vadodara Region
  - The Southern Industrial Region

- The Damodar Valley Region
- The Capital Regions

The Calcutta Conurbation:

- Broadly, a narrow strip running from Banshberia and Naihati in the north to Budge Budge and Uluberia in the south along the river Hooghly may be taken as the demarcating line of this oldest and vast industrial region in India. Several suburban and satellite townships were developed within this region.
- Notable among these are Howrah, Liluah, Bally, Uttarpara, Hind Motor, Konnagar, Rishra, Srirampur, Chandannagar, Bandel, Uluberia in the western bank and Budge Budge, Birlapur, Dum Dum, Belghoria, Sodepur, Titagarh, Barrackpur, Shyamnagar, Naithati in the eastern bank of river Hoogly.
- The major industries located in this region are jute mills, cotton textiles, chemicals, drugs and pharmaceuticals, engineering, machine tools, automobiles, tobacco, food processing, leather, fabrication, paper, match, etc.
- Several factors proved to be advantageous for the growth of these industrial regions. These were:
  - The port facilities of Calcutta
  - Calcutta was then the seat of administration and capital of imperialist power
  - Good transportation, through rail, road and water ways
  - The proximity of the region towards mineral belts of Chotanagpur plateau
  - Large market within Calcutta metropolis
  - Extensive hinterland over eastern India
  - Development of science and technology in renaissance period
  - Cheap, available labour force from adjoining Bihar, Uttar Pradesh
  - Entrepreneurial ability of the foreign and national bourgeoisie etc

The Bombay-Poona Megalopolis:

- This region stretches from Bombay metropolis to Poona in the south. Major industrial centres are Andheri, Belapur, Thane, Kalyan, Pimpri and Poona. The major manufacturing items produced here are: Textile, drugs and pharmaceuticals, chemical, petro-chemical, paper, leather, engineering, fertilizer and precision instruments.
- The major factors responsible for the growth of this industrial region were:
  - Development and growth of Bombay port
  - Development of communication system through rail and road
  - Vast hinterland
  - Managerial and entrepreneurship ability of Parsee, Bhatia people
  - Huge capital from foreign and indigenous source
  - Development of science and technology in the region
  - Cheap power resources
  - Cheap labour from Konakan and other regions etc

The Ahmedabad-Vadodara Region:

- Due to growing congestion and related pro blems, cotton textile industry gradually shifted from Bombay and grew in this region. Later on numerous other industries like petrochemical, chemical, fertilizer and engineering factories were evolved.
- The other centres of manufacturing industries are Varuch, Surat, Kalol etc. Exploration of petroleum in this region gives it a distinct advantage. This is one of the highly growing industrial regions in India.

The Southern Industrial Region:

- The extensive industrial region of South India is popularly known as Madras-Coimbatore-Bangalore region. This is also an old region. The major products of the region are textile, sugar, engineering, refinery, chemical, drugs and pharmaceuticals, automobiles, fertilizer etc.
- The reasons for the development of the region are:
  - The facilities of export-import through Madras Port,
  - Easy communication through rail and road,
  - Large hinterland etc

The Damodar Valley Region:

- The mineral-rich area of Chotanagpur area is now one of the most developed industrial regions in India. The availability of local coal, iron ore, bauxite, limestone, manganese, mica and other minerals, attracted a large number of mineral based industries. Besides mineral, proximity to Calcutta market, cheap labour and high demand also facilitated the development.
- The major industrial areas are steel cities of Jamshedpur, Durgapur, Bokaro, Burnpur, Hirapur, Kulti, Asansol; coal centres like Raniganj, Jharia, Dhanbad and township Ranchi etc. Apart from iron-steel, heavy engineering, metallurgical, glass, ceramics, machine tools, alloy steel, agricultural machinery etc. are produced in this region.

The Capital Regions:

- Adjacent to the Delhi metropolitan area, several industrial establishments developed. This is the new industrial area, compared to the others. The major centres of production are Faridabad, Ghaziabad, Mathura, Saharanpur etc. The major products of the region are textile, engineering, leather, drugs and pharmaceuticals, petroleum refinery, toilet and cosmetic products, detergents etc.

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DAY - 29

TRANSPORT

Means of transport are essential for the economic development of a country, because they connect the distant and remote parts of the country. The vast natural resources of the country cannot be fully exploited without developing means of transport. Industrial capacity remains unutilized for want of transport of raw materials and manufactured goods from surplus regions to deficit regions.

Means of transport play a critical role in times of natural calamities like floods, famines, earthquakes, cyclones, etc., and national emergencies like wars

To link areas of demand with areas of supply, transport facilities have to be provided, and the history of transport is the development of increasingly effective methods of overcoming the friction of distance by the invention of new forms of transport, new methods of propulsion, new construction techniques and so on.

Various means of transport are used in different parts of the world according to their geographical location, topography, geographical environment, economic development, and technological level. For example: The major considerations involving the transport of goods (raw materials and finished products) are: (i) the quantity of goods, (ii) cost of transport, and (iii) speed of transport.

Transport Patterns in the World

Oceanic Transport

- The wide range of ocean transport is rendered possible by the fundamental geographical fact that the world's ocean and seas are interconnected, whereas the land areas are disconnected.
- Cheapness of water transport is due to a number of factors:
  - It is not necessary to construct a route, except for the dredging of harbour channels
  - Sea transport involves less power than by rail or road transport.
  - Transport costs are distributed over large loads, thus lowering the cost per tonne, and
  - At comparatively low speeds, friction is less on sea than on land

Ocean Transport Routes

- The ocean shipping lanes may be grouped into eight major routes:
  - North Atlantic Route
  - Western European-Mediterranean and India Ocean route
  - Cape of Good Hope route
  - Atlantic, South America, East Coast route
  - Pacific South America, North America and European route
  - West Coast North America route
  - Trans-Pacific route, and
  - Caribbean-Gulf route.

The Suez Canal

- The Suez Canal assumes great importance in commercial transport. The canal joins the Mediterranean Sea and the Red Sea. The excavation of the Canal started in 1859 under the guidance of Ferdinand de Lesseps, a French Engineer. It was completed in 10 years and opened in 1869. It is 162 km long, 60 metres wide and 10 metres deep.
- The Canal was nationalised by Egypt in 1956.The Port Said is located on the Mediterranean coast of the Canal. South of Port Said, the Canal passes through the lake Medjhala. Several harbours including Alkantara, Alfirdan and Ismailia are located on this canal. Further south, the Canal passes through Great Bitter and Bitter Lake. On the coast of the Red Sea, Suez Port in the west and Port Taufiq in the east of the Canal are located.
- The Suez Canal has reduced the distance between European countries and south and south eastern Asia to a great extent. The canal has greatly benefited the international trade. A high increase has been registered between Britain and Common Wealth countries.

The Panama Canal

- The Panama Canal joins the Atlantic Ocean and the Pacific Ocean. The idea of the constructing this canal was given in the sixteenth century. However, it took a long time to execute its construction, mainly because of the mountainous relief of the Panama Strait. Several locks were constructed to remove the obstacles. The Canal is 82 km long, 16 metre wide and 12 metres deep. Locks have been constructed at three sites: (i) Gatun Locks on the Atlantic end, (ii) Pedro Locks in the middle, and (iii) Miraflores Locks at the Pacific end. A ship takes 7 to 8 hours to cross the canal. At least 50 ships cross the Canal everyday. The Canal is owned by the USA. It was opened in 1914.
- The Panama Canal route is safer than the Magellan strait route as it is free from storms and ice bergs

Inland Waterways

- Inland water ways serve two functions: (i) transportation to and from ocean ports,and (ii) transportation between important producing districts within the country. Inland water ways consist of natural water bodies: lakes, deep rivers, canals, and deepened and widened river channels. They vary in depth from a few feet to more than 45 feet. They are widely distributed all over the world and intensively used.
- The main advantage of inland water transportation is its cheapness, while the main disadvantages include: (i) their routes being in the same direction as that of the main traffic movement, (ii) their closing by ice, and (iii) their slow speed.

Factors Affecting the Utility of Inland Waterways

- The utility of inland waterways depends on the following factors:
  - width and depth of the stream,
  - direction of flow,
  - relief of the river or canal-bed,
  - obstacles due to bends or falls,
  - climate,
  - industrial or commercial level of population in the region, and the need for water transport, and
  - administrative policies.

Inland Waterways of Asia

- The chief waterways of Asia are in China, and south eastern Asia. They are of special significance in areas without railroads and highways.
- **China:** China has a large mileage of navigable rivers and canals. China's main rivers flow eastward across productive areas . The Yangtze, more than 4,800 kms long and with several lakes and large

navigable tributaries, is by far the most important waterway.It flow through the most productive and densely settled area of the country. Its tributaries and a great system of canals (the Grand Canal extends from the ocean near Ningpo, east of Hangchow, across the great lowland, for 1,600 kms to Tientsin, the port of Beijing) serve this vast area. Ocean vessels navigate the river at all times between Shanghai and Nanking (now Nanning). In the summer season, vessels reach upto Hankow. Shallow draft steamers operate throughout the year to Chunking, 2,400 kms from Shanghai.

- **South eastern Asia:** The Mekong, Menam, and Irrawaddy river systems are important waterways because dense settlement is along the rivers and also because these areas have few modem roads and railroads. They handle more than half of the domestic freight traffic and bring to the leading ports the export products such as rice, logs, lumber, rubber, etc. and distribute imported commodities in the interior areas. Inland shipping is especially important in Indonesia and the Philippines.
- **In India**, about a century ago, rivers carried much freight. The introduction of railways, construction of highways, and the diversion of water for irrigation led to the decline of the inland water transport, especially in the Ganga-and the major rivers of the Peninsular east coast However, the Brahmaputra is the most important inland waterways in India.

Railways

Factors affecting the Railroads

- The density of railroads is affected by the following factors:
  - The level of living standard and the scientific development.
  - The level of the capacity to utilize natural resources.
  - The size and density of population of a region.
  - Nature of relief and topography.
  - The level of industrial and commercial development

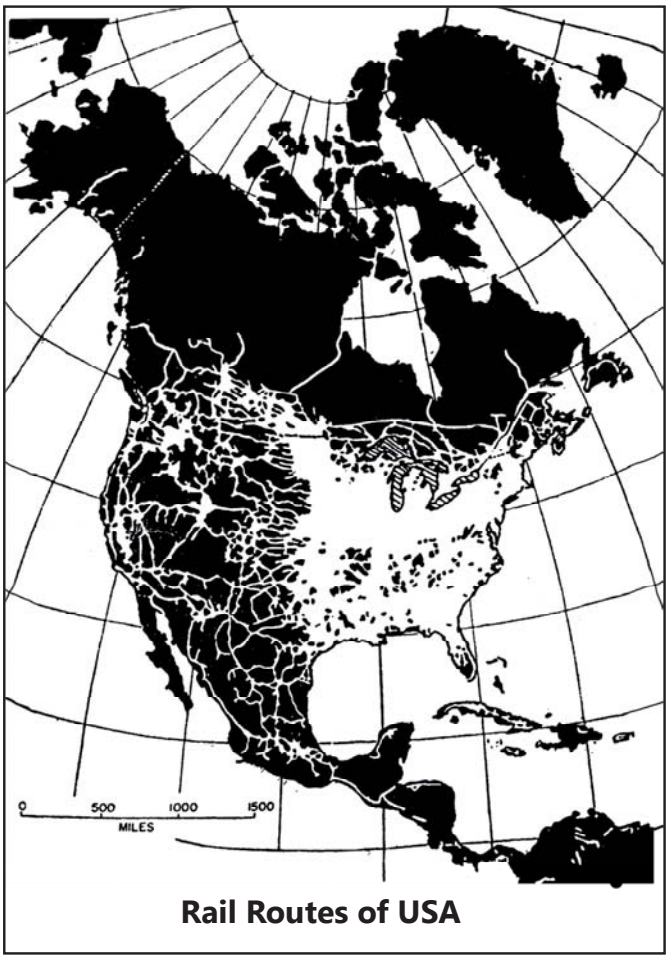
Distribution of Railroads in the World

- Railways rank first in the tonnage of freight carried. Their distribution in the continents differs greatly. The development of railways has taken place in the densely populated and rich plains. The mountainous and desert areas have practically no railways. Similarly, in the areas of heavy rainfall or snow, the development of railways has not taken place. Europe, former USSR and the USA have nearly two thirds of the rail-routes of the world. Asia has 12%, Latin America 12%, Africa 5%, and Australia and New Zealand 3%.

Railways in Anglo-America

- The USA ranks first in railway mileage, claiming more than 30% of the world's total, while Canada has over 5%. Nearly 40% international freight traffic is carried by 370 thousand kms long rail-routes in the USA. After the World War II, the country has registered the maximum retrenchment of rail-routes, as feeder lines were abandoned where motor vehicles and waterways captured much of the freight or where motor vehicles and aeroplanes took over much of the passenger traffic.
- East central North America has the largest network of rail-routes. In the USA, the dense network extends from the Atlantic coast to the eastern part of the Great Plains. This part has nearly 80% of the railway mileage of the country. The dense network also occurs in the Prairies of Canada and reaches upto the Rocky Mountains. In the north, the short growing season and cool summers mark the poleward extension of railways in western Canada. Farther east, the railway network is confined to the Ontario Peninsula, St. Lawrence lowlands, and Maritime Provinces. The density of railway lines within the main network is relatively high; Ohio and Pennsylvania have 20 miles of rail-lines for every 100 miles of area. The eastern states have density between 15 to 19.
- The lines in the eastern network carry the bulk of the railway freight and passengers of the USA and Canada. This region is the most densely populated part of Anglo-America. The region has extensive mineral deposits including coal and iron ore. The region supports the most important industrial developments of North America.

Rail-routes of the USA



Rail Routes of USA

- Most of the rail-routes of the USA have a linear pattern. In fact, in North America, railway lines were laid first, and then settlements were made along the rail-routes.
- To operate the rail-routes and increase the speed of rail transport, high technology, especially signalling techniques and radio communications, was used. The densely populated eastern parts have double and triple railway lines. East bound traffic is heavier than the west bound traffic.
- Northern Trans-Continental Rail-routes: It starts from Seattle on the Pacific coast and terminates at New York on the Atlantic coast. Portland, Minneapolis, St. Paul, Duluth, Miwaukee, Chicago are the major stations on this route. The east bound traffic includes number and minerals from the western states, raw silk, tea, and canned fish from Japan, apples from western states, and several agro-products, meat and livestock, etc. from the central states.
- Central Trans-Continental Rail-routes: It joins San Francisco on the Pacific coast with New York on the Atlantic coast via Salt Lake City, Omaha, Chicago, Pittsburgh, and Philadelphia. Canned fruits, vegetables, wool, livestock, meat, etc. are the major items of freight traffic.
- Southern Trans-Continental Rail-routes: It originates at Los Angeles, and bifurcates at Albuquerque. The northern branch goes to New York via Vichita, Kansas City, and Chicago. The southern branch goes to Orleans via Alpaso, Houston, and Galveston. Minerals, fruits, wook, meat, hides, cotton, etc. are the major products moved on this route.

Railways of Asia

- Asia has nearly 15% of the world's railways.More than one half lies in South Asia. Railways were developed mostly after the World War II. Japan has the densest rail net in Asia. India, China, and Japan are the important regions of rail development in Asia.

Air Transport

Factors Influencing Air Transport

- The air transport is greatly controlled by climatic conditions.
- Heavy rains, fog, and snow storms cause suspension of flying operations.
- Safe landing of aeroplanes becomes difficult for ground fogs.
- Relief of the land also influences air operations. Level lands are preferable so as to have better landing grounds.
- An airway system is determined by the prospect of getting maximum traffic on a given route
  - In the light of the above factors, the density and distribution of air routes and services are very uneven in the world. There are no trans-oceanic air routes to the south of 35°S latitude. There are very few trans-oceanic routes as far north as 10°S latitude.

- Most of the airways of the world are found in the Southern Hemisphere. Two great focal regions of air transportation are central North America and West Central Europe. Out of 300 some schedule air carriers of the world, about four fifths operate in and from North America, and three fifths in the USA alone.

Air Transport in the USA

- In the USA air transportation has tremendously developed connecting points from coast to coast. The airways carry not only passengers but also vegetables, fruits, fish, manufactured products, and mail.
- Cargo plains from Miami, New Orleans and other centres in the USA carry articles such as poultry, cattle, automobiles, machinery, refrigerators, etc. to Latin American countries.
- There are several feeder routes, regional trunk routes, and trans-continental routs in the USA. The chief trans-continental routes are between north Atlantic ports and San Francisco Los Angeles and Seattle on the Pacific coast. There are more than 7,000 airports, nearly half of which are privately owned.
- The factors responsible for the development of air transport in the USA include: (i) large size of the country, (ii) large population, (iii) high standard of living, (iv) great development of industry, (v) large international trade, (vi) participation in scientific, political, and other national and international organization, and (vii) a very large tourist travel.
- Despite all the factors that foster participation in international aviation, only one fourth of the passenger ton miles of all USA airlines are international traffic, as against four fifths of those of the airlines of Western Europe.
- The major routes of the US international air fleet serve six district areas: (i) Trans-Atlantic to Europe, (ii) Canada, (iii) Trans-Atlantic to Africa and Asia, (iv) Trans- Pacific to Asia, Australia and Pacific Islands, (v) Middle America, and (vi) South America.

Air Transport in Europe

- Western Europe has nearly one fourth of the world's international airlines and one fifth of the world's domestic and territorial airlines. The airways in Western Europe form a dense network every capital city and other important cities are served by airlines. The United Kingdom has as many as 15 airlines. The western European airlines account for one fourth of the world ton-miles of passenger, freight, and mail air traffic, and four fifths of this is international air traffic. Three fourths of the total ton-miles of air traffic is accounted for by passenger traffic, and 85% of the passenger traffic is international. This is due to the small size of the countries, intensive use of highways, railways, and inland waterways, the small number of domestic airlines, and the comparatively large number of international airlines serving many distant regions.
- In Russia, the Aeroflot is the principal airways, totalling 4, 00,000 kms. A dense network of cities of connects Russia west of Urals, Western Siberia and Central Asia. Twenty-one routes connect Moscow with 28 capital cities of Europe, Africa, Asia, and America. Passenger traffic of Aerofloat comprises 90% of the ton miles of freight and passenger traffic.

Air Transport in India

- India is situated on strategic route from and to Europe, Asia, Australia and Africa. Though domestic traffic is not commensurate with her area and size of population, yet international traffic is important. India has air transport agreements with 93 countries and her flights are regularly scheduled for these countries neighboring as well as distant. Air India, the international carrier, and Indian Airlines primarily a domestic carrier, serve 17 countries. The international airports are: Indira Gandhi International (Delhi), International Airport (Mumbai), Meenambakkam (Chennai), Dum Dum (Kolkata) and Thiruvananthapuram. Besides these, there are 92 major international and minor aerodromes meant for domestic air traffic.

Pipeline Transport

- Pipelines are the most specialized transport medium for carrying a variety of liquid and gaseous product. Over 99% of all material moved by pipeline are either crude petroleum, its refined derivatives, or natural gas.
- Pipeline transportation has distinct advantages. It provides the lowest cost. Pipelines transport bulk commodities in a relatively straight line through tropical forests and across deserts, bodies of water, and rugged mountains. Long life pipes, in most instances, buried to a depth of three feet or more, are not affected greatly by climatic conditions.
- The only visible features of a pipeline system are terminal tanks and the pumping stations, generally located 65 to 240 kms apart to maintain or boost pressure within the pipe and maintain regularity of flow. Once installed and in operation, the costs of maintenance and running are low.
- Only a few men are needed to operate and inspect a large pipeline system. Moreover, pipeline transportation is easily integrated with ships, barges, tankers, and trucks at economical costs.
- To achieve a high degree of efficiency, a pipeline system must be operated close to its capacity. Pipelines have been employed primarily for the transportation of crude petroleum, its derivations and natural gas.
- Many other products are now transported by pipeline. These include some solids and semi-solids in liquid suspensions. For example, finely ground iron and copper ores, limestone, gilsonite, coal slurry, and wood pulp are also moved by pipelines. In several areas finely ground minerals and chemicals, such as alcohols, acids, hydro carbon base chemicals, hydroxide, sulphur, and other are being transported by pipelines. Such transportation is quite common in the petro-chemical industry.

India

- Development of cheap and efficient means of transport is necessary for the progress of a large and developing country like India.
- India is a vast country with long distances from Kashmir in the north to Kanyakumari in the south and from Kandla in the west to Kohima in the east.
- All types of transport including railways, roadways, waterways, airways and pipelines are available in India.

Railways

Indian railway system is the main artery of the country's inland transport. Railways virtually form the life-line of the country, catering to its needs for large scale movement of traffic, both freight and passenger, thereby contributing to economic growth and also promoting national integration. In fact, railways constitute the **backbone of surface transport system in India**.

Rail Traffic

Rail traffic is broadly divided into two segments, viz., (i) passenger traffic, and (ii) freight traffic.

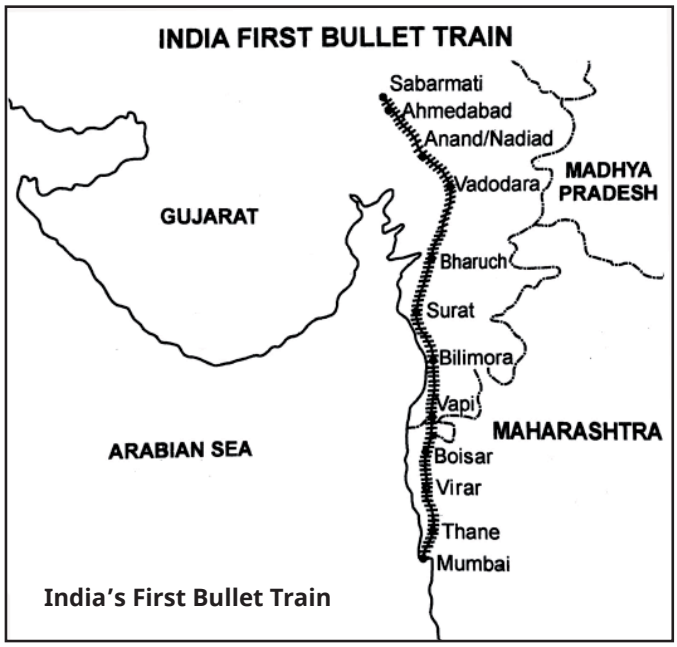
Passenger Traffic

- For passenger service five types of trains are run by the Indian Railways, based on their speed and comfort levels— Ordinary Passenger trains, Express/Mail trains, superfast trains, Rajdhani Express, and Shatabdi and Jan Shatabdi trains.
- Sampark Kranti Express trains have been introduced to connect the national capital, Delhi with the state capitals and other important places. Further, Indian Railways have introduced computer reservation system making it possible to get instant reservation between any two stations from any booking office.
- The above developments have resulted in phenomenal growth in passenger earning by railways. The passenger earnings increased from 98.2 crore in 1950-51 to 46,280.4 crore in 2016-17. On an average, 14 million people arc moved by the Indian railways.

- There are plans to introduce high speed trains on following routes.
  - Delhi-Agra
  - Delhi-Chandigarh
  - Delhi-Kanpur
  - Nagpur-Bilaspur
  - Mysore-Bengaluru-Chennai
  - Mumbai-Goa
  - Mumbai-Ahmedabad
  - Chennai-Hyderabad
  - Nagpur-Secunderabad

Bullet Train

- India's first bullet train got off the ground on September 14, 2017 when its foundation stone was laid at Sabarmati near Ahmedabad in Gujarat. The train will run for a distance of 509 km (156 km in Maharashtra, 351 km in Gujarat and 2 km in Daman and Diu).
- The whole project is scheduled to be ready by August 15, 2022 to coincide with 75th Independence Day of India. The project will create 20,000 construction jobs, 4,000 operations jobs and 20,000 indirect jobs. It will prove a big boost to urban, industrial and other infrastructure development along its route. Its cost would be nearly 1.08,000 crores, 81% of which will be met through soft loan from Japan at a nominal interest rate of 0.1q per annum



India's First Bullet Train

Other Bullet Train Routes Planned

- Delhi-Mumbai
- Mumbai-Chennai
- Mumbai - Nagpur
- Delhi-Kolkata
- Delhi-Chandigarh
- Delhi - Nagpur
- The top speed, maximum operational speed and average speed of the train will be 350 kmph, 320 kmph and 250 kmph respectively. China's Shanghai Maglen with maximum operational speed of 430 kmph and average speed of 251 kmph is the fastest bullet train in the world.

Freight Traffic

- Along with passenger traffic, the freight traffic also increased tremendously. Development in industrial and agricultural sectors has generated high demand for rail transport. Major commodities transported by railways include coal, iron and steel, ores.
- Petroleum products and such essential commodities as food grains fertilizers, cement, sugar, salt, edible oils, etc. Consequently, freight traffic increased from 93.0 million tonnes in 1950-51 to 1,175 million tonnes in 2018-19.

- Transport effort measured in terms of net tonnes kilometres increased from 44.1 billion tonnes kilometers in 1950-51 to 683, 16 billion tonnes kilometres in 2018-19. Tonne kilometres are arrived at multiplying the total tonnage of goods carried by the number of kilometers over which they are moved.

Dedicated Freight Corridor Project

- A very ambitious plan of Dedicated Freight Corridors (DFC) was initiated in the year 2009 which aims at improving the freight carrying capacity of the Indian Railways, reducing the unit cost of transportation and improving service quality.
- It consists of two corridors viz. Eastern Dedicated Freight Corridor (EDFC) and Western Dedicated Freight Corridor (WDFC). The EDFC is 1,856 route kilometers (RKM) and extends from Dankuni near Kolkata to Ludhiana in Punjab while the WDFC is 1,504 route kilometer (RKM) and extends from Jawaharlal Nehru port in Mumbai to Dadri in Uttar Pradesh.
- A special purpose vehicle, the Dedicated Freight Corridor Corporation of India Limited has been set-up to implement the project. Out of 10,703 hectares of land to be acquired for the project 7,768 hectares (73 per cent) has already been awarded under the Railway Amendment Act (RAA) 2008. Following are the salient features of this project.
  - Only goods trains will be allowed to operate on these corridors. These trains will run at a speed of 100 kilometres per hour.
  - These corridors are planned to run along the existing railway routes, but will provide services to railway junctions.
  - With a view to keep minimum impact on social and environmental aspects, these corridors will have provision of bypasses for thickly populated big cities.
  - Rail track on DFCs will be strengthened by providing heavier and stronger rails on concrete sleepers. Transport cost will be reduced by increasing work efficiency.
  - Efforts will be made to deliver the goods at their destinations well in time and minimise losses due to delayed deliveries of goods. Give impetus to industrial growth by providing cheap and efficient transport.

Metro Rail

- Metro rail offers fast, cheap and comfortable journey in metropolitan cities of India. It helps in reducing pressure on the existing road transport and provides clean and eco-friendly transport at the local level. With the introduction of metro rail in the big cities, traffic jams on road crossings have reduced considerably.
- It is a part of rapid mass transport and is of recent origin in India. The first rapid transit system in India was the Kolkata Metro, which started operations in 1984. The Delhi Metro was India's first modern metro and third rapid transit system in India, after the Kolkata Metro and Chennai Mass Rapid Transit System.
- The Delhi Metro Rail started its operations in 2002 and is now providing transport facilities to most parts of the capital city. It also provides metro rail lines to most of the satellite towns like Gurgaon, Noida, Faridabad, Bahadurgarh, etc.
- Rapid Metro Rail Gurgaon is India's first privately owned and operated metro rail system. It started its operations in November, 2013.
- After the grand success of Delhi Metro Rail, other cities are planning to have metro rails and in many cities this rail system is already in operation. The Government has planned to provide metro rail facilities in all cities of India having a population over two million.
- As metro rail projects are highly capital intensive. It is difficult to fund metro rail projects from Government exchequer only. In this context in order to create an ecosystem for proliferation of metro rail system in the country the Government of India has notified Metro Rail Policy, 2017.
- The policy imbibes on the learnings from international examples and bridges the much needed gap for enhancing the feasibility of metro rail projects from economic social and environmental perspective.

Roadways

- Roads have been existing in India for the last 5000 years. In early stages of Indian history, Ashoka and Chandragupta made efforts to construct roads. But the real progress was made during the Mughal period.
- A number of roads were laid during the Sultanate and Mughal periods. Most of the present trunk routes follow the Mughal routes. These routes were essential for strengthening and consolidating the empire.
- One such road was constructed by Sher Shah Suri which connected Peshawar to Kolkata. It was named as Grand Trunk (G.T.) Road and joined Amritsar with Kolkata after partition of India in 1947.

  Presently, it is also known as 'Sher Shah Suri Marg'.

Classification of Roads

- The main significance of the Nagpur Plan lies in the fact that it classified roads into four categories on the functional basis. These are (i) National Highways (ii) State Highways (iii) District Roads and (iv) Village Roads. A brief description of each category is given as under:

National Highways

- The main roads which are constructed and maintained by the Central Public Works Department (CPWD) are known as the National Highways. These roads are meant for inter-state and strategic defense movements and connect the state capitals, big cities, important ports, big railway junctions and link up with border roads.
- The length of National Highways increased from 19,811 km in 1951 79.116 km in 2013. National Highways form the lifeline of road transport and constitute the framework of road system in India.
- Although, the percentage share of the National Highways to the total road length has decreased considerably from 4.95 per cent in 1951 to only 2 per cent in 2017, they carry nearly 40 per cent of the road traffic of India.
- The National Highways have been classified on the basis of carriage way width of the highway. Generally, a lane has a width of 3.75 m in case of single lane and 3.5 m per lane in case of multi-lane.
- The Government has embarked upon a massive National Highways Development Project (NHDP) in the country. The NHDP is the largest highway project ever undertaken in the country. The NHDP is being implemented mainly by NHAI in phases I to VII.
- **Special Accelerated Road Development programme for North Eastern region (SARDP- NE)**: It envisages improvement of road connectivity to the State Capitals with District Headquarters in the North Eastern region. The proposed programme includes improvement of 10,141 km of roads comprising National Highways (4,798 km) and state Roads (5,343 km), to be implemented under Phase-A, phase B and Arunachal Pradesh Package for 'Road Highways. Phase-A now consists improvement of 2,041 km of National Highways and 2,058 km of State Roads.
- **Bharatmala Project**: Established on July 31, 2015. This project aims at improving road connectivity to coastal/border areas/backward areas/religious places, tourists places/construction/rehabilitation/ widening of about 1500 bridges and 200 railway over bridges (ROBs)/railway under bridges (RUBS) on National Highways (Nils), improvement of newly declared NHs, providing connectivity to district headquarters connectivity improvement programme for char-Dham (Kedarnath, Badrinath, Yamunotri and Gangotri in Uttarakhand). The total investment for this plan is estimated at 10 trillion—the largest ever outley for a government road project. The Bharatmala Project includes development of around 51.000 km of road length comprising economic corridors, coastal roads and express ways and will be implemented in phases.
- **Setu Bharatam Programme:** Launched on 4th March, 2016, this programme aims at building bridges for safe and seamless travel on NHs. The main object of this programme is to make all National Highways free of railway crossings by 2019. This is being done to prevent frequent accidents and loss of lives at level crossings. Under this programme, 208 railway over bridges (ROBs) and railway under bridges (RUBs) are to be built at a cost of 20,800 crore. The details of these bridges are as:

Andhra Pradesh (33), Assam (12), Bihar (20), Chhattisgarh (5), Gujarat (8), Haryana (10), Himachal Pradesh (5), and Jharkhand (11).

State Highways

- These are constructed and maintained by state governments and join the state capitals with district headquarters and other important towns. These roads are also connected to the national highways. The length of state roadways in India has almost tabled within a span of about four decades and has increased from 56,765 km in 1971 to 1.48,256 km in 2017. These roads constitute about 3.5 per cent of the total road length of India.
- Although, construction and maintenance of state highways is the responsibility of the concerned state governments, yet with the revamping of the Central Road Fund (CRF) in 2000, the Centre provides financial assistance for development of state roads. Further, to promote inter-state facilities and also to assist the State Governments in their economic development through construction of roads and bridges, Central Government provides 100 per cent grant for inter-state connectivity and 50 per cent grant for projects Of economic importance from CRF. Loan assistance from external funding agency is also taken by some states.
- The distribution of State Highways is very uneven. Maharashtra has the maximum length of state highways.This is followed by Gujarat, Madhya Pradesh, Rajasthan, and Andhra Pradesh (including Telangana). Smaller states such as Goa and states in hilly areas like Mizoram, Sikkim, Nagaland, Tripura. Etc. has less than five hundred km lengths of State Highways each.
- **Conversion of State Highways to National Highways**: The Government received proposals for declaration of more than 64,000 km of State roads as National Highways (NHs) from various State Governments, against which the Ministry has declared about 10000 km. of Roads/routes as new National Highways. So far 3180 km of State Highways have been converted to NHs.

District Roadways

- These roads join the district headquarters with the other places of the district. Development and maintenance of these roads fall within the purview of Zila Parishads. There has been more than five time's increase in the length of district roadways. Formerly most of the district roads were unsurfaced and lacked bridges and culverts. But now the situation has changed and most of these roads are surfaced. Such a situation has improved connectivity and paved way for economic development.
- Maharashtra is at the top followed by Uttar Pradesh, Madhya Pradesh, Rajathan, Punjab, Karnataka, Assam, Himachal Pradesh, Haryana and Kerala

Village Roads

- The village roads are mainly the responsibility of village panchayats and connect the villages with the neighboring towns and cities. These are generally dusty tracks and are usable only during fair weather. They become muddy and unserviceable during the rainy season.
- Efforts have been made in the recent past to connect the villages with metaled roads. The length of these roads has increased by about 13 times from 2, 06,408 km in 1951 to 27, 49,805 km in 2011. These roads accounted for over 58.6 per cent of the, total road length, of the country in 2015.
- Border Roads: Border Roads Organization (BRO) Board was set up in May 1960 for accelerating economic development and strengthening defense preparedness through rapid and coordinated improvement of roads in the north and north-eastern border areas. This organization has constructed world's highest road joining Chandigarh with Manali in Himachal Pradesh and Leh in Ladakh.
- This road runs at an average altitude of 4,270 metres above sea level and negotiates four passes at heights ranging from 4,875 to 5,485 metres.
- It is a vital road link in the western Himalayas and has considerably reduced the distance between Chandigarh and Leh. The Border Roads Organisation has now spread its activities throughout the country and is presently working in states of Rajasthan, Jammu and Kashmir etc.

Air Transport

- Air transport is the fastest mode of transport which has reduced distances and has led to drastic shrinking of the world. This mode of transport is indispensable when speed and time are the main considerations. One can easily cross and reach remote, inaccessible and hostile areas like lofty mountains, thick forests, marshy areas and sandy deserts by air transport which is almost impossible by other modes of transport.
- Air transport plays a vital role in times of emergency as well as in the event of natural and man-made calamities like floods, famines, epidemics and wars. Air transport is very essential for a vast country like India where distances are so long and the terrain and climatic conditions so diverse.
- The weather conditions in India are also quite congenial to air transport. Poor visibility due to clouds, fog and mist hinders air transport but India is lucky to have clear weather for most part of the year except for a short duration in rainy season and foggy particularly in North India.

Airports Authority of India (AAI)

- Airports Authority of India and National Airports Authority were merged on 1 April, 1995 to form Airports Authority of India (AAI). This authority is responsible for providing safe and efficient air traffic services and aeronautical communication services for effective control of air traffic in the Indian air space.
- It controls and manages the entire Indian space even beyond the territorial limits of the country in accordance with the norms set by International Civil Aviation Organisation (ICAO). It comprises of International Airports Division (IAD) and National Airports Division (NAD).
- At present India have 450 air ports/air strips of which 30 are international. There are 26 Civil Enclaves (3 international, 4 customs and 19 domestic) as well as 31 non-operational domestic airports.
- Development works in other remote areas like Jammu and Kashmir, Lakshadweep, Himachal Pradesh and Andaman and Nicobar Islands are also being taken up.
- The improvement of infrastructure at the airports needs heavy capital investment which the government cannot afford of its own. Therefore, private domestic and foreign investors including NRIs have been encouraged to participate in the process of improvement. Improvement and modernization of Indira Gandhi International Airport at Delhi and Shivaji Maratha International Airport at Mumbai, Chennai International Airport and Netaji Subhash Chandra Bose International Airport are some of the outstanding examples.

UDAN (Ude Desh ka Aam Nagrik)

- This scheme was launched in October, 2016 to make flying accessible and affordable for the masses in the regionally important cities. This is a first-of-its-kind scheme globally to stimulate regional connectivity through a market based mechanism. It provides a few seats at affordable passenger fares for an hour long flight. Under UDAN, 70 airports and 128 routes are connected, and over 100 more unserved airports are to be connected in next rounds of bidding of routes.
- The Government offers fiscal support through Viability Gap Funding (VGF) and infrastructural development of under-utilized airport facilities to incentivize regional air traffic. UDAN ensures route profitability to airlines to sustain their operations through reducing operating costs by eliminating airport charges on UDAN routes, subsidizing ATF, providing market based subsidy for half of the seats, and guaranteeing three years exclusivity on routes.
- Under UDAN, 13 Regional Connectivity Scheme airports have been covered in the Eastern and North-Eastern region, 12 each in Northern and Western regions, and 8 in the Southern Region in the first round.
- So far 27 states/union territories have signed MOU (Memorandum of Understanding) with Central Government. Many private sector airlines are actively participating under this scheme.

National Civil Aviation Policy, 2016

- For the first time since Independence an Integrated Civil Aviation Policy was notified in June, 2016, which aims at creating an ecosystem that will push the growth of the civil aviation sector, which in turn, would promote tourism, increase employment and lead to a balanced regional growth.
- The Policy aims to take flying to the masses by making it affordable and convenient, enhance ease of doing business through deregulation, simplified procedures and e-governance and promote the entire aviation sector chain in a harmonized manner covering cargo, general aviation, aerospace manufacturing and skill development.

Water Transport

- Inland waterways were the chief mode of transportation before the advent of railways. Waterways are the cheapest means of transport and are most suitable for carrying heavy and bulky materials having low specific value water transport is a fuel efficient and environment friendly mode of transportation which has vast employment generation potential.
- Water transport suffered a great deal at the hands of roads and railways because it could not compete with the speed of road and rail transport. Although efforts are being made to revive the inland waterways, yet this mode of transportation is at its initial stage.
- Waterways provide only one per cent of total transport of India. The total length of navigable waterways in India comprising rivers, canals, backwaters, creeks, etc. is 14,500 km, out of which only 3,700 km is navigable by mechanized boats.
- Only 2,000 kin is actually used. As regards canals, we have a network of about 4,300 km of navigable canals, of which a stretch of 900 km is navigable by mechanized crafts. The emerging scenario shows that the inland waterways are greatly underutilized.

National Waterways

- In order to increase the significance of inland waterways and to improve their efficiency, the Government has identified 10 important waterways which are to be given the status of National Waterways. Some headway has already been made in this regard.
- Following five inland waterways have so far been declared as national waterways (NW). In addition, declaration of Barak River from Lakhpur to Bhanga (121 km) as sixth National Waterway is under consideration of the Government.
- Ganga is the most important inland waterway in India. It is navigable by mechanised boats upto Patna and by ordinary boats upto Hardwar. It has been declared as National Waterway No. 1. The entire route has been divided into three parts for development purposes.
- These parts are Haldia-Farakka (560 km), Farakka-Patna (46 km) and Patna-Allahabad (600 km). The National Waterways (Allahabad-Haldia stretch of Ganga-Bhagirathi-Hooghly River system) Act, 1982 has the provision that the regulation and development of this waterway is the responsibility of the Central Government.
- The 'Jai Marg Vikas Project' (on National Waterway-1; River Ganga) has been launched with the purpose of ensuring navigation of 1500 to 2000 tonne vessels by developing infrastructure and a fairway of 2.2 to 3 meters depth between Varanasi and Haldia covering a distance of 1380 km at an estimated cost of 5,369 crore. The project is being implemented by the Inland Waterways Authority of India.
- **Brahmaputra** is also navigable by steamers upto Dibrugarh for a distance of 1,384 km which is shared by India and Bangladesh. Its 891 km long stretch from Sadiya to Dhubri in Assam has been declared as a National Waterway and is being developed as an important inland waterway.
- **Ro-Ro (Roll on-roll off) services** have commenced between Dhubri and Hastingimari in July 2017. Roll on-roll off ships are vessels designed to carry wheeled cargo such as cars. Trucks, semi-trailer trucks, trailers and rail-road cars that are driven on and off the ship on their own wheels or using platform vehicle such as self-propelled modular transporter.
- **Rivers of South India** are seasonal and are not much suited for navigation. However, the deltaic channels of the Godavari, the Krishna and the Mahanadi, lower reaches of the Narmada and the

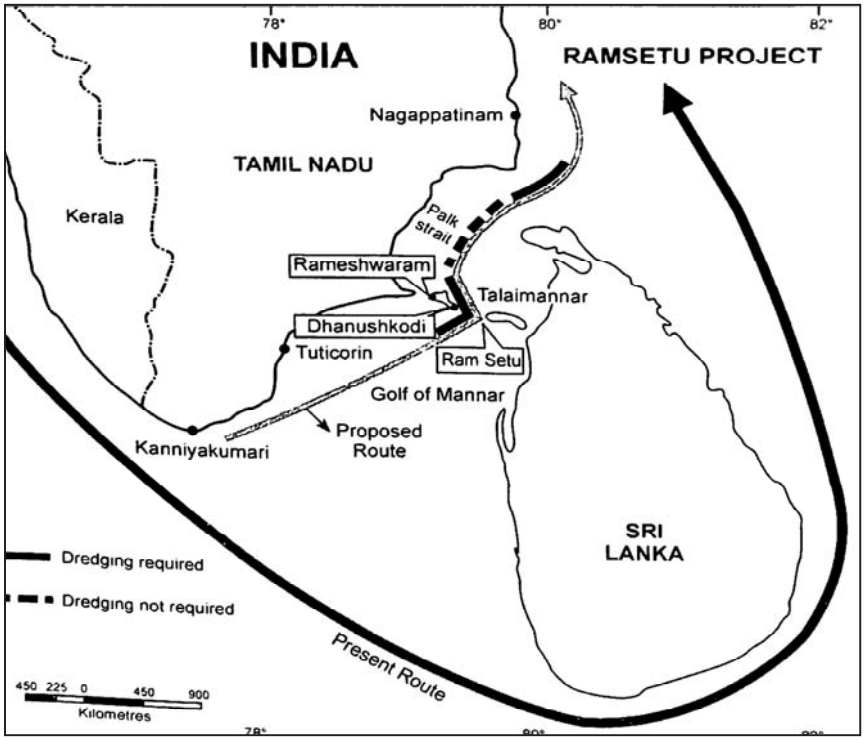
Tapi, back waters of Kerala, Mandovi and Zuari rivers of Goa serve as waterways. The Godavari is navigable upto a distance of 300 km from its mouth. The Krishna is used as a waterway upto 60 km from its mouth.

- There are some navigable canals also which transportation serve as inland waterways. Buckingham canal in Andhra Pradesh and Tamil Nadu is one such canal which provides water transport for a distance of 413 km. It runs parallel to the eastern coast and joins all the coastal districts from Guntur to South Arcot.
- The other navigable canals are Kurnool-Cuddapah Canal (116.8 km), Son Canal (326 km), Odisha Canal (272 km), Medinipur Canal (459.2 km), Damodar Canal (136 km). Some of the irrigation canals of Uttar Pradesh and Punjab are also utilised for local transport.
- The Inland Waterways Authority of India (IWAI) was set up at Noida (Uttar Pradesh) on 27 October, 1987 for development and regulation of inland waterways. The Authority undertakes various schemes for development of Inland Water Transport (IWT) related infrastructure on National Highways.
- Under the National Waterways Act, 2016, 106 additional inland waterways have been declared as National Waterways. Based on techno economic studies, eight new National Waterways have been taken up for development in 2017-18. These include NW (National Waterway)— 16 (Barak river), three in Goa viz. NW-27 : Cumberjua, NW 68—Mandovi, NW-111-Zuari, NW 86 (River Rupnaraan), NW 97 (Sunderbans), NW-9 (Alappuzha-Kottayam-Athirampuzha Canal) and NW-37 (River Gandak).

Ports

- There are 13 major and 200 medium and small ports in India. The major ports are under the supervision of the Central Government while the minor ones are managed by the concerned State Governments. The 13 major ports handle about 90% of our foreign trade. The major ports on the west coast are Mumbai, Jawaharlal Nehru, Kandla, Marmagao, Mangalore and Kochi while on the east coast are Kolkata/Haldia, Paradwip, Vishakapatnam. Chennai, Ennor and Tuticorin.

Ram Setu or Sethusamudram



- Also known as Adam's Bridge, it is an ancient bridge which is made up of a 30 km long chain of shoals and sandbars between the southernmost island of Rameshwaram in Tamil Nadu State of India and Talaimannar of Sri Lanka.
- Two contradictory viewpoints are being put forward regarding the origin and structure of this bridge. According to Hindu mythology, this bridge was built by Lord Rama to attack the Lankan king Ravana.
- Archaeological Survey of India (ASI) in its affidavit submitted to the Hon'ble Supreme Court of India said that the bridge is a natural formation made up of shoals and sand bars formed due to several millennia of wave action and sedimentation. Geological Survey of India (GSI) found that Ram Setu was not a manmade structure but represented a geological divide between the Palk Bay and the Gulf of Mannar.

DAY - 30

MIGRATION

Migration is the movement of people with the intention of setting permanently or temporary at a new location.

When people move from one place to another, the place they move from is called the **Place of Origin** and the place they move to is called the **Place of Destination**.

The place of origin shows a **decrease** in population while the population **increases** in the place of destination.

It may be interpreted as a spontaneous effort to achieve a better balance between population and resources. It may be permanent, temporary or seasonal. It may take place from rural to rural areas, rural to urban areas, urban to urban areas and urban to rural areas.

People migrate for a better **economic and social life.**

There are two sets of factors that influence migration:

- **The Push factors** make the place of origin seem less attractive for reasons like unemployment, poor living conditions, political turmoil, unpleasant climate, natural disasters, epidemics and socio-economic backwardness.
- **The Pull factors** make the place of destination seem more attractive than the place of origin for reasons like better job opportunities and living conditions, peace and stability, security of life and property and pleasant climate.

Effects of Migration

Migration can have a range of social, cultural, political and economic effects. It involves transfer of knowledge and skills, financial assets (including remittances), and the transfer of people from one location to another.

- The absence of young men in the areas of origin impoverishes agriculture and reduces crops yield.
- Migration also has consequences for the individual, the area of origin and the area of destination-on the family, household, society, the economy and development as a whole.
- The effect of international migration is not limited to remittances and cash inflows alone. It includes a wide range of development issues governance and legal protection, employment and social, protection, health services and education, tertiary education, knowledge and skills development, economic growth, financial services and growth, agriculture and rural infrastructural development, and environment issues.
- Sudden mass relocation or displacement has an adverse environmental effect on the migrant host area. This usually occurs directly when immigrants deforest expanse of land to set up human settlements or indirectly when the influx of immigrants to a community contributes to expansion and consequently gentrification and deforestation.
- The environmental impact of protracted overexploitation of natural resources, prolonged indiscriminate disposal of wastes, and other unwholesome environmental practices pose a significant hazard to the immigrants themselves and also to residents in proximity to such a settlement.

Migration occurs at a variety of scales

- Intercontinental (between continents),
- Intra-continental (between countries on a given continent), and
- Interregional (within countries).

Types of Migration

- **Internal Migration:** Moving to a new home within a state, country, or continent.
- **External Migration:** Moving to a new home in a different state, country, or continent.
- **Emigration:** Leaving one country to move to another (e.g., the Pilgrims emigrated from England).
- **Immigration:** Moving into a new country (e.g., the Pilgrims immigrated to America).
- **Population Transfer:** When a government forces a large group of people out of a region, usually based on ethnicity or religion. This is also known as an involuntary or forced migration.
- **Impelled Migration** (also called "reluctant" or "imposed" migration): Individuals are not forced out of their country, but leave because of unfavorable situations such as warfare, political problems, or religious persecution.
- **Step Migration:** A series of shorter, less extreme migrations from a person's place of origin to final destination—such as moving from a farm, to a village, to a town, and finally to a city.
- **Chain Migration:** A series of migrations within a family or defined group of people. A chain migration often begins with one family member who sends money to bring other family members to the new location. Chain migration results in migration fields—the clustering of people from a specific region into certain neighborhoods or small towns
- **Return Migration:** The voluntary movements of immigrants back to their place of origin. This is also known as circular migration.
- **Seasonal Migration:** The process of moving for a period of time in response to labor or climate conditions.

Forms of Migration

- **Rural-Urban Migration:** this type of migration has to do with movement of people from the various villages to towns and cities
- **Urban-Rural Migration:** This refers to the movement of people from towns, cities to villages.
- **Rural-Rural Migration:** This is the movement people from one village to another village, this type of migration often occurs in areas where the soil is very fertile for agricultural purposes. Rural-rural migration may occur in villages where there is inter-tribal war and insecurities.
- **Urban-Urban Migration:** this is the movement of people from one city to another city.

India's Migration Pattern: International Migration

Indians started migrating to West Indies after 1840 and their main destinations were Guinea and Trinidad. Each has over two lakh Indians. Some Indians had migrated to Jamaica. Martinique and Guadeloupe also. Most of the Indians migrated to these islands as labourers to work in the agricultural fields. Majority of such migrants were from Eastern Uttar Pradesh and Bihar. At present, Indians constitute over 50% of the population of West Indies.

Three waves of Indian Diaspora

There have been three waves of Indian Diaspora at three different times in the history of India. **According to Migration Policy Institute, diaspora is defi ned as "people of Indian origin who live outside the country but continue to exhibit some of India's ethnocultural characteristics."**

- **The first wave** took place during the British period when a large number of labourers were sent to Mauritius, Caribbean islands (Trinidad. Tobago and Guyana), Fiji and South Africa by British from Uttar Pradesh and Bihar; to Reunion Island, Guadeloupe. Martinique and Surinam by French and

Dutch and by Portuguese from Goa, Daman and Diu to Angola, Mozambique to work as plantation workers. All such migrations were covered under the time-bound contract known as Girmit Act (Indian Emigration Act). These labourers were living in inhuman conditions and their living conditions were as bad as those of slaves.

- **The second wave** of migrants went to settle in the neighbouring countries like Thailand, Malaysia, Singapore, Indonesia, Brunei and some African countries. This is a recent development under which professionals, artisans, traders, factory workers went out of the country in search of better quality of life. This trend is still continuing. In the 1970s, there was oil boom in West Asia and a large number of skilled and semi-skilled workers went there to avail of the opportunity. Some entrepreneurs, store owners, professionals, businessmen etc. went to western countries also.
- **The third wave** started in 1960s and still continues to operate. In this period high profi le professionals like doctors, engineers etc. migrated out of India. In 1980s, software engineers, management consultants, financial experts, media persons etc. moved out of the country to work in countries like the U.S.A., Canada, U.K., Australia, New Zealand, Germany etc. After liberalisation in 1991, education and knowledge based Indian migration has made Indian Diaspora most powerful in the world.

In-Migration

The present day population of India consists of descendants of people who migrated to this country at different pre-historic and historic times from different parts of the world. These include the Dravidians, the Aryans, Muslims, Mughals, Europeans, etc.

- Most of the international migrants in India are from the Asian countries, followed by Europeans, Africans, Americans and Australians. The maximum migration in India has taken place from the neighbouring countries like Pakistan, Nepal, Bangladesh and Afghanistan.
- Most of the immigrants in India from the neighboring countries mainly from Bangladesh and Nepal, are concentrated in Assam and Uttar Pradesh. Assam receives more Bangladeshis than the Nepalese while Uttar Pradesh has more Nepalese for the obvious reason of significance of distance factor in population migration. Foreign Nationals have settled in West Bengal, Maharashtra, Delhi, Tamil Nadu, Bihar, Punjab, Himachal Pradesh, Madhya Pradesh, Arunachal Pradesh, Odisha, Gujarat, Goa and Kerala.
- According to 2001 Census figures, more than 5 million persons have migrated to India from other countries. Out of these, 96 per cent came from the neighboring countries: Bangladesh (3.0 million) followed by Pakistan (0.9 million) and Nepal (0.5 million). Included in this are 0.16 million refugees from Tibet, Sri Lanka, Bangladesh, Pakistan, Afghanistan, Iran, and Myanmar.

Refugee Influx into India

- Although India has not signed the 1951 Refugee Convention, yet, India has been the main destination for refugees during the last about six decades and there has been a surge in refugees from the neighbouring countries like Tibet (China), Afghanistan, Sri Lanka, Myanmar and Bangladesh.
- The estimated figures say that there are more than 3 lakh refugees in India in 2011 making India one of the top 25 refugee recipients in the world. The following brief description gives an idea of refugee influx into India.
  - **Tibetans**, Dalai Lama was allowed to set up a government in-exile at Dharamshala (Himachal Pradesh) in 1959. This brought in a wave of Tibetan refugees of them 80,000 have resident permits and are offered low paying public works jobs by the Indian government.
  - **Afghans:** In 1979, about 90,000 Afghans fled to India when Soviet Union invaded that country In 1992 and afterwards, thousands of Afghanistanis took refuge in India when Taliban captured power in that country. In 2007, UNHCR estimated 9,200 Afghans in India and 4,000 asylum seekers in the process of refugee certification.
  - **Sri Lanka:** The civil war in 1983 triggered first wave of Sri Lanka Tamil refugees to India by 1995 India. In 2008, 73,000 Sri Lankan refugees were living in 117 camps mostly in Tamil Nadu.
  - **Myanmar:** 50,000 people fled from Myanmar to Mizoram in 2004 in the wake of military oppression. In 2017, nearly 40,000 Rohingyas muslims illegally entered into India from Myanmar.

- **Bangladeshis:** About 50,000 Chakma refugees fled Bangladesh to Tripura in 1988.
- **Until December 2008**, the Indian policy did not charge refugees a "visa or penalty tee" tor a residence permit. This was one or the main reasons of resurge of refugees into India. However, since then the numbers are dwindling. But thousands of Bangladeshis are sneaking illegally into India, making use of porous border between India and Bangladesh.

Reverse Migration

- The worldwide economic succession in 2008 forced a large number of Indian overseas to return to their home land. This reverse migration gathered momentum in 2008. An estimated 3 lakh Indian professionals working overseas are expected to return to India between 2011 and 2015.
- The sustained economic growth and the resilience that India had shown during the slowdown have fueled the reverse movement by those who had left the country in search of better job opportunities and higher standard of living.

India's Migration Pattern: Internal Migration

- Historically, migration of people for work and education has been a phenomenon that accompanies the structural transformation of economies and has paved the way for release of "surplus labour" from relatively low- productive agricultural activities to sectors enjoying higher productivity (like industry, trade, transport etc.).
- The resulting remittance flows increase household spending in the receiving regions and further the economic development of less-developed regions.
- The patterns of flow of people are broadly consistent with popular conception—"less affluent states see more people migrating out while the most affluent states are the largest recipients of migrants."
  - India is increasingly on the move—and so are Indians. The study shows that annually inter-state labour mobility averaged 5-6 million people between 2001 and 2011, yielding an inter-state migrant population of about 60 million and inter-district migration as high as 80 million. The first-ever estimates of internal work-related migration using railways data for the period 2011-2016 indicate an annual average flow of close to 9 million people between the states. Both these estimates are significantly greater than in annual average number of about 3.3 million suggested by successive censuses and higher than previously estimated by any study.
  - Migration is accelerating. In the period 2001-11, according to Census estimates, the annual rate of growth of labour migrants nearly doubled relative to previous decade, rising to 4.5 per cent per annum in 2001-11 from 2.4 per cent per annum in 1991-2001.
  - While internal political borders impede the flow of people, language does not seem to be a demonstrable barrier to the flow of people.

Magnitude and Patterns of Migration

Net flows at the All-India level have averaged close to 9 million, peaking around 2013-14, considerably above level suggested by the Census.

- According to the Economic survey 2017, the largest recipient was the Delhi, Maharashtra, Tamil Nadu, Gujarat, Andhra Pradesh, Kerala, which accounted for more than half the migration, while Uttar Pradesh and Bihar taken together account for half of total out- migrants.
- Maharashtra, Goa and Tamil Nadu had major net in-migration, while Jharkhand and Madhya Pradesh had net out-migration.
- Largest recipient states attract large swathes of migrants from the Hindi heartland of Uttar Pradesh, Bihar, and Madhya Pradesh, Punjab, Rajasthan, Uttarakhand, J & K, West Bengal.
- Kolkata in West Bengal attracts migrants from nearby states of Jharkhand, Uttar Pradesh and Odisha making evident one of the laws of migration propounded by **Ravenstein** (1885)—"There is a process of absorption, whereby people immediately surrounding a rapidly growing town move into it and the gaps they leave are filled by migrants from more distant areas, and so on until the attractive force is spent".

- There is an interesting dynamic between Gujarat and Maharashtra where Surat has started acting as a counter magnet region to Mumbai and attracts migrants from the neighbouring districts of Maharashtra. Other countermagnet region dynamics are observed in Jaipur and Chandigarh (to Delhi).

HUMAN SETTLEMENT

Settlements refer to the process of grouping of people & acquiring of some territory to build houses & also for their economic support. It also refers to any form of human habitation which ranges from a single dwelling to a large city. Settlements can broadly be divided into two types – **rural and urban.** Some basic differences between rural and urban areas in general:

- The major difference between rural and urban areas is the function. Rural areas have predominantly primary activities, whereas urban areas have domination of secondary and tertiary activities.
- Generally, the rural areas have low density of population than urban.

Rural Settlements

Geographers have suggested various schemes of classification, which can broadly be grouped under four categories:

Compact/Clustered Settlements:

- These settlements have closely built up area.
- Therefore in such settlements all the dwellings are concentrated in one central sites and these inhabited area is distinct and separated from the farms and pastures.
- Maximum settlements of our country come under this category. They are spread over almost every part of the country.

Semi- Compact/Semi-Clustered Settlement:

- The dwellings or houses are not well-knitted.
- Such settlements are characterized by a small but compact nuclear around which hamlets are dispersed. It covers more area than the compact settlements.
- These settlements are found both in plains and plateaus depending upon the environmental conditions prevailing in that area.

Hamleted Settlements:

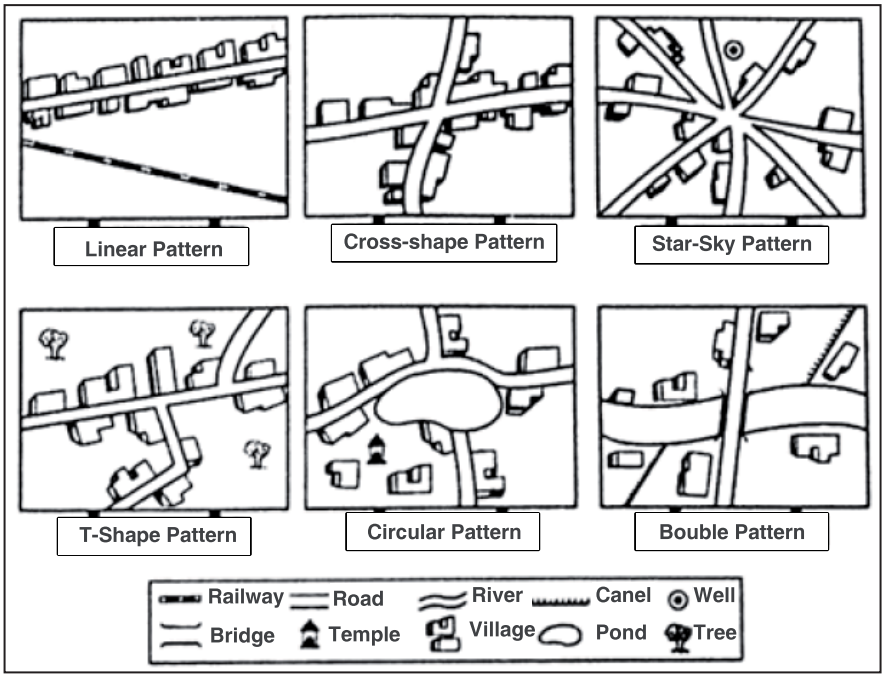
- These types of settlements are fragmented into several small units.
- The main settlement does not have much influence on the other units.
- Very often the original site is not easily distinguishable and these hamlets are often spread over the area with intervening fields.
- This segregation is often influenced by social and ethnic factors.

Dispersed Settlements:

- This is also known as isolated settlements.
- Here the settlement is characterized by units of small size which may consist of a single house to a small group of houses. It varies from two to seven huts.
- Therefore, in this type, hamlets are scattered over a vast area and does not have any specific pattern.

Rural Settlement Patterns

- Pattern refers to geometrical form and shape of the settlement and different settlements have different types of pattern depending on the site and historical background of the settlement. The pattern of a settlement provides a picture of its shape and a distinct pattern gets its name i.e. linear elongated, square. etc.
- Pattern also refers to two dimensional geometrical arrangements of rural settlements in an area. Sometimes a rural settlement may not depict any geometrical shape and the pattern may be termed as non-geometrical. Thus, two patterns — geometrical and non-geometrical— are easily discernible on a large scale map.



Morphology of Rural Settlements

- Morphology of rural settlements is concerned with their internal and external structure and identification, classification, regionalisation and analysation of its components. Thus rural morphology tries to find answers to meaningful basic questions like what is, where and why?
- Carl Sauer opines that rural morphology is based on three postulates viz. (i) organic or quasi-organic, (ii) functional equivalent and (iii) agglomeration and placement of structural elements.
- Thus, rural morphology deals with the study of built up area consisting of houses and streets etc. and the open land surrounding the built up area where agriculture or some other primary activity is carried on.
- The famous settlement geographer C.A. Doxiadis has suggested four main parts of rural settlements:
  - Homogenous part, agricultural fields etc.
  - Central part, built up area or Basti.
  - Circulatory part, roads, streets, footpaths, etc.
  - Special part, school, temples mosque, church, panchayat-ghar, cultural place, etc.
- The built-up area consists of houses, bazars (shops), streets, roads, schools, 'religious places, cultural places, panchayat-ghar, etc. Almost all the rural settlements have built-up area at the centre which is surrounded by agricultural land or grazing land.
- These two types of area are connected to each other by Chak-roads, footpaths, etc. Normally the nucleus of the settlement is located on a higher site which is occupied by the first settlers (normally people belonging to upper castes or landlords locally known as Zamindars). Once the nucleus is properly inhabited, the village starts expanding around this nucleus with the passage of time.

Urban Settlements

- Unlike rural settlements, urban settlements are generally compact and larger in size. They are engaged in a variety of non-agricultural, economic and administrative functions. As mentioned earlier, cities are functionally linked to rural areas around them.
- Thus, exchange of goods and services is performed sometimes directly and sometimes through a series of market towns and cities. Thus, cities are connected directly as well as indirectly with the villages and also with each other.
- The definition of urban areas has been refined in 2011 according to which urban areas are comprised

of two types of administrative units—Statutory Towns and Census Towns.

- **Statutory Towns:** All administrative units that have been defined by statute as urban like Municipal Corporation, Municipality, Cantonment Board, Notified Town Area Committee, Town Panchayat, Nagar Palika etc., are known as Statutory Towns.
- **Census Towns:** Administrative units satisfying the following three criteria simultaneously are treated as Census Towns as mentioned below:
  - A minimum population of 5000;
  - At least 75 percent of male working population engaged in non-agricultural sector; and
  - A density of population of at least 4,000 persons per square kilometer
  - **City:** Towns with population of 1,00,000 and above are categorised as cities.
- **Out Growth:** An Out Growth (OG) is a viable unit such as a village or a hamlet or an enumeration block made up of such village or hamlet and clearly identifi able in terms of its boundaries and location. Some of the examples are railway colony, university campus, port area, military camp, etc.
- **Metropolitan Cities:** Cities with population of one million and over are known as metropolitan cities. The main activities in these cities are industries, trade, commerce, transport, cultural and political. The number of metropolitan cities increased from 12 in 1981 to 53 in 2011.
- **Mega Cities:** Cities with population of 5 million and above are known as mega cities, according to Census of India. But United Nations considers mega cities as those that have a population of 10 million and above. In India, Greater Mumbai, Kolkata and Delhi are examples of mega cities.
- **Conurbation:** This term was coined by **Patrick Geddes.** It comes into being by coalescence of urban settlements which were separated by open space in the past. The coalescence usually occurs through Ribbon Development along the main inter-urban transport routes. Mumbai, Delhi and Kolkata are good examples of conurbations in India.
- **Megalopolis:** It is a Greek word which is derived by combining two terms 'great' and 'city'. It is just like conurbation and is formed when a large city of Boston to sprawls and brings into its fold, the smaller adjacent towns and cities. This term was first used by **Gottman** in 1964 to describe the urban scene of the north-eastern board of the U.S.A. He identified a large conurbation like mass of linked built-up areas (and yet containing much more open land) extending Cities. The over 960 km (600 miles) from north of Boston to Norfolk in Virginia.

Urbanisation in India

The process of society's transformation from a pre-dominantly rural to a predominantly urban population is known as 'urbanisation. It includes two things— an increase in the number of people living in urban settlements, and an increase in the percentage of the population engaged in non-agricultural activities, living in such places.

- Trends in urbanistion in India from 1901 to 2011: Number of towns/urban agglomerations increased by more than four times from 1,915 in 1901 to 7,935 in 2011.
- There was steady increase in number of towns till 1951, but due to more rigorous tests applied in 1961 to determine whether a place qualified to be treated as a town or not, many urban places were declassified and hence, the number of towns declined from 3,035 in 1951 to 2,657 in 1961.
- Since the 1961 census, however, the urban population and number of towns/urban agglomerations had increased steadily. There has been more than three times growth in urban population in four decades which increased from 109.11 million in 1971 to 377.11 million in 2011.

Concept of Smart Cities

- 90% of the world's urban population growth will take place in developing countries, with Indian taking a significant share of that. Urban areas also contribute a higher share of the GDP. The share of the GDP from urban areas in India has been growing.
- While the urban population is currently around 31% of the total population, it contributes over 60%, of India's GDP. It is projected that urban India will contribute nearly 75% of the national GDP in the next 15 years. It is for this reason that cities are referred to as the "engines of economic growth"

and ensuring that they function as efficient engines is critical to our economic development.

- This trend of urbanization that is seen in India over the last few decades will continue for some more time. The global experience is that a country's urbanization upto a 30% level is relatively slow but the pace of urbanization speeds up thereafter, till it reaches about 60-65%. With an urban population of 31%, India is at a point of transition where the pace of urbanization will speed up.

What is a smart city?

- Smart Cities are those that are able to attract investments. Good infrastructure, simple and transparent online processes that make: it easy 'to establish an enterprise and run it efficiently are important features of an investor friendly city. Without this a city loses attraction as an investment destination. An investor is considered as someone who helps a city rather than someone who only profits from it.

Pillars of a Smart City

Essentially, its Institutional Infrastructure (including Governance), Physical Infrastructure and Social Infrastructure constitute the three pillars on which a city rests; the center of attention for each of these pillars is the citizen. In other words, a Smart City works towards ensuring the best for its entire people, regardless of social status, age," income levels, gender, etc.

- **Institutional Infrastructure:** Institutional Infrastructure refers to the activities that relate to the planning and management systems in a city. The new technology has provided a new dimension to this system making it efficient and transparent. It includes the systems of governance the sense safety and security, the opportunities for entertainment and ions, the open spaces and parks that are available.
- **Physical Infrastructure:** Physical infrastructure refers to its stock of physical infrastructure such as the urban mobility system, the housing stock, the energy system, the water supply system, sewerage system, sanitation facilities, (solid waste management system, drainage system, etc.) which are all integrated through the use of technology.
- **Social Infrastructure:** Social Infrastructure relates to those that work towards developing the human and social capital, such as the educational, healthcare, entertainment; etc systems. It would include the following:
  - **Education:** The city should have good quality educational facilities both for schooling and higher education.
  - **Healthcare:** High quality healthcare facilities are important factors in making a city livable and attractive for people and businesses.
  - **Entertainment:** Good entertainment facilities make the people in a city happy. Good sports facilities, cultural centers, open spaces and plazas allow opportunities for recreation, so important for healthy and happy living.

Smart City Mission

- There is no universally accepted definition of a smart city and it may mean different things to different people. The concept of smart city can vary from people to people, city to city and country to country.
- The smart city mission of Government of India focuses on promoting the cities that provide core institutional, physical, social and economic infrastructure; give their dwellers a decent quality of life; sustainable environment and smart solution.
- **Ministry/Department**: Ministry of Urban Development (in collaboration of states)
- **Objective:** To develop 100 cities all over the country making them citizen friendly and sustainable
- **Schemes:**
- Smart cities to be selected through City Challenge Competition
- These cities to be developed as satellite towns of larger cities and by modernizing the existing mid-sized cities.

- Eight critical pillars of India's Smart City Program are:
  - Smart Governance
  - Smart Energy
  - Smart Environment
  - Smart Transportation
  - Smart IT & Communications
  - Smart Buildings
  - Smart Health Hospitals
  - Smart Education
- The 100 potential smart cities were nominated by all the states
- 4 approaches are adopted for development of Smart Cities:
  - Retrofitting i.e. city improvement: Introduce planning in an existing built-up area to achieve smart city objectives, along with other objectives, to make the existing area more efficient and livable. In retrofitting, an area consisting of more than 500 acres will be identified by the city in consultation with citizens. Redevelopment i.e. city renewal: Replacement of the existing built-up environment and enable co-creation of a new layout with enhanced infrastructure using mixed land use and increased density.
  - Redevelopment envisages an area of more than 50 acres, identified by Urban Local Bodies (ULBs) in consultation with citizens.
  - **Greenfield development:** Introduce most of the Smart Solutions in a previously vacant area (more than 250 acres) using innovative planning, plan financing and plan implementation tools (e.g. land pooling/ land reconstitution) with provision for affordable housing, especially for the poor. Ex. **GIFT City**
  - Pan-city development envisages application of selected Smart Solutions to the existing city-wide infrastructure.

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GS SCORE

An Institute for Civil Services

IAS PRELIMS 2020

PRELIMS TEST SERIES

BATCH: 10 - PT MAXIMA

DAILY TEST

Total 63 Tests: 10 NCERT + 29 Sub Sectional + 6 Sectional + 5 Current Affair + 10 Mock Test + 3 CSAT

STARTS 1 MARCH 2020

TEST SCHEDULE

Test No.	Date	Subject	Subject	Topics Covered
Polity (01 March to 08 March, 2020)				
Test 1	1 March, 2020	Polity 1	NCERT	Fundamentals (NCERT 11th & 12th)
Test 2	2 March, 2020	Polity 2	NCERT	Fundamentals (NCERT 11th & 12th)
Test 3	3 March, 2020	Polity 3	Sub-Sectional	Constitutional Development + Preamble + Union Territories + Citizenship
Test 4	4 March, 2020	Polity 4	Sub-Sectional	FR + DPSP + FD + Other Constitutional Provisions such as Emergency Provisions etc.
Test 5	5 March, 2020	Polity 5	Sub-Sectional	Executive + Legislature + Judiciary - 1
Test 6	6 March, 2020	Polity 6	Sub-Sectional	Executive + Legislature + Judiciary - 2
Test 7	7 March, 2020	Polity 7	Sub-Sectional	Governance + Socio Economic Development + Reforms + Bills + Welfare Schemes + Policies
Test 8	8 March, 2020	Polity 8	Sectional	Polity & Governance
Economy (12 March to 18 March, 2020)				
Test 9	12 March, 2020	Economy 1	NCERT	Fundamentals (NCERT 11th & 12th)
Test 10	13 March, 2020	Economy 2	NCERT	Fundamentals (NCERT 11th & 12th)
Test 11	14 March, 2020	Economy 3	Sub-Sectional	Basic Concepts of National Income
Test 12	15 March, 2020	Economy 4	Sub-Sectional	Budgeting + Fiscal and Monetary Policy Agricultural and Industrial Policy
Test 13	16 March, 2020	Economy 5	Sub-Sectional	External Sector + International Institutes
Test 14	17 March, 2020	Economy 6	Sub-Sectional	Money, Banking Financial Market and Other Provisions
Test 15	18 March, 2020	Economy 7	Sectional	Indian Economy
Environment (21 March to 27 March, 2020)				
Test 16	21 March, 2020	Environment 1	NCERT	Fundamentals of Environment (NCERT Biology 12th - Ch. 10 to 16)
Test 17	22 March, 2020	Environment 2	Sub-Sectional	Environment and Ecology
Test 18	23 March, 2020	Environment 3	Sub-Sectional	Biodiversity
Test 19	24 March, 2020	Environment 4	Sub-Sectional	Environmental Pollution and Management
Test 20	25 March, 2020	Environment 5	Sub-Sectional	Climate Change + Global Warming
Test 21	26 March, 2020	Environment 6	Sub-Sectional	Environmental Governance
Test 22	27 March, 2020	Environment 7	Sectional	Environment and Ecolog

Test No	Date	Subject	Subject	Topics Covered
HISTORY & CULTURE (30 March to 07 April, 2020)				
Test 23	30 March, 2020	History 1	NCERT	Fundamentals (Ancient +Medieval) (NCERT Old + New 11th & 12th)
Test 24	31 March, 2020	History 2	NCERT	Fundamentals (Modern) (NCERT Old + New 11th & 12th)
Test 25	1 April, 2020	Culture 3	Sub-Sectional	Visual Arts + Performing Arts
Test 26	2 April, 2020	Culture 4	Sub-Sectional	Religions + Languages + Literature + Institutions
Test 27	3 April, 2020	History 5	Sub-Sectional	Ancient India
Test 28	4 April, 2020	History 6	Sub-Sectional	Medieval India
Test 29	5 April, 2020	History 7	Sub-Sectional	Modern India (1757 – 1885)
Test 30	6 April, 2020	History 8	Sub-Sectional	Modern India (1885 – 1947)
Test 31	7 April, 2020	History 9	Sectional	History and Culture of India
GEOGRAPHY (10 April to 18 April, 2020)				
Test 32	10 April, 2020	Geography 1	NCERT	Fundamentals World Geography (NCERT 11th & 12th)
Test 33	11 April, 2020	Geography 2	NCERT	Fundamentals Indian Geography (NCERT 11th & 12th)
Test 34	12 April, 2020	Geography 3	Sub-Sectional	Geomorphology + Indian Physiography
Test 35	13 April, 2020	Geography 4	Sub-Sectional	Climatology + Indian Climate
Test 36	14 April, 2020	Geography 5	Sub-Sectional	Oceanography + Biogeography
Test 37	15 April, 2020	Geography 6	Sub-Sectional	Demography + Human Geography + Census
Test 38	16 April, 2020	Geography 7	Sub-Sectional	Economic Activities + Agriculture + Minerals + Energy
Test 39	17 April, 2020	Geography 8	Sub-Sectional	Industry + Transport + Trade + Communication
Test 40	18 April, 2020	Geography 9	Sectional	Geography of India and World
SCIENCE & TECHNOLOGY (21 April to 25 April, 2020)				
Test 41	21 April, 2020	Science & Tech 1		NCERTBiology + Everyday Science + + Institutions + Award
Test 42	22 April, 2020	Science & Tech 2		Sub-SectionalBiotechnology + Health + Nuclear tech
Test 43	23 April, 2020	Science & Tech 3		Sub-SectionalSpace + Defence
Test 44	24 April, 2020	Science & Tech 4		Sub-SectionalIT + Telecom + IPR + Nanotech + Robotics
Test 45	25 April, 2020	Science & Tech 5		SectionalScience and Technology
CSAT (28 April to 30 April, 2020)				
Test 46	28 April, 2020	CSAT-1	Sectional	Reasoning
Test 47	29 April, 2020	CSAT-2	Sectional	General Mental Ability
Test 48	30 April, 2020	CSAT-3	Sectional	Reading Comprehension
CURRENT AFFAIRS (03 May to 07 May, 2020)				
Test 49	3 May, 2020	Current Affairs-1		Current AffairsJune + July + August 2019
Test 50	4 May, 2020	Current Affairs-2		Current AffairsSeptember + October, 2019
Test 51	5 May, 2020	Current Affairs-3		Current AffairsNov + Dec 2019 + Jan, 2020
Test 52	6 May, 2020	Current Affairs-4		Current AffairsFeb + March + April, 2020
Test 53	7 May, 2020	Current Affairs-5		Current AffairsEconomy Survey + Budget + Indian Year Book 2020

FULL MOCK TESTS (08 May to 19 May, 2020)

Test No.	Date	Test
Test 54	8 May, 2020	MOCK 1PAPER 1 & 2
Test 55	9 May, 2020	MOCK 2PAPER 1 & 2
Test 56	12 May, 2020	MOCK 3PAPER 1 & 2
Test 57	13 May, 2020	MOCK 4PAPER 1 & 2
Test 58	14 May, 2020	MOCK 5PAPER 1 & 2
Test 59	15 May, 2020	MOCK 6PAPER 1 & 2
Test 60	16 May, 2020	MOCK 7PAPER 1 & 2
Test 61	17 May, 2020	MOCK 8PAPER 1 & 2
Test 62	18 May, 2020	MOCK 9PAPER 1 & 2
Test 63	19 May, 2020	MOCK 10PAPER 1 & 2

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