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### **1.GEOMORPHOLOGY**

#### ORIGIN AND EVOLUTION OF EARTH

Since the Earth is a member of the solar system, it is commonly believed that the origin of Earth is connected with that of the solar system. There are the following theories given for the origin and evolution of Earth.

#### **BIG BANG THEORY:**

- Edwin Hubble propounded this theory in the year 1920. According to this theory, the universe originated around 13.6 billion years ago. There was a big explosion on a singular point known as singularity after which the universe started expanding.
- Nebular Hypothesis:
  - It was given by Immanuel Kant and Laplace in the 18<sup>th</sup> century.
  - This theory says that **initially there was a large hot gaseous nebula** that **lost its heat due to radiation** and as a result, it cooled and contracted.
  - **Due to contraction**, **its speed of rotation increased.** Consequently, the centrifugal force created a bulge in the equatorial region. When the centrifugal force exceeded the gravitational pull, a gaseous ring got separated. The repetition of the process led to the formation of successive rings.
  - The material in the ring accreted to form planets while the **central nebula resulted in the sun**.
  - Limitations:
    - The hypothesis is unable to explain the fact that there is 98% angular momentum in the planets and only 2% is in the sun.
    - There was not enough mass in the ring to provide the gravitational pull for the formation of planets.

#### **PLANETESIMAL HYPOTHESIS:**

- It was given by **Chamberlain and Moulton**.
- It says that a wandering star approached the sun. As a result, a cigar-shaped extension of material was separated from the solar surface. As the passing star moved away, the material separated from the solar surface continued to revolve around the sun and it slowly condensed into planets.
- This hypothesis explains the occurrence of falling meteorites.
- Limitations: Material from the interior of the earth would be hot, so gasses would disperse to space rather than condense.

#### TIDAL HYPOTHESIS:

- It was given by Jeans and Jeffrey.
- **Bi-parental origin of the Sun**: Like the Planetesimal hypothesis, it also considers the bi-parental origin of the solar system.
- Limitation: It does not consider the role of disruptive forces in the sun.

#### **PROTOPLANET HYPOTHESIS**

- **Formation of proto planets**: According to this theory, rapidly rotating material(nebula) developed large vortexes (rotating mass of gases) at various places on the disc of the nebular material.
- Each of these vortexes accreted surrounding material by gravitational attraction which led to the formation of proto planets.
- **Satellites of planets**: Smaller vortexes developed inside the larger vortexes and gave rise to spinning discs that ultimately became satellites of planets.

All the theories have their own limitations and new discoveries often add to the demerits of theories. Thus, the origin of the solar system and earth continues to be an enigma.

#### AGE OF THE EARTH

- Earth is approximately 4.54 billion years old, plus or minus about 50 million years. Scientists have tried to find out the age of the Earth from the oldest rocks by a method known as radiometrically date. Radiometric dating involves the decay, or breakdown, of radioactive elements.
- Radiometric dating is a method which calculates the age in years for geologic materials by measuring the presence of radioactive element which has a short life, e.g., carbon-14, or a long-life radioactive element along with its decay product, e.g., potassium-14/argon-40.





#### MOTIONS OF THE EARTH

- The Earth has two types of motions, namely rotation, and revolution.
- The Earth Rotation About Its Axis: The Earth rotates on its axis relative to the Sun in one "mean solar day".
- **Earth Revolution Around The Sun:** The movement of the Earth around the Sun in a fixed or constant path (known as orbit) is called Revolution.

#### **EFFECT OF ROTATION OF THE EARTH:**

- Formation of Days and Nights: The circle that divides the day from night on the globe is called the Circle of Illumination
- Flatness at the Poles and bulge at the Equator.
- Occurrence of Sunrise, Sunset, and Noon.
- Change in the direction of winds, Ocean currents etc. (Because of Coriolis Force)
- Apparent movement of the Sun, Stars, the Moon.

#### What Happens If The Earth Did Not Rotate?

- Always Day: The portion of the Earth facing the Sun would always have a day time, thus bringing continuous warmth and heat to the region.
- **Frosty Cold**: The other half would remain in darkness and experience frosty cold.
- It would have been an impossible Life in such extreme conditions.

#### **REVOLUTION OF THE EARTH:**

• The Earth Revolves Around the Sun Once a Year: The Earth's orbit around the Sun is an ellipse and travels at different speeds during the year - Speed is slowest at Aphelion (furthest point from the Sun) and fastest at Perihelion (closest point to the Sun)

#### **EFFECT OF THE REVOLUTION OF THE EARTH:**

- Change of Seasons
- Length of Days and Nights
- Shifting of wind belts

#### POLAR VARIATION OF THE EARTH:

- There are three North Poles of the Earth: the geographic, the magnetic, and the geomagnetic.
- **Geographic North Pole:** It is the Northern tip of the axis around which globe spins.
- **The North Magnetic Pole:** is slightly to the south. Its exact location, however, it is not always the same always but changes constantly, because Earth's magnetic field is always changing.
- North Geomagnetic Pole: It is the northern axis of the magnetosphere, the magnetic shield that protects us from solar winds.

#### **PW-ONLYIAS EDGE: KEY PHRASES FOR MAINS**

Hot Gaseous Nebula; Centrifugal Force; Gravitational Pull; Tidal Distortions; Bi-Parental Origin Of Sun; Proto-Planets; Jigsaw fit of the continents; Glacial deposits; Placer deposits; Fossil distribution; Polar fleeing force; Tidal force.; Etc.

#### EARTH'S MAGNETOSPHERE

- The magnetosphere is a region around the planet created by the Earth's internal magnetism.
- Our magnetosphere is part of an interconnected and dynamic system that responds to planetary, solar, and interstellar conditions and it all initiates at deep inside Earth.
- As electrically charged, molten iron rotates deep inside Earth's surface, within the planet's outer core, it generates a magnetic field which is so large enough to extend far out into space.
- The magnetosphere protects our planet from harmful cosmic and solar particle radiation, as well as erosion of the atmosphere by the solar wind.

#### INTERNAL STRUCTURE OF THE EARTH

Most of our knowledge about the interior of the Earth is largely based on estimates and inferences. Yet, a part of the information is obtained through direct observations and analysis of materials.







	Direct Sources		Indirect Sources
•	Deep Ocean Drilling Project	•	Analysis of matter's properties indirectly provides
•	Volcanic Eruption		information about the interior.
		•	Meteors that at times reach the earth
		•	Gravitation
		•	Magnetic Field
		•	Seismic Activity: It is one of the most important
			sources of information about the interior of the earth.
			Hence, we shall discuss it in some detail.

On the basis of seismic investigations, the earth's interior has been broadly divided into three major parts:

- 1. The Crust
- 2. The Mantle
- 3. The Core
- 1. THE CRUST:
- It is the **uppermost shell of the earth**. Its thickness over oceans is **5 to 10 km** while on continents is 35 km, in orogenic belts the thickness is 55 to 70 km.
- Mohorovicic discontinuity marks its lower boundary
- In the continental regions, underneath a zone of superficial sediments, the crust can be divided into sial and sima separated by Conrad discontinuity
  - Sial: It is the upper continental crust. It is rich in silica and aluminum. Its thickness is around 11 km.



• **Sima:** It is known as the lower continental crust. It is rich in **silica and magnesium**. Its thickness is around 22 km.

#### 2. THE MANTLE:

- Source of Internal Energy: It is the second major part of the earth which is the source region of most of earth's internal energy and forces responsible for seafloor spreading, continental drift, orogeny, and major earth-quakes.
- It extends from Mohorovicic discontinuity up to a depth of 2900 km, i.e., it has a **thickness of 2965 km**.
- **Gutenberg-Weichert Discontinuity:** The discontinuity between mantle and core is known as **Gutenberg-Weichert discontinuity**.
- **Density of Mantle**: Since P and S waves record an increase in their velocities in the mantle, it is concluded that the material of **the mantle is denser than the crust**.
- The upper mantle **extends up to a depth of 1000 km** and the lower mantle extends from 1000 km till **Gutenberg-Weichert** discontinuity.
- **Gutenberg Layer:** The upper layer of the upper mantle, known as the **Gutenberg layer** is characterized by a decrease in seismic velocity.
- **Lithosphere:** The crust and the upper part of the Gutenberg layer together constitute the lithosphere.
- Asthenosphere: Below the lithosphere lies the asthenosphere which is in the **plastic** state.

#### 3. CORE

- It is the innermost part of the earth which is separated from the mantle by Gutenberg-Weichert discontinuity.
- It extends up to the center of the Earth.
- The **core consists of the outer core and inner core.** The outer core is in a liquid state while the inner core is in a solid state due to an increase in pressure.
- Outer Core: Since the S-waves do not pass through the outer core, it suggests that the outer core is liquid.
- The pressure in the core is assumed to be over three million atmospheres, while the temperature is around 6000 degree Celsius.
- It is believed that the core is **made up of nickel and iron**.

#### DISTRIBUTION OF OCEANS AND CONTINENTS

The distribution of oceans and continents as it is today has not been the same throughout geological history. Various theories have been put forward to explain the relative motion of the oceans and the continents.

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#### **CONTINENTAL DRIFT THEORY**

- **Propounder of the theory: Alfred Wegner** was the first person who put forward a comprehensive theory of **Continental Drift in 1912**.
- Theory:
  - He considered that all the **continents were once joined together in the form of Pangaea**, surrounded by **sea on all sides known as Panthalassa**.
  - **Pangaea first broke into Laurasia and Gondwana**, forming northern and southern components respectively.
  - In the subsequent phases, Laurasia and Gondwanaland continued to break to occupy today's position.
- Evidence for Continental Drift:
  - **Jig Saw Fit Of The Continents:** Shorelines of the continents suggest that they have been separated from each other. For eg., the shorelines of **Africa and America face each other.**
  - Rocks Lying Across The Continents Having the Same Age: Belt of ancient rocks which are 2000 million years old from the coastlines of Brazil and Western Africa are the same.
  - **Glacial Deposits:** Sediments of the Gondwana system of India are the same across six different land masses. The base is composed of tillite (a form of glacial deposit), which indicates prolonged glaciation.
  - Placer Deposits: Rich placer deposits of gold are found on the Ghana coast but there is an absence of source rock in the region. Gold-bearing veins are found in Brazil which are assumed to be the source of placer deposits.
  - **Fossil Distribution:** The fossils of Mesosaurus (a small reptile found in shallow brackish waters) are found in Brazil and South Africa, which indicates the two localities must have been close.
- Force Responsible For Causing The Drift:
  - **Wegner suggested two forces** responsible for drifting the continents.
    - 1. **Polar Fleeing Force:** It is associated with the rotation of the earth.
    - 2. **Tidal Force:** It is due to the attraction between the sun and the moon.
  - Wegner believed that the application of these forces over a long duration, resulted in the drifting of continents.
  - Although the **theory of Wegner has been accepted**, **the forces responsible for causing the drift have been rejected**.

#### **CONVECTIONAL CURRENT THEORY**

- It was proposed by Arthur Holmes in the 1930s.
- He proposed that the reason for the movement of continents is convectional currents operating in the mantle part.
- And the cause of the production of the convection currents is thermal differences due to the presence of radioactive elements.
- Criticism of Convectional Current Theory:
  - The process of convection currents is based on the heat produced by radioactive materials in the mantle, however, numerous scientists have questioned whether the amount of heat that is needed by radioactive elements is available.
  - Convective currents may not be formed in case of insufficient heat, and so the entire mechanism and working of the theory will be impossible.

#### **SEA FLOOR SPREADING:**

- **Propounder of Theory:** Harry Hess proposed the concept of seafloor spreading in 1961.
- Theory:
  - Hess said that constant eruptions at the crest of oceanic ridges are the reason for the rupture of the oceanic crust and the new lava coming into it, pushing the oceanic crust on either side. Which results in the spreading of the ocean floor.
  - The younger age of the oceanic crust along with the fact that the spreading of one ocean does not result in the shrinking of the other, made Hess think about the consumption of the oceanic crust. He further argued that the









ocean floor that gets pushed due to volcanic eruptions at the crest, sinks down at the oceanic trenches and gets consumed.

#### PLATE TECTONIC THEORY

- **Propounder of Theory:** The concept of Plate Tectonic Theory was **given by McKenzie**, **Parker and Morgan in 1967**.
- Theory:
  - A tectonic plate or **a lithospheric plate** is a huge, irregularly-shaped piece of solid rock, generally composed of both oceanic and continental lithosphere.
  - The **lithosphere is divided into many major and several minor plates**. A single plate can have full oceanic lithosphere or all continental lithosphere, but nearly all plates are made of a combination of both.
  - **A plate may be referred** to as the **continental plate** or **oceanic plate** depending on which of the two occupy a larger portion of the plate.
  - **Example:** Large part of the Pacific plate is an oceanic plate whereas the Eurasian plate may be called a continental plate.
  - Movement of the plates over the Earth's surface is termed plate tectonics.
  - Rate of movement of Plates move is a few centimetres a year.

#### MECHANISM OF PLATES MOVEMENT

- The earth's lithosphere is divided into many major and some minor plates.
- Young Fold Mountain ridges, trenches, and/or faults surround these major plates.
- The major plates are as follows:
  - 1. Antarctica and the surrounding oceanic plate
  - 2. North American (with the western Atlantic floor separated from the South American plate along the Caribbean islands) plate
  - 3. South American (with the western Atlantic floor separated from the North American plate along the Caribbean islands) plate
  - 4. Pacific plate
  - 5. India-Australia-New Zealand plate
  - 6. Africa with the eastern Atlantic floor plate
  - 7. Eurasia and the adjacent oceanic plate.
- Names of some important minor plates are given below:
  - 1. **Cocos plate**: Between Central America and the Pacific plate
  - 2. **Nazca plate** : Between South America and Pacific plate
  - 3. **Arabian plate** : Mostly the Saudi Arabian landmass
  - 4. **Philippine plate** : Between the Asiatic and Pacific plates
  - 5. **Caroline plate** : Between the Philippine and Indian plates (North of New Guinea)
  - 6. Fuji plate : North-east of Australia.
- These plates are constantly moving over the globe throughout the history of the earth.
- Continents are part of some plate and It is the plate that moves.



#### PLATE BOUNDARIES

- Plate boundaries are the **edges where two plates meet.**
- Most geologic activities, like earthquakes, volcanoes, and mountain building, take place at plate boundaries.

#### **DIVERGENT PLATE BOUNDARIES:**

- Plates move away at mid-ocean ridges where new seafloor forms.
- **Rift Valley:** It is formed between the two plates.
- Lava flows at the surface and becomes **basalt after cooling rapidly**, but deeper in the crust, the magma cools more slowly to form **gabbro**.

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#### **CONVERGENT PLATE BOUNDARIES:**

- When two plates come together, it is known as a convergent boundary.
- Oceanic -Continent:
  - **Subduction:** When oceanic crust converges with continental crust, **the denser oceanic plate plunges beneath the continental plate**. This process, called **subduction**, **occurs in the oceanic trenches**.
  - **Example:** The volcanoes of North-Eastern California—Lassen Peak, Mount Shasta, and Medicine Lake volcano along with the rest of the Cascade Mountains of the Pacific Northwest are the result of subduction of the Juan de Fuca plate beneath the North American plate.
- Ocean-Ocean:
  - When two oceanic plates converge, the **denser**, **older plate will subduct into the mantle**. An ocean trench is a place where the **plate is pushed down into the mantle**.
  - **Example**: Japan is an arc-shaped island arc composed of volcanoes.

#### • Continent-Continent:

- Continental plates are **too buoyant to subduct**. It goes up after collision, this creates some of the world's largest mountain ranges.
- $\circ$  Himalayas, are formed due to collision of the Indian Plate with the Eurasian Plate

#### **TRANSFORM PLATE BOUNDARIES:**

- Transform plate boundaries are formed when two plates move past each other in opposite directions.
- **Example:** A transform plate boundary between the Pacific and North American plates creates the San Andreas Fault, the world's most notorious transform fault.

#### SEISMICITY AND EARTHQUAKES

- An earthquake is the **shaking of the surface of the Earth**, resulting from the sudden release of energy in the Earth's lithosphere that creates seismic waves.
- **Hypocenter and Epicenter:** The location below the earth's surface where the earthquake starts is called the **hypocenter**, and the location directly above it on the surface of the earth is called the **epicenter**.
- **Tsunami:** When the **epicenter** of a large earthquake is located in the sea or ocean, the seabed may be sufficiently displaced to cause a tsunami.
- Earthquake is caused due to the tectonic movements of the earth's surface and the release of energy due to that movement. Other causes of earthquakes can be volcano erupts, or a meteor hitting the earth, or an underground nuclear explosion is carried out.



#### THREE TYPES OF EARTH-QUAKE WAVES:

- **Longitudinal, Primary, or P-waves:** They are similar to sound waves. They can travel in solids, liquids, and gasses. They have short wavelengths and high frequency
- **Transverse, Secondary waves, S waves, or Shear waves:** In such waves, particles move to and fro at right angles to the path of the wave. They travel only in solid mediums. They also have short wavelengths and high frequency.
- **Surface waves, L waves, Rayleigh, or R waves:** They are transverse waves and are confined to the outer skin of the crust. These are responsible for the most destructive forces of earthquakes. They have low frequency, long wavelength, and low velocity.

#### SHADOW ZONE:

- Specific areas on Earth where waves are not reported are known as shadow zones. Both P and S waves are observed from the epi-center to 103 degrees. Beyond 150 degrees, only P waves are
   S-WAVE SHADOW ZONE
   P-WAVE SHADOW ZONE
- observed and no S waves are observed.
- Thus, the shadow zone of P waves extends from **103 degrees to 150 degrees** from the epicenter. While the shadow zone of S-waves exists beyond 103 degrees.
- The P and S-wave velocities change with depth and each change can be related to the change in materials. Each region of changing velocity demarcates a zone of discontinuity. The following information is inferred about the interior of the earth.







- The shells of increasing densities are found towards the center of the earth.
- Each shell is formed of different materials.

#### **RECORDING EARTHQUAKES:**

- Seismographs: Earthquakes are recorded by instruments called seismographs. The recording they make is called a seismogram.
- Richter Scale: Earthquake events are scaled according to magnitude or intensity of the shock. The magnitude scale is known as Richter Scale. It is expressed in absolute numbers from 0 to 10.
- Mercalli Scale: The intensity scale is known as the Mercalli Scale. It takes into account visible damage caused by the quake. The range is expressed from 1 to 12.

#### **TYPES OF EARTHQUAKES:**

- 1. Tectonic Earthquake: Generated due to the sliding of rocks.
- 2. **Volcanic Earthquake:** It is a special type of earthquake observed in areas of active volcanoes.
- 3. **Collapse Earthquake:** It is due to intense mining activity which results in the collapse of roofs causing minor earthquakes.
- 4. **Explosion Earthquake:** Due to the explosion of chemical or nuclear devices.
- 5. Induced Earthquake: Occurs in areas of large reservoirs.

#### **EFFECTS OF EARTHQUAKES:**

- Shaking and ground rupture
- Landslides and Avalanches
- Fires
- **Soil liquefaction:** Liquefaction is a phenomenon in which the stiffness and strength of a soil is considerably reduced due to earthquake shaking.
- Tsunami and floods.
- Large scale destruction and harm of properties
- Loss of human and livestock lives.

#### **GLOBAL DISTRIBUTION OF EARTHQUAKES:**

- The **circum-Pacific seismic belt** which is found along the rim of the Pacific Ocean is the world's greatest earthquake belt, in this area around **81 percent** of earth's largest earthquakes occur. Due to which it is known as **"Ring of Fire"**.
- The **Alpide earthquake belt** spreads from Java to Sumatra, goes through the Himalayas, the Mediterranean, and then completes into the Atlantic. This belt causes **about 17 percent of the world's largest earthquakes.**
- The third prominent belt is **mid-Atlantic Ridge which is submerged**. The ridge shows where two tectonic plates are spreading apart (a divergent plate boundary).

#### **SEISMIC MAPPING OF INDIA:**

- According to the history of earthquakes in the country, **a total of ~59% of the land of India** (comprising all states of India) is prone to earthquakes of different intensities.
- Seismic zoning map of the country has classified the total area of the country into four seismic zones.
- Zone V is seismically the most active region, while zone II is the least. Approximately,  $\sim 11\%$  area of the country falls in zone V,  $\sim 18\%$  in zone IV,  $\sim 30\%$  in zone III, and the remaining in Zone II.

#### **CAUSES EARTHQUAKES IN TURKEY:**

• The tectonics of the Eastern Mediterranean area, which includes Turkey, Syria, and Jordan, are driven by complex interactions between the African, Arabian, and Eurasian tectonic plates, as well as the Anatolian tectonic block.



Seismic zonation and intensity map of India









- **Turkey is located on the Anatolian tectonic plate(as shown in the image below), which is bounded by two main faults**: the North Anatolian Fault (NAF) in the west and the East Anatolian Fault (EAF) in the southeast.
- The NAF line is the "**Particularly Devastating**" meeting point of the Eurasian and Anatolian tectonic plates.
- NAF is a right-lateral strike-slip structure in northern Turkey that accommodates much of the Anatolia block's translational migration westward with regard to Eurasia and Africa.
- The EAF is the tectonic border between the **Anatolian Plate and the Arabian Plate**, which is advancing northward. It stretches across 650 kilometers from eastern Turkey to the Mediterranean.
- Moreover, the **Aegean Sea Plate**, which lies in the eastern Mediterranean Sea under southern Greece and western Turkey, is a source of seismic activity in the region.

#### **DECODING SINKING OF JOSHIMATH**

- Joshimath is located in Chamoli district of Uttarakhand which falls in Zone V of the Seismic Zonation Map and has experienced several earthquakes of a magnitude of less than 5 on the Richter scale.
- Joshimath is located on Vaikrita Thurst (VT), a tectonic fault line.
- It is also very close to the main geological fault lines, Main Central Thrust (MCT), and Pandukeshwar Thrust (PT).

#### VOLCANOES

- The term **"volcano"** refers to an opening in the Earth's surface from which lava, gasses, ash, and rock fragments erupt. The structure of a volcano grows with every eruption.
- Below the surface, lava is called magma and builds up in underground reservoirs. Magma and other volcanic materials are channelled to the surface where they are expelled through a crack or hole.

#### **PARTS OF VOLCANO:**

- **Magma Chamber:** It is a hollow within the volcano where magma and gasses accumulate.
- **Conduit:** It is a pipe-like passageway from where Volcanic materials move from the magma chamber.
- Vent: It is an opening on the surface of a volcano that emits gasses, lava, ash or other volcanic materials.
- **Crater:** It is a bowl-shaped depression which surrounds the Central vent. Craters form when explosive eruptions occur.
- **Slopes:** Sides or flanks of a volcano that radiate from the main or central vent.



#### **TYPES OF VOLCANOES**

Composite	Composite volcanoes are made of felsic to intermediate rock.	
Volcanoes:	• The viscosity of the lava means that eruptions at these volcanoes are most of the time explosive.	
Shield Volcanoes:	The lava that creates shield volcanoes is fluid and flows easily.	
	• The low viscosity also means that shield eruptions are often non-explosive.	
Caldera:	They are mostly so explosive that when they erupt they tend to collapse on themselves rather	
	than building any tall structure.	
	The collapsed depressions are called calderas.	
Cinder Cones:	• A cinder cone has a cone shape, but is much smaller than a composite volcano.	
Mid-Ocean Ridge	These volcanoes occur in oceanic areas.	
Volcanoes:	The central portion of this ridge experiences frequent eruptions.	

#### LANDFORMS AND THEIR EVOLUTION

A landform is a feature on the Earth's surface which is formed naturally and it often has a shape like a valley or mountain. Their size ranges from small like hills or much larger like mountains.





#### WIND/AEOLIAN LANDFORMS

- These landforms are found in hot desert regions.
- These landforms have conditions such as very less vegetation cover, insufficient rainfall, high rate of evaporation etc.
- Erosion Landforms:
  - Ventifacts: These are geomorphic features made of rocks that are abraded, pitted, etched, grooved, or polished by wind-driven sand or ice crystals.
  - **Yardangs**: These are streamlined ridges of compact sand lying in the direction of the prevailing wind, and formed by wind erosion of surrounding material.
  - **Deflation Hollows:** These are also known as **blowout dune, created when loose surface material is scooped out** by the wind, leaving a hollow.
  - **Mushroom Rocks: Wind carrying the sand particles erodes the lower part of the rocks** more as compared to the upper part.
  - **Zeugen:** These are **tabular structures** which have a layer of soft rocks lying beneath a surface layer of more resistant rocks.
  - **Inselberg:** They are basically **isolated residual hills** rising abruptly from the ground level. These are **characterized by very steep slopes & rather rounded tops**
- Depositional Landforms:
  - Sand Dune: A dune is a mound of sand formed by the wind, usually along the beach or in a desert.
    - Crescentic Dunes are shaped like crescents, It looks like a wide letter C.
    - Linear Dunes form straight or nearly straight lines.
  - Star Dunes have pointed ridges and slipfaces on at least three sides.
  - **Parabolic Dunes** are similar to crescentic dunes. Their shapes are roughly the same, but the slip face of a parabolic dune is on its inward side.
  - **Dome Dunes** are the rarest type of dune. They are circular and do not have a slipface.
  - Loess comprises **fine dust blown by the wind** beyond the desert. It is mostly homogeneous and highly porous.
    - **Example**: Loess deposited along the Mississippi River valley.

#### LANDFORMS OF GLACIATION

- Glacier is a huge mass of moving ice that moves due to gravity. Erosion by glaciers is mainly due to plucking and abrasion.
- Erosional Landforms:
  - **Cirques:** Cirques are **bowl-shaped**, **amphitheater-like depressions** that glaciers create into mountains and valley side walls at high elevations.
  - Nunataks, Arêtes, and Horns: Nunataks, arêtes, and horns are the result of glacial erosion in areas where multiple glaciers flow in multiple directions.
    - Nunataks are rocky islands that are surrounded by flowing glacier ice.
    - An arête is a thin, jagged crest that separates—or that once separated—two adjacent glaciers.
    - Horns are pointed peaks that are bounded on at least three sides by glaciers.
  - **Crevasse:** A crevasse is a **deep**, **wedge-shaped opening** in a moving mass of ice called a glacier. **Fjord:** It is created when **glacial valleys intersect the ocean** and are partially flooded.
- Depositional Landforms:
  - o Moraines: Moraines are created by the deposition of glacial till when the glacier melts.
  - Glacial Till and Glacial Flour:
    - Glacial till **consists of sediments of every size**, from tiny particles smaller than a grain of sand to large boulders, all jumbled together.
    - **Glacial flour** is the smallest size of sediment (much smaller than sand) and is responsible for the milky, colored water in the rivers, streams, and lakes that are fed by glaciers.
    - **Glacial Erratics:** They are **large**, **isolated boulders deposited by retreating**, **melting glaciers**.
- Significance Of Glaciated Landforms:
  - Glaciated landforms are **indicators of paleoclimate** (climate of the past). For example, the glaciated boulders found in **Talcher in Orissa** show that the region might have been under the influence of some kind of glaciers in the past.

#### KARST LANDFORM/ LANDFORMS FORMED DUE UNDERGROUND WATER

- These landforms are formed in the limestone regions with sufficient rainfall.
- Erosional Landforms:
  - **Sinkholes:** A sinkhole is a depression or hole formed when the land surface sinks because of underground bedrock dissolution or cave collapse.
  - **Doline:** It is formed by the combination of several sinkholes.
  - **Uvala:** These are larger depressions formed by the merger of several dolines and sinkholes.





- **Polje:** These are very large depressions, the part of which may have formed due to faulting.
- **Disappearing stream:** The surface run off goes down under a swallow hole and flows as underground stream and re-emerges at some distance via a cave opening.

#### • Depositional Landforms:

- **Stalactites:** These are hanging pillars (downwards) which are formed by the precipitation of minerals inside the cave.
- **Stalagmites:** It is an upward growing mound of mineral deposits that have precipitated from the water dripping on the floor. They have mostly rounded or flattened tips.
- Pillar: When stalactites and stalagmites join, a pillar is formed.
- Significance of Karst Landscape:
  - Many artifacts found from early human development have been preserved in karst areas.
  - It is also the source of knowledge for our ancestors.
  - Karst and caves have valuable natural resources, they are also host to a wide variety of unique ecological niches.

#### FLUVIAL LANDFORM

- Fluvial systems are dominated by river and streams erosion.
- Erosional Landform:
  - **Waterfall:** A waterfall is **when a river falls over a vertical slope**. It is found in the youth stage of a river where there are areas of hard and soft rocks
  - **Canyon and Gorge:** A **gorge is a deep valley with very steep to straight sides** and a **canyon is characterised by steep steplike side slopes** and may be as deep as a gorge. **River Valleys:** It is a long **lowland between ranges of mountains, hills, or other uplands**, often having a river or stream running along the bottom. It is typically a low-lying area of land, surrounded by higher areas such as mountains or hills.
  - **Potholes:** These are **holes scoured into bedrock** by swirling water/sediments. Abrasion by sediment which enters a depression; bedrock scoured by swirling sediment.
- Depositional Landforms
  - **Alluvial Fan and Cones:** Alluvial **fans are fan-shaped deposits of water-transported material (alluvium).** Alluvial fans have gentler slopes than the cones.
  - **Natural Levees:** An embankment of silt and sand built up by a running of stream along both sides of the stream.
  - **Flood Plain:** An **area of low, flat land along a stream or river**, formed mainly of river sediments and is subject to flooding.
  - **Channels and Bars: Channels are** an elongate accumulation of sand, lying parallel to the shore. Bars are an elevated region of sediment that has been deposited by the flow
  - **Delta:** The **depositional feature of a river or stream having a triangular shape** at the mouth of a river emptying either in a lake or a sea is called delta. It is the characteristic feature of the old stage.
- Significance Of Fluvial Landforms:
  - Plains created out of the deposition of fluvial systems are one of the fertile regions of the world which has supported a number of civilizations.
  - Also the rocks brought by the fluvial system represent the mineral composition of the source rocks.

#### **COASTAL LANDFORMS**

#### • Erosional Landform:

- **Headlands and Bays:-** A bay is an inlet of the sea where the land curves inwards, usually with a beach.- When the softer rock is eroded inwards, the hard rock sticks out into the sea, forming a headland.
- Cliffs And Wave-Cut Platforms: Cliffs are shaped through erosion and weathering. Soft rock erodes quickly and forms gentle sloping cliffs, whereas hard rock is more resistant and forms steep cliffs. A wave-cut platform is a wide gently-sloping surface found at the foot of a cliff.
- **Caves, Arches, Stacks and Stumps:** Caves, stacks, arches, and stumps are erosional features which are commonly found on a headland.
  - **Cracks** are widened in the headland through the erosional processes of hydraulic action and abrasion.
  - **Cave:** As the waves continue to grind away at the crack, it begins to open up to form a **cave**.
  - Arch: When the cave becomes larger and eventually breaks through the headland to form an arch.
  - **Stack:** The base of the arch continually becomes wider through further erosion, until its roof becomes too heavy and collapses into the sea. This leaves a **stack** (an isolated column of rock).
  - **Stump:** The stack is undercut at the base until it collapses to form **a stump**.

#### • Depositional Landforms

- **Beaches:** Beaches are made up from eroded material that has been transported from elsewhere and then deposited by the sea.
- **Spits:** A spit is an **extended stretch of sand** or shingle jutting out into the sea from the land. Spits occur when there is a change in the shape of the landscape or there is a river mouth.





- **Bars:** Sometimes a spit can grow across a bay, and joins two headlands together. This landform is known as a bar.
- Lagoons: Bars can trap shallow lakes behind the bar, these are known as **lagoons**. Lagoons do not last forever and may be filled up with sediment.
- Significance Of Coastal Landforms:
  - $\circ$  They are one of the most preferred tourist locations.
  - $\circ$   $\;$   $\;$  The beaches are a source of commercially important minerals.
  - For eg., gold found on the beaches of Subarnarekha River; thorium found on the beaches of monazite sands of Kerala.
- One-third of India's coastline is vulnerable to erosion, impacting coastal communities:
  - The National Centre for Coastal Research (NCCR) has monitored Indian coastal areas from 1990-2018 and they have found that 33.6 per cent of the Indian coastline is vulnerable to erosion, 26.9 per cent was under accretion (growing), and 39.6 per cent is in a stable state.
  - This long-term shoreline analysis indicates that out of 550 km of the coast in Odisha, 28% of the coast is eroding, 21 per cent is stable, and 51 per cent is accreting.
  - **Impact of Coastal Erosion:** The receding coastline will result in the loss of land/habitat and the livelihood of fishermen, they might be **losing the space for parking boats, mending nets, and fishing operations.**
  - Government Efforts for Prevention of Coastal Erosion:
    - Mangrove plantation
    - Shelterbelt plantation
    - Installation of Geo-Tubes.
    - Allocation of Rs 2500 Crore, Under the 15th Finance Commission for the resettlement of displaced people affected by erosion and mitigation measures to prevent river and coastal erosion.

#### PREVIOUS YEAR QUESTION (MAINS)

Discuss the geophysical characteristics of Circum- Pacific Zone.	2020
How can the mountain ecosystem be restored from the negative impact of development initiatives and tourism?	2019
Define mantle plume and explain its role in plate tectonics.	2018
How does the Juno Mission of NASA help to understand the origin and evolution of the Earth?	2017
Why are the world's fold mountain systems located along the margins of continents? Bring out the association	
between the global distribution of Fold Mountains and the earthquakes and volcanoes.	
Explain the formation of thousands of islands in the Indonesian and Philippines archipelagos.	
What do you understand by the theory of continental drift? Discuss the prominent evidence in its support.	



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#### 2.CLIMATOLOGY

- The air is a mixture of several gases such as Nitrogen, Oxygen etc. and it encompasses the earth from all sides. The air surrounding the earth is called the atmosphere.
- Water vapor and dust particles are also a constituent of air in varying amount.
- The air completely surrounds the earth and literally wraps it up in a shroud that takes a spheroid shape (Similar as egg), **flatter** at the poles and bulging at the Equator, under the effect of gravity and centrifugal force caused by the Earth's rotation.
- A number of layers (spheres) can be identified in the atmosphere. These layers are concentric with the Earth and have variation in temperatures and chemical properties.



The atmosphere is held to the planet by the force of gravity, which also determines what gases are present in it. .

#### DIFFERENCE BETWEEN CLIMATE AND WEATHER

Parameters	Weather	Climate
Timescale	Weather refers to the short-term atmospheric conditions occurring over a relatively short period, typically hours to days.	Climate refers to long-term patterns and averages of weather conditions over a specific region or the entire Earth, usually spanning decades to centuries.
Variability	Weather conditions can change rapidly and are influenced by daily and seasonal fluctuations in temperature, precipitation, wind, humidity, and atmospheric pressure.	Climate represents the average or typical weather conditions of a region, considering the long-term trends and variations.
Spatial Scope	Weather conditions can vary from one location to another over small distances. For example, it can be raining in one area while being sunny in a neighbouring area.	Climate describes the general patterns and characteristics of weather over a larger geographical area, such as a city, region, or even the entire planet.
Predictability	Weather is highly variable and can be challenging to predict accurately beyond a few days due to its sensitivity to small-scale atmospheric processes.	The climate is more predictable on longer timescales as it is influenced by larger-scale factors such as oceanic circulations, solar radiation, and greenhouse gas concentrations.
Impact	Weather affects our day-to-day activities and immediate conditions, such as deciding what to wear or planning outdoor events.	Climate has broader implications as it influences the natural ecosystems, agriculture, water resources, and human societies over an extended period. Changes in climate can have significant long-term impacts on habitats, agriculture, and the frequency of extreme weather events.

#### **PW-ONLYIAS EDGE: KEY PHRASES FOR MAINS**

Intra-Seasonal Oscillation; monsoon's "active" and "break" periods; Surface-level ozone (Ground Ozone); Magnetic dipole Uneven warming and cooling; Short wave and long wave Radiation; Climate forcings; highly reflective blanket; albedo; Decline in Arctic Sea Ice; Coastal community on risk; Permafrost; Polar vortexes, etc.

#### EARTH'S ATMOSPHERE

The atmosphere is made up of different types of gases, water vapour and dust particles. The composition of the atmosphere is not static. It changes according to the time and place. Nitrogen and Oxygen are the two main gases in the atmosphere. 99 per cent part of it is made up of these two gases. Other gases like organs, carbon dioxide, hydrogen, Neon, helium etc. form the remaining part of the atmosphere.

#### STRUCTURE OF ATMOSPHERE

Layers	Details
Troposphere	<ul> <li>The troposphere is the lowest layer of the Earth's atmosphere, extending approximately 13 kilometres in average height.</li> <li>It is thicker at the equator, reaching about 18 kilometres, and narrower near the poles, around 8 kilometres.</li> </ul>
	16 TELEGRAM   WEBSITE



#### **PRAHAAR ReDEFINED 3.0: GEOGRAPHY & DM**



	• The troposphere is responsible for all climatic and weather changes.			
	• As you ascend in the troposphere, the temperature gradually decreases at a rate of approximately			
	1°C for every 165 meters (normal lapse rate).			
	• Above the troposphere lies the tropopause, which acts as a boundary between the troposphere and			
	the stratosphere.			
	• The tropopause exhibits a nearly constant temperature of around -80°C over the equator and			
	approximately -45°C over the poles, earning its name.			
	• It can be found up to 50 kilometres above the earth's surface, beyond the tropopause.			
	• It is responsible for a large portion of the ozone in the atmosphere. The absorption of ultraviolet			
	(UV) energy from the sun by this ozone causes the temperature to rise with height.			
Stratosphere	• Temperatures are highest over the summer pole and lowest over the winter pole in the			
	stratosphere.			
	• This layer is almost free from clouds and associated weather phenomena, making conditions most			
	ideal for flying aeroplanes.			
	• Sometimes, cirrus clouds are present at lower levels in this layer.			
	• The region above the stratosphere is called the mesosphere. Here the temperature again decreases			
	with height, reaching a minimum of about -90°C at the "mesopause".			
Mesosphere	• Most of the meteors burn up in this layer on entering from space.			
• The air is so cold just below the mesopause that even the scarce water vapour can be sublimated				
	into polar-mesospheric noctilucent clouds.			
	• The thermosphere lies above the mesopause and is a region in which temperatures again increase			
	with height. This temperature increase is caused by the absorption of energetic ultraviolet and X-			
Thermosphere	Ray radiation from the sun.			
	• The International Space Station and satellites orbit in this layer.			
	• The Kármán line, located at an altitude of 100 km within the thermosphere, is widely used to			
	describe the border between Earth's atmosphere and outer space.			
	• The ionosphere is a part of the thermosphere. It extends between 80-400 km.			
Ionosphere	• Electrically charged currents flow in the air in this sphere. Radio waves are reflected back on the			
-	earth from this sphere and due to this radio broadcasting has become possible.			
Exosphere	• Located above the ionosphere and extends to 400 km above the earth.			
	• The air is extremely rarefied, and the temperature gradually increases through the layer.			

#### CLIMATE CHANGE AND ATMOSPHERE

- The lower and middle atmospheres affect the upper atmosphere mainly via upwardly propagating atmospheric waves. As atmospheric waves travel upwards, their amplitude increases due to the exponential decrease in atmospheric density with height.
- As a result of man-made climate change in the lower and middle atmosphere, both wave generation processes and the wave propagation conditions in the lower and middle atmosphere have changed over the past 4-5 decades.

#### IMPACTS OF CLIMATE CHANGE ON ATMOSPHERE:

- **Heat Waves:** Climate change will increase the size of stalled high-pressure weather systems called "blocking events" that have already produced some of the 21st century's deadliest heat waves.
- **Contraction of Upper Atmosphere:** The increase in atmospheric CO2 concentration is causing cooling and contraction of the upper atmosphere, which leads to lower densities at high altitudes and thereby a longer lifetime of space debris.
  - In addition, there may be indirect effects of climate change in the lower/middle atmosphere on long-term trends in upper atmosphere density.
- **Formation of Surface level ozone:** Changes in climate can result in impacts on local air quality. Atmospheric warming associated with climate change has the potential to increase ground-level ozone in many regions.
- **Uneven warming and cooling:** Ozone in the atmosphere warms the climate, while different components of particulate matter (PM) can have either warming or cooling effects on the climate.
  - For example, black carbon, a particulate pollutant from combustion, contributes to the warming of the Earth, while particulate sulfates cool the earth's atmosphere.
- **Drastic climatic changes:** Climate models (IPCC, 2007) have been used to project the evolution of the mean temperature and precipitation rate during the coming centuries.
  - When a "business-as-usual" scenario is adopted for the simulations, the projected increase in the global surface mean temperature at the end of the 21st century is 2.8°C, with an average warming of 3.5°C on land and of as much as 7°C in the Arctic.





#### HEAT BUDGET

The Earth absorbs incoming solar radiation (shortwave radiation) and releases heat back into space as terrestrial radiation (longwave radiation). This balance between the incoming and outgoing heat allows the Earth to maintain a stable temperature, which is referred to as the Earth's heat budget.

#### **CLIMATE AND EARTH'S ENERGY BUDGET**

- **Uneven Solar Heating:** The Sun's heat is not distributed evenly on Earth due to its spherical shape, resulting in higher heating in equatorial regions compared to polar regions.
- The atmosphere and Ocean Regulation: The atmosphere and ocean work together through processes like evaporation, convection, rainfall, winds, and ocean circulation to balance the solar heating disparities and maintain equilibrium. This integrated system is known as Earth's heat engine.
- **Climate Forcings:** Any factors that alter the amount of incoming or outgoing energy disrupt Earth's radiative equilibrium and lead to changes in global temperatures. These influences are referred to as climate forcings.
- Surplus 250 200 50 150 50 North 70 60 50 40 30 20 10 0 10 20 30 40 50 60 70 Latitude
- Natural Climate Forcings: Natural forcings include variations
   in the Sun's brightness, Milankovitch cycles (long-term changes
   in Earth's orbit and axis), and large volcanic eruptions that release light-reflecting particles into the stratosphere.
- Man-Made Forcings: Human activities contribute to climate forcings, such as particle pollution (aerosols) that absorb and reflect sunlight, deforestation, and the increasing concentration of greenhouse gases like carbon dioxide, which trap heat and reduce heat radiated into space.
- **Imbalance and Climate Change:** When there is an imbalance in Earth's energy budget, it leads to climate change. The accumulation of greenhouse gases and other human-induced factors disrupts the natural equilibrium, resulting in long-term shifts in global climate patterns.
- **Increased Global Warming:** A new NASA study underscores the fact that greenhouse gases generated by human activity -- not changes in solar activity -- are the primary force driving global warming. The study offers an updated calculation of Earth's energy imbalance, the difference between the amount of solar energy absorbed by Earth's surface and the amount returned to space as heat.

#### SYNERGIES BETWEEN URBAN HEAT ISLAND AND HEAT WAVES

- **Heat Waves:** Heat waves are periods of extremely high temperatures, exceeding typical maximum levels, often occurring in the North-Western and South Central regions of India during the summer season.
- **Impacts of Heat Waves:** Examples of heat wave impacts include the 2018 record-breaking heat wave in Northeast Asia, which resulted in a significant number of hospitalizations for heat strokes in Japan and prolonged high-temperature warnings in China.
- **Role of Anticyclones:** Recent research suggests a correlation between the occurrence of extreme summer heat events in Northeast Asia and the involvement of anticyclones in the region.
- **Urban Heat Island Effect:** During heat waves, urban areas experience amplified temperature increases compared to surrounding rural areas. Factors such as increased sensible heat release, reduced evaporative cooling, and higher anthropogenic heat contribute to this effect. Urban Heat Islands are formed as urban areas exhibit higher temperatures due to changes in the surface energy budget, increased heat storage capacity of artificial surfaces, and reduced evaporative cooling.

#### **Atmospheric River**

- An atmospheric river is a narrow and elongated corridor in the atmosphere that transports large amounts of water vapour from the tropics to higher latitudes.
- It is characterized by its high moisture content and can extend for thousands of kilometres.
- Atmospheric rivers play a crucial role in the global water cycle and can result in heavy precipitation events when they make landfall.
- These events are often associated with intense rainfall, and snowfall, and can lead to floods, landslides, and extreme weather conditions.

#### **CRYOSPHERE AND CLIMATE CHANGE**

According to **the Intergovernmental Panel on Climate Change (IPCC)** Special Report on **the Ocean and Cryosphere in a Changing Climate (SROCC)**, in recent decades, the cryosphere has experienced significant reductions due to global warming. This includes the shrinking of ice sheets and glaciers, diminished snow cover, decreased extent and thickness of Arctic sea ice, and rising temperatures in permafrost regions.





#### **DEFINITION OF CRYOSPHERE**

According to Intergovernmental Panel on Climate Change (IPCC), "The cryosphere refers to those parts of the Earth's surface where water is in solid form, including snow cover, glaciers, ice caps, ice sheets, sea ice, frozen lakes and rivers, and permafrost (permanently frozen ground). The cryosphere interacts with other components of the Earth system, playing a crucial role in global climate patterns, sea level rise, and the availability of freshwater resources."

#### IMPACTS OF CRYOSPHERE ON GLOBAL CLIMATE:

- **Albedo Effect:** The cryosphere's high reflectivity (albedo) helps cool the Earth by reflecting sunlight back into space. As it melts, less sunlight is reflected, leading to increased absorption of heat and further warming of the planet.
- Sea Level Rise: Melting glaciers, ice caps, and ice sheets contribute to rising sea levels. This poses risks to coastal areas, including increased coastal erosion, inundation of low-lying regions, and the potential displacement of populations.
- **Ocean Circulation:** Melting ice alters the salinity and temperature of seawater, impacting ocean circulation patterns. This can disrupt global heat distribution, leading to changes in weather patterns and potentially affecting regional climates.
- **Feedback Mechanisms:** The cryosphere interacts with other components of the climate system, such as the atmosphere and oceans, creating feedback mechanisms.
  - **For example**, melting ice releases stored greenhouse gases, further contributing to global warming and climate change.
- Water Resources: The cryosphere acts as a natural reservoir, storing freshwater in the form of ice and snow. Changes in the cryosphere can affect water availability for human populations, agriculture, and hydropower generation, leading to water scarcity and conflicts.
- **Biodiversity Loss:** The disappearance of cryosphere-dependent habitats and species can result in biodiversity loss. This affects the delicate balance of ecosystems, disrupting ecological functions and diminishing overall biodiversity.
- **Societal and Economic Impacts:** The impacts of a changing cryosphere extend to human societies, with consequences for livelihoods, infrastructure, and resource management. Adaptation strategies are required to mitigate these impacts and build resilience in affected regions.

#### SIGNIFICANCE OF CRYOSPHERE

- **Climate Regulation:** The cryosphere reflects sunlight, cooling the planet. The high albedo of ice and snow surfaces reflects solar radiation, influencing global climate patterns.
- **Sea-Level Regulation:** Melting glaciers and ice sheets raise sea levels, leading to coastal erosion, inundation, and habitat loss.
- Water Resource Management: The cryosphere acts as a crucial freshwater reservoir, supplying water for ecosystems, agriculture, and human settlements downstream.
- **Climate Feedback:** Cryosphere changes can trigger positive feedback loops, amplifying climate change through increased warming and melting.
- **Ecosystems and Biodiversity:** The cryosphere supports unique cold-adapted ecosystems, impacting habitats and biodiversity.
- Weather and Extreme Events: The cryosphere influences weather patterns, affecting storms, precipitation, and temperature extremes.
- **Cultural and Societal Importance:** The cryosphere holds cultural value for indigenous communities and cold region inhabitants, shaping livelihoods and traditions.

#### AMBITION ON MELTING ICE (AMI) ON SEA-LEVEL RISE AND MOUNTAIN WATER RESOURCES:

Ambition on Melting Ice (AMI) refers to the collective global effort to address the impacts of melting ice on sea-level rise and mountain water resources. It involves setting ambitious goals and taking action to mitigate and adapt to these challenges. Its Focus Areas:

- **Sea-Level Rise:** AMI aims to limit global warming by reducing greenhouse gas emissions, promoting renewable energy, and transitioning to low-carbon economies to mitigate ice loss from glaciers, ice caps, and ice sheets.
- **Mountain Water Resources:** AMI focuses on sustainable management of mountain water resources, including integrated water resource strategies, ecosystem protection, and water conservation practices, to ensure a reliable freshwater supply to downstream communities and ecosystems.
- **Scientific Research and Monitoring:** AMI supports enhanced research and monitoring of melting ice, sea-level rise, and mountain water resources to improve understanding, inform policies, and guide adaptation strategies.
- **International Cooperation:** AMI promotes international cooperation for knowledge sharing, capacity building, and technology transfer, aiming to enhance resilience, sustainable development, and protection of vulnerable communities in regions affected by sea-level rise and water scarcity.





- Adaptation and Resilience: AMI encourages adaptation measures such as climate-resilient infrastructure, early warning systems, coastal protection, and diversified water sources to enhance the resilience of communities and ecosystems vulnerable to sea-level rise and water resource changes.
- **Sustainable Development Goals:** AMI aligns with the UN SDGs, integrating its objectives with broader sustainable development agendas, addressing poverty, food security, ecosystem conservation, and social equity in the context of climate change, melting ice, sea-level rise, and water resources.

#### THE POLAR SCIENCE AND CRYOSPHERE RESEARCH (PACER) SCHEME

- The Polar Science and Cryosphere Research (PACER) scheme is a research program aimed at advancing scientific understanding of the polar regions and the cryosphere (frozen parts of the Earth's surface).
- It supports studies related to polar climate, ice sheets, glaciers, sea ice, permafrost, and other aspects of the cryosphere. The PACER scheme promotes multidisciplinary research, encourages collaboration among scientists and institutions, and contributes to the global knowledge base on polar and cryospheric processes.

#### ACROSS

- ACROSS stands for "Atmosphere and Cryosphere through the Earth System Science Research Program." It is a research initiative focused on studying the interactions and processes within the atmosphere and cryosphere components of the Earth system.
- The ACROSS program aims to improve our understanding of the atmosphere and cryosphere and their role in climate change, weather patterns, and environmental processes.

#### POLLUTION DOME

- Introduction: This can occur in urban areas with high pollution levels and unfavourable atmospheric conditions, such as temperature inversions or stagnant air masses.
  - The pollution dome concept suggests that air pollutants are unable to disperse effectively, leading to elevated pollution levels within the dome.
- Conditions:
  - **Stagnant Air:** Calm or light wind conditions hinder air pollutant dispersion, leading to the accumulation of pollutants in the lower atmosphere.
  - **Temperature Inversions:** Warm air overlying cool air traps pollutants near the surface, creating a dome-like structure and preventing vertical dispersion.
  - **Geographic Barriers:** Mountains or valleys can act as barriers, restricting air movement and trapping pollutants within a localized area.
  - **Industrial Emissions:** High industrial activities, including factories, power plants, and vehicles, contribute to pollutant accumulation, particularly when combined with stagnant atmospheric conditions.
  - **Weather Patterns:** Certain weather patterns like anticyclones or atmospheric inversions limit the vertical mixing and dispersal of pollutants, allowing them to accumulate in a confined area.

#### HEAT DOME

- **Definition:** A heat dome, also known as a heatwave dome, is a meteorological phenomenon characterized by a high-pressure system that traps and holds hot air in a particular region.
  - **Impact:** This can result in prolonged periods of extremely hot and stagnant weather conditions. The heat dome acts as a lid, preventing the normal vertical mixing of the atmosphere and trapping heat near the surface.
    - As a result, temperatures within the dome can become dangerously high, leading to heatwaves and potentially severe heat-related impacts on human health, ecosystems, and infrastructure.
- Reasons:
  - **High-Pressure Systems:** Persistent high-pressure systems can lead to the formation of heat domes by trapping warm air and inhibiting vertical air movement.
  - **Subsidence:** Subsidence occurs when air sinks and compresses, causing it to warm and create a dome-like structure of hot air at the surface.
  - Adiabatic Compression: Descending air masses undergo adiabatic compression, resulting in a warming and the formation of a heat dome.
  - **Lack of Moisture:** Dry air can exacerbate the formation of heat domes as it allows for more efficient heating and reduced cooling effects.
  - **Prevailing Weather Patterns:** Certain weather patterns, such as persistent high-pressure systems or blocked atmospheric flow, can contribute to the formation and persistence of heat domes.

#### MAMMATUS CLOUDS





- Introduction: Mammatus clouds are a unique cloud formation characterized by pouch-like or bulbous structures hanging beneath the base of a cloud. These clouds are typically associated with severe thunderstorms or intense convective activity and are often observed following the passage of a storm system.
- Formation: Mammatus clouds are formed when sinking air pockets penetrate the cloud base, creating pockets of cooler and denser air. The distinct appearance of these clouds, resembling hanging or protruding pouches, makes them a fascinating and visually striking phenomenon in the sky.

#### WINTER STORM IN U.S

- **Definition:** Winter storms in the United States are weather events characterized by a combination of cold temperatures, precipitation, and strong winds. These storms can occur across various regions of the country, bringing significant impacts and disruptions.
- **Reasons:** 
  - 0 Arctic Air Masses: Cold air masses from the Arctic region can move southward, colliding with warmer air masses and creating favourable conditions for winter storms.
  - Jet Stream Patterns: The position and strength of the jet stream can play a significant role in the formation of 0 winter storms. When the jet stream dips southward, it can create a pathway for cold air and moisture to converge, leading to storm development.
  - Low-Pressure Systems: The interaction of warm and cold air masses can result in the formation of low-pressure systems, which can intensify and bring precipitation in the form of snow, freezing rain, or ice.
  - **Moisture Supply:** Adequate moisture supply from the Gulf of Mexico or the Atlantic Ocean can contribute to the 0 development and intensity of winter storms, providing the necessary fuel for precipitation.
  - **Orographic Lifting:** When moist air encounters mountains or elevated terrain, it is forced to rise, leading to orographic lifting. This lifting mechanism can enhance precipitation and snowfall on the windward side of mountains.
  - **Cyclogenesis:** The process of cyclogenesis, where a low-pressure system intensifies and develops into a storm, 0 can occur during winter and result in significant precipitation and strong winds.

#### **FUIIWHARA EFFECT**

- **Definition:** The Fujiwhara Effect is a phenomenon in meteorology where two nearby cyclonic systems, such as tropical cyclones or hurricanes, rotate around a common centre and interact with each other. The effect occurs when the cyclones are close enough to influence each other's movement and intensification.
- Features:
  - Interaction of Cyclones: When two cyclonic systems approach each other, they can start rotating around a 0 shared centre, resulting in a dance-like motion. The cyclones may orbit each other, merge into a single system, or repel each other, depending on their relative sizes, strengths, and initial positions.
  - **Influence on Trajectories:** The interaction between the cyclones can affect their individual paths. The smaller or 0 weaker cyclone tends to be steered by the larger or stronger cyclone, leading to a change in its trajectory.
  - **Intensity Modulation:** The Fujiwhara effect can also impact the intensity of the cyclones. The interaction 0 between the systems can result in the transfer of energy, causing one or both cyclones to weaken or strengthen. The effect is more pronounced when the cyclones are of similar size and intensity.
  - **Uncertainty in Predictions:** The presence of the Fujiwhara effect can introduce complexities in forecasting the movement and intensity of cyclones. The interaction between the cyclones adds an additional element of uncertainty to the predictions, making it challenging for meteorologists to accurately forecast their future behaviour.
  - Common in Tropical Regions: The Fujiwhara effect is commonly observed in tropical regions, where tropical cyclones or hurricanes frequently form and move across the same area. The effect is more likely to occur when the cyclones are within a certain proximity of each other.

#### PREVIOUS YEAR QUESTION

Troposphere is a very significant atmosphere layer that determines weather processes. How?	2022
The process of desertification does not have climate boundaries. Justify with examples.	2019
How does the cryosphere affect global climate?	2017
Discuss the concept of air mass and explain its role in macro-climatic changes.	2016
Tropical cyclones are largely confined to the South China Sea, Bay of Bengal and Gulf of Mexico. Why?	
Most of the unusual climatic happenings are explained as an outcome of the El-Nino effect. Do you agree?	
Bring out the causes for the formation of heat islands in the urban habitat of the world.	
What do you understand about the phenomenon of temperature inversion in meteorology? How does it affect	
the weather and the habitants of the place?	
21 <u>TELEGRAM</u>	WEBSITE





#### **3. OCEANOGRAPHY**

Oceanography is the study of the chemical, physical, and biological characteristics of the ocean, it also includes the study of the ocean's ancient history, its present condition, and its future. Oceans cover more than 70% of the earth's surface. Its health, humanity's well-being, and the living environment that keeps us all alive are all intricately interwoven. Despite this, ocean acidification, climate change, polluting activities, and over-exploitation of marine resources have made oceans one of the most endangered ecosystems on the planet.

#### **OCEAN RELIEFS**

- **Continental Shelf**: Shallow submerged extension of the continent is called the Continental Shelf.
- **Continental slope**: The continuous sloping portion of the continental margin, extending down to the deep sea floor of the abyssal plain, is known as Continental Slope.
- **Abyssal plains**: These are the extremely flat and featureless plains of the deep ocean floor.
- **Submarine Trenches**: Oceanic trenches are prominent, long, narrow topographic depressions of the ocean floor.



#### SALINITY

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The amount of dissolved salts in saltwater is referred to as salinity. The amount of salt (in gm) dissolved in 1,000 gm (1 kg) of saltwater is used to calculate salinity.

#### Significance of Salinity:

- Salinity levels are important for two reasons:
  - **First**, along with temperature, salinity affects seawater density, therefore the circulation of ocean currents from the tropics to the poles.
  - **Second**, sea surface salinity is closely linked to **Earth's overall water cycle** and to how much freshwater leaves and enters the oceans through **evaporation and precipitation**.

#### **Factors Affecting Ocean Salinity:**

- **Rate of Evaporation**: Regions with high temperature and low humidity experience a high rate of evaporation and in turn these regions have high salinity.
- **Flow of Freshwater**: When freshwater is added through regular precipitation, streams, and icebergs then the salinity is low. Example: Equatorial region.
- Water Mixing By Currents: Enclosed sea where water mixing due to ocean current is low, experiences high salinity whereas freely moving water in the ocean has low salinity.
- **Climate Change:** Rising global temperature causes more evaporation of sea water and causes more salinity in the ocean.

#### **Distribution of Salinity:**

- Vertical:
  - Salinity rises with depth at high latitudes. It rises to a maximum of 35 metres in the middle latitudes, then falls. Subsurface salinity is lower towards the equator.
- Horizontal Distribution of Salinity:
  - The salinity of the Ocean in general ranges between 33 to 37 grams.
  - The highest salinity of the Ocean is observed between 15° and 20° latitudes.
  - The salinity slowly decreases as we move towards the north.
- Regional Distribution Of Water Salinity Across The Oceans:
  - **Salinity of the Pacific:** The salinity varies in the Pacific Ocean mainly due to its larger shape and vast areal extent.
  - **Salinity of the Atlantic**: The average salinity of the Atlantic Ocean is approximately 36-37 grams.
  - **Salinity of the Indian Ocean:** The average salinity of the Indian Ocean is 35 grams. The low salinity trend is there in the Bay of Bengal because of the influx of fresh river water from the river Ganga. On the other hand, the Arabian Sea has higher salinity due to high evaporation rate and low influx of fresh river water.
  - Salinity of the Other Seas:
    - The North Sea witnesses higher salinity due to more saline water influx by the North Atlantic Drift.
    - The Baltic Sea has low salinity due to the addition of river waters in huge amounts.
    - The Mediterranean Sea shows higher salinity because of high evaporation.





Black Sea records low salinity due to huge fresh water influx by rivers.

#### Impact Of Salinity:

- First, along with temperature, they directly affect seawater density (salty water is denser than freshwater) and therefore the circulation of ocean currents from the tropics to the poles.
- Sea surface salinity is closely linked to Earth's overall water cycle and to flow of freshwater in and out of oceans through evaporation and precipitation.
- Any changes (small or big) in salinity and ocean currents can affect the climate of the region and marine life.

#### OCEAN ACIDIFICATION

- According to the National Oceanic and Atmospheric Administration of USA "Ocean acidification refers to a reduction in the pH of the ocean over an extended period of time, caused primarily by uptake of carbon dioxide (CO2) from the atmosphere."
- Ocean acidification (OA) refers to the ongoing decrease in ocean pH, which is caused primarily by the oceanic uptake of excess carbon dioxide (CO2) from the atmosphere.

#### **Causes of Ocean Acidification:**

- The concentration of carbon dioxide in the atmosphere has increased drastically due to the excessive burning of fuel and other human activities. Increased carbon dioxide is trapped by the ocean which causes an increase in the pH of the Ocean.
- Carbon dioxide in the earth's atmosphere is increasing due to following reasons:
  - Fossil Fuel Combustion
    - o Increasing Deforestation
    - Unchecked Industrial Emissions
    - o Industrial Agricultural Practices and use of Chemicals
  - Volcanic Activity

#### **Effects of Ocean Acidification:**

- Increased CO2 in the Atmosphere causes more pressure on Oceans to trap more CO2.
- Increasing acidity reduces metabolic rates and immune responses of some marine organisms.
- Life of Corals gets affected, which causes the whitening of coral reefs.
- Commercial fisheries are affected because acidification harms calcifying organisms that form the ground of the Arctic food webs.

#### MOVEMENT OF OCEAN WATERS

- The movement of ocean water takes place in three forms which are waves, tides, and currents.
- **Waves:** Rise and fall of ocean water in the **oscillatory movements** is known as waves.
- Characteristics of Waves:
  - Waves move horizontally.
  - $\circ$  ~ In wave movement energy moves, not the water.
  - This energy for the waves is given by the **wind**.
  - Raised part of the wave is called the **crest** while the low-point of the wave is called the **trough**.
- **Tides:** Tides are the rise and fall of the sea levels, they take place once or twice a day, the reason for tides are gravitational forces exerted by the sun, the moon, and the rotation of the earth.
- Types of Tides:
  - Based on the frequency
    - Semi-diurnal Tide: when there are two high tides and two low tides in a day.
    - **Diurnal Tides:** Only one high tide and one low tide in a day.
  - Based on the position of the sun, the moon, and the earth
    - **Spring Tides:** When the sun, the moon, and the earth are in a straight line then the occured tides are called spring tides.
    - **Neap Tides:** When the sun and the moon become at a right angle to each other with respect to the earth then the originating tide is known as neap tide.

#### OCEAN CURRENTS

The ocean currents are the horizontal flow of a oceaning water in a particular direction over a long distance. They are like a flowing river within the ocean.





#### **Forces Behind Ocean Current:**

#### Primary forces, which initiate water movement:

- **Insolation**: The water expands when heated by sun radiation. The ocean water level near the equator is roughly 8 cm higher than in the middle latitudes.
- **Atmospheric circulation**: The surface ocean water is dragged by the wind's frictional force. The size and direction (Coriolis force) of ocean currents are controlled by winds.
  - The oceanic circulation pattern is similar to the atmospheric circulation pattern on Earth.
- **Coriolis force**: In the northern hemisphere, the Coriolis force causes the water to move to the right For example Gulf Stream, while in the southern hemisphere, it moves to the left, for Eg. Brazilian current and West wind drift.
- **Land Mass**: It obstructs and diverts the current, for example Tip of South Chile diverts West wind drift northward as Peruvian current.
- Secondary factors, which impact current flow:
  - The secondary forces are temperature and salinity differences. Ocean currents' vertical motion is affected by differences in water density (vertical currents).
    - High-salinity water has a higher density than low-salinity water.
    - Water that is denser sinks, and water that is lighter rises.
  - **Climate change**: As greenhouse gases trap more energy from the sun, the oceans are absorbing more heat, resulting in an increase in sea surface temperatures and rising sea level. Changes in ocean temperatures and currents brought about by climate change will lead to alterations in climate patterns around the world.
    - For example: The Atlantic Meridional Overturning Circulation (AMOC) is losing its stability and is quite likely to decline

#### Gyre, Drift, and Stream:

Features	Description
Gyre	Large system of rotating ocean current, with large wind movements is called a Gyre. Force - Coriolis force.
Drift	When the huge ocean water moves forward because of the prevailing wind, it is called a Drift. E.g. North
	Atlantic Drift.
Stream	Ocean water moving in a definite path like a river on the continent is called a Stream. They are speedier than
	drifts. E.g. Gulf Stream

#### **Effects of Ocean Current:**

- Effect on Local Climate: Warm and Cold currents affect the local climate of a region.
- **Rains And Desert Formation**: Warm ocean currents cause rains to the coastal area and also the interiors while cold currents do not. Deserts are located in the western margins of continents in the sub-tropical belts where there are cold currents.
- **Effect on Fishing**: The mixing of warm and cold currents help to replenish the oxygen and favor the growth of plankton which makes this region a great fishing ground.
- Effects on Navigation: The oceanic circulation of the currents aids in the navigation of the ships.
- **Moderating Effect**: They are responsible for moderate temperatures at coasts. eg: Warm North Atlantic Drift in England, Canary cold current in Spain, Portugal etc.

#### CLIMATE CHANGE AND OCEAN CIRCULATION

- Mass flows of water, or currents, are essential to understanding how heat energy moves between Earth's water bodies, landmasses, and atmosphere.
- The ocean covers **71 percent** of the planet and holds **97 percent** of its water, making the ocean a key factor in the storage and transfer of heat energy across the globe.
- The movement of this heat through local and global ocean currents affect the regulation of local weather conditions and temperature extremes, stabilization of global climate patterns, cycling of gasses, and delivery of nutrients and larvae to marine ecosystems.
- **Impacting Marine Life:** some fish species only spawn at particular temperatures. The accelerated movement of water masses might therefore alter spawning grounds, or it may impact the connectivity between marine ecosystems.
- **Impact Carbon Cycle**: Antarctic winds strongly affect the break-out and melting of sea ice, which in turn affects the levels of algae which can grow rapidly in surface waters when sea ice is reduced.

#### • Impact of Climate Change on Ocean:

- Temperature increase
- $\circ \quad \text{Sea level rise} \\$
- $\circ$   $\,$   $\,$  Oceans are becoming more acidic as they absorb more CO2 from the atmosphere  $\,$
- Oxygen levels are decreasing





• Changing ocean current patterns threaten recruitment of fish stocks

#### CORAL REEFS

- Coral reefs are formed by the colonies of hundreds to thousands of small individual corals, called polyps.
- India has three major types of coral reefs:
  - 1. **Fringing Reefs**: The coral reefs which are found very near to the land and forms a shallow lagoon.
  - 2. Barrier Reefs: They are mostly found parallel to the coastline at some distance.
  - 3. **Atolls**: Atolls are formed on mid-oceanic ridges. They are circular or elliptical in shape and are surrounded by seas on all four sides.

#### Ideal Environmental Conditions For Corals To Grow:

- Shallow Water: The Zooxanthellae need enough sunlight for photosynthesis.
- **Semi-hard or hard surface**: It helps in compaction, solidification, and cementation of the coral polyps skeletons.
- Clear and warm water: The temperature of the water must be around 20 degrees.
- Saline-filled waters: The polyps get calcium from the salty waters to protect their skeletons.
- Rich supply of nutrients: Coral polyps multiply quicker when they are supplied with nutrients.

#### Impact Of Global Warming On Coral Life System:

- **Coral Life is threatened by rising water temperatures** caused by global warming and they are one of the first ecosystems all over the world that are on the verge of ecological collapse.
- High temperatures hit coral reefs by causing coral bleaching, where corals eject the symbiotic algae in their tissues.
- Coral bleaching is becoming stronger and more frequent due to heat stress.

#### **Factors causing Coral Bleaching:**

- **Change in temperature of the ocean**: Rising ocean temperature due to climate change is the prominent cause of coral bleaching.
- **Sea water pollution**: Storm-generated pollution can quickly dilute ocean water and runoff can carry pollutants these can bleach fringing corals.
- **High exposure to sunlight**: High solar radiation contributes to bleaching in shallow-water corals.
- Extreme Low tides: Exposure to the air during extreme low tides can cause bleaching in shallow corals.

#### Significance of Coral Reef for Ocean Ecosystem:

- **Economic Significance**: Healthy coral reefs play a major role in the fishing and tourism industry, providing crores of jobs and contributing to economies worldwide.
- **Biodiversity Significance**: According to the National Oceanic and Atmospheric Administration of the USA, Coral reefs are home to various marine diversity, including about 4,000 species of fish, 800 species of hard corals, and many other species.
- **Buffer Against Natural Disasters**: Coral reef works as buffer shorelines against the energy from waves, floods, and storms, helping to prevent loss of life, erosion, and property damage.

#### **Conservation of Corals:**

- We need to modify human activities so that damage to healthy coral reefs can be avoided and damaged reefs can recover.
- Laws Protecting The Coral Reefs Of India:
  - 1. Corals are included in Schedule-I list of the Wild Life Protection Act, 1972
  - 2. Environment Protection Act, 1986 (EPA)
  - 3. Coastal Regulation Zone Notification (CRZ) 1991 under the EPA
  - 4. Marine Protected Areas (MPAs)

#### OCEAN POLLUTION

Ocean pollution is a complex mixture of toxic metals, manufactured chemicals, plastics, urban and industrial wastes, petroleum, pesticides, fertilisers, pharmaceutical chemicals, sewage, and agricultural runoff.

#### **Ocean Microplastics:**

- Microplastics are plastic particles less than 5mm in diameter. They contribute to over 80% of the ocean debris.
- Impact of Microplastics:
  - **Effect on Food Chain:** Marine organisms such as fish, crabs, and prawns consume these microplastics by misidentification as food. Humans consume this seafood which leads to several health complications.



#### **PRAHAAR ReDEFINED 3.0: GEOGRAPHY & DM**



- **Affect The Health Of Marine Organisms**: Various studies have shown that once ingested, microplastics can settle in the stomach and lead to a reduction in the feeding capacity of organisms.
- **Ocean Pollution**: Plastic pollution that ends up in the ocean deteriorates and breaks down, ending up as microplastics.
- **Impact On Human Health**: The impact of marine plastic pollution on human health tops a list of health-related concerns over marine threats.

#### **FACT-WISE**

- According to one of the UNESCO research, Plastic waste makes up 80% of all marine pollution, and around 8 to 10 million metric tons of plastic end up in the ocean each year.
- Research states that, by 2050, plastic will likely outweigh all fish in the sea.
- Currently (as of year 2022), there are about 50-75 trillion pieces of plastic and microplastics in the ocean.

#### Impact of Ocean Pollution:

- Impact on Marine Life: Ocean pollution causes the destruction of marine ecosystems.
- **Depletion of Oxygen in Seawater:** As excess debris in the ocean slowly depletes over many years but it uses oxygen to do so, causing less oxygen in the ocean. Low levels of oxygen in the ocean lead to the death of ocean animals.
- **Harmful Elements in Environment:** New research done by Scripps Institution of Oceanography at UC San Diego has confirmed that ocean water pollution transfers to the atmosphere in sea spray aerosol, which can reach people like beachgoers, surfers, and swimmers.
- **Microplastics:** Scientists estimate between 5 and 13 million metric tons of plastic pollution enter the oceans each year, ranging from microplastics to large floating debris.

#### Marine Pollution - Mitigation:

- **Controlling Climate Change**: Significant effort in the reduction of **greenhouse gas emissions**(caused by human activity) is required.
- **Increased Oxygen Observation and Experimentation:**—By integrating existing programs and networks and focusing on areas where more data can help analyse the current state and trends of oxygen change.
- **Generating Awareness:** About the consequences of human economies and societies, particularly where fisheries, aquaculture, and livelihoods are threatened.

#### **Global Laws and Policies:**

- In 1948, Harry Truman signed a law known as the Federal Water Pollution Control Act that allowed the federal government to control marine pollution in the United States of America.
- In 1972, the Marine Protection, Research, and Sanctuaries Act of 1972 was passed by the Council on Environmental Quality which controls ocean dumping.
- In 1973 and 1978, MARPOL was a treaty written to control vessel pollution, especially regarding oil.
- In 1983, the International Convention for the Prevention of Pollution from Ships enforced the MARPOL treaty internationally.
- The 1982 United Nations Convention on the Law of the Sea (UNCLOS) was established to protect the marine environment by governing states to control their pollution to the ocean.

#### MARINE RESOURCES

Marine resources are those materials which are found in the ocean with some value. That value can be intrinsic, or monetary. **Examples:** Fish and seafood supplies, oil and gas, sand and gravel, minerals, renewable energy resources, tourism potential, and coral reef.

#### **Formation Of Marine Resources:**

- It takes a million or billion years for the formation of Marine Resources.
- Example: Oil and gas form when dead marine animals and plants are left on the ocean bed and remain covered in sediments over many years.

#### **Types of Marine Resources:**

- Marine Biological Resources
- Animal resources, (Fishes, crabs, prawns, zooplanktons etc.)
- Plant resources, (phytoplanktons, sea grass etc.)
- Corals
- Minerals of the continental shelf deposits
- Fuel minerals (petroleum, natural gas)





#### Impact of Anthropogenic Activities on Marine Resources:

- As per Global Biodiversity **Outlook 5 (GBO-5) 2020**
- More than **60 percent** of the world's coral reefs biodiversity are under threat
- 2016 Marine heatwaves across north Australia led to severe bleaching of the Great Barrier Reef, led to mangrove dieoffs in the gulf of Carpentaria
- The proportion of fish stocks fished sustainably is down by 5 percent since 2010

#### **Conservation Measures:**

- **International Blue Carbon Initiative**: mitigating climate change through the conservation and restoration of the coastal and marine ecosystem.
- 'Magical mangroves: join the movement' highlights the significance of mangrove conservation.
- Blue Nature Alliance: It is a global partnership with the aim to advance Ocean Conservation Areas.
- In Southeast Asia: "blue infrastructure development" and approaches such as "building with nature," are being introduced as part of efforts to harmonize coastal protection and development with habitat and ecological protection.

#### ATLANTIC MERIDIONAL OVERTURNING CIRCULATION (AMOC)

- The Atlantic Meridional Overturning Circulation (AMOC) is a large system of ocean currents that carry warm water from the tropics northwards into the North Atlantic.
- The AMOC fluctuates from year to year, as per the data, and these variations are likely to have an impact on the weather.
- If it gets weakened, It would raise sea levels along the US east coast, increase the number and intensity of storms that affect the UK, cause more harsh winters, and increase the number and severity of destructive heatwaves and droughts across Europe.
- **Importance of AMOC:** It is essential for the **redistribution of heat and energy throughout the globe**, as the warm water it transports releases heat into the atmosphere, as well as **collecting and storing atmospheric carbon**.
- AMOC and Indian Weather:
  - **Rising temperatures in the Indian Ocean**, according to recent research, can assist increase the AMOC and prolong its slowing.
  - As the Indian Ocean warms, **it produces more precipitation**, which attracts more air from other regions of the world, including the Atlantic.

#### **Global Overturning Circulation (GOC)**

- Global overturning circulation (GOC) is the equatorward transportation of cold, deep waters and the poleward transportation of warm, near-surface waters.
- **Importance**: It controls ocean heat distribution and atmospheric carbon dioxide levels, thus playing a critical role in global climate.

#### DEEP OCEAN MISSION

The deep ocean is poorly explored due to technological challenges. It is also the least understood region on Earth. Deep Ocean Mission will focus on deep-sea mining technology such as underwater robotics, underwater vehicles, and ocean climate change consulting services, among many other things. first phase of deep ocean mission is of three years (2021-2024).

#### **Ocean Thermal Energy (OTEC)**

- Ocean thermal energy conversion is an electricity generation system.
- Ocean Thermal Energy, also known as Ocean Thermal Energy Conversion (OTEC), refers to using the temperature difference between the deep parts of the sea, which are cold and the shallow parts of the sea, which are cold, to run a heat engine and produce useful work.

#### **DOM's Importance for India:**

- **Exploring EEZ:** India's Exclusive Economic Zone (EEZ) covers 2.2 million square kilometres.Deep Ocean Mission will help to find many valuable marine resources.
- **Exploration of Polymetallic Nodules:** The UN International Sea Bed Authority has given India a 75,000-square-kilometer location in the Central Indian Ocean Basin (CIOB) for the extraction of polymetallic nodules (PMN).
- **Promote Research And Development:** It will help in the development of new technologies and innovation in the sector, ranging from underwater vehicles to underwater robotics, hence strengthening India's standing in the field of ocean research.







- **Boosting Blue Economy:** The Mission will help in the country's overall economic progress by giving a boost to the blue economy.
- **Meet Energy Demands:** Even if only 10% of the energy can be obtained, it would be enough to supply the world's energy needs for the next 100 years.

#### SEABED 2030

Seabed 2030 is a **project between the Nippon Foundation of Japan** and the **General Bathymetric Chart of the Oceans (GEBCO)**. It aims to **bring together all available bathymetric data to produce the definitive map of the world ocean floor by 2030** and make it available to all.

#### The Significance of Ocean Floor Research:

- Understanding ocean circulation
- Strengthen our understanding of marine ecosystems
- Understanding climate
- Empower people all over the world to make policy decisions
- Provides critical inputs for navigation

The temperature, chemistry, currents, and life of the world's seas drive global processes that keep the Earth habitable for humans. The livelihoods of almost three billion people are dependent on marine and coastal biodiversity. As a result, ocean health must be considered as a global issue, and all states must work together to achieve SDG 14: To conserve and sustainably use the oceans, seas, and marine resources for sustainable development.

#### **O-STORMS**

- The Ocean Services, Technology, Observations, Resources, Modelling, and Science (O-STORMS) project is a comprehensive initiative that aims to enhance our understanding of the ocean and its various aspects. It focuses on improving ocean services, advancing technology and observations, assessing ocean resources, developing models, and conducting scientific research.
- The O-STORMS project emphasizes the importance of ocean-related data collection, analysis, and modelling to support decision-making, policy development, and sustainable management of ocean resources.

#### PREVIOUS YEAR QUESTION (MAINS)

Discuss the causes of depletion of mangroves and explain their importance in maintaining coastal ecology.	2019	
How do ocean currents and water masses differ in their impacts on marine life and the coastal environment? Give		
suitable examples?		
Assess the impact of global warming on coral life system with examples.	2019	
What are the consequences of spreading 'Dead Zones' on marine ecosystem?	2018	
Account for variations in oceanic salinity and discuss its multi-dimensional effects.	2017	
How does the cryosphere affect global climate?	2017	
Explain the factors responsible for the origin of ocean currents. How do they influence regional climates, fishing	2015	
and navigation?		
Critically evaluate the various resources of the oceans which can be harnessed to meet the resource crisis in the	2015	
world.		
Major hot deserts in northern hemisphere are located between 20-30 degree north and on the western side of		
the continents. Why?		

#### Student's Note:





#### **4.INDIAN CLIMATE**

- Climate plays a very significant role in the physical environment of human beings. In a country like **India climatic** characteristics do play a dominant role in affecting the economic pattern, way of life, mode of living, food preferences, costumes and even the behavioural responses of the people.
- **Indian climate**: Climate is the aggregate of the atmospheric condition involving heat, Moisture and air movement. The climate of India is described as the 'Tropical type monsoon' indicating the impact of its location in the tropical belt and the monsoon wind.
- Weather patterns: In India, Weather patterns are strongly variable epochal droughts, heat waves, floods, cyclones, and other natural disasters are sporadic, but have displaced or ended millions of human lives. Such climatic events are likely to change in frequency and severity as a consequence of human-induced climate change.
- **Physiography**: Although a sizable part of the country lying north of the Tropic of Cancer falls in the northern temperate zone, the shutting effects of the Himalayas and the existence of the Indian Ocean in the south have played significant roles in giving India a distinctive climatic characteristic.

#### **FACT-WISE**

- **Four seasons**: winter (December to February), summer (March to May), monsoon (June to September), and postmonsoon or autumn (October and November).
- **Extreme temperatures**: Above 50°C in summer in Churu (Rajasthan) and in winter -45°C in Drass (Ladakh).
- **Regional variation**: hot/cold in the north, moderate on the coast, arid in the west, and humid in the northeast.
- **Varying rainfall patterns**: heavy on the western coast, wet in the northeast, Highest rainfall occurs in Cherrapunji (Meghalaya) around 1080 Cm and in Jaisalmer (Rajasthan) records merely above 9 Cm.
- **Cyclones**: Coastal regions prone to cyclones, especially in the Bay of Bengal.

#### CHARACTERISTIC FEATURES OF INDIAN CLIMATE

- **Reversal of winds:** Reversal of wind system with the change of season in a year. During the Winter season, the wind generally blows from the northeast to the southwest direction and in the Summer season, it completely reverses
- **Seasonal and Variation of rainfall:** 80% of annual rainfall is obtained in the latter part of the summer whose duration is from 1.5 months.
- **Diversity of Indian Climate:** These are caused by Differences in the location, altitude, and distance from the sea and General reliefs condition at different places.
- **Impact of High and Low pressure over the land:** Due to the low-temperature high-pressure area is formed and vice versa. E.g.: Intense heating of the land in the summer season to the formation of the thermally induced low-pressure cell over the north-western part of the country.
- **Plurality of seasons:** The Indian climate is characterised by constantly changing weather conditions. There are three main seasons but on broader consideration, their number goes to six a year (winter, fall of winter, spring, summer, rainy and autumn).
- **Characterised by Natural Calamities:** Due to its peculiar weather conditions especially rainfall variability during rainy seasons have made the Indian climate more prone to natural calamities like floods, droughts, famines and even epidemics.
- **Upper Air Circulation:** The southern branch of the Westerly Jet Stream is believed to have a great influence on winter weather conditions in India.
- **Location and Latitudinal extent:** The southern parts of India being closer to the Equator experience high temperatures throughout the year. On the other hand, the northern parts lie in the warm temperate zone, hence experiencing low temperatures, particularly in winter.

However, due to the various factors explained above, the **climate of India has many regional variations** expressed in the pattern of winds, temperature and rainfall, rhythm of seasons, the degree of wetness or dryness etc. These regional diversities may be described as sub-types of monsoon climate.

#### **PW-ONLYIAS EDGE: KEY PHRASES FOR MAINS**

Weather patterns; Sea level rise; Reversal of winds; Seasonal and Variation of rainfall; Diversity of Indian Climate; Plurality of seasons; Surface pressure and wind; Jet stream and upper air circulation; Western Cyclonic Disturbance and Tropical Cyclones; Impact of High and Low pressure over the land; Distances from the Sea – Continentality; Distribution of air pressure and winds; Inflow of western cyclones.

#### FACTORS DETERMINING THE CLIMATE OF INDIA

• Factors Related to Location and Relief Latitude:



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- **Distribution of Land and Water:** As compared to the landmass, water heats up or cools down slowly. This differential heating of land and sea creates different air pressure zones in different seasons in and around the Indian subcontinent.
- **Distances 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.
  - E.g. The Konkan coast has moderate temperatures but Kanpur and Amritsar are affected by extreme temperatures.
- **Altitude:** Temperature decreases with height, as air ascends it loses its temperature due to the Normal Lapse Rate.
- **Relief:** The physiography or relief of India also affects the temperature, air pressure, direction and speed of the wind and the amount and distribution of rainfall.
- Factors Related to Air Pressure and Wind:
  - **Air Pressure and Wind Distribution:** Air pressure and wind patterns are influenced by temperature, elevation, and Earth's rotation, resulting in airflow from high to low pressure.
  - **Upper Air Circulation:** Upper-level wind patterns, known as jet streams, play a crucial role in redistributing heat and moisture across the planet.
  - **Inflow of Different Air Masses:** Distinct air masses influence different regions based on temperature and moisture, with India experiencing western cyclones in winter and tropical depressions during the southwest monsoon, leading to favourable rainfall conditions.
  - **Western Cyclones and Disturbances:** India experiences winter western cyclones that bring disturbances and impact weather conditions, including rainfall, in specific regions.
  - **Tropical Depressions during the Southwest Monsoon:** The southwest monsoon in India involves the inflow of tropical depressions developing over the Indian Ocean's warm waters, contributing to widespread monsoon rainfall.
- So, these factors have different mechanisms with reference to the winter and summer season of the year separately:
  - 1. Weather conditions in winter season
  - 2. The weather conditions in the summer season

#### WEATHER CONDITION IN THE WINTER SEASON

Surface pressure and wind	<ul> <li>During Winter, a High-pressure area is built in Central and West Asia which gives rise to the flow of air at the low level from the north towards the Indian subcontinent.</li> <li>These continental winds come in contact with trade winds over north-western India.</li> <li>Now, the contact zone is not stable thus bringing the entire North-western India under the influence of the North-Westerly winds</li> </ul>
Jet stream and upper air circulation	<ul> <li>During the winter season, the upper air westerly jet streams are positioned in Asia.</li> <li>These are bifurcated into two branches due to the Tibetan Himalayan obstruction. The north branch blows north of the Himalayas and the Tibetan Plateau.</li> <li>The southern branch blows south of the mighty mountains. In winter the subtropical westerly jet stream brings rain to the western part of India.</li> </ul>
Western Cyclonic Disturbance and Tropical Cyclones	<ul> <li>The western cyclonic disturbances are weather phenomena of the winter months brought in by the Westerly flow from the Mediterranean region.</li> <li>They usually influence the weather of the north and north-western regions of India. It brings little rain in the winter month which is good for the wheat crops.</li> <li>Tropical cyclones occur during the monsoon as well as in October -November, and are part of the easterly flow.</li> <li>These disturbances affect the coastal regions of the country. These tropical cyclones have very high wind velocity and heavy rainfall and hit the Tamil Nadu, Andhra Pradesh and Orissa coasts.</li> </ul>

#### WEATHER CONDITIONS IN THE SUMMER SEASON

	•	In summer, Sun shifts northward then wind circulation over the sub-continent undergoes a
Surface pressure		complete reversal at both.
and wind	•	This is caused by a Low-pressure belt nearer the surface, Termed an ITCZ (InterTropical
		convergence Zone) shifting north-words in the month of July.





	• So, this time, the westerly jet stream withdrew from the Indian region.
Jet stream and upper air circulation	<ul> <li>An easterly jet stream flows over the southern part of the Peninsula in June, and has a maximum speed of 90 km per hour In August; it is confined to 15 Degree North latitude, and in September up to 22 Degree North latitudes.</li> <li>The easterlies normally do not extend to the north of 30 Degree North latitude in the upper atmosphere.</li> </ul>
Western cyclonic disturbance and Tropical cyclone	<ul> <li>The easterly jet stream steers the tropical depressions into India. These depressions play a significant role in the distribution of monsoon rainfall over the Indian subcontinent.</li> <li>The tracks of these depressions are the areas of highest rainfall in India.</li> <li>The frequency at which these depressions visit India, their direction and intensity, all go a long way in determining the rainfall pattern during the southwest monsoon period.</li> </ul>

#### INDIAN MONSOON

- The term monsoon is derived from the **Arabic word 'Mausam' meaning 'season'**. It is characterized by seasonal reversal of wind direction at regular intervals.
- Although the monsoon is a global phenomenon influenced by a variety of factors not yet completely understood, the real monsoon rains cover mainly the South Asian region, represented by India, Myanmar, Sri Lanka, Bangladesh, Bhutan and parts of Southeast Asia.
- The Indian monsoon is a **significant climatic phenomenon** that brings seasonal rainfall to the Indian subcontinent.
- It plays a vital role in shaping the country's agriculture, economy, and overall livelihoods.
- The monsoon is characterized by its arrival, duration, intensity, and distribution, making it a topic of great importance and interest in India and beyond.

#### THERMAL CONCEPT OF INDIAN MONSOON

- According to this Thermal theory (Halley's Theory of Origin of Monsoon), the differential heating of land and sea at the time when the sun makes an apparent northward movement is the main cause of the Indian monsoonal regime.
- Two factors are mainly responsible for this very strong development of monsoons:
  - 1. Vast size of the Indian subcontinent and adjacent seas.
  - 2. Very high and extensive mountain systems of the Himalayas.

#### **MECHANISM OF HALLEY'S THEORY OF ORIGIN OF MONSOON**

- According to Halley's theory of the origin of the monsoon, the mechanism can be explained as follows:
  - **Thermal Concept:** After the Vernal Equinox, around March 22, the sun's apparent northward shift begins. This leads to increased solar radiation in the northern hemisphere, particularly in the tropics and subtropics.
  - **Intense Heating:** The Indian subcontinent, including the vast northern plains and adjacent highlands, experiences intense heating due to the high incidence of solar radiation. This heating results in the formation of a large low-pressure belt.
  - **Massive Low-Pressure Belt:** The low-pressure belt stretches from the Punjab plains in the northwest to the Bengal delta in the east. This low pressure acts as a magnet, drawing in air masses from the surrounding areas to fill the void.
  - **Air Mass Inflow:** The low-pressure system triggers the inflow of moisture-laden air masses from the Indian Ocean and the Arabian Sea, leading to the onset of the monsoon season in the Indian subcontinent.

#### ORIGIN OF INDIAN MONSOON

Indian Monsoon depends on the Differential heating of sea and land but alone it can't produce the Monsoon circulation. Apart from this, it depends on the Following Concept:

#### **ROLE OF JET STREAM:**

- **Sub-Tropical Jet Stream:** The Sub-Tropical Jet stream, located in the upper troposphere, can hinder the northward movement of monsoon winds during the pre-monsoon period. As it weakens and shifts northward, it creates favourable conditions for the monsoon onset, aiding the quick arrival of monsoon rains.
- **Tropical Easterly Stream:** The southwest monsoon is associated with the tropical easterly stream, which flows from east to west between 8 degrees and 35 degrees North latitudes.
  - This stream guides tropical depressions from the Bay of Bengal and the Arabian Sea towards India, contributing to monsoon rainfall.
  - The tracks of these depressions correspond to regions of high rainfall.
- **Subtropical Westerly Jet Stream:** During the winter monsoon, known as the northeast monsoon, the subtropical westerly Jet Stream influences weather conditions.





 It blows between 20 degrees and 35 degrees North latitudes, bringing western cyclonic disturbances originating from the Mediterranean Sea into India. These disturbances play a role in winter rainfall patterns across the country.

#### **ROLE OF HIMALAYA AND TIBET PLATEAUS:**

- The heating of these areas initiates the monsoon circulation, with clockwise air circulation in the middle troposphere.
- **Two wind streams originate from here:** one becomes the tropical easterly jet stream (TEJ) and the other forms the westerly jet stream over Central Asia.

#### **ROLE OF EL NINO/SOUTHERN OSCILLATION:**

- El Niño/Southern Oscillation (ENSO) refers to large-scale changes in sea-surface temperature across the eastern tropical Pacific, impacting global climate patterns.
- ENSO events have significant implications for the weather patterns and monsoon conditions in India, with El Niño associated with adverse effects on the monsoon and La Niña often leading to improved monsoon conditions.
- Impact on the Indian monsoon:
  - **El Niño:** During winter, El Niño brings warm conditions to the Indian subcontinent, while during summer, it leads to dry conditions and deficient monsoon rainfall.
  - **La Niña:** La Niña typically results in better than normal monsoon rainfall in India.

#### **ROLE OF WALKER CIRCULATION:**

- **Difference in Pressure and Temperature:** The Walker circulation is driven by variations in surface pressure and temperature between the western and eastern tropical Pacific Ocean.
- **Indian Ocean:** In the Indian Ocean region, there is a high-pressure zone where air descends. Surface winds blow as the southwest monsoon towards the Indian subcontinent during summer.
- **Impact on La Niña:** During La Niña, the Indian Ocean branch of the Walker cell strengthens, leading to more intense surface winds. This condition is generally associated with a good monsoon in India.
- **Impact on El Niño:** During El Niño or negative Southern Oscillation Index (SOI), the surface winds or southwest monsoon winds are weaker than normal conditions.

#### JET STREAMS

- Jet streams are powerful, fast-moving air currents located in the upper troposphere and lower stratosphere, typically at altitudes between 10 and 15 kilometres (6 to 9 miles).
- They are characterized by strong winds that blow predominantly from west to east.
- Jet streams form due to the differential heating of the Earth's surface, especially at the boundaries of adjacent air masses with significant temperature differences.
- Several factors influence the flow of jet streams:
  - **Landmasses:** Landmasses disrupt the jet stream flow due to friction and temperature variations, while Earth's rotation amplifies these effects, leading to meandering jet stream patterns. This interaction generates fluctuations and temperature contrasts within the jet stream.
  - **Coriolis Effect:** It deflects moving air masses to the right in the Northern Hemisphere and to the left in the Southern Hemisphere, leading to the curved trajectory of the jet stream.

#### • Jet streams have several characteristic features:

- **Circulation and Trajectory:** Jet streams flow from west to east, influenced by Earth's rotation, and are commonly found between the poles and 20 degrees latitude in both hemispheres, encircling the globe.
  - Their trajectory is characterized by a meandering and wavy pattern, shaped by atmospheric conditions.
     Wind Speed: Jet streams exhibit high wind speeds, averaging around 120 km/h (75 mph) in winter and 50 km/h
- (30 mph) in summer, with maximum velocities typically occurring in the crest and trough of the jet stream.
- **Seasonal Shifts:** The jet stream position varies with seasons, flowing along the southern slopes of the Himalayas in winter and shifting northwards in summer, influenced by land and ocean heating.
- There are two main types of jet streams:
  - 1. **Subtropical Jet streams:** Subtropical jet streams are located to the north of the subtropical high-pressure belt in both hemispheres, typically above 30 to 35 degrees latitude.
    - They have a more regular circulation from west to east and are produced by the rotation of the Earth.
  - 2. **Mid-Latitude or Polar Front Jet Stream:** Mid-latitude or polar front jet streams form above the convergence zone of polar cold air masses and tropical warm air masses, typically between 40 and 60 degrees latitude.
    - These jet streams move in an easterly direction and have a more variable position than subtropical jet streams due to the dynamic nature of the polar front.



#### NATURE AND IMPORTANT ASPECTS OF MONSOON

- Systematic studies of rainfall in the South Asian region provide insights into various aspects of the monsoon, including:
  - 1. Onset of the monsoon
  - 2. Rain-bearing systems
  - 3. Break in the monsoon
  - 4. Retreat of the monsoon

#### **ONSET OF THE MONSOON:**

- The onset of the monsoon in India is influenced by several factors, including:
  - **Differential heating of land and sea:** During the summer months, the differential heating of land and sea leads to the formation of intense low pressure over the north-western part of the subcontinent.
    - This attracts the southeast trade winds across the equator, setting the stage for the onset of the monsoon.
  - **Shift in the position of the Inter-Tropical Convergence Zone (ITCZ):** The shift in the position of the ITCZ is related to the withdrawal of the westerly jet stream and the emergence of the easterly jet stream. These jet streams play a crucial role in the burst of the monsoon in India.
- Factors that influence the onset of the Southwest Monsoon include:
  - **Low-pressure belt systems:** The presence of low-pressure areas or depressions in the Bay of Bengal and the Arabian Sea during the last days of May or the beginning of June. These systems contribute to the onset of the monsoon over the mainland.
  - **Cyclonic vortex:** The formation of cyclonic vortices in the Southeast Arabian Sea, off the Kerala and Lakshadweep region. These vortices can shift along the west coast and aid in pushing the monsoon current.
  - **Trough formation:** The formation of a trough off the west coast due to temperature differences between land and sea. This situation can contribute to a mild start and weak progress of the monsoon.
  - **Cross-equatorial winds:** The occurrence of cross-equatorial flow, where trade winds from the Southern Hemisphere cross over to the Northern Hemisphere. This can bring a strong monsoon surge towards the Indian mainland.
- Understanding these factors and their interactions is crucial for predicting the onset and progression of the monsoon, helping to inform agricultural practices, water management, and overall preparedness for the monsoon season.

#### **RAIN-BEARING SYSTEMS:**

- The southwest monsoon splits into two branches, the Arabian Sea Branch and the Bay of Bengal Branch near the southernmost end of the Indian Peninsula.
  - 1. The Arabian Sea branch:
    - $\circ$   $\,$  The Arabian Sea branch of the southwest monsoons is divided into three distinct streams on arriving in the mainland of India.
    - **The first stream** strikes the west coast of India and gives extremely heavy rainfall of over 250 cm. It strikes perpendicular to the Western Ghats causing plentiful Orographic Rainfall (400 to 500 cm annual rainfall on the windward side). Rainfall is drastically reduced to about 30-50 cm on the leeward side of the crest.
    - **The second stream** enters the Narmada Tapi troughs (narrow rift valley) and reaches central India.
    - The third stream moves parallel to the Aravalli Range without causing much rainfall.

#### 2. The Bay of Bengal Branch:

- The Bay of Bengal Branch of the southwest monsoon is divided into two distinct streams.
- **The first stream** crosses the Ganga Brahmaputra delta and reaches Meghalaya. Here the orographic effect results in intense rainfall. Cherrapunji receives an annual rainfall of 1,102 cm, and Mawsynram, records higher yearly rainfall of 1,221 cm.
- **The second stream** of the Bay of Bengal branch moves along Himalayan foothills as they are deflected to the west by the Himalayas and brings widespread rainfall to Ganga plain.

#### **BREAK IN THE MONSOON:**

• During the southwest monsoon period after having rained for a few days, if rain fails to occur for one or more weeks, it is known as a break in the monsoon. These dry spells are quite common during the rainy season.

#### **RETREAT IN MONSOON:**

• In simple words, retreating means withdrawal. So, the withdrawal of southwest monsoon winds from the skies of north India during the months of October and November is known as the retreating monsoon. The withdrawal is gradual and takes about three months.



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#### INDIAN OCEAN DIPOLE (IOD) AND INDIAN MONSOON

- The Indian Ocean Dipole (IOD) is a **climate phenomenon characterized by the difference in sea surface temperature between the eastern (Bay of Bengal) and western (Arabian Sea) regions of the Indian Ocean.**
- The Indian Ocean Dipole (IOD) has a significant impact on the Indian monsoon, influencing the distribution and intensity of rainfall across the Indian subcontinent.
- The positive and negative phases of the IOD can have contrasting effects on the monsoon rainfall patterns.

Positive IOD	• During a positive IOD phase, with warmer sea surface temperatures in the western Indian Ocean and cooler temperatures in the eastern Indian Ocean, the monsoon rainfall in India tends to increase.
	• The positive IOD enhances the atmospheric conditions favorable for monsoon circulation, leading to enhanced moisture transport and increased rainfall over central India.
	• It has been observed that central parts of India receive more rainfall than usual during positive IOD
	years.
	The positive IOD phase is associated with above-average monsoon rainfall in these regions.
	• In contrast, during a negative IOD phase, when the temperature gradient is reversed, with cooler sea
Negative IOD	surface temperatures in the western Indian Ocean and warmer temperatures in the eastern Indian
	Ocean, the monsoon rainfall in India can be adversely affected.
	• The negative IOD can hinder the progress of the monsoon over India, resulting in weaker and delayed rainfall.
	• It can contribute to drought conditions in some parts of the country, particularly in the central and
	eastern regions.
	• The negative IOD phase is associated with below-average monsoon rainfall in these areas

#### EL-NIÑO AND INDIAN MONSOON

- El Niño is a climate phenomenon that occurs in the tropical Pacific Ocean and has a significant impact on the Indian monsoon.
- El Niño is **characterized by the warming of the central and eastern tropical Pacific Ocean**, which influences atmospheric circulation patterns worldwide.
- The influence of El Niño on the Indian monsoon can vary depending on the strength and duration of the event.
  - Here are some key points regarding the relationship between El Niño and the Indian monsoon:
    - **Weakened Monsoon:** El Niño leads to a weaker Indian monsoon as it disrupts atmospheric circulation, affecting the cross-equatorial flow and reducing moisture supply, resulting in decreased rainfall in the Indian subcontinent.
    - **Delayed Onset:** El Niño conditions can cause a delayed onset of the monsoon, impacting agriculture, water resources, and other sectors reliant on timely monsoon rainfall.
    - Spatial Variability: El Niño impacts on the Indian subcontinent are regionally variable, with central and northern parts of India particularly susceptible to below-normal rainfall and drought conditions during El Niño years.
    - Regional Impacts: El Niño can disrupt the distribution of rainfall in India, leading to regional variations such as increased rainfall deficits in some areas and localized flooding in others, influenced by the strength of the El Niño event and regional atmospheric conditions.

#### LA-LINA AND INDIAN MONSOON

- La Niña is the **large-scale cooling of ocean surface temperatures in the central and eastern equatorial Pacific Ocean**, together with changes in the tropical atmospheric circulation, namely winds, pressure and rainfall.
- Impact on Monsoon:
  - **More Rainfall:** While La Niña conditions enhance the rainfall associated with the Southwest monsoon, it has a negative impact on rainfall associated with the Northeast monsoon.
  - **Cyclone Formation:** During La Niña years, the synoptic systems low pressure or cyclones formed in the Bay of Bengal remain significantly to the north of their normal position.
  - **Less Rainfall:** Besides, instead of moving westwards, these systems recurve. As they lie to the north of their normal position, not much rainfall occurs over southern regions like Tamil Nadu.

#### NO CYCLONES DURING MAIN MONSOON MONTHS LIKE JULY AND AUGUST

- Favourable conditions for tropical cyclones:
  - Warm Ocean waters (of at least 26.5°C throughout sufficient depth at least on the order of 50 m).
    - Relatively moist layers near the height of 5 km.


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- Non- negligible amount of Coriolis force pre-existing near-surface disturbance.
- Low values of vertical wind shear between the surface and upper troposphere.
- **Surface winds:** In July and August winds on the surface are westerly/south-westerly to the south of the monsoon trough and south-easterly/ easterly to its north and are generally stronger over the seas than the Land areas.
- **Upper-Air circulation:** The upper-level winds exhibit a westerly/south-westerly direction to the south and a southeasterly/easterly direction to the north of the trough region, with increasing speeds at higher levels. Westerly winds reach a maximum speed of 20-25 knots, while easterly winds strengthen significantly with height, reaching speeds of 60-80 knots over the Indian peninsula.
- Wind shear: This results in high values of vertical wind shear which is unfavourable for Tropical cyclogenesis. So, we don't get cyclones during the main monsoon months like July and August.

# IMPACT OF CYCLONES/ ANTI-CYCLONES ON MONSOON

- The Indian monsoon may experience further delays and weakening due to the presence of an anticyclone in the Arabian Sea, a cyclone in the Indian Ocean, and a powerful typhoon in the Pacific Ocean.
- The anticyclone and typhoon can hinder the flow of monsoon winds towards the mainland, potentially impacting rainfall distribution and causing delays in the monsoon onset.
- However, the Indian Meteorological Department has rejected these speculations and stated that the impact of these oceanic activities on the monsoon is not scientifically supported.
- The condition of El Niño is also a factor that could affect the monsoon, although its impact is deemed to be insignificant by the IMD.
- The possibility of a weaker and delayed monsoon has already shown its impact on early crop sowing, with a decrease in rice acreage.

### INDIAN CLIMATE – SEASONS

- The climatic conditions of India can best be described in terms of an annual cycle of seasons. The meteorologists recognise the following **four seasons**:
  - 1. The cold weather season
  - 2. The hot weather season
  - 3. The southwest monsoon season
  - 4. The retreating monsoon season.
- Seasons are a special feature of the Indian climate. Temperature, pressure, wind direction and the amount and duration of rain vary from one season to the other. Meteorologists identify four seasons in India.

### THE COLD WEATHER SEASON

- **Duration:** Mid-November to February
- **General Characteristic:** Clear sky, pleasant weather, low temperature, low humidity, high range of temperature, cool and slow north-east trade winds.
- **Temperature:** The diurnal range of temperature, especially in interior parts of the country, is very high. The isotherm of 20°C runs roughly parallel to the Tropic of Cancer. Some parts of Kerala and Tamil Nadu typically experience temperatures near 30°C. The mean minimum temperature is about 5°C over north-west India and 10°C over the Gangetic plains.
- Wind Disturbance: High pressure over north-western India. Winds blow from northwest to southeast. Around four or five westerly Disturbances are carried by westerly jet streams.
- **Rainfall:** The retreating winter monsoons pick up some moisture while crossing the Bay of Bengal and cause winter rainfall in Tamil Nadu, south Andhra Pradesh, south-east Karnataka and south-east Kerala (Usually in the first weeks of November). The western disturbances also cause a little rainfall in northwest India

# THE HOT WEATHER SEASON

- **Duration:** April, May, June
- **General Characteristic:** High temperature and low humidity are the chief characteristics. Also seen as a Dust storm and dryness.
- **Temperature:** In March, the highest temperatures occur in the southern parts (40-45°C). In April the highest temperature of about 45°C is recorded in the northern parts of Madhya Pradesh. In May the highest temperature shifts to Rajasthan where temperatures as high as 48°C may be recorded. The diurnal range of temperature is also very high. It may be as high as 18°C in some parts.
- Wind Disturbance: Low pressure over the northwestern part of India and high pressure over the southern parts of the Bay of Bengal. ITCZ shifts to the Ganges Plain. Wind direction varies from one part of India to the other. Dust storms are frequently experienced in the afternoon in the northern plains.





• **Rainfall:** Completely dry Season. Dust storms and thunderstorms provide some rainfall. Eastern regions receive more rainfall comparatively.

### THE SOUTHWEST MONSOON SEASON

### • **Duration:** June – September

- **General Characteristic:** South West Monsoon Season is also known as the hot-wet season. Sudden onset is an important feature of South West Monsoons. With the onset of monsoons, the temperature falls drastically and humidity levels rise.
- **Temperature:** Sudden onset of South West Monsoons leads to a significant fall in temperature (3° to 6°C). The temperature remains less uniform throughout the rainy season. The temperature rises in September with the cease of southwest monsoons. Other parts of Northwest India also have temperatures above 30°C
- Wind Disturbance: Over the peninsular region, due to the pressure gradient between north and south, winds blow in a southwest to northeast direction from the Arabian Sea and the Bay of Bengal. Their direction undergoes a change in the Indo-Gangetic plain where they move from east to west.
- **Rainfall**: The average rainfall over the plains of India in this season is about 87 per cent. The advance of the monsoon is much faster in the Bay of Bengal than in the Arabian Sea. The monsoons advance quickly accompanied by a lot of thunder, lightning and heavy downpour. This sudden onset of rain is termed a monsoon burst.

### THE RETREATING MONSOON SEASON

- **Duration:** October November
- General Characteristic: Monsoon winds are retreating gradually and suddenly rise in temperature with October heat.
- **Temperature:** With the retreat of the monsoons, the clouds disappear and the sky becomes clear. The day temperature starts falling steeply. The diurnal range of temperature increases due to the lack of cloud cover.
- Wind Disturbance: As the monsoons retreat, the monsoon trough weakens and gradually shifts southward. Consequently, the pressure gradient is low. Unlike the southwest monsoon, the onset of the north monsoon is not clearly defined. The direction of winds over large parts of the country is influenced by the local pressure conditions.
- **Rainfall:** October-November is the main rainy season in Tamil Nadu and adjoining areas of Andhra Pradesh to the south of the Krishna Delta as well as a secondary rainy period for Kerala. The retreating monsoons absorb moisture while passing over the Bay of Bengal and cause this rainfall.

# DISTRIBUTION OF RAINFALL

- The distribution of rainfall in any region is **mostly influenced by the relief features on the surface of the Earth and the direction of the rain-bearing winds in that region**.
- Another important factor which influences the distribution of annual rainfall in India is the path followed by the cyclonic depressions.
- The region located on the windward side of mountains, hills or plateaus receives comparatively more rainfall than the leeward side.

# PATTERN AND DISTRIBUTION OF RAINFALL

- **Rainfall patterns:** As we move from Meghalaya to Haryana or Punjab in the Northern plains, the rainfall decreases and In peninsular India, rainfall decreases from coast to interior parts similarly in North-East India, the rainfall increases with altitude.
- **High Rainfall:** High rainfall (above 200 cms) in India occurs in the western coast, sub-Himalayan regions of north-east and Garo, Khasi and Jaintia hills of Meghalaya
- **Moderate Rainfall (100-200cm):** It occurs in some parts of the Western Ghats, West Bengal, Odisha and Bihar and many states.
- Low rainfall (60 to 100cm): It occurs in parts of Uttar Pradesh, Rajasthan, and the interior Deccan plateau.
- **Inadequate rainfall (Less than 60cm):** Occurs in the western part of Rajasthan and Gujarat, Ladakh and the south-central part receives rainfall of less than 20cm.

# FACTORS DETERMINING THE DISTRIBUTION OF RAINFALL

- **Direction of Moisture laden winds:** Due to the Arabian Sea Branch blowing corresponding to the Aravalli Hills, Rajasthan gets inadequate rainfall.
- **Cyclic depression determined by Pressure gradient:** Cyclonic depressions that arise over the Andaman Sea and usually cross India's eastern coasts cause heavy and widespread rain in the Godavari, Krishna, and Kaveri deltas, as well as the coasts of Odisha and West Bengal.
- **Direction of Relief features:** The Western Ghats get a lot of moisture. As the Arabian Sea branch of the South West monsoon strikes the Western Ghats, moisture-laden winds trigger very strong rainfall. Because of its relief, Mawsynram receives more rain. The Bay of Bengal part of the South-West monsoon brings rain here.





• Inter-Topical Convergence Zone (ITCZ): During the monsoon season, it is also known as the monsoon trough. The trough and its axis continue to troll northward or southward, determining the rainfall distribution.

# CHANGING RAINFALL PATTERN IN THE COUNTRY

**India Meteorological Department (IMD)** has carried out an analysis of observed monsoon rainfall variability and changes in 28 States & 8 Union Territory at State and District levels based on the IMD's observational data of recent 30 years (1989- 2018) during the Southwest monsoon season from June-July-August-September (JJAS).

#### The highlights of the report are as follows:

- **Decrease in Rainfall:** Five states viz., Uttar Pradesh, Bihar, West Bengal, Meghalaya and Nagaland have shown significant decreasing trends in southwest monsoon rainfall during the recent 30 years period (1989-2018).
- **State-wise pattern:** The annual rainfall over these five states along with the states of Arunachal Pradesh and Himachal Pradesh also show significant decreasing trends. Other states do not show any significant changes in southwest monsoon rainfall during the same period.
- **District-wise pattern:** Considering district-wise rainfall, there are many districts in the country, which show significant changes in southwest monsoon and annual rainfall during the recent 30 years period (1989-2018).
- Increase in Rainfall: With regard to the frequency of heavy rainfall days, a significant increasing trend is observed over Saurashtra & Kutch, South-eastern parts of Rajasthan, Northern parts of Tamil Nadu, Northern parts of Andhra Pradesh and adjoining areas of Southwest Odisha, many parts of Chhattisgarh, Southwest Madhya Pradesh, West Bengal, Manipur & Mizoram, Konkan & Goa and Uttarakhand.

#### KOEPPEN'S CLASSIFICATION OF CLIMATIC REGIONS OF INDIA

- Koeppen identified a close relationship between the distribution of vegetation and climate. Koeppen's Classification of Climatic Regions of India is an empirical classification based on mean annual and mean monthly temperature and precipitation data.
- Koppen climatic groups are subdivided into types, designated by small letters, based on the seasonality of precipitation and temperature characteristics.
- Climate Classification and Climate Region are as follows:
  - **Monsoon type with the short dry season (Amw):** The western coastal region south of Goa experiences this type of climate.
  - **Monsoon type with dry season in summers (AS):** The region of this type of climate extends along the Coromandel coast.
  - **Tropical Savanna type (Aw):** Almost the entire peninsular region except for some coastal parts experiences this type of climate.
  - **Semi-arid steppe climate (BShw):** This climatic region includes the interior parts of the peninsular plateau and some parts of Gujarat, Rajasthan, Haryana, Punjab and Jammu & Kashmir.
  - **Hot desert type (BWhw):** This type of climate is found only in the western part of Rajasthan.
  - Monsoon type with dry winters (Cwg): Largely Northern plains of India experience this type of climate.
  - **Cold-humid winter type with short summer (Dfc):** This climate is characterized by a short summer season. This region covers the northeastern parts of India.
  - **Polar type (E):** This type of climate is experienced in Jammu & Kashmir and the neighbouring mountain ranges.

### MONSOON AND ECONOMIC LIFE OF INDIA

- **Livelihood:** Monsoon is the axis around which revolves the entire agricultural cycle of India. It is because about 64 per cent people of India depend on agriculture for their livelihood and agriculture itself is based on southwest monsoon.
- **Crop production:** Except the Himalayas all the parts of the country have temperatures above the threshold level to grow the crops or plants throughout the year.Regional variations in monsoon climate help in growing various types of crops.
- Uneven Rainfall: Variability of rainfall brings droughts or floods every year in some parts of the country.







- **Agriculture:** Agricultural prosperity in India depends very much on timely and adequately distributed rainfall. If it fails, agriculture is adversely affected particularly in those regions where means of irrigation are not developed.
- Benefits to crops: Winter rainfall by temperate cyclones in north India is highly beneficial for rabi crops.
- **Climatic variation:** Diverse Regional climatic variation in India is reflected in the vast variety of food, clothes and house types.

# MONSOON MISSION

Launched	•	Ministry of Earth Sciences	
Year	٠	2012	
Objectives	•	Improvement of seasonal and intra-seasonal monsoon forecast.	
	٠	Improvement of the medium-range forecast.	
	•	Develop a seamless prediction system for monsoon forecasting on multiple time scales: seasonal (entire	
monsoon season), extended range (up to 4 weeks), and short-range (up to 5 days)		monsoon season), extended range (up to 4 weeks), and short-range (up to 5 days).	
	٠	Establish collaborations between Indian and foreign institutes to build a prediction system for extreme	
Targetsweather events and climate applications.		weather events and climate applications.	
	٠	Create and implement a climate application system with social impacts, including agriculture, flood	
		forecasting, extreme event predictions, and wind energy.	
	•	Design an advanced data assimilation system to ensure high-quality data for accurate model predictions.	

# ASSESSMENT OF CLIMATE CHANGE OVER THE INDIAN REGION: A REPORT OF THE MINISTRY OF EARTH SCIENCES (MOES), GOVERNMENT OF INDIA

- **Temperature Rise Over India:** India has experienced a temperature rise of 0.7°C from 1901 to 2018, and it is projected to increase by 4.4°C by the end of the twenty-first-century relative to the recent past.
- **Indian Ocean Warming:** The sea surface temperature of the tropical Indian Ocean has risen by 1°C on average during 1951–2015, markedly higher than the global average SST warming of 0.7°C, over the same period.
- **Changes in Rainfall:** The summer monsoon precipitation (June to September) over India has declined by around 6% from 1951 to 2015, with notable decreases over the Indo-Gangetic Plains and the Western Ghats.
- **Increase in droughts:** The overall decrease of seasonal summer monsoon rainfall during the last 6–7 decades has led to an increased propensity for droughts over India. Both the frequency and spatial extent of droughts have increased significantly during 1951–2016.
- **Sea Level Rise:** Sea-level rise in the North Indian Ocean (NIO) occurred at a rate of 1.06–1.75 mm per year during 1874–2004 and has accelerated to 3.3 mm per year in the last two and a half decades (1993–2017), which is comparable to the current rate of global mean sea-level rise.
- **Frequency of Cyclones:** There has been a significant reduction in the annual frequency of tropical cyclones over the NIO basin since the middle of the twentieth century (1951–2018).
- **Changes in the Himalayas:** The Hindu Kush Himalayas (HKH) experienced a temperature rise of about 1.3°C during 1951–2014 also Several areas of HKH have experienced a declining trend in snowfall.

### CONCLUSION

• The climate of India is undergoing significant changes, with rising temperatures, warming of the Indian Ocean, changes in rainfall patterns, increased drought frequency, sea-level rise, and shifting cyclone patterns. These changes are largely attributed to human-induced factors, such as greenhouse gas emissions and aerosol forcing. It is crucial for India to continue monitoring and studying these changes to better understand their impacts and develop strategies for adaptation and mitigation to ensure the sustainability and resilience of the country's ecosystems, economy, and society in the face of climate change.

### PREVIOUS YEAR QUESTION (MAINS)

- 1. Why is the Indian Regional Navigational Satellite System (IRNSS) needed? How does it help in navigation? (2018)
- 2. What characteristics can be assigned to monsoon climate that succeeds in feeding more than 50 per cent of the won population residing in Monsoon Asia? (2017)
- 3. In spite of adverse environmental impact, coal mining is still inevitable for development." Discuss (2017)
- 4. How far do you agree that the behaviour of the Indian monsoon has been changing due to humanizing landscapes? Discuss. (2015)
- 5. The recent cyclone on the east coast of India was called "Phailin". How are the tropical cyclones named across the world? (2013)
- 6. There is no formation of deltas by rivers of the Western Ghat. Why? (2013)





TELEGRAM | WEBSITE

# **5.POPULATION AND MIGRATION IN INDIA**

- WHO defines population as all the inhabitants of a country, territory, or geographic area, total or for a given sex and/or age group, at a specific point in time.
- In demographic terms, it is the total number of inhabitants of a given sex and/or age group that live within the border limits of the country, territory, or geographic area at a specific point of time, usually mid-year. The mid-year population refers to the actual population on July 1st.
- A country's population makes up the building blocks of the nation. Human hands and the human brain are the most effective instruments to shape the future of the nation.

### **POPULATION: FACT-WISE**

- **Total Population**: According to the census 2011 it was 1.21 billion which reached 1.41 Billion as reported by UN data. India holds 17.7% of the total world population with only 2.4% of the total World surface.
- Population growth Rate: 0.97% as of 2020 according to the latest reports.
- Sex Ratio: According to Census 2011 it was 943 which decreased to 907 in 2018-20.
- **Population Density**: According to Census 2011 it was 382.
- Rural-Urban Population: According Census 2011 Rural-69%, Urban- 31%.

### SIGNIFICANCE OF POPULATION STUDIES

- Economic:
  - **Labour Force Analysis:** Population studies help in analyzing the size, composition, and skill levels of the labour force.
  - **Market Analysis:** Population studies provide insights into consumer behaviour, purchasing power, and market potential.
- Social:
  - **Social Welfare Planning:** Population studies contribute to social welfare planning by identifying vulnerable groups, such as children, the elderly, and low-income populations.
  - **Family Planning and Reproductive Health:** By understanding fertility rates, contraceptive usage, and reproductive health indicators, policymakers can develop effective strategies to promote reproductive health, reduce maternal and infant mortality, and ensure the well-being of families.
- Political:
  - **Electoral Representation:** The population data helps in the delimitation of constituencies, ensuring that political power is distributed proportionally and that each citizen's voice is adequately represented.
  - **Policy Formulation:** Population studies provide a foundation for evidence-based policy formulation. Governments rely on population data to understand the needs, aspirations, and priorities of different demographic groups.
- Administrative:
  - **Infrastructure Planning:** By assessing population density, distribution, and growth patterns, policymakers can determine the demand for transportation networks, housing, utilities, and other essential services.
  - **Resource Allocation:** Population studies guide administrative decisions regarding resource allocation.

### **PW-ONLYIAS EDGE: KEY PHRASES FOR MAINS**

Crude literacy rate; Effective literacy rate; Human Productivity; Demographic Dividend; Demographic disaster; Demographic Bulge; Financial inclusion; Inclusive growth; Online Fraud; Up-skilling; Digital divide; Digital inequality; 5C approach for Financial Literacy: Content + Capacity + Community + Communication + Collaboration.

### TRENDS IN POPULATION GROWTH

Period of Stagnant	High birth rate counterbalanced by high death rate. The Census of 1921 recorded a negative	
Population (1901-1921)	growth rate hence the year 1921 is called the year of the 'Demographic Divide'.	
Period of steady growth	The high birth rate continued. The mortality rate started showing a downward trend due to	
(1921-1951)	improvements in health and sanitation conditions along with a developed distribution	
	system. Hence it was mortality-induced growth.	
Period of rapid high	There was a steep fall in the mortality rate but the fertility rate remained high resulting in a	
growth (1951-1981)	very high rate of population growth. It is referred to as the period of population explosion	
	which was the result of fertility-induced growth.	
Period of high growth	The highest-ever growth rate of 22.2 % was recorded in 1971-1981 after the declining trend	



# PRAHAAR ReDEFINED 3.0: GEOGRAPHY & DM



with definite signs of	in population growth started. The recent Census of 2021 reported addition of fewer people
slowing down(1981-	than its previous decade. This indicates a positive result of official efforts of birth control and
2011)	people's enhanced awareness led to an inclination towards smaller families.

# FACTORS RESPONSIBLE FOR HIGH POPULATION GROWTH IN INDIA

- **High Fertility Rates:** Historically, India has had high fertility rates, with an average of 2.2 births per woman in 2015. According to NFHS-5, it declined to 2.0 in 2019-21.
- **Declining Mortality Rates:** Improved healthcare and nutrition have led to a significant decline in mortality rates, increasing life expectancy. According to NFHS survey-5, IMR in India is 35 deaths per 1,000 live births in the five years
- Limited Access to Family Planning: Limited access to family planning services and contraceptives contributes to higher population growth. Only half of the currently married women (56%) have ever used modern contraceptive methods.
- **Poverty and Education**: Poverty and low education levels are associated with higher fertility rates. According to the Census 2011, 27.5% population of India lives Below the Poverty Line.
- Cultural and Social Factors: Cultural preferences for larger families and societal pressure influence family size.
- **Rural-Urban Migration:** Migration from rural to urban areas has increased population density in cities, posing infrastructure challenges.

# IMPLICATIONS OF HIGH POPULATION GROWTH

- **Pressure on Resources:** Increased strain on essential resources like food, water, housing, and energy.
- The strain on Infrastructure: Overburdened infrastructure systems in areas such as transportation, healthcare, education, and sanitation.
- **Unemployment and Underemployment:** High joblessness rates due to population outpacing job creation.
- **Increased Demand for Healthcare and Education:** Greater need for healthcare services and educational institutions.
- **Environmental Impact:** Exacerbation of environmental issues like deforestation, pollution, and resource depletion.
- **Economic Opportunities:** Potential for economic growth through a larger domestic market and increased consumer demand.
- **Demographic Dividend Potential:** Possibility of increased productivity and economic growth with appropriate investments in education and skills development.
- **Social Services and Welfare:** Challenges in providing adequate social services and welfare programs to a growing population.
- **Urbanization:** Rapid urbanization as people move from rural to urban areas, leading to unplanned growth and strain on urban infrastructure.
- **Planning for Sustainable Development:** The need for long-term planning and policies to promote sustainable development and address associated challenges.

### DISTRIBUTION OF POPULATION AND ITS DENSITY

**Uneven distribution is an important aspect of India's population**. High-density pockets have developed around urbanised, developed areas and plains regions. Backward areas and hilly, desert regions are sparsely populated.

# **REASONS PERTAINING TO UNEQUAL POPULATION DISTRIBUTION:**

- **Terrain:** Plain areas witness higher density compared to hilly, desert regions due to productive agriculture, transportation, and industries-led development. E.g. the Ganges plain shows the highest population density and Arunachal Pradesh shows the lowest population density in India.
- **Climatic Conditions:** Rainfall and temperature play important roles in determining the population of an area. Extreme climate discourages population concentration. E.g. the Himalayas, and Thar deserts. It is observed that the population map of India follows its rainfall map. As we move from Wet areas (Ganga delta) to dry areas (the Thar desert) population density decreases.
- **Mineral Resources:** Minerals are the basic raw material for industrial development. It attracts investment and creates employment opportunities. The mining sector comes under primary activities which is labour intensive in nature. E.g. The Chota Nagpur plateau of Jharkhand and adjoining areas of Odisha have higher population densities.
- **Fertile soil:** Fertile soil of the region attracts human settlements due to productive agriculture and related livelihood securities. E.g. Ganga plains having alluvial soil have attracted a dense population.
- **Urbanisation:** Due to high economic activities and employment opportunities population concentration is maximum in urbanised areas compared to rural areas. E.g. Delhi, Mumbai, Kolkata, Bengaluru, and Chennai are in the top positions of population density.





#### **DISTRIBUTION: SOUTHERN Vs NORTHERN INDIA**

- The population growth and improvement in demographic parameters in India is directly proportional to the level of development in the state. Health and Education facilities are the primary pillars which decide the population pyramid of any region.
- In India southern developed states show improvement in population attributes compared to Northern states.
- Southern states have entered into Stage 4 of the demographic transition model having low death and low birth rates leading to low growth rates. The Total fertility rate of these states is below replacement level of 2.1.

### POPULATION CENSUS IN INDIA

- According to the UN, a population census is a total process of collecting, compiling, evaluating, analysing and publishing or otherwise disseminating demographic, economic and social data pertaining, at a specified time, to all persons in a country or in a well-delimited part of a country.
- Census plays a vital role in policymaking, development planning, and evaluation of government schemes. The census reflects India's commitment to understanding its population dynamics and informing evidence-based decision-making.
- **The first population census** in India was conducted in 1872 by Lord Mayo. It aimed to gather comprehensive data on the population of British India.
- The second census took place in 1881 by Lord Rippon and continued to provide demographic insights to aid governance and policymaking every decade.
- The first census of Independent India was conducted in 1951, which was the seventh census in its continuous series.

# WORKING POPULATION

Labour force:	The labour force in India witnessed an increase of 8.8 million, growing from 428.4 million in		
	March 2022 to 437.2 million in April 2022.		
Labour Force	India's LFPR increased from 47.90% in Q3 of 2022 to 48.20% in Q4 of 2022, according to		
<b>Participation Rate:</b>	MOSPI.		
Working force:	The Economic Survey 2022-23, there is a rise in rural female labour force participation rate		
	from 19.7 % in 2018-19 to 27.7% in 2020-21.		
Worker-population	According to Periodic Labour Force Survey, it has increased from 50.9 per cent in 2019-20 to		
ratio:	52.9 per cent in 2021-22.		
Unemployment rate:	According to the Centre for Monitoring Indian Economy (CMIE) Unemployment rate in India is		
	7.8%; in urban areas, it is 8.4% whereas in Rural areas it stood at 7.5%.		

### FEMALE LABOUR FORCE PARTICIPATION RATE (FLPR) IN INDIA

- According to World Bank, the Female labour force as a percentage of the total show the extent to which women are active in the labour force. The labour force comprises people ages 15 and older who supply labour for the production of goods and services during a specified period.
- World Bank: India has one of the lowest female labour force participation rates in the world.
- **Report of ILO**: During the last decade female labour force participation rate has fallen significantly with 95% of women working in the unorganised sector or in unpaid work.
- **PLFS 2021-22:** In 2021-22, FLPR in India was 29.4%, slightly lower than the previous year (29.8%). Meanwhile, the male participation rate improved from 80.1% to 80.7% during the same period.

#### **CAUSES OF LOW FLPR:**

- Social:
  - **Cultural norms and gender roles** prioritizing domestic responsibilities over workforce participation.
  - Early marriage and societal expectations regarding women's roles as wives and mothers.
  - Limited access to education and skills training, particularly in rural areas.
- Economic:
  - **Limited job opportunities** and sectors with low female workforce participation.
  - **Gender-based discrimination** in the workplace, including unequal pay and limited promotion opportunities.
  - **Lack of access to affordable and quality childcare facilities** makes it difficult for women to balance work and family responsibilities.
- Political:
  - Inadequate implementation and enforcement of policies promoting gender equality in the workforce.



# **PRAHAAR ReDEFINED 3.0: GEOGRAPHY & DM**

- Limited representation of women in decision-making positions and leadership roles.
- o **Inadequate maternity benefits** and support for working mothers.
- **Legal constraints:** The factory act of 1948, puts restrictions on the working hours of women between 6 am to 7 pm. Hence reducing their opportunity during night shifts.
- Cultural:
  - Traditional patriarchal beliefs and practices discourage women from pursuing careers.
  - **Societal biases and stereotypes** regarding women's capabilities and roles.
  - $\circ$  ~ Lack of female role models and mentors in various sectors.
- Structural:
  - **Agriculture:** The de-feminisation of agriculture is resulting due to increasing mechanisation of manual works which are generally performed by women.
  - **Safety:** Increasing cases of sexual harassment in the workplace and many unheard harassments of women in the unorganised sector deters women from finding employment.

### **IMPACT ON THE ECONOMY:**

- **Economic growth:** Higher female labour force participation can contribute to increased economic growth. It expands the labour pool, which can lead to higher productivity, innovation, and overall economic output.
- **Human capital development:** Women can bring diverse skills, perspectives, and expertise, which can contribute to a more skilled and productive workforce.
- **Poverty reduction:** When women are employed and earning income, it improves household income levels, enabling better access to education, healthcare, and basic necessities.
- **Consumer spending:** With more women working, household incomes rise, leading to increased consumer spending. This, in turn, can drive demand for goods and services, stimulating economic activity and benefiting businesses.
- **Gender equality and empowerment:** Higher female labour force participation will provide economic independence, improve decision-making power, and challenges gender stereotypes, leading to a more inclusive and equitable society.
- **Tax revenues and fiscal stability:** More women in the workforce contribute to higher tax revenues, supporting government programs and public services. It enhances fiscal stability and the ability to invest in infrastructure, healthcare, and social welfare.
- **Decreased dependency ratios:** As more women participate in the workforce, dependency ratios (the ratio of dependents to the working-age population) decrease. This can ease the burden on social security systems and promote intergenerational equity.

### **GOVERNMENT INITIATIVES TO INCREASE FLPR:**

- **Pradhan Mantri Kaushal Vikas Yojana (PMKVY):** This scheme provides skill training and certification to enhance employability, including special provisions for women to encourage their participation in various sectors.
- **Mahila e-Haat:** It is an online platform launched in 2016 by the Ministry of Women and Child Development that enables women entrepreneurs to showcase and sell their products, promoting their economic independence.
- **Mahila Shakti Kendra (MSK):** Launched in 2017, MSK aims to empower rural women by providing training, skill development, and support services to enhance their employability.
- Women Entrepreneurship Platform (WEP): Established in 2017, WEP provides a platform for aspiring and existing women entrepreneurs to access resources, mentorship, networking opportunities, and business support services.
- **Stand-Up India:** This scheme is launched in 2016 and aims to promote entrepreneurship among women and other marginalized groups by providing bank loans for starting new ventures.
- **National Skill Development Corporation (NSDC):** NSDC collaborates with various sectors to promote skill development and employment generation, including specific initiatives targeting women's skill development and placement.

### WAY FORWARD:

- Economic Empowerment:
  - **Education and skill development:** Provide equal access to education and skill development programs to enhance women's employability.
  - **Entrepreneurship**: Promote entrepreneurship among women by offering financial assistance, training, and mentorship.
  - **Equal Remuneration:** Ensure fair and equal pay for women in the workforce to bridge the gender pay gap.

# • Social Empowerment:

- **Strengthen laws and enforcement mechanisms:** To prevent gender-based violence and harassment, creating a safe environment for women.
- **Decision-making:** Encourage women's participation in decision-making **processes** at the community level, fostering their leadership and representation.





- Gender-Responsive Policies:
  - **Participation in policy-making:** Ensure adequate representation of women in policy-making and planning processes to shape policies that consider their perspectives.
  - **Impact assessments:** Conduct gender impact assessments to evaluate the effects of policies on women and make necessary adjustments.
- Education and Awareness:
  - **Promote education:** For girls and women, including initiatives to address gender-based disparities in education.
  - **Raise awareness:** About the importance of FLPR and challenge stereotypes that hinder women's career opportunities.
- Supportive Infrastructure:
  - **Invest in infrastructure development:** Such as transportation and connectivity, to facilitate women's access to employment opportunities.
  - Childcare facilities: Establish affordable and reliable childcare facilities to support working mothers.
  - **Access to technology:** Improve access to technology and digital literacy programs to bridge the digital gender divide.

### LITERACY

- **Definition:** According to the census of India, a person aged seven and above who can both read and write with understanding in any language is treated as literate.
- **Crude literacy rate:** It considers the total population of India while effective literacy rate considers only the population above 7 years.
- **Census 2011:** According to it, females outnumber males in total literates added during the last decade and a total decrease in the number of illiterates during the last decade. This indicates the gender gap in literacy is shrinking in the country.
- Literacy is a fundamental skill: that empowers individuals, promotes social inclusion, drives economic progress, and strengthens the fabric of society.
- It is a gateway to personal and collective development, opening doors to numerous opportunities and enabling individuals to lead fulfilling lives.
- Literacy rate is directly proportional to the development of the state. Literate populations tend to show better health indicators and they are easily accommodated into the labour force.
- **Kerala and Mizoram** have occupied top positions and Bihar, and Arunachal Pradesh have remained in the bottom position with respect to the literacy rate in India.

### SIGNIFICANCE OF DIGITAL LITERACY

- It is helpful in acquiring new skills in modern technology.
- It increases accountability and transparency in governance, ensures better public service delivery, and increases people's participation in governance.
- Making online money has become easy through Youtube etc. if a person has basic digital knowledge.
- Digital processes transform the work culture of the enterprise and also widen its reach to increase its client base.

# DEMOGRAPHIC DIVIDEND: WINDOW OF OPPORTUNITIES

- United Nations Population Fund (UNPF): Demographic Dividend is defined as, the economic growth potential that can result from a change in population age structure where shares of the working age (15-64 years) population is greater than non-working age share.
- India would experience this **phase between 2018 2055**. This phase will be available at different times in different states.
- A country with both an increasing number of young people and declining fertility has the potential to reap a demographic dividend.
- Increase in labour force leads to increase in economic productivity → increase in GDP → increase in living standard and improvement in HDI score.

### FACT-WISE

- **Economic Survey 2022-23**: There is a rise in rural female labour force participation rate from 19.7 % in 2018-19 to 27.7% in 2020-21.
- **Economic Survey 2018-19**: India's Demographic Dividend is projected to reach its peak around 2041. This is when the working-age population (20-59 years) is estimated to reach 59% of the total population.
- **Periodic Labour Force Survey:** Worker-Population Ration has increased from 50.9 per cent in 2019-20 to 52.9 per cent in 2021-22.





### • Age Distribution: 0-14 age group: 25.69%; 15-64 age group: 67.51%; Above 65: 6.8%.

### SIGNIFICANCE OF DEMOGRAPHIC DIVIDEND (DD):

- **Economic growth:** A large working-age population boosts productivity and drives economic growth.
- **Innovation and entrepreneurship:** Youthful populations bring fresh ideas and entrepreneurial spirit, fostering innovation.
- Market potential: Growing working-age population expands consumer markets and stimulates economic activity.
- Social security: The dividend phase allows for establishing sustainable social security systems.
- **Poverty reduction:** Harnessing the DD reduces poverty and promotes inclusive development.
- Human capital development: Investments in education and skills enhance the capabilities of the workforce.
- **Technological advancement:** The DD drives technological progress and digital innovation.
- Global competitiveness: Leveraging the DD enhances a country's global competitiveness.
- Social empowerment: Increased workforce participation empowers women and marginalized groups.
- Long-term sustainability: The dividend provides an opportunity for sustainable planning and development.
- **Cheap labour and demand:** The Indian demography will be the world's largest labour force and market for goods and services.

### **CHALLENGES:**

- Social Challenges:
  - **Inadequate Access to Healthcare and Education:** Limited availability of quality healthcare and education, particularly in rural and marginalized areas.
  - **Gender Inequality:** Unequal opportunities and limited participation of women in the workforce.
  - **Social Biases and Discrimination:** Prejudices and discriminatory practices that hinder equal opportunities for all individuals.
  - **Brain Drain:** Skilled individuals migrating to other countries for better opportunities, resulting in a loss of human capital for their home countries.
- Economic Challenges:
  - **Insufficient Job Opportunities:** Inadequate employment opportunities to accommodate the expanding labour force.
  - o **Disparities in Income Distribution:** Unequal distribution of income and concentration of wealth.
  - **Lack of Investment in Critical Sectors:** Insufficient allocation of resources to key sectors such as infrastructure and technology.
- Political Challenges:
  - **Policy Inconsistencies and Lack of Planning:** Inconsistent policies and inadequate long-term planning for human capital development.
  - Limited political will to prioritise education, healthcare, and social welfare.
  - **Corruption and Governance Issues:** Challenges related to corruption and governance that impact the effective implementation of reforms.
- Structural Challenges:
  - **Inadequate Infrastructure and Amenities:** Insufficient availability of basic amenities, especially in rural areas.
  - **Limited Connectivity and Technology Access:** Lack of connectivity and limited access to technology and digital resources.
  - Weak Institutional Capacity: Limited capacity and resources for implementing reforms effectively.
- Environmental Challenges:
  - **Climate Change Impact:** Adverse effects on agriculture, water resources, and natural disasters, jeopardising human well-being and economic stability.
  - **Pollution and Ecosystem Degradation:** Contamination of the environment and degradation of ecosystems leading to health issues and loss of livelihoods.
- Technological Challenges:
  - **Digital Divide:** Limited access to technology and digital literacy in certain regions or communities, exacerbating social and economic inequalities.
  - **Automation and Job Disruption:** Displacement of traditional jobs due to automation and technological advancements, necessitating reskilling and upskilling of the workforce.
- Cultural Challenges:
  - **Cultural Barriers and Resistance to Change:** Cultural norms and resistance to adopt new practices and reforms that hinder progress and development.
  - **Lack of Awareness and Appreciation:** Insufficient understanding and recognition of the value of education, health, and skill development in some communities.



### WAYS AND MEANS TO CONVERT HUMAN RESOURCES INTO DEMOGRAPHIC DIVIDENDS

- **Nutrition:** Ensure access to adequate and nutritious food for all, especially children and pregnant/lactating mothers. Implement and strengthen programs like the National Food Security Act (NFSA) to improve food availability, accessibility, and affordability.
- **Health:** Increase investment in the health sector to improve healthcare infrastructure and services. Aim to allocate at least 2.5% of GDP to healthcare, as envisioned in the National Health Policy.
- **Education:** Make quality education accessible to all and increase public investment in the education sector. Implement the National Education Policy (NEP) recommendations, which include allocating 6% of GDP to education.
- **Skills Development:** Promote skill development programs to enhance the employability of the workforce. The National Skill Development Corporation (NSDC) can play a crucial role in providing skill training to millions of people.
- **Reforms:** Implement economic reforms that prioritize social needs such as nutrition, health services, primary and secondary education, tertiary education quality enhancement, water supply and sanitation, and urban development.
- **Employment:** Promote labour-intensive sectors, and entrepreneurship, and create an enabling environment for job creation.

### WAY FORWARD:

- **Education and Skills:** Prioritize quality education and skill development to equip the youth for the workforce. This includes promoting vocational training, technical education, and digital literacy.
- Job Creation and Entrepreneurship: Foster an enabling environment for job creation by supporting entrepreneurship and small and medium-sized enterprises (SMEs).
- Gender Equality: Promote women's empowerment and equal access to education and employment.
- **Social Protection and Healthcare:** Establish robust social protection systems that provide a safety net for vulnerable groups, including the elderly, children, and those unable to participate in the labour market.
- **Infrastructure Investment:** Enhance investment in infrastructure development, including transportation, communication, energy, and digital connectivity.
- **Policy Coherence:** Align policies across sectors and adopt a multi-sectoral approach. Coherent and integrated policies facilitate synergies and maximize the potential of the demographic dividend.
- **International Collaboration:** Engage in international collaboration, knowledge sharing, and technology transfer to leverage best practices and experiences from other countries.

**In conclusion**, the demographic dividend offers immense potential for economic growth and development. To seize this opportunity, countries should focus on education, job creation, gender equality, social protection, and infrastructure investment. By adopting these measures, nations can effectively leverage their youthful workforce and pave the way for a prosperous future.

#### **DIGITAL DIVIDE**

- **Definition**: Digital divide refers to the deprivation of accessibility, affordability, and availability towards information and communications technologies across the demographics and regions.
- Accessibility: According to Oxfam India Inequality Report 2022, Only 2.7 per cent among the Poorest 20 per cent households in India, have access to a computer and 8.9 per cent to internet facilities.
- **Digital literacy**: Only 38 per cent of households are digitally literate across India.
- **Usage of the Internet**: Furthermore, internet usage is considerably lower in rural areas, with only 31 per cent of the rural population utilizing the Internet, in contrast to 67 per cent of the urban population.
- Lack of access to Marginalised: Merely 4 per cent of students belonging to SC and ST communities had access to both computers and the internet, highlighting significant disparities across caste groups.
- **SDG goals**: Access to ICT is essential to achieve Sustainable Development Goals (SDGs) for 2030.

#### HUMAN DEVELOPMENT

- United Nations Development Programme (UNDP): Human development is "the process of enlarging people's choices", said choices allowing them to "lead a long and healthy life, to be educated, to enjoy a decent standard of living", as well as "political freedom, other guaranteed human rights and various ingredients of self-respect"
- The term **Development indicates qualitative change** which is **value positive** as against quantitative and valueneutral change associated with the term Growth.

#### **FACT-WISE**

- Literacy Rate In India: According to NSO it is 77.70% in 2021 whereas global literacy stands at 87% according to World Bank.
- Life Expectancy: It is 70.19 years in 2022 and expected to reach 82.0 by 2100 according to UN estimates (Globally





#### it is 72.6 years).

- **Gross Enrollment Ratio**: In higher secondary, it is 57.6% in 2021-22.
- Global Health Security Index: India ranked 66 out of 195 countries in the 2021 report.
- Human Development Index: India ranks 132 out of 191 countries in HDI 2022.
- **Global Hunger Index:** 107 out of 121 countries in 2022.
- **Gender Gap Index**: 135 out of 146 in the 2022 report.

### SIGNIFICANCE OF HUMAN DEVELOPMENT

- **Human Capital Development:** Investments in human development help build a skilled workforce, boosting productivity, innovation, and competitiveness.
- **Improved Quality of Life:** Human development aims to enhance the well-being and living standards of individuals by providing access to education, healthcare, and resources.
- **Sustainable Development Goals (SDGs):** Human development efforts in India align with the global SDGs, addressing issues such as poverty eradication, education, gender equality, health, and sustainability.
- **Poverty Alleviation:** Human development strategies contribute to reducing poverty by empowering individuals through education, skills, and opportunities for sustainable livelihoods.
- **Health and Well-being:** Human development prioritizes healthcare services, improving health outcomes and ensuring access to quality healthcare for all.
- **Education and Skill Development:** Human development emphasizes quality education and skill training for personal growth and employment opportunities.
- **Empowerment of Marginalized Groups:** Human development uplifts women, children, rural communities, and tribal populations through equal opportunities.
- **Sustainable Livelihoods:** Human development creates sustainable income-generating opportunities, particularly in agriculture and entrepreneurship.

VARIOUS INDICES TO MEASURE HUMAN DEVELOPMENT				
Human Development	It is the most commonly used index published by UNDP, which combines three basic			
Index (HDI)	dimensions of human development: Life Expectancy, Education and Gross National			
	Income (GNI) per capita.			
	Published by World Economic Forum. This index measures gender disparities by			
Gender Gap Index	incorporating gender-specific data into the HDI calculation. It takes into account the			
	differences in life expectancy, education, and income between men and women. India			
	ranks 135 among 146 countries			
	The GII highlights gender-based inequalities in reproductive health, empowerment, and			
Gender Inequality Index	labour market participation. It considers indicators such as maternal mortality rate,			
(GII)	adolescent birth rate, educational attainment, and representation in parliament. India			
	ranks 122 among 190 countries in 2021			
Inequality-adjusted	This index adjusts the HDI for inequality within a country. It is part of the HDR. It takes			
Human Development	into account disparities in health, education, and income distribution among the			
Index (IHDI)	population.			
Multidimensional	The MPI considers multiple dimensions of poverty, including health, education, and			
Poverty Index (MPI)	standard of living. It identifies individuals who experience simultaneous deprivations in			
	various aspects of their lives. India ranks First in 2022.			

### **KEY CHALLENGES FOR HUMAN DEVELOPMENT IN INDIA**

- **Poverty:** High poverty levels hinder access to basic necessities, healthcare, and education. There are 16.4% incidences of poverty reported by MPI.
- Education: Quality education remains a challenge, particularly in rural and marginalized communities.
- **Healthcare:** Access to quality healthcare is limited, especially in remote areas. According to a report by NITI Aayog, India has a ratio of only 1.4 beds per 1,000 people, with approximately 1 doctor for every 1,445 individuals, and 1.7 nurses per 1,000 people.
- **Gender Inequality:** Gender disparities persist in education, employment, and access to resources.
- **Unemployment:** Insufficient employment opportunities pose a challenge, particularly for the youth. According to CMIE unemployment rate in India is 8.11% in April 2023.
- **Social exclusion:** Marginalized communities face social exclusion and discrimination.
- Infrastructure Development: Adequate infrastructure, including transportation and sanitation, needs improvement.
  Malnutrition: Addressing malnutrition, especially among children and women, is crucial for human development. In the Global Hunger Index 2022, India ranked 107th among 121 countries.
- Water and Sanitation: Ensuring access to clean water and proper sanitation facilities remains a challenge.





- **Digital Divide:** Bridging the digital divide and promoting equitable access to technology is essential.
- **Urbanization:** Managing urban poverty, infrastructure development, and sustainable urbanization is challenging.
- Social Justice: Promoting social justice, inclusive governance, and protecting marginalized groups' rights is important.
- **Population Growth:** Managing the growing population and its impact on resources and services is a challenge. India surpasses China reaching a 1.40 Billion population in the country.

### WAY FORWARD:

- Increase Investment in Education and Healthcare: Allocate more resources to enhance the quality and accessibility of education and healthcare services. This includes improving infrastructure, teacher training, and healthcare facilities across rural and marginalized areas.
- **Enhance Skill Development:** Focus on skill development programs that align with industry needs to enhance employability and address the skill-job mismatch. Promote vocational training and entrepreneurship opportunities to empower individuals and create sustainable livelihoods.
- **Strengthen Social Protection:** Implement robust social protection programs that provide a safety net for vulnerable populations, including comprehensive healthcare coverage, income support, and nutrition programs. This will help reduce poverty, and inequality, and enhance human development outcomes.
- **Promote Gender Equality:** Implement policies and initiatives that empower women, ensure gender equality, and address gender-based violence and discrimination. Provide equal access to education, employment opportunities, and decision-making positions to promote inclusive and sustainable development.
- **Foster Sustainable Development:** Integrate environmental sustainability into development policies and practices. Encourage renewable energy adoption, sustainable agriculture, waste management, and conservation efforts to mitigate climate change impacts and promote sustainable growth.
- **Strengthen Governance and Accountability:** Enhance transparency, efficiency, and accountability in governance mechanisms. Promote citizen participation, decentralization, and effective implementation of policies to ensure equitable distribution of resources and services.
- **Bridge Infrastructure Gaps:** Invest in improving infrastructure, particularly in rural areas, to enhance connectivity, and access to basic services, and promote economic development. This includes transportation networks, electricity, water supply, and sanitation facilities.
- **Promote Research and Innovation:** Encourage research and innovation in various fields, including healthcare, agriculture, and technology. Foster collaborations between academia, industry, and government to drive innovation-driven solutions for sustainable development.

# INITIATIVES BY GOVERNMENT TO INCREASE HUMAN DEVELOPMENT

- **Skill India Mission:** This initiative was launched in 2015 and aims to enhance the employability and skills of the Indian workforce through skill development programs, vocational training, and certification.
- **Pradhan Mantri Ujjwala Yojana (PMUY):** Launched in 2016, this scheme provides clean cooking fuel in the form of LPG connections to households below the poverty line, promoting clean energy and improving health.
- Swachh Bharat Abhiyan (Clean India Mission): Launched in 2014, this nationwide cleanliness campaign aims to promote sanitation, hygiene, and the construction of toilets, with the goal of eradicating open defecation and improving public health.
- **MGNREGA:** Enacted in 2005, this program guarantees 100 days of wage employment per year to rural households, providing livelihood opportunities and promoting rural development.
- **National Health Mission (NHM):** It was launched in 2013 and it focuses on improving healthcare services, infrastructure, and accessibility, with the aim of providing universal access to quality healthcare and reducing maternal and child mortality rates.
- **National Nutrition Mission (POSHAN Abhiyaan):** Launched in 2017, this initiative focuses on combating malnutrition, especially in women and children. It aims to reduce stunting, undernutrition, and anaemia by providing targeted interventions, promoting behaviour change, and improving nutrition-related services.
- **National Urban Livelihoods Mission (DAY-NULM):** Launched in 2013, this mission focuses on poverty alleviation and livelihood promotion in urban areas. It aims to provide social and economic support to the urban poor through skill training, access to credit, entrepreneurship development, and employment generation.
- **National Skill Development Mission (NSDM):** Launched in 2015, this mission aims to provide skill training to the country's youth and enhance their employability. It focuses on creating a skilled workforce by setting up skill development centres, providing vocational training programs, and fostering industry partnerships.

In summary, India faces challenges in education, healthcare, gender inequality, skill development, infrastructure, and social protection. Initiatives like Ayushman Bharat, Skill India, and Swachh Bharat Abhiyan have been launched to address these challenges. However, more efforts are needed to improve access, quality, and equity. Investing in education and





healthcare, bridging infrastructure gaps, promoting gender equality, and fostering sustainable development are key priorities.

# NATIONAL POPULATION POLICY (NPP) 2000

- India's NPP 2000 is the government's **second population policy** that aims to address various aspects of population growth and reproductive health.
- Its immediate objective is to address unmet needs for contraception, healthcare infrastructure, and health personnel while providing integrated services for reproductive and child healthcare.
- Key features of the NPP 2000 include:
  - **Reduction of Total Fertility Rate (TFR):** The medium-term objective is to reduce the TFR to replacement levels (2.1 children per woman) by 2010, with the long-term goal of achieving a stable population by 2045.
  - **Education and Healthcare:** The policy focuses on making school education free and compulsory up to the age of 14 years, reducing dropout rates, decreasing infant mortality rate (IMR) to under 30 per 1000 live births, and reducing maternal mortality rate (MMR) to under 100 per 1 lakh live births by 2010.
  - **Universal Immunization and Institutional Deliveries:** The NPP aims to achieve universal immunization for all children against vaccine-preventable diseases and promote 80% institutional deliveries and 100% deliveries by trained personnel.
  - Access to Reproductive Health Services: The policy emphasizes universal access to information, counselling, and services for fertility regulation and contraception, promoting a range of choices for individuals. It also addresses the prevention and control of communicable diseases, including HIV/AIDS.
  - **Women Empowerment:** The NPP encourages delayed marriage for girls, preferably before 18 years and above 20 years, and aims to integrate Indian medicine systems (AYUSH) in reproductive and child health services. It also aims to achieve 100% registration of pregnancies, births, deaths, and marriages.
  - **Convergence of Social Programs:** The policy emphasizes the convergence of social programs related to family planning and welfare, aiming for a people-centric approach and promoting the small family norm.
- The NPP 2000 takes a comprehensive approach by linking population issues with child survival, maternal health, women's empowerment, and contraception. It recognizes the importance of education, healthcare, and reproductive rights in achieving sustainable population growth and overall development.

# CHINA AND INDIA: CONTRASTING POPULATION TRENDS

### • Population Projection:

- India's population is projected to exceed China's population by April 2023.
- The United Nations estimates India's population to reach 1,425,775,850 people, surpassing China's population.
- Contrasting Demographic Futures:
  - India's population is expected to continue growing for several decades.
  - China, on the other hand, experienced a decline in population in 2022 and is projected to further decrease, potentially falling below 1 billion by the end of the century.
- Importance of Censuses:
  - o Both China and India rely on regular censuses to gather population information.
  - The United Nations uses data from vital records, surveys, and administrative sources to estimate and project population sizes.
  - Population estimations are subject to uncertainties and are revised as more data becomes available.

# • Impact of Fertility Levels:

- China witnessed a sharp decline in fertility in the 1970s, reaching one of the world's lowest fertility rates of 1.2 births per woman in 2022.
- India's fertility decline has been more gradual, with a fertility rate of 2.0 births per woman in 2022, just below the replacement level of 2.1.
- The United Nations projects that India's population will peak around 2064 and then gradually decline.

# • Population Policies:

- China implemented policies promoting later marriages, longer birth intervals, and fewer children in the 1970s, along with the strict "one-child" policy from 1980 to 2015.
- India also implemented measures to slow population growth but with varying impacts across different states due to its federal structure.
- Lower investments in human capital and slower economic growth in India contributed to a more gradual fertility decline compared to China.

# • Ageing Population:

- China has experienced a shift towards older ages, with a higher proportion of adults aged 25-64.
- India's population ageing is occurring more gradually and varies across states.



# **PRAHAAR ReDEFINED 3.0: GEOGRAPHY & DM**



• Investments in education, health, and employment opportunities for youth are crucial for maximizing the benefits of India's demographic situation.

### • Sex Ratio Imbalances:

- Both China and India face imbalances in the sex ratio at birth, with a higher number of boys than girls being born.
- Preference for sons has been achieved through practices like sex-selective abortion, which is outlawed in both countries.
- Post-natal discrimination in some regions of India contributes to higher mortality rates for girls.

### Challenges and Preparation:

- Both China and India are witnessing rapid growth in the number of older persons.
- This poses significant challenges to healthcare and social insurance systems.
- Planning and adaptation to demographic changes are essential for addressing these challenges.
- Sustainable Development Goals:
  - China and India's population size and growth are crucial for achieving the Sustainable Development Goals.
  - Meeting the needs of their populations is essential for sustainable development and ensuring that no one is left behind.

### **STATE OF WORLD POPULATION REPORT OF 2022**

- The report highlights a global annual average of approximately 121 million unintended pregnancies between 2015 and 2019.
- An estimated 257 million women worldwide who wish to avoid pregnancy lack access to safe and modern contraception methods.
- Humanitarian emergencies, such as conflicts and the COVID-19 pandemic, disrupt access to contraception and contribute to unintended pregnancies.

### MIGRATION

- Migration refers to the movement of persons away from their place of usual residence, either across an international border or within a country. It includes a wide variety of movements, such as migration for work, education, family reunification, or humanitarian reasons.
- International Organisation for Migration (IOM): A migrant is a person who moves away from his or her place of usual residence, whether within a country or across an international border, temporarily or permanently, and for a variety of reasons.
- Broadly migration can be divided as **Internal Migration and External Migration**.

### INTERNAL MIGRATION

- Internal migration in India involves the **movement of people within the country** for various reasons such as job opportunities, education, and improved living conditions.
- It contributes to urbanization and economic growth while presenting challenges of housing and social integration.

### FACT-WISE

- **Number of Internal Migrants**: The 2011 Census recorded the number of internal migrants in India at 45.36 crores, which accounted for 37% of the country's population at that time.
- **Annual Net Migrant Flows**: The annual net migrant flows in India amounted to approximately 1% of the working-age population.
- **Economic Survey 2016-17**: It highlighted that relatively less developed states like Bihar and Uttar Pradesh experienced high net out-migration, while more developed states like Goa, Delhi, Maharashtra, Gujarat, Tamil Nadu, Kerala, and Karnataka witnessed net immigration.
- Migration in India Report 2020-21:
  - Females had a significantly higher migration rate of 47.9% compared to males at 10.7%.
  - The primary drivers for migration were marriage, accounting for 86.8% of female migrants, and employment, accounting for 49.6% of male migrants.
  - In 2020-21, the overall migration rate in India was 28.9%, with urban areas experiencing a higher migration rate of 34.9% compared to rural areas at 26.5%.

### **TYPES OF INTERNAL MIGRATION:**

• **Inter-State Migration:** This type of migration occurs when individuals or families move from one state to another within the country. It can be motivated by factors like job transfers, educational opportunities, or better living conditions.







- **Rural-Urban Migration:** This involves the movement of people from rural areas to urban areas in search of better job opportunities, education, healthcare, and improved living standards.
- **Urban-Rural Migration:** It refers to the movement of individuals from urban areas to rural areas. It may be driven by factors such as retirement, lifestyle choices, or a desire for a quieter and less crowded environment.
- **Seasonal Migration:** Seasonal migration involves the temporary movement of people for specific seasons or activities. In India, it is prevalent in sectors such as agriculture, where workers migrate to different regions for planting or harvesting seasons.
- **Educational Migration:** This type of migration involves students moving from their hometowns to cities or other states for pursuing higher education in colleges, universities, or professional institutes.
- **Marriage Migration:** Marriage migration involves the movement of individuals, particularly women, who relocate to their spouse's place of residence after marriage. It can involve moving within the same city, to a different city, or even to a different state.
- **Reverse Migration:** Reverse migration occurs when individuals or families return to their place of origin or ancestral home after living in another location for some time. It can be driven by factors such as job loss, economic downturns, or personal reasons.

# FACTORS RESPONSIBLE FOR INTERNAL MIGRATION:

# • Economic Factors:

- **Employment opportunities:** People often migrate within India in search of better job prospects and higher wages. Economic disparities between regions can drive individuals to move from economically disadvantaged areas to more developed regions.
- **Rural-urban migration:** The lure of urban areas with more diverse employment opportunities, improved infrastructure, and better living standards attracts individuals from rural areas to migrate.
- Social Factors:
  - **Marriage and family:** Marriage is a significant factor driving internal migration in India, particularly for women. Many individuals move to their spouse's place of residence, resulting in migration within the country.
  - **Education:** Access to quality education and educational institutions can lead individuals to migrate to cities or regions with renowned educational facilities.
  - **Social networks and community ties:** People often migrate to areas where they have family or community networks, seeking social support and a sense of belonging.
- Demographic Factors:
  - **Population pressure:** High population density in certain regions, coupled with limited resources and employment opportunities, can prompt individuals to migrate to less congested areas.
  - **Age-specific migration:** Migration patterns can be influenced by age, with younger individuals migrating for education and employment opportunities, while older individuals may migrate for retirement or better healthcare facilities.
- Environmental Factors:
  - **Natural disasters and environmental challenges:** People may be compelled to migrate due to the impact of natural disasters, such as floods, cyclones, or droughts, or environmental issues like water scarcity or pollution.
  - **Climate change:** Changing climate patterns and environmental degradation can lead to internal migration as people seek areas with more favourable climate conditions and reduced vulnerability to climate-related risks.
- Political Factors:
  - **Regional conflicts and unrest:** Political instability, communal tensions, or conflicts in certain regions can result in migration as individuals seek safety and security in more stable areas.
  - **Government policies and development initiatives:** Such as infrastructure projects, industrial corridors, or special economic zones, can create opportunities and attract migration to specific regions.

# SIGNIFICANCE OF INTERNAL MIGRATION:

- **Economic Growth:** Internal migration drives economic growth by supplying labour to growing industries and urban areas, boosting production and development.
- **Regional Development:** It can help to reduce regional disparities, promoting economic growth and improving living standards in less-developed regions.
- **Urbanization:** Internal migration is a driving force behind urbanisation, opening up employment opportunities and enhancing access to services while also promoting economic diversification and a higher standard of living.
- **Social Mobility:** It enables individuals to improve their social and economic status, accessing better education, healthcare, and employment prospects.
- **Skill Transfer and Knowledge Exchange:** The exchange of skills, knowledge, and innovation is facilitated by internal migration, which supports the growth of the local economy and social system.





- **Social and Cultural Exchange:** It helps to promote cultural diversity, intercultural understanding, and social integration, enriching the multicultural fabric of the nation.
- **Human Capital Development:** Internal migration allows individuals to access better education and skill development, enhancing productivity and competitiveness, and contributing to overall economic growth.

### **CHALLENGES:**

- **Urban Overcrowding and Informal Settlements:** Unplanned urban migration causes overcrowding, strains infrastructure, and results in inadequate basic services in informal settlements for water, sanitation, and healthcare.
- **Social Exclusion and Discrimination:** Migrants often face social exclusion, discrimination, and limited access to social welfare schemes, education, and healthcare services in their destination areas.
- **Inadequate Housing and Livelihood Opportunities:** Limited livelihood opportunities, particularly in the informal sector, can result in low wages, exploitation, and precarious working conditions.
- **Vulnerability to Exploitation and Trafficking:** Insufficient legal protection, awareness, and social support exacerbate the vulnerability of migrant women and children to exploitation, human trafficking, and forced labor.
- **Social Dislocation and Family Separation:** Internal migration can result in social network disruption, family separation, and emotional/psychological impacts on migrants and their families, influencing overall well-being.
- Access to Education: Migrant children often face challenges in accessing quality education due to issues like language barriers, documentation requirements, and lack of appropriate infrastructure.
- **Healthcare:** Limited access to healthcare services is also a concern, particularly for migrants in informal settlements.

### WAY FORWARD:

- **Urban Planning and Infrastructure:** Implement integrated planning, adequate infrastructure, and basic services for migration management.
- **Social Inclusion and Welfare Schemes:** Ensure equal access to welfare, education, and healthcare, and eliminate discrimination against migrants.
- Livelihood Opportunities and Skill Development: Enhance job prospects, entrepreneurship, and skill development for sustainable income sources.
- **Legal Protection and Support:** Strengthen migrant rights, combat exploitation, and trafficking, and establish support mechanisms.
- **Family Support and Integration:** Minimize family separation, facilitate reunification, and provide social support networks for well-being.
- **Education and Healthcare Access:** Improve education through language support, simplified documentation, and migrant-friendly healthcare services.

#### **PW-ONLYIAS EDGE: KEY PHRASES FOR MAINS**

Out-Migration and In-Migration; Seasonal Migration; Reverse Migration; Brain drain; Social Remittances; Internal Migration; Pull and Push Factors; Demographic Consequences; Migrant Workers; etc.

#### EXTERNAL MIGRATION

External migration refers to the movement of people from one country to another for the purpose of changing their place of residence. It involves crossing international borders and can be either voluntary or forced. External migration has a significant impact on both the sending and receiving countries.

### **TYPES OF EXTERNAL MIGRATION:**

- **Emigration from India to various parts of the world:** This refers to the migration of Indian nationals to other countries for various reasons, such as employment opportunities, education, family reunification, or seeking better living conditions.
- **Immigration of people from different countries to India:** This involves individuals from different countries moving to India for various purposes, including employment, business, education, or joining family members who are already residing in the country.
- **Refugee Migration:** This type of migration involves individuals who are forced to flee their home countries due to persecution, conflict, or other forms of violence.

### **WORLD MIGRATION REPORT 2022: KEY FINDINGS**

- Over the past five decades, the global number of international migrants has witnessed a significant increase, rising from 84 million in 1970 to 281 million in 2020.
- The figure plummeted from 4.5 billion passengers in 2019 to 1.8 billion in 2020. Simultaneously, internal displacement resulting from disasters, conflicts, and violence surged to 40.5 million individuals, marking an



# increase from 31.5 million in 2019.

# FACTORS RESPONSIBLE FOR EXTERNAL MIGRATION:

- **Economic Opportunities:** People migrate externally in search of better job opportunities, higher wages, and improved economic conditions in other countries.
- **Education:** Students and professionals may migrate externally to pursue higher education, advanced degrees, or specialized training in foreign institutions.
- **Political and Social Factors:** Push factors such as political instability, conflict, persecution, and social unrest in the home country can drive individuals to seek refuge and migrate externally.
- **Environmental Factors:** Natural disasters, climate change impacts, and environmental degradation can force people to migrate externally in search of safer and more sustainable living conditions.
- **Economic Disparities and Poverty:** Extreme poverty, lack of economic opportunities, and unequal distribution of resources in the home country can drive individuals to migrate externally in hopes of improving their living standards.
- **Globalization and International Labor Demand:** Globalization has led to increased demand for labour in various sectors, such as construction, healthcare, IT, and hospitality, attracting migrants from different countries to fill skill gaps and meet workforce demands.
- **Discrimination and Persecution:** Discrimination based on race, ethnicity, religion, or political beliefs can drive individuals to migrate externally in search of a more tolerant and inclusive society that respects their rights and freedoms.
- **Better Healthcare and Medical Treatment:** People may migrate externally to access better healthcare services, specialized medical treatments, or advanced healthcare infrastructure not available in their home country.
- **Quality of Life and Standard of Living:** Migration for a higher standard of living, improved quality of life, better infrastructure, and access to amenities, such as healthcare, education, and social services, is a motivating factor for many individuals.
- **Natural Resource Exploitation:** Migration can occur in regions with significant natural resources, where individuals may seek employment opportunities in industries such as mining, oil and gas, or agriculture.

# INTERNATIONAL MIGRATION AND GLOBAL ACTION

- The United Nations General Assembly held a meeting in 2016 to address the challenges of refugee movements and produced the report "Safety and Dignity: Addressing Large Movements of Refugees and Migrants."
- Member states adopted the New York Declaration for Refugees and Migrants, emphasizing the protection of migrants' rights and dignity.
- This led to the development of the Global Compact for Safe, Orderly and Regular Migration, adopted in 2018.
- International Migrants Day is celebrated annually on December 8th.

# **IMPACT OF EXTERNAL MIGRATION:**

# • Positive Impacts:

- **Economic Growth:** External migration can contribute to economic growth in both the host and home countries through remittances, investments, and transfer of skills and knowledge.
- **Cultural Exchange:** External migration facilitates cultural exchange, diversity, and the sharing of ideas, traditions, and experiences.
- **Skill Acquisition and Knowledge Transfer:** Migrants gain new skills, knowledge, and experiences in the host country, which they can bring back to their home country, contributing to human capital development.
- **Innovation and Entrepreneurship:** Migrants often bring new ideas, perspectives, and entrepreneurial skills, contributing to innovation and business development in host countries.
- **Workforce and Skills Enhancement:** External migration helps address labor market gaps and shortages in host countries by providing a skilled and diverse workforce.
- **Global Connections and Networks:** Migration fosters global connections, networking, and collaboration across borders, benefiting trade, diplomacy, and international relations.

# • Negative Impacts:

- **Brain Drain:** Emigration of skilled professionals from their home countries can result in a loss of talent, expertise, and human capital, hindering development efforts.
- **Exploitation and Vulnerability:** Migrants may face exploitation, discrimination, and abuse in the host country, especially if they lack legal protection and social support systems.
- **Dependency on Remittances:** Overreliance on remittances from migrants can create economic vulnerability and dependency, affecting long-term development in the home country.
- **Social Tensions:** Cultural differences, competition for resources, and perceptions of job displacement can sometimes lead to social tensions and conflicts between migrants and host communities.



- BY PHYSICS WALLAN
- **Loss of Human Capital Investment:** The home country may lose the investment made in the education and training of migrants who choose to permanently settle in the host country, leading to a loss of potential contributions.
- **Social Challenges:** External migration can lead to social challenges such as family separation, loss of social support systems, and difficulties in maintaining cultural identity and traditions.

### WAY FORWARD:

- **Recognize the importance of migration:** Acknowledge that migration is an integral part of human development and sustainable development goals, and understand that preventing migration could have counterproductive effects.
- **Strengthen integration policies:** Develop robust policies and programs to facilitate the integration of migrants at their destination, focusing on areas such as housing, healthcare, education, and social security.
- Enhance social security measures: Provide adequate amenities and social security for migrants, addressing issues such as inadequate housing, low-paid and insecure work, and vulnerability to exploitation. Implement schemes like health insurance and accommodation projects tailored to the needs of migrant workers.
- **Promote portable rights:** Establish mechanisms that guarantee basic rights to workers in their home state while they are employed in other states, ensuring their protection and well-being.
- **Migration-centric policies:** Create specific policies, strategies, and institutional mechanisms that prioritize the needs and rights of migrants, ensuring their inclusion in the development process.
- **Enhance skill development and employment opportunities:** Enhance skill development through public-private partnerships to equip migrants with marketable skills and create employment and entrepreneurial opportunities.
- **Foster social cohesion and cultural exchange:** Promote cultural understanding and integration through awareness campaigns, exchange programs, and community engagement to foster social cohesion between host communities and migrants.
- **Strengthen international cooperation:** Collaborate with international stakeholders to address migration challenges, protect migrants' rights, and ensure safe and orderly migration through information sharing and policy coordination.
- **Raise awareness and provide information:** Raise awareness among migrants about their rights, support services, and legal processes through campaigns, multilingual resources, and online platforms for informed decision-making and access to assistance.

External migration has a profound impact on individuals, societies, and countries. It brings economic growth, cultural exchange, and innovation, but also poses challenges such as brain drain, social tensions, and exploitation. To address these, comprehensive approaches are needed, including integration policies, skill development, social security measures, and international cooperation. By doing so, we can harness the benefits and mitigate the challenges of external migration for a more inclusive and sustainable future.

# PREVIOUS YEAR QUESTION (MAINS)

- 1. Discuss the main objectives of Population Education and point out the measures to achieve them in India in detail. (2021)
- 2. The COVID-19 pandemic accelerated class inequalities and poverty in India. Comment. (2020)
- 3. Mention core strategies for the transformation of aspirational districts in India and explain the nature of convergence, collaboration and competition for its success. (2018)
- 4. Critically examine whether growing population is the cause of poverty OR poverty is the main cause of population increase in India. (2015)
- 5. Discuss the changes in the trends of labour migration within and outside India in the last four decades. (2015)

# Student's Note:





# 6.HUMAN SETTLEMENTS AND ASSOCIATED ISSUES

- In geography a settlement, locality or populated place is a community in which people live. The complexity of a settlement can range from a small number of dwellings grouped together to the largest of cities with surrounding urbanized areas.
  - Settlements may include hamlets, villages, towns and cities.
  - Settlements can broadly be divided into two types rural and urban.
- 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 lower population density than urban areas.

### CLASSIFICATION OF SETTLEMENTS

According to their purposes, size, morphology, quantity and density of homes, and other factors, settlements can be categorised. However, the most common criterion is the role played by a settlement's residents. Due to this, there are two recognised sorts of settlements.

### **RURAL SETTLEMENTS**

- This is referring to communities of homes known as "villages" as well as the land nearby where residents obtain their food.
- Specifically, in India, a village is a "parcel of ground with definite boundaries for revenue purposes without clear and consistent regard for its population," also known as a "mauza" in English.
- According to this definition, a revenue village is a distinct administrative entity that consists of one or more residential groups as well as the land that they own.

# **DISTRIBUTION OF VILLAGES IN INDIA**

- There are 640,867 villages in India as of the 2011 Census, including villages that are not inhabited.
- More than two-thirds of India's population, or 68.84%, resides in more than 6.4 lakh villages, according to census data from 2011.
- More than 16.6% of the total are in Uttar Pradesh alone.
- Chandigarh only has a bare minimum of five villages.

# **URBAN SETTLEMENT**

- The majority of people living in cities work in non-primary industries like manufacturing and services.
- The population density in urban areas is typically high—more than 400 persons per square km.
- Declared an urban settlement by the government.
- The following standards are used in India to categorise urban settlements:
  - According to the 2011 census, there should be more than 5000 people living there.
  - At least 75% of working men should be employed in non-primary industries.
  - The town area committee should have informed the urban area, which should have a municipality, corporation, or canton board.
  - More than 400 people should live in each square km.

Types and Patterns Of Rural Settlements		
Compact/clustered/	• In such settlements, all the dwellings are concentrated in one central site and this	
nucleated settlement	inhabited area is distinct and separated from the farms and pastures.	
	These settlements are distributed over the entire northern Indo-Ganga plain	
Semi-compact/Semi-	• Such settlements are characterized by small but compact nuclear around which	
clustered/fragmented	hamlets are dispersed. It covers more area than compact settlements.	
settlement	• Such settlements are situated along streams in the Manipur Mandla and Balaghat	
	districts of Madhya Pradesh, and the Rajgarh district of Chhattisgarh.	
	• These types of settlements are fragmented into several small units. The main settlement	
Hemleted settlement	does not have much influence on the other units.	
	• This segregation is often influenced by social and ethnic factors. The hamlets are	
	locally named faliya, para, Dhana, dhani, nanglay etc.	
	• This is also known as <b>isolated settlement</b> . Here the settlement is characterized by units	
Dispersed settlement	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 do not have any specific pattern.	





### URBANISATION IN INDIA

- **Definition:** The population transfer from rural to urban regions, the resulting decline in the number of people living in rural areas, and the methods by which societies adjust to this transition are all referred to as urbanisation.
- **Status of Urbanisation in India: Urbanization in India was mainly a post-independence phenomenon**, due to the adoption of a mixed system of economy by the country, which gave rise to the development of the private sector.
  - The urban population of India attained a value of 475 million people in 2021.
  - In 2021, India's urbanisation rate was 1.34%. In 2021, India's urbanisation rate climbed 1.5% year over year. The indicator climbed by 19.6% from 2010 to 2021.
  - Between 2010 and 2021, India's urbanisation rate was at its highest in 2021 and at its lowest in 2010.

### **REASON FOR INCREASING URBANISATION**

- **Industrialization:** In search of improved employment prospects, a large number of individuals moved from rural to urban areas as a result of the industrial revolution.
- Commercialization: Compared to rural areas, urban areas offer superior business opportunities.
- Urban regions offer a wide range of social services and benefits, including improved health care, sanitation, education, and living conditions, all of which contribute to a better social environment overall.
- **Better Employment prospects:** Urban regions offer a wide range of employment prospects in fields like education, transportation, health, industry, sports, and commercial organisations.
- **Modernization:** With highly advanced medical facilities, communication, knowledge, infrastructure, and other social amenities, urban regions are becoming more tech-savvy.
- **Rural-Urban Change:** This can be viewed as improved infrastructure, education, employment possibilities, and transportation in rural communities. As a result, production increases and economic growth.

# 68% of the world population is projected to live in urban areas by 2050, says UN

- By 2050, 68% of the world's population, up from 55% today, is anticipated to reside in cities.
- According to projections, by 2050, there could be 2.5 billion more people living in urban areas worldwide due to urbanisation, which is the gradual movement of people from rural to urban areas.
- Nearly 90% of this population growth would occur in Asia and Africa.

### PROBLEMS WITH INDIA'S URBANISATION

- **High Population Pressure**: Undue strain on existing public services as a result, slums, crime, unemployment, urban poverty, pollution, congestion, ill health, and a variety of deviant social activities plague the cities.
- **Unplanned Development**: The strategy for developing a city includes unplanned development, which exacerbates the divide between the rich and the poor that exists in metropolitan areas.
- **Slums are overflowing**: There are approximately 13.7 million slum dwellings in the country, which contain a population of 65.49 million people.
  - In India, up to 65 per cent of cities have neighbouring slums, where people live in small dwellings next to one other.
- **Inadequate Housing:** The great majority of city dwellers live in filthy circumstances and in densely populated areas.
- **Problems Caused by the Pandemic: The Covid-19 pandemic h**as worsened the plight of the urban poor and slum residents. Slum dwellers' capacity to earn a living was seriously harmed by the sudden imposition of a complete Covid shutdown.
- **Non-Inclusive Welfare Programs**: The benefits of welfare programmes for the urban poor sometimes only reach a tiny percentage of those who are eligible.
  - Slum residents do not get the majority of relief cash and benefits, owing to the fact that these settlements are not legally recognised by the government.
- Heritage of Past construction: With few exceptions, most of the cities of the town have grown without the early guidance of comprehensive city plans. Some which have grown, based on the plan, have now outgrown their earlier designs.

# 'CLASS GHETTOIZATION' AND MIGRATION TO URBAN AREAS

• 'Class Ghettoization' refers to the phenomenon of isolating the members of one class in a separate place. This manifests into inequality at the socio-economic and political level. This is gaining its pace in India because of the growing urban population and unplanned urbanisation.

### THE FAULTY PATTERN OF URBANIZATION:

• **Due to overpopulation and better pull factors**, the urban city gives rise to new areas called suburbs. **But due to unplanned urbanisation and suburbanization**, there are pockets of slums developed in between them.





- **E.g. Sanjay Colony** is a slum in South Delhi situated in the Okhla industrial area.
- Any compact housing cluster of 20 households with poor infrastructure and inadequate sanitation facilities is referred to as a slum as per the **2011 census definition**.

### SOCIAL-CULTURAL IMPLICATIONS:

- **Gated communities**: The rise of gated communities manifest into cosmopolitan areas surrounded by lower-middleclass, poor ghettos/slums. This creates a huge socio-cultural divide between these areas.
- **Social Immobility**: lack of opportunity leads to the informalization of ghettos in terms of employment which results in a lack of upward social mobility.
- **Unconnected with home**: Due to the nature of the job, they remain socially and politically unattached from their hometown thus further delineating them from society.
- **Double Jeopardy:** Slums are habited by lower castes, minorities, and the poor from rural areas hence caste and religious ghettoization further augment their alienation. Most of them are illegal habitations, living under constant threat of removal.
- **Mental Health**: Huge mental barrier between the different habitations of slums and so-called civil habitations; there is a feeling of inferiority complex in slum habitats thus inhibiting their growth as proper humans.
- **Education and Public health**: They have to rely on public schools and hospitals which majorly are in an archaic state. Whereas others have good convents and private hospitals 24/7 with world-class facilities.
- Water supply and sewerage problem: Slum dwellers have to rely on tankers which is also not regular and the issue of tanker mafias exists. In spite of Swachch Bharat Abhiyan, basic sewerage issue pertains.
- **Infrastructure**: There is a visible difference in terms of street lights, roads, community gardens etc.
- **Economy**: The slums and suburbs serve as employees of the cosmopolitan population as household workers, and employees of companies owned by cosmopolitan people.
- In formalisation of employment: mainly employed as rag pickers or low-paying uncertain jobs like fruit thela etc.
- **Urban crime**: Due to lack of basic amenities, opportunities, alienation, and in formalisation of employment, the youth are more prone to crime exposure.
- **COVID-19 impact**: This pandemic has further deteriorated their fragile lifestyle due to a standstill economy.

### **MEASURES/SUGGESTIONS:**

- **AMRUT (2015):** Assuring that every family has access to a tap with a guaranteed supply of water and a sewer connection is the goal of the Atal Mission for Urban Rejuvenation and Urban Transformation.
- **Pradhan Urban Mantri Awas Yojana (PMAY-U: 2015):** By offering a rebate on the Interest Rate of a Home Loan during Repayment via EMI, it makes Home Loans Affordable for the Urban Poor.
- **In-situ Slum rehabilitation programs (2013):** It will remove the fear of removal from their sites e.g. PM Awas Yojana, "Jahaan Jhuggi Wahin Makan" scheme of Delhi Government, etc.
- **Smart City Mission** has the potential to mitigate poverty in the cities as it aims to target basic services for the people in a holistic manner.
- **Right-Based Employment:** Similar to MGNREGA there should be an urban counterpart to provide rights-based employment.
- **Positive Engagement:** There should be constant positive engagement between the so-called developed islands and slums by bridging the cultural gaps through various cultural programmes.
- **Gender-sensitive infrastructure** should be a priority as it has a positive role in health, education, income, and housing in slum families. Had this been in place, slums like Dharavi would not be in the news for being a COVID-19 hotspot.
- **Urban Waterbody Information System (UWAIS):** Provide real-time information on the water spread area for all the water bodies in the country using automated feature extraction algorithms.

**Article 38** of the Indian constitution endeavours to eliminate inequalities in status, facilities and opportunities, not only amongst individuals but also amongst groups of people residing in different areas or engaged in different vocations. Thus, at the earliest the shoots of class ghettoization are removed, the better will be to realise Article 38.

### HUMAN SETTLEMENTS AND AIR POLLUTION

Along with urbanisation comes industrialisation, vehicular pollution and the burning of fossil fuel. Noxious industrial fumes or dust from various industries such as VPT or for that matter vehicular pollution, the geographical location of the city is acting as a catalyst for the rapid growth of air pollutants.

### **FACT-WISE**

India was the 5 most polluted country in 2019, with Ghaziabad in the National Capital Region ranked as the most polluted city in the world, according to a global compilation of PM 2.5 particulate pollution data by IQAir.





# **IMPACT OF AIR POLLUTION**

- **Urban heat island effect**: "Rapid urbanisation has led to the growth of concrete jungle and blacktop roads.
- Almost 85 per cent of the urban area is covered with concrete structures and metal roads. This is **trapping the solar energy and results in the creation of the Urban Heat Island (UHI) phenomenon**.
- Health Issues: Long-term exposure to outdoor and household air pollution contributed to over 1.67 million annual deaths from stroke, heart attack, diabetes, lung cancer, chronic lung diseases and neonatal diseases in India in 2019, according to the State of Global Air 2020.
- **Regarding Biodiversity:** Air pollution emissions' detrimental impacts may have an effect on the diversity of life on Earth.
  - Because of air pollution, SO2 and NOX emissions in the atmosphere undergo oxidation and moist deposition, which results in acid rain. In turn, this means that **acid rain** may harm our biodiversity.
- **On Buildings and Materials:** Emissions of SOX and NOX can damage plant and animal life, as well as material surfaces and potentially cause structural damages.
  - One such illustration is India's **white-marble Taj Mahal**, which is turning yellow as a result of acid rain and SOX emissions from industry.

### **CAUSES OF AIR POLLUTION**

- **Unplanned urbanization:** haphazard growth of urban areas has led to the proliferation of slums and poor public transport has increased the burden of personal vehicles on the road.
  - $\circ$   $\;$  Landfills used for waste management also release pollutants in the air.
- Burning of urban waste, diesel soot, vehicular exhaust, road and construction dust, and power generation.
- **Poor governance:** the issue of environment and pollution is still to get the policy priority it deserves.
  - While agencies like CPCB and SPCBs continue to be under-resourced and understaffed,
  - The multiplicity of the state authorities at the ground level leads to poor coordination, lax enforcement of rules, and lack of accountability as seen in Delhi.
  - The absence of environmental governance continues to be a major challenge.
- **Transportation:** Private car use—particularly older, diesel-powered models—is the main contributor to urban air pollution.
- **Fireworks:** Firecrackers were nevertheless used extensively during Diwali despite the ban. Although it might not be the main reason for air pollution, it undoubtedly helps it to build up.

# STEPS TO COMBAT AIR POLLUTION

- National Clean Air Programme (NCAP): It was intended to build and strengthen the institutional capacity to monitor air quality across India.
- **Prana Portal:** It was introduced in Non-Attainment Cities (NAC), or cities that could not satisfy the Ambient Air Quality Standards under NCAP, as part of the National Clean Air Programme (NCAP).
- The National Air Quality Index (AQI) is being launched.
- Disincentivising Personal Vehicle Use: Governments should make the use of personal vehicles in cities less attractive through strict road pricing mechanisms like Congestion tax, and Green-house Gas tax.
- Renewable Energy: Need to speed up the journey towards LPG and solar-powered stoves.
- Addressing vehicular emissions is within India's grasp but requires a multi-pronged approach. It needs to combine the already-proposed tighter emission norms (in the form of BS-VI), with a push for shared mobility and public transport and the adoption of alternate mobility technologies.
- Flue Gas Desulphurization: Industries in urban areas must comply with desulphurisation norms.
- **BS VI Vehicle:** A quantum jump from BS IV to BS VI and subsequent electric vehicles would be a step in the right direction.
- **Vehicle scrapping policy:** It would arrest the increasing pollution from old vehicles in an economically sustainable way.
- **National ambient air quality standards:** Notification of industry-specific emission and effluent limits as well as national ambient air quality standards.

Combating air pollution is a public concern and, as a result, everyone's responsibility. As a result, organised and coordinated efforts with active participation from all stakeholders are required. This should involve the federal, state, and municipal governments, as well as cities, the general public, and people.

# HUMAN SETTLEMENTS AND WATER POLLUTION

• With rapid urbanisation, the country is facing a massive waste management challenge. Over 377 million urban people live in 7,935 towns and cities and generate 62 million tonnes of municipal solid waste per annum.





• Lakes/water bodies are battling: waste disposal, deposition of pollutants and Continuous disposal of waste have severely depleted the lake's water quality.

# **FACT-WISE**

- Only 43 million tonnes (MT) of the waste is collected, 11.9 MT is treated and 31 MT is dumped in landfill sites.
- According to the World Bank, India's daily waste generation will reach 377,000 tonnes by 2025.

### DISMAL SITUATION OF URBAN WATER BODIES IN INDIA

- **Unplanned Expansion:** Because of unplanned expansion, some of India's major urban centres have become home to dying Water bodies, disrupting water systems and vegetation cycles.
- Some City Specific Situation:
  - **In the National Capital Territory of Delhi** alone, due to haphazard urbanisation, as many as 232 Water bodies are already off the recovery list.
  - Bangalore lost at least 66 Water bodies between 1973 and 2007.
  - **Chennai has fared the worst in conserving Water bodies**. All that remains in the name of a wetland ecosystem in the city, is the Pallikaranai marsh, which has shrunk to a tenth of its size since 1965.

### SIGNIFICANCE OF URBAN WATER BODIES

- **Reduce urban heat island effect**: Water in Water bodies will absorb more heat before the surrounding begins to get warmer and subsequently evaporates. Furthermore, Water bodies also reflect solar radiation, giving a moderating effect.
- **Water bodies stabilize the microclimate parameters:** such as relative Humidity, temperature and air movements etc. Water bodies regulate the diurnal variation of air temperature, making it ambient.
- COP 13 of the Ramsar convention was centred around the theme of 'Water bodies for a Sustainable Urban Future', marking the importance of urban Water bodies by providing drinking water, livelihoods, recreation, flood absorption, reducing temperatures, and filtering waste.
- **Carbon Sequestration:** Instead of releasing carbon dioxide into the atmosphere, plant communities and soils retain carbon.
- **Employment Generation:** Through waterways, fishing, etc.
- **Daily Water Requirement:** Due to the high per capita consumption of water the significance of urban water bodies is huge.
- **Religious Purpose:** Water has historically been worshipped in Indian culture.

### **CAUSES OF URBAN WATER BODIES POLLUTION**

- **General Cause:** They are polluted through agricultural runoff and discharge of untreated sewage and other waste from urban areas. Under normal conditions, water bodies do retain pollutants from surface and subsurface runoff from the catchment and prevent them from entering into streams and rivers.
- **Rapid Unplanned Urbanisation:** Rapid urbanisation in India during the recent decades has given rise to several environmental problems such as water supply, wastewater generation and its collection, treatment and disposal.
- **Discharge of untreated sewage: Nearly 80% of the water supplied for domestic use passes out as wastewater.** In most cases, this wastewater is let out untreated and causes large scale pollution of the surface water.
- **Industrial Discharge**: Their solid wastes and sludges get scattered around or dumped in unlined pits and effluents flow to streams through storm- drains or stagnate in depressions to percolate, leach or get washed-off during the next rainy season.
- **Limitations of State authorities**: the state Disaster Mitigation Plan has a limited scope when it comes to intervening in matters of unplanned urban infrastructure, including drainage and urban sewage systems.
- **Religious and Social Practices:** Carcasses of cattle and other animals are disposed of in rivers or water bodies. Dead bodies are cremated on the water bodies. Partially burnt bodies are also flung into the water bodies.
- All this is done as a matter of religious faith and in keeping with ancient rituals. These practices pollute the river water and adversely affect the water quality.

# WAY FORWARD TO IMPROVE THE CONDITIONS OF URBAN WATER BODIES

- **Improving the capacity of urban drainage systems**: so it would manage waste discharge and municipal waste effectively.
- **Restricting encroachment** and fragmentation of urban water bodies.
- **Ensuring planned Urbanization** so that it takes the delineation and protection of catchment areas, drainage channels and areas of lakes, ponds etc.
- **Stakeholder participation and capacity building** for better management of urban water bodies.
- **Proper monitoring of industrial waste** through enforcing the Environment Protection Act, 1986.





Water bodies act as detoxifiers to purify the environment and as a sponge and sluice to protect the urban ecosystem from hazards posed by numerous anthropogenic and geomorphological factors.

# URBAN FLOODING AND HUMAN SETTLEMENT

- Urban flooding is the term used to describe the flooding of land or property within a constructed environment, especially in locations that are more densely inhabited (like cities), as a result of excessive rainfall that exceeds the capacity of drainage systems.
- Urban flooding, in contrast to country floods (heavy rain over flat or low-lying terrain), is a result of both increased precipitation and unplanned urbanisation (catchments), which-
  - Increases the flood volumes by up to 6 times.
  - Increases the flood peaks from 1.8 to 8 times.

# CAUSES OF URBAN FLOODING IN INDIA:

- **Encroachments on drainage channels:** Due to rising land prices and a lack of available land near the city centre in Indian cities and towns. Low-lying areas are seeing an increase in new construction, typically as encroachments over lakes, wetlands, and riverbeds.
- **Climate change:** Extreme events are exacerbated by a changing climate. The frequency of brief, intense downpours has increased due to climate change, resulting in greater water runoff.
- Unplanned Tourism Activities: For many years, water features have served as a draw for the growth of the tourism industry. In order to maintain tourism, water plants that slow runoff are being removed from rivers and lakes.
  Example: Oil spills from boats have contaminated Ashtamudi Lake in Kollam, Kerala.
- **Uninformed Release of Water from Dams:** When dams and lakes release water unexpectedly and suddenly, it causes floods in metropolitan areas without giving the populace time to prepare.
  - An illustration is the 2015 Chennai floods brought on by the opening of Chembarambakkam Lake.
- **Illegal Mining:** The natural bed of rivers and lakes is depleted by illegal mining of quartzite and river sand for use in building projects. Jodhpur's Jaisamand Lake and Tamil Nadu's Cauvery River are two examples.

### **IMPACT OF URBAN FLOODING:**

- **Loss of Life and Property:** Urban floods frequently result in fatalities and bodily injuries, either directly as a result of the flood's effects or indirectly as a result of water-borne illness infections that spread during the period of flooding.
- **Ecological Effects:** During significant flooding episodes, trees and other vegetation are wiped away, and fast-moving floodwater erodes riverbanks.
- **Effects on Human and Animal Health:** Storm water stagnation in the area and tainted potable water cause a variety of health issues that can cause plagues or epidemics.
- **Psychological Effects:** Losing a place to live and family members causes emotional distress in the stranded's mental health. In such cases, recuperation is a laborious and drawn-out process that frequently results in psychological damage that lasts a lifetime.

# CLIMATE CHANGE IMPACT ON COSTAL INDIA CITIES

- **Unfit Cropland:** 8% of today's cropland will be climatically unfit by 2100 even with modest greenhouse gas emissions, or a rise in world temperatures of less than 1.6°C.
- **Seal level Rise:** 27 million people in Mumbai may be affected by climate change by 2035, with a high risk of flooding and sea level rise.
- **Urban Heat:** There is a significant chance that Ahmedabad's 11 million residents will spend their days in a region with significantly higher temperatures than the surrounding districts.
- **Species Extinction:** Up to 18% of all species on land will be at a high risk of going extinct by the year 2100 at a global warming level of 2°C. Every second plant or animal species will be in danger of going extinct if global warming reaches 4°C.
- **Extreme Events:** If average global temperatures rise by 1.5°C by 2100, children who are 10 years old or younger are expected to endure a nearly four-fold increase in extreme events. A 3°C rise in temperature will result in a five-fold increase in extreme weather.
- Wet Bulb Temperature: By the end of the century, the proportion of people exposed to fatal heat stress is predicted to rise from 30% to 48%-76% globally.
- **Difficult Work Environment:** In some regions of South Asia, the number of days with climatically stressful conditions for outdoor workers may rise by up to 250 workdays annually if the world warms by more than 4°C by the year 2100, which will also lead to lower food output and higher food prices.
- **Chronic Water Scarcity:** At a 2°C warming, droughts are predicted to cause chronic water scarcity for 800 million to 3 billion people worldwide.





• Loss of Biodiversity: Coastal regions consists of a high level of biodiversity.

### CLIMATE SMART CITIES ASSESSMENT AND ITS IMPACT

To inculcate Climate-Sensitive Approach to Urban Planning and Development the Climate Smart Cities Assessment framework, for 100 smart cities, was launched by the Ministry of Housing and Urban Affairs. The framework has 30 diverse indicators, across 5 sectors, that monitor and guide the cities to help them to assess their own preparedness to tackle the issue of climate change as well as degrading air quality.

### MANDATE

- **Energy and Green Buildings**: It aims to achieve energy-efficient street lighting in the city, green building adoption and promotion. With this energy demand of cities is met in a sustainable way so that pollution is minimized.
- **Urban Planning, Green Cover & Biodiversity**: Increase in green cover promotes biodiversity and maintains ecological balance. It will make an effective heat sink in cities and further diurnal temperature patterns would not get adversely affected. Apart from this, it will make cities disaster resilient.
- **Mobility and Air Quality**: Adequate availability of Public Transport would be ensured along with this Clean Technologies shared vehicles promoted so that minimum vehicular pollution occurs. Thus phenomena like temperature anomaly, urban heat islands and air pollution are tackled in urban areas.
- Water Resource Management: Effective Water Resources management and adoption of an energy-efficient wastewater management system ensures the availability of potable water and reduces the pollution of water. Thus it will support local water bodies and flora and fauna there. Further flood/ water stagnation risk would be minimized through efficient drainage patterns.
- Waste Management: It aims to manage landfills and dump sides on scientific lines so that a minimum amount of toxic gases and polluting gases get discharged into the atmosphere. Further dry waste is recovered & recycled leading to waste minimization.

#### SIGNIFICANCE

- This program will provide us with yardsticks which we can then use to modify our plans towards fighting climate change.
- Also, the framework is expected to create awareness, citizen engagement, and an environment of Key Performance Indicator-driven spending and promote a circular economy.
- The focus is clearly on the community, the neighbourhood and the citizen; and tangible steps that can be taken towards the clear impacts.

### CONCLUSION

• At present India is seeing a high pace of urbanisation but its unplanned nature and deregulated development created socio-economic implications. The situation further worsened due to its interwoven relation with climate change. The Climate Smart Cities Assessment framework breaks this intricate bonding and through this sustainable development goal 11 (Sustainable cities and communities) can be achieved.

# SUSTAINABLE CITIES INDIA PROGRAM

- The National Institute of Urban Affairs (NIUA) and the World Economic Forum have signed a Memorandum of Understanding (MoU) to work together on a jointly developed "Sustainable Cities India programme."
- **Objective:** 'Sustainable Cities India' aims to make it possible for cities to decarbonize in a methodical and sustainable fashion that will lower emissions and produce resilient and equitable urban ecosystems.
  - This programme works hand in hand with India's pledge at COP26 to achieve net zero emissions by 2070.
- **Components:** In five to seven Indian cities over the course of two years, the Forum and NIUA will adapt the Forum's City Sprint process and Toolbox of Solutions for decarbonization.
  - **City Sprint Process:** A series of workshops including representatives from business, government, and civil society is part of the City Sprint initiative, which aims to facilitate decarbonization, particularly through clean electrification and circularity.
  - **Toolbox Solution:** It offers a digital platform with more than 200 examples of best practices for clean electrification, efficiency, and smart infrastructure in buildings, energy systems, and mobility from more than 110 towns worldwide.

# SMART CITY MISSION: A REMEDY TO INDIA'S UNPLANNED URBANISATION

• It is an innovative programme under the **Ministry of Housing and Urban Affairs** of the Government of India that aims to boost economic growth and improve people's quality of life by facilitating local development and utilising technology to produce smart outcomes for citizens.



# **PRAHAAR ReDEFINED 3.0: GEOGRAPHY & DM**



- **Objective**: It focuses on inclusive and sustainable development, as well as looking at compact regions to establish a replicable model that will serve as a beacon for other ambitious cities.
- **Scope**: From the financial year (FY) 2015-16 to 2019-20, the Mission will cover 100 cities over a period of five years.

# ISSUES ASSOCIATED WITH THE SMART CITY MISSION:

- **Inadequate private participation**: At the outset, the Smart City Mission set a goal of private participation funding 21 per cent of the overall mission cost.
  - Only 15% of the projects currently being implemented are in the form of a public-private partnership (PPP).
- **Financial Mismanagement**: While the top 60 cities have reported all of their projects, and the costs of most projects are specified in the project proposals (94 per cent), only 17 cities were able to identify the sources of funding at the project level.
- **Increased focus on a few key areas**: Such as transportation, energy and ecology, water and sanitation, housing, and economy, which account for over 80% of the SCM budget.
  - Other financing categories like IT, governance, culture and heritage, and health and education account for barely 15% of the total.

### **Success Stories in Smart Cities Mission**

- Ahmedabad: Free Wi-Fi on BRTS corridors in Ahmedabad increased ridership by 20,000 in March 2018 over February 2018.
- **Bhopal**: Property tax receipts have increased in Bhopal, and the city's transportation services may now be tracked online.
- **Rajkot**: The crime rate has dropped by 18% in the last two quarters, and traffic challan issuing has improved, indicating a shift in behaviour. Littering, public urination, and garbage burning at night have all decreased as a result of the cleaning effort being monitored by CCTV cameras.

# WAY AHEAD FOR SUSTAINABLE AND INCLUSIVE HUMAN SETTLEMENT

- **Inclusive Cities**: In cities, the poor and lower-income groups must be integrated into the mainstream.
  - The planning should take into account the needs of the marginalised groups, such as housing, health, water, transportation, and other services at reasonable pricing.
- **Urban Governance**: India's city governance needs to be overhauled. Large cities throughout the world have empowered mayors with long terms and clear accountability for the city's success, in contrast to India's current urban governance.
- **Integration**: To establish sustainable cities or metropolitan regions, and integrate multiple urban development and related programmes at the municipal, state, and national levels.
- **Devolution**: It must be accompanied by greater reforms in urban finance, which will lessen cities' reliance on the federal government and states while also releasing internal revenue streams.
- **India must make urban planning a central**: By recognised function by investing in talented people, a rigorous fact foundation, and innovative urban design.
  - This can be accomplished through a "**cascaded**" **planning structure** in which large cities have metropolitan-level 40-year and 20-year plans that connect municipal development plans.
- **Affordable housing**: It is a significant concern for low-income populations, and in the absence of a feasible model that meets their needs, India can tackle the problem by enacting a series of regulations and incentives that would bridge the price-affordability gap.
- **Delivery of Services**: The major job of ULBs should be to manage the water supply and sewerage system. They should be in charge of water supply and distribution in their geographical jurisdictions, whether from their own sources or through collaboration with parastatals and other service providers.

In recent years, the government has launched a number of initiatives targeted at urban planning and administration, including Smart City, AMRUT, Digital India, Swach Bharat, and HRIDAY. For these programmes to succeed, they need a solid foundation of effective planning and management.





# 7.LAND USE PATTERN AND ITS CHANGING TREND

- India's land use pattern is characterized by a diverse range of sectors.
  - **Agriculture** is a dominant sector, with land primarily used for growing food crops like rice, wheat, and pulses, as well as cash crops such as cotton, sugarcane, and oilseeds.
  - **Forests cover** a significant portion of the country, serving as habitats for wildlife, sources of timber, and contributors to biodiversity conservation.
  - **Urban areas** are expanding rapidly, resulting in the conversion of agricultural and rural land into residential, commercial, and industrial zones. Industrial land is dedicated to manufacturing and industrial activities.
- These land use sectors interact with each other, and the dynamic nature of India's land use reflects the country's unique geographical and socio-economic characteristics.

### **FACT-WISE**

- According to the Agricultural Census of 2015-16, the total reported area of operational holdings in the country was around 159.59 million hectares, with a net sown area of approximately 140.05 million hectares.
- According to the India State of Forest Report 2021, the total forest cover in the country was estimated to be around 7,13,789 square kilometers, which accounts for approximately 21.71% of the total geographical area of India.
- According to the wasteland mapping exercise conducted by the **Indian Space Research Organisation (ISRO)**, the total wasteland area in India was estimated to be around 55.76 million hectares.

# LAND USE PATTERN IN INDIA

- The use of land is **determined both by physical factors** such as topography, climate, soil types **as well as human factors** such as population density, technological capability and culture and traditions etc. India has land under a variety of relief features such as:
  - **Agricultural Land:** About 43 per cent of the land area is plain, which provides facilities for agriculture and industry. Dominant land use pattern with diverse crops like rice, wheat, pulses, cotton, sugarcane, oilseeds, and fruits/vegetables; varies by region.
  - **Forests:** Significant forest cover for timber, wildlife conservation, and ecosystem services; including rainforests, deciduous forests, coniferous forests, and mangroves.
  - **Urban Areas:** Rapid urbanization with residential, commercial, industrial, and institutional land uses; infrastructure for housing, offices, shopping centres, education, healthcare, and industries.
  - **Industrial Areas:** Concentrated regions for manufacturing and industries; sectors include textiles, automobiles, steel, chemicals, pharmaceuticals, electronics, and food processing.
  - **Water Bodies:** Rivers, lakes, ponds, and reservoirs used for irrigation, drinking water, hydropower, and fisheries; some areas are designated for conservation.
  - **Infrastructure and Transportation:** Land allocated for roads, highways, railways, airports, and ports to facilitate the movement of people and goods.
  - **Rural Settlements:** Villages and agricultural areas primarily for farming, characterized by clusters of houses, farmland, and supporting infrastructure.
  - **Coastal Areas:** Land along the coastline used for activities like fishing, aquaculture, salt production, and tourism.
  - **Mountains and Hill Regions:** Hilly terrains utilized for agriculture, horticulture, tea gardens, and forest plantations, as well as for tourism and hydropower generation.
  - **Desert Regions:** Arid and semi-arid regions with specialized land use patterns, such as the cultivation of drought-resistant crops and animal husbandry adapted to the desert environment.

### SDG 15: Life On Land

By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.

# LAND USE PLANNING

- **Regulate usage of land**: Land Use planning encompasses the development of policies to effectively regulate the usage of land. This is to be done for maximizing the use of the available resources and achieving more desirable outcomes in both social and environmental areas.
  - This includes considerations such as setting aside areas for specific land uses (e.g., residential, commercial, industrial, agricultural), determining permissible densities and building heights, and controlling the location and scale of development projects.
  - Through regulation, land use planning helps maintain order, prevent haphazard development, and promote efficient and sustainable land use practices.

# PRAHAAR ReDEFINED 3.0: GEOGRAPHY & DM



- **Modern land use goals:** The goals of modern land-use planning often include environmental conservation, restraint of urban sprawl, minimization of transport costs, prevention of land use conflicts, and a reduction in exposure to pollutants. For instance,
  - National parks and wildlife sanctuaries are established to conserve ecosystems and safeguard endangered species. Land use policies can also prioritize the preservation of wetlands, forests, and coastal areas to maintain biodiversity and ecological balance.
  - By promoting higher-density development within existing urban areas, land use planning helps limit the conversion of agricultural or natural lands into sprawling suburbs.
  - Transit-oriented development encourages mixed-use projects near public transportation hubs to reduce the reliance on private vehicles.
  - Buffer zones can be established to separate noisy or polluting industries from residential areas.
  - Residential areas can be zoned away from industrial zones or major roadways to reduce air and noise pollution.

# IMPORTANCE OF LAND USE PLANNING

- **Sustainable Development:** It promotes sustainable development by ensuring the efficient use of land resources and balancing economic, social, and environmental considerations. For example, it can facilitate the preservation of agricultural lands for food production, protect natural habitats and ecosystems, and guide the location of infrastructure to minimize environmental impacts.
- **Conflict Resolution and Compatibility:** It helps resolve conflicts and ensure compatibility between different land uses. It establishes clear guidelines and zoning regulations to prevent incompatible activities from coexisting, such as locating industrial facilities away from residential areas or preserving cultural heritage sites in urban development plans.
- **Disaster Risk Reduction:** It plays a crucial role in mitigating and managing the risks associated with natural disasters. For instance, it can designate floodplains as non-buildable areas, ensure proper drainage systems, and restrict development in high-risk zones prone to earthquakes or landslides.
- **Preservation of Agricultural Land:** It helps preserve agricultural land, ensuring food security and supporting the livelihoods of farmers. For instance, land use regulations may restrict the conversion of productive agricultural land for non-farm purposes, preserving the integrity of agricultural landscapes.
- **Conservation of Natural Resources:** It contributes to the conservation of natural resources, such as forests, wetlands, and water bodies. For example, land use plans may include provisions for the protection and restoration of riparian zones to safeguard water quality and maintain ecosystem services.
- **Climate Change Adaptation:** It plays a vital role in climate change adaptation by considering the vulnerability of different areas to climate risks. For example, land use plans may incorporate measures such as green infrastructure or wetland restoration to enhance resilience and reduce the impacts of extreme weather events.
- **Economic Development and Investment:** Land use planning provides a framework for attracting investments and promoting economic development. For example, land use plans may designate specific areas as industrial parks to encourage the establishment of manufacturing facilities and create employment opportunities.

### **PW-ONLYIAS EDGE: KEY PHRASES FOR MAINS**

• Efficient Land Use, Land-Use Change and Forestry (LULUCF); Land Degradation Neutrality (LDN); Regulate usage of land; Modern land use goals; Optimize use of Scarce Land; Sustainable land management; Life on Land; Displacement and dispossession; Diversion of Forests Land; Community land; Culturable Waste Land; Deforestation and Land Erosion and degradation; Unregulated human interference.

### IMPACT OF LAND USE CHANGE

- **Increases pressure on land:** Human influence on land and natural resources is accelerating due to population growth and increasing food requirements. Increasing agricultural intensity puts pressure on land resources and the overall environment.
- Displacement and dispossession:
  - **Developmental displacement:** An estimated 50 million people have been displaced due to 'development projects' in India over 50 years. Displacement includes projects such as dams, mines, industrial development, and the creation of wildlife sanctuaries and national parks.
  - **Dam-induced displacement:** The Polavaram Multipurpose irrigation project in Andhra Pradesh, Chhattisgarh, and Odisha has resulted in the displacement of approximately 117,034 people across 276 villages.
  - **Creation of Protected Areas:** Approximately 100,000 people have been displaced by the creation of Protected Areas between 1970 and 2008. Tribal communities accounted for around 40% of the project-affected and displaced people from 1951 to 1980.





- Loss of livelihood: Land use change leads to the loss of access to agricultural lands, forest areas, and grazing lands, impacting livelihoods and quality of life.
  - Examples include the Parsa East Kete Besan coal mine in Chhattisgarh, which involves a land use change of 2,711.034 hectares and affects the livelihoods of tribal and traditional forest dwellers.
- **Causes environmental degradation and pollution:** Land use change results in a decline in agricultural productivity, groundwater contamination, and other environmental impacts. These effects have long-lasting consequences on health, the economy, and social well-being.
  - The changes in land-use dimensions and decreasing green cover could be possible reasons for Bengaluru experiencing a rise in local temperature. While the built-up area has increased in the last two decades, the green cover and water bodies have decreased considerably. The city is also continuing to experience a decrease in the diurnal temperature range (DTR).

### CHANGING TRENDS IN LAND USE PATTERN IN INDIA

Land-use in a region, to a large extent, is influenced by the nature of economic activities carried out in that region. However, while economic activities change over time, land, like many other natural resources, is fixed in terms of its area. There are **three** types of changes that an economy undergoes, which affect land use.

- 1. **The size of the economy**: Grows over time as a result of increasing population, change in income levels, available technology and associated factors. As a result, the pressure on land will increase with time and marginal lands would come under use.
- 2. **Composition of Economy**: The secondary and the tertiary sectors usually grow much faster than the primary sector, specifically the agricultural sector.
- 3. **Dependency of a particular sector like agriculture:** Though the contribution of agricultural activities reduces over time, the pressure on land for agricultural activities does not decline.

# THE REASONS FOR CONTINUED PRESSURE ON AGRICULTURAL LAND

- **Slow decline in the agricultural sector's share in GDP:** The share of the population dependent on agriculture in India is declining at a slower rate compared to the decline in the sector's share in GDP. This leads to continued pressure on agricultural land as the number of people that the sector has to feed keeps increasing.
- Shift of land from agricultural to non-agricultural uses: In developing countries like India, there is a gradual shift of land from agricultural uses to non-agricultural uses, particularly around large urban areas. Agricultural land is being converted for building purposes, resulting in the loss of agricultural land.
- **Sharp rise in non-agricultural areas:** The area under non-agricultural use has witnessed a significant increase, while the extent of barren and uncultivated land has decreased. This indicates the diversion of land for non-agricultural purposes, further contributing to the pressure on agricultural land.
- **Diversion of forest land:** Forest land has been extensively diverted for other uses in recent times. This diversion has resulted in a significant reduction in forest cover, with a mere 3.2% increment between 1991 and 2009 compared to the 67% increase between 1951 and 1991.

# LAND USE CLASSIFICATION

Land can be classified on the basis of ownership as – private land and community land.

- 1. **Private land** is owned by individuals.
- 2. **Community land** is owned by the community for common uses like a collection of fodder, fruits, nuts or medicinal herbs. These community lands are also called common property resources.

### DIFFERENT TYPES OF LAND USE: CLASSIFICATION

- Land put to Non-Agriculture Use: Lands occupied by buildings, roads and railways or under water, & other lands put to uses other than agriculture.
- **Barren & Unculturable Land**: Land like mountains, deserts, etc. Land which cannot be brought under cultivation except at an exorbitant cost.
- **Permanent Pastures & Other Grazing Lands**: All grazing lands whether they are permanent pastures and meadows or not. Village common grazing land is included under this head.
- Land under Miscellaneous: Tree crops & other groves not included in net area sown This includes all cultivable land which is not included in 'Net area sown' but is put to some agricultural uses.
- **Culturable Waste Land**: Lands available for cultivation, whether not taken up for cultivation or taken up for cultivation once but not cultivated during the current year and the last five years or more in succession for one reason or other.
- **Unculturable Wasteland**: The land that cannot be developed for vegetative cover, for instance, the barren rocky areas and snow-covered glacier areas.







- **Fallow Lands other than Current Fallows**: This includes all lands, which were taken up for cultivation but are temporarily out of cultivation for a period of not less than one year and not more than five years.
- **Current Fallows**: This represents cropped areas, which are kept fallow during the current year.

# INCREASE AND DECREASE IN LAND USE

Four categories have undergone increases, while four have registered declines. Share of the area under forest, the area under non-agricultural uses, current fallow lands and net area sown have shown an increase. **The following observations can be made about these increases**:

- Non-Agricultural Land: The rate of increase is highest in land under non-agricultural uses due to the following reasons
  - **Changing Structure of Indian Economy**: This is due to the changing structure of the Indian economy, which is increasingly depending on the contribution from industrial and services sectors and expansion of related infrastructural facilities.
  - **Rapid Urbanization**: Expansion of area under both urban and rural settlements has added to the increase.
- **Reduction in Wastelands and agricultural lands**: It can be clearly observed that the area under non-agricultural uses is increasing at the expense of wastelands and agricultural land.
- **About Increase in Forest Cover**: Increased area under forest cover can be accounted for by an increase in the demarcated area under forest rather than an actual increase in the forest cover in the country.
- **Increase in Current Fallow**: The increase in the current fallow cannot be explained from information pertaining to only two points. The trend of current fallow fluctuates a great deal over the years, depending on the variability of rainfall and cropping cycles.
- **Decline in Net Sown Area**: Although there's an increase in net area sown which is a recent phenomenon due to the use of culturable wasteland for agricultural purposes. Before which it was registering a slow decrease. There are indications that most of the decline had occurred due to the increases in areas under non-agricultural use. While the pace of expansion of the gross sown area has slowed down, the net sown area is showing a negative trend.

# EXPLANATION TO DECLINING CATEGORIES OF LAND USE

- The four categories that have registered a decline are barren and wasteland, culturable wasteland, the area under pastures and tree crops and fallow lands.
- The following explanations can be given for the declining trends:
  - **Decline in Wastelands:** As the pressure on land increased, both from the agricultural and non-agricultural sectors, the wastelands and culturable wastelands have witnessed a decline over time.
  - **Decline in Culturable Wasteland:** The culturable wasteland, which is land that can be used for agriculture, has been reduced by half since 1951.
  - **Decline in Pastures:** The decline in land under pastures and grazing lands can be attributed to the pressure from agricultural land. Illegal encroachment, resulting from the expansion of cultivation on common pasture lands, is a major factor responsible for this decline.

# LAND UTILIZATION AND POPULATION DISTRIBUTION

Land is used for different purposes such as agriculture forestry, mining, building houses, roads and setting up of industries. This is commonly termed as Land use.

- Land use and Population Distribution: The uneven distribution of population in different parts of the world is mainly due to varied characteristics of land and climate.
- **Densely Populated Areas:** Plains and river valleys offer suitable land for agriculture. Hence, these are the densely populated areas of the world. In India population is mostly concentrated in coastal areas or in the region of fertile plains created by perennially flowing rivers. Population density has an impact on the intensity of land use.
- **Uninhabited areas:** The rugged topography, steep slopes of the mountains, low-lying areas susceptible to water logging, desert areas, thickly forested areas are normally sparsely populated or uninhabited.

# HOW DOES CHANGES IN LAND USE PATTERN OCCUR AND WHAT IS ITS IMPACT?

- Land Degradation:
  - **Continuous use of land without conservation measures:** Long-term use of land without proper conservation and management practices has led to land degradation.
  - **Increase in degraded land:** Most Indian states have experienced an increase in degraded land over the past 15 years, particularly in the biodiversity-rich northeastern states.
  - **Human activities exacerbating natural forces:** Human activities have accelerated natural processes that damage land, such as deforestation, overgrazing, and mining.





• **Example:** Deforestation and Land Erosion: Loss of vegetative cover has made land more susceptible to erosion. Water erosion, at a rate of around 12,000 million tonnes per year, leads to permanent depletion of topsoil, causing significant economic losses.

# • Landslides:

- **Land use change and vulnerabilities:** Unregulated human interference in land use change has increased vulnerabilities to landslides.
- **Construction-triggered landslide events:** India accounts for a significant percentage of construction-triggered landslide events globally, mainly due to factors like cutting the toe of hills for road construction.
- **Landslides triggered by rainfall and mining:** India also experiences landslides triggered by rainfall, particularly during the monsoon season, and mining activities.
- **Example:** Construction-triggered landslides: India accounted for 28% of construction-triggered landslide events globally, indicating the impact of land use change on landslide occurrences.

# • Soil Erosion:

- **Changing land use pattern and soil erosion:** Human interference through land use changes is a major contributor to soil erosion.
- **Impact of crop production and commercialization of agriculture:** Transitioning from natural vegetation to agriculture, especially for crop production, accelerates soil erosion rates.
- **Deforestation and increased pollution:** Conversion of forests to agricultural land leads to increased soil erosion, pollution, and sedimentation in water bodies.
- **Example:** Maharashtra's soil erosion: Over 70% of cultivated land in Maharashtra has been affected by erosion, with a significant portion no longer suitable for cultivation. Inappropriate agricultural activities and single-crop practices contribute to the problem.

# • Desertification and Land Use Change:

- **Land degradation and depletion:** Around 30% of India's land area has been degraded through deforestation, over-cultivation, soil erosion, and depletion of wetlands.
- **Depletion of wetlands:** Wetlands are being depleted due to deforestation, climate change, water drainage, land encroachment, and urban development.
- **Example:** Depletion of wetlands: India loses 2-3% of wetland area annually due to various factors, leading to the loss of valuable ecosystems.

# • Land Diversions:

- **Land diversion for industrial and non-agricultural purposes:** Significant amounts of land have been diverted for industrial and non-agricultural uses.
- **Diversion of common land in rural areas:** Common pool land resources, crucial for rural livelihoods, have been steadily declining, either becoming private household assets or leased to external entities.
- **Example:** Diversion of common land: Common land resources, such as community forests and grazing lands, are being diverted, negatively impacting landless and poor communities.
- Excessive population pressure on land:
  - **Population and land pressure:** India's large population and limited land resources result in significant pressure on available land for various purposes, including agriculture.
  - **Land fragmentation:** Small land holdings and division of agricultural land among heirs due to inheritance laws contribute to land fragmentation.
  - **Example:** Small land holdings: The average size of operational land holdings in India has decreased, with the majority being small and marginal holdings, impacting agricultural productivity.

# LINK BETWEEN LAND USE CHANGE AND CLIMATE CHANGE

- Emission of GHGs: Greenhouse gases (GHGs) such as carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) are released or absorbed through land use activities.
  - Land use activities can result in emissions of these GHGs into the atmosphere, contributing to climate change.
  - Activities like agriculture and cattle rearing are major sources of methane and nitrous oxide emissions, which are potent greenhouse gases.

• Land as a Source and Sink of Carbon: Land acts as both a source and a sink of carbon in the global carbon cycle.

- Activities such as deforestation and urbanization release stored carbon into the atmosphere, contributing to increased carbon dioxide levels.
- Conversely, soil, trees, plantations, and forests absorb carbon dioxide through photosynthesis, acting as carbon sinks and reducing atmospheric carbon dioxide content.
- Feedback Loops and Climate Feedbacks: Land use change can initiate feedback loops that amplify climate change.
  - For example, as temperatures rise due to greenhouse gas emissions, it can lead to changes in land cover and vegetation patterns, such as increased forest fires, dieback of forests, or shifts in vegetation zones. These changes further release carbon into the atmosphere, exacerbating climate change.

# **PRAHAAR ReDEFINED 3.0: GEOGRAPHY & DM**



- **ONLYIAS** BY PHYSICS WALLAF
- Impact of Land Use Change on GHG Emissions: Large-scale land use changes, such as deforestation, urbanization, or changes in cropping patterns, directly impact overall greenhouse gas emissions.
  - Deforestation releases carbon stored in trees, contributing to increased carbon dioxide levels.
  - Changes in agricultural practices can lead to increased methane and nitrous oxide emissions, exacerbating climate change.
- Shift in Land Use and Zoonoses: The UN Convention to Combat Desertification (UNCCD) has advised reversing land use changes to prevent zoonotic diseases like COVID-19.
  - Land use degradation, such as deforestation or habitat destruction, creates conditions that promote zoonotic diseases by increasing the interaction and proximity between animals and humans.
  - By preserving natural ecosystems and maintaining a balance between human activities and wildlife habitats, the risk of zoonotic disease transmission can be reduced.

### WAY AHEAD

- **Sustainable Land Management:** Promote sustainable land management practices that aim to conserve and restore ecosystems, minimize land degradation, and enhance soil health.
  - Implement measures such as agroforestry, conservation agriculture, and precision farming techniques to reduce the environmental footprint of agricultural activities.
- Land Use Planning and Regulation: Strengthen land use planning and regulation to ensure sustainable land use practices and prevent the conversion of valuable agricultural or natural lands for non-essential purposes.
  - Implement effective land-use zoning, land-use change assessment, and environmental impact assessment processes to guide land development decisions.
- **International Cooperation:** Foster international cooperation and collaboration to address land use change and climate change on a global scale.
  - Support initiatives such as the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention to Combat Desertification (UNCCD), and the Convention on Biological Diversity (CBD) to coordinate efforts and share best practices.
- **Policy and Financial Incentives:** Develop and implement policies that incentivize sustainable land management practices and discourage environmentally harmful activities.
  - Provide financial incentives, grants, and subsidies to support land restoration, reforestation, and sustainable agriculture initiatives.

# IPCC'S SPECIAL REPORT ON LAND AND CLIMATE CHANGE: LAND USE AS A TOOL AGAINST GLOBAL WARMING

- **Prevention and Reversal:** Avoiding, reducing, and reversing desertification improves soil fertility, increases carbon storage in soils and biomass, and enhances agricultural productivity and food security.
- **Creation of Green Walls and Dams:** Afforestation, tree planting, and ecosystem restoration programs can create windbreaks that reduce dust and sandstorms, protecting land from degradation.
- **Restoration Commitments:** Restoring and rehabilitating degraded land, with a target of 12 million hectares per year, can contribute to achieving Land Degradation Neutrality and help close the emissions gap.
- **Commitments and Recovery:** The Delhi Declaration and the Peace Forest Initiative aim to restore degraded land, achieve land degradation neutrality, and engage the private sector in taking action on climate change.
- **Sustainable Practices:** Implementing climate-smart agricultural practices, improving cropland and livestock management, adopting agroforestry, and increasing soil organic carbon content contribute to ecosystem conservation and land restoration.
- **Grassland Development:** Examples like the Banni region in Gujarat show that land restoration can be achieved by developing grasslands, supporting pastoral activities, and promoting indigenous techniques in degraded areas.
- **Biodiversity Protection:** Land is crucial for biodiversity, emphasizing the need to urgently address land use change to preserve diverse ecosystems.
- **Responsible Land Governance:** Implementing responsible land governance creates an enabling environment for ecosystem restoration, biodiversity protection, land use-based adaptation, and improving small-scale farmers' livelihoods.
- Waste Land Management: Proper management of waste lands, including control of mining activities and appropriate discharge and disposal of industrial effluents and wastes after treatment, reduces land and water degradation in industrial and suburban areas.

# UNITED NATIONS CONVENTION TO COMBAT DESERTIFICATION (UNCCD)

• Established in 1994, the United Nations Convention to Combat Desertification (UNCCD) is a legally binding international agreement that uniquely connects the environment and development to promote sustainable land management. It is the only convention that originated from a direct recommendation of the Rio Conference's Agenda 21.





• The UNCCD focuses specifically on addressing the challenges faced in arid, semi-arid, and dry sub-humid areas, collectively known as drylands. These regions are home to some of the most vulnerable ecosystems and communities, making their conservation and sustainable development a priority within the convention's framework.

### HIGHLIGHTS OF COP 15:

- The Union Minister for Environment, Forest and Climate Change delivered a speech at the fifteenth session of the Conference of the Parties (COP15) of the United Nations Convention to Combat Desertification (UNCCD) in Cote d'Ivoire, Western Africa.
- **Agenda:** The Conference agenda includes top items like drought, land restoration, and related enablers such as land rights, gender equality and youth empowerment.
- Theme: 'Land. Life. Legacy: From scarcity to prosperity'.
- COP 15 holds significant importance in the battle against desertification, land degradation, and drought, serving as a pivotal moment.
- It will leverage the insights from the second edition of the Global Land Outlook to provide tangible solutions to the intertwined issues of land degradation, climate change, and biodiversity loss.
- The Global Land Outlook (GLO), a prominent publication of the UNCCD, highlights the challenges faced by land systems, presents innovative policies and practices, and identifies cost-effective approaches to promote the widespread adoption of sustainable land and water management.

### **DESERTIFICATION:**

• According to **the UNCCD**, desertification is defined as "land degradation in arid, semi-arid and dry sub-humid areas

resulting from various factors, including climatic variations and human activities." It refers to the process by which fertile land becomes degraded, leading to a decline in productivity and the loss of vegetation cover. Desertification can result from factors such as drought, deforestation, overgrazing, improper agricultural practices, and climate change, among others.

- Causes:
  - **Climate Change:** Changes in climate patterns, including prolonged droughts and reduced rainfall, can accelerate the process of desertification by drying out the soil and vegetation.
  - **Deforestation:** The removal of trees and vegetation cover, often for agricultural expansion, logging, or fuelwood collection, contributes to soil erosion, reduces moisture retention, and increases the vulnerability of land to desertification.
  - **Overgrazing:** Excessive grazing of livestock beyond the carrying capacity of the land can lead to the degradation of vegetation, soil compaction, and erosion, making the land more susceptible to desertification.
  - **Unsustainable Agricultural Practices:** Poor land management practices, such as inappropriate irrigation techniques, excessive use of chemical fertilizers and



pesticides, monocropping, and improper soil conservation measures, can degrade the soil and contribute to desertification.

- **Land Mismanagement:** Improper land-use planning, inadequate land tenure systems, lack of land-use regulations, and uncontrolled land development can all contribute to land degradation and desertification.
- **Mining and Extractive Industries:** Unregulated mining activities, especially in arid and semi-arid regions, can lead to soil disturbance, contamination, and loss of vegetation, exacerbating desertification.
- **Poverty and Population Pressure:** Poverty, population growth, and the resulting demand for resources can lead to unsustainable practices such as overexploitation of natural resources, encroachment into marginal lands, and conversion of forests and grasslands into agriculture or settlements.

### **INDIA and UNCCD**

- India ratified the Convention to Combat Desertification in December 1996.
- The nodal ministry for the convention in India is the Ministry of Environment, Forest and Climate Change.
- India faces a huge desertification problem. A 2016 ISRO report stated that 29% of the land in India was degraded.





Achieving the dual objectives of safeguarding both human well-being and the environment will be unattainable unless developed nations assume the primary responsibility for significantly reducing emissions. This is because their historical and ongoing contribution to global warming is the most substantial. Additionally, landscape restoration goes beyond mere tree planting; it necessitates recognizing the value of indigenous and local wisdom in conjunction with scientific and technological advancements, while also integrating the needs of local communities.

# PREVIOUS YEAR QUESTION (MAINS)

The effective management of land and water resources will drastically reduce human miseries. Explain	2018
Mention the advantages of the cultivation of pulse because of which the year 2016 was declared the International	
Year of Pulses by the United Nations.	
The states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand reaching the limits of their ecological	
carrying capacity due to tourism. Critically evaluate.	







# **8.LOCATION OF PRIMARY, SECONDARY, AND TERTIARY SECTOR INDUSTRIES**

- According to **Section 2(j) of the Industrial Disputes Act of 1947**, "industry" is defined as any business, trade, undertaking, manufacture, or calling of employers, as well as any calling, service, employment, handicraft, or industrial profession or hobby of workers.
- The **industrial sector of the economy** is concerned with the manufacture of final products (vehicles, processed foods) and intermediate items (iron, steel, machinery).
- Manufacturing processes are the **core part of the industrial sector** transforming the natural material endowment primary commodities of utility through processing, assembling and repairing.

### DATA: ECONOMIC SURVEY 2022-23

- **GVA**: For the first half of FY 22–23, the Industrial Sector's overall Gross Value Added (GVA) increased by 3.7%, exceeding the 2.8% average growth seen in the first half of the previous decade.
- Growth of Export: From US \$4.4 billion in FY19 to US \$11.6 billion in FY22, electronics exports nearly tripled.
- Increase in MSMEs: Since January 2022, lending to Micro, Small and Medium-Sized Enterprises (MSMEs) has increased by an average of about 30%, and credit to big industries has increased by double digits since October 2022.
- **FDI Inflow**: From US \$180 million in FY19 to US \$699 million in FY22, FDI flows into the pharmaceutical industry have increased by a factor of four.
- **PLI Scheme**: To connect India to global supply chains, the Production Linked Incentive (PLI) programmes were created across 14 categories, with an expected investment of 4 lakh crore over the following five years.

### PRIMARY ACTIVITIES

- Primary activities are directly dependent on the environment as these refer to the utilization of earth's resources such as land, water, vegetation, building materials and minerals. It includes hunting and gathering, pastoral activities, fishing, forestry, agriculture, mining and quarrying. Atomic Energy Education Society
- Primary sector refer to that sector of the economy which uses natural resources to produce goods. The primary sector dominates in underdeveloped countries.

### **FACT-WISE**

- The Indian economy's primary sector accounts for 18.20% of the GDP.
- About 48.9% of the workforce is employed in the primary sector overall.

### HUNTING AND GATHERING:

- This economic activity depends on their **immediate environment for their sustenance**.
  - Hunters and gatherers subsist on:
    - Animals which they hunted.
  - The edible plants gathered from forests in the vicinity.
  - Geographical regions: Tribal belt of Central India and Hilly regions of North East and Eastern India.
    - In India largely tribal groups particularly PVTGs are engaged in hunting and gathering. E.g. Onges, Jarawas, Shompen of Andaman and Nicobar; Bondas of Odisha, Katkaris of Maharashtra.
- **Commercial opportunities:** In modern times some gathering is **market-oriented and has become commercial.** Gatherers collect valuable plants such as leaves, barks of s and medicinal plants and after simple processing sell the products in the market for beverages, drugs, cosmetics, fibres etc
  - **TRIFED**: The institution is working to provide remunerative prices for the products gathered by tribal.

# **PASTORALISM:**

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- **Domestication for subsistence**: Pastoralism undertakes **the domestication of animals** for subsistence. People living in different climatic conditions selected and domesticated animals found in those regions.
- **Status of practice**: Depending on geographical factors, and technological development, animal rearing today is practised either at the subsistence or at the commercial level.
- **Nomadic herding or pastoral nomadism** is a primitive subsistence activity, in which the herders rely on animals for food, clothing, shelter, tools and transport.
- **Geographical regions**: In mountain regions, such as **the Himalayas**, **Gujjars**, **Bakarwals**, **Gaddis and Bhotiyas migrate** from plains to the mountains in summer and to the plains from the high-altitude pastures in winter. Such seasonal migration is known as **transhumance**.

	Transhumance	Nomadic Pastoralism
About	The routine travel of herders and their cattle for	The erratic migration of the herds in search of new
	grazing and herding is known as transhumance.	pastures is known as nomadic pastoralism.




Region	It is primarily conducted in valleys and highlands of mountains.	It is carried out in areas having cultivable land.
Movement	Consistent and predictable	Random and irregular

### **COMMERCIAL LIVESTOCK REARING:**

- In rural India, raising animals is regarded as a business related to agriculture. Animal husbandry is a crucial part of Indian agriculture and provides a living for over 55% of rural residents.
- **Objective:** Making livestock useful for humans for a variety of uses, many of which have economic value, is the goal of animal rearing. As a result, it has a great potential to provide revenue and non-farm jobs in rural areas.
- **Products**: Important animals include sheep, cattle, goats and horses. **Products such as meat, wool, hides and skin are processed and packed scientifically** and exported to different world markets.
- Major countries: New Zealand, Australia, and the United States of America are important countries where commercial livestock rearing is practised.
- Status in India: According to the 20th Livestock census, India is
  - World's highest livestock owner at about 535.78 million
  - $\circ$  First in the total buffalo population in the world 109.85 million buffaloes
  - Second in the population of goats 148.88 million goats
  - Second largest poultry market in the world
  - o The second-largest producer of fish and also the second-largest aquaculture nation in the world
  - Third in the population of sheep (74.26 million)
  - Fifth in the population of ducks and chickens (851.81 million)
  - Tenth in camel population in the world 2.5 lakhs

### **FACT-WISE**

- Compared to an average of 14% for all rural households, livestock makes up around 16% of the revenue of small farm households. Additionally, it employs roughly 8.8% of the Indian population.
- India has abundant livestock resources, and the industry makes up 25.6% of all agriculture GDP and contributes 4.11% to the overall GDP.

### AGRICULTURE SECTOR IN INDIA

- **Economic Survey 2022-23**: The Indian agriculture sector has been growing at an **average annual growth rate of 4.6 per cent** during the last six years. It grew by 3.0 per cent in 2021-22 compared to 3.3 per cent in 2020-21.
- The **production of the Indian agricultural industry** has gradually expanded from 87 billion dollars to 459 billion dollars or 12% annually. In terms of agricultural production, we come in **second position**.
  - Of all the veggies, India is the one that produces the **most potatoes, ginger, okra, onions, brinjal, etc.**
  - In addition, India is the world's **top producer of jute, cashews, papaya, spices, coconut, mango, bananas, and other products.**
  - The **largest cotton exporter** in the world is India.
  - In India, **animal husbandry** is a significant component of the agricultural industry. It is responsible for over 32% of the output.

### ECONOMIC SURVEY: 2022-23 ON AGRICULTURE SECTOR

- In 2020–21, private investment in agriculture will increase to 9.3%.
- Since 2018, the MSP for all mandatory crops has been set at 1.5 times the weighted average cost of production for all of India.
- Institutional Credit to the Agricultural Sector grew to 18.6 lakh crore in 2021–2022 as growth persisted.
- In India, the production of food grains increased steadily and reached 315.7 million tonnes in 2021–22.
- The Agriculture Infrastructure Fund has authorised 13,681 crores for community farms and post-harvest assistance.
- India became the world's largest net exporter of agricultural goods.
  - India has quickly taken over as the world's top exporter of agricultural goods in recent years.
  - India's exports of agricultural and related goods increased by 18% in 2020–21 compared to the previous year.
  - The value of agricultural exports peaked in 2021–2022 at \$50.2 billion.

### TYPES OF AGRICULTURE

### **1. SUBSISTENCE AGRICULTURE:**

• Subsistence agriculture is one in which the farming areas consume all, or nearly so, of the products locally grown. It can be grouped into two categories — Primitive Subsistence Agriculture and Intensive Subsistence Agriculture.





- Primitive Subsistence Agriculture: Primitive subsistence agriculture or shifting cultivation is widely practised by many tribes in the tropics, especially in Africa, south and Central America and Southeast Asia. E.g. Jhuming in Northeastern states of India, Milpa in Central America and Mexico and Ladang in Indonesia and Malaysia.
- **Intensive Subsistence Agriculture:** Due to small landholding and huge population density around 80% of farmers hold small and marginal lands. Hence they are engaged intensive subsistence agriculture. In this type of agriculture, **the yield per unit area is high but per labour productivity is low.**

### 2. PLANTATION AGRICULTURE

- **Plantation agriculture was introduced by the Europeans in colonies** situated in the tropics. Some of the important plantation crops are tea, coffee, cocoa, rubber, cotton, oil palm, sugarcane, bananas and pineapples. It is a type of commercial farming where monoculture is practised having strong linkages with industries.
- **Geographical areas**: They are largely **confined to tropical areas**. In India plantation agriculture has developed in hilly areas of the **northeast e.g. Tea plantation**, **Nilgiri**, **Annamalai**, **Baba Budan and Cardamom hills etc having plantation of coffee**, **rubber etc**.
- **Employment**: In Southern India **plantation crops generates employment for 13 lakh people** and tea, coffee, pepper grown here **have high demand overseas**.
- Challenges:
  - **Monoculture** has affected the quality of soil and productivity has declined.
  - **Inefficient Policies:** The sector is suffering from distorted policies and a lack of long-term vision. Government support through budgetary allocation and institutional support like the formation of FPO is a must.
  - Lack of mechanisation: High labour costs and lack of scientific interventions cause inefficient cultivation.
  - **Impact of climate change:** There is a need to adapt resilient farming techniques against droughts and floods.
  - Lack of value addition: This reduces its commercial potential and fails to compete in the international market
  - **Plantation agriculture is leading to deforestation:** Large tracts of land must be cleared of their native flora in order to construct plantations, which can result in problems like soil erosion, ecological disruption, and biodiversity loss.
- Way Forward:
  - **Comprehensive and integrated government policy:** It is needed to double the farmer's income **(Ashok Dalwai Committee Recommendation).**
  - **Integrating with modern practices:** Farm mechanisation, inter cropping , value addition , integrated farming activities must be integrated with traditional plantation farming.
  - **Sustainable Development:** Insurance cover for farmers and climate-resilient practices must be adopted for sustainable development of the sector.

### **3. MIXED FARMING:**

- This form of agriculture is found in the highly developed parts of the world, e.g. North-western Europe, Eastern North America, parts of Eurasia and the temperate latitudes of Southern continents.
  - Mixed farms are moderate in size and usually the crops associated with them are **wheat**, **barley**, **oats**, **rye**, **maize**, **fodder and root crops**.
- **Components:** Fodder crops are an important component of mixed farming. **Crop rotation and intercropping play** an important role in maintaining soil fertility.
- Equal emphasis is laid on **crop cultivation and animal husbandry.** Animals like **cattle**, **sheep**, **pigs and poultry** provide the main income along with crops.
- **Case study**: Farmers in the **Hassan district** of Karnataka have taken up **dairy farming in their coconut farms** which have shown that tending to livestock also leads to an **increase in revenue from coconut trees**.
- Advantages:
  - Reduces Risk of Failure of Crops
  - o Enhances Soil Fertility
  - Increased Income for Farmers
- Disadvantages:
  - Spreading Fertilizer to individual crops is difficult.
  - $\circ$   $\;$   $\;$  Threshing and Harvesting crops separately are not possible.
  - Guarding crops from animals is a challenging task.

## 4. CO-OPERATIVE FARMING:

- A group of farmers form a co-operative society by pooling in their resources voluntarily for more efficient and profitable farming.
- Individual farms remain intact and farming is a matter of cooperative initiative.





• Co-operative societies help farmers to procure all important inputs of farming, sell the products at the most favourable terms and help in the processing of quality products at cheaper rates.

#### **PW-ONLYIAS EDGE: KEY PHRASES FOR MAINS**

Primitive Subsistence Agriculture; Intensive Subsistence Agriculture; Plantation Agriculture; Mixed Farming; Climate Resilient Practices; Climate Resilient Agriculture; Climate-Smart Agriculture; Co-operative Farming; Organic farming; Zero Budget Natural Farming; Collective Farming; Feminisation of agriculture; Red Collar Jobs; Hidden Unemployment; Disguised Unemployment; etc.

### COOPERATIVE FARMING IN INDIA

It is an organisation of farmers **where farming is done collectively** however each member remains the **owner of his land individually**. They share their **profit in the ratio of their land holdings**. Cooperative movement in India has started during British rule however it gained the strength due to reforms after independence and favourable policies.

#### **EVOLUTION:**

- **Ideology: Gandhian, socialist ideology** believed that cooperative farming would improve the status of Indian agriculture.
- Land reforms: Land reforms targeted towards the abolition of Zamindari, removal of middlemen tenancy reforms etc were aimed at increasing cooperation between farmers to increase agriculture production.
- **Evolution of FPOs**: Farmers Producer Organisations are complementary to the progress of cooperative farming. FPOs are aggregations of small, marginal and landless farmers aimed at increasing the economic strength of Famers. Over 4,000 FPOs are supported by NABARD and SFAC.
- **FPC: Farmer Producer Company** these are registered under the Companies Act. These are a combination of the cooperative sector and companies act.
- **State subject:** Constitution has included Cooperatives as **a state subject** giving ultimate rights to states to develop them depending upon local conditions.
- Ministry of Cooperation: Recently the Government of India constituted an independent Union Ministry of Cooperation (MoC). The Ministry would work towards a cooperative-based economy by providing an 'administrative, legal and policy framework' and 'Ease-of-doing-business for cooperatives.'

#### SIGNIFICANCE:

- **Institutionalising Principle of Mutual Help:** According to the planning commission, cooperatives represent the institutionalization of the principle and mutual aid. It has the merit of combining freedom and opportunity for the small man with the benefit of large-scale management and organisation.
- Economies of scale: In India, 80% of farmers are small and marginal. Land pooling enables the mechanisation of farming and precision irrigation thus improving the overall productivity of land. This increases the per capita output of the members.
- **Combination of inputs:** It provides a platform where farmers can come together and **share efficient and scientific methodologies thus modern practices** can be implemented. Such complementary exchange **of ideas, capital , labour , and livestock** would help to reap the maximum output from farming.
- Access to credit: The availability of credit to cooperatives is easy due to the combined creditworthiness of the members.
- **Doubling farmer's Income:** Effective organisation of cooperatives would help to realise the doubling of small farmers' income.

#### **Case Study**

Maharashtra: The rural development in Maharashtra revolved around the cooperative movement for decades.

### CHALLENGES IN RESPECT OF CO-OPERATIVE FARMING IN INDIA

- Co-operative farming failed to make a frontal attack on the prevailing inequality in the economic structure as the traditional status distinction of land owners, landless labourers and sharecroppers are still being maintained.
- Mechanisation of agriculture through co-operative farming will squeeze the scope of employment and is likely to make workers redundant in rural areas.
- Co-operative farming is not the only method to raise agricultural productivity. There is the availability of better alternatives like the adoption of HYV seeds, fertilisers, implements etc. for raising the productivity of agriculture.

### WAY FORWARD:





- **Success of cooperative movement has been restricted** to a few states like Maharashtra and Gujarat. At all Indian levels, cooperatives have failed to put a positive impact. Due to political control and corruption in the cooperative institutions.
- FPC:
  - It is a **hybrid between cooperatives and private limited companies registered under the companies act.** It would **plug the structural vulnerabilities of the agriculture sector.**
  - It organises farmers into a collective group to **improve their bargaining strength**.
  - They are owned and governed by shareholder farmers ad **administered by professional managers.**
  - o It combines good principles of cooperatives and efficient practices of companies.
  - FPCs would increase farmer's control over the company under statutory provisions thus removing flaws of cooperative organisation.
  - Success story of the largest FPC **Sahyadri farms** can be replicated throughout the country.
- **Dedicated ministry and success of the FPC model** can rejuvenate the agriculture sector and can play a vital role in realising the goal of doubling the farmer's income.

### RISING SHARE OF AGRICULTURAL EMPLOYMENT

- Safety net: Agriculture provides a low-wage safety net for labour during times of distress in India. It is a sign of distress in the labour market where non-agricultural sectors are unable to provide employment and labour is forced to shift to agriculture.
- Thus agriculture with the right intervention by the government would evolve as a major employment creator when other sectors are failing to create them. These interventions could be:
  - **Startups**: Promotion of agri processing industries by **incentivising private investment and new startups in the sector.**
  - **FPO: Formation Farmer produces companies** are emerging to increase remuneration from the agriculture sector and also retain the youth generation in the agriculture.
  - **Forward and backward linkages: Development of Forward and backward linkages** in the rural areas would create new forms of employment in packaging, storage, processing, logistics, food preparation, restaurants etc
  - Technology: Use ICT technologies to increase agriculture labour productivity.

#### **FACT-WISE**

- **Periodic Labour Force Survey (PLFS) Report 2021–22**: The share of agriculture in the total workforce has fallen from 64.6% in 1993-94 to 42.5% in 2018-19.
- Women make up over 63% of the workforce in the agriculture industry on a national basis, compared to 11.2% of female workers in manufacturing.

### MAJOR CONSTRAINTS IN INDIAN AGRICULTURE

- Structural Constraints:
  - **Operational holdings:** According to the 2010-11 Agriculture Census, **the average operational holdings size of Indian farmers is 1.15 hectares** and **85 per cent are in marginal and small farm categories of less than 2** ha.
  - **Subsistence agriculture:** Indian agriculture is **largely subsistence-oriented** which deprives benefits of economy of scale due to small holdings and inability to practice mechanised farming.
  - Forward and backward linkages: Due to a lack of forward linkages value addition and primary processing to farm products is very low as compared to developed countries.
- Financial Constraints:
  - Lack of credit: Poor access to credit and farmers trapped under the clutches of unorganised creditors forces them to distress sale with low remuneration.
  - **Ineffective Flow of Funds:** According to the Indian Council for Research on International Economic Relations-Organisation for Economic Co-operation and Development (ICRIER-OECD) report, despite the abundance of programmes implemented to assist and subsidise Indian farmers, regressive marketing policies has resulted in the loss of fund.
- Infrastructural Constraints:
  - **Lack of irrigation: Lack of irrigation and erratic monsoon** makes farming unsecured which pushes the young generation with their vigour and entrepreneurship away from the sector.
  - **Poor infrastructure:** A lack of basic infrastructure for storage, transportation, and other purposes led to net losses for Indian farmers, who were consequently not taxed.
- Economic Constraints:





- Selective Procurement: Only wheat and paddy (rice), which must be purchased in substantial numbers to meet the Public Distribution System's (PDS) requirements of 65 million tonnes, are among the 23 crops for which the government declares MSP.
- **Stagnant MSP Rates:** The government's declared minimum support prices don't rise in line with increases in production costs.
- **Unfair Access:** Not all farmers and all crops receive the advantages of this programme. Many areas of the nation, such as the north eastern region, have inadequate implementation.
- **Non-Scientific Agricultural Practises:** MSP results in non-scientific agricultural practices that stress the soil and water to the point where the groundwater table deteriorates and the soil becomes salinized.

### • Other Constraints:

• Small holdings of farmers, primary and secondary processing, supply chain, the infrastructure supporting the efficient use of resources and marketing, reducing intermediaries in the market.

### CHANGING TRENDS IN AGRICULTURE MODERNISATION

- Protected cultivation of green and other vegetables.
- Innovations in the field of innovative products, better seeds, fertilisers, and customised farm machinery for increasing productivity.
- **Use of biotechnology** for the creation of eco-friendly, climate-resilient and nutritious crop varieties.
- Artificial intelligence-led automation for precise application of inputs using sensors and drones.
- Use of **nanotechnology** to minimise nutrient losses in fertilisation and pest management.
- India has improved remarkably in **digital connectivity** and market access has become very easy.
- To gain maximum out of these trends for employment generation and increasing productivity **skill impartation to farmers is the need of the hour.**

### FUTURE SCOPE FOR AGRICULTURE SECTOR

- **Diverse climatic zones**: According to the **ICAR**, India has a lot of arable land divided into 15 agroclimatic zones. A variety of crops can be grown in such varied fruitful environments.
- **Precise practices**: The emergence of innovative ideas like "**precision agriculture**," "farm to fork," and "farming as a service" is having a significant impact on this industry by raising its economic outputs.
- **Urbanisation**: India's growing population, urbanisation, average income, and consequences of globalisation will raise demand for a greater variety, quantity, and quality of food.
  - The agriculture industry would become one of the **sunrise sectors in the next years** if it could meet these demands by improving processing and value-addition skills.
- Industry 4.0: In addition, the use of IoT, AI, and ML in agriculture, private investments in R&D, government initiatives to revive the cooperative movement to address the issues of small holdings and small producers, and other factors are altering the face of agriculture in India.
- **Biotechnology:** Because modern biotechnology products are economically viable, they can enhance both agriculture and the food industry, which will increase the income of subsistence farmers.
  - Therefore, biotechnology is helpful in eliminating diseases, malnutrition, and hunger from underdeveloped nations and the third world.
- Many start-ups in agriculture by professionals: It conveys admiration for the enormous possibility of investing time and money in this field. The main forces in the coming years will be the cumulative effects of technology and the necessary investment in the industry.

### DAIRY SECTOR IN INDIA

- **Contribution to the Economy:** It is the single largest agricultural commodity contributing 5 per cent of the national economy and employing more than 8 crore farmers directly.
- **Production:** From 146.31 million tonnes in 2014–15, milk output in the nation increased at a compound annual growth rate of roughly 6.2% to reach 209.96 million tonnes in 2020–21.
  - India is ranked 1st in milk production contributing 23 per cent of global milk production.
- **Operation Flood:** Due to **Operation Flood** after the 1960s, India's contribution to world milk production rose from 5% in 1970 to 23% in 2021. Today, India is largely self-sufficient in milk production.
  - **According to NITI Aayog, in 2033** India's milk production would rise to 330 MMT while its milk demand would be 292 MMT. Thus, India is likely to be a milk-surplus country by 2033.

### **SIGNIFICANCE OF DAIRY SECTOR:**

• **Diversification of income:** The dairy sector has augmented the income of the farmers and during distress periods of drought and flood it has ensured livelihood security through steady income.





- **GVA contribution:** According to ES 2021-22, from 146.31 million tonnes in 2014–15, milk output in the nation increased at a compound annual growth rate of roughly 6.2% to reach 209.96 million tonnes in 2020–21.
- **Nutritional support:** Milk products are a vital part of a diet to reduce malnutrition and undernutrition. The inclusion of milk products under the **mid-day meal scheme** would help to reduce stunting and wasting in children.
- Women empowerment: It is a labour-intensive sector in India and the female population comprises around **69% of the sector's workforce**. Hence, the dairy sector's development directly promotes women's empowerment.

### **CHALLENGES FACED BY THE DAIRY SECTOR:**

- **Fragmented supply chain:** Milk is a **highly perishable product** so it requires immediate disposal at the customer's end. This requires **a complex supply chain having cold storage infrastructure.**
- **Unorganised sector:** The majority of milk producers are **unorganised and thus fail to advocate their organised demands**. The sector is **not guaranteed with any MSP** unlike 24 agriculture commodities
- **Poor return to farmers: The fat-based pricing policy results in 20-30% less money to farmers** compared to market prices. Therefore, cooperatives are not preferred by landless and small farmers.
- Cattle feed prices: Due to the lack of sustained availability of cattle feed and its high prices, the profit margin of the business reduces.
- The poor economy of scale: In 2017, the average herd size in a dairy farm was just 2 in India. So the output compared to efforts taken to run the business is very low. Therefore young generations are reluctant to venture into their business in the dairy sector.
- **Education and Training:** Lack of vigorous education and training programmes on good dairy practices in India mostly in rural areas.
- **Hygiene Conditions:** Many cattle owners do not provide proper shelter to their cattle leaving them exposed to extreme climatic conditions which further leads to mastitis conditions.
- **Shortage of feed/fodder:** There are an excessive number of unproductive animals which compete with productive dairy animals in the utilisation of available feeds and fodder.
- **New regulation**: Dairy analogues, plant-based products and adulteration pose a major challenge and threat to the dairy industry. The new regulation for analogues and ghee standards has been amended by the Food Safety Standards Authority of India recently.

### **GOVERNMENT INITIATIVES:**

- **Rashtriya Gokul Mission**: It was launched in 2014 under a national programme for Bovine Breeding and Dairy development. For the development of Indigenous breeds and to improve their genetic makeup.
- **Nationwide AI (artificial insemination) program:** It is aimed at enhancing annual milk productivity up to 3000 kg/animal.
- KCC: The dairy farmers have been included in the Kisan Credit Card (KCC) programme. It ensures adequate and timely credit support for the farmers.
- **MGNREGA**: Dairying was brought under MGNREGA to compensate farmers for the income loss due to Covid-19.
- **One Health Mission:** The implementation of the One Health Mission with almost 60% enhancement in fund allocation for Livestock Health and Disease Control for 2022-23 over the previous year will ensure healthier livestock and a healthier India.

### WAY FORWARD:

- **Cooperatives should strengthen their voice by uniting together**. Government should provide the basic needs of the sector i.e. availability of cheap cattle feed , upgradation of the supply chain network and cold storage by boosting private investment under the PPP model.
- **Use of ICT technologies and promotion of start-ups** assisted by government schemes would create new employment opportunities and retain new generations in this sector.
- Milk processing industry is a sunrise industry so cooperatives must venture into cheese , yoghurt , and ice cream products to realise untapped demand and provide more returns to the farmers.

## AGRO-BASED AND AGRO-PROCESSING INDUSTRIES

- Agro-based companies are those that source their basic materials from the agricultural production of both plants and animals. Additionally, they increase the value of agricultural output by processing it and creating goods that can be sold and used. India's textile, sugar, vegetable oil, tea, coffee, and leather goods sectors are a few examples of agro-based businesses.
- **Inputs**: Agro Based industries involve supplying of farm and agriculture inputs and processing and value addition of the agricultural produce for the intermediate and final consumption. These industries mainly depend upon raw materials provided by the agriculture.
  - E.g. Cotton for the cotton textile industry, sugarcane for the sugar industry, milk for dairy products etc





- **Employment generation:** Agriculture and food processing are **labour-intensive industries** that have the potential to generate a significant amount of employment possibilities in rural areas.
  - Local employment possibilities would encourage rural residents to stay in their communities and build urban amenities there.
- **Doubling Farmer Income:** The Agro-based industries are the major avenue to accomplish the goal of doubling the farmer's income.
- Addressing Unemployment in Rural Areas: They absorb the surplus of rural labour and address the problem of large-scale unemployment in rural areas.
- **Sunrise industry**: NITI Ayog has identified Food processing industries as the sunrise industry having huge domestic demand which has the ability to uplift the unorganised sector.
- **Contribution to GDP:** The food processing sector's contribution to India's **GDP is less than 2%.** Thus need private investment and new start-ups to exploit its true potential.

#### **Present Status**

- Even though India is the second-largest producer of fruits and vegetables in the world, after China, just 2% of the crop is processed.
- India has the largest livestock population in the world, with 50% of buffaloes and 20% of cattle, yet just 1% of the country's total meat production is turned into items with value-added.
- Although there is a sizable manufacturing base, the processing is little (less than 10%). About 2% of fruits and vegetables, 8% of marine goods, 35% of milk, and 6% of poultry are processed.

### SIGNIFICANCE:

- **Income diversification**: These industries also provide profitable diversification in the rural areas which ensures all-round industrial growth in the rural areas.
- **Income composition**: The contribution of cropping and animal husbandry to the total income of the farm households is only 35 per cent while wages and services contribute to more than 50 per cent of the average monthly income.
- **Employment**: The **Annual Industrial Survey**, **2016-17 showed that the agro-industries contribute about 36 per cent of the industrial employment**. Substantial employment is generated in production agriculture and the supply chain.
- Forward and Backward linkages: Development of these linkages in post-harvest management, warehouses, cold storages, logistics facilities etc would shift surplus labour from the farming sector to more productive industrial activities.
- **Reduce food waste:** According to the UN, 40% of the production is lost. The annual post-harvest losses were also estimated by NITI Aayog to be close to Rs 90,000.
- **Boosts Trade and Earns Foreign exchange:** It serves as a significant source of foreign exchange. For instance, Middle Eastern nations have a high demand for Indian Basmati rice.
- **Migration Reduction:** Food processing, a labor-intensive business, will create localised job possibilities and lessen the drive for migration in the source countries.
- **Curbing Food Inflation:** Food processing extends the shelf life of the food, which helps to keep supplies in line with demand and reduce food inflation. For instance, frozen Safal peas are offered all year long.

### **GOVERNMENT INITIATIVES:**

- Institutional Set-ups:
  - **Ministry of Agriculture:** It deals with bakeries, cold storage, sugar mills, oil mills, and mills for rice.
  - **Khadi And Village Industries Board:** Traditional agro-based businesses including "gur," handicrafts, and khandsari are covered under it.
  - **Agro-Industries Development Corporation:** Each state's Agro-Industries Development Corporation primarily provides farmers with agricultural equipment, inputs, and consultancy services. In the agro-industries sector, certain businesses have also engaged in specific industrial operations.
  - **Small Industry Development Organisation:** This organisation works with small agro-industries such as hosiery, beverage processing, food and fruit preservation, and agricultural tool manufacturing.
- Policies:
  - **Agro Processing Cluster:** Through a well-equipped supply chain and cutting-edge infrastructure, it aims to connect groups of producers or farmers to the processors and marketplaces.
  - **Mega Food Park:** The programme intends to create modern infrastructure and shared amenities to attract business groupings to establish food processing units using a clustering method.
  - **Creation/ Expansion of Food Processing/ Preservation Capacities (Unit Scheme):** The primary goal of the Scheme is to build processing and preservation capacity and modernize/expand existing food processing units with the intention of raising processing levels and adding value, which will reduce waste.





### WAY FORWARD:

- **Sustainable Yield:** Impetus should be given to **sustainable yield improvements** through scientific farming practices.
- **Enhance agriculture marketing framework:** To increase farmers' price realisation through policy changes. Direct marketing through farmer-producer organisations can be promoted.
- **Formulate an Integrated Agriculture Export Mission:** To scale up food processing and exports by increasing value addition from 10% to 50%.
- **Integrated Approach:** An integrated strategy is required, with a focus on creating backward and forward connections, which are essential for increasing the sector's economic viability.
- **Regulatory Framework:** In this regard, the regulatory framework for contract farming and corporate farming needs to be developed. The NITI Aayog-developed model land leasing law is a start in the right direction.
- **PPP:** Encourage the private sector to participate more actively in the industry's overall development by providing a well-developed framework for risk sharing and financial incentives for building infrastructure for logistics, storage, and processing.
- **Uniform implementation of APMC Act:** Make sure that the APMC Act is implemented uniformly to enhance private sector participation, and that the GST tax structure is harmonised to prevent significant variances in prices.

According to the Economic Survey (2022-23), Indian agriculture has to be reoriented in view of a number of issues, including the negative effects of climate change, fragmented landholdings, inadequate farm mechanisation, low productivity, covert unemployment, growing input costs, etc. For the nation's economy to thrive and create jobs, the agriculture sector's performance must continue to be strong.

### MINING SECTOR IN INDIA

The mining sector in India is termed to be one of the core industries of the Indian economy for it provides basic raw materials to many important industries. **Mining** is the process of extracting valuable geological components from the planet and other celestial bodies.

### Status of Indian Mining (MoSPI)

- Contribution to Economy: Despite only varying between 2.2% and 2.5% of the industrial sector's GDP, the mining sector's GDP contribution ranges from 10% to 11%.
- Employment: The mining industry, which also employs over 5.5 crore people, directly and indirectly employs roughly 1.1 crore people.
- Revenue: India's GDP from mining rose from 645.94 INR billion in the third quarter of 2022 to 787.32 INR billion in the fourth quarter. It is planned to raise mining's contribution to Rs 8 lakh crore by FY 24–25.

### SPATIAL DISTRIBUTION OF MINES IN INDIA

- **Explored Minerals:** India has a wealth of mineral resources. Over **20,000 known mineral deposits** and more than **60 mineral reserves** are recoverable thanks to exploration.
- **90% of the total number of active mines are located in 11 states:** Andhra Pradesh, Orrisa, Chhattisgarh, Jharkhand, West Bengal, Maharashtra, Tamil Nadu, Gujarat, Madhya Pradesh, Rajasthan, and Karnataka.
- India has the following mineral reserve:
  - Iron, chromite, copper, mica, and manganese are examples of **metallic and non-metallic minerals**.
  - **Energy resources** include uranium, thorium, petroleum, and coal.
- India's Coal Industries:
  - The Godavari, Mahanadi, Son, and Damodar river basins contain more than **97% of the known coal deposits.**
  - Raniganj, Jharia, Bokaro, and Madhya Pradesh (Singhrauli) are **important coal mining regions in India**.
  - The largest company in India that produces coal is **Singareni Collieries**.

### THE LEGISLATIVE FRAMEWORK OF MINING SECTOR IN INDIA

- **State List:** The state government is required to own the minerals found within its borders under the entry at serial No. 23 of List II (State List) of the Indian Constitution.
- **Central List:** The central government is required to own the minerals located within India's EEZ by the entry at serial No. 54 of List I (Central List). The Mines and Minerals (Development and Regulation) (MMDR) Act of 1957 was created in response to this.
- **International Seabed Authority:** Exploration and mining of minerals are governed by the International Seabed Authority (ISA).
  - It is governed by a UN treaty, to which India is a party. India has been granted the sole right to explore polymetallic nodules spread across 75,000 square kilometres in the Central Indian Ocean Basin.
- MMDR (Amendment) Act 2021: Salient Features of the Act are -





- **Rejuvenate the mineral sector:** It permits all captive mines to sell up to 50% of the minerals produced during the year.
- **Mining for specific end use (Captive Mining):** The Act allows the government to reserve any mining (apart from coal, lignite, and atomic materials) for leasing through an auction for a specific end-use (such as an iron ore mine for a steel mill).
- **To promote ease of doing business:** To encourage ease of doing business, expired mining leases' statutory approvals are still valid even after their termination or expiration and are given to the mine's new lessee.
- **Defining "without lawful authority":** Now, only violations of Section 23(C)'s rules or acts that raise, transport, or cause to raise or transport of any mineral without a prospecting licence, mining lease, or composite licence can result in penalties for miners under this section.
- **Empowered the Central government:** To hold auctions in cases when states experience problems or missed deadlines determined after consulting with the state governments.
- **Second Schedule of the Act:** The Mines and Minerals (Development and Regulation) Act of 1957 has been revised, specifically the second schedule.

### AUTHORITIES GOVERNING MINING IN INDIA

- **The Ministry of Mines (MoM):** It is in charge of surveying and exploring all minerals (apart from coal, natural gas, and petroleum), mining, and non-ferrous metal metallurgy, as well as the management of the MMDR Act.
- **Geological Survey of India (GSI):** National geoscientific data and evaluations of the mineral resources of the country are produced and updated by the Geological Survey of India (GSI), a department of the Ministry of Mines (MoM).
- Indian Bureau of Mines (IBM): It is tasked with protecting the environment while promoting, conserving, and scientifically developing mineral resources.
- **MOEFCC:** India's environmental and forestry policies and programmes are planned and carried out by the Ministry of Environment, Forest and Climate Change (MOEFCC).

### SIGNIFICANCE:

- **Growth**: According to the government's own assessment, **one percentage point growth in mining pushes up the growth rate of industrial production by 1.2-1.4 percentage points**.
- Employment: One direct job in the sector creates 10 indirect jobs.
- It is a labour-intensive industry which provides employment opportunities largely to unskilled labourers.
- **Production**: **India is the world's second-largest coal producer** and being the 5th largest country in terms of coal deposits. It is a **net exporter of finished steel** and has the potential to become a champion in certain grades of steel.
- **Gross Value Addition:** The mining and quarrying industry's contribution (at current prices) to **GVA accounted for about 2.38% for the first quarter of the year 2018-19**.
- As per 2019 data, the mineral sector's contribution to the GDP is 1.75 per cent.
- **National Mineral Policy 2019:** It directs to increase the domestic mineral production and reduce trade deficits in the mineral sector in the next 7 years.

### NATIONAL MINERAL POLICY 2019

It envisages increasing the production of major minerals by 200 per cent and reducing the trade deficit in the mineral sector by 50 per cent in seven years. The policy aims to attract private investment through concessions like a financial package, right of first refusal at the time of auction etc.

### Features:

- Revenue sharing model: It adopted a revenue-sharing model to encourage the private sector to explore.
- Transfer of mining leases: The policy has provision for the transfer of mining leases and the creation of dedicated mineral corridors to boost private sector mining areas.
- **Export-Import policy**: It provides **emphasis on a long-term export-import policy** for the mineral sector to give stability for investing in large-scale commercial mining activity.
- **Exclusive Mining Zones**: Policy has introduced **the concept of 'Exclusive Minnes'** which will come with in-principle statutory clearances for the grant of mining lease.
- **Easy clearance**: The policy would **simplify the process of clearance** and would make it a time-bound process for mineral development and commencement of mining operations.
- **No-go Areas:** Certain areas would be declared as **no-go areas or inviolate areas** considering the fragility of the ecosystem.
- **District Mineral Fund:** The policy emphasises on **proper utilisation of the District Mineral Fund to ensure the welfare** of mining-affected people by providing rehabilitation and resettlement to affected people.
- **Intergenerational Equity:** The policy has introduced the **concept of Intergenerational Equity in mineral resource exploitation**.





### **Challenges:**

- Legislative Challenges:
  - **The sector is affected by legalities** which have restricted the scope of mining operations and raised costs.
  - Administrative Challenges:
    - **Issue of displacement and rehabilitation:** Acquisition of land for mining causes **displacement of tribal groupings** which creates discontent against the government due to poor rehabilitation of affected people.
    - Lack of skills: Inadequate infrastructure resulting In evacuation problems and poor workforce productivity due to the disconnect between training institutions and industry.
    - **Arbitrary allocations:** Arbitrary allocations for coal mines are followed by protracted legal battles, annulment of allocations, and charges of corruption in block allocations.
- Environmental Challenges:
  - Loss of Biodiversity: Mining causes loss of vegetation cover and loss of biodiversity. Pollution of Damodar River and Kopili River provides evidence for water pollution.
  - Limitless mining: Activities in the Western Ghats have intensified flood conditions in Kerala.

### • Other Challenges:

- **LWE:** These conditions are **fertile to grow Left Wing Extremism in mineral rich areas** of Jharkhand, Chhattisgarh, and Odisha.
- **Rat hole mining: This illegal mining has caused death to mining workers in Meghalaya**. Though it was banned in 2015 poor people get engaged in such activities and lose their lives.

### **Government Initiative:**

- FDI up to 100%: under the automatic route is allowed with certain clauses.
- **PLI scheme:** GOI has given approval to introduce **the Production-Linked Incentive (PLI) Scheme** in Specialty Steel for Enhancing India's Manufacturing Capabilities and Enhancing Exports.
- Amending the Mines and Minerals Development and Regulation Act 1957 (MMDR Act) and National Mineral Exploration Policy 2019: It has brought further transparency, better regulation and enforcement, balanced social and economic growth as well as sustainable mining practices.
- **Mission Purvodaya:** It emphasized unlocking the potential of the eastern India region to fuel the next wave of national growth.
- **District Mineral Foundation Fund:** It has been established for the well-being of mining-affected people.
- **KABIL**: To ensure the supply of critical and strategic minerals to Indian industries.
- **PM Khanij Kshetriya Kalyan Yojana (2015):** To ensure the well-being of those who are impacted by mining and the environment. carried out by DMF. "Affected family" and "displaced family" are examples of those who are affected.
- National Mineral Exploration Trust (NMET), 2004: For regional & detailed exploration of minerals.

### Mines & Minerals (Regulation and Development) Amendment Act, 2021

- Removal of restriction on end-use of minerals: Removing the restriction on the final use of minerals: According to the bill, no mine would be restricted for a specific final use.
- Sale of minerals by captive mines: Captive miners may sell up to 50% of their yearly mineral production on the open market after meeting their own needs, according to the Bill (excluding atomic minerals).
- Auction by the central government in certain cases: In some circumstances, the central government may conduct an auction. If so, the Bill gives it the authority to do so after consulting with the state government.
- Transfer of statutory clearances: According to the Bill, transferred statutory clearances will remain in effect for the entirety of the new lessee's lease term.
- Allocation of mines with expired leases: Mines with expired leases may be assigned to a government business in certain circumstances, according to the Bill, provided that the mines are neither coal, lignite, or atomic minerals.

### Way forward:

- **Effective implementation of National mineral policy 2019** and transparency in mineral block allocation must be maintained.
- **Single window and time-bound environment, forest clearance** will be key to the timely allocation of blocks and meeting the demands of industrial sectors.
- Effective conduct of Environment Impact Assessment (EIA) and Social Impact Assessment (SIA) must be ensured before allocation of any project.
- **NGT guidelines** must also be followed for the protection of ecologically sensitive areas. E.g. Recently NGT has ordered the UP govt to take remedial actions to curb illegal sand mining.





- **Proper rehabilitation of mining project-affected displaced persons** and utilisation of district mineral funds for their welfare is mandatory to gain the trust of these people. It **will restrict them from supporting Left-wing extremism activities.**
- Practising **global safety standards to avoid occupational hazards** is required and strong actions must be taken to stop illegal rat hole mining.

### **Conclusion:**

India has huge mineral potential but explored area is very minimal compared to the actual potential which has caused a huge minerals import bill. Sustainable and regular supply of minerals is key to the uninterrupted functioning of the industrial sector which is the growth engine of any economy. India has no room to miss its mineral sector objectives hence effective functioning providing expected output is must maintain a growth rate of 8-9% per year.

#### SECONDARY SECTOR

- Secondary sector includes the industrial sector which **processes natural raw materials and converts them into finished products.**
- Secondary sector is the backbone of the economy which **provides employment to people who moved from the primary sector and have gathered certain skills.**
- In India secondary sector has not achieved its true potential and the service sector has emerged as the largest sector in the economy.
- One of the important sectors of the Indian economy, the secondary sector **accounts for 14% of all employment** in the country.
- Furthermore, the secondary sector contributes almost **a quarter of the GDP**. Transportation and industry are the two best illustrations of this industry.
- Sector includes Agro-based industries, automobile industry, iron-steel industry etc.

#### IMPORTANCE OF THE INDUSTRIAL SECTOR IN THE INDIAN CONTEXT

- Economic:
  - **Provide Employment:** The industrial sector has made a significant contribution to creating jobs. Employment opportunities grow as industries mature. By giving jobs to 11 crore employees in India, industries like MSMEs played a significant part in absorbing a semi-skilled workforce.
  - **Trickle-Down Effect:** Growth in the industrial sector activates growth in other sectors like:
    - Development of agriculture
    - Development of Science and Technology
  - Self-sustained growth:
    - The booming capital goods sector encourages the expansion of the transportation, agricultural, and communication sectors.
    - It also ends our reliance on foreign nations for the supply of necessities.
    - Data(Index of Industrial Production): While up from a downwardly revised 0.7 per cent gain in December, India's industrial production climbed by 1.3 per cent year over year in January 2022, it fell short of market estimates of 1.5 per cent expansion.
- Political:
  - **Increased International Clout:** The promotion of trade is aided by industrialization, which has a significant impact on global trade. Trade benefits developed countries more than it does less industrially developed nations.
  - **Stability:** An economy with fast economic growth is less vulnerable to social pressures like civil war thus increasing political stability.
- Social:
  - Poverty alleviation: This sectoral transformation to the industrial sector is a precondition for the eradication of unemployment and poverty. According to the UNDP report India has pulled around 25 crore people out of poverty raising job standards in industrial sectors.
  - **Equitable growth**: It was also aimed **at bringing down regional disparities** by establishing industries in tribal and backward areas. E.g. **Promotion industries in backward areas** have helped in distributing fruits of development in remote areas as well. Development of **Vidarbha region of Maharashtra**.
  - **Demographic dividend**: India is going to witness the largest demographic dividend in the coming decade. The manufacturing sector is vital as it can create labour-intensive jobs and can promote an improved standard of living for the future generation. E.g. **Textile, Automobile sectors** have huge demand and potential to create new jobs.
- Technological:







- **Innovation and Collaboration:** An increase in R&D strengthen industries and promotes **plug-and-play technology** through partnerships with higher education institutions.
- **Industry 4.0:** With the emergence of Industry 4.0 it has opened the scope for the use of technology in other social sectors thus making a spillover effect.
- Security:
  - **Increased National Security:** Our ability to produce defence machinery and equipment domestically has allowed us to avoid paying expensive foreign exchange to import it, thanks to the growth of our businesses.
  - **Economic Security:** It makes us non-dependent on Western countries which use various tools to exploit developing countries. For example, **US PL-480 Program**.

### TYPES OF INDUSTRIES

Manufacturing Industries can be classified based on various grounds. The following are some basic classifications of the industries:

### 1. Depending on the Strength of Labour (Size):

- **Large Scale:** Businesses that employ numerous workers in each unit are referred to as large-scale businesses. Large-scale enterprises include the cotton and jute textile industries.
- **Medium Scale:** Medium-scale industries are defined as those that neither employ a very large nor a very small number of workers. Examples of medium-sized enterprises are the bicycle, radio, and television industries.
- **Small Scale:** Individually owned and operated businesses that only hire a few workers are referred to as small-scale businesses.
- 2. Depending on the Source of the Raw Material
  - **Agro-based:** Industries that rely on agriculture as a source of raw materials are known as agro-based industries. Sugar, vegetable oil, jute textile, cotton textile, and cotton textile are examples of agro-based industries.
  - **Mineral-based:** This group includes businesses like iron and steel, aluminium, and cement that principally rely on minerals for their raw materials.
  - **Based on pastoral agriculture:** These sectors rely on animals as a source of raw materials. Some pastoral-based industries include those that produce shoes, dairy, hides, skins, bones, horns, and so on.
  - **Forest-based industries:** They include those that produce paper, cardboard, lac, rayon, resin, tanned leather, wooden tools, and baskets.

### 3. Depending on the Ownership

- **Private Sector:** Industries located in Jamshedpur that are owned by people or companies like Bajaj Auto or TISCO are referred to as private sector industries.
- **Public Sector:** Companies like Bharat Heavy Electricals Ltd., Bhilai Steel Plant, and Durgapur Steel Plant that are owned by the government and its agencies are examples of public sector businesses.
- **Joint Sector:** Businesses like Gujarat Alkalies Ltd. and Oil India Ltd. which are jointly owned by the state and/or its agencies are examples of joint sector businesses.
- **Cooperative:** These are jointly owned and operated by a group of individuals who typically provide the raw materials for a certain industry, such as a sugar mill that is jointly owned and operated by farmers, are referred to as co-operative sector businesses.
- **Multinational:** A multinational corporation (MNC) has locations and additional assets in at least one nation aside from its own.

## 4. Depending on Raw-Material and Finished Goods

- **Heavy:** The term "heavy industries" refers to those that manufacture goods from the same type of heavy and bulky raw materials. Heavy industries are well-represented by the iron and steel sector.
- **Light:** Light industries create Light finished goods and utilise Light raw materials. Light industries include sewing machines and electric fans.

### **Concept of High Technology Industry**

- These are the latest generation of manufacturing activities which includes the application of intensive research and development (RandD) efforts leading to the manufacture of products of an advanced scientific and engineering character.
- Professionals and highly skilled workers make up a large share of the total workforce. E.g. Robotics on the assembly line, computer-aided design (CAD) and manufacturing, electronic controls of smelting and refining processes, and the constant development of new chemical and pharmaceutical products are notable examples of the high-tech industry.
- Planned business parks for high-tech start-ups have become part of regional and local development schemes.
- High-tech industries which are regionally concentrated, self-sustained and highly specialised are called technopolis. The Silicon Valley near San Francisco and Silicon Forest near Seattle are examples of technopolis.





### FACTORS INFLUENCING THE LOCATION OF INDUSTRIES

There are range of factors influencing the location of the industry which can be divided into two broad categories, Geographical factors and Non-geographical factors.

#### **Geographical Factors:**

- **Raw Materials:** Raw material has been the **most fundamental** deciding factor of industrial location. The optimum location would be where the transportation cost is minimum. **Transportation cost is calculated on the basis of the distance and weight of goods.** 
  - **Alfred Weber Theory:** It holds true for raw materials whose weight decreases during manufacturing, whose high transport costs cannot be supported, or whose perishable nature prevents their long-distance transportation.
- **Power**: A consistent power supply is a requirement for the localization of industries. The three most significant traditional sources of power are coal, mineral oil, and hydroelectricity. The majority of industries tend to focus on the power source.
  - **Example:** The Cotton industries (Pykara Dam) industries moved to southern states only when hydropower could be developed in these coal-deficient areas. Thus a cheap and regular supply of power is a vital factor when selecting an industrial location.
- **Labour**: Unless there are compelling arguments to the contrary, nobody can dispute that the presence of a labour force in the past is appealing to industry. The availability of labour is crucial in two ways:
  - Employees in large numbers are frequently needed.
  - Individuals with specific skills or technical knowledge are required.
- **Market**: The entire process of manufacturing is useless until the finished goods reach the market. For rapid disposal of manufactured items, proximity to the market is crucial. It aids in cutting down on transportation expenses and makes goods more affordable for the consumer.
- **Transport**: The assembly of raw materials and the sale of finished goods both require transportation by land or water. Numerous industries in the areas surrounding Kolkata, Mumbai, and Chennai were driven by the construction of railways in India that connected port towns with the countryside.
- **Water:** Industries like **textile, chemical and iron-steel** require huge amounts of water for their functioning hence proximity to water resources is beneficial for these industries. E.g. the Jute industry in Bengal is benefited due to the closeness of the Hugli River.
- **Climate**: E.g., the development of industries is hampered by the harsh environment of northwest India. Contrarily, the temperate temperature of the west coastal region is quite hospitable to the growth of the industry.
  - Because of this, the Maharashtra-Gujarat region alone accounts for around 24 per cent of India's modern industries and 30 per cent of its industrial labour.

### **Non-Geographical factors:**

- **Capital**: Capital-intensive modern industries demand substantial investments. Urban areas have access to capitalists. Due to the presence of large businessmen, major cities like Mumbai, Kolkata, Delhi, and Chennai are important industrial hubs.
- **Government Policies**: Under **competitive federalism different state policies are attracting industries** with their incentives to set up in their states. **E.g. Gujarat's industrial policy has attracted the Nano plant of TATA** from West Bengal due to favourable government policies and incentives.
- Access to agglomeration Economies: Benefits are derived from the linkages which exist between different industries. Functionally dependent industries tend to cluster together where the final product of one industry may act as a raw material for another.
- Industrial Inertia: Industries tend to develop at the place of their original establishment due to inertia of the region. E.g. Lock Industry at Aligarh.
- **Historical Factors: Mumbai, Kolkata and Chennai locations** are greatly influenced by our colonial past. Manufacturing activities in these regions received great impetus provided by the European traders. These locations enjoyed the benefits of an early start.
- **Banking and credit Facilities:** The development of industry necessitates the daily exchange of millions of rupees, which is only made feasible by banking facilities. Therefore, the construction of industries is better suited to places with greater banking facilities.

#### **Case study of IT Revolution**

- The government invested to create high-speed internet connectivity which helped in the integration of the Indian IT industry and the US market.
- High-speed connectivity enabled faster data flow and easy communication.
- Later government allowed the IT industry to duty-free import hardware and software.





- IT industries were established under the Shops and Establishment Act which requires less compliance.
- Government boost to higher education, especially engineering colleges provided skilled labourers at low cost which attracted investment and MNCs in India.

### INDUSTRIAL CORRIDORS (IC) IN INDIA

- The National Industrial Corridor Development Corporation (NICDC) is a Special Purpose Vehicle with the goal of establishing, fostering, and facilitating the implementation of the National Industrial Corridor Development Programme.
  - **Facilities to be developed under this project:** High-speed road and rail transportation network, Modern airports and Ports with world-class cargo handling facilities, Smart industrial townships, Logistic parks, and Financial hubs.
  - **Investment Regions (IRs) and Industrial Areas (IAs):** The project will be developed on the concept of **node-based development** including Investment regions(IRs) and Industrial Areas(IAs). These are proposed as self-sustaining industrial townships with world-class infrastructure.
- **Objectives**: These are envisaged **along the main transport routes giving special thrust to industrial development.** It involves multiple projects targeted towards an increase in exports, employment generation, environment management etc.
  - IC would **create a global manufacturing and investment destination endowed with smart industrial cities** which would compete with the best international manufacturing and industrial regions.
  - The project efforts **would complement the NMP-2011** by creating employment and increasing output and exports.
- **Present Status:** The government has sanctioned and approved eight (8) projects under the National Industrial Corridor Development and Implementation Trust (NICDIT).
  - **Completed Project:** The major trunk infrastructure works for four of the eight projects have been finished.
    - the Integrated Industrial Township in Greater Noida, Uttar Pradesh;
    - the Dholera Special Investment Region in Gujarat;
    - the Shendra Bidkin Industrial Area in Maharashtra; and
    - the Integrated Industrial Township-Vikram Udyogpuri in Madhya Pradesh.
  - **Projects in Process:** The other 4 approved projects are in various stages of implementation/development. The status of these projects is given as below:
    - **Tumakuru Node in Karnataka under Chennai Bengaluru Industrial Corridor (CBIC):** Detailed master planning and preliminary engineering activities for an area of 1,736 acres as an activation area have been completed. Environment Clearance has been obtained. State Govt. has transferred 1668.30-acre land to the SPV of the project.
    - Krishnapatnam Node in Andhra Pradesh under CBIC: The State Govt. has transferred 2139.15 acres to the project SPV. Environment Clearance has been obtained.
    - Integrated Multi Modal Logistics Hub at Nangal Chaudhary in Haryana under Delhi Mumbai Industrial Corridor (DMIC): Works related to water, power, and roads are almost completed. Rail connectivity works approved by DFCCIL have been started.
    - Multi-Modal Logistics/Transport Hub at Dadri in Uttar Pradesh under DMIC: 227.48 Ha land has been transferred to the SPV of the project. Project development activities like preparation and approval of Detailed Project Reports (DPR) have been started.

### SIGNIFICANCE OF INDUSTRIAL CORRIDORS

- It includes 4 key components: Transport, Warehousing, Forwarding and Value added logistics.
- **Economic growth**: Industrial corridors are meant to provide **world-class transportation** facilities connecting industrial clusters. **High capacity dedicated freight corridor** would act as a backbone for creating a global manufacturing and investment destination.
- **Logistic improvement**: IC will help **to facilitate the multi-modal movement of cargo** on par with global logistics standards. It will decrease the cost of logistics improving the competitiveness of Indian goods.
- **Ease of doing business**: IC would facilitate faster **clearance to start a business**, **deal with construction permits**, **and register property**. It will attract more business and investment.
- **Employment creation:** IC **provides both forward and backward linkages to the industries** and hence has wide potential to create employment across the logistics sector , and warehousing sector. It would boost infrastructure development creating jobs in associated sectors.

### STRATEGY OF REGIONAL RESOURCE-BASED MANUFACTURING AND MANAGEMENT

Industries which are located near raw material **utilises local inputs and transforms them into final material**. This also helps in the **creation of employment and overall regional development**. This strategy helps in **backward area** 





**development** and the promotion of equitable development. It **promotes local products and artefacts and tries to covet them into national and Global brands**. Under this strategy industries are attracted based on the availability of natural resources and **provided with other facilities like transportation, electricity etc.** 

### **GOVERNMENT INITIATIVES TO HARNESS REGIONAL POTENTIAL:**

- **Odisha Industrial Development Plan: Vision 2025:** It focuses on five industries with the aim of luring Rs. 2.5 lakh crore in investments and generating 30 lakh direct and indirect jobs.
- **Forest-Based Enterprise:** Numerous states are promoting forest-based businesses and tribal products because of their potential to reduce poverty and unemployment.
- **Products with GI tags:** They can be produced locally and sold internationally in various states and areas.
- **One Station One Product:** On March 25, 2022, this programme was introduced at 19 Indian Railways stations. It was then expanded to 69 additional stations. Following its success, this programme is being gradually introduced at 1000 train stations all around the nation.
- **One District , One Product Scheme of the UP government** strives to promote regional traditional industries.
- North East Industrial development scheme incentivises industries to set up in the northeast region.
- The strategy complements **the 'vocal for local' initiative under Atmanirbhar Bharat** as advocated by the prime minister of India.
- **Mission Purvodaya**: It was launched in 2020 for the accelerated development nt of eastern India through the establishment of an integrated steel hub. The focus will be on the eastern states of India (Odisha, Jharkhand, Chhattisgarh, West Bengthe al) and northern part of Andhra Pradesh which collectively hold ~80% of the country's iron ore, ~100% of coking coal and significant portion of chromite, bauxite and dolomite reserves.
- North East Industrial Development Scheme (NEIDS): To encourage industrialization and increase employment and revenue production, it covers qualified industrial units in the manufacturing and service sectors of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, and Sikkim.

### **CHALLENGES:**

- Lack of infrastructure: Resource-rich regions like Jharkhand , Chhattisgarh , northeast region fails to attract industries due lack of complementary infrastructure.
- Lack of skills and modernisation: Local craftsman fails to modify local artefacts as per global demands due to a lack of modern equipment.
- Lack of vision in policy formulation: Due to poor development of local skills and poor marketing regional products have failed to transform into recognised brands.

### IMPACT OF REGIONAL RESOURCE-BASED MANUFACTURING

- **Functional Specialization:** People with specialist skill sets are required to work in industries where one type of resource is the main focus. The need for workers with that particular skill set will rise as a result. a distillery and a facility for making alcoholic beverages, for instance.
- **Establishing auxiliary industries:** When a particular type of industry is founded with a given resource, numerous subsidiary enterprises in the form of MSMEs are set up to serve the primary industry with smaller items. The creation of new jobs will be aided by these small firms.
- **Secondary Employment:** In addition, there are side industries that support the primary industry as well as secondary job prospects in the shape of cafés, hostels, and shops that open to accommodate the sector's workers.
- **Developed Supply Chain:** The establishment of a supply chain in the region opens up more employment chances because a supply chain is a network between a company and its suppliers that distribute a particular product to the ultimate customer.
- **Decreased Transportation cost:** The proximity of production facilities and raw supplies will lower transportation expenses. This will make it easier to hire more qualified personnel there.
- **Expertise:** The establishment of manufacturing expertise in the area could help with the creation of new jobs.
- **Diversity in Demand:** There would be a greater and more varied demand for consumer goods. This starts a cycle that could lead to expansion in the production, distribution, and support of the secondary and tertiary sectors.
- **Reduced Income Gap:** Income disparity can be indirectly reduced by lowering the incomes of the richest and raising the incomes of the poorest. The latter include policies that increase employment or income as well as transfer income.

By 2022, the National Manufacturing Policy had aimed manufacturing to account for 25% of the nation's GDP. However, it has been seen that some areas experience extraordinarily quick development because of their favourable geographic position and high level of industrialisation, while other regions lag behind. In this sense, regional manufacturing becomes very important.





### **TEXTILE INDUSTRIES**

- **Contribution to GDP:** With a contribution of more than 2% of the nation's overall GDP and more than 12% of the manufacturing sector's GDP, the textile industry is one of India's most important economic sectors.
- **Employment:** Being the second-largest employer in India after agriculture, the industry is crucial to the country's economy. Additionally, it directly and indirectly employs about 10.5 crore people.
- **Export:** India is also the world's second-largest producer and exporter of textiles and apparel, accounting for 5% of all international trade. In 2018–19, it made up 12% of all exports from India.
- **Market:** The two biggest export markets for Indian textiles are the US and the EU, followed by a number of Asian nations and the Middle East.
- **Valuation:** India's textile and apparel market, which had a 2015 value of US\$108.5 billion, is anticipated to rise to US\$226 billion by 2023, with a CAGR of 8.7% from 2009 to 2023.
  - The government is dedicated to boosting India's textile exports from the current \$44.4 billion to \$100 billion over the following five years.
- Various policy initiatives and programmes
  - Scheme for integrated textile parks.
  - National Handicraft Development Program (NHDP).
  - Comprehensive Handicrafts Cluster Development Scheme (CHCDS).
  - North Eastern Region Textile Promotion Scheme (NERTPS).

### COTTON TEXTILE INDUSTRY

- **Climatic Condition:** Frost-free climates, temperatures between 20 and 30 degrees Celsius, and little annual precipitation is necessary for cotton growing. Black soil or alluvial soil both support cotton growth effectively.
- **Production:** After synthetic fibres, the cotton industry in India is seen as having reached a certain level of development. India is the world's largest producer of cotton, contributing 18% to worldwide production.
- Area under Cultivation: Additionally, it cultivates the most cotton, accounting for nearly 25% of all agricultural land worldwide. The largest cotton-producing states in India include Gujarat, Maharashtra, Andhra Pradesh, Haryana, Punjab, Madhya Pradesh, Rajasthan, Karnataka, and Tamil Nadu.
  - **India's cotton basket**, which is made up of the states of Maharashtra, Gujarat, Andhra Pradesh, and Telangana, produces over two-thirds of the country's cotton.
- Share: Power looms account for the largest share (around 80%) in cotton textile production followed by handlooms and mills. It is an agro-based industry depending upon pure raw materials.
- **Key Market:** The USA, the European Union, Asia, and the Middle East are the main markets for Indian textile and clothing exports.
  - According to AEPC, the USA has a 26.3% market share for knitted clothing, followed by the UAE at 14.5% and the UK at 9.6%.
  - With 27% of all textile exports in FY22, the US led all other export destinations, ahead of Bangladesh (12%) and the EU (18%).

### FACTORS RESPONSIBLE FOR GROWTH OF COTTON INDUSTRY:

- **Historical Factor:** The **Industrial Revolution and later the First and Second World Wars**, the Swadeshi Movement, and the grant of fiscal protection rapidly propelled the growth of this industry.
- Locational factors: Post-independence, the industry also tended to shift from areas of high labour cost to those with low labour cost. The labour cost factor played a crucial role in establishing this industry at Madurai, Tirunelveli, and Coimbatore.
  - **Important centres:** Mumbai, Ahmedabad, Coimbatore, Indore, Kanpur etc.

### GROWING IMPORTANCE OF INDIAN TEXTILES IN GLOBAL TRADE

- **Extensive Network:** Due to its extensive network of both small and major manufacturers, exporters, and traders, the Indian textile sector is quite competitive.
- **Stimulate Local Manufacture:** The "Make in India," "Aatmanirbhar Bharat," and Performance Linked Incentives (PLI) initiatives, which seek to stimulate local manufacturing and increase exports, have also helped the industry.
- **Important Factors:** The industry's expansion can be ascribed to a number of elements, including the availability of reasonably priced labour, a sizable consumer base, supportive governmental regulations, and extremely creative business owners.
- **Enhanced Quality:** Additionally, India is now able to create high-quality textiles that satisfy international standards because to its highly skilled workforce and technical breakthroughs.
- **Diverse Goods:** The sector exports a wide variety of goods, including ready-to-wear clothing and textiles manufactured of cotton.





- **Initiatives:** The Technology Upgradation Fund Scheme (TUFS), one of the government's many programmes and initiatives, offers financial support to textile businesses so they can modernise and advance their technology.
- **Brand India:** The business community is dedicated to marketing "Brand India" on a variety of international forums, emphasising its advantages in labour standards, sustainability, circularity, ethical sourcing, and manufacturing.

### **TEXTILE INDUSTRY: BACKBONE OF INDIAN EMPLOYMENT**

- **Contribution to Economy:** India currently accounts for 13% of its export revenue and 5% of the world's GDP, with a 4% share of global trade.
- **Second Largest Employer:** The primary industry in the nation is textile, which also contributes significantly to the economy and is the second largest employer after agriculture.
- **Employment number:** According to government statistics, the industry directly employs about 4.5 crore people and indirectly supports another 6 crore jobs. Women make up the majority of the workforce, making up between 60% and 70% of the entire labour force.
- **Women:** Over 27 million women in India depend on the textile industry for their income, of which 50% work in unorganised industries like handlooms, handicrafts, and sericulture.
- **Rural Areas:** Given that the majority of textile companies are found on the periphery of cities, the textile industry is also one of the most important sources of employment for rural residents.
- **PLI Scheme:** The Production Linked Incentive (PLI) Scheme, which was authorised in September 2021 for the textile sector and is anticipated to add about 7.5 lakh new jobs directly and a few lakhs more through supporting activities.

### **Problems:**

- **Scarcity of Raw Cotton:** Raw cotton is scarce and has never been enough to meet demand. In order to meet a large portion of the demand for long-staple cotton, imports from Pakistan, Kenya, Uganda, Sudan, Egypt, Tanzania, the United States of America, and Peru are used.
- **Obsolete Equipment:** Only 18 to 20 per cent of looms in India are automatic, compared to 83 to 76 per cent in Norway, 70 to 70 per cent in Australia, 60 per cent in Pakistan, and 45 to 50 per cent in China.
- **Low Labour Productivity:** India's labour productivity is incredibly poor when compared to other developed nations. A worker in India typically manages two looms, compared to thirty in Japan and sixty in the USA.
- **Strikes:** Labour disputes are prevalent in the industrial sector, but the cotton textile industry suffers greatly as a result of regular worker strikes. The 1980 protracted strike severely harmed the organised sector.
- **Stiff Competition:** Taiwan, South Korea, and Japan, whose products are more affordable and of higher quality, are the main competitors for Indian cotton textile products in international markets.
- Sick Mills: The National Textile Corporation, established in 1975, has taken over the management of 125 sick mills in an effort to avoid sick mills. The fact that hundreds of mills have already been shut down is concerning.
- **Rising Cotton Prices:** The price of cotton has nearly doubled between 2021 and 2022, much exceeding above the government's minimum support price of Rs 6,025 per quintal for long-staple cotton varieties.
- **Production decline:** In India, the area planted with cotton fell from 134.77 lakh hectares (lh) in 2019–20 to 132.85 lh in 2020–21 and 123.5 lh in 2021–22. This is partly attributable to the declining advantages of Bt cotton, which has undergone genetic modification.

### **GOVERNMENT INITIATIVES**

- **Budget 2023-24:** With a budgetary outlay of INR 106.83 billion, the programme will offer incentives for five years, from FY 2025-26 to FY 2029-30.
- **Extension for RoSCTL:** In order to increase the competitiveness of the Indian textile industry on the global market, the RoSCTL scheme, has been extended for exports of apparel/garments and made-ups.
- **PM MITRA scheme:** The establishment of seven Pradhan Mantri Mega Integrated Textile Region and Apparel (PM MITRA) Parks in Greenfield and Brownfield locations with a cost of Rs. 4,445 crores for a seven-year period ending in 2027–28 was approved by the government.
- **Removal of anti-dumping duty:** Anti-dumping tax was withdrawn on PTA (Purified Terephthalic Acid), acrylic, and viscose staple fibre in order to increase exports in the man-made fibre (MMF) sector.
- **ATUFS Amended Technology Upgradation Fund Scheme**: It was launched in 2015 for technology upgradation of the textile industry.
- **SITP Scheme for Integrated Textile Parks:** To provide world-class state of art infrastructure facilities to small and medium units with a cluster approach.
- **SAMARTH- Scheme for Capacity Building In the Textile Sector:** The scheme is aimed at addressing the shortage of skilled labours in the textile sector.
- **National Technical Textile Mission:** To position the country as a global leader in technical textiles and increase the use of technical textiles in the domestic market. It strives to enhance R&D and export promotion in technical textiles.





- **Confederation of Indian Textile Industry:** One of India's top industry chambers for the textile industry, Confederation of Indian Textile Industry (CITI), operates in 1700 villages throughout the states of Rajasthan, Madhya Pradesh, and Maharashtra.
- **PLIS Production Linked Incentive scheme:** The scheme is aimed at promoting industries that invest in the production of man-made fibre apparel, man-made fibre fabrics and technical textile segments.

### WAY AHEAD FOR TEXTILE SECTOR:

- **Capacity Building:** Higher disposable income is the result of strong economic growth. A vast domestic market has been created as a result of the increase in product demand. Building the skills and capabilities of employees and business owners is essential and necessary.
- **Investment in Value Added Services:** A requirement for the sector to grow is investment in value-added services, such as marketing, warehouse rentals, shipping, courier, and other product fulfilment costs.
- **Modernization:** It is necessary to boost output, save costs, rationalise manpower in multiple tasks, lower maintenance, and improve the energy efficiency of the sector.
- **Research & Development:** Government R&D organisations and academic institutions ought to work more closely with businesses and engage in R&D that is more pertinent to the changing demands of the cotton textile industry.
- **Revamping the MSP Scheme:** The government would spend less money and cotton farmers would receive the same amount of relief if a plan could be developed for the direct transfer of subsidies to the extent of the difference between market prices and MSPs whenever market rates fall below MSPs.
- **Market related strategy:** The cotton sector must set high prices, target specialised products and markets, and redesign products for greater value-added markets. For sustained development, it also has to concentrate on regional and cluster subsidies, technology upgrades, and talent development subsidies.

### NITI India@75: Relationship between energy shift and cotton production

- **Renewable energy in 21st century**: The future of renewable energy Clean, renewable energy will propel the smallscale, environmentally conscious Indian companies to the top of the heap in the twenty-first century, just as energy from fossil fuels helped usher in the era of mass production in the nineteenth.
- **Low-energy production is emphasised**: Old ideas of efficiency will alter as fossil fuels run out, and low-energy manufacturing techniques will become more valuable.
- Handwoven textiles will become more popular once more: The demand for the customised items that dispersed manufacturing may provide is growing at the same time that markets are becoming saturated with identical goods produced in factories.

### CONCLUSION

• Programs like **Skill India**, **Make-in-India**, **and Aatmanirbhar Bharat** as well as the continued development and growth of management consulting firms in India for foreign companies, are assisting in the growth of the Indian textile industry. The textile industry would become competitive in the global market if it had **access to skilled manpower and a good market** for its products. With **proper market entry strategies** in place for global behemoths, the Indian textile industry's future looks bright, buoyed by both strong domestic and export demand.

### JUTE INDUSTRY

- **Climatic Condition:** It is best to grow jute in hot, humid areas. High humidity levels of 80 to 90 per cent, significant precipitation of 120 to 150 cm, and temperatures between 24 and 35 °C are necessary.
- **Production:** India is the largest producer of Jute products. However, in terms of acreage and trade, Bangladesh takes the lead accounting for three-fourths of the global jute exports in comparison to India's 7%.
- **Employment:** This company supports around 40 lakh farming families and directly employs 1.4 lakh tertiary workers and 2.6 lakh manufacturing workers.
- **Process of Production:** The jute industry's production process includes a number of phases, such as the preparation of jute fibres, spinning, weaving, bleaching, dyeing, finishing, and marketing of both the raw material and its finished products.
- **A profitable crop:** Even before the crop is harvested, its leaves are offered for sale in marketplaces as a vegetable. While the outer layer creates the fibre, the inner stem can be used to make paper.
- Other Important Details:
  - This is the **second most important textile industry** in India after the cotton textile industry.
  - Jute production is a **labour intensive industry**.
  - **West Bengal** has the largest concentration (80%) of jute industry in India followed by Andhra Pradesh.

### MAJOR JUTE PRODUCING STATES

• The majority of jute mills and output, more than 80% of total production, are located in West Bengal.





- With 10% of the whole industry in **Andhra Pradesh** and the remainder in **Uttar Pradesh and Bihar**, the sector has spread westward.
- The majority of jute mills are restricted to a small, 100-kilometre-long belt along the **Hugli River within a 64kilometre radius of Calcutta**. This belt is only 3 km wide.
- In addition to West Bengal, jute mills are located in Purnea, Katihar, Samastipur, Darbhanga, and Gaya in Bihar, Raigarh in Chhattisgarh, Cuttack in Orissa, and Guntur, Visakhapatnam, Nellimarla, Chellivelsa, Eburu, and Ongole in Andhra Pradesh. There is one jute mill each in Tripura and Assam.

### **Favourable Condition for West Bengal**

- **Temperature**: Jute demands a warm, humid climate with temperatures between 25 and 35 °C.
- **Rainfall**: West Bengal receives an average annual rainfall of about 150–250 cm, which is adequate for the growth of the crop. Adequate rainfall is essential for jute production.
- **Soil**: Jute thrives on fertile, alluvial soil that is high in organic matter and has a good ability to retain water.
- Land: Jute needs terrain that is level or gently sloping, well-drained, and has a high water retention capacity. The state of West Bengal has an extensive network of canals and reservoirs that make irrigation possible, and its deltaic plains are well-adapted for the cultivation of jute.
- Labour: A lot of labour is required for jute farming, especially during harvest and processing.

### **CHALLENGES FACED BY JUTE INDUSTRY**

- **Raw material:** Most of the jute-producing areas went to Bangladesh resulting in an acute shortage of raw material. Hence the availability of quality raw jute and shrinking acreage
- **Obsolete Machinery:** Most of the mills are old with obsolete machinery which results in low productivity and inferior quality and insufficient efforts of modernising technology.
- Newly established jute mills with **advanced technology in Bangladesh** produce better quality jute products at a cheaper rate compared to Indian jute products.
- **Competition**: Competition from synthetic packing materials has shrunk the market for jute goods.
- **Obsolete processing technology** and the **lack of product diversification** have limited the jute products only to handicrafts and packaging.
- **Infrastructural bottlenecks:** Power, transportation and capital also pose several threats to the sustainability of the Jute industry.
- High prices: mills are procuring raw jute at prices higher than what they are selling them at after processing.
- **Poor Quality of Jute Fibres**: Natural disaster such as cyclone Amphan, Floods cause water logging in the fields. Due to this, farmers do harvesting the crops prematurely.

### INDIA'S JUTE ECONOMY IS FALTERING WHILE BANGLADESH'S IS FLOURISHING

- According to a **2021 report by the Commission for Agricultural Costs and Prices (CACP)**, between 2000-01 and 2009-10, the average area in the nation under jute was 0.82 million ha. Between 2010–11 and 2019–20, this decreased to 0.73 million ha.
  - The area covered by jute in West Bengal, which is the state with the most jute mills in India with 70, decreased by 0.1 million ha between 2009–10 and 2020–21.

	Indian Case		Bangladesh Case
٠	Falling Prices: It dropped to Rs 25,000 a tonne in	٠	Advantageous Position: low cost of production,
	2010-2011 from Rs 30,000-40,000 per tonne in the		which is fueled by lower salaries, favourable power
	late 2000s. This barely covered the expense of the		rates, cash subsidies for export, and improved fibre
	input.		quality.
•	<b>Central Procurement</b> : 90% of the jute bags are given	•	Better Quality: India's jute production has struggled,
	to the Food Corporation of India and state procurement		especially with quality. India's jute industry suffers
	organisations, while the remaining 10% are exported		from inadequate retting infrastructure, which is a step
	or sold directly.		after crop harvesting.
•	India's Share: According to the CACP research, India	•	Various Subsidies: Bangladesh has three to four
	also accounts for barely 7% of global jute exports,		various types of subsidies, which helps it do well in
	compared to approximately 75% for Bangladesh.		the export market.
•	Decreasing area under cultivation: In 2019–20, this	•	Diversification: Another factor in the nation's success
	decreased to 0.73 million ha.		is its capture of the market for diverse jute products,
			which has a sizable market.





### **CASE OF ANTI-DUMPING DUTIES:**

- The **CACP report** said imports from Bangladesh had adversely affected the domestic industry, given that the landed price of jute and its products from the neighbouring country was less than the domestic rate.
- The Indian jute industry has complained about Bangladesh's monetary incentives for jute exports, claiming that **India's jute industry is suffering due to Dhaka's subsidised operations.**
- In 2017, **India introduced a protectionist anti-dumping duty** to protect its local jute industry. The duty was imposed on jute yarn, burlap and sacks in 2017 at the rate of \$19-352 per ton supplied from Bangladesh, for a period of 5 years till 2022.

### INDIA TO BOOST JUTE INDUSTRY WITH MANDATORY PACKAGING NORMS

- Jute sacking bags: It account for 75% of the nation's total production of the jute industry; 85% of these are provided to the Food Corporation of India (FCI) and state procurement agencies (SPAs), and the other 25% are exported or sold directly.
- **Obligation:** The obligatory regulations call for a full reservation for the packaging of food grains and a 20% reservation for the jute-bag packaging of sugar.
  - The **Jute Packaging Materials (JPM) Act of 1987's** reservations regulations guarantee 3.70 lakh people direct employment and defend the interests of almost 40 lakh agricultural families involved in the jute industry.
- Benefits:
  - It will encourage the diversification of the jute industry and help the jute sector grow.
  - It will enhance and sustain demand for jute products as well as improve the quality and productivity of raw jute.
  - Farmers and labourers in the Eastern and North Eastern parts of the nation, particularly in the states of West Bengal, Bihar, Odisha, Assam, Andhra Pradesh, Meghalaya, and Tripura, will gain from it.

### Jute Business Sprouts New Shoots As Global Demand For Green

- **Context**: According to Indian Jute Mills Association, big brands buy shopping bags worth more than Rs 1,000 crore each year.
- **Quantum Jump**: The value of India's jute bag exports was approximately Rs 350 crore in 2016, but by the end of the recent fiscal year 2021, that amount has nearly tripled to Rs 1,000 crore.
- Note: A jute shopping bag's lifespan is 600 times longer than a plastic one.

### **GOVERNMENT INITIATIVES:**

- Anti-Dumping Duty: In 2017, India introduced a protectionist anti-dumping duty to protect its local jute industry. The duty was imposed on jute yarn, burlap and sacks in 2017 at the rate of \$19-352 per ton supplied from Bangladesh, for a period of 5 years till 2022.
- **Jute Mark India Logo:** To give collective identification and guarantee regarding the origin and quality of jute and jute products, the Jute Mark India scheme was launched.
- **Jute SMART**: It provides a platform for the procurement of jute products and promotes transparency in the jute sector.
- **Jute ICARE**: It helps farmers by providing them with certified seeds , nail weeders for periodic weeding , and seed drills to facilitate line sowing.
- **The Jute Packaging Materials (Compulsory Use in Packing Commodities) Act** was enacted in 1987 to protect the jute sector from the plastic packaging segment.
- Government has put a ban against plastic bags and single-use plastic packaging holds potential for the jute sector.
- Government has made mandatory packaging of 100% food grains and 20% sugar in jute bags.
- MSP: Jute is included into the MSP regime to incentivise farmers for jute cultivation.
- Jute Geo-Textiles (JGT): It has been included under the Technical Textiles Mission. JGT is one of the most important diversified jute products. It can be applied in many fields like civil engineering, soil erosion control, road pavement construction and protection of river banks.

### SUGAR INDUSTRY

The sugar business in India uses sugarcane, a bulky, low-value, perishable raw material. Any crop that produces sugar, such as sugarbeet or sugarcane, can be used to make sugar. India's main source of sugar, on the other hand, is sugarcane. After the cotton textile industry, this is the second-largest agricultural sector in the world.

### **FACT-WISE**

Production: More than 5000 LMT (Lakh Metric Tonnes) of sugarcane, a record amount, was produced in the country from October to September (2021–2022). India bypassed Brazil to become the largest producer of sugar in the world.
 Consumption: The domestic demand is roughly 27 million tonnes per year. Sugarcane is also used to create ethanol in





addition to sugar.

- **Export**: The highest exports of 109.8 LMT, which were made without any financial assistance and sustained through 2020–21.
- **Employment**: The sugar industry is a significant agro-based business with 50 million sugarcane farmers and around 5 lakh directly employed workers in sugar mills.

### LOCATIONAL FACTORS

- Geographical Conditions for the Sugar Production:
  - **Temperature:** Between 21-27°C
  - **Climate:** Hot and humid climate.
  - **Rainfall:** Approx. 75-100 cm.
  - Soil: Deep rich loamy soil.
  - Top Sugarcane Producing States: Maharashtra>Uttar Pradesh > Karnataka
- Geographical Distribution:
  - Sugar industry has two major areas of concentration-
    - North: Uttar Pradesh, Bihar, Haryana.
    - South: Maharashtra , Karnataka, Tamil Nadu.
  - **Maharashtra:** It has progressed to the top position surpassing UP. Important centres are Ahmednagar , and Kolhapur.
  - **Uttar Pradesh:** It has more sugar mills than Maharashtra but they are smaller in size hence production is lesser than in Maharashtra. Important centres are Meerut and , Gorakhpur.
  - **Tamilnadu:** It has shown high productivity per acre of sugarcane, higher sucrose content, a high recovery rate and a long crushing season which enabled it to obtain the highest yield in India. Important centres are Coimbatore, Karur.
  - Note: It is based on raw material sugarcane which is heavy, low value, weight losing and perishable. Sugarcane cannot be stored for long as it loses its sucrose content. Therefore sugar industries are established near areas of sugarcane cultivation.

### SIGNIFICANCE OF THE SUGAR INDUSTRY

- **Multiple Links:** From cane cultivation to the production of sugar and alcohol, the sugar industry relies heavily on labour. It is the primary source of employment in numerous districts in Uttar Pradesh, Maharashtra, Tamil Nadu, Karnataka, and several other states.
- **Source of Employment:** 50 million farmers and their families rely on the sugar business for their livelihood and 5 lakh skilled workers as well as semi-skilled workers in sugar mills and related businesses all throughout the country are directly employed by it.
- **By-products:** The many by-products of the sugar business support a variety of related industries and contribute to economic prosperity.
  - Using sugarcane as a primary raw material, producers can now produce sugar, ethanol, paper, energy, etc.
- For Livestock Feeding: Due to its great nutritional value, sugar cane molasses is utilised for both cattle feeding and the manufacturing of alcohol.
- **Biofuel:** Sugarcane molasses, a by-product of sugar production, is used to make the vast majority of the ethanol consumed in India. Fuel containing ethanol can aid in lowering the import of crude oil.
- **Bagasse:** The primary use of bagasse is still as a fuel. However, it also makes a good raw material for the paper industry. Agricultural leftovers supply 30% of the cellulose needed.

### FACTORS BEHIND SHIFTING THE LOCATION OF THE SUGAR INDUSTRY FROM NORTH TO SOUTH INDIA

- Previously North India used to produce 90% of India's sugar which is reduced to 35-40% now because following reasons:
- **Suitable climate: Tropical climate** of the peninsular region gives a higher yield per unit area as compared to north India.
- Sucrose content is higher in tropical varieties of sugarcane.
- **Crushing season** in South India is longer (7-8 months) compared to North India's 4 months.
- **Cooperative Movement** in Peninsular India is more successful than in Northern India. Cooperative sugar mills are better managed in South India.
- **Politicisation of cooperative movement** helped farmers to put their demands effectively to get higher prices for sugarcane **through FRP- Fair and remunerative prices and SAP State advised prices.**
- Most of the mills in the south are new and equipped with **modern machinery having high productivity**.





### MAHARASHTRA OVERTOOK UTTAR PRADESH TO RE-EMERGE AS TOP SUGAR PRODUCER

#### Factors Driving Maharashtra's Massive Sugar **Reason for reduced Sugar Production in Uttar Pradesh Production** Abundant water supply: Sugarcane is a crop that **Diversion for Ethanol**: Because a significant portion of • requires a lot of water, which Maharashtrian farmers Uttar Pradesh's sugarcane crop was shifted to the were successfully obtaining through rainfall, water ethanol industry, Uttar Pradesh has emerged as the reservoirs, a system of canals, and groundwater. nation's top producer of ethanol. **Cane production is underreported:** The information **Excessive Rain**: The state of Uttar Pradesh • provided about the state of Maharashtra's real experienced major losses in sugarcane crops as a result sugarcane production was not entirely correct. In the of excessive rain and water logging issues. end, this led to an increase in the area used for Using Single Variety: A single type of sugarcane (Cosugarcane cultivation, from 11.42 lakh to 12.4 lakh

- 0238) is grown on the majority of the land in Uttar Pradesh's sugarcane region (87%). This sugarcane variety doesn't have a large yield.
  Fungal Disease: The adverse effects of the fungus red
- **Fungal Disease**: The adverse effects of the fungus red rot on the sugarcane crop are a major factor in Uttar Pradesh's declining sugarcane production.

### PROBLEMS AND CHALLENGES WITH SUGAR INDUSTRY:

- Low yield: India has the largest area under sugarcane cultivation but the yield per hectare is very low. This has led to low production and a short supply of sugarcane to mills.
- **Short crushing seasons:** Sugar manufacturing is a **seasonal phenomenon varying from 4-7 months in a year.** The mills and workers remain ideal during the remaining period of the year. It has created financial problems for the industry. **Sowing and harvesting at different intervals** would help in a continuous supply of sugarcane and increase in the crushing period.
- **High cost of production:** The production **cost of sugarcane is one of the highest in the world because of the high cost of sugarcane , inefficient technology , uneconomic process of production and heavy excise duty etc.** The production cost can be reduced by utilising by-products like bagasse and Molasses.
- **Old and Obsolete machinery**: Particularly north Indian mills use **old machinery having poor productivity**. It has led to poor productivity of mills and reduced production.
- Government policies:

hectares.

- Sector is suffering from **the government's control and populist policies.** Unviable sugarcane pricing caused the sugar cycle to oscillate between surplus and severe shortage.
- The government grappled with **large cane arrears** while the industry survived on periodic government funded **bail-outs and subsidies**.

### Rangarajan Committee

- It was established in 2012 to make suggestions for regulating the sugar business.
- Elimination of quantitative controls on sugar import and export; their replacement with suitable tariffs.
- States should change their laws to enable mills to use bagasse-generated energy.

### **GOVERNMENT INITIATIVES:**

- **Encouragement of Ethanol Production:** To help sugar mills maintain their operations, the government has urged them to shift excess sugar to ethanol production and export the remaining sugar.
- **Ethanol Blending with Petrol (EBP) Programme:** According to the National Policy on Biofuels 2018, the Ethanol Blended Petrol (EBP) Program's suggested target for ethanol blending is 20% by 2025.
- Fair and remunerative Price (FRP): In order to assist sugar farmers and pay off their outstanding cane debts, the Union Government has agreed to raise the Minimum Selling Price (MSP) of sugar from Rs. 29 to Rs. 31 for the 2019–20 fiscal year.
- **State Advised Price:** State governments have the ability to determine a State Advised Price that a sugar mill must pay to the farmers even though the Central Government sets the FRP.

### Case Study: Fiji wants India's help to revive the Sugar Industry

- The sugar business has historically contributed the most to Fiji's foreign exchange earnings. The tourism industry overtook the sugar industry as the leading industry, however, as a result of outdated machinery and a labour shortage.
- When the Covid pandemic hit the world, tourism revenues were completely lost. The sugar business, though, remained robust.





### WAY FORWARD:

- **Sugarcane Mapping**: Despite the importance of sugarcane in the water, food and energy sectors in India, there are no reliable sugarcane maps for recent years and in time series. Thus, there is a need to deploy remote sensing technologies to map sugarcane areas.
- **Innovation:** Research and development in sugarcane can help address the issues like low yield and low sugar recovery rates. For example, in 2016-17, a new variety of sugarcane **(CO 238)** was developed for use in Uttar Pradesh (UP).
- **The ethanol option:** If the ethanol option- 'blending ethanol with petrol for use as auto fuel' is implemented properly, it will offer the required cash flow to sugar mills, ensure better prices for farmers, enhance India's energy security and reduce pollution.
- **Sugar Pricing:** In this context, the Rangarajan Committee has suggested a Revenue Sharing Formula formula to fix cane prices by factoring in the price of sugar and other by-products.
- The Rangarajan Committee formula:
  - The Committee has suggested a formula to **fix the cane price factoring in the price of sugar and other by-products.**
  - If the formula-based cane price drops below what the government considers as a reasonable payment then the government can **bridge the gap by making a dedicated fund through cess levies.**
  - A **minimum radial distance of 15 km** must exist between any two sugar mills, according to the national government.
  - Based on the findings, the Commission on Agricultural Costs and Prices (CACP) recommended a hybrid strategy for sugarcane price fixing that includes a **fair and remunerative price (FRP)**.

### Karnataka HC: Ethanol manufacturing unit cannot be established within a 15-km radius of a sugar factory

- As a result of legislative changes, a factory producing only ethanol is now also referred to as a "sugar factory," and the law's prohibition on building another "sugar factory" within 15 kilometres of an already-existing one still applies to such establishments, according to the High Court of Karnataka.
- After examining the terms of the Sugarcane (Control) Order between 1966 and 2021, the court determined that starting in 2021, just the production of either sugar or ethanol was required to qualify as a "factory or sugar factory" for the purposes of this statute.

### ETHANOL BLENDING PROGRAMME

### Significance:

- **Energy Security:** India is the third-largest consumer of energy in the world after China and the US. Ethanol will promote AtmaNirbhar Bharat Abhiyan by ensuring energy self-dependency to some extent.
- **Support for the agricultural sector**: It will help the sugar mill owner to pay farmers their pending FRP for sugarcane. It will also mitigate the problem of low sugar prices in the international market.
- **Ecological Benefit**: This fuel has the potential to reduce the harmful greenhouse gases from the atmosphere. Gases like Carbon Monoxide, Oxides of Nitrogen and hydrocarbons have a significant contribution to air pollution. Ethanol blending can help in decreasing these emissions.
- **Entrepreneurial Opportunity**: India is expected to need 10 billion litres of ethanol annually to meet the 20% blending target in 2030 if petrol consumption continues to grow at the current pace. At present, the capacity stands at 1.55 billion litres a year.
- **Effective waste management**: Bioethanol can be produced from fruit and vegetable waste, crop residues, wood pulp, animal waste or garbage in general. It can help in managing the waste generated around us daily, apart from being a non-competing source to produce ethanol.
- **Increasing farmer incom**e: Ethanol production can diversify the source of income for the farmers. It will prove to be a boon for the farmers as they could get a better price for their produce.

### Challenges

- **Fuel Efficiency**: Fossil Fuels produce more energy than some of the biofuels. E.g. 1 gallon of ethanol produces less energy as compared to 1 gallon of gasoline (a fossil fuel).
- **Unregulated emissions:** The unregulated carbonyl emissions, such as acetaldehyde emission were higher with E10 and E20 compared to normal petrol. No reduction in NOx is seen even after the use of ethanol-blended fuel.
- Water use: Massive quantities of water are required for proper irrigation of Sugar cane crops as well as to manufacture the fuel, which could strain local and regional water **resources**.
- **Expensive:** These fuels although are cleaner and complete combustion take place in them but have higher evaporative emissions from fuel tanks and dispensing equipment. Thereby making them costly.
- **Regulatory clearance:** At present, Ethanol production plants/distilleries fall under the "Red category" and require environmental clearance under the Air and Water Acts for new and expansion projects.





- **Grain availability:** Competition between the distilleries and the public distribution system for subsidized food grains could have adverse consequences for the rural poor and expose them to enhanced risk of hunger.
- **Inter-state movement of ethanol:** While an amendment has been made to the Industries (Development and Regulation) Act which legislates exclusive control of denatured ethanol by the central government for the smooth movement of ethanol across the country, the same has not been implemented by states thereby restricting this movement of ethanol.
- **National Biofuel Policy:** Due to grain surpluses and the widespread availability of technologies, the new ethanol blending aim predominantly focuses on feedstocks that are used in food production. The plan departs from the National Policy on Biofuels for 2018.

### Way Forward

- Shift Focus from 1G to next-generation Biofuels: It will counter the most genuine fear of loss of food security.
- **Making Vehicle manufacturers future-ready**: The industry and petrol pump should be made ready for the next pushes like E85 and E100
- **Refocus on ethanol made from waste:** India has a real opportunity here to become a global leader in sustainable biofuels policy if it chooses to refocus on ethanol made from waste.
- **Water-friendly Crops:** The new ethanol policy should ensure that it doesn't drive farmers toward water-intensive crops and create a water crisis in a country where its shortage is already acute.

Government has **aimed to double the growth rate of the manufacturing sector by 2022** which requires foreign investment, promotion of the latest technologies like '**Industry 4.0**' and effective implementation of government schemes: **Make In India , Ease Of Doing Business and Digital India.** Industrial sector in India has **yet to achieve its true potential in terms of GDP contribution** and **employment generation**. India is bestowed with a **potential demographic dividend**. **Structural reforms in economy** and **infrastructure development** accompanied **by skilled human capital** would form a win-win situation to accomplish the goal of **Atmanirbhar Bharat**.

### TERTIARY SECTOR

- Tertiary activities are related to the service sector. The majority of tertiary tasks are carried out by consultants, professionals with formal training, and a skilled workforce.
- The tertiary sector offers a wide range of services, including travel, banking, insurance, education, trade, transportation, and communication. Instead of dealing with raw resources, it deals with finished and final commodities.
- The primary distinction between the secondary and tertiary sectors is that services rely more significantly on the specialist knowledge, experience, and abilities of the workforce than on industrial processes, technology, or production methods.

### FACT-WISE

- India is the **fifteenth largest country** in the world in terms of services' output.
- **Employment**: This sector provides employment to 23% of the workforce and is the fastest growing sector, with a growth rate of 7.5% in 1991–2000.
- **Tertiary sector depends on scientific research and innovative developments to increase productivity**. Developed countries employ more than 80% of the services sector.
- Service sector accounts for around 60% of the total size of the economy, about 38% of total exports and twothirds of the total FDI inflows into India.
- **Global exports**: Share of the Indian service sector in global services exports is expected to increase from 3.3% to 4.2% for 2022.

### SIGNIFICANCE OF INDIAN SERVICES SECTOR

- **Robust demand**: India has emerged as an export hub for software services. The Indian software industry is **expected to reach US \$1 trillion by 2030.** Foreign exchange earned through exports of services has helped to raise all-time high foreign reserves.
- **Employment**: It provides **employment opportunities to 25% labour force of India**. **Tourism, healthcare, education**, business processing sector are among the top employment provider.
  - E.g. Healthcare Tourism and Yoga Tourism are attracting global tourists due to increased recognition of Ayurveda, Hatha yoga, Vipassana etc
- **Competitive advantage**: India's has highly skilled manpower and demographic dividend available at low cost has attracted **BPO**, **KPO**, **Business processing industries India**.





- **Policy support:** Government **efforts on focussing Make In India, Digital India initiatives** and expanding India's entrepreneurship across all service sectors.
- Urbanisation: Increasing population, urbanisation, increasing average income and globalisation effects in India will increase demand for quality and variety of services. Capturing these demands by creating new startups and enterprises would further boost the Indian economy.
  - E.g. New start-ups like **bla-bla cars, Dunzo, Zomato** are increasing their market share day by day.
- **Communication**: Emerging Edtech companies like BYJUs, Unacademy benefited from revolution in communication services are seen as sunrise industries
- **Transport**: Ola, Uber companies urban transport and logistics facilities provided by URL, Delhivery to online sellers shows increasing contribution in GDP and employment generation.
- Services: Zomato IPO sale, increasing subscriptions to OTT platforms indicates their future potential to grow.

### QUATERNARY SECTOR/ KNOWLEDGE BASED INDUSTRIES

Knowledge-based and requiring particular knowledge and technical abilities, this area of the service sector is knowledgeoriented. The majority of primary and secondary employment has been supplanted by the quaternary sector and the tertiary sector as the foundation for economic growth. Like some tertiary activities, quaternary activities can be outsourced. Resources, the environment, or market localization are not constraints on them.

### SIGNIFICANCE

- **IT sector**: India with the onset of globalization, **having a youth population and massive growth in the IT sector** makes it a strong candidate to usher in the knowledge based industry. It will help in creating new better paying jobs, good infrastructure and technology upgrade.
- Innovation: The knowledge based industry uses modern Information & Communication Technologies principles, innovation and research, specialized skills to create, disseminate and apply knowledge. It works towards reducing poverty through inclusive economic growth.
- Industry 4.0: With the advent of newer and advanced technologies like Artificial Intelligence (AI), Machine Learning (ML) and Internet of Things (IOT), conventional manual jobs would easily get replaced. Newer jobs requiring specialized skills will be created. Therefore, the Knowledge industry is the way ahead for India as well as the globe.
- **Enhancing income**: With increase of knowledge based industry share in the economy India is likely to **rise over the problems of middle income trap and income inequality.**

### **CHALLENGES**

- Labour Intensive: The Indian economy is still a labour intensive economy. India has a huge amount of unskilled laborers and untrained workers. The knowledge industries will need education and skill impartation to the majority of people.
- Lack of Skilled Professional: Due to discrepancies in the Indian education system, the knowledge industry doesn't have the right amount of highly skilled professionals mainly because of lack of skill based training and academics focused on rote learning rather than thinking abilities and innovation.
- **Problem of Unemployment:** Knowledge based industries are **likely to cause problems like unemployment** as it would only create high skilled jobs.

### CONCLUSION

• The Industrial Revolution didn't end agriculture as people still have to eat. Similarly, the Knowledge Revolution cannot undermine the importance of industries as people still need physical goods. Thus, **the Knowledge Economy in India must be paired up with sound agricultural and sustainable industrial growth**, only then it can benefit India all round.

### QUINARY SECTOR

It includes creation, re-arrangement and interpretation of ideas, data interpretation, business analysis, critical thinking, evaluation and upgradation of new technologies. The term **"gold collar"** is frequently used to describe senior company executives, government officials, research scientists, financial and legal experts, and other professionals in this group Sector includes Senior business personnel, CEO's, MD's, Scientist, Higher government officials, Financial and legal experts etc.

### SIGNIFICANCE

• **High share in GDP**: The sector provides employment to highly skilled professionals thus **share in employment generation is very low** at the same time **contributing to GDP is very high** due to the high value and specialized services provided by them.



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- **Employment**: Though the share of employment in the Quinary sector is low but the **growth of this sector ensures employment generation in other sectors which are skilled , semiskilled or unskilled**.
  - $\circ~$  E.g. Growth of Entrepreneurs would create more enterprises creating new jobs.
- The **sector ensures the pace of technological advancement** which directs the economic growth of the nation.
- In **developed countries quinary sector is highly evolved and** engaged in research and innovation.
- E.g. Design and development of electric cars
- Knowledge house: The sector includes highly qualified and intellectual professionals. Their guidance and knowledge sharing helps to reap dividend from newer generations.
  - **E.g.** Knowledge transfer from veteran doctors helps their juniors **to bring out the best doctors of them.**

### **CHALLENGES**

- Poor education: The quality of education in the country decides the quality of the quinary sector in the country. Best universities bring out the best talent in the world.
- **Poor quality of higher education:** It compels much of the **talent visiting foreign universities**. They carry out their research works outside of India. Such **export of Indian talent** must be retained in the country. E.g. Many MNCs in the world have Indian CEOs. **Sundar Pichai is CEO of Alphabet Inc.**
- Poor innovation: The research and development ecosystem in India is very poor and the quality of innovation is secondary to global innovations. The basic motto behind education is finding a job through theoretical learning.
- **Entrepreneurship efforts**: In India Entrepreneurship efforts are only concentrated in the **ITES sector**. Agriculture, Automobile, Electronics sectors are not explored by new entrepreneurs. These sectors are lagging behind in achieving their real potential.
- **Policy absence**: Government efforts are not targeted to boost this sector. **The national policy to promote the quinary sector has not been formulated yet.**

### WAY FORWARD

- **Increasing budgetary allocation to the education system:** There is a need to bring **change the in attitude of students**. They must be inspired to create jobs rather than finding a job.
- **Promotion of innovation culture since early education**: Promotion of PhD and R&D **by providing stipends and provision of advanced laboratories and world class instruments.**
- **Diversification of entrepreneurship:** Through incentives to other areas: Agriculture , Electronics etc.

### **CURRENT TREND**

- New trends in quinary services include knowledge processing outsourcing (KPO) and 'home shoring', the latter as an alternative to outsourcing. The KPO industry is distinct from Business Process Outsourcing (BPO) as it involves highly skilled workers. It is information driven knowledge outsourcing.
- **Examples of KPOs** include research and development (R and D) activities, e-learning, business research, intellectual property (IP) research, the legal profession and the banking sector.
- Security of citizens: Police departments are in charge of carrying out surveillance and inquiry tasks.
- **Non-governmental organisations (NGOs):** Independent, non-profit groups that were started by regular people and have a significant positive influence on the areas in which they work.
- **Public education:** All primary, secondary, and postsecondary educational services provided by public institutions are free of charge.
- **Cultural Institution:** These organisation offer a variety of activities, including music, theatre, art, sculpture, and recreational pursuits.
- **Tele-medicine, Tele-education, Tele-Law** are emerging trends which are attracting investment and talent across the world.
- Industry 4.0 AI and ML, IoT etc have received the largest attraction from the government , professionals and MNCs.

# PREVIOUS YEAR QUESTION (MAINS)

Discuss the factors for localization of agro-based food processing industries of North-West India.		
What is the significance of Industrial Corridors in India? Identify industrial corridors, explain their main	2018	
characteristics.		
Why did the Green Revolution in India virtually by-pass the eastern region despite fertile soil and good availability	2014	
of water?		
Do you agree that there is a growing trend of opening new sugar mills in the Southern states of India? Discuss with	2013	
justification		
Analyze the factors for highly decentralized cotton textile industry in India	2013	



# **9.MINERALS AND ENERGY RESOURCES**

Minerals are naturally occurring substances that are not produced by living organisms. They are found in the Earth's crust and have a specific chemical composition and a regular arrangement of atoms, forming a crystalline structure. Minerals can be composed of one or more elements and occur in various forms, colours, and hardness levels. They have important physical and chemical properties and are used in various industries and everyday life.

#### **FACT-WISE**

The Gross Domestic Product (GDP) contribution of the mining industry varies from 2.2% to 2.5% only but going by the GDP of the total industrial sector, it contributes around 10% to 11%.

### **TYPES OF MINERAL RESOURCES:**

### • Ferrous Minerals:

- **Iron Ore**: India has the largest reserve of iron ore in Asia. About 95 per cent of the total reserves of iron ore is located in the States of Odisha, Jharkhand, Chhattisgarh, Karnataka, Goa, etc. The value of metallic minerals in 2021-22 was Rs.1,22,142 crores, which increased by about 69.18% over the previous year.
- Manganese: Manganese deposits are found in various geological formations and are primarily associated with the Dharwar system. Leading producers of manganese are Odisha, Karnataka, Telangana, Goa, and Jharkhand. The production of manganese ore at 2.70 million tonnes in 2021-22 decreased by about 0.27% compared to that in the previous year.



### Non-Ferrous Minerals:

- **Bauxite**: India ranks fourth in the world in terms of bauxite reserves. It is mainly found in tertiary deposits and associated with laterite rocks. Major producers of bauxite are Odisha, Jharkhand, Gujarat, and Chhattisgarh. The production of bauxite at 22.49 million tonnes in 2021-22 decreased by 10.37% compared to the previous year.
- **Copper**: Copper deposits are mainly found in Jharkhand, Madhya Pradesh, and Rajasthan. Copper is essential in the electrical industry for manufacturing wires, motors, transformers, and generators. The production of copper concentrate at 114.42 thousand tonnes in 2021-22 increased by about 5.25% as compared to the previous year.

### • Non-Metallic Minerals:

- $\circ~$  The value of production of non-metallic minerals at Rs 10606 crore during 2021-22 increased by 14.83% as compared to the previous year.
- **Mica**: Mica is an important non-metallic mineral used in the electrical and electronic industries. It is found in states like Jharkhand, Andhra Pradesh, Telangana, etc.
- **Other non-metallic minerals**: Limestone, dolomite, and phosphate are other significant non-metallic minerals in India.

### DISTRIBUTION OF KEY MINERAL RESOURCES IN INDIA

**Mineral Belts in India**: India is geologically rich and has several mineral belts across the country. These mineral belts are regions that are known for their significant mineral deposits.

Belts	Area/Region	Potentials			
	This mineral belt	•	It is known for its rich deposits of coal, iron ore, copper, lead, and zinc.		
	extends from the	•	Coal: The region has extensive coal reserves, providing a significant		
The North	Aravalli range in		source of energy for power generation and industrial use.		
Eastern	Rajasthan in the west to	•	Iron Ore: The belt has substantial iron ore deposits, contributing to		
Peninsular	the Chotanagpur	India's iron and steel industry.			
Belt	Plateau in Jharkhand	•	Copper, Lead, and Zinc: These metals have economic potential and can		
	and Odisha in the east.		be extracted for various industrial applications.		
The	Located in the states of	•	This belt is known for its abundant reserves of iron ore, manganese,		
SouthWestern	Karnataka, Goa, and		limestone, and bauxite.		
Belt	parts of Maharashtra.	•	Iron Ore: The region is known for its high-grade iron ore deposits,		
			making it a crucial source for the iron and steel industry.		
		•	<b>Manganese</b> : The belt has significant manganese reserves, which are essential for steel production and various other industries.		





		• <b>Bauxite</b> : The presence of bauxite ore offers opportunities for aluminium production.
The North Western Belt	This mineral belt is spread across Rajasthan and Gujarat.	<ul> <li>It is known for its deposits of limestone, marble, gypsum, rock phosphate, lignite, and bentonite.</li> <li>Limestone and Marble: The belt has abundant reserves of limestone and marble, which are used extensively in the construction industry and cement manufacturing.</li> <li>Gypsum: The region has gypsum deposits, which find applications in construction materials, agriculture, and manufacturing sectors.</li> <li>Bentonite: Bentonite deposits have the potential for various industrial uses, such as in drilling fluids, foundry moulds, and environmental applications.</li> </ul>
The Central Belt	This belt is located in Chhattisgarh and Madhya Pradesh.	<ul> <li>It is known for its significant coal reserves, as well as deposits of iron ore, bauxite, limestone, and dolomite.</li> <li>Coal: The region has substantial coal reserves, contributing to India's energy needs.</li> <li>Iron Ore: The belt has iron ore deposits, supporting the iron and steel industry.</li> <li>Bauxite, Limestone, and Dolomite: These minerals have the potential for industrial use, including aluminium production, cement manufacturing, and construction materials.</li> </ul>
The Southern Belt	Located in Tamil Nadu, Andhra Pradesh, and Karnataka,	<ul> <li>This belt is known for its rich deposits of iron ore, bauxite, and limestone.</li> <li>Iron Ore: The region has iron ore deposits that are used for steel production.</li> <li>Bauxite and Limestone: These minerals are utilized in aluminium production, cement manufacturing, and construction materials.</li> </ul>
The Eastern Belt	This mineral belt extends through Odisha, West Bengal, and parts of Jharkhand.	<ul> <li>It is known for its vast reserves of iron ore, coal, manganese, and chromite.</li> <li>Iron Ore: The region has extensive iron ore deposits, supporting the iron and steel industry.</li> <li>Coal: The belt has significant coal reserves, contributing to India's energy requirements.</li> <li>Manganese and Chromite: These minerals have the potential for steel production, ferroalloy manufacturing, and various industrial applications.</li> </ul>
The Western Belt	Located in Maharashtra and Gujarat.	<ul> <li>This belt is known for its deposits of manganese, bauxite, limestone, and gypsum.</li> <li>Manganese: The belt has manganese reserves, which are essential for steel production and other industries.</li> <li>Bauxite: The region offers opportunities for bauxite extraction for aluminium production.</li> <li>Limestone and Gypsum: These minerals have potential for construction materials, cement manufacturing, and other industrial applications</li> </ul>

### **PRODUCTION OF MINERALS:**

During the year 2021-22, mineral production was reported from 19 States of which the bulk of the value of mineral production of about 97.04% was confined to 7 States only.

- **Coal**: India is one of the largest producers of coal globally. It has significant coal reserves and produces various types of coal, including bituminous, sub-bituminous, and lignite. Coal is primarily used for power generation, industrial processes, and as fuel in households.
- **Iron Ore**: India is a major producer of iron ore, particularly hematite ore. The major iron ore-producing states in India are Odisha, Chhattisgarh, Karnataka, and Jharkhand. Iron ore is a vital raw material for the production of steel.
- Limestone: India is among the top producers of limestone, which is primarily used in the cement industry. States like Rajasthan, Madhya Pradesh, Andhra Pradesh, and Gujarat have abundant limestone deposits.



Share of States in Value of Mineral Production 2021-22





- **Bauxite**: India has significant bauxite reserves and is a major producer of bauxite ore. Bauxite is the primary ore used for aluminium production. States like Odisha, Gujarat, and Jharkhand are major bauxite-producing regions in India.
- **Manganese**: India is a significant producer of manganese ore, which is mainly used in the steel industry for the production of ferroalloys. Major manganese-producing states include Odisha, Maharashtra, Madhya Pradesh, and Karnataka.
- **Chromite**: India is one of the largest producers of chromite, which is a key source of chromium used in various industries such as metallurgy, chemicals, and refractories. Odisha and Karnataka are the primary chromite-producing states.

### SCOPE

- **Mining Operations**: Mineral belts offer favourable geological conditions and abundant deposits, attracting mining companies to extract minerals like coal, iron ore, limestone, bauxite, manganese, and chromite.
- **Industrial Development**: Mineral deposits in the belts spur industrial development and value addition for industries like steel, cement, aluminium, power generation, and chemicals.
- **Employment Generation**: Mining operations in mineral belts create employment opportunities, benefiting local communities. Skilled miners, engineers, support staff, and service providers contribute to job creation and economic growth in the region.
- **Revenue Generation**: Mineral extraction generates government revenue through royalties, taxes, and lease payments. These funds can be used for infrastructure, social welfare, and economic development.
- **Infrastructure** Development: Mineral belts necessitate infrastructure development like roads, railways, ports, and power supply, facilitating efficient mineral transportation and fostering regional development.
- **Research and Exploration**: Mineral belts provide research opportunities to identify new deposits, assess existing ones, and expand the mining sector through exploration and geological surveys.
- **Sustainable Development**: Mineral belts can support sustainable mining practices, ensuring environmental protection, community engagement, and social responsibility for long-term development while minimizing negative impacts.

### **CHALLENGES:**

- **Environmental Concerns**: Balancing mineral extraction with sustainable environmental practices is a major challenge due to potential environmental impacts like deforestation, soil erosion, water pollution, and habitat destruction.
- **Regulatory Framework**: Complying with complex regulations, obtaining permits, and meeting legal requirements is a challenge for mining companies due to the intricate regulatory framework governing the mining sector in India.
- Land Acquisition and Community Displacement: Complying with complex regulations, obtaining permits, and meeting legal requirements is a challenge for mining companies due to the intricate regulatory framework governing the mining sector in India.
- **Infrastructure Development**: Inadequate infrastructure in remote and challenging terrains poses logistical and operational challenges for developing the necessary transportation networks and power supply, crucial for efficient mineral extraction and processing.
- **Technological Advancements**: Availability and adoption of modern technologies pose challenges for smaller mining companies and remote areas in maximizing mineral extraction, minimizing environmental impacts, and adopting advanced mining technologies and equipment.

### WAY FORWARD:

- **Sustainable Mining Practices**: Encourage sustainable mining practices through strict environmental regulations, responsible techniques, and advanced technologies to minimize environmental impacts and prioritize community engagement and social responsibility.
- **Strengthen Regulatory Framework**: Streamline the mining sector's regulatory framework by integrating regulations, reducing bureaucracy, and providing clear compliance guidelines. Effective monitoring and enforcement of regulations is vital.
- **Community Engagement and Consent**: Promote community engagement in mineral extraction decisions, ensuring free, prior, and informed consent of local communities to mitigate conflicts, address social concerns, and foster sustainable development.
- **Infrastructure Development**: Prioritize infrastructure development in mineral belts, including transportation, power supply, and water management. This involves strategic planning, public-private partnerships, and investments to enhance connectivity and operational efficiency.
- **Research and Development:** Encourage research and development for sustainable mining through collaboration between companies, research institutions, and government agencies. Focus on enhancing exploration techniques, resource recovery, and developing innovative technologies for the sector's technological advancements.







- **Capacity Building and Skill Development**: Invest in training and skill development for mining industry personnel to ensure a skilled workforce adept at adopting advanced technologies, implementing sustainable practices, and promoting responsible mining.
- **Stakeholder Collaboration**: Foster collaboration and dialogue among stakeholders, including government bodies, mining companies, local communities, and environmental organizations. This can facilitate a holistic and inclusive approach to address challenges, find common solutions, and promote sustainable development in mineral belts.

### NATIONAL MINERAL POLICY, 2019

The objective of National Mineral Policy 2019 is to have a more effective, meaningful and implementable policy that brings in further transparency, better regulation and enforcement, balanced social and economic growth and sustainable mining practices.

### **DETAILS:**

- Introduction of the Right of First Refusal for RP/PL holders;
- Encouraging the private sector to take up exploration;
- Auctioning in virgin areas for composite RP cum PL cum ML on revenue share basis;
- Encouragement of merger and acquisition of mining entities;
- Transfer of mining leases and creation of dedicated mineral corridors to boost private sector mining areas;
- Proposes to grant the status of industry to mining activity to boost financing of mining for the private sector and for acquisitions of mineral assets in other countries by the private sector;
- Proposes to auction mineral blocks with pre-embedded clearances to give a fillip to auction process;
- Proposes to make efforts to harmonize taxes, levies & royalty with world benchmarks to help private sector.

### **BENEFITS:**

- The NMP 2019 **ensures more effective regulation**. It will help in sustainable mining sector development in future while addressing the issues of project-affected persons residing in tribal areas.
- **Reduction** in transportation cost due to Dedicated Mineral Corridors.
- **Easy finance**: As soon as the mining industry gets an industrial status, it will be easy for entrepreneurs to get finance from banks and other institutions.
- Policy is in sync with objectives of ease of doing business.
- Private Sector will be able to generate output from those reserved areas which have yet not been utilized by the PSUs.

### **ASSESSMENT OF MINERAL POLICY**

- **Environmental Threats and the Common Cause Judgment**: The Supreme Court's Common Cause judgment highlighted the environmental issues associated with illegal mining in Odisha.
  - It acknowledged the destructive impact on the environment and forests caused by rapacious mining activities, particularly in the districts of Keonjhar, Sundergarh, and Mayurbhanj.
  - The judgment emphasized the need for mining regulation, forest area recognition, and temporary cancellation of mining leases to protect the environment and prevent unlawful practices.
- **Mine Closure and Rehabilitation**: The policy should have addressed the crucial issue of mine closure and rehabilitation.
  - Improper mine closure can significantly affect the livelihoods of communities dependent on mining activities.
  - Proper design, supervision, and effective implementation, including financial obligations, are necessary to mitigate the negative consequences of mine closure.
  - The policy lacks a detailed plan to address these challenges, leaving indigenous populations, who rely on mining for their livelihoods, without alternative income sources.
- **Importance of Gradual Mine Closure**: Advocating for gradual mine closure is essential to minimize the impact on affected communities.
  - o Gradual closure allows individuals to find alternative means of sustenance, even in challenging circumstances.
  - While sudden closure focuses on immediate survival, gradual closure minimizes long-term losses.
  - A preventive approach through gradual closure can significantly reduce the negative consequences.
- **Balancing Development and Environmental Concerns**: Although the policy emphasizes increasing investment and adopting aggressive exploration policies to revamp the mining industry and boost production, the welfare of indigenous communities and environmental considerations should not be overlooked. Neglecting these aspects can have far-reaching ecological and biodiversity effects.
- **Safety of Miners**: The policy fails to address the rise in mining-related incidents and deaths, particularly in illegal mines where safety regulations are not extensively followed.
  - Stricter regulations to curb illegal mining and implementation of global mining safety standards are crucial to ensure the safety and well-being of miners.







- **Involvement of Local Population in Law Enforcement**: The policy suggests involving the local population to supplement local law enforcement, ostensibly as a means of providing employment opportunities for the youth.
  - However, this proposition is ambiguous and raises concerns about inadequate checks and balances during implementation.
  - Similar situations, such as the Salwa Judum conflict, have demonstrated the potential risks when local forces go rogue, leading to looting, assault, and endangering the lives of the population.
  - In the context of the violent illegal mining mafia, introducing inadequately trained forces without proper regulation can put local communities at risk.

India is well endowed with natural resources, particularly minerals. They serve as raw material for many industries, paving a path for rapid industrialisation and infrastructural development. It, in turn, will facilitate the economy's growth to a path of sustained growth and a five trillion-dollar economy. It ensures the sustainable growth of the economy.

### ENERGY RESOURCES

According to the International Energy Agency (IEA), "Energy is the ability to do work, or the capacity to cause change or perform tasks. It exists in various forms, including kinetic energy (associated with motion), potential energy (associated with position or state), thermal energy (associated with temperature), chemical energy (associated with chemical reactions), and electrical energy (associated with the movement of electric charges). Energy can be converted from one form to another and is essential for driving economic and social development."

### **FACT-WISE**

- **Energy Consumption**: According to the Central Electricity Authority (CEA) of India, the total energy consumption in India during the fiscal year 2021-2022 is 1,374.02 billion units (BU). This includes electricity consumption as well as other forms of energy like oil, coal, and natural gas.
- **Energy Mix:** In terms of electricity generation, the energy mix in India includes various sources. As of 2021, the major contributors to India's electricity generation were coal (about 71%), renewable energy sources (about 23%), hydroelectric power (about 3%), and nuclear power (about 2%), according to the Ministry of Power.
- **Renewable Energy Capacity**: India has been actively promoting renewable energy sources. As of April 2022, India's installed renewable energy capacity reached around 105 gigawatts (GW), which includes solar power, wind power, biomass, and small hydropower, as reported by the Ministry of New and Renewable Energy (MNRE).

### SOURCES OF ENERGY

Parameters	Conventional Sources of Energy	Non-Conventional Sources of Energy
Definition	Conventional sources of energy refer to the	Non-conventional sources of energy, also known as
	traditional and widely used sources for	renewable or alternative sources, are derived from
	energy generation that have been in use for a	natural resources that are replenished and have a
	long time.	minimal impact on the environment.
Examples	Conventional sources include fossil fuels such	Non-conventional sources include solar energy, wind
	as coal, oil, and natural gas, as well as	energy, hydropower, biomass, geothermal energy,
	conventional nuclear power.	and tidal energy.
Availability	Conventional sources are generally abundant	Non-conventional sources are considered
	and easily accessible in many parts of the	sustainable as they utilize abundant and naturally
	world.	replenished resources.
Environmental	The use of conventional sources of energy is	Non-conventional sources have lower carbon
Impact	associated with environmental challenges,	emissions and reduced environmental impact
	including air pollution, greenhouse gas	compared to conventional sources, making them
	emissions, and climate change.	more environmentally friendly.

### MAJOR SOURCES OF POWER GENERATION IN INDIA

### • Thermal Power:

- Generated using oil and coal, thermal power is an important source of electricity in India.
- India's coal consumption reached 20.9 exajoules in 2021, showing a significant increase from the previous year.
- Challenges:
  - Resource wastage: The Indian coal-based power sector is considered one of the most resource-wasteful and polluting sectors globally, partly due to the high ash content in coal.
  - Ash content regulations: The Ministry of Environment and Forests mandates the use of coal with reduced ash content (34% or lower) in power plants located in urban, ecologically sensitive, and critically polluted areas.



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- BY PHYSICS WALL
- Inefficient power plants: Many thermal power plants in India are inefficient, necessitating their replacement with more cost-effective renewable technologies to reduce greenhouse gas emissions.

### • Hydroelectric Power:

- Hydroelectric power harnesses the energy of moving water to generate electricity and is a form of renewable energy.
- India's hydropower potential is estimated to be around 125,000 MW at a 60% load factor.
- **Underutilized potential**: India ranks fourth globally in terms of underutilized hydropower potential.
- Benefits:
  - Cost-effective: Hydroelectric power plants can produce secondary or seasonal power at no additional cost during periods of excess water flow.
  - Storage alternatives: Storing electricity using alternative systems such as batteries or compressed air storage can be costlier than generating electricity from standby generators.

### • Nuclear Power:

- Nuclear power is the fifth-largest source of electricity in India, following coal, gas, hydroelectricity, and wind power.
- India currently operates 22 nuclear reactors with an installed capacity of approximately 6,780 MW.
- Nuclear power contributes to India's energy mix and helps diversify the sources of electricity generation.

### PROBLEMS WITH INDIA'S POWER SECTOR

- **Insufficient Power Supply**: Despite progress in power generation, India still experiences frequent shortages and blackouts in many regions. This limits economic growth, affects industrial productivity, and hampers citizens' quality of life.
- **Inadequate Grid Infrastructure:** Outdated and inadequate power grid infrastructure in India leads to high transmission and distribution losses, causing inefficiencies and wastage of power.
- **Dependency on Fossil Fuels:** India's reliance on coal and other fossil fuels for power generation contributes to air pollution, greenhouse gas emissions, and climate change. Transitioning to cleaner and renewable energy sources is crucial for a sustainable future.
- **Financial Viability of Power Distribution Companies (Discoms):** Power distribution companies in India face financial distress due to transmission losses, inefficient billing systems, and subsidized tariffs. This hampers infrastructure upgrades and a reliable power supply.
- **Pricing and Tariff Issues**: India's power sector faces pricing and tariff challenges, including regional tariff disparities, cross-subsidization, and subsidies, leading to financial imbalances and hindering sector sustainability.
- **Renewable Energy Integration**: India's progress in renewable energy deployment faces technical challenges in integrating variable sources like solar and wind into the grid. Ensuring grid stability, managing intermittency, and establishing effective infrastructure remain ongoing concerns.
- **Energy Access in Rural Areas**: Providing reliable electricity access to rural areas remains a significant challenge. Many remote villages still lack electricity connections, which hampers socio-economic development and quality of life for rural communities.

### INITIATIVES TAKEN TO RESOLVE CHALLENGES

- **National Infrastructure Pipeline**: The Government of India has allocated Rs. 111 lakh crore (US\$ 1.4 trillion) under the National Infrastructure Pipeline for FY 2019-25. The energy sector is likely to account for 24% of capital expenditure over FY 2019-25.
- Automatic approval of Foreign Direct Investment: Automatic approval for 100% foreign equity is permitted by the government of India in generation, transmission and distribution, and trading in the power sector without any upper limit on the investment.
- **Ultra-Mega Solar Power**: Ultra Mega Solar Power projects in Rajasthan, Gujarat, Tamil Nadu, and Laddakh in J&K have been announced.
- Ujwal Discoms Assurance Yojana (UDAY) was launched by the Government to encourage operational and financial turnaround of State-owned Power Distribution Companies (DISCOMS) with an aim to reduce Aggregate Technical & Commercial (AT&C) losses to 15% by FY19.
- **Saubhagya Scheme**: Launched in 2017, this scheme aims to achieve universal household electrification in the country. It provides free electricity connections to households below the poverty line and subsidizes connections for others, ensuring electricity access for all.
- **National Smart Grid Mission (NSGM):** The NSGM focuses on modernizing the power grid infrastructure in India. It aims to develop smart grids that enable efficient and reliable electricity transmission and distribution, along with integrating renewable energy sources and promoting demand response mechanisms.







- Accelerated Renewable Energy Deployment: The government has set ambitious targets for renewable energy capacity addition, including the National Solar Mission and the National Wind Mission. Various financial incentives, tax benefits, and policy frameworks have been implemented to promote the adoption of renewable energy sources.
- **Energy Efficiency Programs**: The government has launched energy efficiency programs such as the Perform, Achieve, and Trade (PAT) scheme and the Energy Conservation Building Code (ECBC). These programs aim to promote energy conservation and efficiency in industries, buildings, and appliances.
- **Green Energy Corridors**: The government is developing green energy corridors to facilitate the evacuation and transmission of renewable energy from resource-rich regions to consumption centres. These corridors help in addressing the challenges related to renewable energy integration into the grid.

### WAY FORWARD

- **Future Prospects**: India's coal-fired power generation, currently standing at 747.8 GW as of 2022-23 (April to November). The Central Electricity Authority (CEA) projects India will reach 267GW of coal-fired capacity by 2030
- **Promote Renewable Energy**: Increase deployment of renewable energy sources.
- **Upgrade Grid Infrastructure**: Modernize power grid infrastructure to accommodate renewable energy and reduce losses.
- Improve Energy Efficiency: Implement energy-efficient practices across sectors.
- Strengthen Distribution Systems: Reduce losses and improve billing and collection systems.
- Implement Demand-Side Management: Encourage energy conservation and demand response programs.
- Foster Public-Private Partnerships: Collaborate to attract investments and promote innovation.
- Enhance Regulatory Framework: Implement tariff reforms and ensure financial sustainability.
- Focus on Rural Electrification: Prioritize electrification of rural areas for inclusive growth.
- International Cooperation: Collaborate with global stakeholders for knowledge sharing and funding.
- **Public Awareness and Education**: Promote energy conservation and responsible energy consumption.

### **PW-ONLYIAS EDGE: KEY PHRASES FOR MAINS**

Conventional and Non-conventional Sources of Energy; Energy Basket; Gas-Based Economy; Electric Power; Thermal Power; Waste To Wealth; High and Low Ash Content; Hydroelectric Power; Underutilised potential; Alternative system of storage; Nuclear Power; Transmission and Distribution Losses; etc.

### NON-CONVENTIONAL SOURCES OF ENERGY

Non-conventional sources of energy, also known as renewable energy sources, are defined as energy sources that are naturally replenished and have a significantly lower environmental impact compared to conventional fossil fuels. These sources harness energy from natural processes or phenomena and convert it into usable forms of energy without depleting finite resources or emitting large amounts of greenhouse gases.

### WHAT IS THE IMPORTANCE OF THE NON-CONVENTIONAL SOURCE OF ENERGY?

- **Environmental Sustainability**: Non-conventional energy sources have a minimal carbon footprint, reduce greenhouse gas emissions, and preserve natural resources, aiding in climate change mitigation and air pollution reduction.
- **Energy Security**: Diversifying the energy mix with non-conventional sources reduces dependence on fossil fuels and imported energy, enhancing energy security and reducing vulnerability to price fluctuations and geopolitical tensions.
- **Economic Growth and Jobs:** Renewable energy investments create jobs in manufacturing, construction, installation, and maintenance, driving economic growth and attracting investments while fostering innovation and competitiveness.
- Access to Energy in Remote Areas: Non-conventional sources provide off-grid solutions, extending electricity access to underserved areas and enabling sustainable energy provision in remote communities.
- **Affordability and Price Stability**: Cost reductions in renewable energy technologies make them competitive with traditional sources, ensuring more affordable and stable energy prices for consumers.
- **Technological Innovation**: Non-conventional energy drives research and development, improving efficiency, storage capabilities, and grid integration, stimulating innovation and advancing a sustainable energy future.
- **Public Health Benefits**: Reduced air pollution and greenhouse gas emissions from non-conventional sources improve public health by mitigating respiratory illnesses and other health issues associated with pollution.

The sustainable economic development and growth of any country are closely related to the development and security of its energy sectors. Concerning the finite and limited reserves of conventional energy sources and their impact on the environment, great emphasis should be given to the development of non-conventional energy sectors and their proper





utilization for the benefit and betterment of mankind. countries. In India, there is great scope for the development of nonconventional and renewable energy sectors.

### SOLAR POWER

According to the **International Renewable Energy Agency (IRENA)**, "Solar power refers to the conversion of sunlight into electricity or heat using solar photovoltaic (PV) or solar thermal technologies. Solar PV systems use solar panels made up of semiconductor materials to directly convert sunlight into electricity, while solar thermal systems use mirrors or lenses to concentrate sunlight and generate heat for various applications, including electricity generation, heating, and cooling."

#### **FACT-WISE**

- **Installed Solar Capacity:** India has made significant progress in solar power installations. As of 2022, the cumulative installed solar power capacity in India was around 45.4 gigawatts (GW).
- **Solar Park Development:** The Indian government has been actively promoting solar park development across the country. As of 2022, over 50 solar parks with a combined capacity of more than 40 GW were in various stages of development.
- **Solar Rooftop Installations**: India has been focusing on promoting solar rooftop installations for residential, commercial, and industrial sectors. As of 2022, the cumulative installed capacity of solar rooftops in India was around 8 GW.
- **Largest Solar Power Plant**: The Bhadla Solar Park in Rajasthan is one of the largest solar power plants in India. It has a total installed capacity of 2.25 GW and has been instrumental in boosting India's solar energy capacity.

	Advantages of Solar Power		Disadvantages of Solar Power
•	<b>Renewable &amp; Sustainable</b> : Solar power relies on sunlight, is abundant, and doesn't deplete resources or produce emissions.	•	<b>Intermittency</b> : Solar power relies on sunlight availability, making it variable and requiring energy storage or backup systems for continuous supply.
•	<b>Reduced Carbon Footprint:</b> Solar power minimizes greenhouse gas emissions, combating climate change. <b>Energy Cost Savings:</b> Installing solar panels leads to	•	<b>High Initial Costs</b> : The upfront investment for solar panels and equipment can be prohibitive, potentially deterring adoption.
•	significant savings on electricity bills, reducing reliance on traditional utilities.	•	Land and Space Requirements: Solar power systems need significant space, posing challenges in densely populated areas or where land is limited
-	creates employment opportunities and contributes to local economies.	•	<b>Dependency on Sunlight:</b> Solar power is highly reliant on sunlight, making it unsuitable for regions with limited
•	energy sources reduces dependence on fossil fuels, enhancing security.	•	<b>Environmental Impacts of Manufacturing</b> : Solar panel production involves materials and chemicals with
•	<b>Scalability &amp; Modularity:</b> Solar systems can be adjusted to energy needs and easily expanded.		a concern.
•	<b>Low Maintenance &amp; Long Lifespan</b> : Solar power requires minimal upkeep and offers reliable energy over a long period.	•	<b>Energy Storage Challenges</b> : Storing excess solar energy for later use requires additional equipment, like batteries, increasing overall costs.
•	<b>Off-Grid Power Supply</b> : Solar provides electricity in remote areas without traditional grid access.	•	TransmissionandDistributionChallenges:Integration into existing grids may demand upgrades to
•	<b>Community &amp; Distributed Generation</b> : Enables self- sufficiency and resilience through local power production.	•	accommodate the decentralized nature of solar power. Limited Efficiency: Current solar panel technologies have modest conversion efficiencies, driving ongoing
•	<b>Sustainable Development &amp; Environment</b> : Solar promotes clean energy, improves air quality, and conserves resources.	•	research for improvement. <b>Geographical Limitations</b> : Solar power may be less viable in regions with low sun exposure or significant shading from tall structures or dense vegetation.

#### WAY FORWARD:

- Advancements in energy storage: Research and development in battery storage and innovative solutions to address solar power intermittency.
- **Cost reduction**: Technological advancements, economies of scale, and supportive policies to make solar power more affordable and accessible.
- **Improved efficiency**: Enhancing solar panel efficiency through material, design, and manufacturing innovations.





- **Grid integration and infrastructure upgrades**: Smart grid technologies and transmission/distribution enhancements for seamless integration of solar power.
- **Supportive policies and incentives**: Government initiatives like feed-in tariffs, tax credits, and streamlined permitting processes to encourage solar adoption.
- **Education and awareness**: Public outreach to promote understanding of solar benefits and its role in sustainable energy transition.
- **Collaboration and partnerships**: Stakeholder cooperation to address technical challenges and drive solar power adoption.
- Environmental responsibility: Sustainable manufacturing, recycling, and disposal practices in the solar industry.
- Geographic adaptation and diversification: Exploring alternative solar technologies and diversifying renewable energy sources.
- **Continued research and development**: Investment in innovation to overcome disadvantages and improve the efficiency, reliability, and widespread use of solar power.

Solar power offers numerous advantages as a renewable and sustainable energy source. It reduces carbon emissions, provides energy cost savings, promotes job creation and economic growth, enhances energy security, and enables access to electricity in remote areas. To address disadvantages, advancements in energy storage, cost reduction, efficiency improvement, grid integration, supportive policies, education, collaboration, environmental responsibility, geographic adaptation, and continued research and development are essential.

#### TIDAL ENERGY

Tidal energy is a **form of renewable energy that harnesses the power of tidal movements in oceans and seas to generate electricity.** It involves the use of tidal turbines or barrages, which capture the kinetic energy of tidal currents and convert it into usable electrical energy. Tidal energy is considered a sustainable and environmentally friendly source of power as it relies on the natural ebb and flow of tides, which are predictable and consistent. This energy source has the potential to contribute to the global transition towards cleaner and more sustainable energy systems.

### FACT-WISE

- **Tidal Energy Potential**: India has an estimated tidal energy potential of about 12,455 megawatts (MW) along its coastline.
- **Gulf of Kutch:** The Gulf of Kutch in Gujarat is considered one of the most promising sites for tidal energy development in India. The region experiences strong tidal currents, making it suitable for tidal energy extraction.

	Advantages of Tidal Power		Disadvantages of tidal Power
•	<b>Clean And Renewable:</b> No pollution and doesn't take up much physical space when compared to other renewable energy systems.	•	<b>Environmental impact</b> : The systems require turbulent water to power them, and a large foundation needs to be built. This type of underwater construction
•	Predictable And <b>Reliable:</b> Most areas experience two high tides and two low tides per day. This cycle is easily predicted and isn't subject to unexpected changes, unlike many other renewable resources.	•	<ul><li>can result in habitat destruction.</li><li>High construction Costs: Building structures strong enough to withstand the turbulent, corrosive nature of seawater is by no means a cheap undertaking</li></ul>
•	<b>Long-Lasting Equipment</b> : The average estimate for most tidal systems is 75-100 years of working use. In comparison, a solar panel usually degrades after an average of 25-30 years. <b>Effective at Low Speeds</b> : Tidal energy systems can	•	<b>Scarcity of suitable locations</b> : Not every seascape near a shore is suitable for a tidal energy facility. They require a very specific set of factors in order to operate effectively and efficiently. For example, the height of the sea during low and high tides
	produce energy even when the water passing over or through them is moving relatively slowly. Water is 1,000 times denser than air, which means it can power a turbine even when moving at a snail's pace.	•	<b>It can be very inconsistent</b> : Engineering flaws and technical errors like excessive turbine failure rates, failures in generating electricity during low water conditions, and strong currents are preventing turbines from operating properly. It is also inconsistent because it relies on the tide

**Globally**, tidal energy is not cost-competitive and is still at a nascent development stage. Combine efforts of the government and private sector is necessary to set up tidal power projects in India by overcoming the financial, technological, environmental and other risks.

#### HYDROGEN-BASED ENERGY

• India launched National Green Hydrogen Mission. Objectives of the Mission are-



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- Making India a leading producer and supplier of Green Hydrogen in the world.
- $\circ\quad$  Creation of export opportunities for Green Hydrogen and its derivatives.
- $\circ$   $\quad$  Reduction in dependence on imported fossil fuels and feedstock.
- Development of indigenous manufacturing capabilities.
- $\circ$   $\;$  Attracting investment and business opportunities for the industry.
- $\circ\quad$  Creating opportunities for employment and economic development.
- Supporting R&D projects.

### **TYPES OF HYDROGEN BASED ON EXTRACTION METHODS:**

- 1. **Grey Hydrogen**: It is produced via coal or lignite gasification (black or brown), or via a process called steam methane reformation (SMR) of natural gas or methane (grey). These tend to be mostly carbon-intensive processes.
- 2. **Blue Hydrogen**: It is produced via natural gas or coal gasification combined with carbon capture storage (CCS) or carbon capture use (CCU) technologies to reduce carbon emissions.
- 3. **Green Hydrogen:** It is produced using the electrolysis of water with electricity generated by renewable energy. The carbon intensity ultimately depends on the carbon neutrality of the source of electricity (i.e., the more renewable energy there is in the electricity fuel mix, the "greener" the hydrogen produced).

### **MISSION OUTCOMES:**

- The mission outcomes projected by 2030 are:
  - Development of green hydrogen production capacity of at least 5 MMT (Million Metric Tonne) per annum with an associated renewable energy capacity addition of about 125 GW in the country.
  - Over Rs. Eight lakh crore in total investments.
  - Creation of over Six lakh jobs.
  - Cumulative reduction in fossil fuel imports over Rs. One lakh crore.
  - Abatement of nearly 50 MMT of annual greenhouse gas emissions.

### Ministry of New and Renewable Energy to improve research in Hydrogen based technology

- The Ministry of New and Renewable Energy, in collaboration with research institutions and industries, is actively supporting Research, Development, and Demonstration (RD&D) projects focused on hydrogen fuel-based vehicles. The Council for Scientific and Industrial Research (CSIR) has also undertaken RD&D projects on hydrogen fuel cell vehicles through the National Chemical Laboratory (NCL).
- Hydrogen, as a fuel, can be utilized in vehicles either through fuel cells that convert hydrogen's chemical energy into electricity or through modified internal combustion engines designed to use hydrogen. However, both these technologies are currently in the pilot stage of development and have not yet undergone commercial testing in India. Hence, specific cost estimates and timelines for establishing the hydrogen fuel industry are not currently available.

### HYBRID RENEWABLE ENERGY

Hybrid Renewable Energy refers to the integration of two or more renewable energy sources to generate electricity. It combines different renewable energy technologies such as solar, wind, hydro, biomass, or geothermal, in a complementary manner to maximize energy production, improve system reliability, and optimize resource utilization. This approach enables a more stable and consistent power supply, mitigates the intermittency of individual renewable sources, and enhances the overall efficiency and sustainability of the energy system.

### FACT-WISE

- According to a report titled "Investing for Impact: Renewable Energy & Cleantech" by Aspire Circle, India has the potential to generate a remarkable \$212 billion in revenue and create 3.4 million jobs by 2030. This investment of \$350 billion in various renewable energy and cleantech ventures and initiatives could have a profound impact, benefiting 919 million individuals.
- According to Global Status Report 2022:
  - Renewable Energy Rankings: In 2021, India secured the third position globally in terms of renewable energy installations, following China and Russia.
  - Wind Power: India ranked third globally for the total installed capacity of wind power, with 40.1 GW, following China, the US, and Germany.
  - Hydropower Capacity: In 2021, India witnessed an addition of 843 MW in hydropower capacity, reaching a total capacity of 45.3 GW.

	Advantages		Disadvantages
•	Continuous power supply: The hybrid renewable	•	Complicated controlling process: With different
	systems provide power continuously, without any		types of energy sources in use, the systems require




interruption, as the seasonality of solar energy can be compensated by wind power generation.

- Utilize renewable sources in the best way: As the batteries are connected to the system to store the energy, there is no waste of the excess energy generated on bright sunny days and days of high wind speed.
- **Low maintenance cost**: The maintenance cost of the hybrid renewable energy systems is low as compared to the traditional generators which use diesel as fuel.
- **High efficiency**: Hybrid solar energy systems work more efficiently than traditional generators which waste the fuel under certain conditions.
- **Load management**: Unlike traditional generators, which provide high power as soon as they are turned on, most hybrid renewable power systems manage load accordingly.

some knowledge. The operation of different energy sources, their interaction and co-ordination must be controlled and it can become complicated.

- **High installation cost**: The maintenance cost is low, but the initial investment for the installation of the systems is high as compared to a solar system.
- **Less battery life**: The batteries connected to the system may have a lower life as they are often exposed to natural elements like heat, rain, etc.
- The number of instruments connectable is limited: The number of devices that can be connected to a hybrid solar energy system is limited.

Hybrid Renewable Energy can become a viable solution to meeting future power requirements of the country, that too all at zero carbon emissions and future cost-inflation proof. Indian corporates are also showing active interest in increasing the usage of clean power if round-the-clock solutions are provided.

### **GAS-BASED ECONOMY**

- The concept of a gas-based economy generally refers to an economic model that relies heavily on the production, distribution, and consumption of natural gas as a primary energy source. It involves utilizing natural gas for various sectors, including power generation, industry, transportation, and residential use.
- **Natural Gas in India**: India's current share of natural gas in its energy mix is only 6%, significantly lower than the global average of 23%.
- **Increasing Share and Future Growth**: The Indian government has set an ambitious target to increase this share to 15% by 2030. Currently, India's natural gas consumption is one-third of the global average, but it is expected to increase in the future.
- **Import**: 55% of natural gas is imported in the form of Liquified Natural Gas (LNG).
- Administration: In India, 80% of natural gas produced by ONGC and Oil India Limited falls under Administered Price Mechanism (APM) which means the government controls its price.
- Natural gas can be easily found and is abundant as it is available from nature.
- Natural gas is highly flammable due to high levels of methane.
- Natural gas is colourless, tasteless, and odourless.
- The density of natural gas is lower than that of the density of the air which makes it lighter than air. As in case of leakage, it can easily dissipate into the air.
- Natural gas is less corrosive due to high methane and low carbon composition.

Advantages of Natural Gas			Disadvantages of Natural Gas		
•	Natural Gas is Environmentally Clean because,	•	Limited Quantities: India does not don't have vast		
	unlike other gases, natural gas emits very less by-		reserves of natural gas. Most of the natural gas that is		
	products into the atmosphere as pollutants. This keeps		consumed by the country has to be imported from		
	the air cleaner.		other countries. These constant purchases can turn into		
•	It is Economical: It is not as expensive as other		a rather expensive proposition over time.		
	burning fuels.	•	Natural Gas is Highly Combustible: As natural gas is		
•	It is Convenient for cooking or electric purposes, it		odourless, it is difficult to detect leakage as well.		
	can be directly connected to the consumer's house with	•	Natural Gas is a Non-Renewable Source of Energy:		
	the help of pipelines. This eliminates the long process		Experts state that natural gas will be depleted in the		
	of collecting, processing, packing and delivering the end		future and we will have to import it from other nations.		
	product to the customers.	•	Natural Gas Emits Carbon Dioxide: It emits carbon		
•	Natural Gas is Safe to Use: One of the biggest		dioxide which is bad for our atmosphere. The constant		
	fear while using LPG cylinders or any other type of fuel		introduction of carbon dioxide into the atmosphere will		
	is the possibility of leakage. Natural gas is lighter than		lead to climate change and also global warming.		
	air. In case of a leakage, it dissipates quickly into the air	•	Long Processing Process: As natural gas has other		
	avoiding fire.		components that have to be removed before using it for		
•	It is Available Abundantly: As per the study, the		residential or commercial purposes, it takes a lot of		
	11	07			





amount of natural gas available is more than crude oil or other such products.

- It is More Efficient: When compared to things like propane gas, natural gas provides more energy when it burns, which makes it much more efficient.
- **Natural Gas is Easy to Deliver**: Considering the current mode of delivery of gas to homes in India, a lot of metal cylinders changing hands. To deliver natural gas there is a need for a network of pipes.

time and manpower to process it.

- **Leakage**: Even though it is lighter than air and can disperse easily, a big danger with natural gas is that since it is colourless, odourless and tasteless, should it start leaking, detection of the leak is very hard.
- **Storage**: Its volume happens to be four times that of petrol which makes it more expensive to store since more needs to be spent on additional storage.

Despite all these disadvantages, natural gas is one of the cheapest and easily available fossil fuels in this world. It can be considered that natural gas can serve as a viable alternative to other fossil fuels till such time as something more efficient can be found.

### NEW EMISSION NORMS FOR THERMAL POWER PLANTS

The Environment Ministry has amended rules allowing the thermal power plants within 10 kilometres of the National Capital Region (NCR) and in cities with more than 10 lakh population to comply with new emission norms by the end of 2022.

#### **FACT-WISE**

- Installed Capacity: India has a significant capacity for thermal power plants. As of September 2021, the total installed capacity of thermal power plants in India was around 230 gigawatts (GW), accounting for a significant portion of the country's power generation capacity.
- Coal-Based Power Plants: The majority of thermal power plants in India are coal-based. Coal is the primary fuel used for electricity generation in these plants. India has extensive coal reserves, making it a key source of energy for the country.
- Location: Thermal power plants are distributed across various states in India. Some states with a significant number of thermal power plants include Maharashtra, Gujarat, Tamil Nadu, Uttar Pradesh, and Andhra Pradesh.
- Public and Private Sector: Thermal power plants in India are owned and operated by both public and private sector companies. The National Thermal Power Corporation (NTPC) is one of the largest public sector companies involved in thermal power generation.

#### **GIST OF NEW EMISSION NORMS:**

- A task force will be constituted by the Central Pollution Control Board (CPCB) to "categorise thermal power plants (TPPs) in three categories on the basis of their location".
- TPP units in "**non-attainment cities**" and those within 10 kilometres of critically polluted areas are required to meet the emission norms by December 31, 2023.
- Coal-fired power plants in the rest of the areas have to comply with the new standards by December 31, 2024, according to the notification.
- TPPs declared that TPPs retiring before December 31, 2025, are not required to meet the specified norms in this case such plants to submit an undertaking to the CPCB and the CEA (Central Electricity Authority) for exemption on grounds of retirement.

The energy sector causes over 40% of India's greenhouse gas emissions. It comes from heavy dependence on coal. It becomes necessary to strictly adhered to New Emission Norms for thermal power plants to ensure a cleaner and greener environment.

#### FLY ASH

- Fly ash emanating from the dumping ground of the National Thermal Power Corporation (NTPC) plant at VindhyaNagar (Madhya Pradesh) like serpents is posing a hazard to the health of over 1,000 people.
- Fly ash or flue ash, coal ash, pulverised fuel ash or coal combustion residuals (CCRs), is a coal combustion product that is composed of the particulates (fine particles of burned fuel) that are driven out of coal-fired boilers together with the flue gases.
- The components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO2) (both amorphous and crystalline), aluminium oxide (Al2O3) and calcium oxide (CaO).

#### **USES:**

• It helps in concrete production, as a substitute material for Portland cement, and sand.



- BY PHYSICS WALLAN
- It can be used as a corrosion control measure in RC structures. Fly-ash pellets can replace normal aggregate in a concrete mixture.
- It can be used for making embankments and other structural fills (usually for road construction).
- It helps in waste stabilization and solidification. It acts as a solution for mine reclamation. Acts as a stabilizer for soft soils.
- Acts as aggregate substitute material (e.g. for brick production).

### **ADVANTAGES:**

- In terms of usability in Concrete and Cement: It provides higher ultimate strength, increased durability, improved workability etc.
- In terms of usage as fly ash bricks: It reduces excavation of clay, Low cost of brick as compared to clay brick of same quality, etc.
- Other benefits of using fly ash: Reduces soil erosion by replacing topsoil as ingredients for most construction mixes.
- Reduces pollution measures by re-use of wastes.
- Reduces the amount of greenhouse gases being added to the atmosphere.
- Hydrophobic nature helps in the proper draining off of water from roads and structures.

### **ENVIRONMENTAL PROBLEMS:**

- **Groundwater contamination**: Fly ash obtained after the combustion of coal that resulted in enhanced concentrations of elements(such as arsenic, barium, beryllium, etc.). They are the main cause of the ash to cause groundwater pollution.
- **Ecology**: Fly ash dust can be deposited on topsoil increasing the pH and affecting the plants and animals in the surrounding ecosystem.
- **Spills of bulk storage**: Where generally fly ash is stored in bulk in wet rather than dry to minimize fugitive dust. The resulting ponds are typically large and stable for long periods, but any breach of their dams or bunding is rapid and on a massive scale.
- **Contaminants**: Fly ash contains trace concentrations of heavy metals (such as cadmium, barium, chromium, copper, lead, mercury etc.) that are detrimental to health.
- **Impediments in its full-scale utilization in India**: Imperfections typical of quasi-markets, such as information asymmetry and high transaction costs, vested interests, technical and technological limitations, and the lack of regulatory oversight and political will etc.

#### **BEST PRACTICE**

Maharashtra has become the first state in the country to adopt the Fly Ash Utilization Policy. The policy paves the way for prosperity by generating wealth from waste and environmental protection.

Policy framework and national strategy can make it possible to utilize all fly ashes in a gainful manner. It would mitigate the environmental threat, generate employment and industrial wealth, conserve mineral resources, provide sustainable construction and agriculture including forestry and a cleaner environment.

### LITHIUM RESERVES

According to the researchers at the **Atomic Minerals Directorate for Exploration and Research (AMD)**, Department of Atomic Energy, Government of India, potential lithium reserves have been found in the Mandya district, Karnataka, about 100 km from Bengaluru. The discovery is significant since the reserve is being touted as the country's single largest source of lithium, an element that is increasingly finding applications in battery technology used in electric vehicles.

### **IMPORTANCE OF THIS DISCOVERY:**

- Increasing Demand for Electric Vehicles and Global Lithium Reserves Debate: Rising demand for electric vehicles and the consequential discussion on global lithium reserves.
  - World Economic Forum (WEF) predicts a potential lithium shortage by 2025 due to the projected need for 2 billion EVs.
- **Diverse Applications of Lithium Beyond Electric Vehicles**: Lithium usage extends to the medical sector and electronics, powering devices like phones, solar panels, and renewable technologies.
  - $\circ$   $\;$   $\;$  The discovery of lithium reserves holds significance for both India and the world.
- **China's Dominance in the Lithium Industry**: China's position as the largest electric vehicle market and its control over the supply and demand of lithium.
  - $\circ$   $\;$  China's dominance in global lithium processing, cell components, and battery cell production.
- **Mitigating Dependency on China and India's Self-Reliance**: Concerns over India's potential dependency on China due to the proliferation of EVs.





- The lithium reserves in Jammu & Kashmir present an opportunity for India to achieve self-reliance.
- The discovery offers hope for a country that has relied heavily on lithium imports.

#### LITHIUM RESERVES IN INDIA

India has discovered substantial lithium reserves in the Reasi district of Jammu & Kashmir, amounting to approximately 5.9 million tonnes. This deposit is considered to be one of the world's largest, accounting for approximately 5.7% of global lithium reserves. Moreover, these reserves are of higher quality, with a grade of 550 parts per million (ppm), compared to the average grade of 220 ppm found elsewhere. As a result, these lithium reserves are highly attractive and offer significant economic potential.

### CHALLENGES WITH LITHIUM MINING:

- Adverse Environmental Impact: Extraction of lithium from its ore leads to environmental consequences, including water, soil, and air pollution.
  - The extraction process is highly water-intensive, requiring approximately 2.2 million litres of water per tonne of lithium.
- **Impact on the Fragile Himalayan Ecosystem**: The Himalayas, being a fragile and eco-sensitive region, are susceptible to long-term negative effects resulting from unplanned development activities.
  - $\circ$  The recent incident of subsidence in Joshimath highlights the vulnerability of the region.
- **Biodiversity Loss**: Mining operations in the Himalayan region, including the area between J&K, can lead to significant biodiversity loss.
  - $\circ$  The unique ecological diversity of the region could be adversely affected by mining activities.
- **Effect on River Systems:** The Himalayas serve as the origin for numerous rivers, making any mining activity a potential threat to the entire riparian ecosystem.
  - The pollution resulting from mining operations can have far-reaching consequences on the river systems.
- **Food Security Concerns**: Mining and processing of lithium can pose risks to food security due to high carbon emissions, water consumption, and land use methods.
  - Countries like Chile, where large amounts of water are required to yield one tonne of lithium, highlight the potential impact on water resources.
- Local Water Basin Contamination: Areas already grappling with limited access to clean water may face further challenges due to lithium water-mining techniques.
  - Local water basins could be contaminated, impacting rural communities, livestock, and agricultural activities that depend on these scarce water supplies.

Assess agricultural impacts before proceeding with lithium mining due to climate vulnerability. Electric vehicle shift creates opportunities. Sustainable and inclusive lithium extraction could be a game changer for resource-limited India.

#### **BIOFUEL - LESSONS FROM BRAZIL**

**Recently**, the government announced an ambitious plan to roll out vehicles running on 20% ethanol-blended petrol by 2025, against the current level of blending of 5-6%. To achieve this target there is a need for a paradigm shift in production and distribution of ethanol, the lessons for which could be taken from Brazil.

### **PROGRESS OF BRAZIL IN BIOFUEL:**

- Brazil is the world's second-largest producer of ethanol fuel.
- Brazil is considered to have the world's first "sustainable" biofuel economy and the biofuel industry leader, and its sugarcane ethanol is "the most successful alternative fuel to date.
- Biofuels are central to Brazil's low carbon emission strategy.
- It can act as a policy model for other countries.

### HOW DID BRAZIL ACHIEVE THIS?

- Focus on a new variety of sugar cane known as energy cane, which is low in sucrose but high in biomass content.
- High productivity of up to 350 tonnes of biomass per ha, against 80 tonnes per ha of traditional sugarcane, it offers a perfect balance.
- Brazil has mandated a blending of 27% ethanol with gasoline. In 2019, Brazil saved about 0.5 million barrels per day of gasoline and saved \$13 billion worth of imports.
- At present, 78% of Brazilian automobiles run on 27% of ethanol blend.

### THE ISSUE WITH THE BRAZILIAN MODEL

• Some scientists consider that the successful Brazilian ethanol model is sustainable only in Brazil due to its advanced agri-industrial technology and its enormous amount of arable land available.







- According to other authors, it is a solution only for some countries in the tropical zone of Latin America, the Caribbean, and Africa.
- It can compete with the food security of populous countries like India.
- Sugarcane is a water-guzzling crop. It may imbalance sustainable water uses.

The government has come up with National Policy on Biofuels, 2018 in order to promote biofuels in the country. The latergeneration biofuels have sprung up which don't use food crops that are explicitly grown for fuel production. It can help in a smooth transition to biofuel from conventional energy sources.

## NATIONAL OFFSHORE WIND ENERGY POLICY, 2015

- Offshore wind energy refers to the deployment of wind farms inside the water bodies. They utilise the sea winds to generate electricity. These wind farms either use fixed-foundation turbines or floating wind turbines.
- A fixed-foundation turbine is built in shallow water, whereas a floating wind turbine is built in deeper waters where its foundation is anchored in the seabed. Floating wind farms are still in their infancy.
- Offshore wind farms should be at as minimum as 200 nautical miles from the shore and 50 feet deep in the ocean.
- Offshore wind turbines generated electricity is returned to shore through the cables buried under the ocean floor. Based on priority the coastal load centres distribute this electricity.

### **BENEFITS OFFSHORE WIND ENERGY**

- **Limited availability of land**: In India, where land is limited and the population is increasing, large wind farms positioned over water bodies will be vital.
- **Efficiency**: Offshore wind turbines are more efficient compared to onshore ones. Wind speed over water bodies is high and consistent in direction. As a result, offshore wind farms generate more electricity per installed capacity.
- **Consistent energy generation**: As the offshore wind is stronger during the daytime, it ensures a more consistent and efficient electricity generation when consumer demand is at its highest. In contrast, wind power on land performs better at night when power consumption is lower.
- **Long operating hours:** Offshore wind power allows for longer operating hours due to its higher capacity utilisation factor (CUF) than that of onshore wind farms.
- **Energy Security and Diversification**: Developing offshore wind power helps diversify India's energy mix, reducing dependence on fossil fuels and enhancing energy security. It provides a reliable and indigenous source of electricity, reducing reliance on imported fuels.
- **Carbon Emission Reduction**: Offshore wind energy is a carbon-neutral source of electricity, contributing to the reduction of greenhouse gas emissions. By displacing fossil fuel-based power generation, offshore wind helps combat climate change and supports India's commitment to reducing carbon emissions.
- **Economic Growth and Job Creation**: The development of the offshore wind sector in India presents significant economic opportunities. It creates jobs in various stages, including project development, manufacturing, construction, installation, and operation, stimulating local economies and promoting skilled employment.
- **Technological Innovation and Industry Development**: Offshore wind projects require advanced technologies and expertise, encouraging innovation and the growth of domestic offshore wind industry. This fosters the development of manufacturing capabilities, supply chains, and research and development in renewable energy technologies.
- **Infrastructure Development**: Offshore wind projects necessitate the establishment of infrastructure such as ports, transmission networks, and grid interconnections. This infrastructure development contributes to the overall growth and modernization of India's energy infrastructure.
- **Resilience and Grid Stability**: Offshore wind farms can enhance the resilience and stability of the power grid by diversifying the energy sources and locations of generation. Offshore wind's consistent and predictable power generation characteristics can help balance the intermittency of other renewable energy sources.

### **CHALLENGES OF OFFSHORE WIND ENERGY**

- Lack of supporting infrastructure like local substructure manufacturers, installations vessels and trained workers.
- **Higher installation costs of offshore wind turbines** due to the requirement of stronger structures and foundations than onshore wind farms.
- **High cost of generation**: Offshore wind tariffs in India are likely to range between Rs 7-9 per unit as compared to Rs 2.8-2.9 per unit for onshore wind.
- **Offshore wind farms require high maintenance costs** due to the damaging action of waves and even high winds.

### **RECOMMENDATIONS ON OFFSHORE WIND ENERGY DEVELOPMENT IN INDIA**



- BY PHYSICS WALLAN
- **Renewable purchase obligation**: Government-specified obligated entities such as power distribution companies, open access consumers and captive users can purchase clean energy as part of their total electricity consumption through a renewable purchase obligation.
- **Lower taxes:** In India, the GST Law exempts electricity and power sales from GST. In contrast, wind power generation companies cannot claim input tax credits when they pay GST to purchase goods and/or services for setting up the project. The majority of wind farm components need to be imported. If excise duties and GST could be waived, early project development will be more affordable.
- **Feed-in tariff**: Discoms can adopt feed-in tariff (FiT) regulations and make it mandatory to procure offshore wind power. Offshore wind power in the early stages of development can be promoted through FiT until it becomes economically viable.
- **Deemed generation provision**: Offshore wind projects need protection against curtailment concerns due to the inability of State Load Dispatch Centres (SLDCs) to absorb possibly generated large quantities of power. For this, the offshore wind can be given a "deemed generation provision.
- **Frame a visionary policy**: Articulate clear objectives to reduce costs and ensure long-term security regarding off-taker risks.

The advantages of offshore wind farms and the abundance of offshore wind potential in India enable them to play a huge role in achieving the desired climate commitment and energy security goals.

### M-SAND POLICY

Manufactured sand (M-Sand) is a substitute for river sand for concrete construction. Manufactured sand is produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edges, washed and graded as a construction material. The size of manufactured sand (M-Sand) is less than 4.75mm.

Advantages	Disadvantages		
<ul> <li>Advantages</li> <li>Wide availability: M-Sand can be manufactured nearby construction sites, thus driving down transportation costs.</li> <li>Denser particle packing: M-Sand is free of silt and clay particles and has denser particle packing compared to river sand. This ensures lesser impurities and good working properties.</li> <li>High strength: M-Sand is superior to river sand with its higher compressive strength, higher flexural attemption better water</li> </ul>	<ul> <li>Disadvantages</li> <li>Manufactured sand can be of a coarser and more precise surface than regular sand, which is smooth and adjusted because of normal degree needs more water and cement requirement. This can prompt to accomplish the normal usefulness, prompting expanded expenses.</li> <li>Manufactured sand can contain bigger amounts of micro-fine particles than normal sand, inferable from its creation cycle. This again can influence the strength and usefulness of the tirade or sement.</li> </ul>		
strength, better damage resistance, better water retention ability, higher unit weight and lower	<ul> <li>The state of the stream is adjusted and has a smooth</li> </ul>		
<ul> <li>Better workability: M-Sand provides excellent plasticity to the mortar, thus ensuring better workability compared to river sand.</li> <li>Economical: M-Sand is proving highly economical and a perfect replacement for river sand due to its higher durability, better workability, higher strength, and</li> </ul>	<ul> <li>M sand contains bigger amounts of micro-fine particles than normal sand going to its creation interaction. this again can influence the strength and usefulness of the substantial.</li> </ul>		
reduction in segregation and permeability.			

However, usage of M-Sand avoids exploitation of river beds for river sand. It helps in preventing environmental catastrophes like water scarcity, groundwater depletion etc. It ensures sustainable development for all.

#### VANADIUM IN ARUNACHAL

- Vanadium in its pure form is a soft, grey and ductile element primarily derived from mined iron ore, carbonaceous shale or phyllites and steel slag. According to the Indian Bureau of Mines (2018 database), the total estimated reserves or resources of vanadium ore is 24.63 million tonnes, with an estimated V205 content of 64,594 tonnes.
- In Arunachal Pradesh, vanadium deposits have been identified in certain regions, particularly in the districts of Papum Pare, Lower Subansiri, and Kurung Kumey. The mineralization of vanadium in these areas is associated with ultramafic and mafic rocks, which are known to host vanadium-bearing minerals.





### SIGNIFICANCE OF RECENT FINDINGS:

- Vanadium mineralization in Arunachal Pradesh is geologically similar to the "stone coal" vanadium deposits of China hosted in carbonaceous shale. This high vanadium content is associated with graphite with a fixed carbon content of up to 16%.
- According to GSI, the expected grade of vanadium mineralisation in Arunachal Pradesh is comparable to the important vanadium deposits of the world.
- The largest deposits are in China, followed by Russia and South Africa.

### **APPLICATIONS:**

- **High tolerance**: Vanadium alloys are durable in at very high temperatures and extreme environments, and are corrosion-resistant.
- **High strength:** The addition of Vanadium improves the tensile strength of steel and reinforcing bars used for buildings, tunnels and bridges.
- **High Strength to weight ratio**: Its high strength-to-weight ratio helps in increasing fuel efficiency in the automotive and aviation industries.
- **Vanadium redox batteries**: Vanadium forms an integral part of vanadium redox batteries. It has the least ecological impact on energy storage.
- **Speciality Steel alloy**: Vanadium is also used to produce speciality steel alloys such as high-speed tool steels, and some aluminium alloys.
- **Catalyst**: Vanadium pentoxide is used as a catalyst for the production of sulfuric acid.

The global demand for vanadium has been skyrocketing but there was a deficit of 17,300 metric tonnes between demand and supply in 2017. According to the GSI specialist, the vanadium found in Arunachal Pradesh could help boost the local and national economy.

### PREVIOUS YEAR QUESTION (MAINS)

Discuss the multi-dimensional implications of the uneven distribution of mineral oil in the world.		
Despite India being one of the countries of the Gondwanaland, its mining industry contributes much less to its		
Gross Domestic Product (GDP) in percentage. Discuss.		
Account for the present location of iron and steel industries away from the source of raw material, by giving	2020	
examples.		
India has immense potential for solar energy though there are regional variations in its developments. Elaborate	2020	
Why is India taking a keen interest in the resources of the Arctic Region?		
How does India see its place in the economic space of rising natural resource-rich Africa?		
Account for the change in the spatial pattern of the Iron and Steel industry in the world.		
With the growing scarcity of fossil fuels, atomic energy is gaining more and more significance in India. Discuss the		
availability of raw materials required for the generation of atomic energy in India and in the world.		
It is said that India has substantial reserves of shale oil and gas, which can feed the needs of the country for a		
quarter century. However, tapping the resources doesn't appear to be high on the agenda. Discuss critically the		
availability and issues involved.		

#### Student's Note





# **10.WATER RESOURCES AND THEIR MANAGEMENT IN INDIA**

- India has 18% of the world's population yet only 4% of the freshwater. The monsoon, which has an average annual rainfall of 4000 BCM (1 billion cubic meters), or 1170 mm, is the primary supply of freshwater.
- The majority of Indian states rely on the monsoon for their water needs. At the same time, certain northern states have an abundance of water, while others, including Rajasthan, Maharashtra, and Tamil Nadu, are deficient.

#### **CONSTITUTIONAL PROVISION: SEVENTH SCHEDULE**

- Central List (Entry 56 of List I): Regulation and development of inter-State rivers and river vallsinceh as such regulation and development are under the competence of the Union and are deemed necessary in the public interest by Parliament through legislation.
- State List (Entry 17 of List II): It adds water to the state list, along with water sources, canals for irrigation, drainage systems, water storage, and water power.

#### WATER SCARCITY

- Falkenmark Index: According to it, if a nation's annual renewable water use per person is:
  - Water Stress: The country is reportedly experiencing water stress if the volume is under 1,700 m3.
  - **Water Shortage:** It is believed to have a water shortage below 1,000 m3.
  - **Water Scarcity:** Below 500 m3, there is water scarcity.



Fig: The Dilemma of Free Water

#### DAY ZERO

- The day when a city's taps dry out and people have to stand in line to collect a daily quota of water.
- International Case(South Africa): In Cape Town, the prospect of "Day Zero," or the day the water will run out, existed between 2016 and 2018.
- **Indian Case**: Chennai, one of India's major cities facing an acute, unprecedented water shortage and witnessing urban floods alternately. According to NITI Aayog's recent assessment Many other big cities, including the national capital Delhi, are likely to run out of groundwater by 2020.

#### WATER RESOURCE MANAGEMENT (WRM)

- The World Bank defines WRM as the "process of planning, developing, and managing water resources, in terms of both water **quantity** and **quality**, across all water uses'.
- It includes the institutions, infrastructure, incentives, and information systems that support and guide water management.
- According to the World Bank, water resources management seeks to harness the benefits of water by ensuring there is sufficient water of adequate quality for drinking water and sanitation services, food production, energy generation, inland water transport, and water-based recreational, as well as sustaining healthy water-dependent ecosystems and protecting the aesthetic and spiritual values of lakes, rivers, and estuaries.
- Water resource management also entails managing water-related risks, including floods, drought, and contamination.





#### FACT-WISE

- Water availability per person in India was 5177 cubic meters in 1951, but it has since fallen to 1545 cubic meters in 2011 and is predicted to fall even lower to 1300 cubic meters by 2030.
- According to **NITI Aayog**, a government think tank, 20 more cities, including Bengaluru, Delhi, and Hyderabad, would run out of groundwater in the next years if strategies for water conservation in India were not followed.
- **SDG 6:** Ensure access to water and sanitation for all. Access to safe water, sanitation and hygiene is the most basic human need for health and well-being.

#### HISTORICAL PERSPECTIVE TOWARDS WATER MANAGEMENT IN INDIA

- **Indus Valley Civilisation:** A significant Indus Valley Civilization site, Dholavira (3000–1500 BC), has a number of ponds to catch monsoon rainwater. Additionally, the drainage system was first-rate.
  - Wells were presumably created by the Harappans. Every third dwelling in the Indus Valley Civilization featured a well, according to a recent archaeological assessment.
- **Kautilya's Arthasastra**: It was written in the third century BC, and has evidence of irrigation with water collecting. According to the text, people were aware of different soil types, rainfall patterns, and irrigation methods.
- **Chandragupta Maurya (321-297 BC)**: A regular class of officers was assigned to monitor the rivers, survey the land and check the sluices used to release water from the main canals.
- **Junagadh inscriptions:** The Lake Sudarsana was restored and an embankment that had been ruined by flooding in the ninth century AD was repaired, according to the Junagadh inscriptions from the second century AD.
- **Bhoja:** The ruler of Bhopal, built an embankment across two hills to create a sizable lake. In the 11th century AD, it was one of India's biggest manmade lakes.
- **Rajatarangini:** It is a description of Kashmir from the year 1200, By Kalhana, important buildings such as the Dal and Anchar lakes, the Nandi Canal, and an irrigation system that was kept up to date are described.
- West Bengal (17th century AD): Up until the arrival of the British, the overflow irrigation system used in West Bengal in the 17th century AD performed admirably. In addition to improving the soil, it significantly reduced malaria.

### **PW-ONLYIAS EDGE: KEY PHRASES FOR MAINS**

Unprecedented Water Shortage; Water Scarcity; Floods And Droughts; Depletion of Groundwater; Impact of water scarcity; Water Pollution; Pesticides Use; Polluted Rivers; Unscientific Cropping Pattern; Destruction of Wetlands and Lakes; Groundwater contamination; Water Resource Management; Judicious allocation of Water; Preventing Unsustainable Exploitation; Need for Behavioural Change; Water as a common pool; Developing Water Protection Zones; etc.

#### NEED OF WATER MANAGEMENT IN INDIA

- **NITI Aayog:** In June 2018, NITI Aayog released a report titled "Composite Water Management Index (CWMI)" that stated that India was experiencing the worst water crisis in its history, that close to 600 million people were experiencing high to extreme water stress, and that 200,000 people were dying annually as a result of insufficient access to safe water.
  - According to the survey, with about 70% of its water being contaminated, India was ranked 120th out of 122 nations in terms of water quality.
  - It predicted that by 2030, the country's water demand would outpace its supply by two to one, resulting in acute scarcity for hundreds of millions of people and a potential decline in GDP.
- Central Ground Water Board: According to the most recent Central Ground Water Board data (from 2017), as many as 256 of India's 700 districts have declared "critical" or "over-exploited" groundwater levels.
  - With a 25% share of the global total, India has surpassed all other countries as the world's largest groundwater extractor. Our major rivers are dying as a result of pollution, and over 70% of our water sources are polluted.
- **Uneven Distribution:** Large portions of India continue to lack rain and groundwater due to the uneven distribution of water. Most of the population is forced to deal with water scarcity due to this uneven distribution across the nation.



- **Demand for Urban Areas:** In cities, there is a greater need for water than there is supply. Additionally, conserving water will guarantee that there will be clean water for future generations. This can be achieved by making sure that a freshwater ecosystem's freshwater intake does not exceed its natural rate of replenishment.
- **Cyclical Rainfall:** Since India's rainfall is largely cyclical, irrigation of crops requires water. Water safeguards wildlife and the ecology.





- **Energy Saving:** The requirement for power supply and water-based power generation has increased along with the demand for water to a significant degree.
- **Women's struggles:** A National Commission for Women report claims that rural Rajasthani women must trek approximately 2.5 kilometres each day just to access a source of water.
- **UN Dam Ageing report:** Over 1,000 large dams in India will be roughly 50 years old in 2025 and such ageing embankments across the world pose a growing threat.
- **Rise in Water-Stressed Regions:** More than a third of India's population lives in water-stressed areas and this number is set to grow due to depleting groundwater and rising urbanization. India placed thirteenth among the **world's 17 extremely water-stressed countries**, according to the Aqueduct Water Risk Atlas released by the World Resources Institute (WRI).
- **Chronic Water scarcity:** A NITI Aayog report in 2018 stated bluntly that **600 million people**, or nearly half of India's population, face extreme water stress. **That three-fourths of India's rural households do not have piped, potable water and rely on sources that pose a serious health risk.**
- Social and Political Conflicts: Water scarcity is leading to social and political conflicts at different levels of the government. Internal water crises are also a national security concern.
- **Skewed Priorities:** Diversion of water towards an urban megacity at the cost of the millions living in semi-urban and rural communities in the surrounding regions has been a routine practice in India.
- **Contaminated water resources:** Regardless of improvements to drinking water, many other water sources are contaminated with both bio and chemical pollutants, **and over 21% of the country's diseases are water-related.** Furthermore, only 33% of the country has access to traditional sanitation.

#### Name About **Baolis** Baolis were built by the ruling class for political, civic, or charitable reasons. All members of • society were welcome to use these facilities. Stepwells called baolis were exquisitely crafted with patterns and arches. **Jhalaras** Ihalaras were built in the past to provide a consistent water supply for communal consumption, religious rites, and royal events. These stepwells are rectangular in design and have tiers on three or four sides. Talab or Bandhi Reservoirs for storing water for drinking and domestic use are called talabs or ponds. They • could be man-made or natural ponds. A bandhi is a medium-sized lake, whereas a talab is a reservoir covering less than five . bighas. Kunds Kunds were constructed, primarily in Gujarat and Rajasthan, to conserve water and collect • rainwater for drinking. Bawari Stepwells called Bawari Bawaris were the first water storage networks in Rajasthan. • • They were specifically created to use canals built on mountainous terrain. Nadi • Village ponds known as nadis are where rainwater from nearby natural catchment areas accumulates. These bodies of water receive their water from sporadic, heavy rainfall. • Taanka Taanka is one of the indigenous water conservation methods that use a rainwater gathering • technology unique to Rajasthan's Thar desert. Rainwater is collected in Taanka, a paved cylindrical subterranean pit, from courtyards, . rooftops, and specially constructed catchments. Zings Zings are Ladakh-specific water collection devices. Small tanks like these were constructed • to hold the water from melting glaciers. A system of guiding channels directs water from the glacier to the tank. • **Bamboo Drip** Prevalent particularly in the northeastern regions. • **Irrigation System** It is a method for irrigating terrace fields that indigenous farmers devised more than 200 • years ago. In this system, bamboo pipes are used to transfer water from recurring springs. Kuhls One of the earliest methods of water conservation in Himachal Pradesh's hilly terrains is the • exploitation of glacial waters coming from rivers and streams through surface water channels. **Jackwells** Small pits called jack wells are used to collect rainwater. • The building was originally built using bamboo and wood logs by locals in the Great Nicobar Islands' low-lying areas Water harvesting The Maharashtra-based Ramtek concept is one of the conventional water-saving initiatives

### TRADITIONAL WATER MANAGEMENT PRACTICES IN INDIA



structures of Ramtek and methods.

 From the foothills to the plains, the system uses a network of groundwater and surface water bodies, where tanks connected by underground and surface canals form a link.

### MODERN METHODS OF WATER MANAGEMENT

- **Rainwater Harvesting:** Collecting rainwater is a very efficient way to replenish the groundwater table and save natural water.
- **Water metering:** Installing water metres to track water usage in both residential and business buildings is another effective technique to reduce water waste. It can aid in leak detection.
- **Greywater recycling:** It is a technique for reusing used and wastewater from showers, washing machines, and kitchen sinks for things like flushing toilets and watering plants.
- **Pressure Reducing Valves:** In a hydraulic system, a pressure-reducing valve essentially regulates the amount of pressure. These valves guarantee that the water level to be used is predetermined.
- Water-efficient Accessories: New developments are pushing the limits of water saving without compromising usage patterns, such as altered spray patterns in taps and showers and enhanced flush pressure in toilets.

### INTEGRATED URBAN WATER MANAGEMENT SYSTEM (IUWM)

- IUWM is a process, which ensures water supply, used water management, sanitation and stormwater management can be planned in line with economic development and land use.
- Approaches:
  - **Collaborative Action:** It prioritises accountability, has clear coordination between all the stakeholders, and is simply defined.
  - Change in Water Perception: It is crucial to comprehend how water is interconnected with urban planning, transportation, and land use.
  - **Understanding Water as a Resource:** Because water serves a variety of uses, it is easier to treat different types of water for use in agriculture, industry, and the environment.
  - Customised Solutions for Different Cities: IUWM prioritises a rights-based solution approach over a one-size-fits-all strategy and focuses on individual situations and local requirements.



#### WATER USE EFFICIENCY

It is defined as the amount of carbon assimilated as biomass **or grain produced per unit of water used by the crop.** It is about careful management of water supply sources, use of water serving technologies, reduction of excessive demand and other actions. There can be the following methods to increase water use efficiency.

#### **Micro Irrigation**

- Water utilisation efficiency: It is guaranteed by micro irrigation to the extent of 50–90%.
- **Potential:** The potential for drip irrigation in India is thought to total 27 million hectares, according to the Task Force on Micro-Irrigation in India (2004).
- **Scope:** Micro irrigation can be adopted in all kinds of land, especially where it is not possible to effectively use flooding methods for irrigation.

#### Sprinkler irrigation

- It is a method of applying water like rain. It is suited for most row, field and tree crops.
- Water can be sprayed over or under the crop canopy. The sprinkler breaks up the water **into droplets sized 0.5–4 mm**.

#### **Drip Irrigation**

• It has the potential to save water and nutrients by allowing water to drip slowly to the roots of plants, either from above the soil surface or buried below the surface.



- BY PHYSICS WALLAH
- The goal is to place water directly into the root zone and minimize evaporation. In the drip irrigation process, water and nutrients are delivered across the field in pipes called '**dripper lines**' featuring smaller units known as '**drippers**'.

#### Sub-surface irrigation

- This irrigation technique irrigates plants with water that is delivered from below the soil's surface. This microirrigation is effective and advantageous.
- It only needs a little water pressure to work correctly.

#### **Bubbler irrigation:**

- It disperses water at a rate of about 230 litres per hour through little streams and fountains.
- It is preferred in circumstances where a lot of water needs to be applied quickly.

#### **Advantages of Micro Irrigation**

- **Helps in Saving of Water:** Micro-irrigation can reduce water usage by 25–40 per cent as compared to overhead systems and 45–60 per cent as compared to surface irrigation.
- **Uniform Water application:** Higher uniformity results in efficient irrigation, thereby, causing less wastage of water, power and fertilisers.
- **Helps in saving electricity:** Usually, delivery pipes in micro-irrigation systems operate at low pressure (2–4 bar). Therefore, these require less energy for pumping.
- **Improves chemical application:** Micro irrigation systems can apply chemicals to plants through **fertigation units**.
- **Reduces weeds and diseases:** They compete with the crops for nutrients, moisture and sunlight, which can reduce the crop quality and the yield. These also serve as a habitat for diseases and insect pests, which attack the main crop.
- **Success story of Israel:** a desert nation with water scarcity has become a water surplus nation because it adopted micro-irrigation practises, especially drip irrigation that saves **almost three-fourths of the water used for irrigation done through open canals.**

#### **Fertigation**

- 'Fertigation' is the application of fertilisers used for making soil amendments in order to improve plant growth.
- Fertigation results in a balanced nutrient application, reduced fertiliser requirement of around 7 to 42 per cent (thus, saving expenditure cost incurred by the farmer), higher nutrient uptake and nutrient use efficiency.

#### Micro Irrigation in India:

- As of 2021, India has an **average penetration of micro irrigation—19%**—substantially lower than many other nations.
- **Only four Indian states**—Sikkim, Andhra Pradesh, Karnataka, and Maharashtra—have more than 50% of their net cultivable land covered by micro irrigation at the moment; the remaining states have less than 15%.
- Even though Uttar Pradesh produces the most **sugarcane**, a crop that requires a lot of water it only has 1.5% and, Punjab only has 1.2% of its area under micro irrigation.
- Over the next five years, the government wants to cover **100 lakh acres of land with micro-irrigation**.

#### MICRO-WATERSHED DEVELOPMENT AND MANAGEMENT

- A watershed is a **geo-hydrological land unit** that gathers water and empties it through a central location. The main goal of watershed management is to store and replenish groundwater using a variety of techniques, including percolation tanks, recharge wells, and artificial ponds.
- It's one of the most efficient methods of conserving water and managing scarce Water resources with a decentralized approach.
  - $\circ$  ~ Size of the Micro watershed ranges from 100 to 1000 Hect.
  - So, it gives scope for adopting area-specific approaches for better water resource management.
- Integration of Technologies: Watershed management is the integration of technologies within the natural boundaries of a drainage area for the optimum development of land, water, and plant resources to meet the basic needs of the people and animals in a sustained manner.
- Classification of watershed (based on size):
  - Micro watershed (100 to 1000 Hect)
  - Mini watershed (1-100 Hect)
  - Macro watershed (> 50,000 Hect)

### **Micro Watershed**

The **smallest one** covers 100-1000 ha. It covers regional planning at the village level with the objective to improve the efficiency of water use for the betterment of agricultural productivity and the value addition of rural populations. (SWAJAL Scheme)





### **BENEFITS OF MICRO-WATERSHED MANAGEMENT**

- **For drought-prone areas**: Micro-watershed management became inevitable for the development in drought-prone and semi-arid regions that could sort out the problem of water scarcity and drought. Micro-watershed projects can prevent unwanted evaporation by **increasing the biomass component of the area**.
- **Restoration of Natural Water resources:** By Restoring the natural resources of water collection like ponds. lakes. etc.
- **Infrastructure Development:** It leads to the development of infrastructures like tanks, artificial ponds, check dams, etc. to store the rainwater and increase the moisture level of the soil.
- **Increased Water use Efficiency:** It also includes Improving **water use efficiency** for agriculture with methods like drip irrigation and sprinkler irrigation.
- **Prevention of Soil Erosion:** It also helps in Preventing soil erosion, planting trees in the wastelands, groundwater reaching, and conservation of soil moisture.
- **Improves Quality of Life:** Micro Watershed management helps in Improving the quality of life of the drought-prone region by the increased availability of water both for drinking and irrigation purposes E.g., Women and Girls will not have to trudge longer distances for fetching water.
- It improves the quality of life of villagers through increased productivity of the land, availability of water surface and ground, an increase in the vegetation cover, improving cattle health resulting in higher milk production, and improving the overall environment by tree plantation.
- **Corresponding Development in Vegetation:** Increasing the vegetation occurs in semi-arid regions by rational utilization of water resources. Micro-watershed development can result in phenomenal success in regions like Vidarbha. Bundelkhand. & Rajasthan.

### EVOLUTION OF WATERSHED DEVELOPMENT POLICY

- **1970s:** In order to alleviate India's water shortage, the Indian government developed the **Drought Prone Areas Programme (DPAP)** and **Desert Development Programme (DDP)**.
- **1985:** The **National Wastelands Development Board** was established under the Ministry of Environment and Forests to quicken the development of wastelands and degraded lands.
  - **1990s:** During the 1990s, the phrase "watershed management" has become more popular.
  - The Integrated Watershed Development Programme (IWDP) was started by the government.
  - World Bank assistance is provided by the National Watershed Development Programme for Rainfed Areas (NWDPRA).
- **2015:** A credit agreement was negotiated by the World Bank and the Ministry of Rural Development to combine these programmes under the "Neeranchal National Watershed Project (NWP)
- **PMKSY:** Later, the Watershed Development Component of Prime Minister Krishi Sinchayee Yojna (WDC-PMKSY) was formed by combining DPAP, DDP, and IWDP for the purpose of maximising resource usage, achieving sustainable results, and integrating planning.

**Thus, Micro Watershed management** is an **area-specific decentralized approach** with improved chances of better implementation. Activities such as desiltation of common water bodies like wells, and lakes and the building of check dams on small rivers will improve water availability. It also gives scope for the application of traditional knowledge of communities in the conservation of water.

### PROBLEMS WITH WATER RESOURCE MANAGEMENT

- **Uneven distribution of rainfall:** Even though India experiences the monsoon or southwest monsoon, there is an unequal distribution of rainfall.
- **Proliferating demand for water:** Water demands are expanding rapidly in India as a result of the country's rapid urbanisation, population growth, growing need for irrigation systems for the country's farms, and other home uses.
- **Urbanisation caused water problems:** Due to the rapid growth of urban areas, there are concerns with the management of water resources.
- **Sewage problems in cities:** Sewage problems in cities cause more water contamination in the available water resources.
- **Overuse of groundwater:** During the past forty years, nearly 85% of groundwater has been used. This irresponsible use of water raises the burden on the water supply.

#### IMPACT OF WATER MISMANAGEMENT

• **Economic Impact:** According to **NITI Aayog**, there will be a two-fold increase in water demand by 2030, and India could lose 6% of GDP growth as a result of poor management.





- **Agricultural Impact:** Water management practises would have a negative impact on agriculture because the production of all agricultural products depends entirely on water.
- **Increase in Water Conflicts:** There have already been water disputes between the states of India, including those over the Cauvery River, the Narmada River, the Krishna River, and other bodies of water.

#### **GOVERNMENT INTERVENTIONS**

- Jal Shakti Ministry: Formed in 2019 by integrating earlier two water-related ministries for water management in the country.
- **Swajal Scheme:** Under the National Rural Drinking Water Programme, the Ministry in February 2018 has initiated a project in the name of **"Swajal"** that is designed as a demand-driven and **community-centred** program to provide sustainable access to drinking water to people in rural areas. It encourages Partnership between village communities, NGOs and the government as the facilitator.
- Jal Jeevan Mission (2019): To provide piped potable water to every rural household by 2024. In the past year, the Jal Jeevan Mission.
- **Interlinking of Rivers project:** To ensure greater equity in the distribution of water by enhancing the availability of water in drought-prone and rain-fed areas.
- **National Hydrology Project (2016)**: To improve the extent, quality, and accessibility of water resources information and to strengthen the capacity of targeted water resources management institutions in India.
- Atal Bhujal Yojana (ABHY): Launched in 2019 to improve the management of groundwater resources in selected states.
- **PM Krishi Sinchayi Yojana:** To improve farm productivity and ensure better utilization of the resources in the country i.e., **Per Drop, More Crop.**
- **National Water Mission:** To ensure integrated water resource management helping to conserve water, minimize wastage and ensure more equitable distribution both across and within states.

### **Case Study: Anmol Jeevan Abhiyan**

- The 'Anmol Jeevan Abhiyan' (Precious Life Campaign) is a recent project in Barmer, Rajasthan that has inspired rural panchayats and property owners to upgrade tanka structure by adding hand pumps and locking lids.
- The 'Anmol Jeevan Abhiyan' (Precious Life Campaign) has pushed house owners and village panchayats to structurally upgrade their tankas with hand pumps and locking coverings.
- As part of the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), they were built in homes.

### **OTHER GOVERNMENT INITIATIVES:**

Initiatives	About			
AMRUT 2.0	<ul> <li>To carry out the Atal Mission for Rejuvenation and Urban Transformation (AMRUT)'s goal of providing underwater service coverage to all statutory towns in the nation, which now covers 500 cities.</li> <li>To ensure complete sewage and septage management in 500 AMRUT cities and establishing the "self-reliance" and "water security" of those cities. Changes in the water industry, citizen comfort, and financial sustainability are the three main focuses of the mission's reform strategy.</li> </ul>			
Bharat Tap Rating • The Bharat Tap initiative, developed as part of AMRUT 2.0 to promote wate				
System for Water	would house the star grading system under one canopy.			
Fixtures	<ul> <li>The project seeks to spread and use water-saving fixtures.</li> </ul>			
Water Bodies Census	• The census sought to gather information on the encroachment of water bodies as well as to			
	give an inventory of India's water resources, including both natural and artificial water			
	bodies such as ponds, tanks, and lakes.			
Network of	• Around 16,000–17,000 digital water level recorders will be linked to piezometers in the			
<b>Groundwater Sensors</b>	wells as part of this new effort in order to communicate data digitally.			

#### INTERNATIONAL INITIATIVES

Initiatives	About
UN Water Conference and	<ul> <li>An worldwide gathering called the UN-Water gathering tries to better coordinate government, business, nonprofit, and funding initiatives around a few key water sector concerns.</li> <li>It provides a platform for nations to invest, transfer technology, and learn from the mistakes of others.</li> </ul>





Key Takeaways	• It led to the creation of the first worldwide "Action Plan," which recognised that everyone had the right to access clean water and sanitation.
Universal Declaration of the Rights of Rivers	<ul> <li>The declaration is a civil society project to outline the fundamental rights to which all rivers are entitled.</li> <li>A significant change away from an extractive worldview and towards one in which conservation safeguards are being extended to nature is being heralded by the global trend of providing rights to nature.</li> </ul>

## WAY AHEAD FOR WATER RESOURCE MANAGEMENT

- Arth Ganga Model: New govt model for the River's Sustainable Development
  - The Arth Ganga model's fundamental goal is to **connect people with the river through the economy.** 0
  - It aims to provide at least **3% of the GDP** from within the Ganga Basin. 0
  - Interventions made as part of the Arth Ganga project are in line with India's commitments to the UN sustainable 0 development goals.
- Water management needs a hydro-social approach
  - The relationship between social vulnerability and changes to water systems was underlined in the IPCC's fourth 0 assessment report (2007).
  - Globally, it is predicted that if current trends continue, the **difference between freshwater demand and supply** might increase to 40% by 2030.
  - The right valuation of water is stressed in the **UN World Water Development Report**, 2021, which takes five 0 viewpoints into account.
  - water infrastructure, water sources, and water services 0
  - Water's role in manufacturing, socioeconomic development, and sociocultural values
- **Holistic Water Management System** 
  - Water consumption has grown significantly as cities have expanded quickly. Water scarcity and depletion are major problems that will soon confront people, even as desires drive people to move to metropolitan areas.
  - In order to assure that the majority of metropolitan areas can be self-sufficient in the future, water management needs to undergo a revolution.
- India's Water Vision: Roadmap for a Sustainable Future
  - A government programme called India's Water Vision aims to provide all Indians with access to clean, safe water. 0
  - The initiative also emphasises water resource preservation and the advancement of sustainable water practices. 0
- **River Cities Alliance**: It provides the member cities with a platform to discuss and exchange information on aspects that are vital for sustainable management of urban rivers such as -
  - Minimising their water footprint, 0
  - Reducing impacts on river and water bodies, 0
  - Capitalising on natural, intangible, architectural heritage and associated services and 0
  - Develop self-sufficient, self-sustainable water resources through recycle, reuse strategy. 0

### DRAFT WATER POLICY

- This National Water Policy (NWP) strive for a multi-disciplinary, multi-stakeholder approach to water management.
- **Objectives:** 
  - It aims to promote a circular economy of water through the development of the City Water Balance Plan for each city focusing on recycling/reuse of treated sewage, rejuvenation
  - of water bodies and water conservation.
  - It focuses on making the cities 'self-reliant' and 'water secure'. Mission targets the provision of 2.68 crore tap connections to achieve the intended outcomes.
- The proposed NWP has two key recommendations:
  - Instead of continuously increasing the water supply, pay attention to demand control strategies.
  - Focus shifting to the supply side is also necessary because there aren't any more suitable locations in the nation to build huge dams, and many places' water tables and groundwater quality are declining.

### **Need of New Water Policy:**

Increasing Demand: Recent estimates suggest that if the current pattern of demand continues, about half of the national demand for water will remain unmet by 2030.

6,042	SHORT C	World	India			
ubic metres)	WATER RESOURCE	S 496	ter availability co	nstantly decreas	ing P	rolection
(ho	1,816	1,545	1,486	1,367 O	1,282	1,228
1947	2001	2011	2021	2031	2041	2051

 Avg annual water by precipitation in India: 4,000 billion cubic metres (BCM) Avg annual availability as natural runoff afterevaporation:1,869BCM Avg annual 'utilisable' potential by geological & other factors: 1.122 BCM (Surface water: 690 BCM) (Ground water: 432 BCM) (1 cubic metre = 000 litres)



of annual ground water recharge is consumed in India. While net ground water availability (extractable) per year is 393 billion cubic metres (BCM), 249 BCM is drawn for irrigation, domestic and industrial uses



- Water availability is set to worsen with the average annual per capita water availability estimated to fall by 37% by 2050.
- Water Stress Scenario: India is the largest extractor of groundwater in the world. Nearly 600 million Indians face high to extreme water stress,
- **Falling water table and deteriorating water quality:** This has made the need of the hour to shift towards a water management approach
- **Unpredictable Rainfall:** Changing patterns and intensity of precipitation show that it can no longer be assumed that the water cycle operates within an invariant range of predictability.
- **Rapid urbanisation:** This is leading to more informal sourcing of water, mainly through tankers using groundwater, increasing demands for long-distance import of water. This not only increases the cost of supply but also the waste of water due to leakage.
- **Reforming Water Governance: Command-and-control approach:** Rules and regulations within the policies are framed by the government agencies without giving due consideration.

#### Salient features of Policy:

- Supply-centric approach: The policy emphasizes a shift away from a supply-centric approach to the management of demands. For example Crop Diversification
- **Reduce-Recycle-Reuse approach**: This approach has been proposed for the integrated urban water supply and decentralized wastewater management, with the treatment of sewage and eco-restoration of urban river stretches.
- **Channelising of Supply-side options:** By utilizing water stored in big dams, the irrigated area could be greatly expanded at a very low cost by deploying pressurized closed conveyance pipelines, combined with Supervisory Control and Data Acquisition (SCADA) systems and pressurized micro-irrigation.
- **Nature-based solutions:** The policy focuses on the supply of water through "**nature-based solutions**" such as the rejuvenation of catchment areas, to be incentivised through compensation for ecosystem services.
- **National Water Commission:** Creation of a unified multi-disciplinary, multi-stakeholder **National Water Commission (NWC)**, which would become an exemplar for states to follow.
- **Use of indigenous knowledge**: Techniques of Water management of our people is an invaluable intellectual resource that must be fully leveraged.

#### DAM SAFETY ACT, 2021

Water is under the state list, but the Union government has made Dam safety law under Article 246 of the Constitution. Article 246 empowers Parliament to legislate on matters listed in the state list under certain conditions. The act provides for proper surveillance, inspection, operation and maintenance of all specified dams in the country to ensure their safe functioning.

#### Features

- **National Committee on Dam Safety**: The act provides for the constitution of a National Committee on Dam Safety (NCDS) which is to be chaired by the Central Water Commissioner (CWC).
- National Dam Safety Authority (NDSA): It provides for the formation of a NDSA which will be responsible for implementing the policies of the NCDS, and will resolve issues between State Dam Safety Organisations (or SDSOs) and dam owners.
- **State Dam Safety Organisations (SDSOs)** The act will also result in the establishment of SDSOs, and State Committees on Dam Safety (SCDSs). The jurisdiction of the SDSOs will extend to all dams in that specific state.
- **Surveillance of dams**: It provides for the surveillance, inspection, operation, and maintenance of all specified dams across the country.
- **Provision for Penalaty**: The act provides for stringent penalties in case of violations, including two years of jail term.

#### Challenges and issues with the Act

- **Interference with federal Structure**: The act is a legislation passed by the Union through brute majority to blatantly usurp the States' power.
- Within the Control of the Centre: Act usurped the power of the State governments and placed the operation of specified dams under the control of the Centre.
- **Specified dam**: Certain terms including the word 'dam' in the Act, had been deliberately defined vaguely to give unbridled power to the Centre to treat any dam as a 'specified dam'. If those definitions were followed, almost all dams in the country would fall under the purview of the Act.
- Entry 56 of Union list: The power of the Centre under Entry 56 of the Union list was only with respect to inter-State rivers or river valleys and nothing more. Entry 56 cannot be stretched to include dams and embankments exclusively within the control of the States.
- Silent on Compensation: The bill is silent on the payment of compensation to people affected by dam projects.







- **Ambiguity in the Provisions**: Power over the subject 'interstate river and river valley' cannot be confused with the control over dams.
- Adverse impact: It would have an adverse impact on agriculture, fisheries, hydropower generation, provision of drinking water to the people and so on.
- **Criminal prosecution**: The act provided for criminal prosecution for not obeying directives issued under the legislation. Bureaucrats will now be kept under fear and threat which will lead to mechanical compliance with the dictates of the Union Government.

### Significance of the Act

- **Brings Uniformity**: The government wants that there should be a uniformity of procedures which is followed by all dam owners for a particular type of large dam.
- **Provide Strict Guidelines**: Water is a state subject and the act has also provided authority to the state. The act provides guidelines and a mechanism to ensure that the guidelines are followed.
- **Ensure Quality**: The act provides a mechanism where accreditation of the people who are really going to take part in the construction and maintenance, has to be taken care of.
- **Security**: Dams are prone to damage and therefore their safety is very important. The act provides for the formulation of dam safety standards.

#### SDG Goal 6: Ensure access to water and sanitation for all

- **6.3:** By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing the release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally
- **6.4**: By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity

#### **Conclusion: efficient water management**

• It is necessary to come up with new ideas for improved urban water management because population expansion and climate change are increasing water usage. The difficulties need to be made more widely known to more people in various local contexts. Similar adjustments are necessary for organisations like regional departments that have a significant impact. In order to address water challenges, comprehensive and systemic solutions must be put into practice.

### PREVIOUS YEAR QUESTION (MAINS)

What are the environmental implications of the reclamation of the water bodies into urban land use? Explain with		
examples.		
The interlinking of rivers can provide viable solutions to the multi-dimensional inter-related problems of droughts,	2020	
floods and interrupted navigation. Critically examine.		
How will the melting of Himalayan glaciers have a far-reaching impact on the water resources of India?	2020	
What is water stress? How and why does it differ regionally in India?	2019	
"The ideal solution of depleting groundwater resources in India is water harvesting system." How can it be made	2018	
effective in urban areas?		
What is water use efficiency? Describe the role of micro-irrigation in increasing their-use efficiency.	2016	
Enumerate the problems and prospects of inland water transport in India.		
In what way do micro-watershed Development projects help in water conservation in drought-prone and semi-		
arid regions of India?		
What is the economic significance of the discovery of oil in the Arctic Sea and its possible environmental		
consequences?		
India is well endowed with fresh water resources. Critically examine why it still suffers from water scarcity.		
Bring out the relationship between the shrinking Himalayan glaciers and the symptoms of climate change in the		
Indian sub-continent.		



# **11.TRANSPORT AND COMMUNICATION IN INDIA**

Transportation in India is a complex and diverse system that plays a vital role in the country's economy and daily life. It encompasses a wide range of modes, including road, rail, air, and water transport. India has one of the largest road networks in the world, with a significant reliance on buses and private vehicles. Water transport, particularly along the coastline and major rivers, also contributes to India's transportation landscape.

### MODES OF TRANSPORTATION

Different Modes of Transportation					
<b>Road</b> • India has one of the world's largest road networks, covering over 5.8 million kilometres.					
<b>Transport</b> • Road transport is the dominant mode, catering to the majority of passenger and freight mo					
	• There are approximately 326.3 million registered motor vehicles in India as of 2020.				
	• According to Indian Railway India has the fourth-largest railway network globally, spanning				
Railways	over 67,000 kilometres.				
	• Indian Railways is <b>one of the world's largest railway systems</b> , carrying millions of passengers				
daily.					
	• According to <b>Statistia</b> , India has a rapidly growing aviation sector with <b>over 400 airports out of</b>				
Air Transport	which 153 are operational airports.				
	• According to the Airport Authority of India In 2019-2020, Indian airports handled around 341				
	million passengers.				
	<ul> <li>India has an extensive network of waterways, including major rivers and coastal areas.</li> </ul>				
Water	• The total navigable inland waterway length is <b>approximately 20,236 kilometres</b> .				
Transport	• The Inland Waterways Authority of India is developing and modernizing water transport				
	infrastructure.				

### UTILITY OF TRANSPORTATION IN IMPROVING INDUSTRIAL GROWTH

- **Moving inputs and outputs:** Transportation enables the movement of raw materials, and labour to industries and delivers the final product to the consumers. Hence, it is the main channel to complete any trade transaction.
- **Market Access:** Improved connectivity through transportation networks enables industries to tap into new markets, expanding their reach and boosting sales and revenue potential, thus driving industrial growth.
- **Location of Industry:** Transportation cost is a vital parameter in deciding the location of industries. Hence efficient and cheap transportation facilities are attracting industries in their region.
- **Cost Optimization:** Efficient transportation systems minimize costs, allowing industries to allocate resources to research, development, innovation, and growth-oriented activities, fostering industrial progress.
- Access to remote areas: Efficient and widespread transportation facilities help to establish industries in backward areas e.g. gas pipelines enable establishment of petrochemical complexes in Barauni and Mathura. and taps the market in remote areas.
- **Specialization:** Transport helps to move labour and capital to desired location which results in division of labour and specialization of expertise. E.g. IT hubs in Bangalore and Pune have attracted talent and capital across the nation.
- **Industrial Clusters and SEZs:** Strong transport infrastructure is vital for successful industrial clusters and SEZs, enabling efficient supply chains, resource sharing, and collaboration for optimal growth.
- **Economic growth:** A good transportation system is vital to attract development which would create employment and spur economic growth. Transport cost decides the competitiveness of the produced goods and services. E.g. Lack of transportation facilities is the main reason behind poor industrial development in resource-rich North eastern regions.
- **Employment generation:** Surface, Water and Aviation sector provides employment opportunities to millions of people. The infrastructure development for transportation also spurs other industries like steel, cement etc
- **Trade and Export Opportunities:** Well-connected transport networks enable industries to access global markets, engage in international trade, and drive economic growth through increased exports and market exposure.

#### RAILWAY TRANSPORT SYSTEM

- The Railway transport system is highly responsible for propelling India's overall development.
- The Indian Railways is the **lifeline of India**. With its vast network across the length and breadth of India, it is not just a mere transporter of passengers and goods but also a social welfare organisation.
- Indian Railway is the **4th longest rail network in the world** which spreads **around more than 67000 Km carrying 23 million passengers daily.**





- Indian Railway runs 9000 freight trains daily which carry around 3.05 million tonnes of freight.
- Indian Railway operates in **16 zones and has three railway Gauge Systems** including Broad Gauge (1.676 meter), Meter Gauge (1 meter) and Narrow Gauge (0.762 meter or 0.610 meter).
- Share of the railways in the transportation of surface freight has **declined** due to a shortfall in carrying capacity and lack of price competitiveness.

### **OBJECTIVES SPECIFIED BY NITI AAYOG**

- Infrastructure: Increase the speed of infrastructure creation to 19 km/day by 2022-23.
- **Electrification**: Achieve 100% electrification of broad gauge track by 2022-23.
- **Revenue**: Increase the share of non-fare revenues in total revenue to 20 per cent.
- Safety: Improving safety standards to achieve zero fatalities.

### NEED FOR ROBUST RAILWAY INFRASTRUCTURE

- **Economic Growth:** Railways play a vital role in facilitating economic growth by providing an efficient and cost-effective mode of transportation for goods and passengers.
- **Connectivity:** Railways can enable people to travel easily, fostering social and cultural exchange while enhancing access to education, healthcare, and employment opportunities.
- **Mass Transportation:** With a large population, India heavily relies on railways for mass transportation. A robust railway infrastructure ensures safe, comfortable, and affordable travel options for millions of people, reducing congestion on roads and highways.
- **Freight Movement:** It helps in reducing logistics costs, enhancing supply chain efficiency, and supporting industries such as agriculture, manufacturing, and mining.
- **Environmental Benefits:** By promoting rail travel and freight transport, India can reduce carbon emissions, alleviate air pollution, and contribute to sustainable development and environmental conservation.

### NATIONAL RAIL PLAN VISION - 2030

- The Indian Railways has prepared a National Rail Plan (NRP) for India 2030, with the vision of creating a "future-ready" railway system by 2030.
- The National Rail Plan aims to transform the Indian Railways into a **modern**, **efficient**, **and sustainable transportation system**, meeting the growing demands of both freight and passenger traffic while reducing transit times and increasing the modal share of rail transport.
- The plan aims to increase the modal share of the Railways in freight to 45% and create capacity ahead of demand to cater to future growth until 2050.
  - The key objectives of the National Rail Plan are as follows:
    - **Increase Modal Share of Railways in Freight:** Formulate strategies to increase the Railways' modal share in freight to 45% through operational capacities and commercial policy initiatives.
    - **Reduce Transit Time of Freight:** Substantially reduce the transit time of freight by increasing the average speed of freight trains to 50 km/h.
    - **Dedicated Freight Corridors:** Identify new dedicated freight corridors to facilitate efficient movement of freight.
    - High-Speed Rail Corridors: Identify new high-speed rail corridors to enhance passenger connectivity.
    - **Rolling Stock and Locomotive Assessment:** Assess the rolling stock requirement for passenger traffic and wagon requirement for freight, as well as the locomotive requirement to meet the objectives of 100% electrification and increasing the modal share of freight.
    - **Capital Investment:** Assess the total capital investment required and provide a periodic break-up of the investment needed.
    - **Private Sector Involvement:** Promote sustained involvement of the private sector in various areas, such as operations and ownership of rolling stock, development of freight and passenger terminals, and development/operations of track infrastructure.
  - These projects include the construction of new railway lines and the modernization of existing infrastructure.

### NATIONAL RAIL PLAN VISION 2024

As part of the National Rail Plan Vision 2024 has been launched for accelerated implementation of critical projects by 2024, including:

- 100% electrification
- Multi-tracking of congested routes
- Speed upgradation to 160 km/h on Delhi-Howrah and Delhi-Mumbai routes
- Speed upgradation to 130 km/h on other Golden Quadrilateral-Golden Diagonal (GQ/GD) routes
- Elimination of all level crossings on GQ/GD routes.





### **CHALLENGES OF THE INDIAN RAILWAYS**

- **Passenger transport:** Cross subsidization burden and high operating ratio have prevented Indian railways from providing high-quality services and safety features.
- Average speed: Average speed of railways is very low compared to railways of developed nations. Because of these reasons, the passenger crowd is shifting towards road and aviation transport.
  - The average speed of the semi-high-speed train was 81.38 kmph in 2022-23, whereas freight trains run at an average speed of 46.71 kmph.
- Freight transport: High competition from road transport due to cheaper rates and destination-based delivery.
- **Capacity Constraints:** Limited track and terminal availability hampers accommodating increasing demand, leading to full trains and reduced frequencies.
- **Safety Concerns:** Accidents due to human error, track defects, and equipment failures remain a significant challenge. For instance, the Amritsar train accident in 2018.
- **High operating cost:** Indian Railways faces revenue challenges while grappling with increasing staff management expenditures, including salaries, pensions, and medical facilities, leading to financial strain.
- **Congestion:** Indian Railways faces congestion at major junctions like Mumbai and Howrah, causing delays and reduced efficiency.
- Ageing Infrastructure: Outdated tracks, bridges, and signalling systems pose challenges in safety and reliability.
- **Poor connectivity and electrification:** Penetration of railways in hilly states like Himachal Pradesh, Uttarakhand, North East etc is very poor. The rate of electrification of tracks is very slow.
- **Financial Sustainability:** Rising costs, social obligations, and subsidies strain the railway's finances, impacting infrastructure investments.
- Last-Mile Connectivity: Inadequate connectivity options from railway stations hinder seamless travel for passengers.
- **Technological Upgradation:** Limited automation and outdated systems hamper operational efficiency and passenger experience.

### **GOVERNMENT INITIATIVES**

- Amrit Bharat Station scheme (2022): Ministry of Railways has formulated a new policy for the modernization of stations named the "Amrit Bharat Station" scheme. Amrit Bharat Station scheme envisages the development of 1000 small stations on a continuous basis with a long-term vision.
- **"One Nation One Card" system (2019):** "One Nation One Card" simplifies payments and enhances convenience for travellers by enabling a single card for multiple modes of transport including trains, buses, and metro services.
- **Kavach:** India has been developing its own Train Collision Avoidance System (TCAS) since 2012, now known as Kavach or "armour." Kavach consists of electronic devices and Radio Frequency Identification (RFID) devices that are installed in locomotives, signalling systems, and tracks.
- **National Rail Plan (NRP):** The NRP aims to create a future-ready railway system by 2030. It includes the construction of dedicated freight corridors (e.g., Eastern and Western Dedicated Freight Corridors) and high-speed rail corridors (e.g., Mumbai-Ahmedabad Bullet Train project).
- **Rail India Development Fund (RIDF) (2017):** The establishment of RIDF to mobilize funds for critical railway projects, providing financial support for infrastructure development, capacity expansion, and modernization of the railway network.
- **Public-Private Partnership (PPP):** The development of the Mumbai-Ahmedabad Bullet Train project is being carried out under a PPP model, with the involvement of Japanese companies.
- Make in India (2014): For example, the production of Train 18 (Vande Bharat Express), India's first indigenously built semi-high-speed train, and the manufacturing of train coaches by Indian Railways' production units.
- **Dedicated Freight Corridors (DFCs):** The construction of the Eastern Dedicated Freight Corridor (EDFC) and Western Dedicated Freight Corridor (WDFC) is aimed at improving freight transportation efficiency and reducing congestion on existing railway lines.

### **RECOMMENDATIONS OF BIBEK DEBROY COMMITTEE ON RAILWAY MODERNISATION (2015)**

- **Encouraging Private Players**: The committee suggests involving private players in running trains and railway-related services to bring in efficiency and expertise.
- **Elimination of Railway Budget**: The report proposes eliminating the separate Railway Budget and integrating it with the General Budget to streamline financial planning and resource allocation.
- **Decentralization of Operations**: The committee emphasizes decentralization to improve the management and effectiveness of railway operations.
- **Infrastructure Development**: The committee emphasizes the need for accelerated infrastructure development, including the construction of new lines and dedicated freight corridors.
- **Rationalization of Fare Structures**: The committee suggests rationalizing fare structures to optimize revenue and encourage passenger traffic.





- **Enhancing Customer Experience**: The report highlights the importance of improving passenger amenities, cleanliness, and overall customer experience.
- **Technology Adoption**: The committee stresses the adoption of modern technologies for enhanced safety, efficiency, and service quality.
- **Skill Development**: The report emphasizes the need for skill development programs to enhance the capabilities of railway staff.

#### WAY FORWARD:

- **Skill Development and Human Resources:** Focus on training and capacity-building programs for railway staff to enhance their skills, knowledge, and professionalism.
- **Modernization and Upgradation:** Invest in modern technologies, signalling systems, and rolling stock to improve operational efficiency, safety, and passenger experience.
- **Infrastructure Expansion:** Continue the development of new railway lines, dedicated freight corridors, and high-speed rail networks to enhance connectivity, reduce congestion, and support economic growth across regions.
- Make in India and Self-Reliance: Promote indigenous manufacturing and R&D capabilities in the railway sector to reduce dependence on imports.
- **Sustainability and Renewable Energy:** Promote the use of renewable energy sources like solar power and explore energy-efficient solutions to reduce the carbon footprint of the railways.
- **Digital Transformation:** Embrace digital technologies to improve customer services, including online ticketing, realtime tracking, and passenger information systems.
- **Roll-on Roll-off Model for Freight Transport:** Implementing the roll-on roll-off model on Dedicated Freight Corridors (DFCs) to transport loaded trucks on the rail, enhancing revenue generation and reducing carbon footprint.
- **Commercialization and Outsourcing:** Exploring opportunities to commercialize Railway Production Units and outsource medical services to streamline operations and improve efficiency.
- **Fare Rationalization and Modernization:** Rationalizing fare structures, modernizing railway stations, and enhancing safety features to enhance the overall passenger experience and attract more travellers.
- **Ease of Doing Business:** Improving the ease of doing business in the railway sector to attract investments, promote efficient resource allocation, and encourage private sector participation.
- **Financial Viability and Revenue Generation:** Implement strategies to increase revenue streams, optimize resource utilization, and explore innovative financing models.

The Indian railway system plays a crucial role in the country's transportation infrastructure, with significant improvements, digitalization, skill development, and safety enhancements, while facing challenges of revenue, expenditure, and fossil fuel dependence, which are being addressed through initiatives such as the National Rail Plan, public-private partnerships, and sustainable practices.

#### ROAD TRANSPORT

Road transport plays a vital role in India's transportation system, serving as a lifeline for both passenger and freight movement across the country. The demand for mobility on roads has risen continuously and sharply in recent decades. It provides a cheaper, more convenient alternative and the only avenue which provides destination-based delivery. With a vast network of roads, India has one of the largest road networks in the world, connecting rural and urban areas, facilitating trade and commerce, and enabling the mobility of people and goods.

	DATA AND FACTS ON ROADS IN INDIA
Total length of the Roads	<ul> <li>India has a network of over 63,31,757 kilometres of roads as of March 31, 2019, making it the second-largest road network in the world.</li> <li>The total road length in India increased from 62,15,797 km in 2018 to 63,31,757 km in 2019, registering a growth of 1.9 per cent.</li> </ul>
Contribution to GVA	• Road transport is the dominant segment in India's transport sector and contributed 3.06 per cent to Gross Value Added (GVA) in the year 2019-20.
National Highways	<ul> <li>As of March 31, 2019, the total length of National Highways was 1,32,499 km (2.09% of the total road network), which increased by 4.9 per cent compared to the previous year.</li> <li>Maharashtra has the largest network of National Highways with 17,757 km (13.4%), followed by Uttar Pradesh and Rajasthan with 11,737 km (8.9%) and 10,342 km (7.8%) respectively, as of March 31, 2019.</li> </ul>
State Highways	<ul> <li>As of March 31, 2019, the total length of State Highways was 1,79,535 km (2.8% of the total road network).</li> <li>Maharashtra has the largest State Highways network in the country, accounting for 17.83 per</li> </ul>





	cent (32,005 km) of the total, followed by Karnataka, Gujarat, Rajasthan, and Andhra Pradesh.
Rural Roads	<ul> <li>Constitute 71.4 per cent of the total road network in the country. As of March 31, 2019, the length of Rural Roads was 45,22,228 km.</li> <li>Maharashtra has the largest network of Rural Roads with 4,26,327 km (11.7%), followed by Assam, Bihar, Uttar Pradesh, and Madhya Pradesh.</li> <li>The five states of Maharashtra, Assam, Bihar, Uttar Pradesh, and Madhya Pradesh account for 42.4 per cent of the total Rural Roads in the country.</li> </ul>

### **CHALLENGES:**

- **Financing and Investment:** Though the government has made efforts to increase investment in the sector, there is a need for more sustainable financing models, private sector participation, and innovative funding mechanisms to meet the growing demands of road infrastructure.
- **Road Congestion:** Insufficient road capacity and inadequate traffic management contribute to congestion, leading to increased travel time, fuel consumption, and air pollution. Three cities in India ranked in the top 10 in Global Traffic Congestion.
- **Poor Road Infrastructure:** Despite the extensive road network, many roads suffer from poor quality, inadequate maintenance, and lack of proper signage and lighting. This hampers road safety, increases vehicle maintenance costs and affects the overall efficiency of transportation.
- **Road Safety:** India has one of the highest rates of road accidents in the world. Factors such as poor road design, inadequate enforcement of traffic rules, lack of awareness, and reckless driving contribute to the high number of accidents. In 2022, there were 1,55,622 deaths due to road accidents registered in India.
- Lack of Last-Mile Connectivity: Many villages and communities lack proper road access, making it difficult for people to connect with essential services, markets, and transportation hubs.
- **Road User Behavior:** Non-compliance with traffic rules, including over speeding, improper lane usage, and disregard for pedestrian safety, adds to the challenges of road transport.
- **Road Connectivity in Hilly and Remote Areas:** Establishing road connectivity in hilly terrains, challenging geographical regions, and remote areas with difficult terrain poses unique challenges.
- **Road Infrastructure in Disaster-Prone Areas:** Building and maintaining roads in disaster-prone regions face additional challenges due to the risk of natural calamities such as floods, landslides, and earthquakes.
- **Environmental Impact:** Road transport contributes to air and noise pollution, impacting both human health and the environment.
- **Integration of Transport Modes:** Efficient integration of different modes of transport, such as road, rail, and waterways, is essential for a seamless and multimodal transportation system.
- **Road Maintenance and Upkeep:** Insufficient budget allocations for maintenance, lack of effective maintenance practices, and delayed repairs contribute to the deterioration of road infrastructure.
- **Encroachment and Right-of-Way Issues:** Encroachments along roads and disputes related to right-of-way hinder the smooth functioning of road transport.

#### **OBJECTIVES SPECIFIED BY NITI AAYOG**

- Double the length of national highways by 2022-23.
- Improve regulatory framework to achieve better compliance, road safety and quality.
- Being a signatory to Brasilia Declaration, reduce the number of road accidents by 50% by 2020.

### BHARATMALA PARIYOJANA (2017)

- The Bharatmala Pariyojana, a flagship program for the highways sector initiated by the **Ministry of Road Transport and Highways**, aims to optimize the efficiency of freight and passenger movement in India through various interventions.
- It aims to generate employment opportunities and connect 550 districts across the country through national highway linkages.
- The key features and components of the project include:
  - **Economic Corridors:** Construction and development of around 26,200 km of economic corridors to ensure seamless and speedy travel for heavy freight traffic.
  - **Feeder Routes or Inter Corridors:** Development of 6,000 km of feeder routes or inter corridors to address infrastructure asymmetry and improve connectivity.
  - **National Corridor Efficiency Improvement:** Focus on improving the efficiency of the National Corridor, including the Golden Quadrilateral and North-South and East-West corridors, through the construction of elevated corridors, bypasses, ring roads, lane expansion, and logistics parks.
  - **Border Road and International Connectivity:** Construction of 2,000 km of roads along the international borders to promote trade with neighbouring countries like Myanmar, Bangladesh, Bhutan, and Nepal.





- **Port Connectivity and Coastal Roads:** Development of 2,000 km of roads to connect areas along the shorelines and important ports for better accessibility and trade.
- **Green Field Expressways:** Emphasis on the construction and development of greenfield expressways to enhance traffic management and freight movement.
- **Brownfield Projects:** Upgradation and maintenance of existing road infrastructure to improve connectivity and efficiency.
- **Balance NHDP Works:** Construction and maintenance of approximately 10,000 km of new roads under the National Highways Development Project (NHDP).
- However, the project has faced challenges such as increased land costs and a higher estimated budget, leading to delays in completion.
- The government is exploring additional investments from the market, private sector, foreign debts, and bond markets to meet the budget requirements and ensure the timely execution of the project.

#### PM-GATI SHAKTI (2021)

• On India's 75th Independence Day, Prime Minister Narendra Modi announced the launch of the 'PM Gati Shakti Master Plan', a Rs. 100 lakh-crore project for holistic infrastructure development.

### • Six pillars of the plan:

- 1. **Comprehensiveness**: Centralized portal for all existing and planned initiatives, providing critical data for comprehensive planning and execution.
- 2. **Prioritization**: Cross-sectoral interactions to help different Departments prioritize projects.
- 3. **Optimization**: National Master Plan to identify critical gaps and select the most optimal routes for transportation.
- 4. **Synchronization**: Holistic coordination and synchronization of activities among Ministries and Departments to avoid delays and improve implementation.
- 5. **Analytical**: GIS-based spatial planning and analytical tools with multiple layers for better visibility and monitoring.
- 6. **Dynamic**: Real-time progress monitoring and periodic updates of cross-sectoral projects through satellite imagery.

### **PROJECT PARVATMALA (2022)**

- Project Parvatmala, part of the National Ropeways Development Programme, aims to enhance connectivity in hilly areas using ecologically sustainable ropeway systems. **Here are the key points about the scheme:**
- Basics:
  - It will be implemented through the PPP (Public-Private Partnership) mode.
  - It also offers an environmentally friendly alternative to conventional roads in challenging terrains.
  - Focuses on improving connectivity, convenience for commuters, and promoting tourism.
- **Targeted Areas:** Initial focus on regions like Uttarakhand, Himachal Pradesh, Manipur, Jammu & Kashmir, and other north-eastern states.
- **Nodal Ministry:** Ministry of Road Transport and Highways (MORTH) is responsible for development, construction, research, and policy. MORTH's mandate was expanded in 2021 to include ropeways and alternate mobility solutions.

### • Economic and Fast Transportation:

- Ropeways provide an economical mode of transportation with lower land acquisition costs compared to roadways.
- Faster transportation by following a direct aerial route over hilly terrains.

### **Environmental Benefits:**

- Ropeways produce minimal dust emissions and have design features to prevent environmental pollution.
- o Considered environmentally friendly due to their low impact on the surroundings.

#### • Last Mile Connectivity:

- Ropeway systems, especially those utilizing 3S (a kind of cable car system) or similar technologies, improve lastmile connectivity in hilly areas.
- Can transport a significant number of passengers per hour.

### • Benefits of Ropeways:

- o Ideal for challenging terrains with long rope spans and low space requirements on the ground.
- Reduced construction and maintenance costs compared to traditional transportation modes.
- $\circ$   $\;$  Ability to transport different materials simultaneously.
- Can handle steep slopes and large differences in elevation.

### • Low Footprint:

- Ropeways require narrow-based vertical supports at intervals, leaving the majority of the ground free for other purposes.
- Enables ropeway construction in built-up areas and places with limited land availability.



The implementation of Project Parvatmala is expected to provide sustainable and efficient transportation solutions while addressing the challenges posed by difficult terrains in hilly regions.

### CIVIL AVIATION

Civil Aviation refers to the operation, regulation, and development of aviation activities within the country. Civil Aviation in India is a rapidly growing sector, playing a crucial role in the country's transportation infrastructure and economic development. With a robust network of airports, both domestic and international, and a thriving aviation market, India is a key player in the global aviation industry. Despite the challenges posed by the COVID-19 pandemic, the industry is resilient and focused on future growth and innovation.

#### **DATA-WISE**

- The Indian aviation industry contributes 5% to GDP, provides 4 million jobs, and supports 7 million jobs through tourism.
- In the fiscal year 2020-2021 (FY21), India's passenger traffic stood at 115.37 million.
- In this year, domestic passenger traffic declined by 61.7% and international passenger traffic by 84.8% compared to the previous year.
- India ranks as the 7th largest civil aviation market globally and is projected to become the 3rd largest by 2024.
- **By 2036,** India's total passenger traffic is expected to reach 480 million, surpassing the combined traffic of Japan and Germany.

### CHALLENGES IN CIVIL AVIATION IN INDIA:

- **Infrastructure:** The rapid growth of air travel in India has put pressure on existing infrastructure, including airports, air traffic management systems, and ground handling facilities.
- **Funding and Investment:** Mobilizing adequate funding, attracting private investment, and ensuring sustainable financial models for airport development and expansion remain challenges.
- **Air Traffic Congestion:** With increasing air traffic, congestion at major airports and airspace becomes a concern. This leads to delays, increased fuel consumption, and higher costs.
- **Regulatory Environment:** The regulatory framework in India's civil aviation sector needs continuous refinement to keep up with the evolving industry dynamics.
- **Skill Shortage:** Meeting the growing demand for skilled aviation professionals, such as pilots, air traffic controllers, and maintenance engineers, remains a challenge.
- **Safety and Security:** Ensuring robust safety and security measures is paramount in the aviation sector. Strengthening security protocols, implementing advanced technologies, and enhancing coordination among various stakeholders are ongoing challenges.
- **Regional Connectivity:** Promoting regional connectivity and accessibility to remote areas requires overcoming geographical challenges, developing smaller airports, and addressing logistical constraints.
- **Cost Structure:** Managing operational costs, including fuel prices, taxes, and airport charges, is critical for the financial sustainability of airlines. Balancing cost-effectiveness with quality service provision poses a challenge in the highly competitive market.
- **Environmental Impact:** Aviation's environmental impact, including carbon emissions, noise pollution, and land use, necessitates sustainable practices and mitigation measures. Implementing eco-friendly initiatives and promoting cleaner technologies are vital challenges.
- **Competition and Market Dynamics:** Managing competition, ensuring fair practices, and facilitating a level playing field pose challenges for regulatory authorities.

#### NATIONAL CIVIL AVIATION POLICY, 2016

The National Civil Aviation Policy 2016, released by Minister of Civil Aviation Shri P. Ashok Gajapathi Raju, aimed to make regional air connectivity a reality by focusing on affordability, convenience, and the growth of the civil aviation sector. **The policy covered 22 areas of the Civil Aviation sector and included several key features:** 

- **Regional Connectivity Scheme (RCS):** The scheme aimed to enhance regional connectivity through the revival of airstrips/airports as No-Frills Airports, providing airfare of about Rs 2500 per passenger for a one-hour flight.
- **Route Dispersal Guidelines (RDG):** The policy rationalized Category I routes based on transparent criteria and allocated a percentage of Category I traffic to Category II and IIA routes. It included provisions for revising routes, subject to compliance with the RDG.
- **5/20 Requirement:** The 5/20 requirement, which mandated airlines to have a minimum of five years of operational experience and a fleet of 20 aircraft to commence international operations, was replaced with a scheme that provided a level playing field. Under the new scheme, all airlines could commence international operations by deploying either 20 aircraft or 20% of their total capacity, whichever was higher.





- **Bilateral Traffic Rights:** The policy aimed to establish 'Open Sky' Air Service Agreements (ASA) with SAARC countries and countries located beyond 5000 km from Delhi. It also proposed a method for the allotment of additional capacity entitlements for countries within a 5000 km radius.
- **Ground Handling Policy:** The policy introduced a new framework for ground handling, ensuring the presence of three Ground Handling Agencies (GHA) at major airports. It allowed domestic airlines to carry out self-handling and prohibited the hiring of employees through manpower suppliers or contractors for security reasons.
- **Airport PPP/AAI:** The policy encouraged the development of airports by the Airports Authority of India (AAI), state governments, the private sector, or through public-private partnerships (PPP).
- Aviation Security, Immigration, and Customs: The policy aimed to enhance service delivery modules for aviation security, immigration, customs, and quarantine officers.
- **Helicopters and Charters:** Separate regulations for helicopters were proposed, along with coordination for Helicopter Emergency Medical Services. Airport charges for helicopter operations were also to be rationalized.
- **Maintenance, Repair, and Overhaul (MRO):** The policy focused on promoting the MRO sector by rationalizing customs duty, simplifying clearance procedures, making VAT zero-rated on MRO activities, and providing incentives such as land provisions and exemption from airport royalty for a period of five years.
- Aviation Education and Skill Building: The policy emphasized the importance of skill development and provided support to the Aviation Sector Skill Council and similar organizations/agencies.

### UDAN (UDE DESH KA AAM NAGRIK) SCHEME

- UDAN (Ude Desh Ka Aam Nagrik) is a **regional connectivity scheme launched in 2017** by the Ministry of Civil Aviation in India. Following the four successful rounds of bidding, the Ministry of Civil Aviation has launched the 5th round of the Regional Connectivity Scheme (RCS) Ude Desh Ka Aam Nagrik (UDAN) to further enhance the connectivity to remote and regional areas of the country and achieve last mile connectivity.
- Here are the key features and benefits of UDAN 5.0:
  - **Focus on Category-2 and Category-3 aircraft:** UDAN 5.0 focuses on enhancing connectivity using aircraft with seating capacities ranging from 20 to over 80 seats.
  - **Waiver of stage length cap**: The previous restriction of a maximum stage length of 600 km has been removed, allowing flights to operate without distance limitations between the origin and destination.
  - **Viability Gap Funding (VGF) cap**: The VGF provided to airlines for operating routes will be capped at a stage length of 600 km, both for Priority and Non-Priority areas.
  - **Flexibility in route proposals**: Airlines can submit network and individual route proposals, and there are no predetermined routes offered. This encourages airlines to propose routes based on demand and feasibility.
  - **Route exclusivity and performance criteria**: Routes will not be awarded to a single airline multiple times, and exclusivity will be withdrawn if the average quarterly Passenger Load Factor (PLF) exceeds 75% for four consecutive quarters.
  - **Incentives for operationalization**: Performance Guarantees can be encashed if there are delays in commencing operations, incentivizing airlines to start services within 4 months of route award.
  - **Simplified novation process**: The process for transferring routes from one operator to another has been simplified and incentivized.

### **GOVERNMENT INITIATIVES:**

- **Infrastructure Development:** The government focuses on developing airport infrastructure, including the construction of new airports, expansion of existing airports, and improving air navigation services.
- **Regulatory Reforms:** The government has undertaken regulatory reforms to simplify procedures, enhance ease of doing business, and attract investment in the aviation sector.
- **UDAN Scheme:** The Ude Desh ka Aam Nagrik (UDAN) scheme promotes affordable regional air connectivity by offering financial incentives to airlines and improving airport infrastructure.
- **Regional Connectivity Scheme (RCS):** The government launched RCS to enhance regional connectivity by reviving airstrips/airports as No-Frills Airports and offering affordable airfare.
- **National Civil Aviation Policy:** The government introduced the National Civil Aviation Policy in 2016, aiming to promote tourism, employment, and balanced regional growth. It includes measures to enhance ease of doing business, fiscal support, and infrastructure development.
- **Open Sky Agreements:** The government entered into Open Sky Agreements with SAARC countries and countries beyond 5000 km from Delhi, promoting international air connectivity.
- **Skill Development Initiatives:** The government supports the Aviation Sector Skill Council and similar organizations for skill development and provides budgetary support for the Type Rating of Pilots.
- **Make in India:** The Make in India initiative encourages domestic manufacturing and assembly of aircraft, aircraft components, and maintenance, repair, and overhaul (MRO) facilities.





- **Krishi Udaan:** The government launched the Krishi Udaan scheme in 2019 to boost agricultural exports by providing air transportation for perishable agricultural products from small towns to international markets.
- **Green Initiatives:** The government promotes eco-friendly practices in aviation, including incentives for MRO activities, land allocation for MRO service providers, and VAT zero-rating on MRO activities.
- **Technology Adoption:** The government encourages the adoption of advanced technologies such as air traffic management systems, digital systems for passenger services, and e-governance solutions to improve efficiency and passenger experience.

#### **REFORMS UNDER ATMA-NIRBHAR BHARAT ABHIYAN**

#### • Efficient Airspace Management for Civil Aviation:

- The Indian government plans to ease restrictions on the utilization of airspace to enhance the efficiency of civilian flying.
- The expected benefits include an estimated annual gain of about Rs 1,000 crore for the aviation sector.
- The optimization of airspace will lead to reduced fuel consumption, decreased flight time, and positive environmental impacts.
- Expansion of World-Class Airports through Public-Private Partnership (PPP):
  - Six additional airports have been identified for the second round of bidding for Operation and Maintenance under the PPP model.
  - Private players' investments in the first and second rounds, covering 12 airports, are projected to bring in around Rs. 13,000 crores.
  - Furthermore, six more airports will be put up for bidding in the upcoming third round.
  - India's Global Hub for Aircraft Maintenance, Repair, and Overhaul (MRO):
    - The tax regime for the MRO ecosystem has been rationalized to promote growth.
    - Over the next three years, there is an expected increase in aircraft component repairs and airframe maintenance from Rs. 800 crore to Rs. 2,000 crore.
    - Major engine manufacturers worldwide are anticipated to establish engine repair facilities in India.
    - Additionally, efforts will be made to create a convergence between the defence sector and civil MROs to achieve economies of scale and reduce maintenance costs for airlines.

### SHIPPING AND INLAND WATERWAYS

Shipping and inland waterways play a vital role in India's transportation network, facilitating the movement of goods and passengers. With a vast coastline and extensive river systems, India has significant potential for maritime and inland waterway development. **The Inland Waterways Authority of India (IWAI)** is responsible for regulating and developing these waterways, ensuring navigability for vessels and improving transportation efficiency. Overall, shipping and inland waterways hold immense importance in India's transportation infrastructure.

#### **DATA-WISE**

- Around 90% of India's external trade by volume and 70% by value are handled by ports.
- Inland Water Transport (IWT) is an economical mode for bulk cargo but currently represents only 2% of India's modal mix.
- The government aims to increase its share to 5% by 2030 through the Maritime India Vision (MIV)-2030.
- Cargo traffic through operational national waterways in India was 83.61 MMT in FY 2020-21 and reached 96.31 MMT by Feb 28, 2022.
- The target for cargo movement on National Waterways by 2030 is 200 MMT as per the Maritime India Vision (MIV) 2030.
- India boasts an extensive network of inland waterways that **spans over 20,000 kilometres**, encompassing rivers, canals, and backwaters.
- With **111 Inland Waterways declared as National Waterways** vide National Waterways Act, 2016.

#### **OPERATIONAL NATIONAL WATERWAYS OF INDIA:**

Sr.	National Waterway (NW)		Location (States)				
No.		(km)					
1	NW-1: Ganga-Bhagirathi-Hooghly River System (Haldia -	1620	Uttar Pradesh, Bihar, Jharkhand,				
	Allahabad)		West Bengal				
2	NW-2: Brahmaputra River (Dhubri - Sadiya)		Assam				
3	NW-3: West Coast Canal (Kottapuram - Kollam),	205	Kerala				
	Champakara and Udyogamandal Canals						
4	NW-4: Phase-1 development of the stretch Muktiyala to	82	Andhra Pradesh				





	Vijayawada of river Krishna		
5	NW-10 (Amba River)	45	Maharashtra
6	NW-83 (Rajpuri Creek)	31	Maharashtra
7	NW-85 (Revadanda Creek - Kundalika River System)	31	Maharashtra
8	NW-91 (Shastri river–Jaigad creek system)	52	Maharashtra
9	NW-68: Mandovi - Usgaon Bridge to Arabian Sea	41	Goa
10	NW-111: Zuari - Sanvordem Bridge to Marmugao Port	50	Goa
11	NW-73: Narmada river	226	Gujarat & Maharashtra
12	NW-100: Tapi river	436	Gujarat & Maharashtra
13	NW-97: Sunderbans Waterways (Namkhana to Athara Banki	172	West Bengal (through Indo-
	Khal)		Bangladesh Protocol Route)

### **OBJECTIVES SET BY NITI AAYOG**

- Double the share of freight transported by coastal shipping and inland waterways by 2025.
- Reduce the turnaround time at major ports up to 1-2 days by 2022-23.
- Augment the capacity of inland water transport by increasing the least available depth.

### **BENEFITS OF WATERWAYS TRANSPORT**

- Cost effective: The cost of IWT is nearly 0.25 Rs/km, of rail is 1.5 Rs/km while that of road transport is 2.5 Rs/km.
  Fuel efficient: Inland transport consumes less fuel as compared to rail or roadways. According to the World Bank,
- One litre of fuel moves 105 ton-Km by inland waterways but only 85 ton-Km by rail and 24 ton-Km by road.
- Fewer emissions: CO2 Emissions from container vessels range much lesser than road transport vehicles.
- **Capacity**: It has an enormous capacity to carry bulk cargo, coal etc.
- **Export Promotion:** Lower factor costs will make our exports more competitive.
- Decongestion: It will decongest our choked highways and overburdened railways. There will be fewer accidents also.
- **Navigable:** In India, around 14,500 km of river channels are navigable. But only 2000 km is used.
- Accessibility: Waterways provide access to remote areas and connect inland regions to coastal ports.
- Bulk cargo transportation: Water transport efficiently moves large quantities of bulk commodities.
- **Reliable:** Waterways are less affected by weather disruptions, ensuring consistent transportation.
- Tourism and recreation: Waterways offer opportunities for tourism, boosting local economies.
- **Growth:** The development of waterways will stimulate industrial growth and tourism. It will also promote export and import as it reduces the logistics cost of moving cargo between ports and the hinterland. Fewer accidents and less congestion compared to roads.
- Accessibility: It can provide access to remote areas. For instance, North-eastern states now receive coal, and food grains through inland water transport.

#### **CHALLENGES:**

- **Infrastructure development:** Developing and maintaining waterway infrastructure requires significant investment and ongoing maintenance.
- Limited coverage: Waterways may not be available in all regions, limiting their accessibility and applicability.
- **Seasonal variations:** Water levels and navigability can be affected by seasonal variations, limiting the operational period.
- Intermodal connectivity: Effective intermodal connectivity between waterways, road, and rail networks is crucial for seamless transportation.
- **Regulatory framework:** Regulations and bureaucratic processes related to permits, licenses, and customs can pose challenges to waterways transport.
- **Environmental impact:** Waterways transport may have environmental consequences, such as habitat disruption and pollution if not managed properly.
- **Transhipment port:** Due to the absence of a transhipment port in India a large share of containers in India are currently transhipped through other ports like Colombo, and Singapore.
- **Issues in inland waterways:** The varying depths due to meandering and erosion hinder the processes like unloading, non-mechanised navigation lock systems etc.
- **Competitiveness:** Waterways transport faces competition from other modes of transport, such as road and rail, which may offer greater flexibility and faster delivery.
- Lack of standardized regulations: Harmonization of regulations across different states and regions can be challenging, leading to inconsistencies and complexities in operations.
- **Maintenance and dredging:** Regular maintenance and dredging of waterways are necessary to ensure navigability, but these activities require continuous investment and can be affected by environmental concerns.





- **Limited market integration:** Integrating waterways transport into existing supply chains and logistics networks can be complex, requiring coordination among various stakeholders and systems.
- **Climate change and natural disasters:** Climate change-related factors, such as changing water levels, extreme weather events, and natural disasters, can impact waterways transport operations and infrastructure.

#### ADVANTAGES OF WATERWAYS TO ENVIRONMENT AND SOCIETY:

### • Environmental Benefits:

- **Reduced Carbon Emissions:** Waterway transport is generally more energy-efficient and produces fewer carbon emissions compared to other modes of transportation, such as road or air transport.
- **Congestion and Road Traffic Reduction:** Waterways transport helps alleviate road congestion by providing an alternative means of transporting goods.
- **Wildlife and Habitat Disruption:** Waterway infrastructure development, such as the construction of canals or the deepening of river channels, can disrupt natural habitats and impact wildlife.
- o Invasive Species Spread: Waterways transport can unintentionally facilitate the spread of invasive species.
- **Water Pollution:** Fuel or chemical spills from vessels or improper waste disposal practices can contaminate water bodies, harming aquatic life and affecting water quality.
- **Noise and Air Pollution:** While waterway transport generally has lower emissions compared to other modes, vessels can still contribute to localized noise and air pollution in port areas or along heavily trafficked waterways.
- **Habitat Fragmentation:** Waterway infrastructure, such as dams and locks, can fragment river systems and disrupt the natural flow of water.
- Socio-Economic Benefits:
  - **Economic Growth:** Waterways play a vital role in facilitating trade and commerce. It provides a cost-effective means of transporting goods, particularly bulk or heavy cargo.
  - **Employment Opportunities:** Waterways transport creates job opportunities in various sectors. It involves shipbuilding, port operations, logistics, and maintenance, providing employment for a diverse range of skilled and unskilled workers.
  - **Regional Development:** Waterways transport can stimulate regional development by connecting inland areas to coastal regions and international markets.
  - **Transportation Efficiency:** Waterways transport offers an efficient mode of transportation, particularly for large quantities of cargo.
  - **Accessibility and Connectivity:** It provides a reliable transportation option for remote communities, facilitating access to goods, services, and healthcare.
  - **Tourism and Recreation:** River cruises, boating, fishing, and water sports attract tourists and provide leisure opportunities for local communities and tourists.
  - **Cultural Heritage and Identity:** They have shaped human civilizations, served as trade routes, and influenced cultural practices. Waterways often represent a sense of identity and heritage for communities, fostering pride and promoting cultural tourism.

#### **EFFORTS TAKEN BY THE GOVERNMENT:**

The Inland Waterways Authority of India Act, 1985	<ul> <li>The Act provides for the establishment of an authority for the regulation and development of inland waterways for shipping and navigation and matters related to it.</li> <li>Accordingly, The Inland Waterways Authority of India (IWAI) was formed in 1986.</li> <li>It undertakes projects for the development and maintenance of IWT infrastructure on national waterways via a grant received from the Ministry of Shipping.</li> </ul>
Indian Vessels Act of 1917 (Amended in 2007)	• It deals with the survey and registration of inland vessels, removal of obstructions in navigation, carriage of goods and passengers, prevention and control of pollution etc.
Inland Water Transport Policy 2001	<ul> <li>Policy talks about IWT being the economical, fuel-efficient and environment-friendly mode of transport.</li> <li>It recommends large-scale participation of the private sector both for the creation of infrastructure and for fleet operations.</li> </ul>
National Waterways Act 2016	<ul> <li>The Act declared 111 rivers or river stretches, creeks, estuaries as National (inland) Waterways.</li> <li>It allows the Central Government to regulate these waterways for development with respect to shipping, navigation, and transport by means of mechanically propelled vessels.</li> </ul>
Jal Marg Vikas Project (JMVP) (2015)	• It seeks to improve the navigational capacity of National Waterway-1 (NW-1). The project is being implemented by the Government of India with technical assistance and





	investment assistance of the World Bank.
Sagarmala Project (2015)	<ul> <li>The Sagarmala program focuses on modernizing and developing ports, improving port connectivity, promoting port-led industrialization, and supporting coastal communities.</li> <li>It aims to reduce logistics costs for domestic and international trade and increase the share of water transportation in the overall modal mix.</li> <li>It seeks to minimize the logistics costs by increasing the share of domestic waterways in the modal mix from the current 6%.</li> </ul>
Central Road and Infrastructure Fund (CRIF)	<ul> <li>It is a dedicated fund established by the Ministry of Finance in India.</li> <li>The fund was amended in 2019 to include inland waterways as one of the infrastructure sub-sectors eligible for funding.</li> <li>This allows the utilization of the fund for the development and maintenance of inland waterway infrastructure.</li> </ul>
Action plan for 26 National Waterways	<ul> <li>To promote Inland Water Transport (IWT) in India, 111 waterways, including previously notified National Waterways, have been declared under the National Waterways Act, 2016.</li> <li>Feasibility studies have been conducted for 26 waterways, and development initiatives are underway for 18 of them.</li> <li>These efforts aim to enhance navigability, improve connectivity, and facilitate efficient cargo and passenger transportation on the waterways.</li> </ul>

### MARITIME INDIA VISION (MIV) 2030:

- Maritime India Vision 2030 (MIV 2030) is a blueprint formulated by the Ministry of Ports, Shipping, and Waterways to propel India to the forefront of the global maritime sector.
- It aims to ensure coordinated and accelerated growth of India's maritime sector in the next decade.
- MIV 2030 has been developed through consultations with over 350 public and private sector stakeholders, including ports, shipyards, inland waterways, trade bodies, and industry experts.

### • Indian Maritime Sector Highlights:

- India has 12 major ports and over 200 non-major ports along its 7500 km coastline, playing a crucial role in trade and growth.
- o 95% of the country's trade volume and 65% of the trade value are undertaken through maritime transport.
- Inland water transport has witnessed significant growth, with a modal share of cargo increasing from 0.5% to 2% in the last five years.
- o India ranks 2nd globally in ship recycling and 21st in shipbuilding.
- The country is among the top 5 countries supplying trained manpower for the maritime industry.

### • Key Guiding Principles of MIV 2030:

- Analyze current and future challenges to define initiatives.
- Drive innovation by utilizing the latest technology.
- Create a time-bound action plan.
- Benchmark and adopt best-in-class practices.
- Address capability building and human resources.
- Explore ideas to achieve "Waste to Wealth."

### • Key Themes of MIV 2030:

- Develop best-in-class port infrastructure.
- o Drive end-to-end logistics efficiency and cost competitiveness.
- Enhance logistics efficiency through technology and innovation.
- Strengthen policy and institutional framework to support all stakeholders.
- Enhance India's global share in shipbuilding, repair, and recycling.
- Enhance cargo and passenger movement through inland waterways.
- Promote ocean, coastal, and river cruise sectors.
- Enhance India's global stature and maritime cooperation.
- Lead the world in safe, sustainable, and green maritime practices.
- Become a top seafaring nation with world-class education, research, and training.
- These themes encompass a wide range of initiatives and interventions to develop the Indian maritime sector and ensure its sustainable growth, including infrastructure development, technological advancements, policy reforms, capacity building, environmental sustainability, and international collaboration.

#### WAY FORWARD:

• **Promote Awareness and Demand:** Create awareness among businesses and consumers about the benefits of water transportation, such as cost-effectiveness, reduced congestion, and environmental advantages.







- **Integration with Multimodal Transport:** Enhance coordination and integration between different modes of transport, such as road, rail, and air, to facilitate seamless movement of goods and passengers.
- **Infrastructure Development:** Invest in the development of ports, inland waterways, and related infrastructure to improve connectivity and accessibility. This includes modernizing existing ports, constructing new ports, and expanding the network of inland waterways.
- **Skill Development:** Focus on skill development and training programs for the workforce involved in water transportation. This includes training seafarers, port workers, and other personnel to meet international standards and enhance the quality of services in the sector.
- **Public-Private Partnerships:** Foster collaborations between the government and private sector to leverage expertise, resources, and investments.
- **Environmental Sustainability:** Encourage the use of cleaner fuels, implement waste management systems, and adopt eco-friendly technologies to ensure sustainable operations.
- **International Collaboration:** Strengthen collaborations with international organizations, neighbouring countries, and global stakeholders to share best practices, exchange knowledge, and enhance cross-border connectivity and trade.
- **Monitoring and Evaluation:** Establish a robust monitoring and evaluation framework to track the progress and impact of initiatives undertaken in the water transportation sector.

Digital Solutions For Ease-Of-Doing Business			
CAR-D (Cargo Data) Portal:	<ul> <li>Web-based portal: CAR-D is an online portal accessible to stakeholders involved in cargo and cruise movement on National Waterways.</li> <li>Data collection and compilation: The portal enables the collection, compilation, and analysis of cargo and cruise movement data, providing valuable insights to stakeholders.</li> </ul>		
PANI (Portal for Asset & Navigation Information):	<ul> <li>Integrated solution: PANI serves as an integrated platform that brings together river navigation and infrastructure information in a single interface.</li> <li>Detailed information: The portal provides detailed information about various features of National Waterways, including fairways, infrastructure facilities, cross-river structures, connectivity at jetties, and emergency services.</li> <li>Facilitates transportation of cargo: PANI's comprehensive information helps in planning and executing cargo transportation by providing necessary details about the assets and resources available along the waterways.</li> </ul>		

### INTERLINKING OF RIVERS

- The concept of interlinking rivers in India has been proposed for several decades, with the aim of better utilizing the country's water resources and reducing the adverse impacts of water scarcity and floods.
- The project envisions the interconnection of major rivers, such as the Ganges, Brahmaputra, Godavari, Krishna, Mahanadi, and others, through a complex network of canals and reservoirs.
- The concept of interlinking rivers was initially proposed by **Sir Arthur Cotton, the Chief Engineer of the Madras Presidency, in 1919.**
- In 1960, KL Rao, the Minister of State for Energy and Irrigation, revived the idea and proposed linking the Ganga and Cauvery rivers.
- To facilitate the implementation of interlinking river projects, **the National Water Development Agency was established in 1982** during the tenure of Prime Minister Indira Gandhi.
- **The Cabinet approved the Ken-Betwa River Linking Project in 2014.** However, the project has faced opposition from environmentalists, which has prevented its implementation thus far.

### **NEED FOR INTERLINKING OF RIVERS:**

- The concept of interlinking rivers in India aims to address the challenge of drought in some regions and recurring floods in others.
- While the Indo-Gangetic rivers benefit from consistent water sources such as rainfall and Himalayan glaciers, the peninsular rivers rely mainly on the southwest monsoons, resulting in seasonal water availability.
- As a result, the Indo-Gangetic plains face floods, while the peninsular states experience droughts.
- By redirecting excess water from flood-prone areas to drought-prone regions, interlinking rivers have the potential to significantly mitigate the problems of floods and droughts.
- This approach seeks to achieve a more balanced and fair distribution of river waters, promoting greater equity in water resources across India.

# THE NATIONAL RIVER LINKING PROJECT (NRLP):



- BY PHYSICS WALLA
- The National River Linking Project (NRLP) is an ambitious project aimed at addressing water scarcity and flooding issues in India by interlinking 37 rivers through a network of approximately 3000 storage dams. This interlinking would create a vast South Asian water grid.
- National Water Development Agency (NWDA) is the nodal agency of the project.
- The linking of **Godavari and Krishna** was completed in 2015. The next project being taken up is the **Ken-Betwa link**.
- The project consists of two main components: the Himalayan Component and the Peninsular Component.

### • The Himalayan Component:

- The Himalayan Component focuses on the rivers originating from the Himalayas and includes 14 proposed projects.
- It involves the construction of storage dams on the Ganga and Brahmaputra rivers, along with their tributaries.
- Additionally, it proposes linking the Ganga and Yamuna rivers. This component aims to control flooding in the Ganga-Brahmaputra river system and provide water to drought-prone regions in Rajasthan, Haryana, and Gujarat.
- It is further divided into two sub-components: connecting the Ganga and Brahmaputra basins to the Mahanadi basin and connecting the eastern tributaries of the Ganga to the Sabarmati and Chambal river systems.

### • The Peninsular Component:

- The Peninsular Component of NRLP focuses on interlinking the rivers in southern India. It involves transferring surplus water from the Mahanadi and Godavari rivers to the Krishna, Cauvery, Pennar, and Vaigai rivers.
- This component encompasses four sub-component linkages:
  - 1. Connecting the Mahanadi and Godavari river basins to the Cauvery, Krishna, and Vaigai river systems;
  - 2. Linking the Ken and Betwa rivers, as well as the Parbati and Kalisindh rivers to the Chambal river;
  - 3. Connecting west-flowing rivers south of Tapi to those north of Bombay; and
  - 4. Interlinking certain west-flowing rivers with east-flowing rivers.
- The NRLP aims to address the challenges of water scarcity and flooding through the transfer of water from waterabundant basins to water-deficient basins, promoting better water resource management and meeting the increasing water demands of various regions in India.

### **BENEFITS:**

- **Equitable Water Distribution:** Interlinking rivers ensure fair sharing of water resources between regions, addressing water scarcity and promoting sustainable water use.
- **Drought Mitigation:** By transferring water from water-abundant areas, interlinking rivers help combat droughts, supporting agriculture and livelihoods in water-deficient regions.
- **Flood Control:** Interlinking rivers regulates water flow, reducing the risk of floods and minimizing damage to lives, property, and infrastructure.
- **Irrigation and Agriculture:** River interlinking enhances irrigation capabilities, expanding cultivable areas and boosting agricultural productivity.
- **Hydropower Generation:** Interconnected rivers provide opportunities for clean energy production through hydropower, contributing to the country's energy needs.
- **Socio-economic Development:** Access to water resources drives economic growth, job creation, and improved living standards in connected regions.
- **Environmental Conservation:** River interlinking projects incorporate ecosystem restoration efforts, promoting biodiversity preservation and sustainable water management.
- **Logistics cost:** This project would enhance the infrastructure for logistics and movement of freight and decrease logistics costs.
- **Clean transport mode:** The development of a cleaner, low-carbon mode of transport would help in decreasing carbon footprints and would facilitate cheaper modes of transportation.

### **CRITICISM:**

- **Ecological Impact:** Interlinking rivers can harm ecosystems and leads to loss of habitat and biodiversity.
- Cost and Financial Burden: Projects require significant investments and can become expensive.
- **Displacement of Communities:** Construction can lead to the displacement of local communities.
- Interstate Water Disputes: Projects can trigger conflicts over water-sharing among states.
- **Environmental Consequences:** Altered river courses can have unintended environmental impacts, including changes in groundwater levels, soil salinity, and the degradation of downstream ecosystems.
- **Climate Change Adaptation:** Projects may not effectively address long-term climate challenges such as shifting rainfall patterns.
- Alternative Solutions: Some argue for decentralized and sustainable water management practices like rainwater harvesting, and watershed management.
- **Poor EIA**: In-depth analysis of the socio-economic and ecological impacts of this project is lacking.





#### DEVELOPMENT OF PIPELINE TRANSPORT

Pipelines are the most convenient, efficient and economical mode of transporting petroleum, petroleum products, natural gas, water, milk etc. Solids can also be transported through pipelines after converting them into a slurry. Pipelines have relieved increasing pressure on the existing surface transport system.

#### **ADVANTAGES:**

- **Suitable mode:** They are the most convenient mode of transporting liquids and gases. Transit losses are minimal through pipelines.
- **Easy to lay:** Pipelines are easy to place in difficult terrains and even under water. Even they are not affected by seasonal variations like floods, snowfall, cyclones etc.
- Low maintenance: Pipelines require very low energy and little maintenance.
- **Environment friendly:** Pipelines are safe, accident-free and environment-friendly.
- Cheap Transport: Transportation cost is very low compared to other modes of transportation.
- **Industrial development:** It brings industries in nearby regions e.g. Establishment of fertilizer industries near gas pipelines (Jagdishpur, Sawai Madhopur).

#### **DISADVANTAGES:**

- Lack of flexibility: Pipelines can't be laid everywhere, they can be utilised for a few destinations.
- **Capacity:** Its capacity is fixed and cannot be increased.
- Initial cost: Initial cost is very high and hence requires high capital investment.
- **Security:** They are vulnerable to attacks from non-state actors. E.g. Destruction of the international TAPI pipeline by terrorist groups.
- **Repair:** Underground pipelines are difficult to repair and leakage detection is very difficult.

### SOME IMPORTANT PIPELINES IN INDIA

- Naharkatia-Nunmati-Barauni Pipeline.
- Mumbai High-Mumbai-Ankleshwar-Koyali Pipeline.
- Salaya-Koyali-Mathura Pipeline.
- Hajira-Bijapur-Jagdishpur Gas Pipeline.

### **REGIONAL DEVELOPMENT:**

- Pipelines are an important agent of attracting petrochemical and fertilizer industries in the vicinity. Dispersal of pipelines has helped in regional development by establishing industries and through employment generation.
- E.g. Development of the HBJ gas pipeline has fostered the construction of power plants (Kawas, Gj; Auraiya, UP) and fertilizer industries(Sawai Madhopur, RJ, jagdishpur, UP)along the route.
- Development of petrochemical complexes in Mathura, Barauni region was a result of pipeline penetration in this region.
- It provides a boost to other ancillary industries and service providers for the pipeline maintenance.

#### WAY FORWARD:

- India which aspires to be an economic superpower is visibly in need of a transport policy that is in tune with the times.
- Policy would be based on two prominent parameters:
  - 1. Assessing the transport requirements for the next two decades.
  - 2. Assessing the investment requirements of the sector.
- Future development in the transport sector would be based on increasing the share of public transport, utilisation of clean fuels like electricity, CNG gas, Bullet trains and cheaper aviation fares etc.
- Enhancing budgetary allocation and attracting private investment through PPP mode would decide the fate of the sector.

The development of pipeline transport in India presents opportunities for efficient resource transportation, reduced dependency, and environmental benefits. However, addressing infrastructure limitations, safety concerns, and social-environmental impacts is crucial to progress. Strategic planning, technological advancements, stakeholder collaboration, and sustainable practices are essential for achieving energy security and inclusive development.

### PREVIOUS YEAR QUESTION (MAINS)

- 1. How is efficient and affordable urban mass transport key to the rapid economic development of India? (2020)
- 2. The interlinking of rivers can provide viable solutions to the multi-dimensional inter-related problems of droughts, floods, and interrupting navigation. Critically examine. (2020)





# **12.GEOGRAPHICAL PERSPECTIVE TO DISASTERS IN INDIA**

- The **DM Act 2005** uses definition for disaster: "Disaster" means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area."
- According to the National Disaster Management Authority, due to its vulnerability to different kinds of disasters, it is said that India is a disaster prone country, the reasons are:,
  - $\circ~~$  ~85% of land vulnerable to single or multiple disasters
  - $\circ~~$  ~59% of the land area is vulnerable to earthquakes,
  - $\circ$  ~12% is flood-prone,
  - $\circ$  ~8% is vulnerable to cyclones and
  - $\circ~~\sim 70\%$  of the land under cultivation is drought prone
  - $\circ$  ~57% of the area lies in high seismic zones

#### **FACT-WISE**

- According to a report produced by Delhi-based non-profit **Centre for Science and Environment (CSE)**, India saw harsh weather conditions on 241 of the 273 days between January 1 and September 30, 2022. Heatwaves, cold waves, cyclones, lightning, torrential rain, floods, and landslides are a few of them.
- According to a new analysis, Madhya Pradesh was the worst hit, with one occurrence occurring every other day.

### HAZARD VIZ-A-VIZ DISASTER

	Hazard		Disaster
٠	A hazard is a dangerous physical condition or event	•	According to the United Nations, a disaster is the
	that occurs in proximity.		occurrence of a sudden or large calamity that affects
	<ul> <li>Small number of people are affected.</li> </ul>		the essential makeup and regular operations of a
	• It may cause injury, loss of life or damage to		society (or community).
	property.	•	Classification:
•	Classification:		• Tectonic occurrence (earthquakes, volcanoes)
	• <b>Natural Hazard</b> : Every year, natural hazards and		• Meteorological (hurricanes, cyclones, tornadoes,
	risks such as earthquakes, cyclones, floods, and		floods, droughts)
	drought affect India.the loss of mangroves.		• Topographical occurrence (landslides. avalanches)
	• Man Made Hazard: Explosions; release of		• Infestic (locust invasion of crops, epidemics), and
	hazardous waste; Dam failures; Air, water, and land		• Human (industrial accidents, nuclear bombs).
	nollution: terrorism civil unrest and war		

#### **CLASSIFICATION OF DISASTER**

Atmospheric	• Blizzards, Thunderstorms, Lightning, Tornadoes, Tropical Cyclone, Drought, Hailstorm,
	Frost, Heat Wave or Loo, Cold Waves, etc.
Terrestrial	• Earthquakes, Volcanic Eruptions Landslides, Avalanches, Subsidence, Soil Erosion.
Hydrological	Floods, Tidal Waves, Ocean Currents, Storm Surge, Tsunami
Biological	• Plants and Animals as colonisers (Locusts, etc.). Insect infestation— fungal, bacterial and
	viral diseases such as bird flu, dengue, etc.

#### EARTHQUAKE

**According to NDMA**, An earthquake is a phenomenon that occurs without warning and involves violent shaking of the ground and everything over it. It results from the release of accumulated stress of the moving lithospheric or crustal plates. In the Indian context, the Movement of the Indian plate is being constantly obstructed by the Eurasian plate resulting in excessive accumulation of energy that ultimately leads to the sudden release of energy causing earthquakes along the Himalayan arch.

#### **FACT-WISE**

- **Indian Share in Globe**: According to the seismic data, there were almost 1,300 earthquakes with a magnitude of five in the past year, with 40 of them occurring in India alone.
- **2022**: The average disaster-like earthquake occurrence was higher than the past two decades' average.
- Indian Case: About 60% of India's landmass, including all of its states, is vulnerable to earthquakes of various shaking





#### intensities.

- According to government statistics, up to 59% of India's land area is vulnerable to earthquakes of various intensities.
- Nearly 11% of the nation is in Zone V, followed by 18% in Zone IV, 30% in Zone III, and the remainder in Zone II.

#### India and Earthquake:

- During the last 15 years, the country has experienced 10 major earthquakes that have resulted in over 20,000 deaths.
- The entire Himalayan belt is susceptible to great earthquakes of magnitude more than 8.0. The main cause of earthquakes in these regions is due to the movement of the Indian plate towards the Eurasian plate at the rate of about 50 mm per year.
- Besides the Himalayan region and the Indo-Gangetic plains, even the peninsular India is prone to damaging earthquakes as clearly illustrated by the Koyna (1967), Latur (1993), and Jabalpur (1997) earthquakes.
- **Koyna earthquake**: The Koyna earthquake was human-made and was caused by the huge Koyna dam completed in 1962. Such an earthquake can occur through the process of Reservoir Induced Seismicity (RIS)

#### **Earthquake-Prone Areas:**

- The **Bureau of Indian Standards** has classified regions in India into four seismic zones on the basis of historical seismic activity. These are zones II, III, IV and V. Among these, Zone V is the most seismically active region and Zone II is the least active.
  - Zone V: Entire North-eastern India, parts of Jammu and Kashmir and Himachal Pradesh, Uttaranchal, Rann-of Kutch in Gujarat, parts of North Bihar and Andaman & Nicobar Islands.
  - Zone-IV: Remaining parts of Jammu and Kashmir and Himachal Pradesh. Delhi-NCR region, 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: Goa, Kerala, Lakshadweep, remaining parts of Uttar Pradesh, Gujarat and West Bengal, parts of Punjab, Rajasthan, Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh, Maharashtra, Orissa, Andhra Pradesh, Tamilnadu and Karnataka.
- The remaining portion of the country falls under zone II.

#### THE SEISMOLOGY AND GEOSCIENCE RESEARCH (SAGE)

- The Seismology and Geoscience Research (SAGE) is a research initiative focused on advancing the field of seismology and geoscience. The project aims to enhance our understanding of Earth's structure, seismic activity, and geological processes through scientific research and technological advancements.
- SAGE involves the study of seismic waves, earthquakes, and their impacts on the Earth's surface. It encompasses research on the causes and mechanisms of earthquakes, the monitoring and analysis of seismic data, and the development of predictive models for earthquake occurrence and hazards.

#### Reason for Earthquake proneness of India:

- **Moving Indian Plate**: The Indian plate is pushing into Eurasia at a pace of about 47 mm/year, which is the main cause of the earthquakes' high frequency and intensity.
- **Himalayan belt**: Collision of the Java-Sumatra-Java plate with the Indo-Austral plate, the Eurasian plate, and the Burmese plate. The energy of the underlying rocks is greatly strained by this contact, and some of that energy is released as earthquakes.
- **The Andaman and Nicobar Islands**: It have undersea volcanoes and seafloor displacement that affect the equilibrium of the earth's surface.
- **Deccan Plateau**: Some geologists have proposed a theory regarding the formation of a fault line and the buildup of energy along the river Bhima (Krishna) fault line near Latur and Osmanabad (Maharashtra).
- **Other Reasons:** India is becoming more populous and using improper methods to utilise land for construction.

#### Impact of Earthquake

• **Human loss**: About 563 earthquakes, including related tsunamis, accounted for 56% of the total deaths or 747,234 lives lost between 1998 to 2017.





- **Structural Damage**: According to the World Bank 10% of damage occurs to infrastructure due to earthquakes.
- **Surface Rupture & Ground Displacement**: Caused by vertical or horizontal movement on either side of a ruptured fault.
- **Economic impact**: The total loss of public and private property was estimated at 4.97 billion USD according to the World Bank and the percentage loss in terms of GDP was 1% of India's GDP of India.
- **Changes in river courses**: Sometimes river channels are blocked or their courses are changed due to the impact of the earthquake. eg. Brahmaputra river, Indus River.
- Landslides: Earthquakes can trigger landslides and mudslides, especially in areas with water-soaked soils.e.g. Malin landslide, Maharashtra, Kedarnath landslide, Uttarakhand.
- Liquefaction: The shaking from an earthquake can turn loose soil into a liquid during an earthquake.
- **Tsunamis**: Large tsunamis which travel from the ocean floor to the surface are dangerous to human health, property, and infrastructure. e.g. 2004 Indian Ocean earthquake and tsunami.
- Fires: Earthquake fires start when electrical and gas lines are dislodged due to the earth's shaking.

### Earthquake Swarm:

- An Earthquake swarm is a sequence of mostly small earthquakes with no identifiable main shock. It is a series of lowmagnitude earthquakes that occur in a localised region over a period of time.
- Swarms can last weeks and produce many thousands of earthquakes within a relatively small volume.
- The Palghar district in northern Maharashtra has been witnessing unusual tremors as an 'earthquake swarm'
- Similarly **earthquake swarms were recorded in the Rampur area of Himachal Pradesh**. This Himalayan swarm was later attributed to the low strength of the earth's crust in the area which could not hold the tectonic energy.

### **Characteristics of the Earthquake Swarms**

- **Localized region**: An earthquake swarm' is a series of low-magnitude earthquakes that occur in a localized region and over a period of time ranging from days, weeks to even months.
- **Released in Small amounts**: When seismic energy piles up inside the Earth and is released in small amounts from certain points, such a series of earthquakes can occur.
- **No specific rule**: The earthquake swarms occur at rates and with magnitudes that don't obey any of the "rules" that aftershock sequences follow.
  - Sometimes, these rumblings of the Earth are also accompanied by acoustic or sound emissions.
- Different Nature:
  - At volcanoes that are active and getting ready to erupt, swarms can be a sign of magma moving in the subsurface.
  - However, not all swarms are associated with fluids and volcanoes, tectonic forces can also trigger swarms.
  - **For example**, in India, a Geological Survey of India (GSI) report held that the Deccan Plateau region experiences earthquake swarms, owing to tectonic activity.
- **As Foreshocks**: They can come as foreshocks to the main earthquake which could be much greater in magnitude.
- **Swarms vis a vis Aftershocks**: While many swarms are connected to geothermal activity, aftershocks are a result of the fault's "readjustment process" following the main slip, according to the USGS.
  - Similar to swarms, aftershocks can persist for days or even years following the original earthquake, albeit their magnitude gradually decreases.

	Foreshocks		Aftershocks
•	Foreshocks are earthquakes that precede larger earthquakes in the same location. An earthquake cannot be identified as a foreshock until after a larger earthquake in the same area occurs.	•	When an earthquake occurs, the state of stress around the earthquake dramatically changes. The Earth wants to get back to some type of equilibrium. Aftershocks become less frequent with time, although they can continue for days, weeks, months, or even years
			for a very large main shock.

### Way Forward:

- **Building codes:** Re-framing buildings' codes, guidelines, manuals and byelaws and their strict implementation. Example: National Building Code of 2005.
- **Public utilities**: Making all public utilities like water supply systems, communication networks, electricity lines etc. earthquake-proof.
- **Research and development**: Supporting R&D in various aspects of disaster mitigation, preparedness and prevention and post-disaster management.
- **Retrofitting**: The NDMA released guidelines on "seismic retrofitting" along with specialists from several IITs and the necessary ministries. Example: Under the Home Ministry, the National Retrofitting Programme was introduced in 2014.





- **Education**: Evolving educational curricula in architecture and engineering institutions and technical training in polytechnics and schools to include disaster-related topics.
- **Community participation**: Getting communities involved in the process of disaster mitigation through education and awareness. Networking of local NGOs working in the area of disaster management.
- **Holistic Approach**: The Sendai Framework for Disaster Risk Reduction is a fairly all-encompassing approach to catastrophe management.
- **Proper Preparedness**: In seismic zones with a very high risk of earthquakes, a specific department for earthquake management must be established.

#### **Mobile Apps Under National Retrofitting Programme**

- 'India Quake': The mobile app, which was created by the National Centre for Seismology, disseminates information about earthquakes in real-time.
- 'Sagar Vani': A smartphone app that distributes ocean-related information and alerts to the user community with the intention of serving coastal areas.

#### **Conclusion:**

• "It is not the disaster, but the lack of preparedness for the disaster that kills". The solution to minimising the loss of lives and properties is the effective preparedness against the earthquake. Thus, disaster preparedness is one of the most vital components in disaster management. People's participation, cooperation and awareness among all stakeholders will help to reduce the disaster.

#### CYCLONES

According to NDMA, Cyclones are caused by atmospheric disturbances around a low-pressure area distinguished by swift and often destructive air circulation. Cyclones are usually accompanied by violent storms and bad weather. The major natural disaster that affects the coastal regions of India is cyclones and as India has a coastline of **about 7516 km**, it is exposed to **nearly 10 per cent of the world's tropical cyclones**. Tropical cyclones are intense low-pressure areas confined to the area lying **between 30° N and 30° S latitudes**, in the atmosphere around which high-velocity winds blow.

#### **FACT-WISE**

- The subcontinent, which has an **8041-kilometer-long coastline**, is **subject to around 10% of the tropical cyclones that occur worldwide**.
- There are around **four times** as many cyclones in the Bay of Bengal as in the Arabian Sea.

Occurrence of	• In India, most of the cyclones occur in the post-monsoon season, i.e. from October to
cyclones	December or in the pre-monsoon season from April to May.
	• The lifespan of a cyclone is generally from 7 to 14 days.
	• Large sea surface with a temperature higher than 27° C.
Initial conditions for	• A pre-existing weak low-pressure area or low-level-cyclonic circulation.
the emergence of a	• Presence of the Coriolis force enough to create a cyclonic vortex.
tropical cyclone	• Small variations in the vertical wind speed.
	Upper divergence above the sea level system.
	• About 71 per cent of this area is in ten states (Gujarat, Maharashtra, Goa, Karnataka, Kerala,
Location	Tamil Nadu, Puducherry, Andhra Pradesh, Orissa and West Bengal).
	• On an average, about five or six tropical cyclones form in the Bay of Bengal and Arabian Sea
	and hit the coast every year. Out of these, two or three are severe.
	• The southwest monsoon is characterised by the presence of strong westerly winds in the
	lower troposphere (below 5 km) and very strong easterly winds in the upper troposphere.
	This prevents the upward movement of air.
Why very few tropical	• Also the potential zone for the development of cyclones shifts to the North Bay of Bengal
cyclones during	during the southwest monsoon season.
southwest monsoon	• During this rainy season, the low-pressure system up to the intensity of depressions form
season?	along the monsoon trough, which extends from northwest India to the north Bay of Bengal.
	• The depression forming over this area crosses the Orissa-West Bengal coast in a day or two.
	These systems have shorter oceanic stay which is also one of the reasons for their non-
	intensification into intense cyclones.
Why fewer cyclones	• The Arabian Sea is colder than the Bay of Bengal, hence the tropical cyclone generated is
over the Arabian Sea	weak and many fade away before reaching the characteristic level.
compared to the Bay	• The Arabian Sea is more enclosed compared to the Bay of Bengal which is extensively


#### PRAHAAR ReDEFINED 3.0: GEOGRAPHY & DM

Of Bengal?	connected to the north pacific.
	• For tropical cyclones a wide sea area with warm water is necessary to provide sufficient
	condensation force. The frequency of typhoons observed in the north pacific shows its
	influence on the Bay of Bengal and more cyclones are found here.
	• Location of the Arabian Sea: Tropical cyclones normally move from east to west. Bay of
	Bengal has a wide area but the Arabian Sea has geographical constraints.
	• However recently, The Arabian Sea is one of the fastest-warming basins across the global
	oceans. One of the reasons for cyclones in the Arabian Sea is because of ocean warming,
	rapid ocean warming.

#### Impact of cyclones:

- **Human loss**: Cyclones, which are responsible for much loss of life, damage to property and deterioration of day-to-day life.
- **Economic impact**: Impacts of cyclones cause direct economic losses such as loss in asset value, and reduction in investments which is a socioeconomic impact of a disaster.
- **Food scarcity**: Food scarcity is the main impact of cyclones as they lose their agricultural supplies.
- **Livelihood**: Cyclones mostly affect coastal districts. Several people in coastal villages who depended only on fishing had lost access to food and clean drinking water as fishing was prohibited.
- **Structural damage**: Damage to infrastructures such as roads, bridges, and revetment results in loss to both the public and the Government.



- **Floods**: Cyclones may result in heavy rainfall and floods which is the next devastation to the environment. Floods caused by the cyclone can cause waterlogging in unwanted places which causes many diseases.
- **Agricultural damage**: Devastation of crops may result in reduced income for farmers, increased prices for food, unemployment, and increased crimes which in turn human populations are at higher level of risk.
- Sea level: Abnormal rise in sea level caused by cyclones is known as storm surge.
- **Inequality**: The impact of a natural disaster may also cause inequalities. The poor, who suffer from income fluctuations, and also have limited access to financial services, in the aftermath of a disaster, may be more prone to scarcity.

#### Way Forward:

- **Construction of cyclone shelter:** For multi-purpose use such as school buildings, community centres, or any other public utility buildings.
- **Construction of canals and embankments for improved drainage:** Besides improvement to minor drains in the coastal areas a canal network in the coast is an effective tool of water management.
- **Shelterbelt plantation:** Shelterbelts are barriers of trees that are planted to reduce wind velocities and prevent wind erosion to protect human habitations and agricultural crops.
- **Construction of missing road links:** It helps in ensuring speedy evacuation of people from vulnerable places to safer areas in the face of an impending disaster threat.
- **Capacity building :** While the hazards due to tropical cyclones cannot be reduced, mitigation strategies to reduce their impacts can be devised.
- **Improvement of on-shore warning system:** Early reliable warning is one of the important short-term mitigation measures that can reduce the severity of the cyclone-related disasters if acted upon timely.
- **Retrofitting of vital installations:** Roads/culverts/bridges in the cyclone-prone areas need to be maintained well.
- Awareness generation for cyclone risk mitigation: The public awareness programme with community involvement is an important component of disaster risk management.
- **Approach:** Thus a multi-pronged approach is needed to mitigate the risk of tropical cyclones, which shall be certainly helpful for minimal loss of life and resources.

#### **Conclusion:**

• Tropical cyclones are natural phenomena which India faces frequently. With the advent of climate change, tropical cyclones are developing more frequently and accompanied by increased intensity. Regardless of state support and administrative help, people themselves have to step up to create local solutions using their own practices. People's participation, cooperation and awareness among all stakeholders will help to reduce the disaster.





#### DROUGHT

The **India Meteorological Department (IMD)** defines drought in any area when the rainfall deficiency in that area is  $\geq 26\%$  of its long-term normal. According to the **Union Agriculture and Cooperation Ministry's** Drought Crisis Management Plan document 68 per cent of the country is prone to drought with nearly 33 per cent area having a chronic drought problem while another 35 per cent is drought-prone.

#### FACT-WISE

- According to the **Drought in Numbers Report**, **2022**, India is one of the nations that has been most severely hit by the drought. Between 2020 and 2022, approximately two-thirds of the nation experienced drought.
  - The report also noted that between 1998 and 2017, severe droughts in India caused a 2 to 5% decline in the Gross Domestic Product (GDP).
- The Global Drought Vulnerability Index includes India. India is just as vulnerable to drought as Sub-Saharan Africa.
   According to statistics, India's territory susceptible to drought has grown by 57% since 1997.
- Nearly 30% of the nation's land was deteriorated in 2018–19, according to the Indian Space Research Organization's Desertification and Land Degradation Atlas of India.

#### **Types of Droughts**

- **Meteorological Drought :** It is a situation when there is a prolonged period of inadequate rainfall marked with mal-distribution of the same over time and space.
- **Agricultural Drought :** It is also known as soil moisture drought, characterised by low soil moisture that is necessary to support the crops, thereby resulting in crop failures.
- **Hydrological Drought** : It results when the availability of water in different storages and reservoirs like aquifers, lakes, reservoirs, etc. falls below what the precipitation can replenish.
- **Ecological Drought** : When the productivity of a natural ecosystem fails due to shortage of water and as a consequence of ecological distress, damages are induced in the ecosystem.



#### **Causes of Drought**

- Uneven distribution of rainfall over different parts of the country.
- Low average annual rainfall of 750mm over 33% of cropped area heightens susceptibility to drought.
- **Over-exploitation of ground water** and **sub-optimum conservation** of surface water leading to inadequate water availability for irrigation.
- Limited irrigation coverage and poor irrigation techniques: Net irrigated area in the country is less than 50%. The impact of drought on account of complete dependence of agriculture in such areas on rainfall

#### India can be divided into the following regions

- **Extreme Drought Affected Areas**: Most parts of Rajasthan, particularly areas to the west of the Aravali hills and Kachchh regions of Gujarat fall in this category.
- Severe Drought Prone Area: Parts of eastern Rajasthan, Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka Plateau, Tamil Nadu, Jharkhand and Odisha
- Moderate Drought Affected Area: Rajasthan, Haryana, Uttar Pradesh, Gujarat, Maharashtra, Jharkhand and Tamil Nadu.
- The remaining parts of India can be considered either free or less prone to drought.

#### Impact of drought:

- **Environmental**: Lowers surface water levels, increased pollution of surface water, the drying out of wetlands and loss of biodiversity.
- **Socio-economic**: Droughts cause scarcity of food and water, People die of hunger, malnutrition and epidemics and Impact the health of people.
- **Economic**: Agricultural contributions to the Gross Domestic Product (GDP) dipped by 3.1 per cent and agricultural income losses were estimated at Rs 39,000 crore.
- **Agricultural** : Crops fail due to scarcity of water. Severe droughts in rainfed areas have reduced agricultural production by 20 to 40 per cent.
- **Employment**: Farmers are deprived of their employment .Nearly 50 per cent of the rural workforce is concentrated in drought-prone districts.
- **Poverty**: Drought and poverty are interconnected with millions of very poor people living in drought-prone areas





• **Migration**: People are forced to migrate from their area of residence in the pursuit of food, water, green fodder and employment.

#### Way Forward:

- **Suitable farming methods for arid areas:** Like Production of coarse and hardy cereals; conservation of soil moisture by deep ploughing, storing water behind small dams, collecting water in ponds and tanks and use of sprinklers for irrigation.
- **Sowing drought-resistant crops:** By sowing drought-resistant crops of cotton, Moong, pearl millet, wheat etc, the impact of the drought could be mitigated to a certain extent.
- **Rainwater harvesting :** Collection of each and every drop of rain could help in coping with the drought. By making high bunds around the fields, adopting of terrace cultivation, and planting trees on the bunds of fields, the use of rainwater can be maximised.
- **Switching to renewable energies:** The alternative is to switch to renewable energy sources, such as wind and solar, which have negligible to no environmental impact and won't cause droughts.
- **Stricter government policies:** Using these at the local, national, regional, and international levels. Stricter government regulations. They include raising taxes for non-compliance and regulating the amount of greenhouse gases that are released into the environment.
- **Being environmentally conscious:** It entails teaching the next generation about the need of preserving, improving, and protecting the environment, as well as recycling, reusing, and planting more trees.

#### **Conclusion:**

• Government needs to invest in Research and Development projects to invent new techniques for effective water management in our country. Climate change will potentially be increasing the frequency of events like droughts. Effective implementation of medium and long-term solutions will help mitigate the impact of droughts.

#### LANDSLIDES

According to **the Geological Survey of India** a Landslide is a physical phenomenon when a part of rock, and/or debris/ soil falls due to the action of gravity. It is caused by a set of terrain-specific geo-factors (e.g., slope, lithology, rock structure, land use/ cover, geomorphology etc.) and in general is triggered by heavy rainfall or earthquake tremors. In Indian terrain, landslide events are **mostly triggered by monsoonal rainfall** but **examples of earthquake-triggered landslide** is also not uncommon in India (e.g., Uttarkashi Earthquake, Chamoli Earthquake, Sikkim Earthquake etc).

#### **FACT-WISE: GEOLOGICAL SURVEY OF INDIA**

- In India, about 0.42 million sq. km or **12.6% of land area**, excluding snow covered area, is prone to landslide hazard.
- Out of this, 0.18 million sq. km falls in North East Himalaya, including Darjeeling and Sikkim Himalaya; 0.14 million sq.
- It is estimated that **30 percent of the World's landslides occur in the Himalayan ranges.**

#### Landslide Atlas Of India

- Based on incidents from 1998 to 2022, the **National Remote Sensing Centre of ISRO** generated a database of India's landslide-prone regions.
- High-resolution satellite images taken with **ResourceSat-1 and 2**, among other tools, were also used to examine the landslides in addition to aerial photographs.
- Finding:
  - India is **one of the top five landslide-prone** nations in the world, with at least one landslide-related mortality per 100 square kilometres reported year.
  - Except for places covered with snow, the Atlas records that-
    - Approximately 0.42 million square kilometres, or **12.6% of the country's total land** area, are subject to landslides.
    - The **North-Western Himalayas** are claimed to be responsible for up to 66.5 percent of the landslides, followed by the **North-Eastern Himalayas** with 18.8 percent and the Western Ghats with 14.7 percent.
  - The country's most significant contributor to landslides is the **pattern of rainfall variability**, with the Himalayas and the Western Ghats remaining particularly vulnerable.

#### **Causes of landslides**

- **Heavy rain**: Heavy rain is the main cause of landslides.
- **Deforestation**: Trees, brushes and grasses keep the soil particles compact. Mountain slopes lose their protective cover by felling of trees. The rain water flows on such slopes with unimpeded speed.
- **Earthquakes and volcanic explosions:** Earthquake is a common feature in the Himalaya. Tremors destabilize the mountains and the rocks tumble downwards. Volcanic explosions also trigger landslides in the mountainous areas.



#### **PRAHAAR ReDEFINED 3.0: GEOGRAPHY & DM**



- **Building of roads:** This process dislodges the rock structure and changes the angle of slopes through debris and rocks which consequently landslides are triggered.
- **Shifting agriculture:** In the North Eastern part of India, the number and frequency of landslides has increased due to the practice of shifting agriculture.
- **Construction of houses and other buildings:** In building processes large amounts of debris are created which causes landslides.
- **Urbanisation:** In some parts of India, rising population pressure is concerning. For instance, landslides frequently occur in Dharamshala.
- **Mining:** The forest cover and soil gravel are removed by human activities like mining and quarrying. This reduces the ability of the ground to retain water. Additionally, it raises the chance of floods.

#### Landslide Vulnerability Zones

- **Very High Vulnerability Zone**: Highly unstable, relatively young mountainous, high rainfall regions with steep slopes in the Western Ghats and north-eastern regions, along with areas that experience frequent ground-shaking due to earthquakes.
- **High Vulnerability Zone:** All the Himalayan states and the states from the northeastern regions except the plains of Assam are included in the high vulnerability zones.
- **Moderate to Low Vulnerability Zone:** Areas that receive less precipitation, rain shadow areas in the Western and Eastern Ghats.
- **Other Areas:** The remaining parts of India.

#### Impacts of landslide:

Short Term Impacts			Long Term Impacts
•	Property and life losses.	•	Changes to the landscape that might last forever.
•	<ul> <li>Roadblocks and railway line destruction.</li> </ul>		A reduction in arable land.
•	Channel obstruction brought on by rockfalls.	•	Erosion and soil loss as a result of environmental
•	River stream changes brought on by floods caused by		impact.
	landslides.	•	Relocation and population shift of areas and
•	Loss of Natural Beauty.		businesses.
		•	Decreasing water sources.

#### Way Forward:

- Afforestation : Trees and brushes help in binding the soil particles.
- **New technology in road construction:** Roads should be constructed in such a way that a lesser amount of debris is generated.
- **Banning:** Ban on quarrying of stones and mining of minerals
- Forest use: Instead of exploitation of forests, they should be used scientifically.
- **Crop replacement:** Permanent crops like orchards of fruits should replace the seasonal or annual Drops.
- **Water control:** By controlling the surface flow of water, seepage of water should be minimised.
- **Retaining walls:** They can be built on mountain slopes to stop the land from slipping.
- **Mapping:** Hazard mapping should be done to locate areas commonly prone to landslides.

#### **Conclusion:**

• Landslides are one among the other natural hazards, which cannot eliminate completely but preparedness for hazards and suitable warning systems can minimize the losses. By the above measures we can mitigate the landslides to some extent but disaster preparedness is also very important, especially in case of unavoidable disaster events. **Collective participation and awareness among people** can even contribute towards its mitigation.

#### HEATWAVE

- The **World Meteorological Organization** defines a heat wave as five or more consecutive days of prolonged heat in which the daily maximum temperature is higher than the average maximum temperature by 5 °C.
- Higher daily peak temperatures and longer, more intense heat waves are becoming increasingly frequent globally due to climate change.
- In India it occurs mainly from March to June and in some rare cases even in July. The peak month of the heat wave over India is May.





#### FACT-WISE: GEOLOGICAL SURVEY OF INDIA

- According to NCRB there may have been 374 heat-related deaths in India in 2021, which is a decrease from the 530 cases reported in 2020.
- The NDMA, estimates 17,767 deaths from heat waves between 2000 and 2020,
- **State of India's Environment in figures, 2022** claims the country saw 280 heat wave days from March 11 to May 18, 2022, the most in the previous 12 years.

#### Criterion for declaring heat waves in India:

- Heatwave is considered if the maximum temperature of a station reaches at least 40°C or more for Plains and at least 30°C or more for Hilly regions.
- Based on Departure from Normal Heat Wave: Departure from normal is 4.50°C to 6.40°C.
- Severe Heat Wave: Departure from normal is >6.4°C
- When actual maximum temperature  $\geq$  45°C.
- Severe Heat Wave: When actual maximum temperature ≥47°C
- If the above criteria are met at least in 2 stations in a Meteorological subdivision for at least two consecutive days and it is declared on the second day.

#### Reasons for recent Heat Waves experienced in India:

- **Increase in Concrete areas:** Urban heat island effects can make ambient temperatures feel 3 to 4 degrees more than what they are.
- **Absence or Weaker Western Disturbances:** The rain-bearing Western Disturbances or tropical storms which bring rain from the Mediterranean over north India in March-April have been absent.
- **Dry & Hot Westerly Winds:** The continuous dry and hot westerly winds blowing from Baluchistan, central Pakistan and the Thar Desert over northwest and central India have contributed to the rise in heatwaves.
- **Climate Change:** More heat waves were expected as global temperatures had risen by an average of 0.8 degrees in the past 100 years. Night-time temperatures are rising too.
- Lack of Rainfall: Usually, periods of high temperature are punctuated by periodic episodes of rain, but this was largely absent during March and April.

#### Heat wave-prone states:

- This year's heat waves were concentrated in just five states, or 54% of them. According to SoE data from 2022, they were Rajasthan, Madhya Pradesh, Himachal Pradesh, Gujarat, and Haryana.
- These figures are therefore likely to be understated because, as of May 3, 2022, at least 39 heat-related deaths have been reported from just 5 states: Maharashtra (26), Jharkhand (2), Odisha (6), Rajasthan (2), and Telangana (2).

#### Impact of Heat Waves:

- **Risk of Wildfires:** The heat waves act as fuel to wildfires, which destroys a lot of land area every year.
- **Prevents Cloud Formation**: The condition also prevents clouds from forming, allowing for more radiation from the sun to hit the ground.
- Heat Strokes and Sudden Fatalities: Very high temperatures or humid conditions pose an elevated risk of heatstroke or heat exhaustion.
- **Health problems:** Older people and people with chronic illnesses such as heart disease, respiratory disease, and diabetes are more susceptible to heatstroke, as the body's ability to regulate heat deteriorates with age.
- **Effect on Vegetation**: The trapping of heat can also damage crops, dry out vegetation and result in droughts.
- **Increased Energy Demands**: The sweltering heat wave also leads to a rise in energy demand, especially electricity, leading to pushing up rates.

#### Way forward:

- **Heat Waves Action Plan:** With the State taking the lead and other stakeholders sharing responsibility for the effective implementation of the **Sendai Framework for Disaster Risk Reduction 2015–30**.
- **Implementing Climate Action Plans:** Not just for addressing climate change-induced heat waves, but also for doing it in a way that is ethical and promotes intergenerational justice, **nature-based solutions** should be taken into consideration.
- Plans for mitigating heatwaves: Access to water, oral rehydration solutions (ORS), and shade, especially in public places, coupled with flexible work schedules at companies, and special arrangements for outdoor employees, are all effective ways to reduce the risk of heat-related mortality.
- **Early warning system:** Establish Early Warning System and Inter-Agency Coordination to alert residents on predicted high and extreme temperatures to various government agencies especially for health.



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- **Capacity building:** Capacity building/training programme for health care professionals at the local level to recognize and respond to heat-related illnesses, particularly during extreme heat events so they can effectively prevent and manage heat-related medical issues to reduce mortality and morbidity.
- Awareness: Public Awareness and community outreach Disseminating public awareness messages on how to protect against the extreme heat
- **Collaboration with non-government and civil society:** To improve bus stands, building temporary shelters, wherever necessary, improve water delivery systems in public areas and other innovative measures to tackle Heatwave conditions.
- **Review labour laws** and other regulations taking climatic conditions into account.

#### **Conclusion:**

• Human-induced climate change has contributed to changing patterns of extreme weather across the globe, from longer and hotter heat waves to heavier rains. The intensity and frequency of heat waves can be reduced by creating awareness among people and disaster preparedness measures to mitigate the Impact of heat waves.

#### FOREST FIRE

• Forest fire may be defined as an unclosed and freely spreadingcombustion that consumes the natural fuels. Co mbustion is another word for fire. When a fire burns out of control it is known as Wildfire. They seriously endanger the bio-diversity, ecology, and ecosystem of a place in addition to posing a threat to the entire regime of fauna and flora.

#### **FACT-WISE: FOREST SURVEY OF INDIA**

- A total of 35.71% of India's forests have not yet experienced any significant fires, compared to 54.40% that are occasionally exposed to fires, 7.49% that are moderately frequently exposed to flames, and 2.40% that are highly frequently exposed to fires.
- In the period from November 2020 to June 2021, there were 52,785 forest fires discovered by the MODIS (Moderate Resolution Imaging Spectro-radiometer) sensor and 3,45,989 by the SNPP-VIIRS (Suomi-National Polar-orbiting Partnership Visible Infrared Imaging Radiometer Suite).

#### Classifications of forest fire depending upon their nature and size

- **Surface fires:** Surface fire is the most common forest fires that burn undergrowth and dead material along the floor of the forest.
- **Underground fires**: The fires of low intensity, consuming the organic matter beneath and the surface litter of forest floor
- **Ground fires:** This fire burns root and other material on or beneath the surface i.e. burns the herbaceous growth of forest floor.
- **Crown fires:** Crown fires are the most unpredictable fires that burn the top of trees and spread rapidly by wind.

#### **Causes of Forest fire:**

- **Natural causes:** Many forest fires start from natural causes such as lightning which set trees on fire. However, rain extinguishes such fires without causing much damage. High atmospheric temperatures and dryness (low humidity) offer favourable circumstances for a fire to start.
- **Man-made causes:** Fire is caused when a source of fire like naked flame, cigarette or bidi, electric spark or any source of ignition comes into contact with inflammable material. More than ninety five percent of forest fires are anthropogenic.
  - According to **WWF International** in its 2020 report estimated that humans are responsible for 75% of wildfires worldwide.

#### Forest prone to fire:

- As of 2019, about 21.67% (7,12,249 sq km) of the country's geographical area is identified as forest, according to the India State of Forest Report 2019.
- Forests of the Northeast and central India regions are the most vulnerable areas to forest fires.
- Forests in Assam, Mizoram and Tripura have been identified as 'extremely prone' to forest fire.
- States with large forest areas under the 'very highly prone' category include Andhra Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Maharashtra, Bihar and Uttar Pradesh.

#### Impact of forest fires:

• Loss of Ecosystems and Biodiversity: Ecosystem and biodiversity loss is caused by forest fires destroying the habitats and complex interactions of a wide variety of flora and wildlife.







- **Forest Degradation:** The quality of some forest elements, such as soil fertility, biodiversity, and ecosystems, is steadily declining as a result of the nearly annual occurrence of forest fires in various forest locations.
- Air Pollution: Massive air pollution is caused by the enormous smoke clouds that wildfires produce.
- **Health Issue:** The respiratory and cardiovascular systems may be impacted by wildfire smoke, particularly if it has a high concentration of PM 2.5 particles (particles smaller than 2.5 millimetres).
- **Global Warming:** When vegetation is destroyed by fire, the amount of greenhouse gases in the atmosphere increases, causing climate change and global warming.
- **Soil Degradation:** Forest fires destroy helpful soil microbes that break down the soil and encourage microbial activity in the soil, resulting in soil degradation.
- **Livelihood**: Loss of livelihood for tribal people and the rural poor, as approximately 300 million people are directly dependent upon collection of non-timber forest products from forest areas for their livelihood.

#### Way forward:

- **Firefighting reservoirs**: Water is still the main way to extinguish forest fires. Therefore in large, contiguous and fireendangered forested areas, it is necessary to have, or build and maintain, a fire-fighting water supply system within suitable water courses or to create artificial reservoirs for water extraction.
- **Infrastructure:** In order for fire engines to reach a forest stand it is important that the roads can bear heavy vehicles.
- **Machinery and equipment:** Maintaining appropriate fire-fighting tools and machinery is necessary to tackle forest fires.
- **Forest Fire Monitoring:** Using forest fire observation systems, the number of forest fires has not reduced but their extent has reduced.
- Aerial Surveillance: Aerial surveillance flights are a possible means to detect forest fires at an early stage during times of high fire risk.
- **Communication equipment**: Forest fires can only be quickly and successfully fought with functioning communication between the fire service and forest authority operational teams.
- **Cooperation and joint exercises:** Collaboration between forest owners, the administration and different branches of the fire and emergency services is of special importance when it comes to forest fires.

#### **Recent Forest Fires**

- **2023**: According to the Forest Survey of India's (FSI) satellite-based forest fire monitoring, 42,799 forest fires were discovered between March 1 and March 12. This is an increase over the 19, 929 fires discovered during the same period last year.
- **2022**: Before the end of March 2022, forest fires have been reported in the Sariska Tiger Reserve in Rajasthan, the Similipal Wildlife Sanctuary in Odisha, the Ladkui jungles in Madhya Pradesh, the Majhgawan region of Satna District, and the Perimalmalai Peak near the Kodaikanal Hills in Tamil Nadu's Dindigul District.
- **2021**: Long-lasting fires were reported in 2021 in Uttarakhand, Himachal Pradesh's Kullu Valley, and the border between Nagaland and Manipur's Dzukou Valley. Between the end of February and the beginning of March, there was a significant fire in Odisha's Simlipal National Park.

#### Recommendation of Council on Energy, Environment and Water (CEEW)

- **Recognise as a Disaster**: The Forest fires should be treated as "natural disasters" and be brought under the National Disaster Management Authority. Moreover, by designating forest fires as natural disasters, there will also be a financial allotment made to manage them.
- **Develop Alert system**: A forest fire-only alert system needs to be developed that can provide real-time impact-based alerts.
- **Enhance Adaptive Capacity**: Capacity-building initiatives targeted at district administrations and forest-dependent communities can avert the extent of loss and damage due to forest fires.
- **Provide Clean Air Shelters**: The state government/ state forest departments (SFDs) should repurpose public buildings like government schools and community halls by fitting them with clean air solutions like air filters to create clean air shelters for communities worst impacted by fires and smoke from forest fires.

#### **Conclusion:**

• Forest fires are usually seasonal. They usually start in the dry season and can be prevented by adequate precautions. The best way to control a forest fire is therefore, to prevent it from spreading, which can be done by creating firebreaks in the shape of small clearings of ditches in the forest.





#### FLOODS

India is highly vulnerable to floods. Out of the total geographical area of 329 million hectares (MHA), more than 40 mha is flood-prone. Floods are a recurrent phenomenon, which cause huge loss of lives and damage to livelihood systems, property, infrastructure and public utilities.

#### Flood distribution in India

- vulnerability is highlighted by the fact that 40 million hectares out of the geographical area of 3290 lakh hectares are prone to floods, which is 12%.
- State-wise study shows that about 27% of the flood damage in the country is in Bihar, 33% in Uttar Pradesh and Uttarakhand, and 15% in Punjab and Haryana.
- The middle and lower courses of North Indian rivers such as Ganga, Brahmaputra, Kosi, Damodar, Mahanadi, etc. Are prone to floods due to very low gradients.
- Peninsular rivers are mature and have hard rock beds, so they have shallow basins. This makes them prone to flooding.

#### The causes of flood in India:

- Natural Reasons
  - **Heavy rainfall**: Heavy rain in the catchment area of a river causes water to overflow its banks, which results in the flooding of nearby areas.
  - **Sediment deposition:** River beds become shallow due to sedimentation. The water-carrying capacity of such rivers is reduced. As a result, the heavy rainwater overflows the river banks.
  - **Cyclone:** Cyclone generated sea waves of abnormal height and spreads the water in the adjoining coastal areas. In October 1994 Orissa cyclone generated severe floods and caused unprecedented loss of life and property.
  - **Cloud bursts**: They result in flash floods, as seen in the Uttarakhand floods in 2013 (Kedarnath Flash Flood) and 2021 (Chamoli Disaster).
  - **Change in the course of the river:** Meanders and changes in the course of the river cause floods.
  - **Tsunami:** Large coastal areas are flooded by rising seawater when a tsunami strikes the coast.
- Anthropogenic Reasons:
  - **Interference in a drainage system:** Drainage congestion caused by the badly planned construction of bridges, roads, railway tracks, canals etc. hampers the flow of water and the result is flooding.
  - **Deforestation**: Vegetation hampers the flow of water and forces it to percolate in the ground. As a result of deforestation, the land becomes obstruction free and water flows with greater speed into the rivers and causing floods.
  - **Flood plain encroachment**: Population pressure resulting in encroachments into the flood plains over the years has aggravated the flood problem
  - **Urban planning**: Improper town planning and inadequate drainage arrangement lead to urban floods. Ex-Chennai Floods.

#### Impact of floods:

- **Casualties:** Human and livestock death due to drowning, serious injuries and outbreaks of epidemics like diarrhoea, cholera, jaundice or viral infections are common problems faced in flood-affected areas.
- **Structural damage:** During floods mud huts and buildings built on weak foundations collapse endangering human lives and property.
- **Material loss:** All materials mounted on the ground e.g. food stock, equipment, vehicles, livestock, machinery, salt pan and fishing boats can be submerged and spoiled.
- **Utility damage:** Utilities such as water supply, sewerage, communication lines, power lines, transportation network and railways are put at risk.
- **Financial Burden:** Some losses and damages brought on by floods are covered by insurance, but not all of them. The government occasionally provides state-level assistance to those affected by floods.
- **Emotional trauma:** Flood victims frequently experience a wide range of feelings during and after the disaster, including worry, fear, sadness, loss, and frustration. Eg of Inhabitants of Majuli Island who face regular floods.

#### Measures for flood management:

- **Embankments:** By building flood protection embankments, flood water can be controlled from overflowing the banks and spreading in nearby areas. The building of embankments on Yamuna, near Delhi, has been successful in controlling the flood.
- Afforestation: The fury of the flood could be minimized by planting trees in catchment areas of rivers.





- **Restoration of original drainage system:** The drainage system is generally choked by the construction of roads, canals, railway tracks etc. Floods could be checked if the original form of drainage system is restored.
- **Reservoirs:** By constructing reservoirs in the course of rivers could store extra water at the time of the flood. Such measures adopted till now, however, have not been successful. Dams built to control floods in Damodar could not control the flood.

#### Shifting the focus from flood management to flood governance

- Desilting/Dredging of rivers
- Integrated Water Resources Management
- Rejuvenation of wetlands, lakes, dykes, and drains as it will check the flooding to a large extent.
- Capacity building through training and public awareness Flood response teams, SDRF and NDRF as well as adequate contingency funds for immediate flood response
- Flood Management Plans to be prepared by all relevant agencies

#### **Conclusion:**

• India is vulnerable to annual flooding because of its geographical location and it causes huge damage to life and property. A Flood is a natural phenomenon, it cannot be fully controlled. However, the government can mitigate the risks posed by floods to a greater extent by taking appropriate steps.

#### FLASH FLOODS

These are sudden surges in water levels generally during or following an intense spell of rain. It is defined as floods which occur within six hours of the beginning of heavy rainfall. Flash Floods are highly localized events of short duration with a very high peak and usually have less than six hours between the occurrence of the rainfall and peak flood. Ex. Chennai Flood in 2015

#### **FACT-WISE**

- After Bangladesh, India is the nation with the worst flood damage in the world, and it is responsible for one-fifth of all flood-related fatalities worldwide.
- Cities like Chennai and Mumbai have frequently seen flash floods. Flash floods are also brought on by depression and cyclonic storms in the coastal regions of Orissa, West Bengal, Andhra Pradesh, and other states.

#### **Reasons:**

- Natural Reasons:
  - **Heavy Rainfall**: Water from Heavy rainfall concentrates and flows quickly through urban paved areas and impounds into low-lying areas raising the water level.
  - **Lakes**: Lakes can store the excess water and regulate the flow of water. When lakes become smaller, their ability to regulate the flow becomes less and hence causes flooding.
  - **Silting:** The drains carry large amounts of sediments and are deposited in the lower courses making beds shallower thus channel capacity is reduced. When there is heavy rain, these silted drains can't carry full discharge and result in flooding.
  - **Melting of Glaciers due to Volcanoes**: In areas on or **near volcanoes**, flash floods have also occurred after eruptions, when glaciers have been melted by the intense heat.

#### • Man-Made Causes:

- **Population pressure**: Because of a large number of people, more materials are needed, like wood, land, food, etc. This aggravates overgrazing, over-cultivation and soil erosion which increases the risk of flooding.
- **Deforestation:** Large areas of forests near the rivers/catchment of cities are used to make room for settlements, roads and farmlands and are being cleared due to which soil is quickly lost to drains. This raises the drain bed causing overflow and in turn urban flooding.
- **Trespassing on water storm drains:** The areas which were essentially created by the stormwater drains to let their flood waters pass freely being tress-passed for developmental purposes result in obstruction of water flow and thus contributed immensely to the fury of floods.
- **Un-Authorized colonies**: Un-Authorized colonies have been developed by the local colonisers without consideration to the city plans, drainage, sewerage etc. and thus subjected to flooding during heavy rainfalls.
- Poor Water and Sewerage Management: Old drainage and sewerage system has not been overhauled nor is it adequate now . All the drainage and sewer system in many parts of Delhi has collapsed resulting in flooding. This can be seen during rainy seasons every year.





#### Initiatives to improve Early Warning system related to Flash Flood:

- Flash Flood Guidance Services: It is a robust system designed by the India Meteorological Department (IMD) to provide the necessary products in real-time to support the development of warnings for flash floods about 6-12 hours in advance at the watershed level for the flash flood-prone South Asian countries viz. India, Nepal, Bhutan, Bangladesh, and Sri Lanka.
- South Asian Flash Flood Guidance System (FFGS): The India Meteorological Department (IMD) launched the South Asian FFGS. It is aimed at helping disaster management teams. Helps governments make timely evacuation plans ahead of the actual event of flooding.

#### Way Forward

• There is a need Collaborative approach to improve weather observational networks so that more data is available at the time of issuing warnings. Soil moisture data is also important and there is a need to augment the existing network.

#### GLACIAL LAKES OUTBURST FLOODS

- **Nanda Devi Glacier Incident:** The recent breaking off of a portion of the Nanda Devi glacier in Joshimath, Uttarakhand, resulted in significant flooding in parts of the state.
- **Dammed Glacial Lakes:** GLOFs occur when a substantial amount of water stored in a glacial lake is suddenly discharged.
- Serious Concern in Himalayan States: Building moraine-dammed glacial lakes and the occurrence of GLOFs are significant concerns in India's Himalayan states.
- **Impact of Global Warming:** Glacial lakes are expanding in size and number due to the melting of glaciers caused by global warming.
- **Potential for Flooding and Destruction:** These growing glacial lakes have the potential to cause widespread flooding and destruction.

#### FACT-WISE

- According to recent studies, the number of glacial lakes has increased dramatically as a result of glacier retreat induced by higher temperatures (due to global warming), and these lakes have the potential to inflict widespread flooding and destruction.
- **For example**, a fracture in a big glacial lake was involved in the Kedarnath tragedy in 2013.
- The Indus, Ganga, and Brahmaputra basins, respectively, have 352, 283 and 1,393 glacial lakes and water bodies, according to a study done by the Central Water Commission (CWC) between 2011 and 2015.
- The Glacial Lake Atlas of the Ganga Basin was issued by the Department of Water Resources, River Development, and Ganga Rejuvenation (DoWR, RD & GR) under the National Hydrology Project, the Ganga River Basin Atlas published (NHP). The National Remote Sensing Centre (NRSC) and ISRO collaborated on the atlas under the National Hydrology Project (NHP).

#### **GLOF ARE TRIGGERED BY A VARIETY OF FACTORS:**

- **Fast Slope Migration:** Rapid slope movement (slides, falls, avalanches) into the lake leads to displacement waves, causing the dam to overtop or triggering an immediate dam breach.
- Heavy Rainfall/Snowmelt and Cascading Processes: Intense rainfall or rapid snowmelt, along with cascading processes, result in a significant increase in water intake into the lake, potentially leading to a flood from an upstream lake.
- **Earthquake:** Earthquakes can directly cause dam breaches and failures, resulting in a glacial lake outburst flood.
- **Long-Term Dam Deterioration:** Over time, the internal structure of the dam can deteriorate, leading to increased hydrostatic pressure caused by basal ice melting, ultimately resulting in dam failure.
- **Black Carbon:** Increasing levels of black carbon, produced by incomplete combustion of fossil fuels, wood, and other fuels, contribute to a lower albedo, leading to accelerated glacier melting.
- Anthropogenic Activities: Mass tourism, development projects like road construction and hydropower projects, and certain agricultural practices such as slash-and-burn farming in specific areas of the Indian Himalayan region can contribute to the risk of GLOFs.

#### **IMPACT OF GLOF**

- **Destruction of Property, Infrastructure, and Loss of Lives:** GLOFs can result in the rapid and forceful inundation of areas, leading to the destruction or disruption of buildings, infrastructure, and human lives.
- **Impact on Ocean Circulation and Climate:** The massive release of cold freshwater into the ocean during a GLOF can lower the salinity of the surface layer. This alteration in salinity can impact ocean circulation patterns, potentially affecting regional and global climate systems.





• Alteration of Local Geomorphology: GLOFs have the potential to significantly alter the interactions between erosion and accumulation processes. They can result in modifications to stream and river channels, such as bank erosion, meander shifting, channel replacement, construction of new channels, and the formation of erosional terraces.

#### RECENT DEVELOPMENTS PERTAINING TO DISASTERS AND HAZARDS

#### LAND SUBSIDENCE IN COASTAL AREAS

- When subsurface earth materials are removed or moved, the result is a slow sinking of the earth's surface or an abrupt sinking.
- It is regarded as an irreversible natural and artificial threat.
- By 2040, it is predicted that 8% of the world's top layer will be affected by land subsidence, and 21% of the world's major cities will be home to 1.2 billion people.
- Other than Mumbai, Delhi and Kolkata are experiencing ground sinking in India. Localities with thin soil particles, such as the alluvial deposits of the rich Gangetic plains, are particularly at risk.

#### • Factors Responsible:

- **Natural factors:** Land subsidence occurs because of gradual or sudden natural compaction or collapse of soils due to
  - Tectonic activities (e.g. earthquake and faulting).
  - Landslide.
  - Volcanic activities.
  - Thawing of permafrost.
  - Formation of sinkholes.
- Anthropogenic causes:
  - Due to prolonged groundwater withdrawals, aquifer systems get compacted, which causes the land to sink
  - Excessive underground mining of minerals, oil, and gas.
  - Formation of underground infrastructure such as metro, tunnels, etc.
  - High construction loads such as high-rise buildings.

#### MINING IN ARAVALLI

- Over 3,200 sites in the Aravalli region continue to engage in illicit mining, according to the Forest Survey of India (FSI).
- A striking observation on the health of the environment is the connection between Delhi's increasing pollution levels and the loss of the hills.
- The Supreme Court's comments are shocking enough to warrant careful evaluation and the right course of action.

#### **BOMB CYCLONE**

- A bomb cyclone is a sizable, powerful storm that forms in the mid-latitudes. It features low pressure at its centre, weather fronts, and a variety of accompanying weather, including blizzards, severe thunderstorms, and heavy precipitation.
- Reason for Formation:
  - Storms arise when a mass of low pressure (warm air mass) collides with a mass of high pressure (cold air mass).
  - Winds are produced as air moves from areas of high to low pressure.
  - It happens when a midlatitude cyclone intensifies quickly, losing at least 24 millibars in a 24-hour period.

#### JOSHIMATH LAND SUBSIDENCE

- Subsidence, as defined by the National Oceanic and Atmospheric Administration (NOAA), is the term used to describe the earth sinking as a result of subterranean material movement.
- Numerous factors, both natural and man-made, including mining operations and the loss of water, oil, or other natural resources, can cause it.
- Possible Reasons:
  - **Fragile Ecology:** Ecology is incredibly fragile since Joshimath City was constructed on an old landslip deposit, which is made up of sand and stone rather than rock and has a low load-bearing capability.
  - **Unplanned urbanisation:** Because of unlicensed and unplanned buildings, the natural flow of water has been obstructed, which frequently causes landslides.
  - **Disregarded the 1976 Mishra Committee Report's recommendations:** The Committee had come to the conclusion in its report that the area on which the town is built is actually a sand and stone deposit, the remains of a long-ago landslip.
  - **Hydel Projects:** Joshimath's foundation may have suffered more harm than any other factor from the construction of the 520 MW NTPC Tapovan Vishnugad Hydro Power Plant (Dhauli Ganga River).





- **Land Erosion:** Other factors contributing to the fate of the city include sliding along natural streams and rushing streams from Vishnuprayag.
- **Geographic fault:** Where the Indian Plate has pushed under, there may have been a reactivation of a geographic fault, which is described as a fracture or zone of fractures between two blocks of rock.

#### PREVIOUS YEAR QUESTIONS (MAINS)

Discuss about the vulnerability of India to earthquake-related hazards. Give examples including the salient				
features of major disasters caused by earthquakes in different parts of India during the last three decades.				
Describe the various causes and effects of landslides. Mention the important components of the National				
Landslide Risk Management Strategy.				
Account for the huge flooding of million cities in India including the smart ones like Hyderabad and Pune. Suggest				
lasting remedial measures.				
In what way can flood be converted into a sustainable source of irrigation and all-weather inland navigation in				
India?				
Major cities in India are becoming more vulnerable to flood conditions. Discuss.				
Mumbai, Delhi and Kolkata are the three mega cities of the country but the air pollution is a much more serious				
problem in Delhi as compared to the other two. Why is this so?				
Bring out the causes for more frequent landslides in the Himalayas than in the Western Ghats.				





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