Drishti IAS Presents...

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GEOGRAPHY

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Contents

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Nimmu-Padam-Darcha Road in Ladakh

Recently, The **Border Roads Organisation (BRO)** has achieved a significant milestone by connecting the strategic **Nimmu-Padam-Darcha road** in **Ladakh.**

- This road serves as a **crucial link between Manali and Leh,** passing through **Darcha** and **Nimmu** along the **Kargil–Leh highway.**
- It now stands as the **third axis** connecting **Ladakh to the hinterland,** alongside the existing **Manali-Leh** and **Srinagar-Leh routes.**
- The road holds **strategic importance due to its shorter distance** compared to other routes. It will **provide all-weather connectivity** to the Ladakh region.
- It crosses only one pass i.e. **Shinkun La** at an elevation of **16,558 feet** where tunnel work is about to commence under the BRO's supervision.
- The road's completion will not only strengthen defence preparedness but also contribute to economic development in the **Zanskar Valley.**
- **BRO** was conceived and raised in **1960** by **Pandit Jawaharlal Nehru** to coordinate the speedy development of a network of roads in the **North** and the **North Eastern border regions** of the country.
- It works under the administrative control of the **Ministry of Defence.**

Read more: **Vibrant Villages Programme**, **BRO Opens Rohtang Pass**, **Zoji La**, **Importance of Ladakh**.

Note:

Cancellation of Bauxite Lease

Why in News?

Ahead of Odisha State Pollution Control Board's (OSPCB) hearing on **Environment Clearance** **of Mali Parwat Bauxite Mining Lease**, local people have started protests demanding permanent cancellation of the lease.

- **Concerns:**
  - Environmentalists have also said that mining can **deplete water sources from around 32 perennial streams** and four canals in Maliparbat, adversely affecting the livelihoods of the tribals.
  - The Mali and forest area are **inhabited by members of Kondha, Paraja and Gadaba tribes.**

What is the Environment Impact Assessment?

- It can be **defined as the study for predicting the effect of a proposed activity/project on the environment.**
- It is statutory under the **Environment Protection Act, 1986** for some projects.
- **Process:**
  - Screening based upon scales of investment, type of development, and location of the development is done to see whether a project requires an environmental clearance as per the statutory notifications.
  - Scoping is a process of detailing the Terms of Reference (ToR) of EIA, that is the main issues or problems in the development of a project.
  - Impact Prediction involves mapping the environmental consequences of the significant aspects of the project and its alternatives.
- The public mandatorily needs to be informed and consulted on the proposed development after the completion of the EIA report.

What is Bauxite?

- **About:**
  - Bauxite is an ore of aluminum. It is a rock **consisting mainly of hydrated aluminium oxides.**
  - The deposits of Bauxite are mainly associated with laterites and occur as capping on hills and plateaus, except in **coastal areas of Gujarat and Goa.**
  - Bauxite is primarily used to **produce alumina through the Bayer process.**
  - Like many metals, world demand for aluminium, and therefore **bauxite, has grown substantially over the past several years in response to economic growth in emerging Asian economies.**
- **World Distribution:**
  - **Reserves:** As per **2015 data**, world bauxite reserves are estimated **at 30 billion tonnes and are located mainly** in Guinea (25%), Australia (20%), Vietnam (12%), Brazil (9%), Jamaica (7%), Indonesia (4%) and China (3%).
- **Australia continued to be the major producer** and accounted for about 29% share in the total production, followed by China (19%), Guinea (18%), Brazil (10%) and India (7%).
- **Distribution in India:**
  - **Reserves:** By States, **Odisha alone accounts for 51% of country's resources of bauxite followed by** Andhra Pradesh (16%), Gujarat (9%), Jharkhand (6%), Maharashtra (5%) and Madhya Pradesh & Chhattisgarh (4% each) in 2019. Major bauxite resources are concentrated in the East Coast bauxite deposits in Odisha and Andhra Pradesh.
  - **Production:** In terms of production, in 2020, **Odisha accounted for 71% of the total output** followed by Gujarat (9%) and Jharkhand (6%).

Heat Dome

Why in News?

Several countries in Europe recorded their hottest January weather ever in 2023 with temperatures 10 to 20 degrees Celsius above average.

- These included **Poland, Denmark, the Czech Republic, the Netherlands, Belarus, Lithuania and Latvia.**
- Experts said that the **continent is experiencing an extremely warm spell** because of the **formation of a heat dome over the region.**
- In 2021, a heat dome formed over western Canada and the US, causing deadly **heat waves.**
- **Another heat dome settled over the US in September 2022** and raised temperatures to a new high.

Note:

What is a Heat Dome and Heat Wave?

- **Heat Dome:**
  - A **heat dome occurs when an area of high-pressure traps warm air over a region, just like a lid on a pot**, for an extended period of time.
  - The **longer that air remains trapped, the more the sun works to heat the air,** producing warmer conditions with every passing day.
  - Heat domes **generally stay for a few days but sometimes they can extend up to weeks,** which might cause deadly heat waves.
  - Scientists suggest that **any region of high pressure, whether a heat dome or not, forces air to sink and once it reaches the ground**, it gets compressed and becomes even warmer.
  - Moreover, **when air sinks, it gets drier and further raises the temperature of the area.**
- **Heat Domes and the Jet Stream:**
  - The heat dome's formation is **related to the behaviour of the jet stream.**
    - Jet streams are relatively narrow bands of strong wind in the upper levels of the atmosphere
  - The **jet stream is believed to have a wave-like pattern** that keeps moving from north to south and then north again.
  - **When these waves get bigger and elongated**, they move slowly and sometimes can become stationary.
  - This is **when a high-pressure system gets stuck** and leads to the occurrence of a heat dome.
  - **Although heat domes are** likely to have always existed, researchers say that **climate change** may be making them more intense and longer.
  - They suggest with the rising temperatures, it is expected that the jet stream will become more wavy and will have larger deviations, causing more frequent extreme heat events.

Cold Wave

Why in News?

Delhi and other parts of northwest India have been **reeling under a Cold Wave since the beginning of 2023.**

What Factors are Responsible for this Cold Wave?

- **Large Scale Fog:**
  - One of the major factors contributing to colder than normal temperatures over north India in January 2023 is the **large-scale fog cover**, according to **India Meteorological Department (IMD).**
  - Fog has been lasting for longer durations, **preventing sunlight from reaching the surface and affecting the radiation balance.** There is no heating in the day time, and then **there is the impact of the night**.
- **Foggy Nights:**
  - Foggy or cloudy nights are usually **associated with warmer nights, but if the fog remains for two or three days, cooling begins even at night**.
  - Light winds and **high moisture near the land surface have been contributing to the formation of a blanket of fog** over large swathes of the **Indo-Gangetic plains** in the morning.
- **Westerly Winds:**
  - Since there has not been any significant impact of **western disturbances** over the region, cold northwesterly winds have also been contributing to low temperatures.
  - Westerly and **northwesterly winds of around 5 to 10 kmph in the afternoon have also been contributing to the dip in temperature**

What is Cold Wave?

- **About:**
  - A cold wave is a rapid fall in temperature **within 24 hours to a level requiring substantially increased protection to agriculture**, industry, commerce, and social activities.
- **Cold Wave Conditions:**
  - For the plains, a cold wave is declared when the minimum temperature is 10 **degrees Celsius or below and is 4.5 degrees Celsius (C) less than normal for two consecutive days.**
    - A "severe" cold day is when the maximum temperature is at least 6.5 notches below normal.
  - For coastal stations, the **threshold value of minimum temperature of 10 degree Celsius is rarely reached.** However, the local people feel discomfort due to

Note:

the wind chill factor which reduces the minimum temperature by a few degrees depending upon the wind speed.

- A wind chill factor is a measure of the cooling effect of the wind on the temperature of the air.

➢ **India's Core Cold Wave Zone:**

- **India's 'core cold wave zone'** covers Punjab, Himachal Pradesh, Uttarakhand, Delhi, Haryana, Rajasthan, Uttar Pradesh, Gujarat, Madhya Pradesh, Chhattisgarh, Bihar, Jharkhand, West Bengal, Odisha and Telangana.

➢ **Causes of Cold Wave in India:**

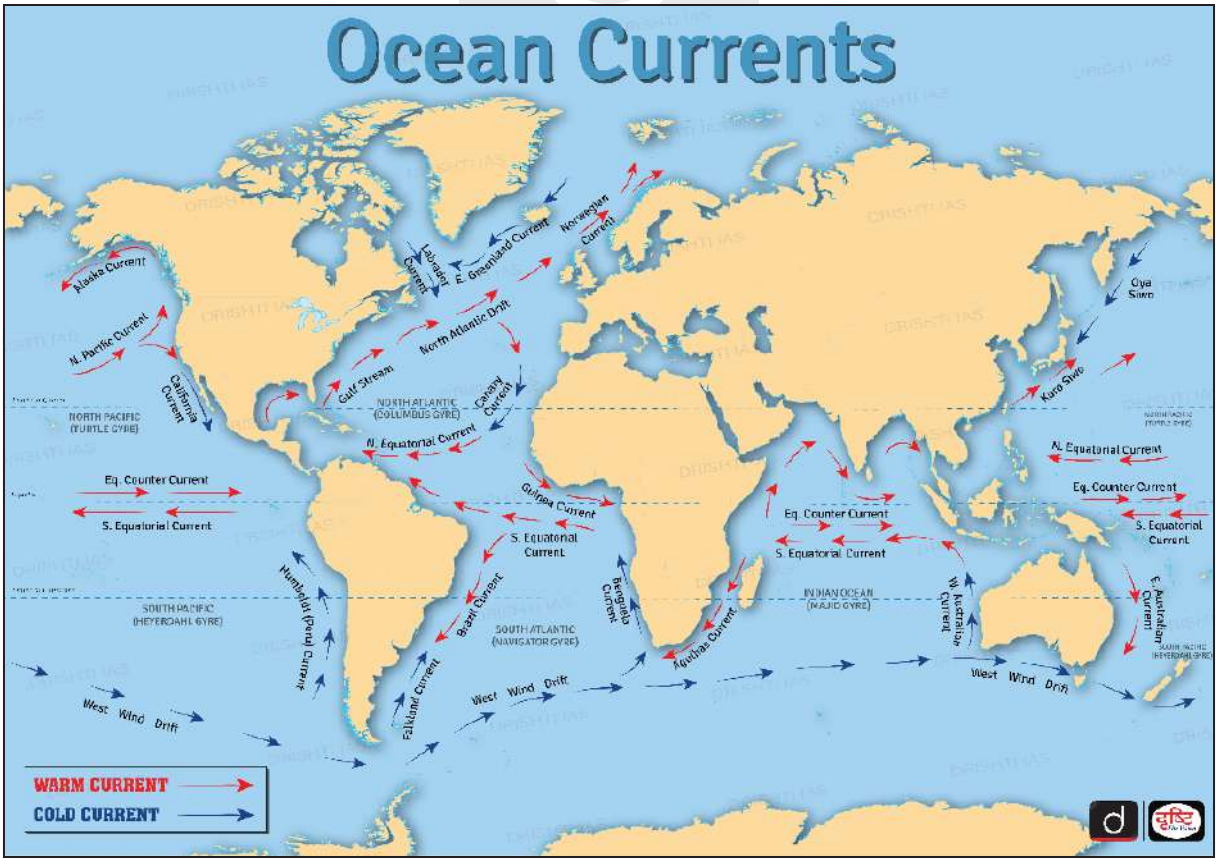
- **Absence of Cloud Cover in the Region:** Clouds trap some of the outgoing infrared radiation and radiate it back downward, warming the ground.
- Snowfall in the upper Himalayas that has blown cold winds towards the region.
- **Subsidence of Cold Air over the Region:** Subsidence is the downward movement of cold and dry air closer to the surface.
- **La Nina:** Prevailing La Nina conditions in the Pacific Ocean. La Nina is the abnormal cooler sea surface temperatures reported along the equatorial Pacific Ocean and it is known to favour cold waves.
  - During La Nina years, the severity of cold conditions becomes intense. The frequency and area covered under the grip of a cold wave becomes larger.
- **Western Disturbances:** Western disturbances can cause cold waves in India. Western disturbances are weather systems that **originate in the Mediterranean Sea and move eastward,** bringing cold winds, precipitation and cloud cover to the northwest regions of India. These disturbances can lead to a drop in temperature and cause cold wave conditions. However, not all western disturbances bring cold wave conditions.

What is the India Meteorological Department?

➢ IMD was established in 1875.

➢ It is an agency of the Ministry of Earth Sciences of the Government of India.

➢ It is the principal agency responsible for meteorological observations, weather forecasting and seismology.



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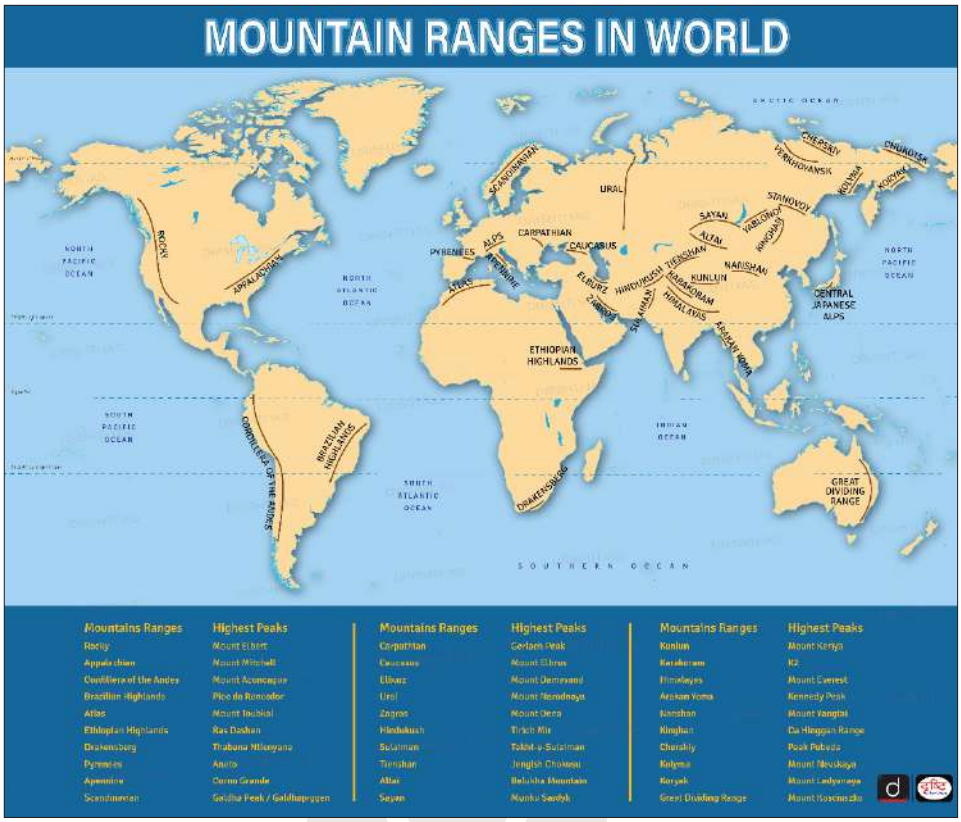
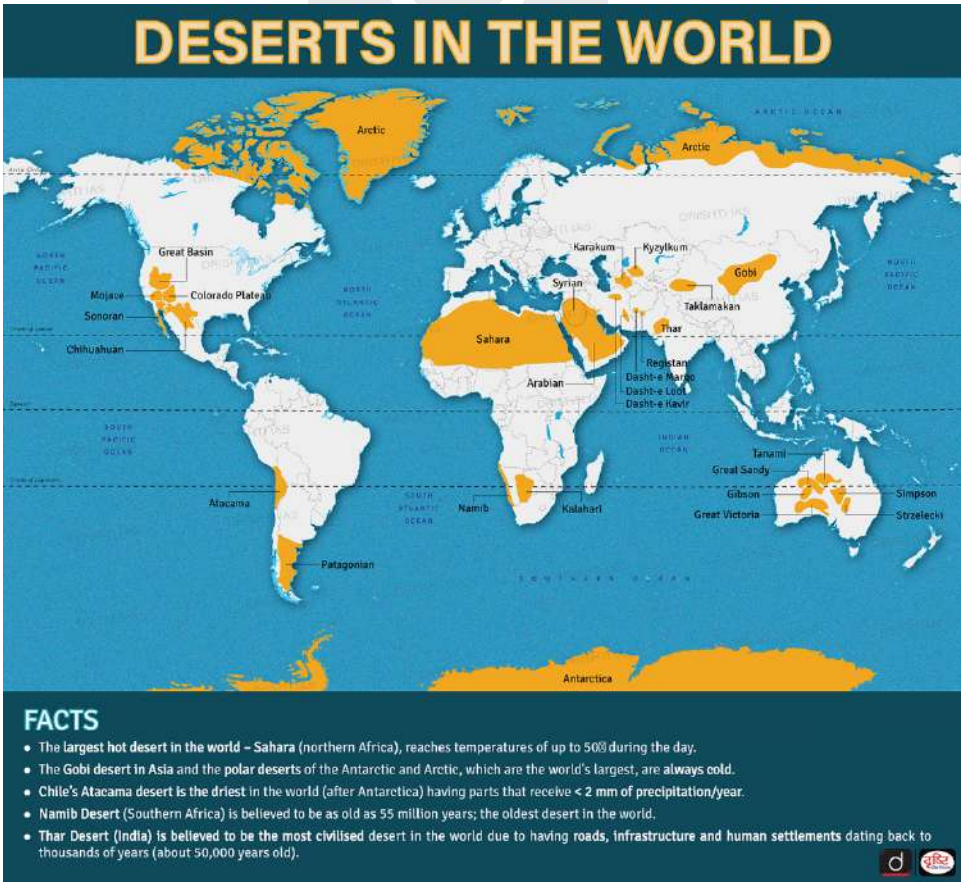

MOUNTAIN RANGES IN WORLD
ARCTIC OCEAN
SCANDINAVIAN
URAL
CHEKANOV
VERKHOYANSK
CHUKOTSK
KOLYMA
KORYAK
STANOVOY
SAYAN
YABLONOY
KHINGAN
ROCKY
APPALACHIAN
CARPATHIAN
CAUCASUS
PYRENEES
ALPS
APENNINE
ATLAS
ALTAY
TIENSHAN
HINDUKUSH
ELBURZ
ZAGROS
SULAIMAN
KARAKORAM
HIMALAYAS
KUNLUN
NARUSHAN
CENTRAL JAPANESE ALPS
ARAKAN YOMA
ETHIOPIAN HIGHLANDS
NORTH PACIFIC OCEAN
NORTH ATLANTIC OCEAN
SOUTH PACIFIC OCEAN
INDIAN OCEAN
SOUTH ATLANTIC OCEAN
CORDILLERA OF THE ANDES
BRAZILIAN HIGHLANDS
DRAKENSBERG
GREAT DIVIDING RANGE
SOUTHERN OCEAN
Mountains Ranges
Highest Peaks
Rocky
Mount Elbert
Appalachian
Mount Mitchell
Cordillera of the Andes
Mount Aconcagua
Brazilian Highlands
Pico da Bandeira
Atlas
Mount Toubkal
Ethiopian Highlands
Ras Dashen
Drakensberg
Thabana Ntlenyana
Pyrenees
Aneto
Apennine
Corno Grande
Scandinavian
Galdhøpiggen / Galdhøpiggen
Carpathian
Gerlach Peak
Caucasus
Mount Elbrus
Elburz
Mount Damavand
Ural
Mount Narodnaya
Zagros
Mount Dena
Hindukush
Tirich Mir
Sulaiman
Takht-e-Sulaiman
Tienshan
Jengish Chokusu
Altai
Belukha Mountain
Sayan
Munku Sardyk
Kunlun
Kerakoram
Himalayas
Arakan Yoma
Hengduan
Khingan
Changbai
Great Dividing Range
Koryak
Kolyma
Chersky
Mount Keriya
K2
Mount Everest
Kennedy Peak
Mount Yangtai
Da Hinggan Range
Peak Pobeda
Mount Nevskaya
Mount Ledyanaya
Mount Kosmosa


DESERTS IN THE WORLD
Arctic
Great Basin
Mojave
Colorado Plateau
Sonoran
Chihuahuan
Sahara
Arabian
Karakum
Kyzylkum
Syrian
Gobi
Taklamakan
Thar
Registan
Dasht-e Margo
Dasht-e Lout
Dasht-e Kavir
Tanami
Great Sandy
Gibson
Great Victoria
Simpson
Strzelecki
Atacama
Namib
Kalahari
Patagonian
Antarctica
FACTS
The largest hot desert in the world – Sahara (northern Africa), reaches temperatures of up to 50℃ during the day.
The Gobi desert in Asia and the polar deserts of the Antarctic and Arctic, which are the world's largest, are always cold.
Chile's Atacama desert is the driest in the world (after Antarctica) having parts that receive < 2 mm of precipitation/year.
Namib Desert (Southern Africa) is believed to be as old as 55 million years; the oldest desert in the world.
Thar Desert (India) is believed to be the most civilised desert in the world due to having roads, infrastructure and human settlements dating back to thousands of years (about 50,000 years old).

Note:

EARTHQUAKE

ABOUT

- Shaking of the earth; caused due to release of energy, generating seismic waves in all directions

HYPOCENTER

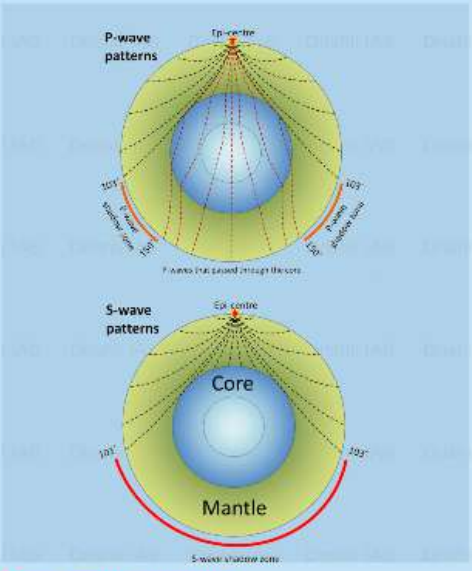
- Location where the earthquake starts (below earth's surface)

EPICENTER

- Location right above the Hypocenter (on the earth's surface)

EARTHQUAKE WAVES

- Body Waves: Move in all directions travelling through the body of the earth
  - P Waves: Move faster, First to arrive at surface, Similar to sound waves, Travel through gaseous, liquid and solid materials
  - S Waves: Arrive at surface with some time lag, Travel only through solid materials
- Surface Waves: Last to report on seismographs, More destructive, Cause displacement of rocks
  - Love Waves: Same motion as S-waves (horizontal) without vertical displacement, Sideways motion perpendicular to the direction of propagation, Faster than Rayleigh waves
  - Rayleigh Waves: Cause the ground to shake in an elliptical pattern, Spread out the most of all seismic waves, Move vertically and horizontally in a vertical plane

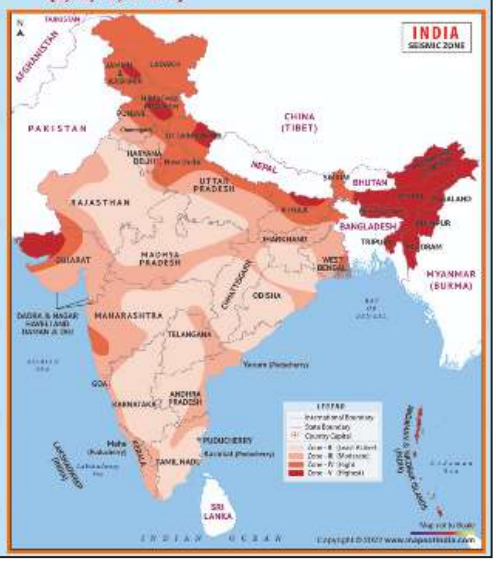


CAUSES OF EARTHQUAKES

- Release of energy along a Fault/Fault Zones (break in the crustal rocks)
- Movement of tectonic plates (most common)
- Volcanic eruption (stress changes in rock-injection/withdrawal of magma)
- Human activities (mining, explosion of chemical/nuclear devices etc.)

EARTHQUAKE IN INDIA

- India is one of the highly earthquake affected countries due to the presence of technically active mountains - the Himalayas.
- India has been divided into 4 seismic zones (II, III, IV, and V)



MEASURING EARTHQUAKE

- Seismometers - Measures seismic waves
- Richter Scale - Measures magnitude (energy released; range: 0-10)
- Mercalli - Measures intensity (visible damage; range: 1-12)

DISTRIBUTION

- Circum-Pacific Belt - 81% of earthquakes
- Alpide Earthquake Belt - 17% of the largest earthquakes
- Mid-Atlantic Ridge - Mostly submerged underwater

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Manufactured Sand

Why in News?

Coal India Limited (CIL) is making headlines for its innovative solution to the sand shortage problem. The company is using **crushed rock fines (crusher dust), sand from Overburden (OB) of coal mines and soil removed during opencast coal mining**, to produce **Manufactured Sand (M-Sand)**.

- This not only **repurposes waste materials** but also **reduces the need for natural sand mining** and creates an additional revenue stream for the company.

What is the Status of Sand Mining in India?

- **About:**
  - Sand is classified as a **"minor mineral"**, under The **Mines and Minerals (Development and Regulations) Act, 1957 (MMDR Act)** and administrative control over minor minerals vests with the State Governments.
  - **Rivers and coastal areas** are the main sources of sand, and the demand for it has increased significantly in recent years due to the construction and infrastructure development boom in the country.
  - The **Ministry of Environment, Forests, and Climate Change (MoEFCC)** has issued "**Sustainable Sand Mining Management Guidelines 2016**" to promote **scientific sand mining** and environmentally friendly management practices.

Deep-Water Circulation

Why in News?

Recent studies have indicated that **tectonically driven changes in the ocean gateways** had a dramatic impact on the global overturning circulations.

What do the Latest Findings Suggest?

- Studies suggest that **changes in ocean routes caused by tectonics**, like the closing of the **Central American Seaway**, had a big effect on **ocean circulation**.
  - **Central American Seaway** is a body of water that **once separated North America from South America,**
- These changes **may have led to the creation of two distinct water bodies**:
  - Northern component water in the **North Atlantic Ocean.**
  - **Antarctic Bottom Water (AABW)** in the Southern Ocean.
- Consequently, it is also **hypothesised that there would have been large-scale changes in the Deep-Water Circulation (DWC)** in the oceans across the world, impacting **global climate** and heat exchanges.

What is Deep Water Circulation (DWC)?

- **About:**
  - It refers to the movement of water in the deep ocean. It is **driven by the density differences between water masses** caused by variations in temperature and salinity.
  - In the Earth's polar regions ocean water gets very cold, forming sea ice. As a consequence, the **surrounding seawater gets saltier, because when sea ice forms, the salt is left behind.**
  - As the **seawater gets saltier,** its density increases, and **it starts to sink.** Surface water is pulled in to replace the sinking water, which in turn eventually becomes **cold and salty enough to sink.**
    - This creates a circulation pattern that is known as the **thermohaline circulation.**
- **Significance:**
  - **Heat Distribution:** It helps to distribute heat around the globe, which helps to **regulate the Earth's temperature** and keep different regions from becoming too hot or too cold.
  - **Maintaining Carbon Dioxide Levels**: It plays a critical role in controlling **atmospheric carbon dioxide levels** by **helping to transport carbon from the surface to the deep ocean,** where it can be stored for long periods of time.
  - **Shaping Ocean Currents**: It is responsible for **shaping the ocean's currents** and the circulation patterns of the world's oceans.
    - These currents in turn influence the **marine ecosystem, weather patterns, and coastal regions.**
  - **Maintaining Sea level:** It also has an impact on sea level, as **warm water is less dense than cold water,** therefore it can also affect **sea level** by redistributing heat and thermal expansion.

Note:

- **Deep-Water Circulations of the Indian Ocean:**
  - The Indian Ocean does not produce its own deep water, it **only receives it from other sources** such as the North Atlantic and Antarctic.
  - The **northern part of the Indian Ocean is located far away from the areas where deep water is formed** and ocean routes, making it a good place to study the impact of ocean circulation changes.
  - Studies have been done in the Indian Ocean to understand past deepwater circulation **using records from iron-manganese crusts and authigenic neodymium isotope composition** of sediment cores.
    - These records have few limitations:
      - **Iron-manganese crusts are found at deeper depths** and are only bathed by **Antarctic Bottom Water (AABW)**, so they can only provide information about the history of AABW.
      - **Authigenic neodymium isotope** records are only available from the **Bay of Bengal region**, but they are also not accurate as the **Himalayan rivers that flow into the Bay bring in a lot of neodymium particulates** which can interfere with the results.
  - However, recently Scientists have generated an **authigenic neodymium isotope record from the Arabian Sea** and reconstructed the **DWC record of the Indian Ocean** for the period from **11.3 million years ago (Miocene era) to 1.98 million years ago (Pleistocene era).**

Rare Earth Elements Discovered in Sweden

Why in News?

Recently, Sweden's **state-owned mining company LKAB** has **discovered Europe's largest deposit of rare earth metals**.

What is the Significance of the Discovery?

- The store, **situated in Kiruna** located in the **northern region of Sweden**, holds a stockpile of over **1 million metric tons of rare earth oxides.**
- This discovery bolsters **Europe's ambition to rely less on imported raw materials** needed for the **green transition.**
- Currently**, no rare earths are mined in Europe** and it mostly **imports** them from other regions.
  - According to a report in the BBC, **98% of rare earths** used by the **European Union** (EU) were sent by China.
- The discovery can also **prove to be a significant turning point not just for the EU but also for other western countries** as they have been trying to reduce their reliance on China for the import of these **rare earth elements.**

What are Rare Earth Elements?

- **About:**
  - They are a set of **17 metallic elements.** These include the **15 lanthanides on the periodic table** in addition to **scandium and yttrium** that show similar physical and chemical properties to the lanthanides.
- **Significance:**
  - They are important in technologies of **consumer electronics, computers and networks, communications, clean energy,** advanced transportation, healthcare, environmental mitigation, and **national defence**, among others.
    - **Scandium** is used in **televisions** and fluorescent lamps
    - **Yttrium** is used in drugs to **treat rheumatoid arthritis** and **cancer.**
  - Rare earth elements are also used in **space shuttle components,** jet engine turbines, and drones.
    - **Cerium,** the most abundant rare earth element, is essential to **NASA's Space Shuttle Programme.**
  - Moreover, the push for switching from **internal combustion cars to electric vehicles** has also led to a rise in demand for rare earth.
- **Monopoly of China:**
  - China has over time **acquired global domination of rare earths**, even at one point, it produced **90% of the rare earths the world need**s.
    - Today, however, it has **come down to 60%** and the remaining is produced by other countries, including the **Quad (Australia, India, Japan and United States).**
  - Since **2010**, when China **curbed shipments of Rare Earths to Japan**, the US, and Europe, production units have come up in **Australia**.

Note:

- Even so, the **dominant share** of processed Rare Earths **lies with China.**

➢ **Rare Earth Elements in India:**

- India has **6% of the world's rare earth reserves**, it only produces **1% of global output**, and meets most of its requirements of such minerals from China.
- **Indian Rare Earths Limited (IREL)** is majorly responsible for **mining and extraction of primary mineral** that contains **Rare Earth Elements**: **monazite** beach sand, found in many coastal states.
- IREL's prime focus is to provide **thorium** — extracted from monazite — to the **Department of Atomic Energy.**

Inner Core of the Earth

Why in News?

Recently, new research suggested that Earth's inner core has **stopped spinning faster than its surface and might now be rotating slower** than it.

What sare the Highlights of the Research?

➢ **Methodology:**

- The research analyzed **seismic waves from repeating earthquakes** over the last six decades.
- By analysing changes in the time and propagation of these signals, they could estimate **the rotation of the inner core**, which is believed to move independently from the mantle and rest of the planet.

➢ **Findings:**

- The inner core started rotating slightly faster than the rest of the planet in the early 1970s. But it had been slowing down before coming in sync with Earth's rotation around 2009.
- There has been a **"negative trend",** meaning the inner core is now rotating slower than the surface. Next change may occur in the mid-2040s.
- The results seem to indicate that **the Earth's inner core changes its speed of rotation every 60-70 years on average**.

➢ **Significance:**

- The Study can motivate **some researchers to build and test models which treat the whole Earth as an integrated dynamic** system.
- The slowdown could change how rapidly the entire planet spins, as well as influence how the core evolves with time.

How is the Earth's Inner Core?

➢ **About:**

- It is the innermost layer of the Earth. It is a hot iron ball of the size of Pluto.
- The inner core is **solid due to the pressure caused by the weight put** on it by the Earth's other top layers.
- It is distinct **from the outer core, which is a liquid.**
- Roughly 5,000 kilometers (3,100 miles) below the surface we live on, the inner core **can spin independently because it floats in the liquid metal** outer core.

➢ **Radius:**

- The inner core has an average radius of 1220 km.
- The boundary between the inner and outer cores is located at approximately 5150 km below the surface of the Earth.
- This boundary is called the **Lehman Seismic Discontinuity**.

➢ **Temperature:**

- Between **7,200–8,500ºF (4,000–4,700ºC).**

➢ **Properties:**

- It is predicted to have **very high thermal and electrical conductivity.**

What are the Three Layers of Earth?

➢ **Crust:** This is the outside layer of the earth and is made of solid rock, mostly basalt and granite.

➢ **Mantle:** It lies below the crust and is up to 2900 km thick. It consists of hot, dense, iron and magnesium-rich solid rock.

➢ **Core:** It is the center of the earth and is made up of two parts: the liquid outer core and solid inner core. The outer core is made of nickel, iron and molten rock.

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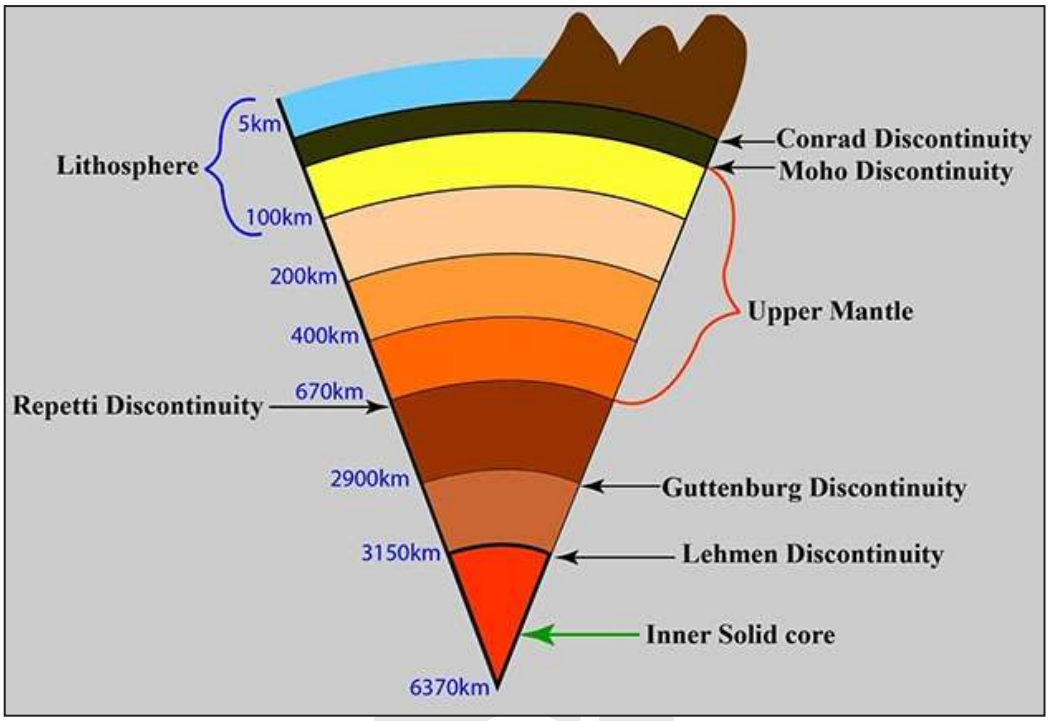


Earthquakes in Turkey and Causes

Why in News?

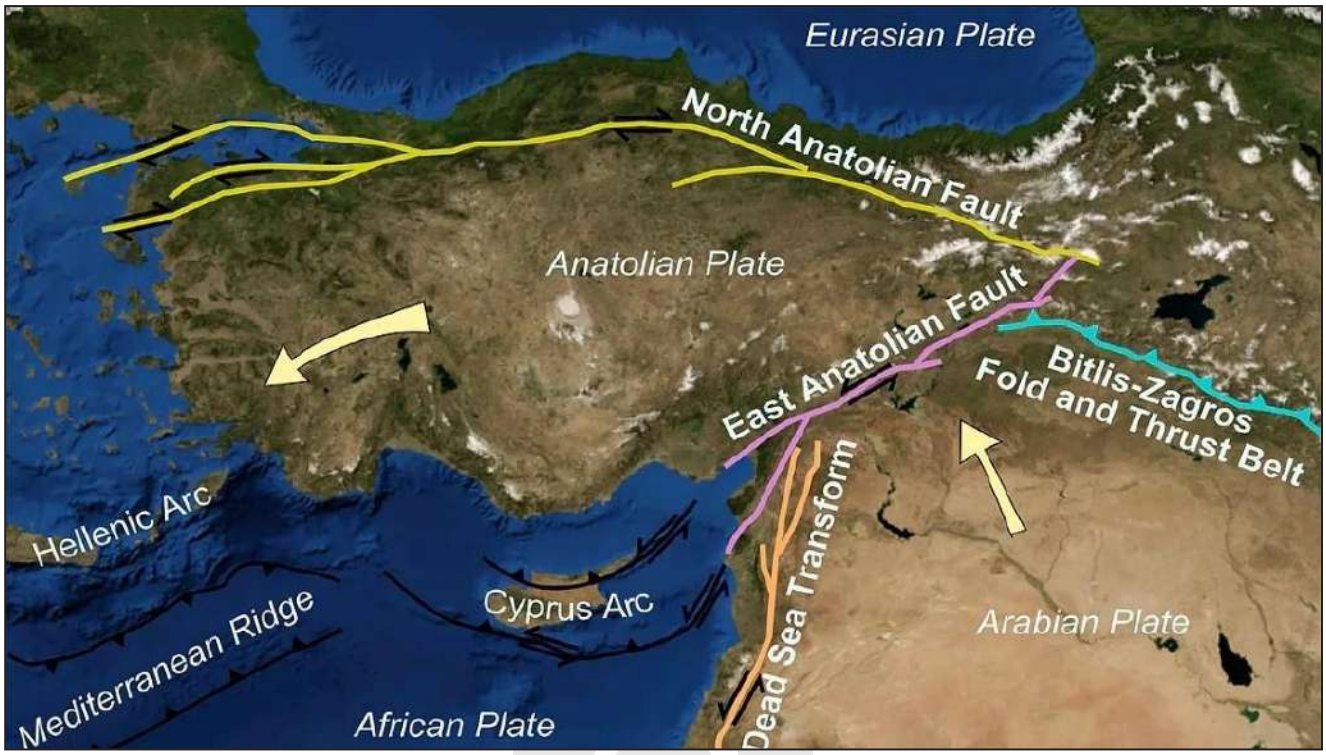
Recently, powerful tremors were felt in Turkey after an earthquake **of magnitude 7.8 struck along a well-known fault line called the Anatolia tectonic block.**

- The earthquakes emerged from relatively shallow depths and **were a "strike-slip quake"**.
- It is being described as the strongest Earthquake that Turkey has experienced in over a century and the worst disaster since 1939. The **1939 earthquake was the Erzincan Earthquake** that had caused "extreme damage in the Erzincan Plain and the Kelkit River Valley.

What Makes Turkey Prone to Earthquakes?

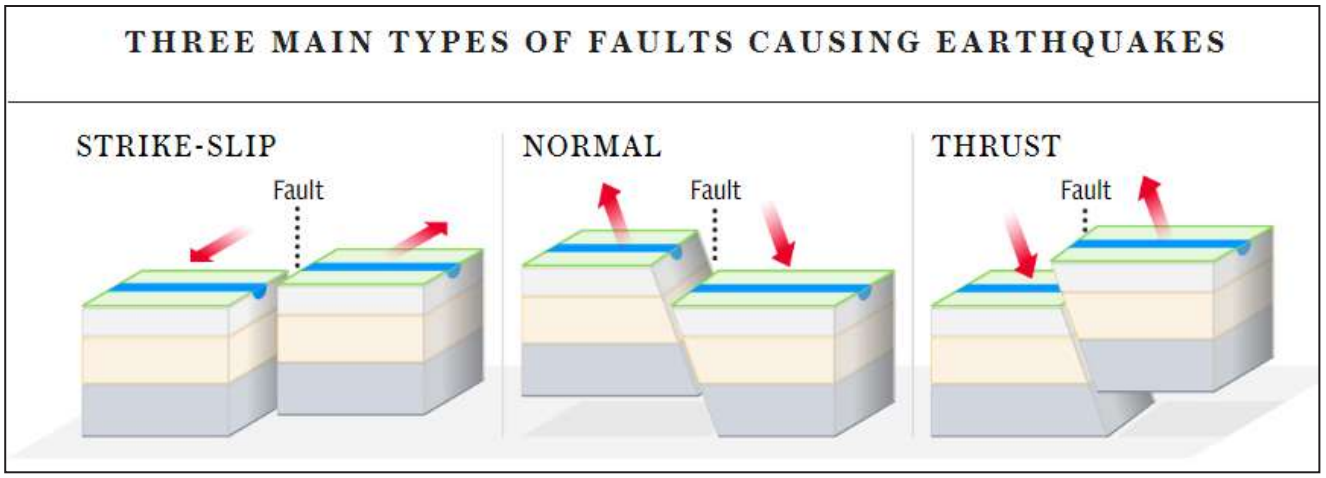
- In the Eastern Mediterranean region comprising **Turkey, Syria and Jordan,** tectonics are dominated by **complex interactions between the African, Arabian, and Eurasian tectonic plates**, and the **Anatolian tectonic block.**
- Turkey sits on the Anatolian tectonic plate, which borders two major faults, the **North Anatolian Fault (NAF) that cuts across the country from west to east,** and the East Anatolian Fault (EAF) in the southeast.
  - The NAF line is the meeting point of the **Eurasian and Anatolian tectonic plates that** is known to be "Particularly Devastating".
    - NAF is **right-lateral strike-slip structure** in northern Turkey accommodating much of the translational motion of the Anatolia block westwards with respect to Eurasia and Africa.
    - The EAF is the **tectonic boundary between the Anatolian Plate and the northward-moving Arabian Plate**. It runs 650 kilometers from eastern Turkey and into the Mediterranean.
- In addition to this, the **Aegean Sea Plate,** located in the eastern Mediterranean Sea under southern Greece and western Turkey, **is also a source of seismic activity in the region.**
- According to one estimate, almost **95% of Turkey's land mass is prone to earthquakes,** while about a third of the country is at high risk, including the areas around the major cities of **Istanbul and Izmir and the region of East Anatolia.**

Note:



How is Regular Earthquake is Different from Strike Slip Earthquake?

- **Plate Movement:** In a strike-slip earthquake, two tectonic plates **move horizontally past each other,** whereas in a regular earthquake, the movement is vertical.
  - Fault Zones, Tectonic Earthquakes, Volcanic Earthquake, Human Induced Earthquakes are the different **types of Earthquakes.**
- **Fault Type and Location:** Strike-slip earthquakes occur along transform boundaries such as the San Andreas Fault in California while regular earthquakes **occur along divergent or convergent plate boundaries** where the plates move vertically such as along the **Pacific "Ring of Fire.**
- **Causes:** The cause of strike-slip fault earthquakes is due to the movement of the two plates against one another and the release of **built-up strain.**



Note:

Do Shallow Earthquake Cause Greater Damage?

- A shallow earthquake is an earthquake that **occurs at a shallow depth, usually within the Earth's crust,** near the surface. They typically have **a depth of less than 70 km and can result in strong ground shaking** and surface faulting.
- They are **often more damaging than deep earthquakes** because the energy from the seismic waves is released **closer to the surface, leading to stronger ground motion** and more intense shaking.
  - This can cause damage to buildings and infrastructure, as well as triggers landslides, rockfalls, and other secondary hazards.
- However, the amount of damage caused by an earthquake **depends on a number of factors, including the magnitude of the earthquake**, the distance from the epicenter, the depth of the earthquake, the type of soil and geological conditions at the surface.

India's Earthquake Preparedness

Why in News?

A severe earthquake followed by an almost **equal magnitude aftershock hit southeastern Turkey and Syria** on February 6, 2023, causing widespread destruction and loss of life.

- The Turkey-Syria earthquake should motivate a review of **India's earthquake preparedness,** as **poor enforcement of zoning and construction rules** is prevalent in the country.

What Makes India Susceptible to Earthquakes?

- **About:**
  - India's terrain is **prone to great earthquakes,** particularly in the Himalayan plate boundary**,** which has the potential for large quakes (**magnitude 7 and above)**.
  - In India, earthquakes are primarily caused by the collision of the **Indian Plate with the Eurasian Plate.**
    - This collision has resulted in the formation of the **Himalayas**, as well as frequent earthquakes in the region.
- **Seismic Zones:**

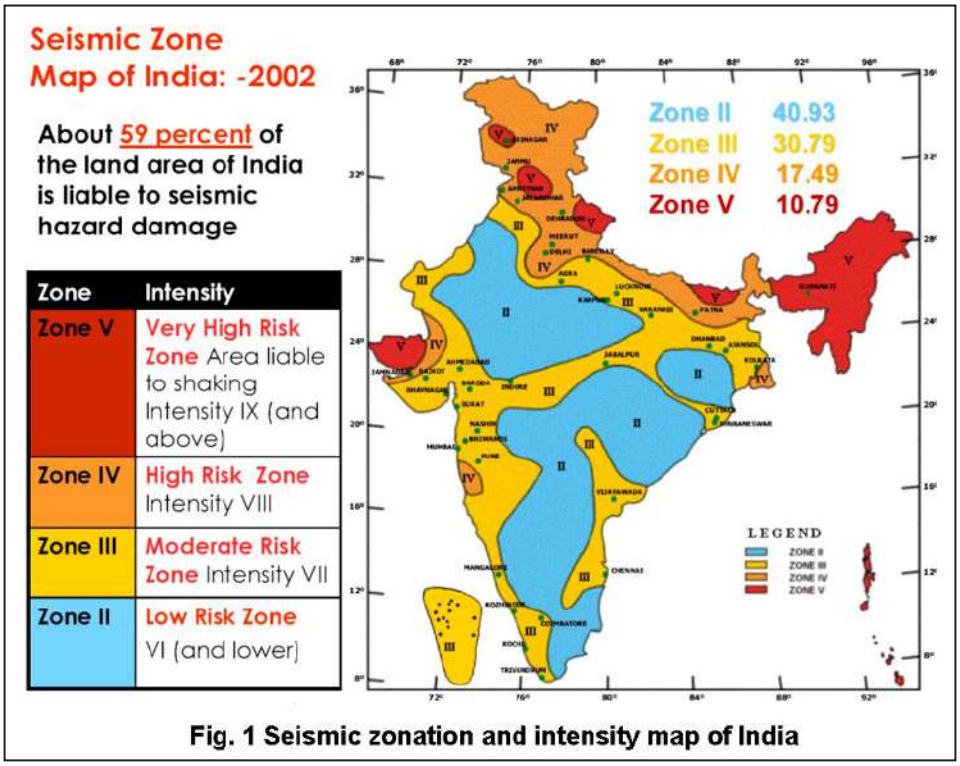


Fig. 1 Seismic zonation and intensity map of India

Note:

- **Susceptibility of Major Earthquakes:**
  - Scientists are aware of identifiable **seismic gaps** along the Himalayan axis where the historical **release of geological tension** doesn't fully account for the strain that has built up.
    - For instance, the **Central Himalaya has been historically deficient in earthquakes compared to other areas**. So, it's **one region that can reasonably be expected to generate a large earthquake** in the future.

Note: Seismic Gap is the part of an active fault that has experienced little or no seismic activity for a long period, indicating the buildup of stresses that are useful in predicting earthquakes.

- **Earthquakes In/Around India:**
  - India has experienced several significant earthquakes over the years, here are some examples:

Number	Place	# of Deaths	Date, Time, and Year	Magnitude	Epicenter
1	Indian Ocean	> 283, 106	08:50, December 26th, 2004	9.1–9.3	West coat of Sumatra, Indonesia
2	Kashmir	130,000	08:50:38, October 8th, 2005	7.6	Muzaffarabad, Pakistan-administered Kashmir
3.	Bihar and Nepal	> 30,000	14:13, January 15th, 1934	8.7	South of Mount Everest
4.	Gujarat	20,000	08:50, January 26th, 2001	7.7	Kutch, Gujarat
5.	Kangra	> 20,000	06:10, April4th, 1905	7.8	Himalayas

- **Nepal Earthquake 2015:** On April 25, 2015, a **magnitude 7.8 earthquake** struck Nepal. The earthquake also had a significant impact in northern India.
- **Imphal Earthquake 2016:** On January 4, 2016, a magnitude **6.7 earthquake** struck the **northeastern Indian state of Manipur,** causing widespread damage.
- **Uttarakhand Earthquake 2017**: On February 6, 2017, a **magnitude 6.7** earthquake struck the northern Indian state of Uttarakhand.

GSI Discovers Lithium Resources in J&K

Why in News?

The Geological Survey of India has for the first-time established Lithium **'inferred' resources(G3)** of 5.9 million tonnes in **Salal-Haimana area of the UT of Jammu & Kashmir.**

What are Inferred Resources?

- The "inferred" mineral resource is a resource for which **quantity, grade and mineral content are estimated only with a low level of confidence**.
- It is based on information gathered from locations such as outcrops, trenches, pits, workings and drill holes that may be of **limited or uncertain quality**, and also of lower reliability from geological evidence.
- It is based on the classification from **United Nations International Framework Classification for Reserves/ Resources – Solid Fuels and Mineral Commodities of 1997 (UNFC-1997)**.

What is UNFC-1997?

- **UNFC-1997** is a system for the classification and reporting of reserves and resources of solid fuels and mineral commodities and provides a standardized, internationally recognized system for the reporting of reserves and resources.
  - It has been developed by **the UN Economic Commission for Europe.**
- It **promotes transparency and consistency in the reporting** of mineral and energy assets and ensures that geological, engineering, and economic information is used consistently.
  - It provides a **basis for comparing reserves and resources data** between countries and regions which is widely used by governments, industry, and financial institutions around the world.

Note:

- According to UNFC-1997, there are four stages of exploration for any mineral deposit:
  - **Reconnaissance (G4)**
  - **Preliminary exploration (G3)**
  - **General Exploration (G2)**
  - **Detailed Exploration (G1)**

What is Lithium?

- **About:**
  - Lithium (Li), sometimes also referred as **'White gold'** due to its high demand for rechargeable batteries, is a soft and silvery-white metal.
- **Extraction:**
  - Lithium can be extracted in different ways, depending on the type of the deposit — generally either through **solar evaporation of large brine pools**, or from **hard-rock extraction of the ore**.
- **Uses:**
  - Lithium is an important component of **electrochemical cells** used in batteries of EVs, Laptops, Mobiles etc.
  - It is also used in **thermonuclear reactions**.
  - **It is used to make alloys** with aluminium and magnesium, improving their strength and making them lighter.
    - **Magnesium-lithium alloy** - for **armour plating**.
    - **Aluminum-lithium alloys** - in **aircraft, bicycle frames and high-speed trains**.
- **Major Global Lithium Reserves:**
  - Chile > Australia > Argentina are top countries with Li reserves.
  - **Lithium Triangle: Chile, Argentina, Bolivia.**
- **Lithium Reserves in India:**
  - Preliminary survey showed estimated lithium reserves of 14,100 tonnes in a small patch of land surveyed in **Southern Karnataka's Mandya district.**
  - Other **potential sites:**
    - Mica belts in **Rajasthan, Bihar, Andhra Pradesh**.
    - Pegmatite belts in **Odisha** and **Chhattisgarh**.
    - **Rann of Kutch** in Gujrat.

How India Currently Fulfills its Lithium Demand?

- India is currently **dependent on imports for lithium cells** and batteries. **Over 165 crore lithium batteries** are estimated to have been **imported into India between FY17 and FY20** at an estimated import bill of upwards of $3.3 billion.
- The country's efforts to secure lithium sourcing agreements are seen as a move against imports from China, which is the major source of both raw materials and cells.
- India is perceived as a **late entrant into the lithium value chain**, entering at a time when the EV sector is expected to undergo significant disruption.
- **2023 is considered a turning point for battery technology,** with the potential for several improvements to the Li-ion technology.

What is the Significance of Discovery?

- **Assistance in Achieving Targets:**
  - India has pledged to reduce its emissions towards **net zero by 2070**, which requires the availability of lithium as a critical component in electric vehicle (EV) batteries.
  - The **Central Electricity Authority of India has estimated that the country will need 27 GW of grid-scale battery energy storage systems by 2030**, which will require massive amounts of lithium.
- Addressing Global Shortages:
  - The **World Economic Forum (WEF)** has **warned of global lithium shortages** due to rising demand for EVs and rechargeable batteries, which is estimated to reach 2 billion by 2050.
  - The world's supply of lithium is under strain due to the **concentration of resources in a few locations with** 54% of the world's Lithium reserves are found in **Argentina, Bolivia and Chile.**
  - The **International Energy Agency (IEA) predicts** that the world could face **lithium shortages by 2025**.

What is Geological Survey of India?

- Presently, GSI is an attached office to the **Ministry of Mines.** It was **set up in 1851 primarily to find coal deposits for the Railways.**
- Over the years, it has grown into a **repository of geo-science information** and also has attained the **status of a geo-scientific organization** of international repute.
- It is headquartered in **Kolkata** and has **six regional offices** located at Lucknow, Jaipur, Nagpur, Hyderabad, Shillong and Kolkata. Every state has a state unit.
- **Central Geological Programming Board (CGPB)** is an important platform of the Geological Survey of India (GSI) to facilitate discussion for synergy and to avoid duplication of work.

Note:

Groundwater Loss for the Indian Ganga Basin

Why in News?

A recent report, "Estimation of groundwater storage loss for the Indian Ganga Basin using multiple lines of evidence," estimates that groundwater **storage levels in the Ganga basin have been declining by 2.6 centimeters per year.**

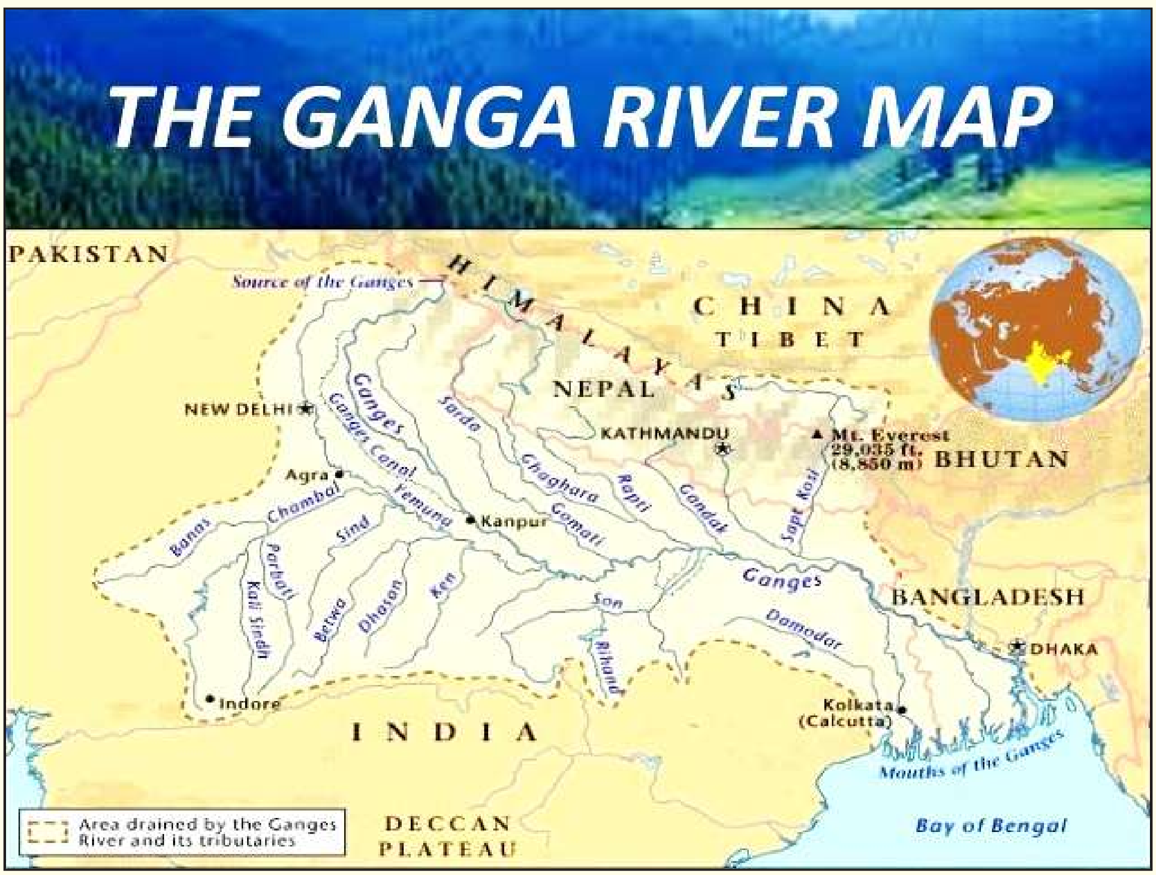
- The Ganga Basin's aquifers are one of the largest reservoirs of groundwater in the world.

What are the Findings?

- The average groundwater levels have been declining at a rate of **2.6 cm year^{-1} between 1996-2017**.
- The analysis of satellite data from the Gravity Recovery and Climate Experiment (GRACE), yielded **an average loss of 1.7 cm per year^{-1}.**
    - GRACE satellites, launched in 2002, assess Earth's water reservoirs over land, ice and ocean.
- The average storage decline in Uttar Pradesh, Bihar and West Bengal was estimated to be roughly 2 cm year^{-1}, 1 cm year^{-1} and 0.6 cm year^{-1}, respectively.
- The impacts were more pronounced in **Rajasthan, Haryana and Delhi,** with average storage declines of roughly 14 cm year^{-1}, 7.5 cm year^{-1} and 7.2 cm year^{-1}, respectively.
- West and southwest areas, including agriculturally intensive regions and urban areas like Delhi and Agra, **took the biggest hit.**
- Delhi and Haryana have high groundwater abstraction rates, which explains the steep decline.
- The Brahmaputra basin shows **more groundwater level reduction than the Ganga and Indus basins.**

What is the Ganga River System?

- It is the longest river of India flowing over 2,510 km of mountains, valleys and plains and is revered by Hindus as the most sacred river on earth.



Note:

- The Ganga basin outspreads in **India, Tibet (China), Nepal and Bangladesh** over an area of 10,86,000 Sq.km.
- In India, it covers states of **Uttar Pradesh, Madhya Pradesh, Rajasthan, Bihar, West Bengal, Uttarakhand, Jharkhand, Haryana, Chhattisgarh, Himachal Pradesh and Union Territory of Delhi** draining nearly 26% of the total geographical area of the country.
- It originates in the snowfields of the **Gangotri Glacier in the Himalayas.**
- At its source, the river is called as the Bhagirathi. It descends down the valley upto **Devprayag** where after joining another hill stream Alaknanda, it is called **Ganga.**
- The **principal tributaries** joining the river from **right** are the **Yamuna and the Son.**
- The **Ramganga, the Ghaghra, the Gandak, the Kosi and the Mahananda** join the **river from left.** The Chambal and the Betwa are the two other important sub- tributaries.
- The **Ganges River Dolphin is an endangered animal that specifically habitats this river.**
- The Ganga joins the Brahmaputra (Jamuna) in Bangladesh and continues its run under the name Padma.
- **The Ganga widens out into the Ganges Delta in the Sundarbans** swamp of Bangladesh, before it ends its journey by emptying into the Bay of Bengal.

Major Ports in India

Note:

Atmosphere and Its Layers

ATMOSPHERE AND ITS LAYERS

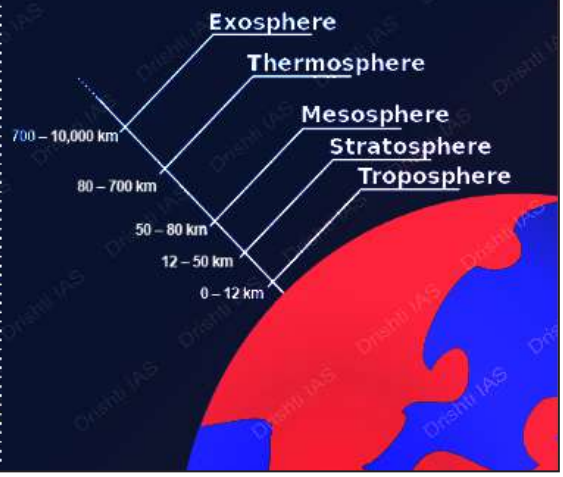
Drishti IAS

ATMOSPHERE

- One of the main components of Earth's interdependent physical system
- It is composed of about 78% nitrogen, 21% oxygen, and 1% other gases

LAYERS

- Troposphere:
  - Extends from Earth's surface upto 12 kilometers
  - The lowest part of the atmosphere- the part we live in
  - Temperature in the troposphere decreases with height
    - The top of the troposphere is called tropopause
  - Densest atmospheric layer
  - Contains about 75% of all of the air in the atmosphere, and 99% of water vapour (which forms clouds and rain)
- Stratosphere:
  - Located between 12 and 50 kilometers above Earth's surface
  - Contains much of the ozone in the atmosphere
    - Ozone molecules in this layer absorb ultraviolet (UV) radiation from the Sun, resulting in an increase in temperature
  - It is nearly cloud- and weather-free
  - It's the highest part of the atmosphere that jet planes can reach
- Mesosphere:
  - Located between about 50 and 80 kilometers above Earth's surface
  - The top of this layer is the coldest place found within the Earth system
  - It forms noctilucent clouds, the highest clouds in Earth's atmosphere
  - Most meteors burn up in this atmospheric layer
  - Sounding rockets and rocket-powered aircraft can reach the mesosphere
- Thermosphere:
  - Located between about 80 and 700 kilometers above Earth's surface
  - Its lowest part contains the ionosphere
  - The temperature of the thermosphere varies between night and day and between the seasons
  - The aurora borealis (northern) and aurora australis (southern) are sometimes seen here
- Exosphere:
  - Located between 700 and 10,000 kilometers above Earth's surface.
  - The highest layer of Earth's atmosphere.
  - There's no weather at all in this layer.
  - Most Earth satellites orbit in this layer.
  - At the bottom of the exosphere is a transition layer called the thermopause.



Note:

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States Demand to Declare Lightning as a Natural Disaster

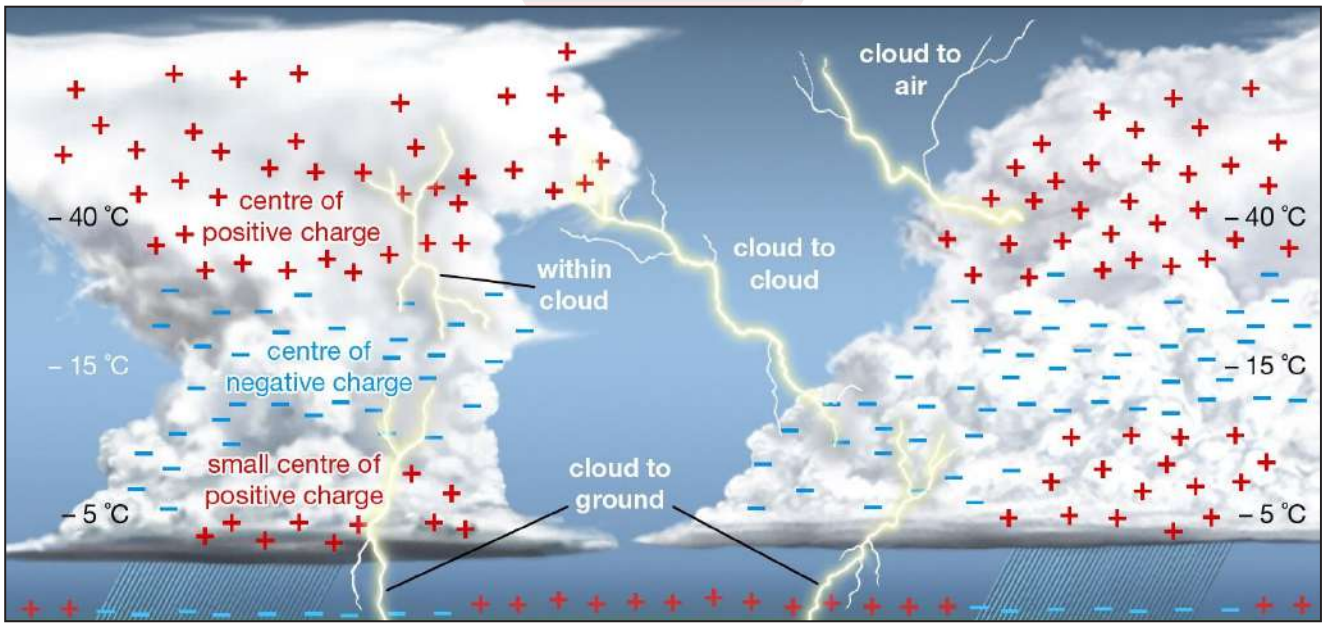
Why in the News?

Recently few States have demanded that "lightning" be declared as a "natural disaster" because deaths caused by it surpass any other disaster in India.

- According to present norms, cyclone, drought, earthquake, fire, flood, tsunami, hailstorm, landslide, avalanche, cloudburst, pest attack, frost and cold waves are considered as disasters that are covered under the State Disaster Response Fund (SDRF), 75% of which is funded by the Centre.

What is Lightning?

- **About:**
  - It is the natural process of "**an electrical discharge of very little duration and high voltage** between a cloud and the ground or within a cloud," accompanied by a bright flash, a loud sound, and occasionally thunderstorms.
  - **Cloud-to-ground (CG) lightning is dangerous** because it can electrocute people due to its high electric voltage and current. **Inter- or intra-cloud lightning** is visible and safe.
- **Process of Lightning:**
  - Lightning is **caused by a difference in electrical charge** between the top and bottom of a cloud, which generates a huge current of electricity.
  - Water vapor in the cloud condenses and rises, generating heat and pushing **water molecules further up until they become ice crystals**. Collisions between the ice crystals trigger the release of electrons, leading to a chain reaction that results in a positively charged top layer and negatively charged middle layer in the cloud.
  - When the difference in charge becomes large enough, **a huge current of electricity flows between the layers**, producing heat that causes the air column to expand and produce shock waves that create thunder sounds.



- **Lightning and the Climate Change:**
  - In a 2015 study from California University, the university cautioned that **a rise in one degree Celsius would result in a 12% increase in the frequency of lightning strikes.**
  - Another study that was released in Geophysical Research Letters in March 2021 found connections between climate change and an increase in lightning strikes in the Arctic.

Note:

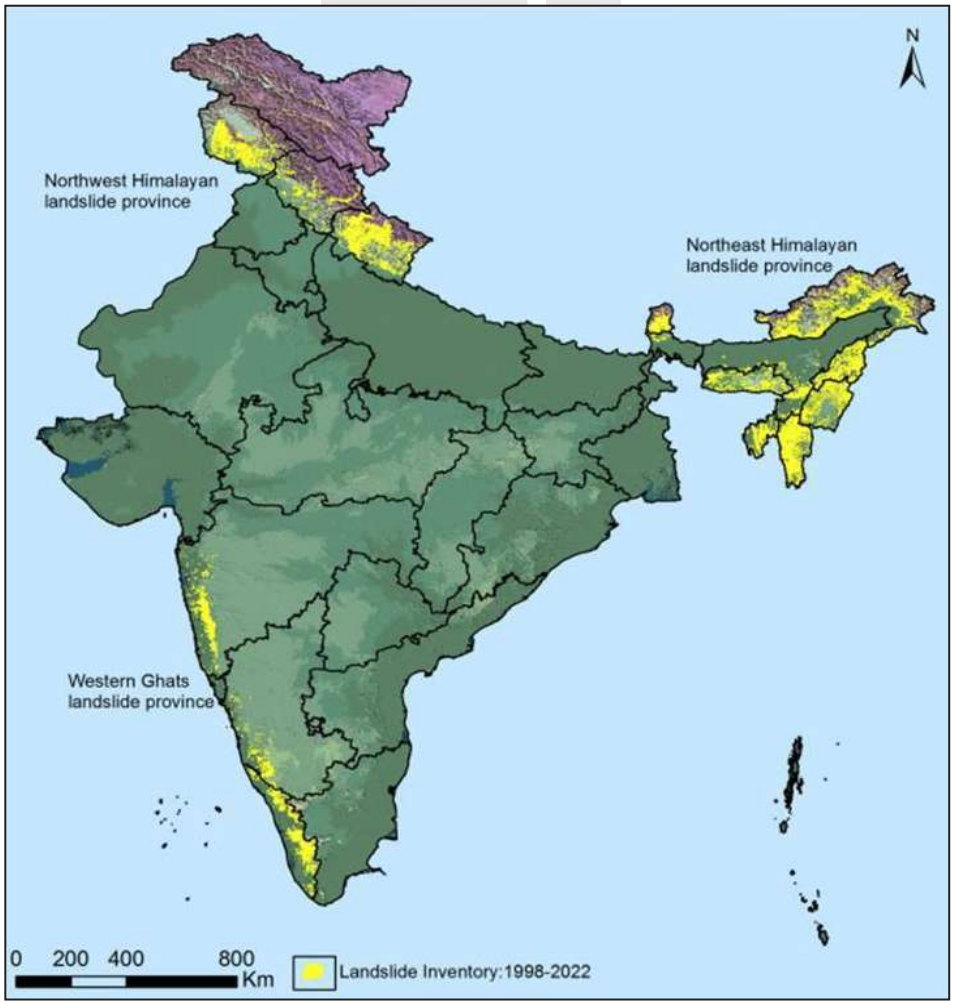
- **Lightning Strikes in India:**
  - According to a newly published yearly report on lightning from the **Lightning Resilient India Campaign (LRIC)**, India may have seen up to 18.5 million lightning strikes between April 2020 and March 2021.
  - Each year, lightning claims the lives of more than 2,500 Indians.
  - According to a study by the Delhi-based RMSI, a global leader in geospatial and engineering solutions, **Odisha, Madhya Pradesh, Chhattisgarh, West Bengal, and Jharkhand** have witnessed the maximum lightning strikes in recent years.
  - According to government statistics, **more than 100,000 individuals** have died in the nation as a result of lightning strikes **between 1967 and 2019.** This represents more than a third of the deaths brought on by natural disasters throughout this time.

Landslide Atlas of India

Why in News?

Recently, **National Remote Sensing Centre (NRSC)** under the **Indian Space Research Organisation (ISRO)** has released the **Landslide Atlas of India**, a detailed guide **identifying Landslide Hotspots in the country.**

- NRSC has the **mandate for** remote sensing satellite data acquisition, processing, archiving, and dissemination to various users.



Note:

How was the Atlas Prepared?

- For the first time, scientists **did a risk assessment on the basis of 80,000 landslides** recorded between **1998 and 2022** in 147 districts in 17 states and two **Union Territories** to build a "Landslide Atlas" of the country.
- The atlas used satellite data of **ISRO to map all seasonal and event-based landslides like the Kedarnath disaster in 2013** and landslides triggered due to the Sikkim earthquake in 2011.
- The pan-India landslide database classifies landslides into – seasonal (2014, 2017 monsoon seasons), event-based and route-based (2000 – 2017).

What are the Key Highlights?

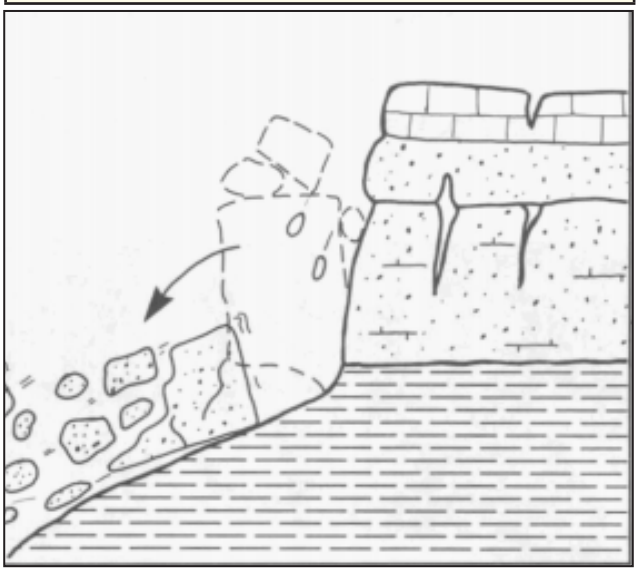
- Uttarakhand, Kerala, Jammu and Kashmir, Mizoram, Tripura, Nagaland and Arunachal Pradesh reported the **highest number of landslides during 1998 – 2022.**
- Mizoram topped the list, recording 12,385 landslide events in the past 25 years, of which 8,926 were recorded in 2017 alone.
- Mizoram is followed by Uttarakhand (11,219) and Kerala.
  - Uttarakhand's fragility was recently exposed during the **land subsidence** events reported from Joshimath.
- The number of **districts with the maximum landslide exposure** are in Arunachal Pradesh (16), Kerala (14), Uttarakhand and Jammu and Kashmir (13 each), Himachal Pradesh, Assam and Maharashtra (11 each), Mizoram (8) and Nagaland (7).
  - Rudraprayag and Tehri Garhwal districts of Uttarakhand have the **highest landslide density and landslide risk exposure** in the country.

How Vulnerable India is to Landslides?

- India is considered **among the top five landslide-prone countries globally**, where at least **one death per 100 sq km is reported in a year** due to a landslide event.
  - **Rainfall variability** pattern is the **single biggest cause for landslides in the country**, with the **Himalayas** and the **Western Ghats** remaining highly vulnerable.
- Excluding snow covered areas, approximately 12.6 % of the country's geographical land area is prone to landslides. As many as 66.5 % of the landslides are reported from the **North-western Himalayas**, about 18.8 % from the North-eastern Himalayas, and about 14.7 % from the Western Ghats.
- In the Western Ghats, **despite fewer events**, landslides were found to be making **inhabitants significantly vulnerable** to fatalities, especially in Kerala.

What causes landslides?

- **About:**
  - Landslides are **natural disasters occurring mainly in mountainous terrains** where there are conducive conditions of soil, rock, geology and slope.
  - A **sudden movement of rock, boulders, earth or debris down a slope** is termed a landslide.
- **Causes:**
  - Natural causes that trigger it include **heavy rainfall, earthquakes, snow melting and undercutting of slope**s due to flooding.
  - They can also be caused by **anthropogenic activities such as excavation, cutting of hills and trees**, excessive infrastructure development, and overgrazing by cattle.
  - Some of the main factors that influence landslides are **lithology, geological structures like faults, hill slopes, drainage, geomorphology**, land use and land cover, soil texture and depth, and weathering of rocks.
  - All these are factored in when a **landslide susceptibility zone is earmarked for planning and making predictions.**



Note:

Glacial Retreat

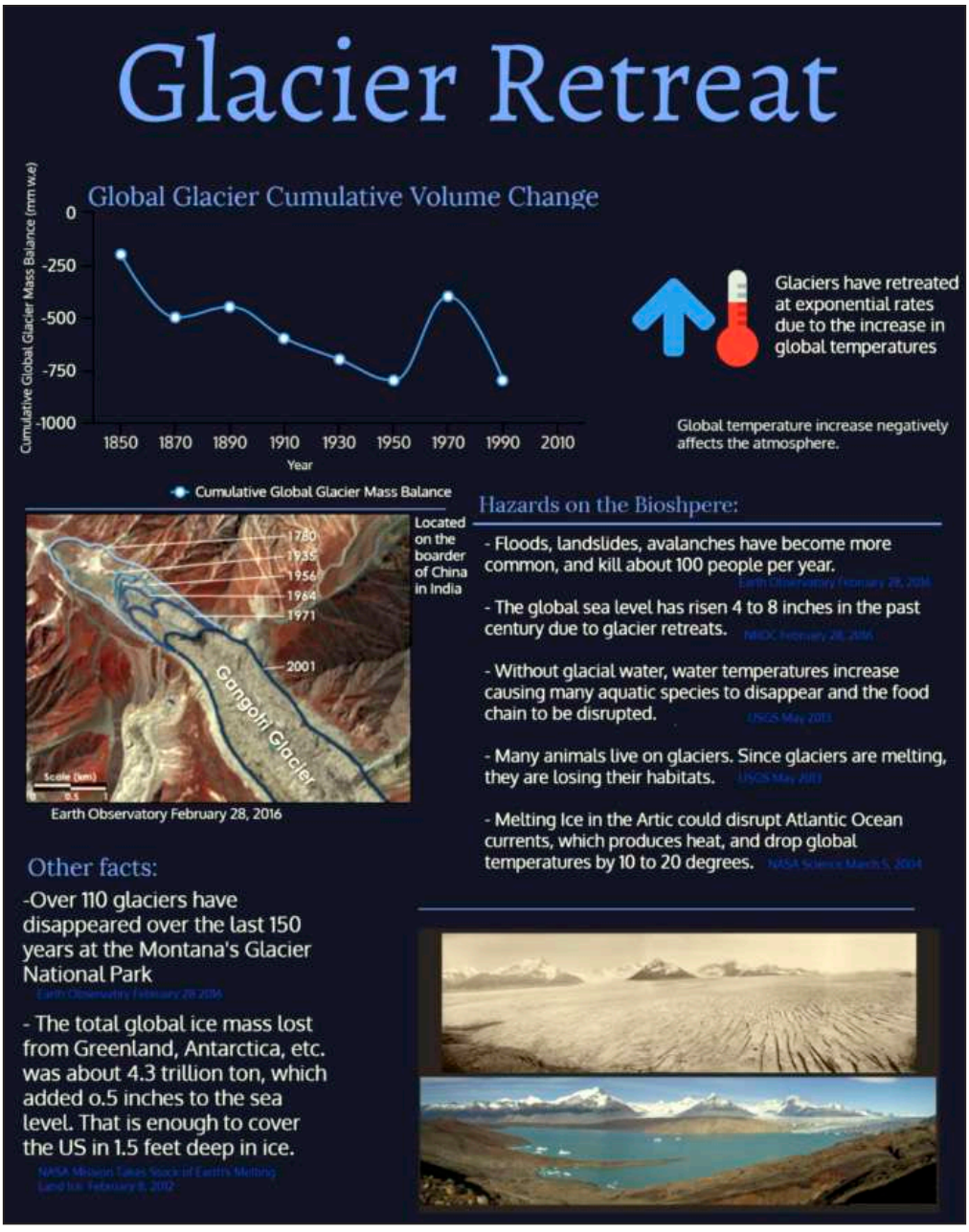
Why in News?

Recent studies on Himalayan glaciers show that the **variability in retreat rate and mass balance** in different sectors of the mountain range is primarily linked to **topography** and **climate.**

- However, **variable retreat rates of glaciers** and inadequate supporting field data make it **challenging to develop a coherent picture of climate change impact.**

What are the Factors Influence Glacial Dynamics?

- A team from **Wadia Institute of Himalayan Geology** (Uttarakhand) studied two glaciers with different characteristics, the **Pensilungpa Glacier (Ladakh) and the Durung-Drung Glacier, (Ladakh)** for a comparative study of glacier fluctuations between **1971 and 2019**.
  - They quantitatively evaluated the influence of the **debris cover on the loss of ice mass** in summer and on the terminal recession of glaciers.



Note:

- Their study confirms that the **glacier retreat rate is controlled by climate change** and the **topographic setting and morphology of the glacier.**
  - They also found that the **thickness of the debris cover significantly alters the glacier response** to climate forcing.
- Other factors such as **snout geometry, glacier size, elevation range, slope, aspect, debris cover, as well as the presence of supra and proglacial lakes** also influence the heterogeneous glacial dynamics.

What is Glacial Retreat?

- **About:**
  - Glacial retreat refers to the **process of a glacier shrinking or receding in size** over time due to a decrease in ice accumulation or an increase in ice melt.
- **Causes:**
  - This can be caused by a number of factors, including **rising global temperatures, changes in precipitation patterns,** or changes in the geography of the surrounding landscape.
- **Impacts:**
  - As a glacier retreats, it can lead to a number of significant environmental impacts, including **changes in water availability, alterations to local ecosystems, and increased risk of natural disasters** such as **floods** and **landslides.**
  - In addition, the **loss of glacial ice can contribute to rising sea levels,** which can have significant impacts on coastal communities and **ecosystems** around the world.

Tapping into Helium Reserves

Why in News?

Researchers propose a **new model to tap into helium reserves to address shortage issues and** a recent new study suggests that reservoirs of this gas, with no **carbon footprint**, likely exist in geological formations beneath the Earth.

- The helium production process comes with a high carbon footprint as **its production is related to drilled natural gas or oil.**

What is the Proposed Model to Tap Helium Reserve?

- The **gas can be produced and stored in crystalline basement rocks,** dense rocks that extend from the mantle to the near-surface or surface.
  - These rocks naturally contain **uranium and thorium**, both of which decay to form helium naturally.
- These rocks are **30-40 kilometre thick.** They have also existed for millions or billions of years, allowing large amounts of helium to be produced and stored.
- Also, these rocks could also be a source of hydrogen. The model showed that **energy generated from the radioactive decay of uranium and thorium** could split water to form hydrogen.

What is the Significance of Helium Gas?

- **About:**
  - Helium is a **noble gas and has a closed-shell electronic configuration,** making it stable and unreactive.
  - It has the **lowest boiling and melting points of any element** and exists only as a gas, except under extreme conditions.
- **Discovery of Helium:**
  - Helium was **first discovered in 1868 by French astronomer Jules Janssen and English astronomer Joseph Norman Lockyer,** who observed a yellow spectral line in the light emitted by the sun during a solar eclipse.
    - Helium gets its name from the **Greek word "helios," which means sun.**
- **Sources and Extraction of Helium**:
  - Helium is the **second most abundant element in the universe,** after hydrogen. However, **it is relatively rare on Earth, with most of it being produced by the decay of radioactive elements** in the Earth's crust.
  - **Natural gas is the primary source of helium on Earth**.
    - Helium is extracted from natural gas using a process called **cryogenic distillation.**
- **Reserves and Production:**
  - As of 2022, the reserves of helium in the **United States has the largest reserves of helium** globally followed by Algeria and Russia.

Note:

- **India's Rajmahal volcanic basin in Jharkhand** is the **storehouse of helium** trapped for billions of years.

➢ **Uses of Helium:**

- **Balloons and airships** (because it is lighter than air and does not react chemically with other elements).
- **Industrial applications**, including **welding, cooling, and as a protective gas** in the production of semiconductors and fiber optic cables.
- In **medical applications**, such as **magnetic resonance imaging (MRI)**, as a cooling agent for superconducting magnets.
- It is also used in **nuclear magnetic resonance (NMR)** spectroscopy and as a carrier gas in gas chromatography.

➢ **Shortage of Helium:**

- There is currently a shortage of helium in the world, with **demand outstripping supply.**
- The shortage is due to a variety of factors, including the **shutdown of some helium plants, the increasing demand for helium in emerging economies**, and the lack of new helium sources.
- The shortage of helium has led to concerns about its use in balloons and airships, as well as its use in medical and industrial applications.

Hidden Mantle Layers

Why in News?

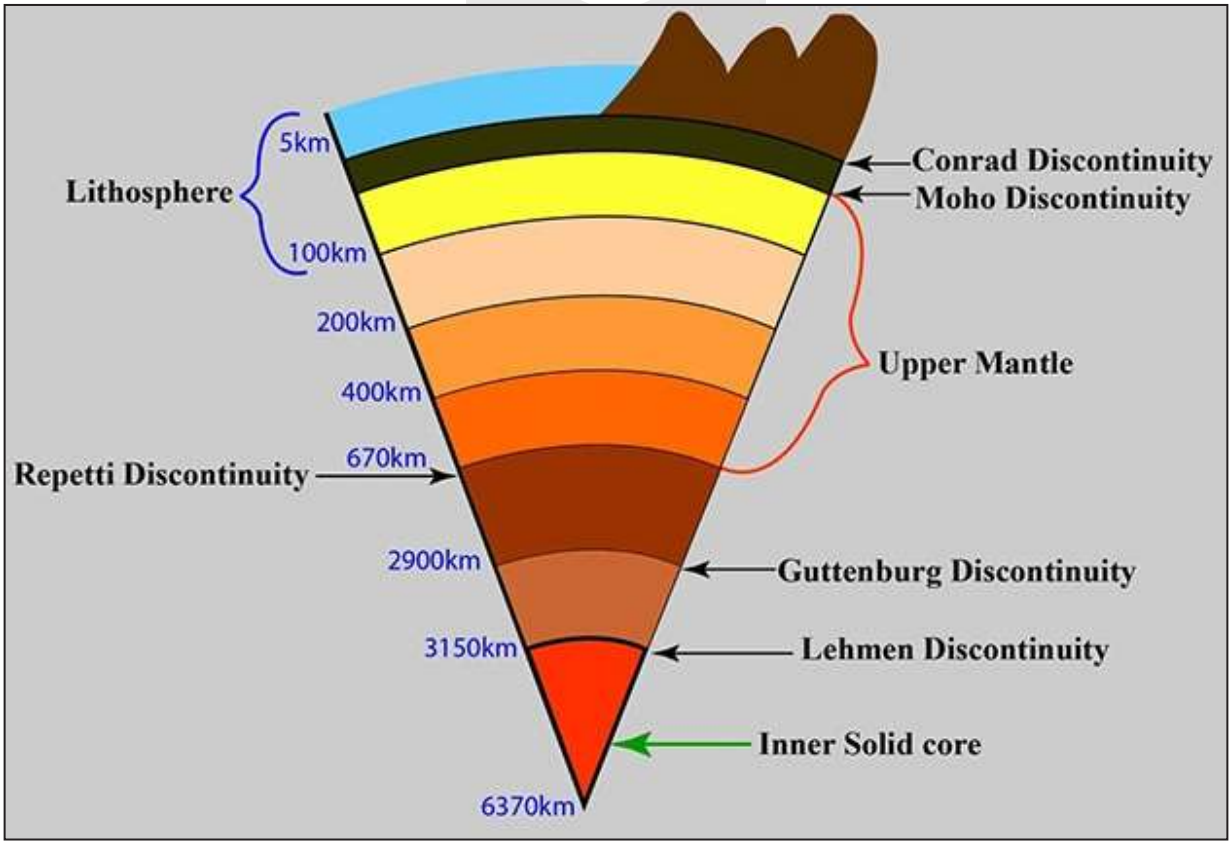
According to two new studies, the mantle, **a layer of solid rock sandwiched between the Earth's upper crust and lower core**, has been **hiding two new layers**.

What are the New Studies Suggest About Hidden Mantle Layers?

➢ The **first layer is a low viscosity zone in the upper mantle**, approximately **100 kilometres thick,** which was discovered by **studying deep earthquakes** (2018 Fiji earthquake of 8.2 magnitude) **using GPS sensors.**

➢ The **second layer is a partially molten layer that extends from 90 km to 150 kilometre**s and sits below the tectonic plates.

- This layer was discovered by **analysing seismic waves from earthquakes** and suggests a higher temperature.



Note:

What is the Mantle Layer of Earth?

- **About:**
  - The Earth's mantle is a layer of solid rock that extends from the bottom of the crust to the top of the core, with a thickness of approximately **2,900 kilometres (1,800 miles).**
  - The mantle is the **largest layer of the Earth's interior, making up about 84% of the Earth's volume** and about 68% of its mass.
- **Composition:**
  - The mantle is **composed of silicate rocks rich in iron and magnesium**, and is divided into the upper mantle and the lower mantle.
- **Significance:**
  - The mantle is an important part of the Earth's structure and plays a critical role in the **geologic processes that shape the planet's surface,** such as **plate tectonics and volcanic activity.**
  - The mantle's viscous properties govern convection — the **transfer of heat between areas of different temperatures**.
    - The heat generated by the core is transferred through the mantle, which **drives the motion of the tectonic plates** on the Earth's surface.

Daylight Saving Time

Why in News?

Recently, the Lebanon Government has delayed the start of **Daylight-Saving Time (DST)** by a month. Meanwhile, Greenland has chosen to **stay with DST forever.**

- **Lebanon** usually sets its clocks forward an hour **on the last Sunday in March.** However, its Prime Minister said this year, the clocks **would be reset on 21 April, without citing any reason.**

What is Daylight Saving Time?

- According to Norway-based Time and Date, DST is the **practice of setting the clocks forward one hour** from the standard time during the summer and back again in the autumn.
- This is done to make **better use of natural daylight.** India does not follow daylight saving time as **countries near the Equator do not experience high variations** in daytime hours between seasons.

What is the Significance of DST?

- Those in favour of DST argue that **it means a longer evening daytime.** Individuals will complete their daily work routines an hour earlier, and that extra hour of daylight means **a lower consumption of energy.**
- In April 1916, during **World War I**, Germany and Austria introduced DST to minimise the use of artificial lighting. It gradually caught on in many countries.
  - In the EU, clocks in the 28 member states move forward on the last Sunday in March and fall back on the last Sunday in October.

What are the Disadvantages of DST?

- According to a study in Popular Science magazine in the US, one hour of lost sleep in the US increases the **fatal crash rate by 5.4% to 7.6%** for six days following the transition.
- Other studies found a **higher rate of workplace injuries after the switch**, leading to lost days of work; a slight drop in stock market performance; health problems as a result of disruption of the **Circadian Rhythm.**

Atmospheric Rivers

Why in News?

California has experienced an exceptionally wet winter with **11 atmospheric rivers battering the state** since late December 2022.

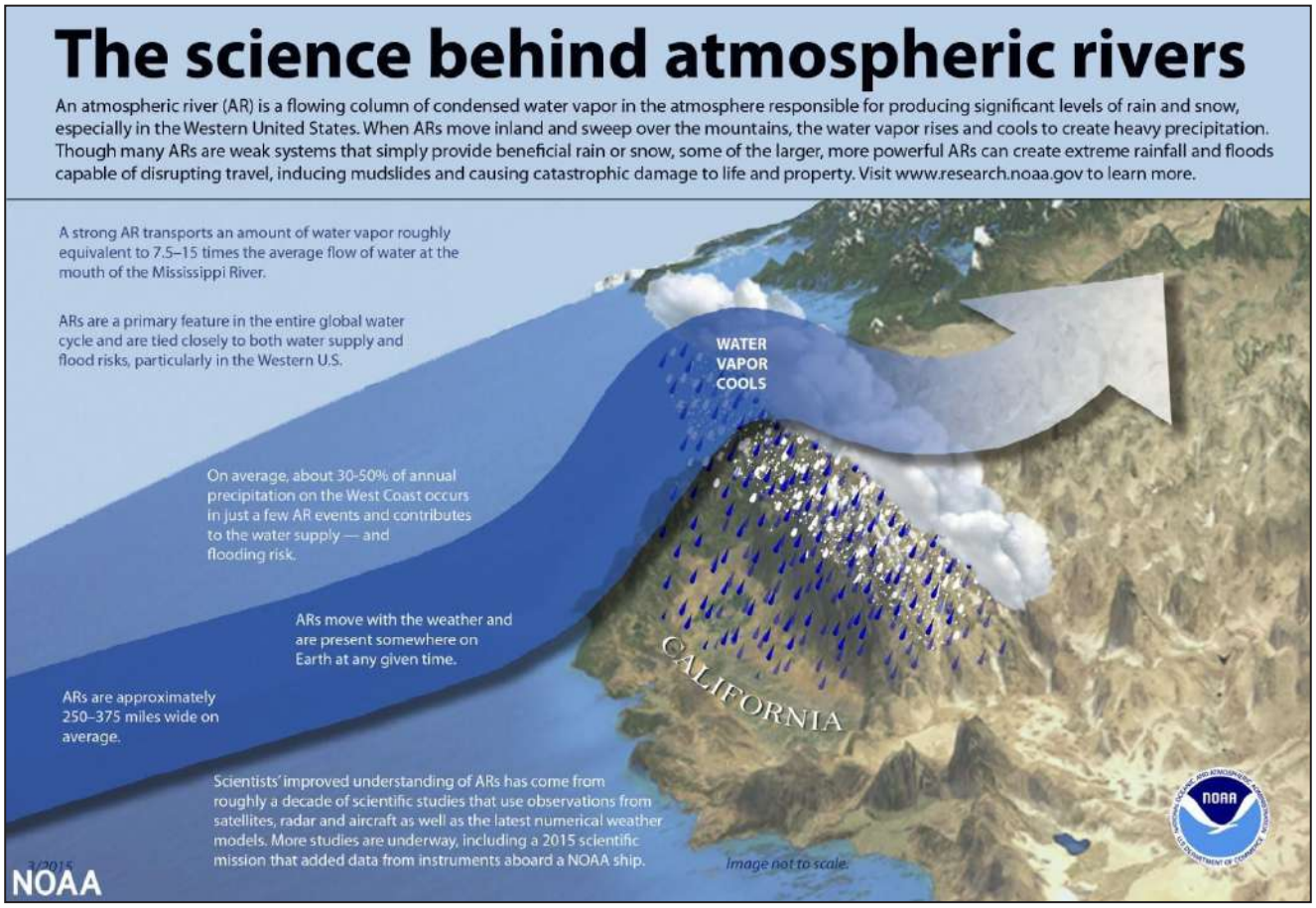
What are Atmospheric Rivers?

- **About:**
  - **Atmospheric rivers** are relatively long, narrow regions in the atmosphere – like rivers in the sky – that transport most of the water vapor outside of the tropics.
    - One well-known atmospheric river called the **"Pineapple Express"** picks up warm, moist air near Hawaii.
    - When the **Pineapple Express hits land in the Western United States and Canada**, it can cause heavy rain and snow. In California, it can cause up to 5 inches of rain in a day.
  - Atmospheric rivers typically occur **in the extratropical North Pacific/Atlantic, southeastern Pacific, and South Atlantic** oceans often making landfall on the west coasts of North and South America.

Note:

Other regions that experience atmospheric river landfalls include **Greenland, Antarctica, and the south-central United States.**

- **Formation**:
  - Atmospheric rivers usually begin over tropical regions. Warm temperatures cause **ocean water to evaporate and rise into the atmosphere.** Strong winds help to carry the water vapor through the atmosphere.
  - As atmospheric rivers move over land, the **water vapor rises up farther into the atmosphere.** It then **cools into water droplets, which fall as precipitation.**



- **Impacts:**
  - Heavy rainfall associated with ARs can cause **flooding, landslides, and mudslides.**
    - They can also lead to water supply disruption, and develop **drought-like conditions.**
- **Significance:**
  - Not all atmospheric rivers cause damage; most are weak systems that often **provide beneficial rain or snow that is crucial to the water supply.**
- **Climate Change:**
  - **Climate change** is **expected to increase the frequency and intensity of ARs** in some regions of the world, particularly in the mid-latitudes.
    - This could have significant implications for water resources management, flood control, and other areas of public policy.

Changing Western Disturbances

Why in News?

According to recent studies, the **changing character of Western Disturbances** might be the primary cause of the abnormal **winter seasons** in India.

- India has **not experienced a normal winter season in the past three years.** The second wettest season in the country after the **monsoons** has remained unusually **dry and hot.**

Note:

How Western Disturbances Affected Winters in India Recently?

- The northwest region of India, which receives almost **30% of its annual rainfall during the winter season,** saw an **83% and 76% rainfall deficit in December 2022 and February 2023 respectively.**
- The absence of Western Disturbances caused the north Indian plains to **experience severe cold waves and cold days in December 2022** and most of January 2023 **due to the cold northern winds flowing down from the Himalayas**.
- Western Disturbances are also responsible for hailstorms that **damage standing crops, fog events that interrupt air, rail and road services** and cloud bursts that result in **flash floods.**

What are Western Disturbances?

- **About:**
  - Western Disturbances are a series of **cyclonic storms that originate in the Mediterranean region, travel over 9,000 km to bring winter rains to northwest India.**
    - A Western Disturbance **collects moisture from the Mediterranean Sea, Black Sea, and Caspian Sea** and traverses over **Iran and Afghanistan before hitting the western Himalayas.**
  - While the storm systems occur throughout the year, they travel to India mostly between **December and April because the trajectory of the subtropical westerly jet stream**, which transports them, shifts during the winter months to the rim of the Himalayas.
    - For the rest of the year, the jet stream travels from above the **Himalayas to the Tibetan Plateau and China.** Its trajectory changes as per the position of the Sun**.**
- **Significance for India:**
  - Western Disturbances are the **primary source of snowfall that replenishes the Himalayan glaciers** during winter.
    - These glaciers **feed major Himalayan rivers like the Ganga, Indus and Yamuna** as well as myriad mountain springs and rivulets.
  - These low-pressure storm systems **help farmers in India grow their rabi crop.**
- **Issues:**
  - The Western Disturbances are **not always the harbingers of good weather**. Sometimes WDs can cause **extreme weather events like floods, flash floods, landslides, dust storms, hail storms** and cold waves, destroying infrastructure and impacting life and livelihoods.

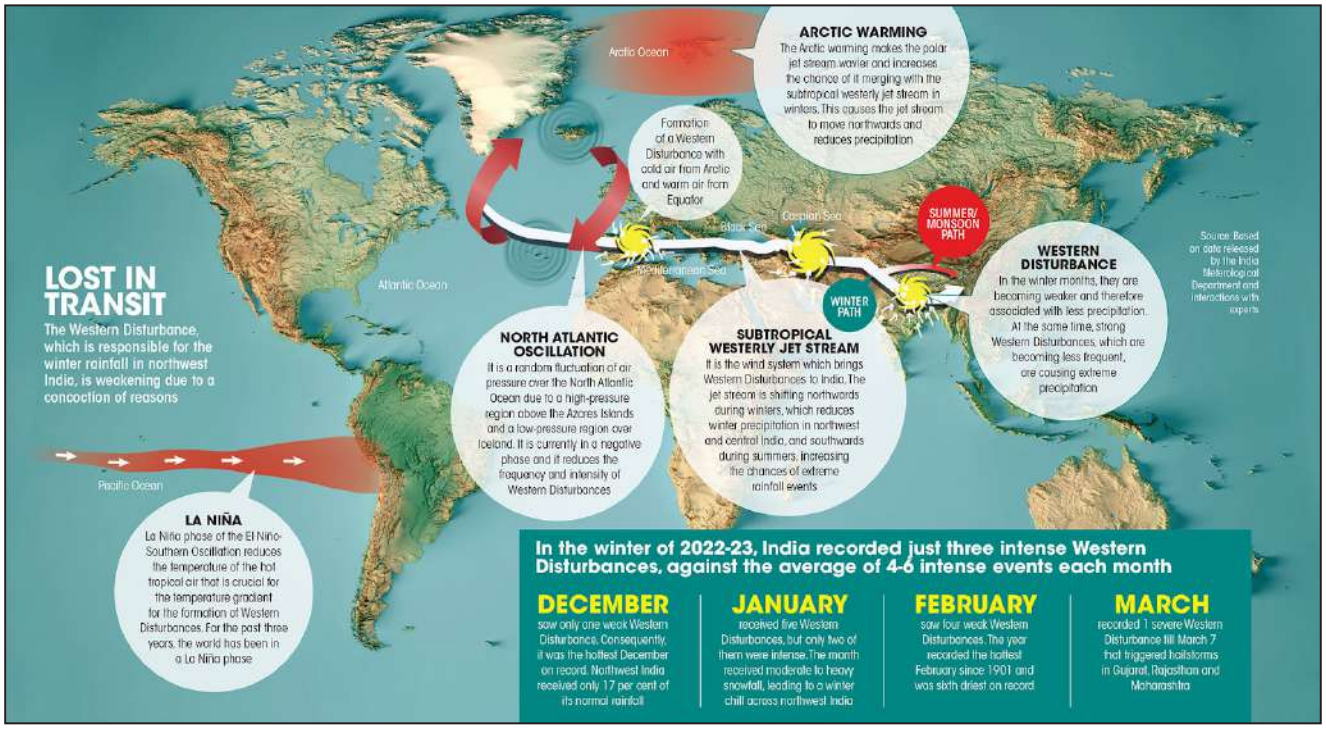
How Western Disturbances are Affected by Other Climatic Phenomena?

- **La Nina Event:**
  - For the past three years, the world has been in a La Niña phase, which refers to the **cooling of ocean surface temperature in the Pacific Ocean.**
    - It **weakens the temperature gradient for the formation of Western Disturbances** as it reduces the temperature of the hot tropical air.
- **North Atlantic Oscillation:**
  - Western Disturbances are also influenced by the **North Atlantic Oscillation**, a **random fluctuation of air pressure over the North Atlantic Ocean** due to a high-pressure region above the **Azores Islands in the central North Atlantic and a low-pressure region over Iceland.**
    - Due to this, the weather system is currently in a negative phase, as both **low- and high-pressure systems are weak**, and it makes Western Disturbances 20% less frequent and **7% less intense than a positive phase.**
- **Subtropical Jet Stream:**
  - The **northward shift of the subtropical westerly jet stream** not only reduces the chance of Western Disturbances **striking India but also increases the chance of them affecting higher latitudes such as the Tibetan Plateau** or even as far up as China and Russia.
    - This could indirectly affect the southwest monsoon, which accounts for **80 % of India's annual rainfall.**
- **Interaction with Southwest Monsoon:**
  - The **warming of the Arctic region makes the polar front jet wavier,** causing **Western Disturbances to visit India more frequently during summers.**
  - Western Disturbances during **summer, monsoon, and post-monsoon periods increase the chances**

Note:

of them interacting with the southwest monsoon and other associated local convection systems such as tropical depressions that travel northward from either the Bay of Bengal or the Arabian Sea.

- Such interactions can cause catastrophic weather disasters.
- For instance, In May 2021**, a remnant of the extremely severe cyclone Tauktae, which made landfall along the Gujarat coast**, travelled all the way to Delhi and **interacted with a Western Disturbance to cause heavy rainfall in Delhi and its vicinity.**



Vernal Equinox

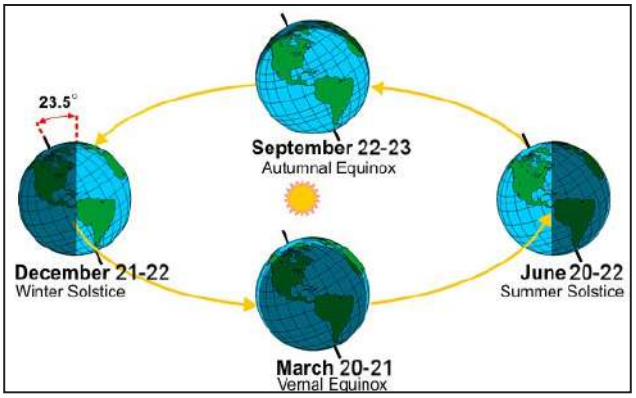
Why in News?

The vernal equinox is observed on March 21st 2023.

What is Equinox?

➢ **About:**

- Equinox happens twice a year when the sun is directly above the equator, and it **occurs on approximately 21st March and 23rd September.**
- During an equinox, both the Northern and Southern Hemispheres **have equal day and night time.** The **vernal equinox (spring equinox) takes place in the Northern Hemisphere around 20th or 21st March**, while in the Southern Hemisphere, it happens on 22nd or 23rd September.
- Conversely, during the autumn season in the Northern Hemisphere on 23rd September (autumn equinox), it is springtime in the Southern Hemisphere, and on **21st March, it is the opposite.**



➢ **Significance:**

- As a result, the Sun is located directly above the equator, and **both hemispheres receive an almost equal amount of sunlight.**
- After the spring equinox, **the northern hemisphere tilts closer to the sun in March, resulting in more hours of daylight**, with earlier sunrises and later sunsets.

Note:

- According to Hindu astrology, Vernal Equinox is known as Vasant Vishuva or Vasant Sampat.
- The Spring equinox brings earlier sunrises, later sunsets, and sprouting plants in the northern hemisphere.
- **Later sunrises, earlier sunsets,** chillier winds, and dry and falling leaves are observed in the south of the **equator (southern hemisphere).**

Gandak River

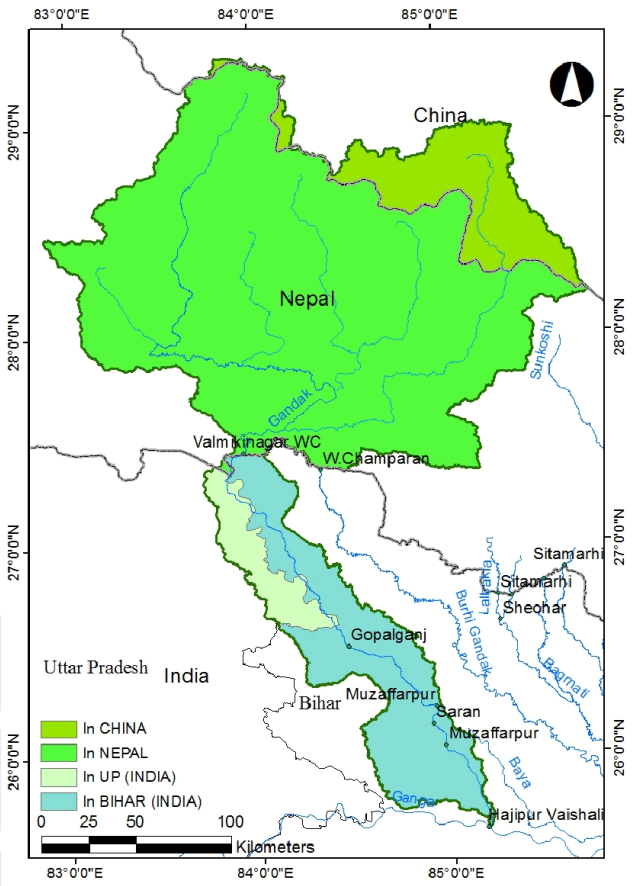
Why in News?

Recently, under **Namami Gange Program,** the development of **river front** on **Gandak River** in the district of Gopalganj, Bihar has been undertaken and two Ghats have been constructed.

- River Gandak was declared as **National Waterway (NW)-37** from Bhaisalotan Barrage to Gandak and Ganga River confluence at Hajipur, Bihar along with **111 NWs in the country vide National Waterways Act, 2016.**

What are the Key Facts about River Gandak?

- **About:**
  - The river Gandak, is also known as the **Gandaki and Narayani River in Nepal**. It is a significant river that flows through the **northern part of India and Nepal.**
  - Valmiki National Park and Tiger Reserve in Bihar is located on the banks of this river.
- **Source:**
  - The river Gandak originates at an altitude of 7620 m above main sea level in the **north of Dhaulagisi in Tibet near Nepal border.** Originating from the Himalayas, the river stretches over a length of 630 kilometers, with 445 kilometers running through India and 185 kilometers in Nepal.
- **Drainage Basin**:
  - The Gandak River has a total drainage basin area of 29,705 square kilometers.
  - The river **flows through the Indian states of Bihar and Uttar Pradesh,** and joins the Ganges near Patna just downstream of Hajipur.
- **Tributaries:**
  - The major tributaries of the Gandak River include the Mayangadi, Bari, Trisuli, Panchand, Sarhad, Budhi Gandak.



What is National Waterways Act-2016?

- The **National Waterways Act, 2016** is an act of the Indian parliament that was passed in March 2016. The act provides for the declaration of 111 waterways as National Waterways in India, including inland rivers, and canals.
  - The act aims to promote the development of inland water transport and provide an alternative mode of transportation for goods and passengers.

Zojila Pass and Razdan Pass Reopen After Short Winter Closure

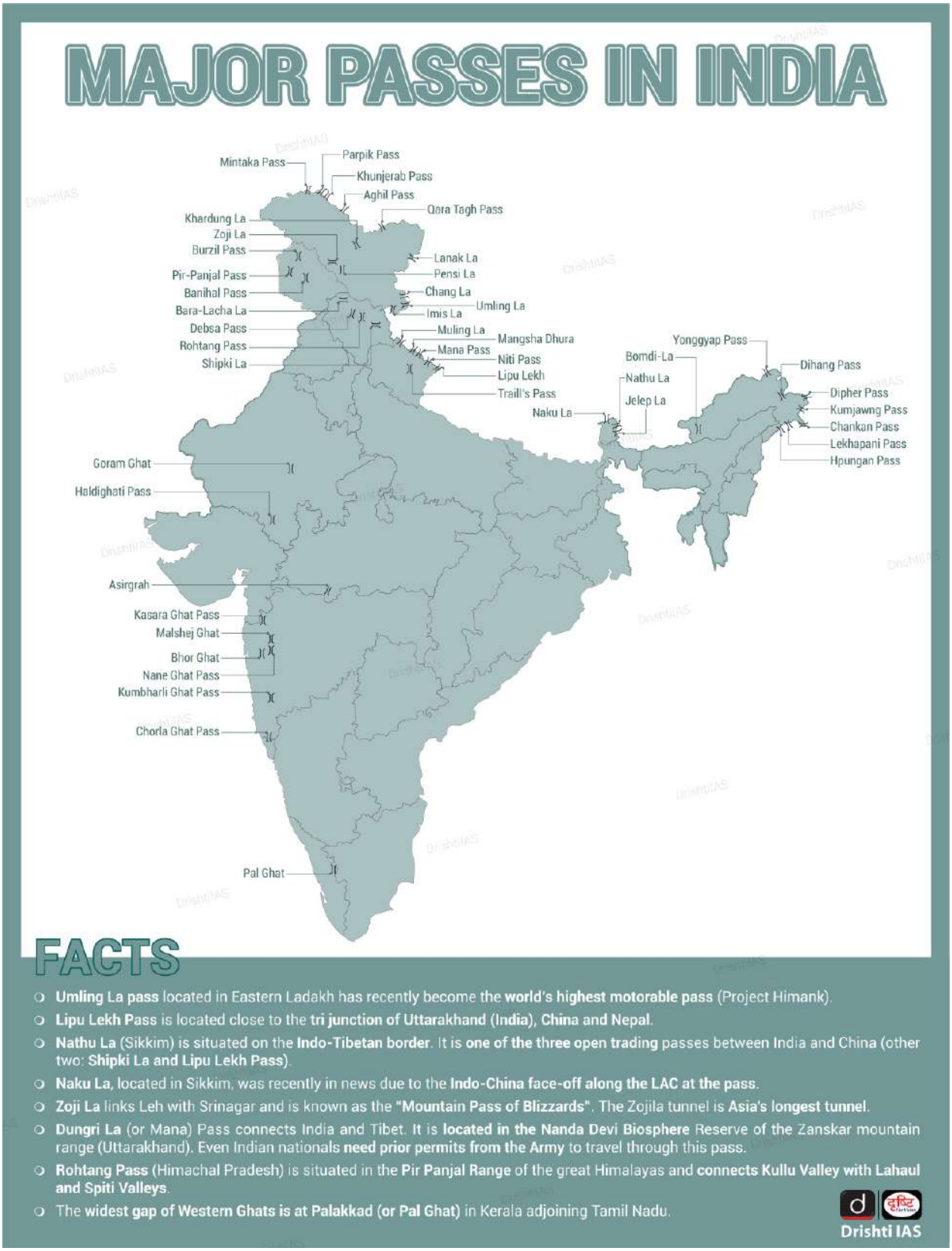
Why in News?

The Border Roads Organisation (BRO) has announced that the **strategic** Zoji La Pass, located at an altitude of **11,650 feet** in the Greater Himalayan Range, has been reopened after a winter closure.

- Similarly, the **Razdan Pass**, which connects the **Gurez sector to the Kashmir Valley,** has also been reopened after a brief winter closure.
- Snow clearance operations were undertaken by **Project Beacon and Vijayak** from both sides of the pass.

Note:

What are the Other Important Passes in India?



Note:

What is the Significance of Zoji La Pass?

- Zoji La is a **high mountain pass located in the Kargil district of Ladakh.**
- The pass links **Leh and Srinagar** and provides an important link between **Union Territories of Ladakh and Kashmir.**
- Zoji La pass remains closed during winters due to heavy snowfall, **cutting off Ladakh region from Kashmir.**
- In 2018, the **Zoji La tunnel project was launched**. The **tunnel is Asia's longest and strategic bi-directional tunnel,** which will provide all-weather connectivity between **Srinagar, Kargil and Leh.**

Africa's Rift Valley and the Creation of a New Ocean Basin

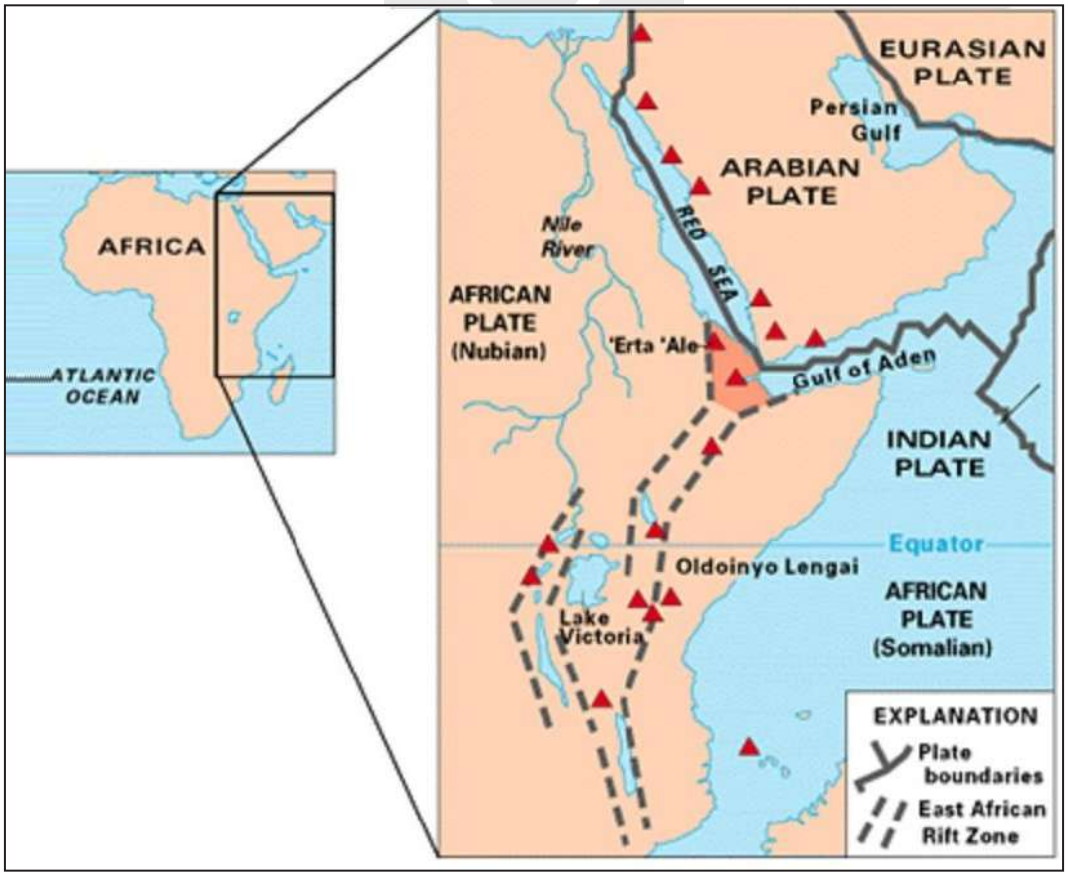
Why in News?

In 2020, a study revealed that the **gradual separation of the African continent is leading to the formation of a new ocean basin**.

- The division of the continent is **connected to the East African Rift (also called the Great Rift Valley)**, a crack that stretches 56 kilometres and appeared in the desert of Ethiopia in 2005, triggering the formation of a new sea.

What are the Factors Responsible for Africa's Rifting Plates?

- **Factor:**
  - The three plates — the **Nubian African Plate, Somalian African Plate and Arabian Plate** — are separating at different speeds.
  - The **Arabian Plate is moving away from Africa** at a rate of about an inch per year, while the **two African plates are separating even slower**, between half an inch to 0.2 inches per year.
    - In the past **30 million years,** the **Arabian Plate has been gradually moving away from Africa,** which has already led to the creation of the **Red Sea and the Gulf of Aden.**



Note:

- **Possible Outcome:**
  - As the **Somali and Nubian tectonic plates** continue to pull apart from each other, a **smaller continent will be created** from the rift, which will include **present-day Somalia and parts of Kenya, Ethiopia, and Tanzania**.
  - The **Gulf of Aden and the Red Sea** will eventually flood into the **Afar region** in **Ethiopia and the East African Rift Valley**, leading to the formation of a **new ocean.**
    - **This new ocean will result in East Africa becoming a separate small continent with its own unique geographic and ecological characteristics.**
  - The necessary separation of the Somali and Nubian tectonic plates will take **5 to 10 million years** to create a new ocean basin.
- **Current Situation:**
  - While the rifting process has been occurring for some time, the potential division made headlines worldwide in **2018** when a **large crack emerged in the Kenyan Rift Valley.**

What is Rifting?

- The Earth's lithosphere is divided into **several** tectonic plates that move in relation to each other at varying speeds.
  - **Tectonic forces** not only move the plates but also have the potential to cause them to rupture, resulting in the **formation of a rift and potentially leading to the creation of new plate boundaries.**
- Rifting refers to the geological process in which a **single tectonic plate is split into two or more plates** separated by divergent plate boundaries.
  - This process leads to the emergence of a lowland region known as a **rift valley.**
  - **Example: Narmada Rift Valley (India), Baikal Rift Valley (Russia).**

What is Great Rift Valley?

- The Great Rift Valley is a massive geological formation that stretches around **6,400 kilometers from northern Syria to central Mozambique in East Africa.**
- The valley is home to the **Jordan River,** which flows through the Jordan Valley and eventually empties into the Dead Sea on the border between Israel and Jordan.
- The **Gulf of Aden is an eastward continuation of the Rift**, and from there it extends southeastward as **part of the mid-oceanic ridge of the Indian Ocean.**
- In eastern Africa, the **valley divides into the Eastern Rift and the Western Rift.** The Western Rift, also known as the **Albertine Rift,** contains some of the **deepest lakes** in the world.

International Day of Action for Rivers 2023

Why in News?

Every year on March 14, the **International Day of Action for Rivers (IDAR)** is observed to promote awareness of the importance of the river systems on the planet earth.

- This year, the 25th anniversary of the day was observed. The day was earlier known as International Day against Dams, for Rivers, Water, and Life.

What are the Key Points Related to IDAR?

- **Theme:** Rights of Rivers.
  - It calls for the **designation of rivers as a national treasure.**
- **History:**
  - The participants of the First International Meeting of People Affected by Dams held in March 1997 in Curitiba Brazil adopted the International Day of Action Against Dams and For Rivers, Water, and Life.

What are the Related Indian Initiatives?

- **Namami Gange Programme:** It is an Integrated Conservation Mission, approved as a 'Flagship Programme' by the Union Government in June 2014 to accomplish the twin objectives of effective abatement of pollution and conservation and rejuvenation of National River Ganga.
  - Ganga was declared as the **'National River' of India in 2008.**
- **Ganga Action Plan:** It was the first River Action Plan that was taken up by the Ministry of Environment, Forest and Climate Change in 1985, to improve the water quality by the interception, diversion, and treatment of domestic sewage.
  - The **National River Conservation Plan** is an extension to the Ganga Action Plan.

Note:

- **National River Conservation Plan (NRCP):**
  - NRCP is the Centrally Sponsored Scheme implemented **for abatement of pollution in identified stretches of rivers in the country, excluding those in Ganga basin**, by providing financial and technical assistance to the States/ Union Territories (UTs) on cost sharing basis.
- **National River Rejuvenation Mechanism:**
  - The National Green Tribunal (NGT) directed the Ministry of Jal Shakti to devise an appropriate National River Rejuvenation Mechanism for effective monitoring of steps **to curb pollution and for rejuvenation of all polluted river stretches across the country.**

Subansiri Dam Project

Why in News?

The Subansiri Lower Hydroelectric project (SLHEP) on the **Assam-Arunachal border** was recently hit by a **landslide** during pre-monsoon rain.

- However, no damage has been caused to the project and **it is set to become operational by June 2023.**

What is a Landslide?

- **About:**
  - A landslide is defined as the movement of a mass of rock, debris, or earth down a slope. The term encompasses 5 modes of slope movement: **falls, topples, slides, spreads, and flows.**
- **Major Causes:**
  - **Geology:** Characteristics of the material; the earth or rock might be weak or fractured, or different layers may have different strengths and stiffness.
  - **Morphology:** Structure of the land; slopes that lose their vegetation to fire or drought are more vulnerable to landslides.
  - **Natural Causes:** Heavy rainfall, earthquakes, snowmelting and undercutting of slopes due to flooding.
  - **Human Activity:** Agriculture and construction increases the risk of a landslide.
- **Landslide-Prone Areas:**
  - **Entire Himalayan tract**
    - ~66.5% of the landslides are reported from the North-western and ~18.8% from Northeastern Himalayas.
  - **Western Ghats** (~14%) and **Konkan areas**
  - **Nilgiris** in Tamil Nadu

What is the Subansiri Lower Hydroelectric Project?

- **About SLHEP:**
  - SLHEP is an **under-construction gravity dam** (nearly 90% of the work completed) with capacity **2000 MW** (8 × 250 MW).
  - It is the **biggest hydroelectric project undertaken in India so far** and is a **run of river scheme** on **river Subansiri.**
    - A run-of-river dam is one in which the **flow of water in the river downstream of the dam is the same as the flow of water upstream** of the dam.
    - In other words, the dam doesn't hold back/store water behind it; it runs with the river.
  - The construction of SLHEP is being undertaken by **National Hydroelectric Power Corporation (NHPC) Limited.**
- **About Subansiri River:**
  - **Subansiri, or "Gold River"** is the **largest tributary of the Upper** Brahmaputra river.
  - It **originates from the Tibetan Himalayas** and makes its way to India via **(Miri Hills) Arunachal Pradesh.**

Note:

Note:

- **Arunachal Pradesh is often dubbed as the powerhouse of the country** and is home to 34% (50,328 megawatts) of the country's 148,701 MW hydropower potential.

What is a Gravity Dam?

- Gravity dam is constructed from concrete or cement (unlike mud and masonry stones used in embankments).
- It is designed to hold back water by primarily utilising the weight of the material alone to resist the horizontal pressure of water pushing against it.

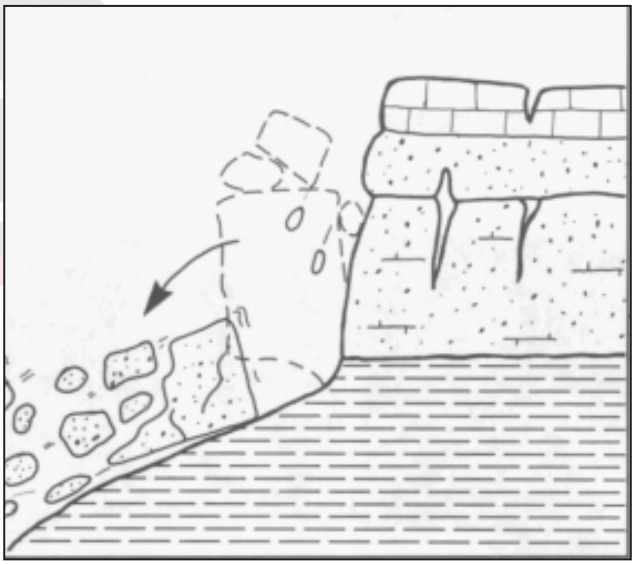
Avalanche

Why in News?

Recently, a massive **Avalanche** hit Sikkim's Nathu La.

What is Avalanche?

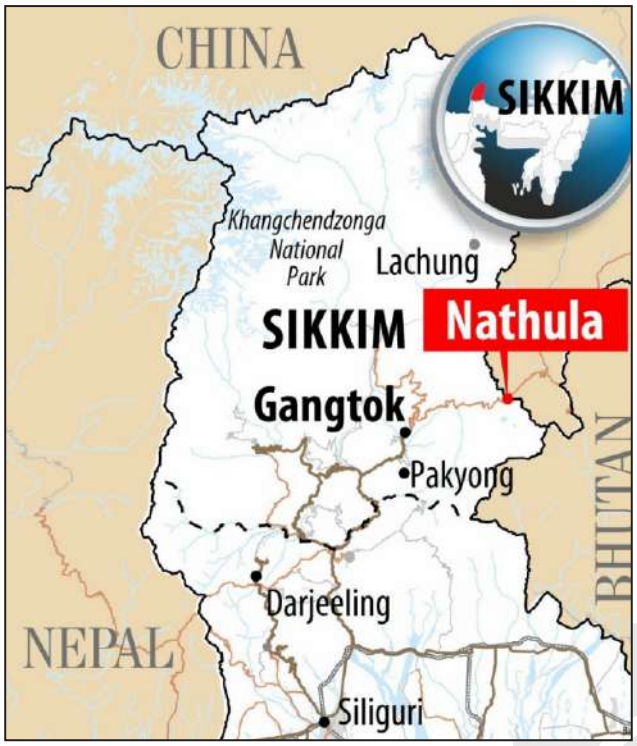
- **About:**
  - An avalanche is a sudden, rapid flow of **snow, ice, and debris down** a mountain or slope.
  - It can be triggered by various factors such as heavy snowfall, rapid temperature changes, or human activity.
  - Many regions that are prone to avalanches **have specialized teams that monitor and control avalanche risks** by using various methods such as explosives, snow barriers, and other safety measures.
- **Types:**
  - Rock Avalanches (which consist of large segments of shattered rock),
  - Ice Avalanches (which typically occur in the vicinity of a glacier),
  - Debris Avalanches (which contain a variety of unconsolidated materials, such as loose stones and soil).
- **Causes:**
  - **Weather Conditions:** Heavy snowfall, rapid temperature changes, strong winds, and rain can all contribute to avalanche conditions.
  - **Slope Conditions:** The steepness, orientation, and shape of **a slope can contribute to the likelihood of** an avalanche occurring. Steep slopes with a convex shape are particularly prone to avalanches.
  - **Snowpack Conditions:** The structure and stability of the snowpack **can also contribute to avalanche conditions**. Weak layers of snow or ice within the snowpack can cause it to collapse and trigger an avalanche.
  - **Human Activity:** Skiers, snowmobilers, and other recreational users can trigger avalanches by their movements on the slope.
  - **Natural Events:** Earthquakes, volcanic eruptions, and rockfalls can all trigger avalanches.



What are the Key Facts of Nathu La?

- Nathu La, one of the highest motorable roads in the world, is a mountain pass in the Himalayan peaks situated on the Indo-Tibetan border 14450 ft. above sea level.
- Nathu means **'listening ears', and La means 'pass'.**
- It is an open trading border post between India and China.
- The other passes located in the state of Sikkim are **Jelep La Pass, Donkia Pass, Chiwabhanjang Pass.**

Note:



What are the Other Important Passes of India?

Pass	Link/Features
Banihal Pass	Kashmir Valley with the outer Himalaya and the plains to the south.
Bara-Lacha-La Pass	Lahaul district in Himachal Pradesh with Leh district in Ladakh.
Fotu La Pass	Leh with Kargil of Ladakh
Rohtang Pass	Kullu Valley with the Lahaul and Spiti Valleys of Himachal Pradesh.
Shipki La Pass	Kinnaur district of Himachal Pradesh with Autonomous Region of Tibet, China.
Jelep La Pass	Sikkim with Autonomous Region of Tibet, China.
Lipu Lekh Pass	Chaudans valley of India with Autonomous Region of Tibet, China. It is located close to the tri junction of Uttarakhand (India), China and Nepal.
Khardung La	Ladakh with Siachen glacier. It is the highest motorable pass in the world.
Bom di La	It is in Arunachal Pradesh

5th International Conference on Disaster Resilient Infrastructure

Why in News?

Recently, the Prime Minister of India, addressed the **5th International Conference on Disaster Resilient Infrastructure (ICDRI) 2023.**

What is ICDRI?

- **About:**
  - **ICDRI is the annual international conference of the Coalition for Disaster Resilient Infrastructure (CDRI)** in partnership with member countries, organizations and institutions to strengthen the global discourse on disaster and climate-resilient infrastructure.
- **Highlights of ICDRI 2023:**
  - The Prime Minister said that since **India is leading the G20 group**, the **CDRI will be included in many important discussions.**
    - This means that the solutions discussed in the CDRI will be considered at the highest levels of global policymaking.

What is CDRI?

- **About:**
  - **CDRI** is an Independent International Organization consisting of global partnership of national governments, **United Nations** agencies and programs, multilateral development banks and financing mechanisms, the private sector, and academic and research institutions.
    - It aims to increase the resilience of infrastructure systems to climate and disaster risks, thereby ensuring **sustainable development.**
    - It was launched in 2019, at the **United Nations Climate Action Summit in New** York.
  - CDRI is India's second major global initiative after the **International Solar Alliance (ISA).**
    - The CDRI **Secretariat is based in New Delhi,** India.

Note:

- **Members:**
  - Since its inception, **31 countries, 6 international organisations and 2 private sector organisations** have joined CDRI as members.

What are the Initiatives of CDRI?

- **Infrastructure for Resilient Island States (IRIS):**
  - India launched this initiative as a part of the CDRI that would focus on building capacity, having pilot projects, especially in Small Island Developing States or SIDS.
    - SIDS face the biggest threat from climate change.
  - India's space agency ISRO will build a special data window for them to provide them with timely information about cyclones, coral-reef monitoring, coastline monitoring etc. through satellite.
- **Infrastructure Resilience Accelerator Fund:**
  - The Infrastructure Resilience Accelerator Fund is a fund supported by both the United Nations Development Programme (UNDP) and United Nations Office for Disaster Risk Reduction (UNDRR).
  - It is a trust fund that will be managed by the **United Nations Multi-Partner Trust Fund Office (UN MPTFO)** to help in improving the ability of infrastructure systems to withstand disasters, with a special focus on developing countries and Small Island Developing States (SIDS).

Internet Connectivity in Andaman and Nicobar Islands

Why in News?

Port Blair **has seen significant improvements in** Internet Connectivity since August 2020, when the **Chennai-Andaman & Nicobar Islands (CANI)** cable was inaugurated.

- However, Andaman & Nicobar Islands (ANI) is currently encountering a **number of challenges that necessitate the adoption of an objective viewpoint** in order to ensure the comprehensive and enduring progress of ANI towards **inclusivity and sustainability.**

What are the Recent Developments in Internet Connectivity in ANI?

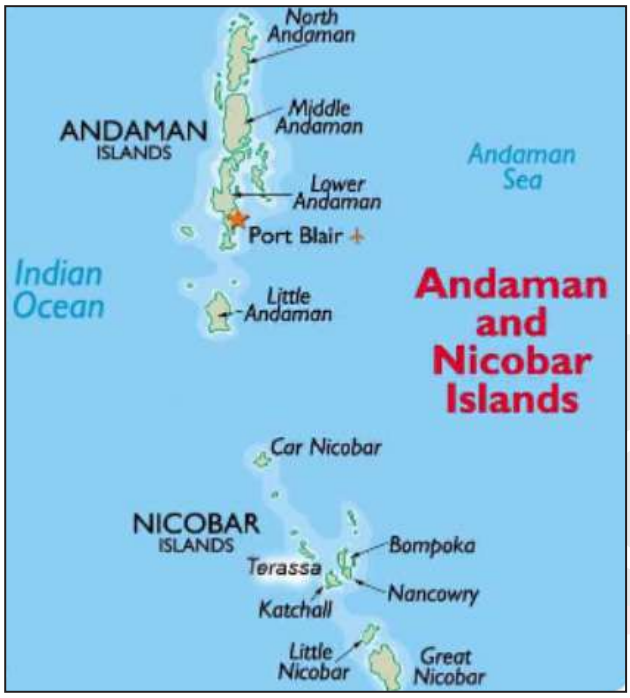
- The undersea cable between **the Andaman and Nicobar Islands and Chennai**, i.e., CANI, connecting the Union Territory to the global Internet, has seen **a reasonable level of interest from telecom operators**.
- The Universal Service Obligation Fund (USOF) provided information that telecom operators have purchased over **70 GBPS of bandwidth for internet connectivity in Andaman and Nicobar Islands (ANI).**
- Airtel and BSNL account for the lion's share of the bandwidth purchased, with 60 GBPS being allocated to the two telcos. Airtel even launched **5G services in Port Blair.**

What is the Significance of ANI for India?

- **About:**
  - The Andaman and Nicobar Islands are a group of islands at the **southeastern edge of the Bay of Bengal.**
  - They are part of the **union territory of India** and are **situated approximately 1,400 km from the Indian mainland.**
- **Significance:**
  - **Treasure of Tribes:** The Andaman and Nicobar Islands are home to 5 Particularly Vulnerable Tribal Groups: **Great Andamanese, Jarwas, Onges, Shompens and North Sentinelese.**
  - **Strategic Location:** They give India a commanding position over the **Sea Lines of Communication (SLOCs)** and the considerable traffic that flows to and fro between the **Indian and Pacific Oceans through the** Malacca Strait.
  - **Space for Maritime Partners**: India's key maritime partners such as the **US, Japan, Australia and France** acknowledge and recognise the strategic location of the Andaman and Nicobar.
  - These islands not only provide India with a **key maritime space but also carry significant potential in shaping the strategic and military dynamics** of the Indian Ocean region**.**
- **Recent Developmental Plans for ANI:**
  - **Japan's Overseas Development Assistance:** Japan approved a **USD 265 crore grant aid for ANI** development projects in 2021.

Note:

- **NITI Aayog's Project for Great Nicobar:** It includes an international container **transhipment terminal, an airport, a power plant, and a township.**
- **NITI Aayog's Proposal for Little Andaman:** The plan calls for the development of a **new greenfield coastal city** to compete with **Singapore and Hong Kong.**



Western Disturbance Threatens India's Wheat Crop

Why in News?

Recent inclement weather conditions, including **an unusual rise in mercury in February and untimely spells of widespread rain, gusty winds, and hails during March** under the influence of **western disturbances** in key wheat-producing states have left farmers worried about a potential drop in yield, output, and quality of wheat.

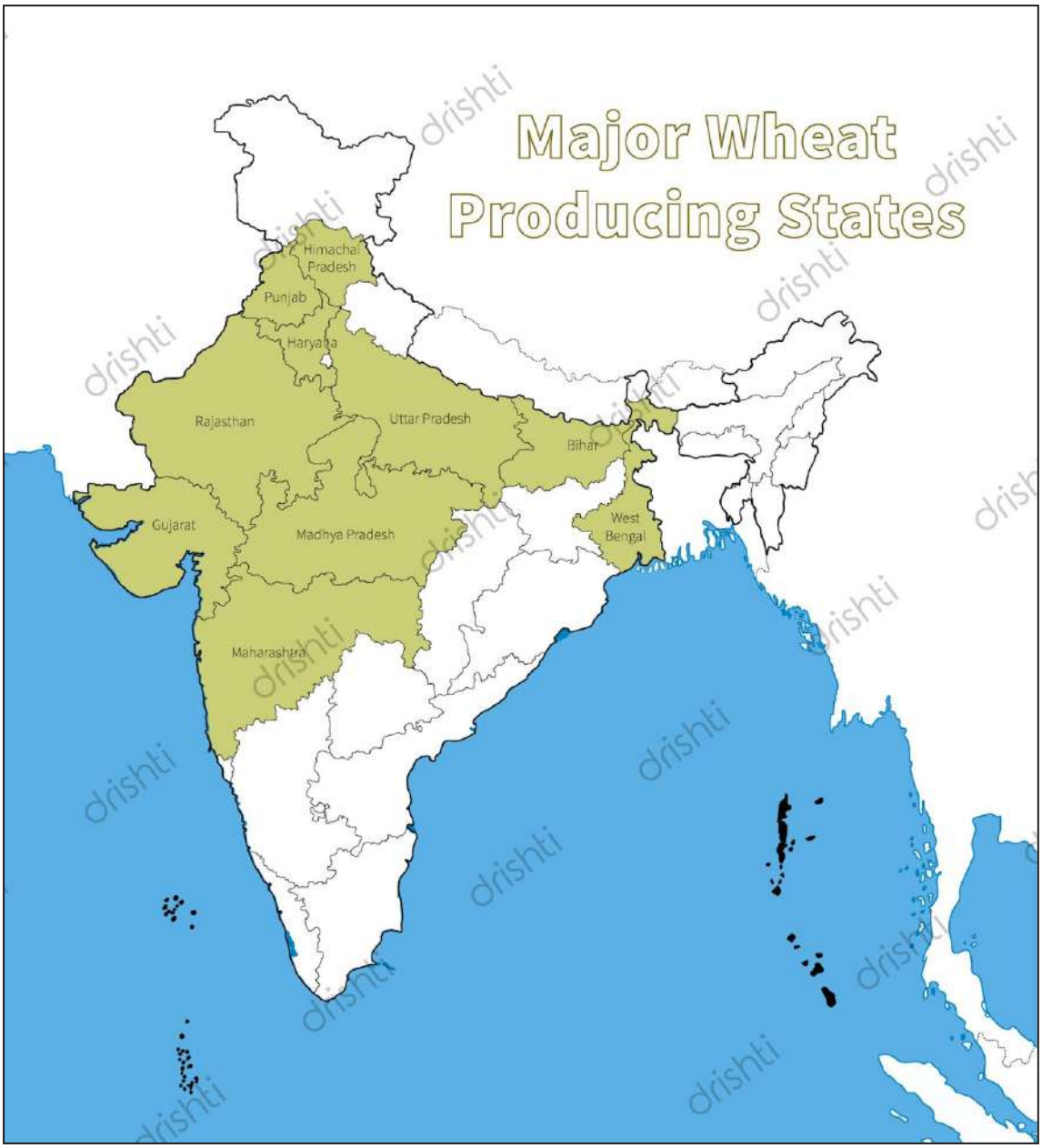
What is the Impact of Untimely Rains and Winds on Wheat Crops in India?

- **Impact of Untimely Rains and Winds:**
  - The **India Meteorological Department (IMD)** reported that the rains, along with stormy winds between 40-50 kilometers per hour, could be detrimental to the crop's health, especially if they occur close to the ripening and harvesting stage. Unfortunately, there have been instances of crop flattening and waterlogging in fields, which could further damage the ready-to-harvest wheat crop.

What are the Key Points related to Wheat?

- **About:**
  - This is the **second most important cereal crop in India after rice.**
  - It is the main food crop, in the north and north-western part of the country.
  - Wheat is **a** rabi crops that requires a cool growing season and bright sunshine at the time of ripening.
  - Success of the **Green Revolution** contributed to the growth of Rabi crops, especially wheat.
- **Temperature:**
  - Between 10-15°C (Sowing time) and 21-26°C (Ripening & Harvesting) with bright sunlight.
- **Rainfall:**
  - Around 75-100 cm.
- **Soil Type:**
  - Well-drained fertile loamy and clayey loamy (Ganga-Satluj plains and black soil region of the Deccan).
- **Top Wheat Producing States:**
  - Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, Bihar, Gujarat.
- **Status of Indian Wheat Production and Export:**
  - India is the **world's second-biggest wheat producer** after China. But it **accounts for less than 1% of the global wheat trade.** It keeps a lot of it to provide subsidised food for the poor.
  - Its top export markets are Bangladesh, Nepal and Sri Lanka - as well as the United Arab Emirates (UAE).
- **Government Initiatives:**
  - Macro Management Mode of Agriculture, **National Food Security Mission** and Rashtriya Krishi Vikas Yojana are few government initiatives to support wheat cultivation.

Note:



What are Western Disturbances?

- Western disturbances are **storms that originate in the Caspian or Mediterranean Sea**, and **bring non-monsoonal rainfall to northwest India,** according to the India Meteorological Department (IMD).
- They are labelled as an **extra-tropical storm** originating in the Mediterranean, is an area of low pressure that brings sudden showers, snow and fog in northwest India.
- It arrives with rain and snow in Pakistan and northern India. The moisture which WDs carry with them **comes from the Mediterranean Sea and/or from the Atlantic Ocean.**
- WD brings winter and pre-monsoon rain and is important for the development of the **Rabi crop** in the Northern subcontinent.
- The WDs are not always the harbingers of good weather. Sometimes WDs can cause extreme weather events like floods, **flash floods**, **landslides**, dust storms, hailstorms and **cold waves** killing people, destroying infrastructure and impacting livelihoods.

Note:

El Nino

Why in News?

Many climate models have forecasted an **El Nino** in May 2023.

- A **record three-year La Niña event ended in March 2023** and currently, the **equatorial Pacific Ocean is at normal temperatures**, known as the **neutral phase.**

What is El Nino?

- El Nino was first recognized by **Peruvian fishermen off the coast of Peru** as the appearance of unusually warm water.
  - The Spanish immigrants called it El Nino, meaning "the little boy" in Spanish.
- The El Nino is the warmer-than-normal phase of the **El Nino Southern Oscillation (ENSO) phenomenon**, during which there are **generally warmer temperatures and less rainfall** than normal in many regions of the world, including India.
- During an El Nino event, the **Sea Surface Temperatures (SST)** in the equatorial Pacific Ocean off the northern coast of South America became at least 0.5 degrees Celsius warmer than the long-term average.
  - In the case of a strong El Nino event as occurred in 2015-2016, anomalies can reach as high as 3°C, which is a record.
- The El Nino event is **not a regular cycle, they are not predictable** and occur irregularly at two- to seven-year intervals.
  - Climatologists determined that El Nino occurs simultaneously with the Southern Oscillation.
    - The Southern Oscillation is a change in air pressure over the tropical Pacific Ocean.

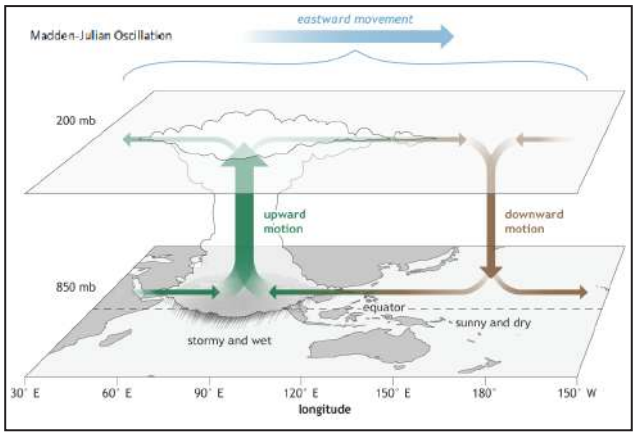
What do the Climate Models Say About Upcoming El Nino?

- **Impact on India:**
  - **Weak Monsoon for India:** The development of an El Nino in May or June 2023 may cause weakening of the **southwest monsoon season**, which brings around 70% of the total rainfall India receives and on which most of its farmers still depend.
    - However, **sub-seasonal factors such as the Madden-Julian Oscillation (MJO)** and monsoon low-pressure systems **can temporarily enhance rainfall** in some parts as witnessed in the year 2015.
  - **Hot Temperatures:** It may also cause **heatwaves** and **droughts** in India and other regions around the world such as South Africa, Australia, Indonesia and the Pacific Islands.
- **Heavier Rainfall in the West:** It brings heavy rainfall and flooding to other regions such as California in the United States and could cause **bleaching and death of coral reefs**.
- **Rising Global Average Temp:** The El Nino in 2023 and going into 2024 may push the global average temperature towards 1.5°C warmer than the preindustrial average.
  - The warming of the oceans is also one of the major impacts of an El Nino event.
    - This is when ocean heat content is already at a record high, according to the **World Meteorological Organization (WMO).**
- **Previous Such Occurrences – Impacts:**
  - In the 2015-2016, there were **widespread heatwaves in India that killed around 2,500 people** in each of the years.
    - Coral reefs around the world also suffered from bleaching and the s**ea level rose by 7 millimetres** due to thermal expansion.
  - The El Nino, along with global warming, had made **2016 the warmest year on record.**
  - **El Nino events of 1982-83 and 1997-98** were the **most intense** of the 20th century.
    - During the 1982-83 event, **sea surface temperatures in the eastern tropical Pacific were 9-18°C above normal.**

What is MJO?

- The MJO is made up of two parts: **an enhanced rainfall phase and a suppressed rainfall phase.**
  - During the enhanced phase, surface winds converge, causing air to rise and create more rainfall. In the suppressed phase, winds converge at the top of the atmosphere, causing air to sink and leading to less rainfall.
  - This dipole structure moves west to east in the Tropics, creating more cloudiness and rainfall in the enhanced phase, and more sunshine and dryness in the suppressed phase.

Note:



How does ENSO Affect India?

- The influence of ENSO on India's climate is most pronounced during the monsoon season. During an El Niño event, **India experiences below-average rainfall.**
  - The El Niño also leads to a rise in temperatures, exacerbating heat waves and causing heat-related health issues.
- On the other hand, during a La Niña event, **India experiences above-average rainfall.**
  - This can lead to flooding and landslides, damaging crops and infrastructure. However, La Niña also brings cooler temperatures, which can provide relief from heat waves.

Sunken Ocean Floor above Earth's Core

Why in News?

Recently, Geologists have **discovered a previously unknown layer between the core and the mantle of the Earth, likely to be a thin but dense sunken ocean floor.**

- This layer is **pencil-thin in geological terms, measuring tens of kilometers,** which is minuscule when compared to the thickness of Earth's other layers.

What are the Key Highlights?

- The discovery of this **ocean floor layer could play an important role in how heat escapes from the core.**
  - The material from ancient ocean floors can also get caught up in **mantle plumes, traveling** back to the surface through volcanic eruptions.
- There are mountains on the core, these underground **"mountains" could be up to 5 times taller than Mt. Everest,** and they could help explain the changes in physical properties between the outer core and the mantle, which are greater than those between the surface of the Earth and the air above it.
- The subducted oceanic material could collect along the core-mantle boundary where it can be pushed by the slowly flowing rock in the mantle over time. This suggests that **Earth's history is more complex than previously thought**, with the possibility of **multiple sunken ocean floors** adding to the complexity of the planet's geological makeup.

What are the Implications for Future Research?

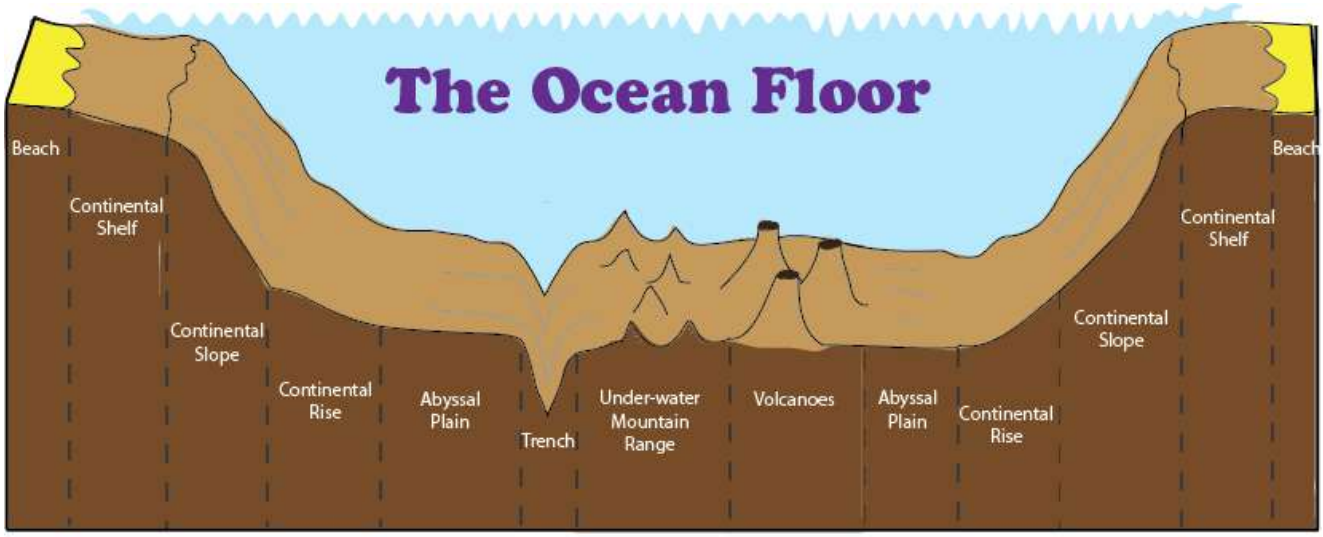
- This new discovery opens up new avenues of research for geologists and could lead to a better understanding of **Earth's geological processes.**
- The detailed method used to probe a large portion of the southern hemisphere using sound wave echoes from the core-mantle boundary could be used in other parts of the world to uncover similar anomalies.
- It also highlights the importance of continued investment in **high-resolution imaging technology** for exploring the **mysteries of our planet's interior.**

What is an Ocean Floor?

- The **ocean floor is the bottom of the ocean** that covers more than 70% of the Earth's surface. **It has different features and depths depending on the location and the movement of tectonic plates**. The ocean floor can be divided into four main zones:
  - **Continental Shelf:**
    - The **shallowest and widest part of the ocean floor.**
    - Extends from the coast to the edge of the continent, where it drops sharply into the continental slope.
    - Rich in marine life and resources, such as fish, oil, and gas.
  - **Continental Slope:**
    - The steep slope that **connects the continental shelf to the abyssal plain**
    - Cut by deep canyons and valleys that are formed by **underwater landslides and rivers of sediment.**
    - Home to some **deep-sea creatures**, such as **octopuses, squids, and anglerfish.**

Note:

- **Abyssal Plain:**
  - The **flattest part of the ocean floor.**
  - Covers most of the ocean basin and **lies between 4,000 and 6,000 meters below sea level.**
  - Covered by a thick layer of fine sediments that are carried by ocean currents and settle on the seafloor.
  - Inhabited by some of the most bizarre and mysterious animals on Earth, such as giant tube worms, bioluminescent fish, and vampire squids.
- **Oceanic Deeps or Trenches:**
  - These areas are **the deepest parts of the oceans.**
  - The trenches are relatively steep sided, narrow basins. They are some 3-5 km deeper than the surrounding ocean floor.
  - They occur at the bases of continental slopes and along island arcs and **are associated with active volcanoes and strong earthquakes.**
  - That is why they are very significant in the study of plate movements. As many as 57 deeps have been explored so far; of which **32 are in the Pacific Ocean; 19 in the Atlantic Ocean and 6 in the Indian Ocean.**



Protests in Chhattisgarh Over Coal Mining

Why in News?

Recently, the **Adani Enterprises Limited (AEL) coal mining project** in Chhattisgarh has sparked a controversy due to its impact on the environment and local communities.

- AEL has been mining coal in the **Parsa East and Kente Basan coal blocks** of **Chhattisgarh's Surguja district for over a decade now.**
- For more than a year now, locals, largely from the **Gond tribe**, in Hariharpur, Ghatbarra, and Fattepur villages of Chhattisgarh, have been holding a sit-in at the entrance to Hariharpur against mining.

What is Coal?

- **About:**
  - It is a type of fossil fuel found in the form of **sedimentary rocks and is often known as 'Black Gold'.**
  - It is a conventional source of energy and is widely available. It is used as a domestic fuel, in industries such as iron and steel, steam engines and to generate electricity. Electricity from **coal is called thermal power.**
    - The leading coal producers of the world include **China, US, Australia, Indonesia, India.**
- **Distribution of Coal in India:**
  - **Gondwana Coal Fields (250 million years old):**
    - Gondwana coal makes up to 98% of the total reserves and 99 % of the production of coal in India.

Note:

- It forms **India's metallurgical grade as well as superior quality coal and has a high ash content**.
- It is found in Damodar (Jharkhand-West Bengal), Mahanadi (Chhattisgarh-Odisha), Godavari (Maharashtra), and Narmada valleys.

❍ **Tertiary Coal Fields (15 – 60 million years old):**

- Carbon content is **very low but is rich in moisture and sulphur.**
- Tertiary coalfields are mainly confined to extra-peninsular regions.
- **Important areas** include Assam, Meghalaya, Nagaland, Arunachal Pradesh, Jammu and Kashmir, Himalayan foothills of Darjeeling in West Bengal, Rajasthan, Uttar Pradesh, and Kerala.

➢ **Classification:**

❍ **Anthracite** (80 - 95% carbon content, found in small quantities in J&K).

❍ **Bituminous** (60 - 80% carbon content and is found in Jharkhand, West Bengal, Odisha, Chhattisgarh and Madhya Pradesh).

❍ **Lignite** (40 to 55% carbon content, high moisture content and is found in Rajasthan, Lakhimpur (Assam) and Tamil Nadu).

❍ **Peat** (less than 40% carbon content and it is in the first stage of transformation from organic matter (wood) to coal).

➢ **Coal Reserves:** Top States in terms of total coal reserves in India are **Jharkhand, Odisha, Chhattisgarh, West Bengal, and Madhya Pradesh.**

India's Climate and Weather Trends

Why in News?

Although India has received some rain recently, experts predict that the year 2023 will be hotter and drier.

➢ The **Indian Meteorological Department (IMD)** has predicted a normal monsoon, but the development of **El Nino could lead to a reduction in monsoon rainfall**.

➢ Additionally, the **IMD has released data on fatalities caused by extreme weather events**, marking the first time they have done so.

What is the Current Situation in India?

➢ **Uneven Rainfall Distribution:**

❍ Despite the recent showers, the entire country has received ample rainfall, except for the **northeastern states, Jharkhand, and West Bengal.**

❍ Some areas in Maharashtra, Gujarat, Uttar Pradesh, and Madhya Pradesh have experienced up to **15 times more rainfall than expected** due to various local weather phenomena.

➢ **El Nino and Global Warming:**

❍ The **IMD** has predicted normal monsoon, but the development of **El Nino could suppress rainfall over India.**

❍ Globally, 2023 is expected to be **one of the top four warmest years on record due to the rapid development of the El Nino event,** which has an overall warming impact on the planet.

➢ **India's Warming Trend:**

❍ **India's warming trend is slightly lower than the global average**, with the year 2022 being 1.15 degree Celsius warmer than pre-industrial times.

❍ The warming over India is not uniform across regions. Some states like **Himachal Pradesh, Goa, and Kerala have become much hotter than others**, while eastern states such as **Bihar, Jharkhand, and Odisha have experienced the least warming.**

❍ Sea surface temperatures in the tropical **Indian Ocean have risen by almost one degree Celsius between 1950 and 2015.**

What do the Climate Models Say About the Impact of Upcoming El Nino?

➢ **Weak Monsoon for India**: The development of an El Nino in May or June 2023 may cause a weakening of the **southwest monsoon season**, which brings around 70% of the total rainfall India receives and on which most of its farmers still depend.

➢ However, sub-seasonal factors such as the **Madden-Julian Oscillation (MJO)** and monsoon low-pressure systems can temporarily enhance rainfall in some parts as witnessed in the year 2015.

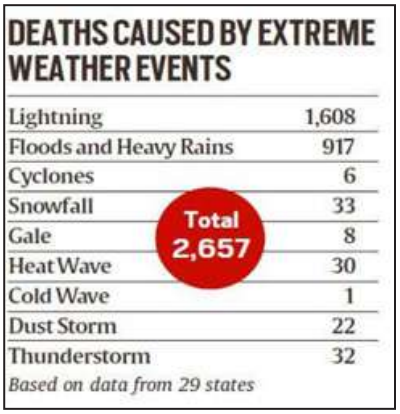
➢ **Hot Temperatures:** It may also cause **heatwaves** and **droughts** in India and other regions around the world such as South Africa, Australia, Indonesia and the Pacific Islands.

Note:

- **Heavier Rainfall in the West**: It brings heavy rainfall and flooding to other regions such as California in the United States and could cause bleaching and death of coral reefs.
- **Rising Global Average Temp:**
  - The El Nino in 2023 and going into 2024 may push the global average temperature towards 1.5°C warmer than the preindustrial average.
  - The warming of the oceans is also one of the major impacts of an El Nino event.
    - This is when ocean heat content is already at a record high, according to the World Meteorological Organization (WMO).

Which Weather Event Causes the Most Fatalities?

- Lightning strikes caused more deaths than any other weather event in India.
- In 2022, lightning strikes were responsible for 60% of weather event-related deaths in India (1,608 out of 2,657 recorded deaths).
- Floods and extreme rainfall events claimed 937 lives.
- The actual number of casualties could be higher, as IMD and state governments relied on media reports to compile the list.



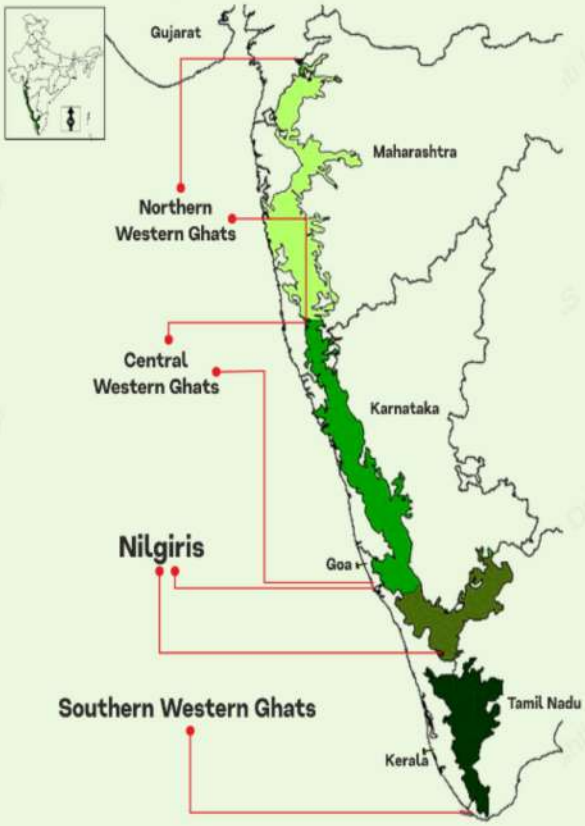
What are India's Climate Change Mitigation Initiatives?

- National Action Plan on Climate Change (NAPCC):
  - Launched in 2008 to **address climate change challenges** in India.
  - Aims to **achieve low-carbon and climate-resilient development for India.**
  - There are **8 national missions** forming the core of the NAPCC which represent multi-pronged, long term and integrated strategies for achieving key goals in climate change. These are-
    - National Solar Mission
    - **National Mission for Enhanced Energy Efficiency**
    - **National Mission on Sustainable Habitat**
    - National Water Mission
    - National Mission for Sustaining the Himalayan Ecosystem
    - National Mission for A Green India
    - National Mission for Sustainable Agriculture
    - **National Mission on Strategic Knowledge for Climate Change.**
- Nationally Determined Contributions (NDC):
  - India's commitments to reduce greenhouse gas emissions and adapt to climate change.
  - Pledged to **reduce the emissions intensity of GDP by 45%** by 2030 from 2005 levels and generate **50% of electricity from non-fossil fuel sources by 2030.**
  - Pledged to create additional carbon sink and **achieve net zero emissions by 2070.**
- National Adaptation Fund on Climate Change (NAFCC):
  - Established in 2015 **to provide financial assistance to state governments for implementing adaptation projects** in various sectors.
- State Action Plan on Climate Change (SAPCC):
  - Encourages all states and union territories to prepare their own SAPCCs based on their specific needs and priorities.
  - SAPCCs outline strategies and actions for addressing climate change at the sub-national level.
  - Aligned with the objectives of the NAPCC and the NDC.

Note:

Western Ghats

One of the four biodiversity hotspots of India; recognised as a UNESCO WHS (2012)



Names
- Sahyadri - northern Maharashtra; Sahya Parvatham - Kerala

Diverted views about Mt. type
- View 1: Block Mt. formed due to down warping of a part of land into Arabian Sea
- View 2: Not true mt. rather the faulted edge of Deccan Plateau

Major Rocks
- Basalt, granite gneiss, khondalites, metamorphic gneisses, crystalline limestone, iron ore

Geographical Extent
- Satpura (in north) to the end of TN at Kanyakumari (in south)

Mt. Ranges
- Nilgiri ranges, Shevaroys and Tirumala range
- Highest peak - Anamudi (Kerala)

Rivers (originating)
- West-flowing: Periyar, Bharathappuzha, Netravati, Sharavathi, Mandovi
- East-flowing: Godavari, Krishna, Kaveri, Tunga, Bhadra, Bhima, Malaprabha, Ghataprabha, Hemavathi, Kabini

Endemic Species
- Nilgiri tahr (IUCN Status - EN)
- Lion-tailed macaque (IUCN Status - EN)

Imp Protected Areas
- Biosphere Reserves - Agasthyamala and Nilgiri
- NP - Silent Valley, Bandipur, Eravikulam, Wayanad-Mudumalai, Nagarhole
- TR - Kalakad-Mundanthurai, Periyar

Imp Passes
- Thal Ghat Pass (Kasara Ghat)
- Bhor Ghat Pass
- Palakkad Gap (Pal Ghat)
- Amba Ghat Pass
- Naneghat Pass
- Amboli Ghat Pass

Significance
- Hydroelectricity production
- Influences Indian monsoon weather patterns
- Carbon sequestration (neutralise ~4 MT of carbon every year)
- One of the 8 global hottest hotspots of biodiversity (due to richness in species and endemism)
- Rich in iron, manganese and bauxite ores, timber, pepper, cardamom, oil palm and rubber
- Sizeable indigenous population (including PVTGs)
- Important tourism/pilgrimage centres

Major Threats
- Mining, Industrialisation
- Massive extraction of forest produce
- Human-wildlife conflict, encroachment, illegal hunting
- Livestock grazing, deforestation
- Large hydropower projects
- Climate change

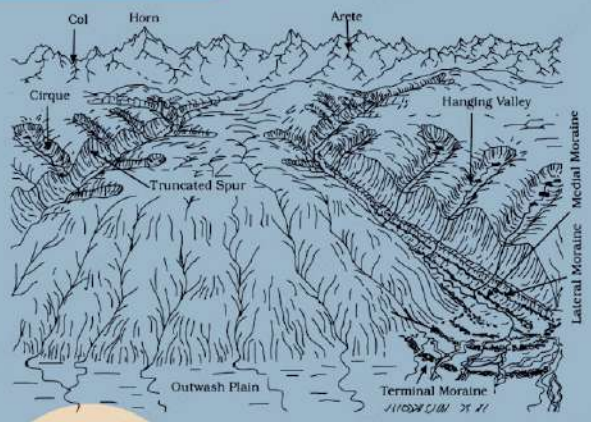
Imp Committees
- Gadgil Committee (2011) (Western Ghats Ecology Expert Panel)
  - Recommendation: All of WG be declared as Ecological Sensitive Area (ESA) with only limited development allowed in graded zones.
- Kasturirangan Committee (2013)
  - Recommendation: Instead of whole, only 37% of the total area of WG be brought under ESA + complete ban on mining, quarrying and sand mining be imposed in ESA.

Note:

GLACIAL LANDFORMS

"Glacier is any large mass of perennial ice that originates on land by the recrystallisation of snow or other forms of solid precipitation"

EROSIONAL LANDFORMS



Cirque/ Cirque/ Cwm
- Small glaciers and are characteristically bowl -shaped
- Found at the heads of glacial valleys

Horns and Serrated Ridges
- Form through head ward erosion of the cirque walls
- Present in areas where multiple glaciers flow in multiple directions

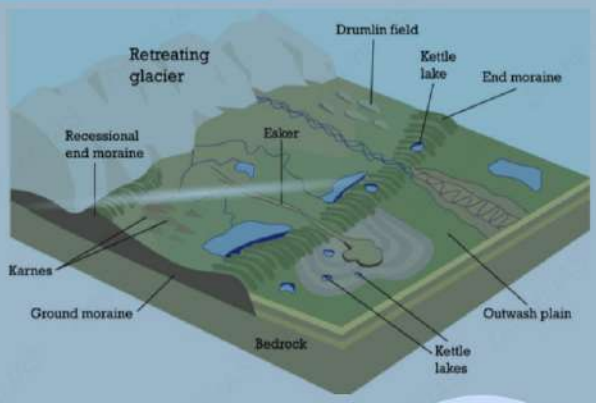
Glacial Valleys /Troughs
- Trough-like and U-shaped with broad floors and relatively smooth, and steep sides
- Fjords are deep glacial troughs filled with seawater, forming shorelines

Bergschrund
- A crevasse/crack or series of crevasses often found near the head of a mountain glacier

Hanging Valley
- Form when glacier ice deeply erodes a main or trunk valley, leaving tributary valleys hanging far above the main valley floor.

Crag and Tail
- Crag: Mass of hard rock with a precipitous slope.
- Tail: Formed by the deposition of glacial debris or till as the glacier retreats.

DEPOSITIONAL LANDFORMS



Moraines
- Lateral Moraines: Form on the sides of glaciers
- Ground Moraines: Deposits varying greatly in thickness and in surface topography
- Medial Moraines: Form where two tributary glaciers come together

Eskers
- Winding ridges of sand and gravel formed by streams flowing within or beneath glaciers

Outwash Plains
- Deposit of sand and gravel carried by running water from the melting ice of a glacier

Drumlins
- Hills of sediment that have been streamlined by glacier flow.
- Up to 1 km in length and 30 m or so in height
- So commonly described as having a *basket of eggs' topography*

Drishti IAS

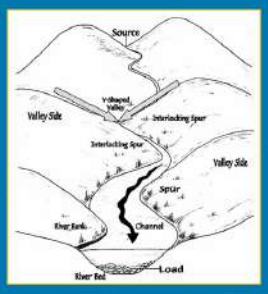
Note:

RIVER LANDFORMS

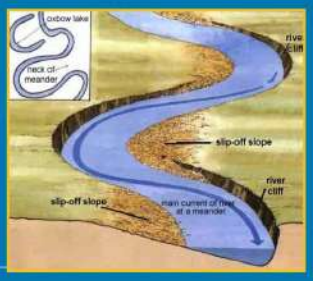
Different types of landforms formed at different courses of a river - Upper, Middle & Lower

UPPER (MOUNTAIN) COURSE

- Starts at source of river (usually a mountain range)
- Very fast speed of river due to steep slope
- Main action of river is vertical corrasion
- Landforms -
  - » V-shaped Valleys (formed due to vertical corrasion)
    - Lao Valley, Hawaii
  - » Interlocking Spurs
    - West Liddar valley above Pahalgam, Kashmir
  - » Gorges (formed where rocks are too hard and resistant)
    - Indus Gorge, Kashmir
  - » Canyons (formed where rainfall is very low)
    - Bryce Canyon, US
  - » Rapids and Waterfalls
    - Lava Falls Rapid, US and Niagara Falls, Canada



Corrasion (or abrasion) is the erosion of a rock surface by rock fragments transported over it by water, wind, or ice



MIDDLE (VALLEY) COURSE

- Here, lateral corrasion overtakes vertical
- Confluence of tributaries → More volume of water → More loaded river
- Transportation main event in the region
- Interlocking spurs also formed on both sides of the valley
- Landforms -
  - » Meanders
    - Owens River, SE California, US
  - » River Cliffs and Slip-off slope
    - White Cliffs of Dover, UK

LOWER (PLAIN) COURSE

- River now heavy with material brought down from upper courses
- Vertical corrasion almost negligible, lateral corrasion still active
- Deposition plays key role in formation of riverbeds and extensive flood plains
- More volume in water; finer material carried to the mouth of river
- Landforms -
  - » Floodplains and Levees
    - Ganga-Yamuna floodplain
  - » Deltas
    - Sunderbans Delta

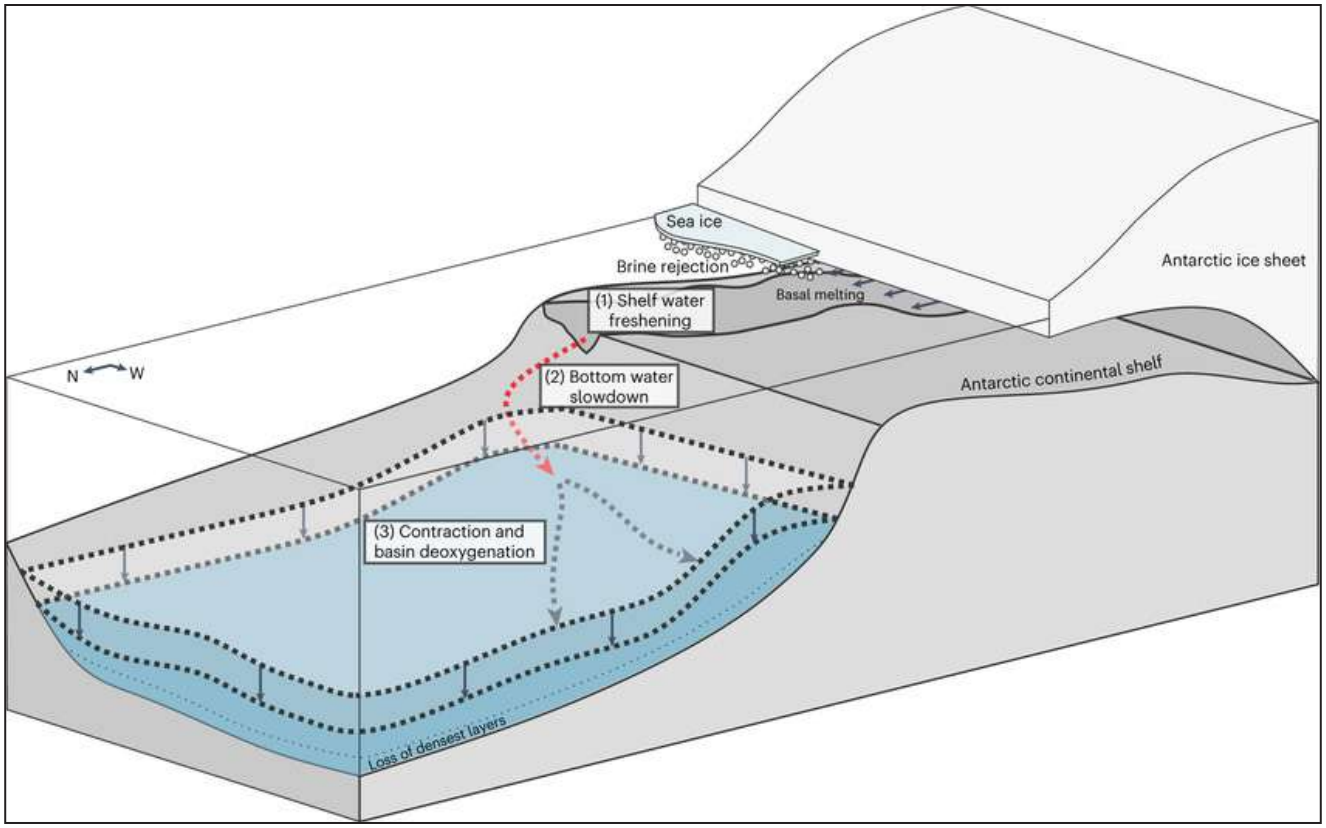
Drishti IAS

Note:

The Slowdown in Overturning Circulation

Why in News?

- Recently, **Deep Ocean currents in Antarctica are slowing down** earlier than predicted, potentially **disrupting the crucial overturning circulation**.
- The slowdown in circulation and declining oxygen levels in the deep ocean have been observed, indicating significant changes in the **Antarctic deep ocean over the past three decades.**
- The consequences of this phenomenon are further underscored by the **impacts of melting Antarctic ice** on the overturning circulation.



What is Overturning Circulation?

- **About:**
  - Overturning circulation refers to the **global network of ocean currents that redistribute heat, carbon, and nutrients across the world's oceans.**
  - In Antarctica, it involves the **sinking of dense, oxygen-rich water from the surface, its spread along the sea floor, and slow rise in distant regions.**
- **Process:**
  - In polar regions, the surface water cools due to **low temperatures and exposure to frigid air masses.**
  - The cooling leads to the formation of **sea ice, which extracts freshwater from the surrounding seawater**. This process increases the **salinity and density of the remaining water.**
  - The high salinity and density cause the **surface water to become denser, making it more likely to sink.**
  - The dense water sinks to deeper layers, forming what is known as **bottom water.**
- The sinking of dense water drives the deeper limb of the **overturning circulation.** It flows towards the equator, while at the same time, warmer surface water from lower latitudes moves towards the poles.
- As the deep-water travels, it gradually mixes with surrounding water masses, **exchanging heat, carbon, and nutrients.** Eventually, the upwelling of this modified water occurs in other regions, completing the overturning circulation.

Note:

- **Importance:**
  - Overturning circulation plays a crucial role in maintaining **climate stability on Earth.**
  - It facilitates the **transport of heat, carbon, and nutrients, influencing the planet's climate system.**
  - Additionally, it **ensures the supply of oxygen to the deep ocean,** supporting **marine life and its ecosystems.**
- **Impact of Slowdown in Overturning Circulation:**
  - The observed slowdown of deep ocean currents in Antarctica, occurring earlier than anticipated, raises concerns about climate stability.
  - A reduced flow of bottom water results in a **decline in oxygen supply** to the deep ocean, impacting **oxygen-dependent organisms.**
  - Lower oxygen levels may lead to **behavioral changes, migrations, and disruptions in the marine food chain.**
    - Moreover, the slowdown amplifies **global warming** as the ocean's **capacity to store carbon dioxide and heat diminishes**, intensifying the **greenhouse effect.**
- **Melting Antarctic Ice and its Contribution:**
  - Melting Antarctic ice disrupts the formation of **Antarctic bottom water,** making **surface waters fresher and less dense, impeding their sinking.**
    - This disruption weakens the overturning circulation, further diminishing the oxygen supply to the deep ocean.
    - The replacement of bottom water with warmer, oxygen-depleted waters exacerbates the **decline in oxygen levels.**
    - Additionally, melting ice contributes to **rising sea levels** through thermal expansion as warmer water occupies more space.

What are the Key Highlights about Antarctica?

- Antarctica is **uninhabited except for those manning the nearly 40 permanent stations** established by several countries, including India, for carrying out scientific research.
  - India maintains **two research stations on the continent**: 'Maitri' (commissioned in 1989) at Schirmacher Hills and 'Bharati' (2012) at Larsemann Hills.
  - It has also **launched 41 scientific expeditions every year** thus far. Together with **'Himadri' station in Svalbard**, above the Arctic circle, India is among an **elite group of countries with multiple research** in the polar regions.
- Antarctica is **Earth's southernmost continent**. It contains the **geographic South Pole** and is situated in the **Antarctic region of the Southern Hemisphere.**
- At 14,000,000 square kilometres, it is the **fifth-largest continent.**
- The **Indian Antarctic Programme** is a multi-disciplinary, multi-institutional programme under the control of the National Centre for Antarctic and Ocean Research, Ministry of Earth Sciences.
- India officially **acceded to the Antarctic Treaty System in August 1983.**

Son River

Why in News?

The **National Green Tribunal (NGT)** has issued a directive to halt all mining activities in **Son riverbed** in Sonbhadra district, Uttar Pradesh.

- The directive addresses **illegal mining, imposing environmental compensation on mining companies.**

What are the Characteristics of Son River?

- **About:**
  - The Son River, also known as the **Sone River**, is a **perennial river** that flows through central India.
  - The Son River is the **2nd-largest southern (right bank) tributary** of the **Ganges** after the **Yamuna River.**
- **Geography:**
  - It originates near **Amarkantak Hill in the Gaurela-Pendra-Marwahi** district of Chhattisgarh and finally merges with the **Ganges River near Patna in Bihar.**
    - **Son forms a series of waterfalls at** the edge of Amarkantak plateau.
  - It flows through four states: **Chhattisgarh, Madhya Pradesh, Uttar Pradesh, and Bihar.**

Note:

- **Tributaries:**
  - Ghaghar, Johilla, Chhoti Mahanadi, Banas, Gopad, Rihand, Kanhar and North Koel River.
- **Prominent Dams and Hydroelectric Projects:**
  - **Bansagar Dam** in Madhya Pradesh
  - **Rihand Dam** near Pipri in Uttar Pradesh on **Rihand River.**
  - **Indrapuri Barrage** in Bihar; it diverts water from the Son River to the Sone Canal System for irrigation purposes.
  - **Koilwar Bridge** constructed in 1862 in Bihar; it serves as **India's oldest river bridge**, connecting Arrah with Patna.

The Palghat Gap

Why in News?

Often called as a significant discontinuity in the **Western Ghats**, the **Palghat Gap** is a geographical marvel spanning approximately 40 km in width, **separating the Nilgiris and Anamalai hills,** both towering above **2,000 meters above sea level.**

Note:

What is the Significance of Palghat Gap?

- **Origin and Formation:** The Palghat Gap originated due to the **drift of continental shelves** after the **separation of Australia and Africa** from the **Gondwana landmass.**
  - The **splitting of India and Madagascar** led to the formation of the Gap approximately 100 million years ago.
- **Vegetation:** In contrast to the tropical rainforests of the Western Ghats, the vegetation in the Palghat Gap is classified as **dry evergreen forest.**
- **Significance:**
  - **Historical:**
    - **Gateway to Kerala**: The Palghat Gap has historically served as a vital entry point into Kerala, **facilitating both road and rail transportation between Coimbatore and Palakkad.**
      - **Also,** the **Bharathappuzha river** **flows** through the Palghat Gap, enhancing its importance as a transportation route.
  - **Geographical:**
    - **Shear Zone:** The Palghat Gap is a geological shear zone, **running from east to west,** which represents a weak region in the earth's crust.
      - This geological characteristic can explain **occasional tremors** experienced in the Coimbatore region.
    - **Climate:** While the **Western Ghats north of the Palghat Gap receive more annual rainfall**, the **southern region experiences more evenly distributed rainfall** throughout the year.
  - **Ecological:**
    - **Biogeographic Distinctions:** The distinct flora and fauna on either side of the Palghat Gap are believed to be a **consequence of ancient river systems or past incursions of the sea.**
    - **Genetic Variations:** Genetic studies have revealed differences in the **mitochondrial DNA of elephant populations** residing on the Nilgiris side compared to those in the Anamalai and Periyar sanctuaries.
    - **Bird Species Variation**: Research conducted by IISc Bangalore highlighted genetic divergence in the **White-bellied Shortwing,** an endemic and threatened bird species.
      - The **Nilgiri blue robin and White-bellied blue robi**n populations exhibit slight variations in appearance based on their location around **Ooty and the Anamalai hills.**
    - **Species Richness and Phylogenetic Diversity:** A recent study conducted by groups from CCMB at Hyderabad and other institutions revealed that the southern region of the Western Ghats, located south of the Palghat Gap, **boasts abundant species richness and phylogenetic diversity.**
      - This region is home to more than **450 tree species,** including ancient species like **Magnolia champaca** (Champa; Tamil: Sambagan), which have **thrived for over 130 million years.**
  - **Other Gaps:**
    - **Thalghat (Mumbai and Nashik)**
    - **Bhorghat(Mumbai and Pune)**

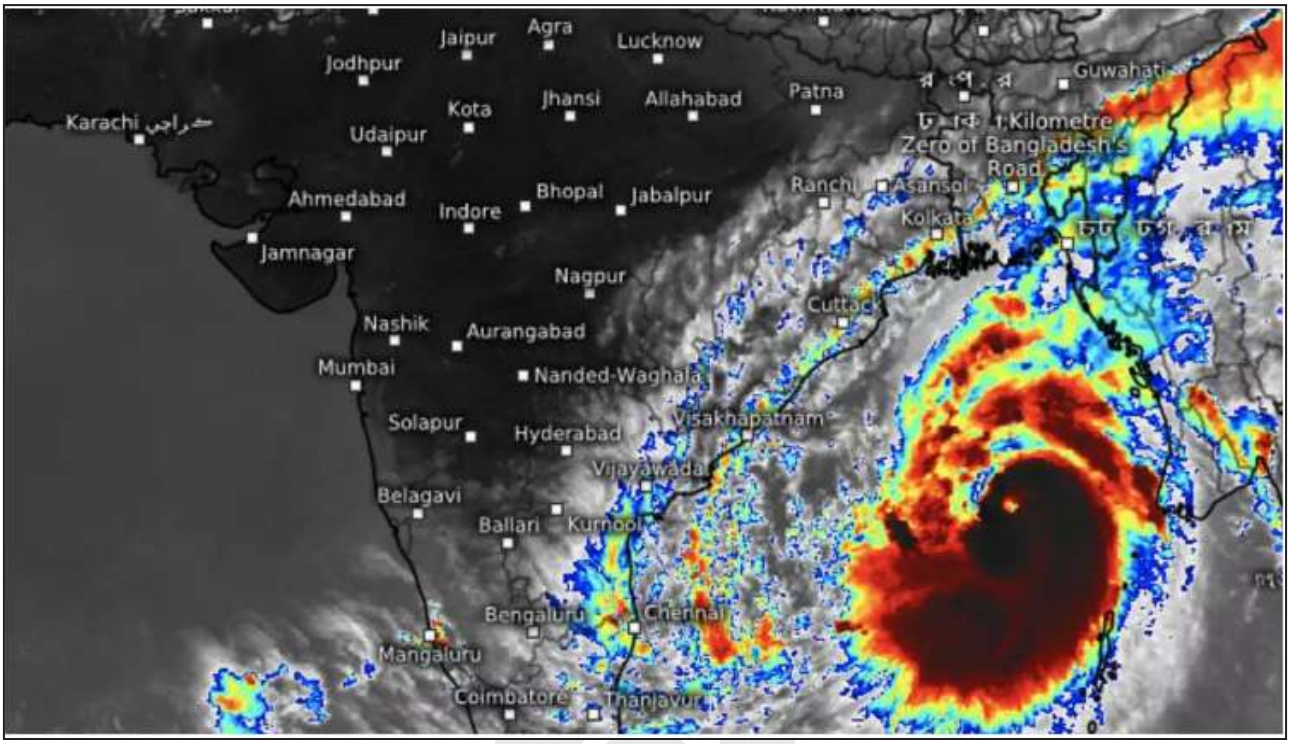
Cyclone Mocha

Why in News?

Cyclone Mocha that made landfall recently in Myanmar has been categorized as an **Extremely Severe Cyclonic Storm** by the **IMD (Indian Meteorological Department)** and as a 'Super Cyclone' by global weather website Zoom Earth.

- It became the strongest cyclone on earth so far in 2023 according to Typhoon Research Center in South Korea's Jeju National University.
- There have been 16 cyclones so far this year in **both Northern and Southern Hemispheres.**

Note:



What is Mocha?

- **Naming:**
  - Yemen suggested the name **'Mocha', which is supposed to be pronounced as Mokha.**
  - The cyclone has been named after a **Red Sea port city known for its coffee production.** The city also gave its name to the popular beverage, café Mocha
- **Origin:**
  - It originated in the **Bay of Bengal.**
- **Intensity:**
  - With a recorded wind speed of 277 kmph, Mocha became the strongest cyclone for all seasons in both **Arabian Sea and Bay of Bengal**, since 1982, in the North Indian Ocean, tying with **Cyclone Fani in terms of speed and intensity.**
    - **Amphan**, witnessed in 2020, was 268 kmph while **Tauktae** in 2021 it was 222 kmph and Gonu in 2007 recorded a speed of 268 kmph.

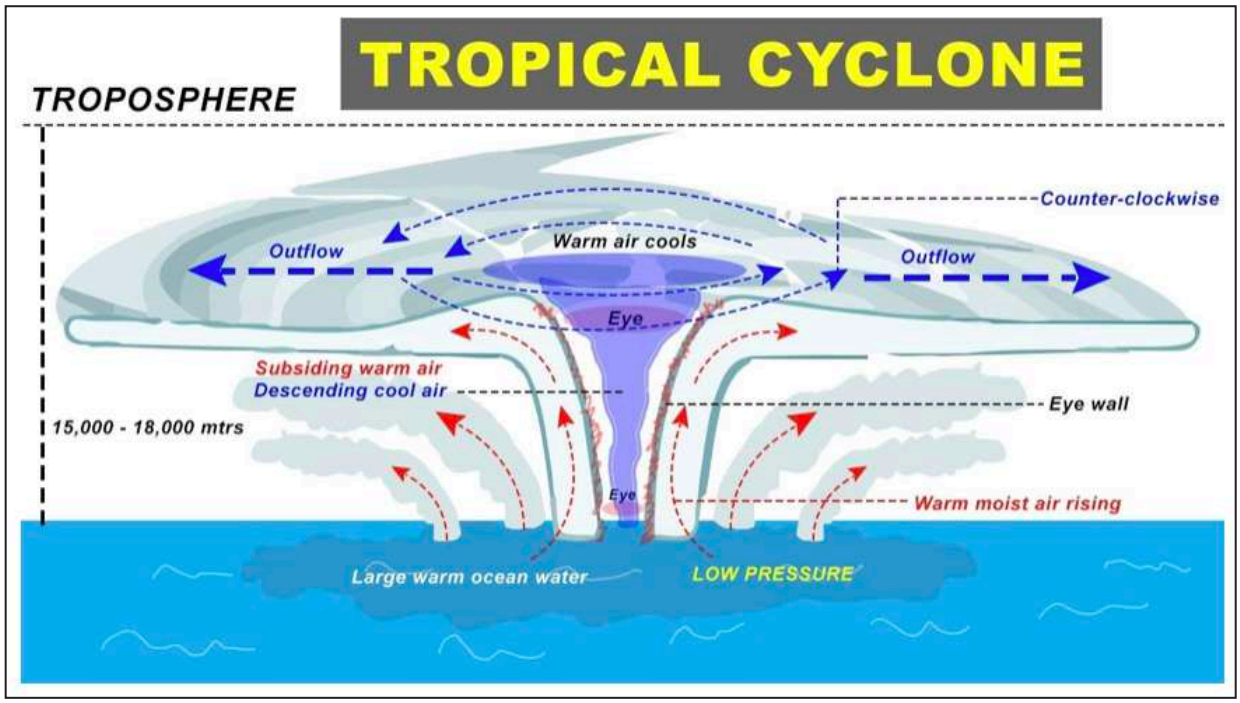
What is a Cyclone?

- **About:**
  - Cyclones are **rapid inward air circulation around a low-pressure area.** The air circulates in an **anticlockwise direction in the Northern hemisphere** and clockwise in the Southern hemisphere.
  - Cyclones are usually **accompanied by violent storms** and bad weather.
  - The word Cyclone is derived from the **Greek word Cyclos meaning the coils of a snake**. It was coined by Henry Peddington because the tropical storms in the Bay of Bengal and the Arabian Sea appear like coiled serpents of the sea.
- **Types:**
  - **Tropical Cyclones:** The **World Meteorological Organisation** (WMO) uses the term 'Tropical Cyclone' to cover weather systems in which winds exceed 'Gale Force' (minimum of 63 km per hour).
    - Tropical cyclones develop in the **region between the Tropics of Capricorn and Cancer.**
  - **Extra Tropical cyclones**: They are also called Temperate cyclones or middle latitude cyclones or Frontal cyclones or Wave Cyclones.
    - They occur in **temperate zones and high latitude regions,** though they are known to originate in the Polar Regions.

Note:

What are Tropical Cyclones?

- **About:**
  - A tropical cyclone is an intense circular storm that originates over warm tropical oceans and is characterized by low atmospheric pressure, high winds, and heavy rain.
  - A **characteristic feature of tropical cyclones is the eye**, a central region of clear skies, warm temperatures, and low atmospheric pressure.
  - Storms of this type are called **hurricanes in the North Atlantic and eastern Pacific** and **typhoons in SouthEast Asia and China**. They are called **tropical cyclones in the southwest Pacific and Indian Ocean region** and **Willy-willies in north-western Australia.**
  - Storms **rotate counterclockwise in the northern hemisphere** and clockwise in the southern hemisphere.
- **Conditions for Formation:**
  - The **conditions favourable** for the formation and intensification of tropical storms are:
    - Large sea surface with temperature higher than 27° C.
    - Presence of the Coriolis force.
    - Small variations in the vertical wind speed.
    - A pre-existing weak low- pressure area or low-level-cyclonic circulation.
    - Upper divergence above the sea level system.



How are Low-Pressure Systems Classified based on their Intensity?

- The IMD has developed criteria for **classifying low-pressure systems in the Bay of Bengal and the Arabian Sea** based on their potential for causing damage which have been adopted by the WMO.

Type of Disturbances	Wind Speed in Km/h	Wind Speed in Knots
Low Pressure	Less than 31	Less than 17
Depression	31-49	17-27
Deep Depression	49-61	27-33
Cyclonic Strom	61-88	33-47
Severe Cyclonic Stom	88-117	47-63
Super Cyclone	More than 221	More than 120

Note: 1 knot - 1.85 km per hour

How are Names of Cyclones Decided?

- Cyclones that form in every ocean basin across the world are named by the regional **specialised meteorological centres (RSMCs)** and Tropical Cyclone Warning Centres (TCWCs).

Note:

- There are six RSMCs in the world, including the India Meteorological Department (IMD), and five TCWCs.
  - In 2000, a group of nations called WMO/ESCAP (World Meteorological Organisation/United Nations Economic and Social Commission for Asia and the Pacific), which comprised Bangladesh, India, the Maldives, Myanmar, Oman, Pakistan, Sri Lanka and Thailand, decided **to start naming cyclones in the region.**
- After each country sent in suggestions, the **WMO/ESCAP Panel on Tropical Cyclones (PTC) finalised the list.**
  - The WMO/ESCAP expanded to include five more countries in 2018 — Iran, Qatar, Saudi Arabia, United Arab Emirates and Yemen.

What is the Occurrence of Cyclones in India?

- India has a **bi-annual cyclone season** that occurs between **March to May and October to December.** But on rare occasions, cyclones do **occur in June and September months.**
- Typically, t**ropical cyclones in the North Indian Ocean region** (Bay of Bengal and Arabian Sea) develop during the **pre-monsoon (April to June)** and post-monsoon (October to December) periods.
- May-June and October-November are known to produce cyclones of severe intensity that affect the Indian coasts.

Delayed Monsoon

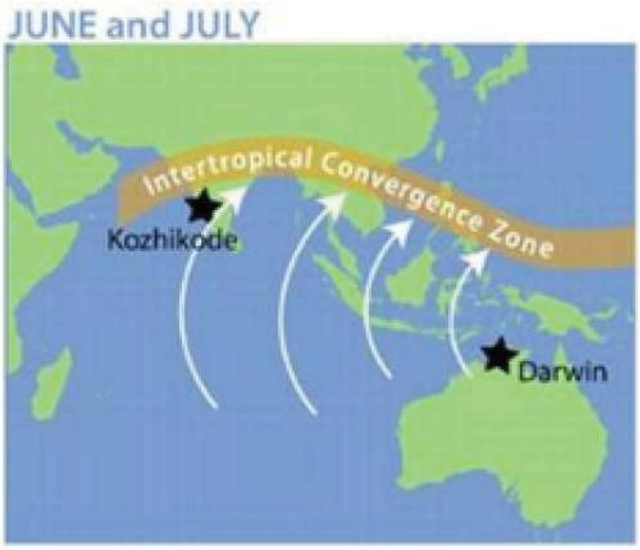
Why in News?

In 2023, the **monsoon** arrived over the Kerala coast on June 8, which is a delay compared to its normal onset date of June 1.

What is Monsoon?

- **About:**
  - Monsoons are **seasonal winds** (Rhythmic wind movements or Periodic Winds) **which reverse their direction** with the change of season.
- **Factors Influencing South-West Monsoon:**
  - The **differential heating and cooling of land and wate**r creates a low pressure on the landmass of India while the seas around experience comparatively high pressure.
  - The **shift of the position of Inter Tropical Convergence Zone (ITCZ)** in summer, over the Ganga plain (this is the equatorial trough normally positioned about 5°N of the equator.
    - It is **also known as the monsoon-trough** during the monsoon season).
- The presence of the **high-pressure area, east of Madagascar**, approximately at 20°S over the Indian Ocean. The intensity and position of this high-pressure area affect the **Indian Monsoon**.
- The **Tibetan plateau gets intensely heated during summe**r, which results in strong vertical air currents and the formation of low pressure over the plateau at **about 9 km above sea level**.
- The **movement of the westerly jet stream to the north of the Himalayas** and the presence of the **tropical easterly jet stream** over the Indian peninsula during summer.
- **Southern Oscillation (SO)**:
  - It is a shift in wind and sea surface temperature between the tropical eastern Pacific Ocean and the Indian Ocean. It is commonly referred to as the phenomenon of shifting air pressure.
  - **La Nina is the cooling phase, and El Nino** is the warming phase.
  - La Nina generally impacts positively on Indian Monsoon.
  - **Indian Ocean Dipole (IOD)**:
    - IOD is the difference between the temperature of eastern (Bay of Bengal) and the western Indian Ocean (Arabian Sea).
    - A positive IOD brings more rainfall in India while negative IOD impacts negatively.

Note:



What is the Onset of Monsoon?

- **Monsoon Onset:**
  - The onset of the monsoon over the Kerala coast signifies the **start of the four-month southwest monsoon season**, which **accounts for over 70% of India's annual rainfall.**
  - Contrary to common assumptions, the onset does not refer to the first rain of the season but rather follows specific technical criteria set by the **India Meteorological Department (IMD).**
- **Conditions for Monsoon Onset:**
  - The IMD determines the monsoon onset based on significant transitions in atmospheric and ocean circulations in the **Indo-Pacific region**.
  - The declaration of onset relies on specific parameters related to rainfall consistency, intensity, and wind speed.
- **Rainfall:**
  - The onset is declared when at least 60% of 14 designated meteorological stations in **Kerala and Lakshadweep record** at **least 2.5 mm of rain for two consecutive days** after May 10.
  - The **onset is declared on the second day if specific wind and temperature criteria are met.**
- **Wind Field:**
  - The **depth of westerlies within the equator to 10ºN latitude and the 55ºE to 80ºE** longitude range should extend up to 600 hectopascal (hPa).
  - The **zonal wind speed between** 5-10ºN latitude and 70-80ºE longitude should be around 15-20 knots (28-37 kph) at 925 hPa.
- **Heat:**
  - The **Outgoing Longwave Radiation (OLR**) value, **derived from INSAT,** should be below 200 watt per sq m (wm2) in the area between 5ºN and 10ºN latitudes and 70ºE and 75ºE longitudes.

El Nino 2023: Unusual Warming Like 2009

Why in News?

Recently, an **unusual phenomenon** is developing along the **equatorial Pacific region,** indicating the **emergence of El Nino conditions in 2023**. Experts warn that this **simultaneous warming of the eastern and western regions of the equatorial Pacific**, a trend **last observed in 2009,** could have severe implications for marine life worldwide.

What are the Causes for this Phenomenon?

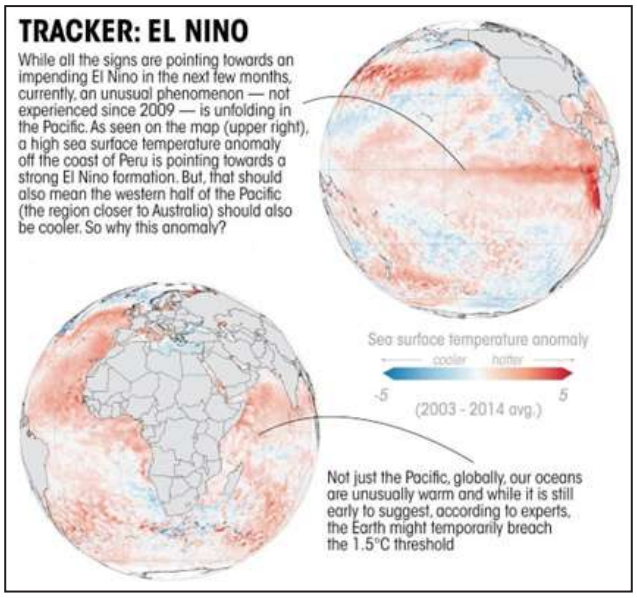
The **eastern Pacific is getting warmer,** which should make the **west cooler**.

- However, due to **global warming**, there is **basin scale warming** across the **tropical Pacific.**

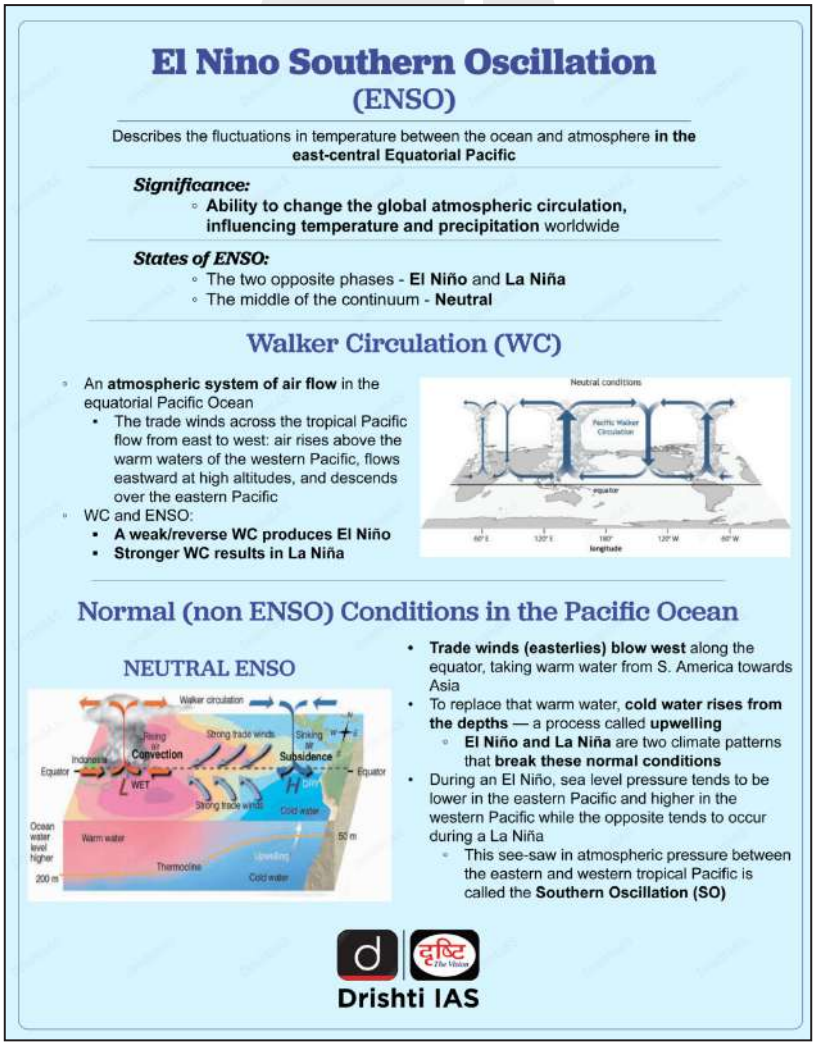
Note:

- Two things could have triggered this phenomenon:
  - **Global warming** in the Pacific and other modes of natural variability
  - The transition from **La Nina winter** into an **El Nino summer** which is part of the **El Nino-Southern Oscillation (ENSO) cycle**.

- **Basin Scale Warming in the Equatorial Pacific:**
  - Due to **global warming,** the equatorial Pacific experiences basin scale warming, **causing both eastern and western regions to become warmer.**
  - The measurement of basin scale **refers to the spatial extent of a basin or common water outlet,** in this case, the **equatorial Pacific region.**
  - Recent data analysis shows that the ocean temperatures on May 29, 2023, were unusually warm compared to the 2003-2014 average.



What is ENSO?



Note:

Previous El Nino Events:

- El Nino events of **1982-83 and 1997-98** were the **most intense** of the 20th century.
- During the **1982-83** event, sea surface temperatures in the eastern tropical Pacific were 9-18° F above normal.
- The El Nino event of **1997-98** was the first El Nino event to be **scientifically monitored from beginning to end.**
- The 1997-98 event produced drought conditions in Indonesia, Malaysia, and the Philippines. Peru and California experienced very heavy rains and severe flooding.
- The Midwest experienced record-breaking warm temperatures during a period known as **"the year without a winter."**
- **The El Nino, along with global warming, had made 2016 the warmest year on record.**

Unveiling Ancient Climate Secrets with Ladakh

Why in News?

Scientists have made significant strides in **understanding climate variations during the transition from the last deglaciation period**, approximately 19.6 to 6.1 thousand years ago.

- By studying sediment deposits from **ancient lakes in the Indus River valley in Ladakh,** they have reconstructed climate records and shed light on the region's climate history.

What are the Major Findings of the Research?

- **Research Methodology:**
  - Scientists sampled sediment deposits from an 18-meter-thick sequence found along the **Indus River** at an altitude of 3287 metres.
  - The researchers conducted meticulous laboratory analyses on the samples, examining physical characteristics such as **colour, texture, grain size, grain composition, total organic carbon, and magnetic parameters.**
    - These parameters were used to extract information about past climate conditions from the **palaeolake sedimentary archive.**
- **Major Findings Related to Climate Evolution:**
  - Between 19.6 and 11.1 thousand years ago, a **cold arid climate dominated the region** due to the influence of **westerly circulation**.
  - From 11.1 to 7.5 thousand years ago, **monsoon forcings became the primary driver of climate,** leading to a period of strong monsoons.
  - Afterward, **orbitally controlled solar insolation** played a crucial role in shaping the climate by influencing the position of the **Inter Tropical Convergence Zone (ITCZ)** and the variability of atmospheric circulations.
  - During the mid-Holocene (7.5 to 6.1 thousand years ago), the westerlies regained strength, coinciding with decreasing insolation, **a weakening monsoon, and enhanced El Nino activities.**
    - The study also demonstrates the **potential of using multiple physical parameters of sediments to reconstruct paleoclimate variations** (changes in Earth's climate that occurred in the geological past**)** with high resolution and accuracy.

Westerly Circulation

- It refers to the **predominant west-to-east flow of winds in the mid-latitudes of both hemispheres.**
- It is caused by the **rotation of the Earth and the temperature differences between the equator and the poles**. The westerlies play a crucial role in weather patterns and the transport of heat, moisture, and pollutants across regions.

Orbitally Controlled Solar Insolation

- It refers to the **variations in the amount of solar radiation received on Earth due to changes in Earth's orbit around the sun.**
- These orbital variations occur over long periods, such as tens of thousands of years, and can impact climate patterns.

Intertropical Convergence Zone

- The **ITCZ is a low-pressure zone near the equator** where trade winds from the northern and southern hemispheres converge.
- It is **characterised by abundant rainfall and is responsible for the formation of tropical rainforests and monsoon systems.**
  - The **ITCZ migrates north and south with the changing seasons**, following the sun's zenith position.

Note:

Indian Ocean Dipole

Why in News?

The Indian **Monsoon** is expected to be influenced by the **El Nino phenomenon in 2023**, there are also anticipations of a positive **Indian Ocean Dipole (IOD)** developing, which could potentially offset the **impact of El Nino.**

- According to the **India Meteorological Department (IMD)**, there is about 80% probability for positive IOD conditions and 15% of a neutral IOD during June-August 2023 season.
- While El Nino is already firmly established in the Pacific Ocean in 2023, the IOD is **still in the neutral phase** and may develop in the coming months.

What is the Indian Ocean Dipole (IOD)?

- **IOD or Indian Nino:**
  - IOD, sometimes referred to as the **Indian Nino**, is similar to the **El Nino** phenomenon, **occurring in the relatively smaller area** of the Indian Ocean between the **Indonesian and Malaysian coastline** in the **east and the African coastline near Somalia** in the west.
    - **The El Nino** is the warmer-than-normal phase of the **El Nino Southern Oscillation (ENSO) phenomenon,** during which there are generally warmer temperatures and less rainfall than normal in many regions of the world, including India.
  - One side of the ocean, along the equator, gets warmer than the other.
  - IOD is said to be positive when the western side of the Indian Ocean, near the **Somalia coast, becomes warmer** than the eastern Indian Ocean.
  - It is negative when the **western Indian Ocean is cooler.**
- **Mechanism:**
  - **Negative IOD:**
    - The air circulation in the Indian Ocean basin moves from **west to east,** that is from the **African coast towards the Indonesian islands**, near the surface, and in the opposite direction at the upper levels. That means the **surface waters in the Indian Ocean get pushed from west to east.**
    - In a normal year, **warmer waters in the western Pacific** near Indonesia cross over into the Indian Ocean and make that part of the Indian Ocean slightly warmer. That causes the air to rise and helps the prevailing air circulation.
    - In the years when the air circulation **becomes stronger, more warm surface waters from the African coast** are pushed towards the Indonesian islands, making that region warmer than usual. This causes hotter air to rise, and the **cycle reinforces itself.**
    - This is the **state of negative IOD.**
  - **Positive IOD:**
    - Air circulation becomes **slightly weaker** than normal. In some rare cases, the air circulation **even reverses direction**. The consequence is that the African coast **becomes warmer while the Indonesian coastline gets cooler.**
      - A positive IOD event is often seen developing at times of an **El Nino, while a negative IOD is sometimes associated with La Nina.**
    - During El Nino, the Pacific side of Indonesia is cooler than normal because of which the Indian Ocean side also gets cooler. That **helps the development of a positive IOD.**
  - **Impact of IOD:**
    - In the Indian Ocean, IOD exhibits **an ocean-atmosphere interaction** that closely resembles the fluctuations observed during El Niño events in the **Pacific Ocean**. However, the IOD is considerably **less powerful compared to El Niño, resulting in relatively minimal impacts.**
    - A positive IOD helps rainfall **along the African coastline and also over the Indian sub-continent** while suppressing rainfall over Indonesia, southeast Asia and Australia. The impacts are opposite during a negative IOD event.
  - **Past Events:**
    - In 2019 the IOD event developed during the late monsoon but was **so strong that it compensated for the deficit rainfall** during the first month of the monsoon season (June had 30% deficiency that year).
    - The deficit in June that year was also **attributed to a developing El Nino but that fizzled out later.**

Note:

What is ENSO?

- In a normal year, the eastern side of the Pacific Ocean, near the **northwestern coast of South America**, is cooler than the western side near the islands of Philippines and Indonesia.
  - This happens because the **prevailing wind systems that move from east to west sweep the warmer surface** waters towards the Indonesian coast.
- The relatively **cooler waters from below come up** to replace the displaced water.
- An El Nino event is the **result of a weakening of wind systems that leads to lesser displacement** of warmer waters.
- This results in the **eastern side of the Pacific becoming warmer** than usual. During **La Nina, the opposite happens.**
- Both these conditions, together called **El Nino Southern Oscillation (ENSO),** affect weather **events across the world.**
- Over India, the El Nino has the **impact of suppressing monsoon rainfall.**

Impact of Ground Water Extraction on Earth's Spin

Why in News?

A recent study published in **Geophysical Research Letters** has shed light on the significant impact of **Groundwater Extraction on Earth's Rotational Axis** and its contribution to global sea-level rise.

- Researchers analyzed changes in the drift of Earth's rotational pole and water movement — first, by accounting for **just ice sheets and Glaciers** and then by adding different groundwater redistribution scenarios.

What are the Key Findings of the Study?

- **Earth's Tilt:**
  - Groundwater pumping has tilted Earth nearly **80 centimeters east between 1993 and 2010** alone.
  - The water circulated across the planet **determines how mass is distributed.**
    - Between **1993 and 2010, people pumped 2,150 gigatons of groundwater,** or more than 6 millimeters of sea level increase.
- **Impact on Polar Drift:**
  - Excessive groundwater pumping has caused **the Earth's pole to drift at a rate of 4.36 centimeters per year between 1993 and 2010,** making it the climate-related factor with the greatest impact on polar motion.
  - Redistributing water from the **mid-latitudes significantly influences polar drift;** therefore, the location of redistribution determines polar drift.
    - During the study period, most redistribution occurred in western North America and northwestern India — both located at mid-latitudes.
- **Impact of Groundwater Pumping on Sea-Level Rise:**
  - Groundwater pumping contributed to a **sea-level rise of 6.24 mm** during the mentioned period.
  - Pumping from mid latitude areas, such as northwest India and western North America, has the **most substantial influence on Earth's axis drift.**
- **Impact of Polar Drift:**
  - The rotational pole normally **changes by several metres within about a year,** so changes due to groundwater pumping **don't run the risk of shifting seasons**.
  - But on geologic time scales, **polar drift can have an impact on climate.**
- **Recommendations:**
  - Attempts to slow groundwater depletion rates, especially in those sensitive regions, **can theoretically alter the change in drift**, but only if such conservation approaches are sustained for decades.

Massive Shelf Clouds Formation

Why in News?

Recently, a massive Shelf Cloud formation has been spotted in Haridwar, Uttarakhand.

Note:

What are Shelf Clouds?

- **About:**
  - Shelf clouds - also known as **Arcus clouds** - are often associated with powerful **storm systems, and many times they are reported as wall clouds**, funnel clouds, or rotation.
  - These clouds are sometimes seen **beneath cumulonimbus clouds**, the dense, towering vertical cloud that causes intense rain.
  - They often appear **ahead of powerful Thunderstorms with heavy rain**, strong winds, and occasionally hail or tornadoes.
- **Formation:**
  - When a cold **downdraft from a cumulonimbus cloud** reaches the ground, the cold air may spread rapidly along the ground, **pushing existing warm moist air upwards.**
  - As the cold air descends, it pushes warm air upward, **causing condensation and cloud formation**. This process creates the distinct horizontal shape and appearance of a shelf cloud.

What are the Types of Clouds?

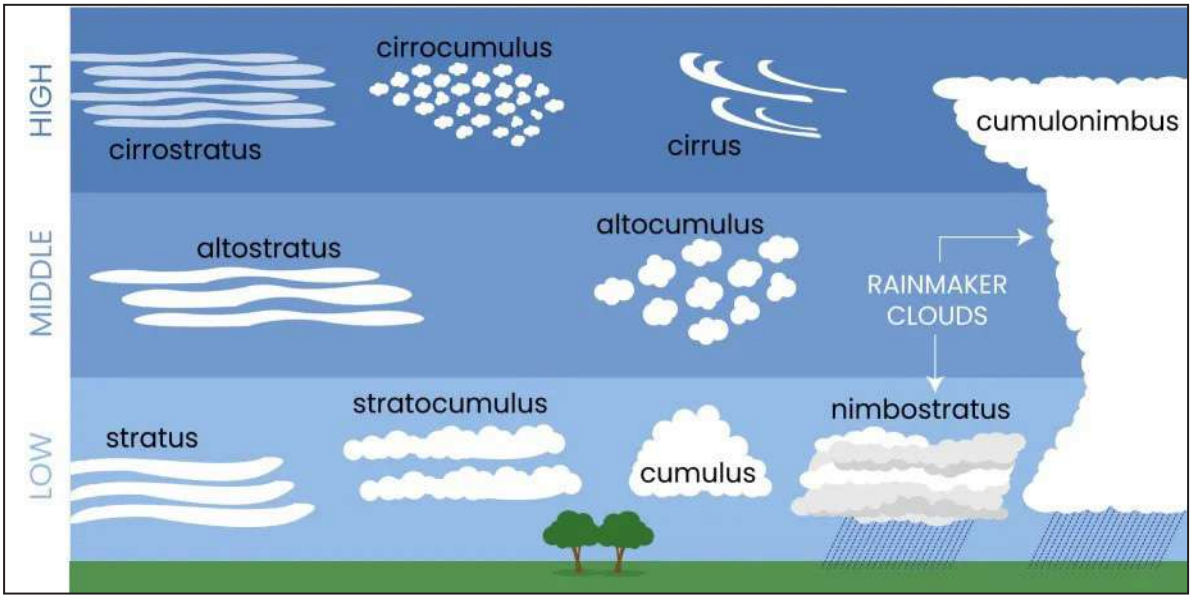
- **High Clouds:**
  - **Cirrus Clouds:** Cirrus clouds are h**igh-altitude clouds that appear wispy**, feathery, and white. They are composed of i**ce crystals and are often associated with fair weather**.
    - Cirrus clouds **can cause halo, a ring around the sun or the moon.**
  - **Cirrocumulus Clouds:** High-altitude clouds **that appear as small, white, and fluffy cloud** patches. They often have a wavy or honeycomb-like pattern.
  - **Cirrostratus Clouds:** High-altitude clouds that form a thin, whitish veil covering the sky. They can produce halos around the sun or moon.
- **Middle Clouds:**
  - **Altocumulus Clouds:** Mid-level clouds that form white or gray patches or layers. They often have a wavy or lumpy appearance.
  - **Altostratus Clouds:** Mid-level clouds that create a uniform, gray or bluish-gray layer covering the sky. They are **thicker and denser than cirrostratus clouds** and can lead to light precipitation.
- **Low Clouds:**
  - **Cumulus Clouds:** Cumulus clouds are **fluffy, white clouds with a flat bas**e and a rounded top. They are typically formed by **rising warm air currents and are often seen on sunny days.** Cumulus clouds can develop into cumulonimbus clouds, which are associated with thunderstorms.

Note:

- **Stratus Clouds:** Stratus clouds are **low-level clouds that appear as a uniform grayish layer** covering the sky. They often bring drizzle or light precipitation and can create a dull, overcast appearance.
- **Stratocumulus Clouds:** Low-level clouds with **a patchy appearance,** often appearing as rounded masses. They can be white or gray and cover a significant portion of the sky.
- **Nimbostratus Clouds**: Thick, dark, and featureless clouds that cover the sky. They bring continuous precipitation, often lasting for an extended period.

➢ **Clouds that exhibit Significant Vertical Development:**

- **Cumulonimbus Clouds:** Large, towering clouds **associated with thunderstorms.** They have a dark base and can reach high altitudes, producing heavy rain, lightning, and strong winds.



Anthropocene Epoch

Why in News?

Recently, the Anthropocene Working Group (AWG) has proposed that the **Anthropocene,** a new geological epoch characterized by significant human impact on Earth's systems, **began in 1950.**

➢ The AWG is an interdisciplinary research group dedicated to the investigation of the Anthropocene.

➢ If the proposal wins the necessary majority support, the **International Union of Geological Sciences** could officially ratify the new **Global boundary Stratotype Section and Point (GSSP) in August 2024**.

Note: The GSSP is a designated geological reference point that marks the boundary between **two geological time units.** It serves as an internationally agreed-upon standard for defining and **correlating different periods in Earth's history.** GSSPs are crucial for establishing the boundaries of epochs, ages, and other divisions within the geologic time scale.

What is the Anthropocene?

➢ The Anthropocene epoch as a term was first **coined by Nobel Prize-winning chemist Paul Crutzen** and biology **professor Eugene Stoermer in 2000** to denote the present geological time interval, in which the **Earth's ecosystem has gone through radical changes** due to human impact, especially since the onset of the **Industrial Revolution**.

➢ There are numerous phenomena associated with this epoch, such as **Global Warming, Sea-Level Rise, Ocean Acidification**, mass-scale soil erosion, the advent of deadly **Heat Waves**, deterioration of the biosphere and other detrimental changes in the environment.

What is the Holocene Epoch?

➢ The Holocene is the **current geological epoch, which began approximately 11,700** years ago at the end of the last major ice age.

➢ It is characterized by a relatively **stable and warm climate**, as well as the development of human civilization.

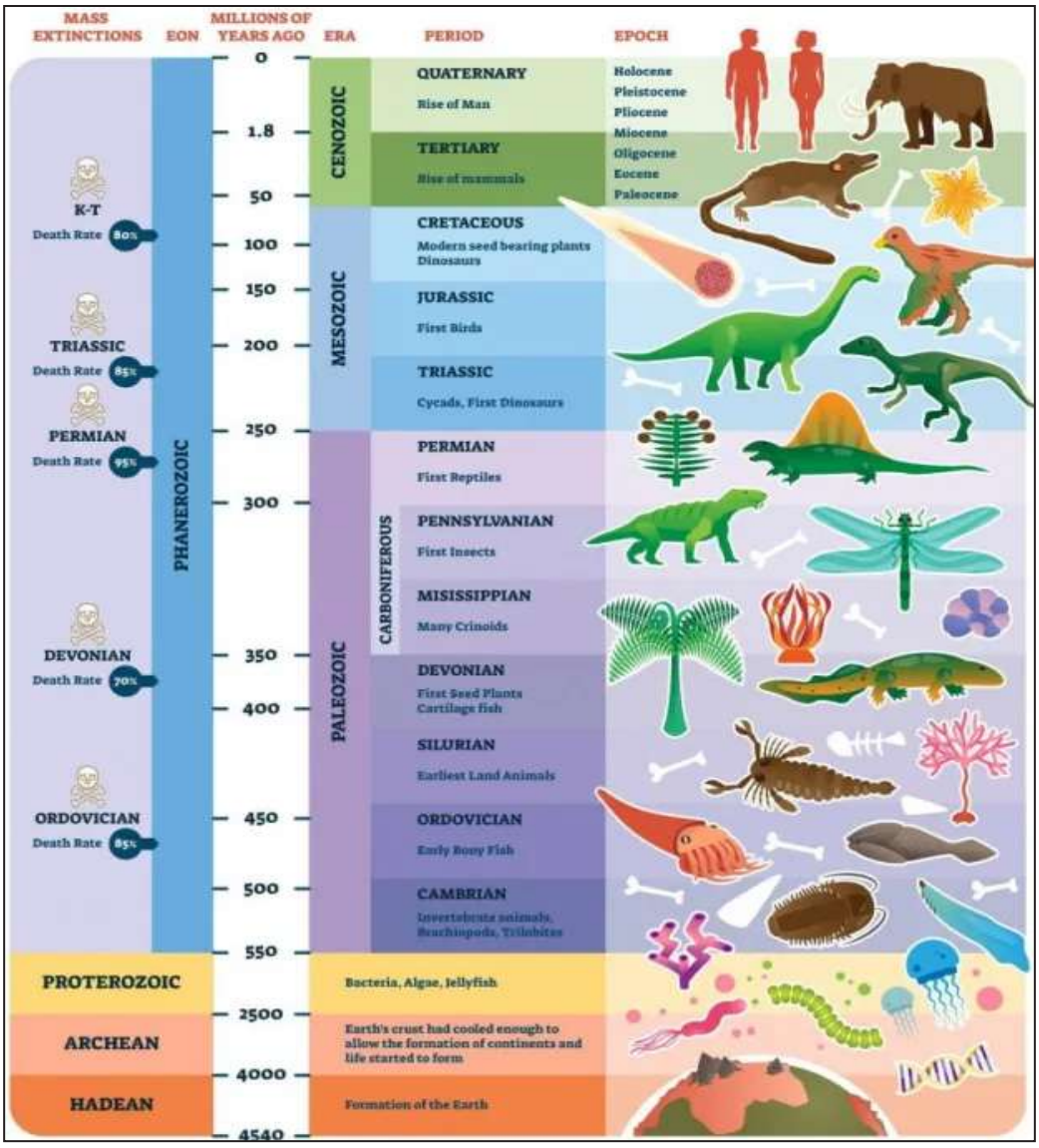
Note:

- The Holocene follows the **Pleistocene epoch and is part of the larger Quaternary period**.
- During the Holocene, Earth's climate experienced fluctuations, but overall, it has been a period of **relatively milder and more stable conditions compar**ed to the preceding ice age. The retreat of glaciers and the rise in global temperatures allowed for the expansion of forests, grasslands, and diverse ecosystems.

What is the Geological Time Scale?

- Geologists divide the **4.6-billion-year existence of Earth into slices of time** such as Eon, Era, System/ Period, Series/Epoch, and Stage/Age.
- Eons are divided into **Eras, Eras into Periods, Periods into Epochs, and Epoch**s into Ages.

- Each slice corresponds to **significant happenings** - such as the break-up of continents, dramatic shifts in climate, and even the emergence of particular types of animals and plant life.



Note:

What is the International Union of Geological Science?

- The International Union of Geological Sciences (IUGS) is a global non-governmental organization that **aims to promote and advance the Earth sciences**. It serves as the international coordinating body for professional geological research and education.
- The IUGS was founded in **1961 and is a member of the International Science Council (ISC).**

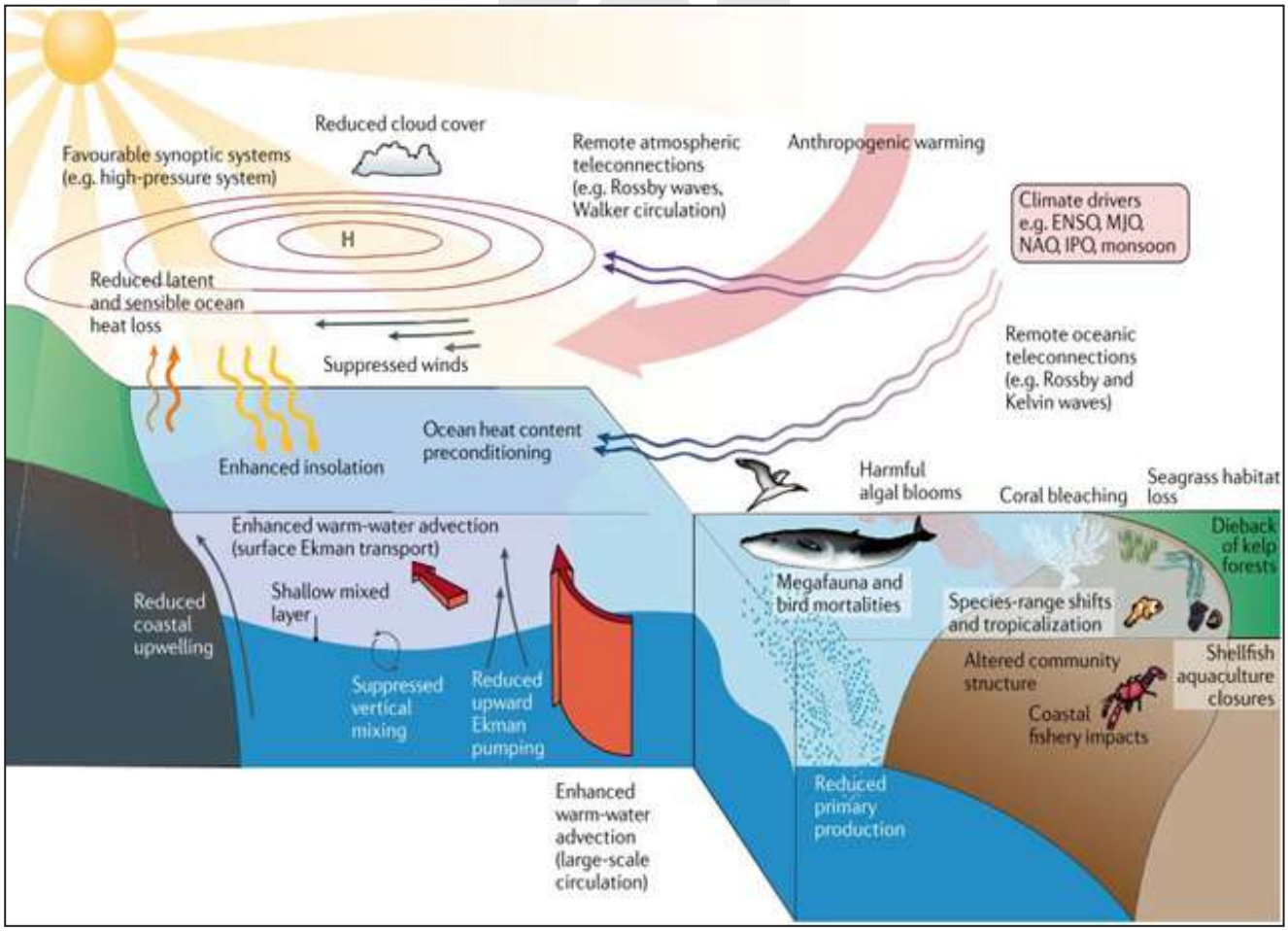
Marine Heatwave and its Impacts

Why in News?

The northern **Bay of Bengal** has been experiencing an intense **Marine Heatwave** since 28th June 2023, leading to India's **usually arid northwest receiving extreme rainfall**.

What is Marine Heatwave?

- Marine Heatwaves are **prolonged periods** of anomalously high **Sea Surface Temperature (SST).**
- These events are linked to **coral bleaching**, **seagrass destruction, and loss of kelp forests, affecting the fisheries sector** adversely.
- The most common drivers of marine heatwaves include **ocean currents which can build up areas of warm water** and air-sea heat flux or warming through the ocean surface from the atmosphere.
  - Winds can enhance or suppress the warming in a marine heatwave, and **climate modes like El Niño** can change the likelihood of events occurring in certain regions.



Note:

How does Marine Heatwave Impact Rainfall in Northwest India?

- The marine heatwave in the Bay of Bengal **increased sea surface temperatures, causing higher evaporation rates** and a greater moisture supply in the atmosphere. This surplus of moisture contributed to above-average rainfall in northwest India.
- The marine heatwave likely in**fluenced the formation and behavior of depressions** in the Bay of Bengal, which may have contributed to an **increase in the frequency and intensity of depressions**, particularly on faster timescales (3-10 days).
  - Depressions, which are low-pressure systems, play a significant role in the monsoon and rainfall patterns.
- The marine heatwave, along with changing timescales of depressions, **affected the path and trajectory of these weather systems.** Depressions tended to move more towards northwest India rather than **north-central India, causing** a **higher concentration of rainfall in the northwest region**, leading to **above-average rainfall** in that area.

Flash Floods in Himachal Pradesh

Why in News?

The 2023 Monsoon rain in Himachal Pradesh has brought severe Flash Floods in many regions causing unprecedented loss of lives and assets.

What are Flash Floods?

- **About:**
  - They are **sudden surges in water levels** generally during or following an **intense spell of rain.**
    - These are highly **localised 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.
  - The flood situation worsens in the **presence of choked drainage lines** or encroachments obstructing the natural flow of water.
- **Causes:**
  - It may be caused by heavy rain **associated with a severe thunderstorm**, hurricane, tropical storm, or meltwater from ice or snow flowing over ice sheets or snowfields.
  - Flash Floods can also occur due to Dam or Levee Breaks, and/or Mudslides (Debris Flow).

How have been the Instances of Precipitation in Himachal Pradesh (HP)?

- In the Himalayas, there is a noticeable **pattern of increased precipitation occurring in shorter periods** of time.
  - The IPCC (Intergovernmental Panel on Climate Change) 6 report has clearly stated that the Himalayas and coastal regions of India **will be the hardest hit by climate change.**
  - The India Meteorological Department (IMD) data shows that the normal rainfall during this period is expected to be between 720mm and 750 mm. However, in certain instances, it has exceeded **888 mm in 2010 and 926.9 mm in 2018.**
- In 2023, the precipitation in HP so far has been attributed to the combined effect of the South-West Monsoon **with** Western Disturbances.
- The total rainfall from June to date **was 511 mm.**

What are the Government Initiatives to Tackle Flash Floods?

- National Flood Risk Mitigation Project (NFRMP)
- National Disaster Management Plan (NDMP).
- National Disaster Management Authority **(NDMA).**
- India Meteorological Department **(IMD)**
- National Flood Management Programme
- **Rashtriya Barh Ayog (National Flood Commission) 1976**

Lightning in India

Why in News?

Lightning has been a cause of concern in India, leading to a significant number of fatalities each year. As demands arise from states like **Bihar and West Bengal** to declare **lightning a natural disaster**, the Union government has taken a cautious stance.

Note:

- If approved, victims would be entitled to compensation from the State Disaster Response Fund (SDRF), of which **75% is contributed by the Central government.**

Note: At present **cyclone, drought, earthquake, fire, flood, tsunami, hailstorm, landslide, avalanche, cloudburst, pest attack, frost and cold waves** are considered disasters that are covered under the SDRF. This does not include lightning yet.

What is the Current Scenario of Lightening in India?

- **About:**
  - **Lightning** is a **powerful and visible electrical phenomenon** that takes place when there is a **buildup of electrical charges within clouds and between clouds and the ground.**
    - The discharge of this electrical energy results in a **brilliant flash of light and a rapid expansion of air**, creating the characteristic thunder that accompanies lightning.
    - **Cloud-to-ground (CG)** lightning is dangerous because it can electrocute people due to its high electric voltage and current.
  - India ranks among the **five countries worldwide** with an **early warning system for lightning.**
    - The system provides forecasts ranging from **five days to as close as three hours before the occurrence of lightning.**
- **Lightning Fatalities: Statistics and Trends**
  - National Crime Records Bureau (NCRB) Data: In 2021**, lightning accounted for 2,880 deaths,** comprising **40% of all accidental deaths caused by "forces of nature."**
    - The trend indicates an increase in lightning-related fatalities compared to other natural events.
- **Geographical Distribution in India:**
  - Lightning frequency is highest in northeastern states and West Bengal, Sikkim, Jharkhand, Odisha, and Bihar.
    - However, the number of lightning-related deaths is higher in central Indian states like **Madhya Pradesh, Maharashtra, Chhattisgarh, and Odisha.**
  - Bihar is one of the **most vulnerable states to lightning strikes**, with a significant number of deaths reported annually.
    - In 2023, till July 6, **Bihar recorded 107 deaths due to lightning.**
- **Union Government's View About Lightning:**
  - The **Union government opposes declaring lightning a natural disaster.** The government believes that education and awareness can help prevent lightning-related deaths effectively.

What are the Possible Factors Behind the Increasing Trend of Lightning Strikes?

- **Climate Change**: Global warming and climate change could potentially influence atmospheric conditions, leading to an increase in thunderstorms and lightning activity.
  - As the planet's temperature rises, there may be **changes in the distribution of moisture, instability, and convective processes** that could favor more frequent lightning occurrences.
  - Kalbaisakhi is a localised thunderstorm occurrence that is **accompanied by lightning,** typically observed during the **pre-monsoon season in the Indian subcontinent.**
- **Urbanization:** The expansion of urban areas can create what is known as the **"urban heat island effect."**
  - Cities tend to be warmer than surrounding rural areas due to increased **human activity, energy consumption**, and impervious surfaces.
  - These localized heat islands may lead to the formation of more thunderstorms and, consequently, an increase in lightning strikes.
- **Land Use Changes:** Deforestation, changes in agricultural practices, and alterations of natural landscapes may disrupt local atmospheric conditions.

Note:

- Such changes might contribute to the development of thunderstorms and, consequently, more lightning.

- **Pollution and Aerosols**: Air pollution, including aerosols and particulate matter, can affect cloud formation and electrical activity within storms.
  - Anthropogenic emissions might influence the frequency and intensity of thunderstorms, potentially leading to more lightning strikes.

Monsoon, El Nino And Their Impact on Agriculture

Why in News?

The **2023 southwest monsoon season in India** started late, with the initial two weeks experiencing a **significant rainfall deficiency of 52.6% below the normal long-period average(LPA).**

- However, as of July 30, 2023 there was an overall **6% surplus rainfall.** This **turnaround has positively impacted kharif crop plantings**. However, concerns persist regarding the **potential impact of the approaching El Nino phenomenon on rabi crops.**

What is the Long-Period Average (LPA) of Rainfall?

- The IMD defines the "LPA of rainfall" as the **average rainfall recorded over a specific region for a long period**, like **30 or 50 years**. Based on this, the IMD classifies rainfall into five categories on an all-India scale:
  - **Normal or near normal:** Rainfall between 96-104% of LPA.
  - **Below normal:** Rainfall between 90-96% of LPA.
  - **Above normal:** Rainfall between 104-110% of LPA.
  - **Deficient**: Rainfall less than 90% of LPA.
  - **Excess:** Rainfall more than 110% of LPA.

What are Kharif and Rabi Crops?

- **Kharif Crops:**
  - Kharif crops are sown during the **monsoon season,** from **June to October,** and harvested in the **late summer or early autumn**.
  - They depend on the **southwest monsoon for irrigation and growth**.
  - Major Kharif crops include rice, maize, sorghum, pearl millet (bajra), finger millet (ragi), groundnut and pulses like **pigeon pea (arhar) and green gram (moong).**
  - They account for about **55% of the total foodgrain production in India.**
- **Rabi Crops:**
  - These crops are sown around the **Retreating Monsoon and Northeast monsoon season,** which begins in October and are called rabi or winter crops.
  - The harvest for these crops happens typically during April and May, during the summer season.
  - Major Rabi crops **are wheat, gram, peas, barley etc.**
  - A warm climate is required for seed germination and cold climate for the growth of crops.

- **About El Nino**:
  - **El Nino** is a climate phenomenon that occurs **irregularly in the tropical Pacific Ocean,** characterized by the **warming of sea surface temperatures**.
    - It can have significant impacts on weather patterns around the world, including India.
  - The Oceanic Nino Index (ONI) reached 0.8 degrees Celsius in **June, 2023** surpassing the **El Nino threshold of 0.5 degrees.**
    - Global weather agencies forecast El Nino to persist and strengthen through the 2023-24 winter.

Note:

El Niño and La Niña

El Niño

- **Warming** of the ocean surface/ Above average **sea surface temp.** (SST)
- **Easterly winds either weaken** or start blowing in the **opposite direction**
- First noticed by **Peruvian fishermen** in the 1600s
- **More frequent than La Niña**

Impacts

- **Drastically higher rainfall in S. America** (coastal flooding and erosion)
- **Droughts in Indonesia and Australia**; wildfires
- **Weaker monsoons** and even **droughts** in **India and SE Asia**
- **Reduces the upwelling** of cooler, nutrient-rich waters from the deep - along the west coast of South and Central America.

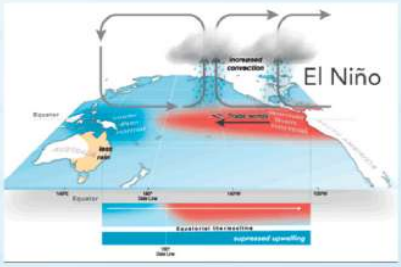


Fig. 1 - Depiction of El Niño Phenomenon

La Niña

- Also called **El Viejo, anti-El Niño, or simply "a cold event"**
- **Normal easterly winds** along the equator **become even stronger**
- **May last 1-3 years,** unlike El Nino (which usually lasts no more than a year)

Impacts

- **Heavier rains in SE Africa**, catastrophic **floods in Australia**
- **Drier-than-normal conditions** in S. America
- **Summer Monsoon rainfall** - greater than normal rainfall in **India**; beneficial for agriculture dependent Indian economy
- Off the west coast of the Americas, **upwelling increases**, bringing cold, nutrient-rich water to the surface.

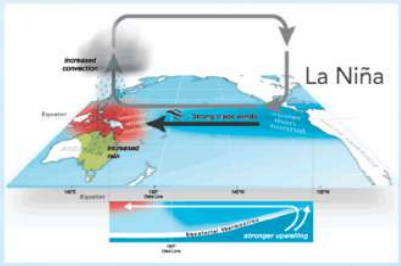


Fig. 2 - Depiction of La Niña Phenomenon

Oceanic Nino Index (ONI)

- It is a measure of the departure from normal sea surface temperature in the east-central Pacific Ocean.
- It is the **standard means by which each El Nino episode is determined,** gauged, and forecast.

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Equatorial Origin Cyclones and Pacific Decadal Oscillation

Why in News?

Equatorial-origin cyclones have been unusually subdued in recent decades.

- However, as per a study published in the journal ***Nature Communications***, the combination of global warming and the Pacific Decadal Oscillation (PDO) could make such cyclones more frequent in the coming years.

What are Equatorial-Origin or Low Latitude Cyclones?

- Equatorial origin or Low Latitudes Cyclones (LLCs) originate between 5°N and 11°N. These cyclones are much smaller in size than those in higher latitudes but **intensify more rapidly.**
  - Cyclones forming near the equator (low-latitude) is usually rare but when the waters are warm, they can gain more moisture and rise in intensity.
  - **Majority of cyclones originate in the Western Pacific Ocean.**
- The last major cyclone of this kind in the Indian neighbourhood was the 2017 **Cyclone Ockhi** which travelled >2000 km and **devastated Kerala, Tamil Nadu and Sri Lanka.**
- The north Indian Ocean (NIO) in the post-monsoon season (Oct-Nov-Dec) is a hotbed for LLCs that **constitute about 60% of all Tropical Cyclones** formed in the NIO (since 1951) but has received relatively less attention.

Note:

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CYCLONE

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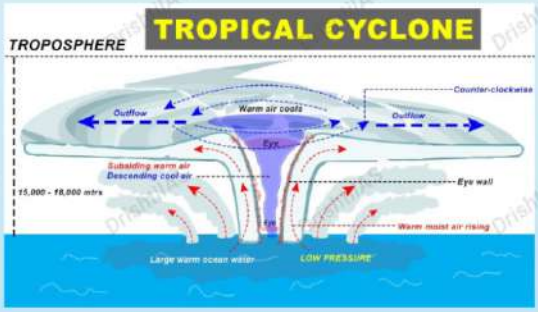
Cyclones are rapid **inward** air circulation around a **low-pressure** area.

Cyclone v/s Anticyclone

Pressure System	Pressure Condition at the Center	Pattern of Wind Direction	
		Northern Hemisphere	Southern Hemisphere
Cyclone	Low	Anticlockwise	Clockwise
Anticyclone	High	Clockwise	Anticlockwise

Classification

- **Tropical Cyclones;** originate between the **Tropics of Capricorn and Cancer**
- **Extra Tropical/ Temperate Cyclones;** originate in the **Polar Regions**



Conditions for Formation

- Large sea surface with temperature >27° C.
- Presence of the **Coriolis force**
- Small **variations in the vertical wind speed**
- **A pre-existing weak low- pressure area**
- **Upper divergence** above the sea level system

Nomenclature

- Nodal Authority - **World Meteorological Organization (WMO)**
- Indian Ocean Region - **Bangladesh, India, Maldives, Myanmar, Oman, Pakistan, Sri Lanka** and **Thailand** contribute to naming cyclones that occur in this region.

Different Names for Tropical Cyclones

- **Typhoons** - Southeast Asia and China
- **Hurricanes** - North Atlantic and eastern Pacific
- **Tornados** - West Africa and southern USA
- **Willy-willies** - Northwest Australia
- **Tropical Cyclones** - Southwest Pacific and Indian Ocean

Cyclones in India

- **Bi-annual Cyclone Season** - March to May and October to December
- Recent Cyclones - **Tauktae, Vayu, Nisarga and Mekanu** (in Arabian Sea) and **Asani, Amphan, Fani, Nivar, Bulbul, Titli, Yaas and Sitrang (in Bay of Bengal)**

Note:

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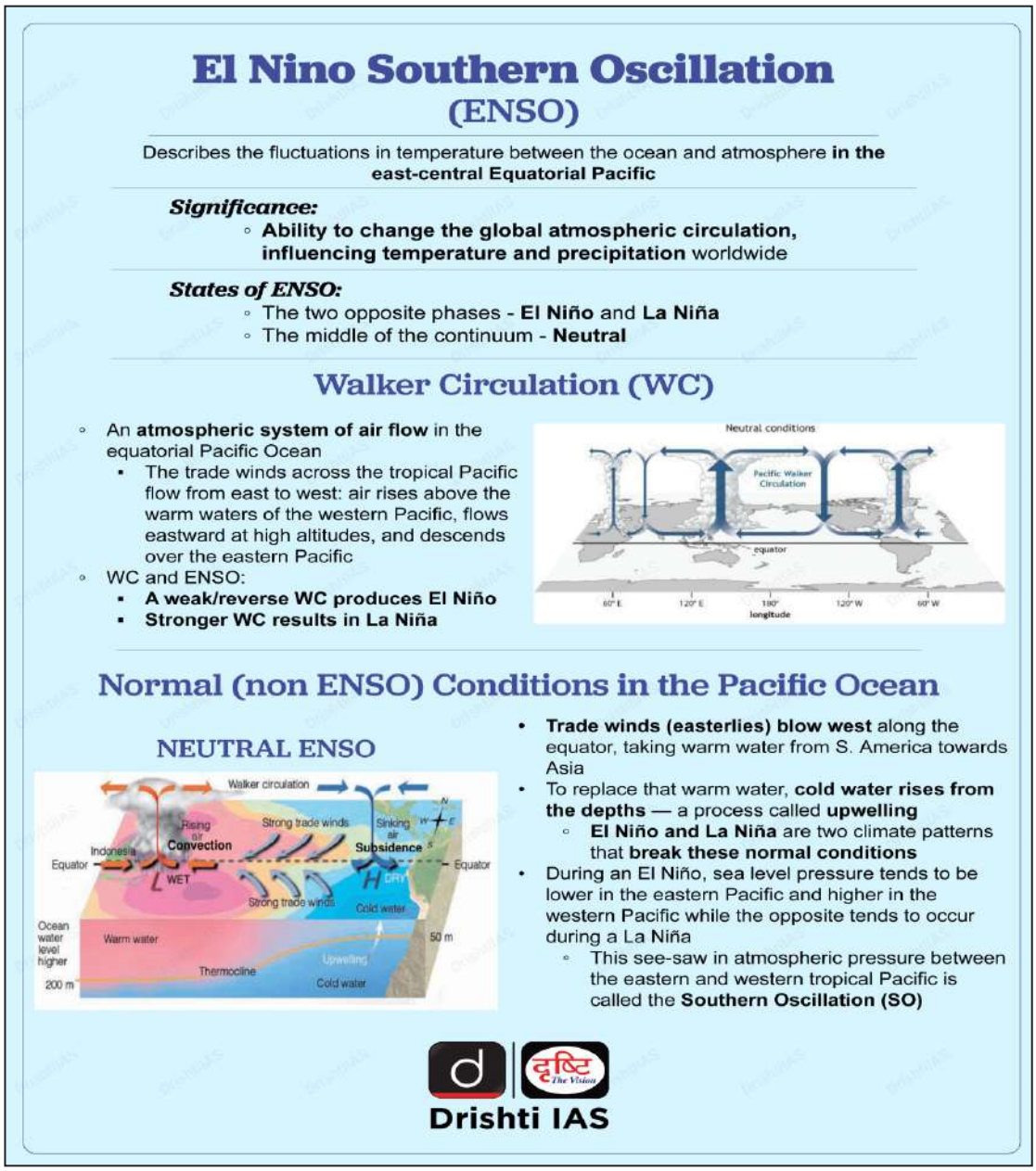
What is Pacific Decadal Oscillation?

- **About:**
  - The Pacific Decadal Oscillation (PDO) is a **long-term ocean fluctuation of** the Pacific Ocean. It is a **cyclical event that repeats every 20-30 years** and just like **ENSO**, has a 'cool' and 'warm' phase.
  - **Positive (warm) PDO = cooler west Pacific Ocean** and warmer eastern side (vice versa for negative PDO).
  - The term PDO was coined in about 1996 by Steven Hare.
- **Impact of PDO:**
  - **On Global Climate:** PDO phase can have significant implications for the global climate, affecting Pacific and Atlantic hurricane activity, **droughts and flooding around the Pacific basin**, the productivity of marine ecosystems, and global land temperature patterns.
  - **On Cyclones:** A warmer (positive-phased) PDO implies **fewer equatorial-origin cyclones.**
    - In 2019, the PDO entered a cooler, negative phase and which if continues, could mean more such cyclones in post-monsoon months.



Note:

- **ENSO and PDO:**
  - ENSO with a positive PDO is generally not good, however, **ENSO with a negative PDO brings more rain to India.**
  - If both ENSO and the PDO are in the same phase, it is believed that El Niño/La Nina impacts may be magnified.
- **PDO vs ENSO:**
  - El Nino or La Nina events repeat in the Pacific over 2-7 years, however, **PDO has a signature for a longer time** (on the decadal scale).
  - A 'positive' or 'warmer phase' of a PDO **can be known only after several years of measuring ocean temperatures** and their interaction with the atmosphere (stage of an ENSO can be determined any year).

Container Terminal Project at Deendayal Port

Why in News?

Recently, the **Deendayal Port Authority and Dubai-based DP World, a multinational logistics company,** partnered for the **Mega Container Terminal Project** at Tuna Tekra, Gujarat. The initiative was initiated by **India's Ministry of Ports, Shipping & Waterways (MoPSW).**

- With the aim to enhance port capacity, foster multimodal logistics, and promote global connectivity, this venture signifies a pivotal step in public-private partnership.

What are the Key Highlights of Container Terminal?

- The terminal will have an annual capacity t**o handle 2.19 million twenty foot equivalent units (TEUs)** with capability to handle next-generation vessels carrying more than 18,000 TEUs.
- Mega Container Terminal Project is fully compliant with the green port guidelines.
- The terminal will connect **Northern, Western and Central India with the Global market.**
- The project aligns with **India's Vision 2047 to quadruple port handling capacity.**
- The terminal will be a part of the National Infrastructure Pipeline **complementing** PM Gati Shakti.
- The Container Terminal is expected to transform the **economic landscape of Kutch,** with the creation of several ancillary services like warehousing, etc. and also result in the creation of **direct and indirect employment opportunities.**

What are the Key Points About Deendayal Port?

- Deendayal Port, also known as Kandla port, is one of the twelve Major Ports in India and is located on the **West Coast of India, in the Gulf of Kutch in the State of Gujarat.**
- Deendayal Port primarily services northern India, including the landlocked Jammu and Kashmir, Uttar Pradesh, Madhya Pradesh and Rajasthan.
- Deendayal Port's journey began in 1931 with the construction of **RCC Jetty by Maharao Khengarji.** After the independence of India in 1947, **Deendayal Port emerged to be India's No. 1 Port in the year 2007-08 and has retained the top position for the 14th consecutive year since then.**
- In 2016, Deendayal Port created history by handling 100 MMT cargo in a year – the first Major Port to achieve this milestone.
- It is the largest port in India by volume of cargo handled.

Note:

Earthquake in Morocco

Why in News?

The most powerful earthquake in Morocco's history struck late on the 8th of September 2023. The earthquake had a **magnitude of 6.8** and its epicenter was located in the **Al-Haouz province, within the Atlas Mountains near the historic city of Marrakech.**

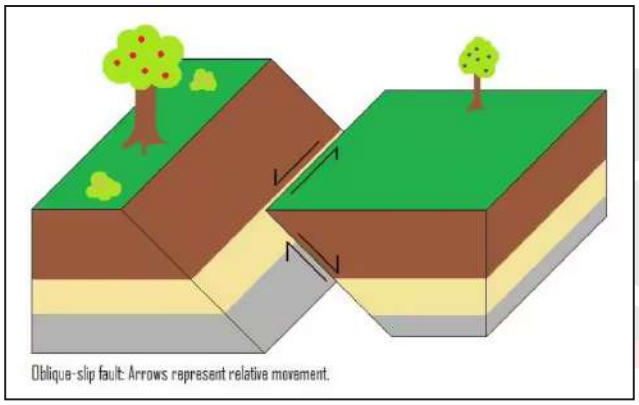
- A series of aftershocks, including a 4.9 magnitude tremor, added to the region's distress.

What are the Causes of the Earthquake in Morocco?

- The earthquake resulted from the **convergence of the African plate and the Eurasian plate along a complex plate boundary.**
- The earthquake's faulting mechanism was classified as **"oblique-reverse,"** indicating movement along the **fault plane where the upper block moves up and over the lower block** within the Moroccan High Atlas Mountain range.

Note:

- Faults are **fractures in rock formations** that **enable rock blocks to move relative to each other**. Rapid movement along faults can trigger earthquakes.
- Faults are categorized by their **dip (angle with respect to the surface) and slip direction.**
  - **Dip-slip faults** include **normal faults (upper block moves down lower block)** and **reverse fa-ults (upper block moves up and over lower block),** reverse faults are common in areas of tectonic compression.
  - **Strike-slip faults** involve **horizontal movement along the fault plane.**
  - **Oblique-slip faults** exhibit characteristics of **both dip-slip and strike-slip faults.**



Oblique-slip fault: Arrows represent relative movement.

- The earthquake occurred at a relatively **shallow depth beneath the Earth's surface,** which is a contributing factor to its destructive potential.
  - **Shallow earthquakes are more dangerous due to their proximity to the Earth's surface.**
    - They release more energy compared to deeper quakes, making them potentially more destructive.
  - Deeper earthquakes lose energy as seismic waves travel greater distances.

Key Facts About Morocco:

- Morocco is situated in western North Africa, directly across the **Strait of Gibraltar** from Spain.
- It shares borders with **Algeria to the east and southeast, the Western Sahara to the south,** and is surrounded by the **Atlantic Ocean to the west and the Mediterranean Sea to the north.**
- **Capital City : Rabat.**
- **Major Mountain Ranges**: The Atlas and Rif Mountains.
- **Morocco is situated on the convergence plate of Africa and Eurasia**, which are two of the major tectonic plates that make up the **Earth's crust.** These plates are constantly moving and colliding, creating mountains, volcanoes, earthquakes, and other geological features.
  - **The Atlas Mountains in Morocco** are a result of the collision between these plates, as they are squeezed and uplifted by the compressional forces.

Strongest Earthquakes in History

Why in News?

- Recently, a powerful 6.8 magnitude **earthquake struck Morocco** killing over 2,900 people.
  - According to the **Significant Earthquake Events (SEE) database**, this is the strongest quake to hit Morocco.
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Note:

- The Significant Earthquake Database is maintained by the **National Centers for Environmental Information (NCEI)**, a US government agency.
- It contains information on earthquakes **from 2150 BCE to the present** that meet at least one of the following criteria:
  - **Moderate damage** (approximately USD 1 million or more)
  - **10 or more deaths**
  - **Magnitude of 7.5 or more**
  - **An earthquake that generated a tsunami**

Note:

EARTHQUAKE

ABOUT

- Shaking of the earth; caused due to release of energy, generating seismic waves in all directions

EARTHQUAKE WAVES

- Body Waves: Move in all directions travelling through the body of the earth
  - P Waves: Move faster, First to arrive at surface, Similar to sound waves, Travel through gaseous, liquid and solid materials
  - S Waves: Arrive at surface with some time lag, Travel only through solid materials
- Surface Waves: Last to report on seismographs, More destructive, Cause displacement of rocks
  - Love Waves: Same motion as S-waves (horizontal) without vertical displacement, Sideways motion perpendicular to the direction of propagation, Faster than Rayleigh waves
  - Rayleigh Waves: Cause the ground to shake in an elliptical pattern, Spread out the most of all seismic waves, Move vertically and horizontally in a vertical plane

CAUSES OF EARTHQUAKES

- Release of energy along a Fault/Fault Zones (break in the crustal rocks)
- Movement of tectonic plates (most common)
- Volcanic eruption (stress changes in rock-injection/withdrawal of magma)
- Human activities (mining, explosion of chemical/nuclear devices etc.)

MEASURING EARTHQUAKE

- Seismometers - Measures seismic waves
- Richter Scale - Measures magnitude (energy released; range: 0-10)
- Mercalli - Measures intensity (visible damage; range: 1-12)

DISTRIBUTION

- Circum-Pacific Belt - 81% of earthquakes
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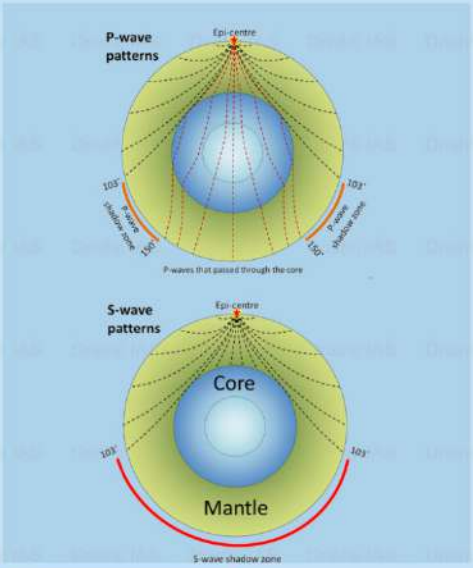
- Location where the earthquake starts (below earth's surface)

EPICENTER

- Location right above the Hypocenter (on the earth's surface)



EARTHQUAKE IN INDIA

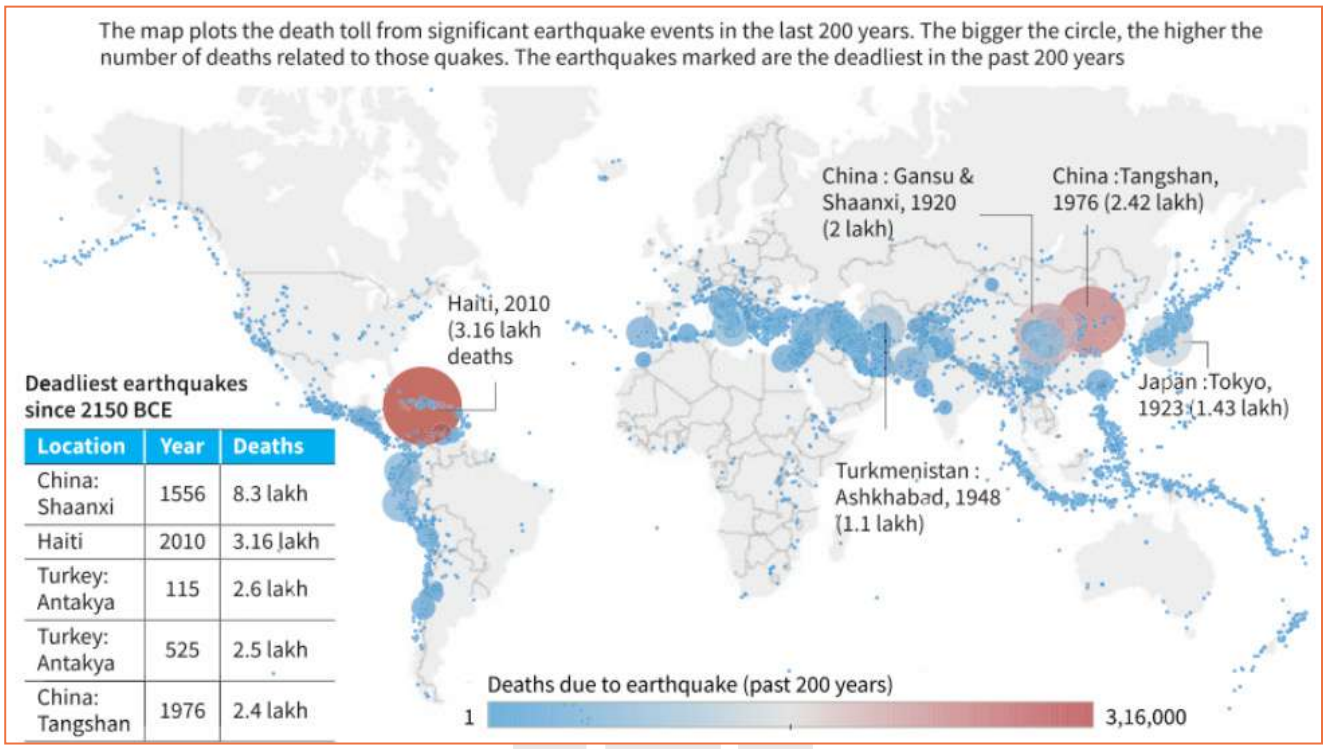
- India is one of the highly earthquake affected countries due to the presence of technically active mountains - the Himalayas.
- India has been divided into 4 seismic zones (II, III, IV, and V)

Drishti IAS

Note:

drishti

What is the NCEI's Data on Earthquakes?



Deadliest earthquakes since 2150 BCE

Location	Year	Deaths
China: Shaanxi	1556	8.3 lakh
Haiti	2010	3.16 lakh
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- **Global Highest Earthquakes:** As per NCEI, in the last 200 years, **China has suffered the highest number of quakes — 428.**
  - It is followed by **Indonesia** (366 quakes), **Iran** (272), **Japan** (256), and **Turkey** (209).
- **Most Severe Earthquakes:** In the past 200 years, there have been **four quakes with a magnitude of 9+.**
  - The most severe quake struck the **Chilean city of Puerto Montt in 1960** (9.5).
    - This is followed by **Alaska** in 1964 (9.2), **Honshu** (Japan) in 2011 (9.1), and **Sumatra** (Indonesia) in 2004 (9.1).
  - Of the **10 most severe** earthquakes since 2150 BCE, **seven have occurred in the last 200 years.**
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  - However, the Bhuj earthquake was not the strongest; the **1941 earthquake in Andaman** (poorly recorded due to **WW-II**), and the **1897 earthquake in Assam,** were both considered the strongest with a magnitude of 8.

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Major Earthquakes in and around India

Number	Place	# of Deaths	Date, Time, and Year	Magnitude	Epicenter
1	Indian Ocean	> 283,106	08:50, December 26th, 2004	9.1–9.3	West coast of Sumatra, Indonesia
2	Kashmir	130,000	08:50:38, October 8th, 2005	7.6	Muzaffarabad, Pakistan-administered Kashmir
3	Bihar and Nepal	> 30,000	14:13, January 15th, 1934	8.7	South of Mount Everest
4	Gujarat	20,000	08:50, January 26th, 2001	7.7	Kutch, Gujarat
5	Kangra	> 20,000	06:10, April 4th, 1905	7.8	Himalayas
6	Latur	> 9,748	22:25, September	6.4	Killari, Latur

Drop in India's Reservoir Water Levels

Why in News?

India, a country heavily reliant on monsoon rains, faced a significant challenge in **August 2023 with an unprecedented rainfall deficit.**

- As a result, the **water levels in the nation's crucial reservoirs** have experienced a **sharp decline**, raising concerns about water supply for households, industries, and power generation.
- August is typically a month when India's reservoirs see their water storage levels increase significantly. However, **August 2023 was an exception, as it marked the driest August in over 120 years.** Instead of the **expected 255 mm of rainfall, the country received only about 162 mm, resulting in a 36% rainfall deficiency.**

How Dry are India's Reservoirs?

- According to the Central Water Commission (CWC), the live storage in the **150 reservoirs was 113.417 billion cubic meters (BCM) as of 31st August, 2023,** which was **63% of their total live storage capacity.**
  - This was about **23% less than the storage during the same period in 2022 and about 10% less than the average of the last 10 years.**
- The water levels in the reservoirs varied across different regions and river basins. The southern region, which had a **rainfall deficiency of 60% in August, had the lowest storage level of 49% of its combined capacity.**
- The eastern region, which received normal rainfall, had the **highest storage level of 82% of its combined capacity.**
- Some of the **river basins that had highly deficient or deficient** water levels were:

Note:

- **Highly Deficient:**
  - Pennar basin in Karnataka and Andhra Pradesh
  - Mahanadi **basin** in Chhattisgarh and Odisha
- **Deficient:**
  - Subarnarekha, Brahmani **and Vaitarni** basins in Jharkhand, West Bengal and Odisha
  - Kaveri basin in Karnataka and Tamil Nadu
  - **Mahi** basin in western India
  - Krishna basin in Maharashtra, Karnataka and Telangana

➢ Water storage in the reservoirs of the eastern, western, central and southern regions, except the northern region is less than last year (2022).

Note:

➢ A **20% reduction in a river basin is close to normal,** according to the CWC.

➢ A basin is categorized as **deficient** if the reduction is **greater than 20% and less than or equal to 60%.**

➢ A reduction of over 60% is called **highly deficient.**

Carrying Capacity of Himalayan States

Why in News?

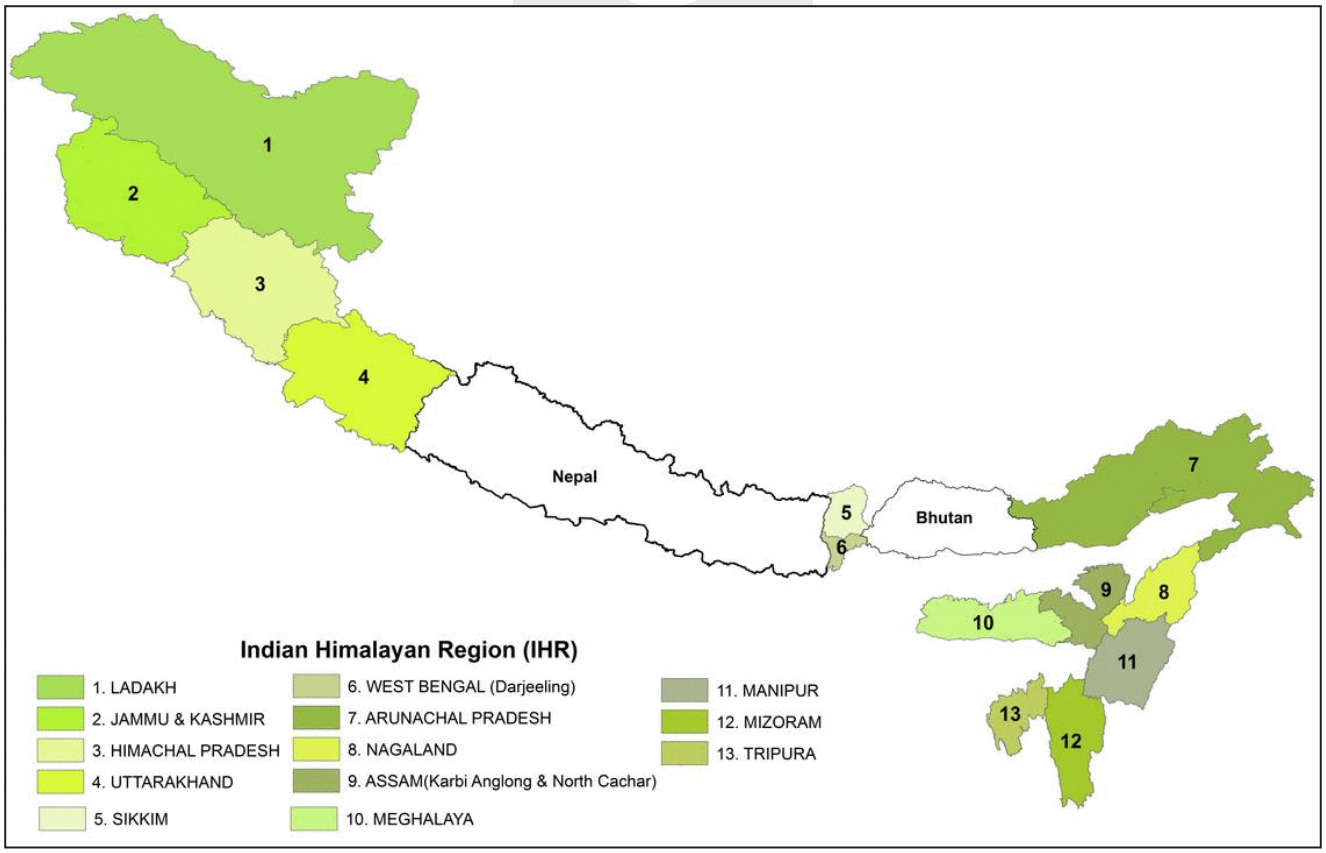
The Centre has urged the Supreme Court to direct 13 Himalayan states of the country to assess their '**carrying capacity**' and proposed setting up of an expert panel to evaluate the action plans submitted by each of them.

➢ This initiative is essential to ensure **sustainable development and preservation of the fragile Himalayan ecosystem.**

What is Carrying Capacity?

➢ Carrying capacity refers to the **maximum population size that an ecosystem or environment can sustainably support** over a specific period without causing significant **degradation or harm to its natural resources** and overall health.

➢ Carrying capacity assessments is crucial for understanding and **managing the balance between human activities and the preservation of natural ecosystems** to ensure long-term sustainability.



Note:

What are the Government Initiatives Related to the Conservation of the Himalayan Region?

- **National Mission on Sustaining Himalayan Ecosystem (2010):**
  - Covers **11 states (Himachal Pradesh, Uttarakhand, Sikkim, all northeast states, and West Bengal)** and **2 UTs (Jammu & Kashmir and Ladakh).**
  - Part of the National Action Plan on Climate Change (NAPCC), comprising eight missions.
- **Indian Himalayas Climate Adaptation Programme (IHCAP):**
  - It aims to enhance the **resilience of vulnerable communities in the Indian Himalayas** by strengthening the capacities of **Indian institutions in climate science**, with a specific focus on glaciology and related areas
- **SECURE Himalaya Project:**
  - Integral to the **"Global Partnership on Wildlife Conservation and Crime Prevention for Sustainable Development"** (Global Wildlife Program), funded by the Global Environment Facility (GEF).
  - Focuses on promoting sustainable management of alpine pastures and forests in the high-range Himalayan ecosystems.
- **Mishra Committee Report 1976**:
  - Named after **MC Mishra**, the then Garhwal commissioner in erstwhile Uttar Pradesh. It provided findings on land subsidence in Joshimath.
  - Recommendations included **imposing restrictions on heavy construction work,** blasting, excavation for road repairs and other construction activities, and tree felling in the region.

Pacific Weather Changing: More Multi-Year El Nino and La Nina

Why in News?

A recent study has raised concerns about the **impact of human activities on the duration and behaviour of El Nino and La Nina events.**

- It found that Walker Circulation has changed its behavior since the industrial era and **multi-year El Nino and La Nina events could become more frequent.**

What do the Recent Studies Suggest?

- The **Walker Circulation,** a key atmospheric component of ENSO, drives weather patterns worldwide. Researchers aimed to assess whether greenhouse gas emissions **had influenced this critical climate driver.**
- The study's findings revealed that the transition from El Nino to La Nina has slightly slowed over time. This suggests that **multi-year** climate patterns may become more frequent in the future, posing heightened risks of **droughts, fires, heavy rainfall, and floods.**
- While the overall strength of the **Walker Circulation has not yet decreased,** researchers speculate that **elevated** carbon dioxide **levels could weaken it.**
  - Many climate models also predict a **decline in the Walker Circulation by the end of the century.**
- The study also highlighted a **connection between volcanic eruptions and the weakening of the Walker Circulation.** This phenomenon often leads to El Nino-like conditions.
  - The research identified three significant **El Nino events in the twentieth century that followed volcanic eruptions: Mount Agung in 1963, El Chichón in 1982, and Mount Pinatubo in 1991.**

- **Walker Circulation**:
  - The Walker Circulation is a **large-scale atmospheric circulation pattern** in the tropical Pacific region of the Earth.
    - It is a system of winds that plays a crucial role in shaping climate and weather patterns in the tropics and beyond.
  - The **Walker Circulation is primarily associated with the Pacific Ocean** but has global impacts.
    - A **weaker Walker Circulation is associated with El Nino**, while a **stronger circulation signals La Nina.**
- **El Nino:**
  - **El Nino** is a climate pattern that describes the **unusual warming of surface waters in the Tropical Pacific Ocean.** It means Little Boy in Spanish and it occurs more frequently than La Nina.
    - It is known to **suppress monsoon rainfall in India.**
  - It occurs due to the **weakening or reversal of trade winds** in the tropical Pacific.
    - Normally, **trade winds blow from east to west,** pushing warm surface waters towards the **western Pacific**.

Note:

- **La Nina:**
  - La Nina is a pattern that describes the **unusual cooling of the Tropical Pacific Ocean.** It means **"Little Girl"** in Spanish and is sometimes called **El Viejo, anti-El Niño, or simply "a cold event."**
    - It is known to aid rainfall over India.
  - It occurs as a result of the **strengthening of the trade winds in the tropical Pacific Ocean.**
    - During La Nina events, these trade winds become **even stronger, intensifying the normal east-to-west flow** of warm surface waters across the equatorial Pacific.
    - This strengthening of the trade winds leads to cooler-than-average sea surface temperatures in the **central and eastern equatorial Pacific.**
- **El Nino-Southern Oscillation (ENSO):**
  - It is a climate phenomenon resulting from the interaction between ocean and atmospheric conditions.
    - The "**southern oscillation"** component refers to **differences in sea-level air pressure over the western and eastern Pacific Oceans.**
  - **El Nino and La Nina** represent the warm and cool phases of the **El Nino-Southern Oscillation (ENSO) cycle**.
    - El Nino and La Nina episodes typically occur every 2 to 7 years. La Nina events may last **between one and three years**.
- However, it is rare for El Nino events to last longer than a year.
  - Multi-year El Niño and La Nina events are those that persist for more than one year without returning to normal conditions in between.
- In 2023, **La Nina concluded a three-year period,** and El Nino made its presence felt. Such long-lasting ENSO phases are unusual.

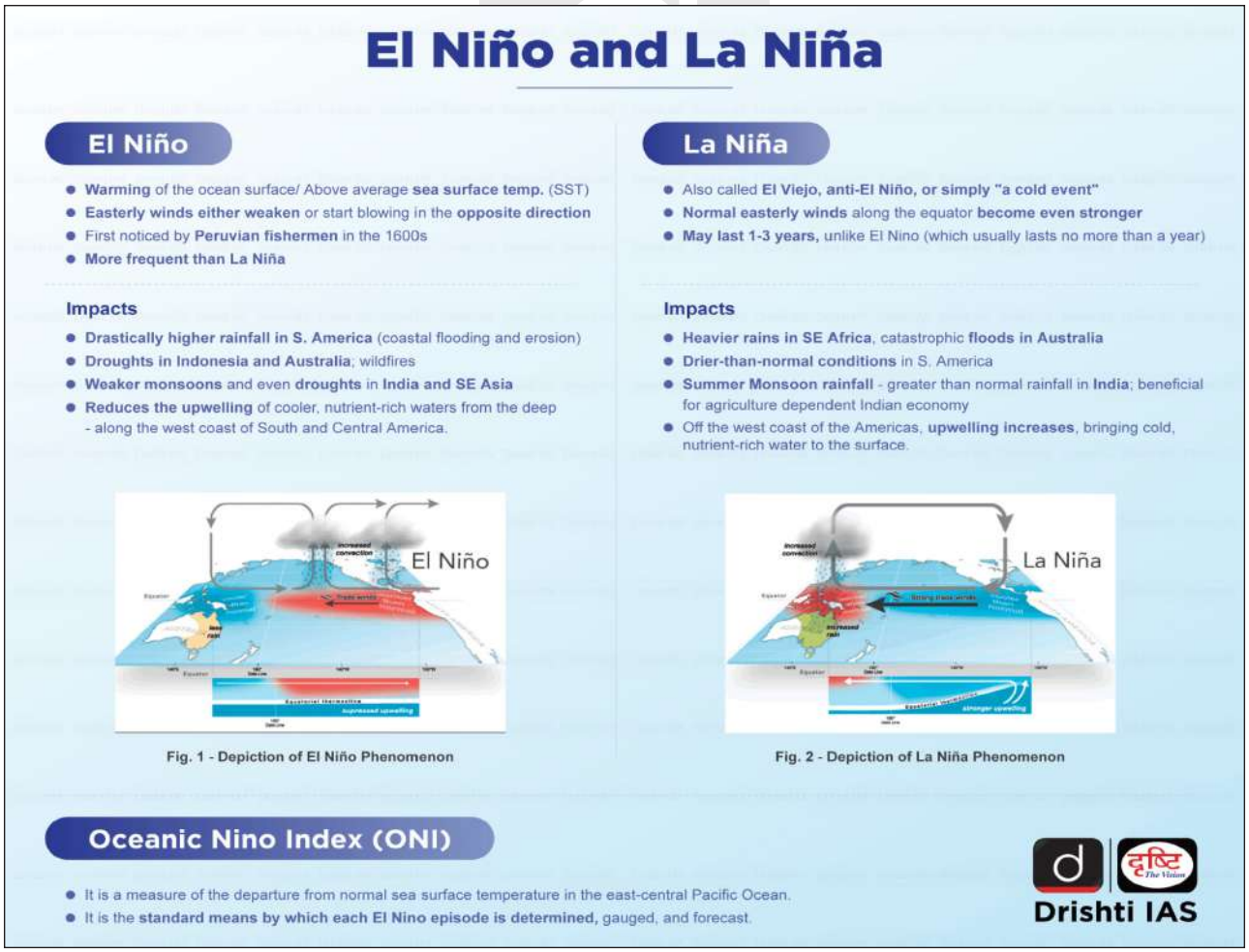


Fig. 1 - Depiction of El Niño Phenomenon

Fig. 2 - Depiction of La Niña Phenomenon

Note:

Study on Joshimath Sinking

Why in News?

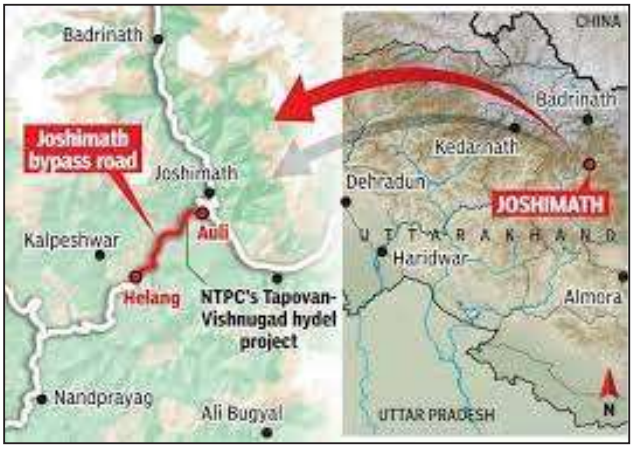
Recently, separate studies were conducted by eight premier institutions of India including the **Indian Space Research Organisation (ISRO)** to know the cause of land subsidence in Joshimath town of Uttarakhand and provided independent reasons for the sinking of the Himalayan town.

What are the Reports by Institutions about Joshimath Sinking?

- **Central Building Research Institute (CBRI):**
  - In its report, the CBRI stated that Joshimath town has 44%, 42%, 14% of masonry, RCC and other (traditional, hybrid) construction typologies, respectively, among which 99% are non-engineered.
    - These structures are not in compliance with the **National Building Code of India, 2016.**
  - **Other Findings:**
    - Joshimath town is situated on **Vaikrita groups of rocks (made up of coarse mica-garnet-kyanite and sillimanite-bearing psammitic metamorphics)** overlain by morainic deposits which are composed of irregular boulders and clay of varying thicknesses.
    - Such deposits are **less cohesive and susceptible to slow subsidence** and landslide subsidence.
- **National Institute of Hydrology (NIH) Report:**
  - It mapped **various springs, drainage networks and areas of subsidence** inferring that land subsidence and subsurface water in Joshimath might have some connections.
  - The institution recommended the **safe disposal** of the water coming from the upper reaches and waste disposal as the top priority.
- **Wadia Institute of Himalayan Geology (WIHG) Report:**
  - Institution mentioned **earthquakes as a reason** for slow and gradual land subsidence.
  - The main reason for the subsidence appears to be internal erosion caused by the subsurface drainage, which may be due to infiltration of rainwater/melting of ice/wastewater discharge from households and hotels.
- **ISRO's stand:**
  - The subsidence in the Joshimath region may be due to the **toe-cutting phenomenon.**
  - Also due to slope instability as a result of seepage of local drainage water in the soil.
  - **Terrain and edaphic characteristics** are also responsible for subsidence.
  - **Loose and unconsolidated moraine materials** of the slope (due to old landslides) and flash flood events in and around the area in the recent past, also contributed to land sinking.

Where is Joshimath Located?

- Joshimath is a hilly town located on the **Rishikesh-Badrinath National Highway (NH-7) in Chamoli district of Uttarakhand.**
- The city serves as a **tourist town as it acts as an overnight rest stop for people** visiting Badrinath, Auli, Valley of Flowers, and Hemkund Sahib, among other important religious and tourist locations in the state.
- Joshimath is also of great strategic importance to **the Indian armed forces and is home to one of the Army's** most important cantonments.
- The town (falls in **high-risk seismic Zone-V**) is traversed by running streams with a high **gradient from Vishnuprayag, a confluence of the Dhauliganga and the Alaknanda rivers.**
- It is home to one of the **four cardinal Maths or monasteries established by Adi Shankara - Sringeri in Karnataka,** Dwarka in Gujarat, Puri in Odisha and Joshimath near Badrinath in Uttarakhand.



Note:

What is Landslide?

- A landslide is defined as the **movement of a mass of rock, debris, or earth down a slope.**
- They are a type of **mass wasting,** which denotes any downward movement of soil and rock under the direct influence of gravity.
- The term **landslide encompasses five modes of slope movement:** falls, topples, slides, spreads, and flows.

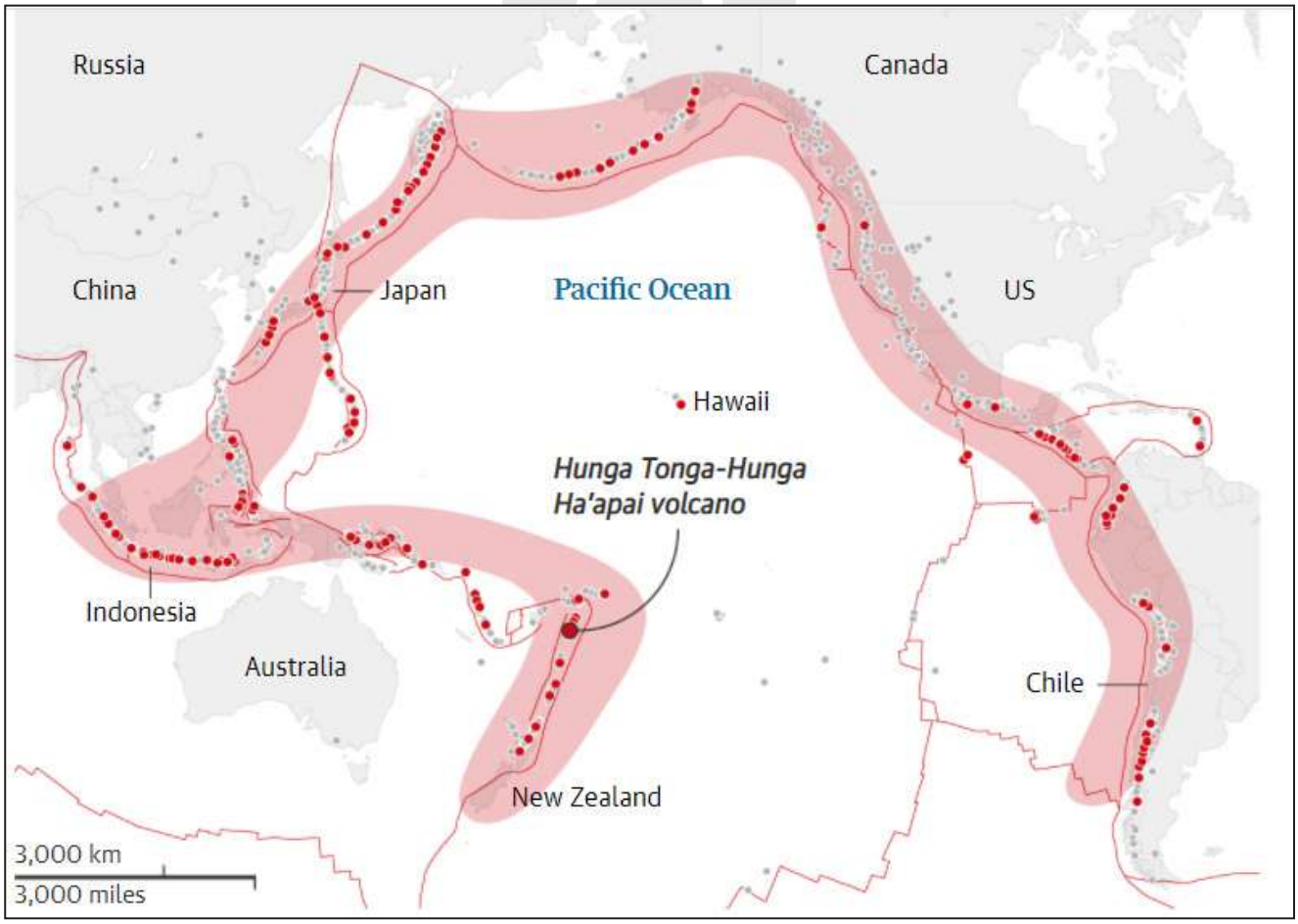
Hunga Tonga-Hunga Ha'apai Volcano

Why in News ?

The Year 2023 has recorded unprecedented temperatures. Scientists believe one of the reasons for this may be an underwater volcanic eruption of **Hunga Tonga-Hunga Ha'apai in the South Pacific** in 2022.

What are the Key Points About Hunga Tonga-Hunga Ha'apai Volcano ?

- The Hunga Tonga-Hunga Ha'apai volcano is in the **western South Pacific Ocean**, west of the main inhabited islands in the Kingdom of Tonga.
- It is one of 12 confirmed **submarine volcanoes along the Tofua Arc**, a segment of the larger Tonga-Kermadec volcanic arc.
  - The Tonga-Kermadec arc formed as a **result of subduction of the Pacific Plate beneath the Indo-Australian Plate.**
- It is an **undersea Volcano** consisting of two small uninhabited islands, Hunga-Ha'apai and Hunga-Tonga.



Note:

What are the Different Types of Volcanoes?

- In general, Volcanoes can be divided on the basis of **Type of Eruption** & **Periodicity of Eruption.**
  - **Based on Type of Eruption:** The nature of the eruption mainly depends on the viscosity of the magma and are of two types:
    - **Basic**: The basic magma are dark coloured like basalt, rich in iron and magnesium but poor in silica. They travel far and generate broad shield volcanoes.
    - **Acidic**: These are light-coloured, of low density, and have a high percentage of silica and therefore it makes a familiar cone volcano shape.
  - **Based on frequency of Eruption:**
    - **Active volcanoes**: They erupt frequently and are mostly located around the Ring of Fire.
      - E.g.: **Mount Stromboli** is an active volcano and it produces so many gas clouds that it is called the Lighthouse of the Mediterranean.
    - **Dormant Volcano**: These are not extinct but have not erupted in recent history. The dormant volcanoes may erupt in future.
      - E.g: **Mount Kilimanjaro**, located in **Tanzania, also** the highest mountain in **Africa, is known** to be a dormant Volcano.
    - **Extinct or inactive volcanoes** have not worked in the distant geological past.
      - In most cases the crater of the Volcano is filled with water making it a lake. E.g.: **Deccan Traps,** India.

Narmada River

Why in News?

Narmada and other rivers have caused widespread flooding in Gujarat and cut off various villages from the mainstream in the southern and central regions of the State.

- The water level of the Narmada is beyond the danger mark and the India Meteorological Department (IMD) issued red and orange alerts in parts of Gujarat.
- Narmada River's major dam is Sardar Sarovar Dam, which is one of the important reasons behind the rising levels.

What is the Sardar Sarovar Project ?

- **About:**
  - The Sardar Sarovar project is the Gravity dam on Narmada River crossing Gujarat.
    - **Gravity dam** is constructed of concrete or stone designed to transfer the entire water load downward.
  - It is primarily meant for large scale irrigation and Hydroelectric multi-purpose projects.
- **Features:**
  - The Project was conceived in 1979 majorly for the purposes of Agricultural and Mitigating power Crisis in the state.
  - The Hydro electric Power generated would be **shared between the states of Gujarat, Madhya Pradesh, and Maharashtra,** whereas **the irrigation benefits can be utilized by Gujarat and Rajasthan.**

What are Key Facts of Narmada River?

- **About:**
  - The Narmada River (also known as Rewa) serves as a traditional boundary between North and South India.
  - It is 1,312 km west of its origin from the Amarkantak peak of Maikal mountain. It flows into the Gulf of Khambhat.
  - It drains a large area in Madhya Pradesh besides some areas in the states of Maharashtra and Gujarat.
  - **It is a West flowing river of the peninsular region** flowing through a rift valley between the Vindhya Range on the north and the Satpura Range on the south.
- **Tributaries:**
  - The **predominant tributaries from the right** are – Hiran, Tendori, Barna, Kolar, Man, Uri, Hatni, and Orsang.
  - The **predominant left tributaries are** – Burner, Banjar, Sher, Shakkar, Dudhi, Tawa, Ganjal, Chhota Tawa, Kundi, Goi, and Karjan.
- **Dams:**
  - The Major dams on the river include Omkareshwar and Maheshwar dams.

Note:

What are the Different Color-coded Alerts Issued by the IMD?

- The **IMD** uses 4 colour codes are:
  - **Green (All is well):** No advisory is issued.
  - **Yellow (Be Aware)**: Yellow indicates severely bad weather spanning across several days. It also suggests that the weather could change for the worse, causing disruption in day-to-day activities.
  - **Orange/Amber (Be prepared)**: The orange alert is issued as a warning of extremely bad weather with the potential of disruption in commute with road and rail closures, and interruption of power supply.
  - **Red (Take Action):** When the extremely bad weather conditions are certainly going to disrupt travel and power and have significant risk to life, the red alert is issued.

Strongest Earthquakes in History

Why in News?

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  - According to the **Significant Earthquake Events (SEE) database**, this is the strongest quake to hit Morocco.
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- Release of energy along a Fault/Fault Zones (break in the crustal rocks)
- Movement of tectonic plates (most common)
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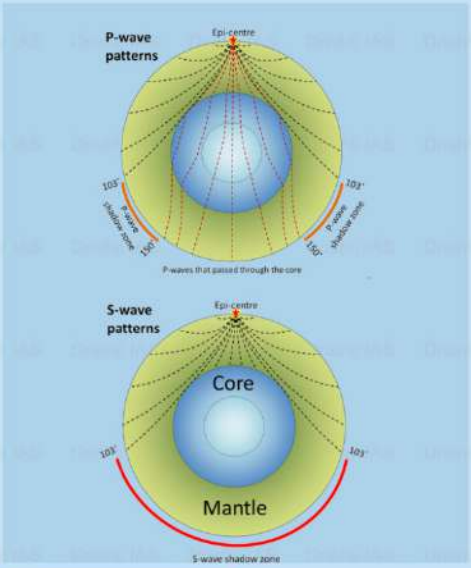

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Drishti IAS

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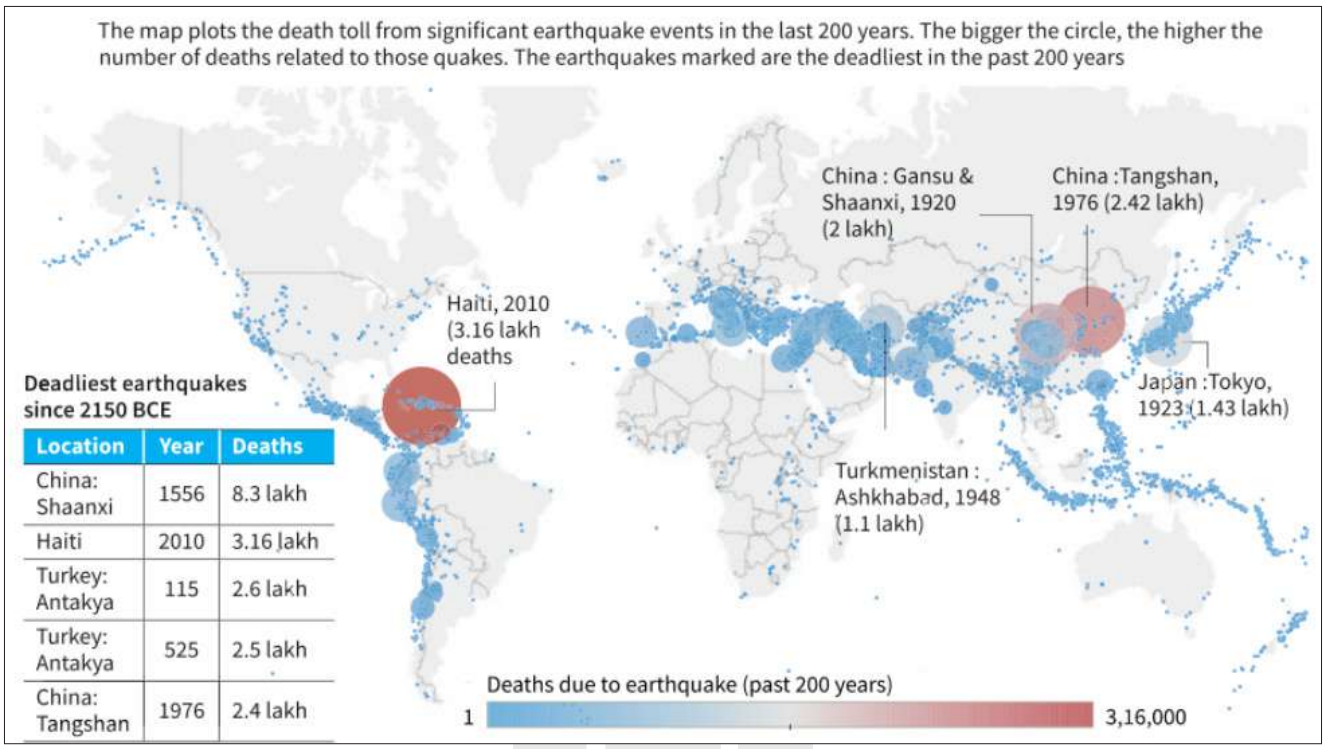

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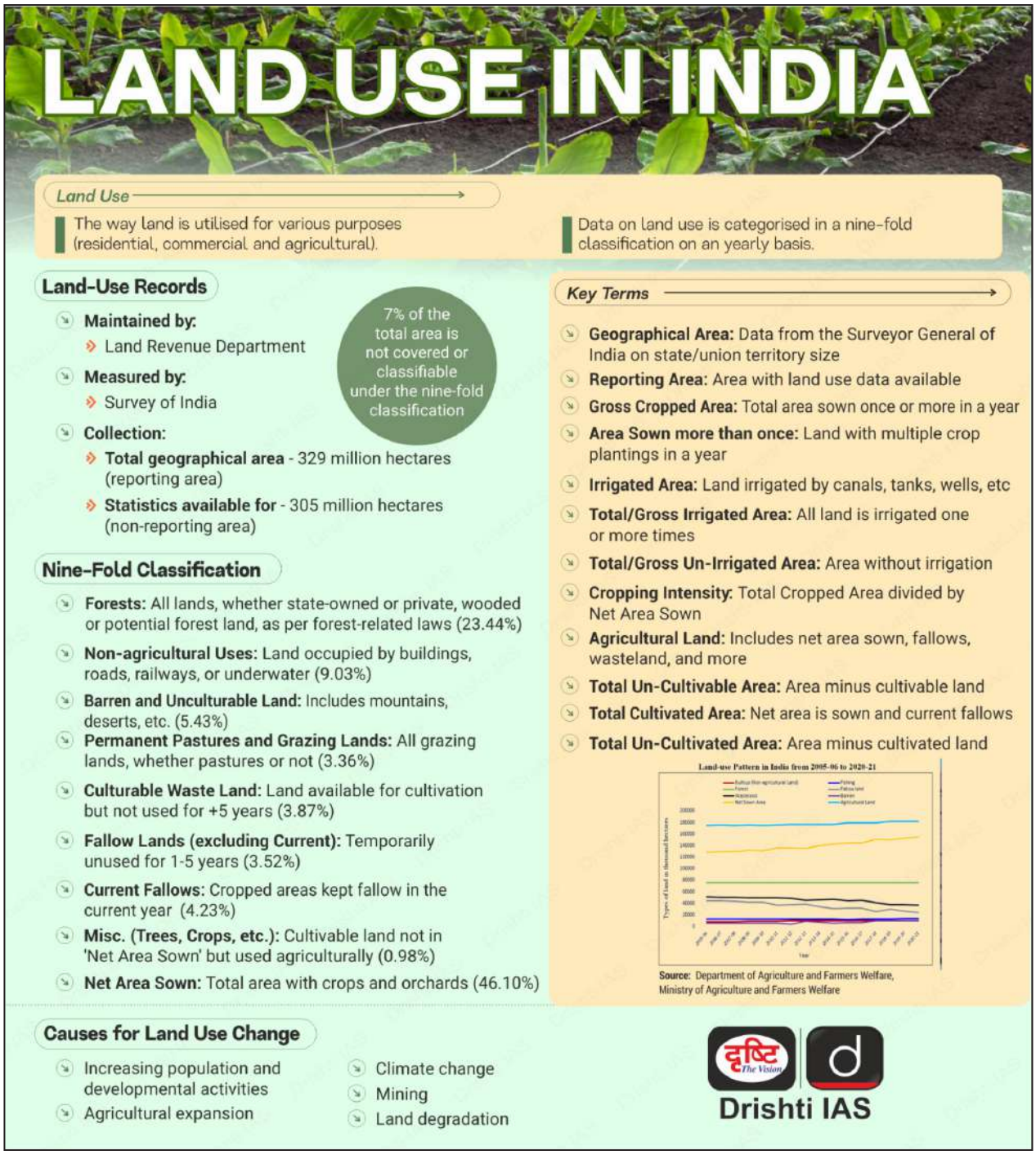
No.	Place	# of Deaths	Date, Time, and Year	Magnitude	Epicenter
1	Indian Ocean	> 283, 106	08:50, December 26th, 2004	9.1–9.3	West coat of Sumatra, Indonesia
2	Kashmir	130,000	08:50:38, October 8th, 2005	7.6	Muzaffarabad, Pakistan-administered Kashmir
3	Bihar and Nepal	> 30,000	14:13, January 15th, 1934	8.7	South of Mount Everest
4	Gujarat	20,000	08:50, January 26th, 2001	7.7	Kutch, Gujarat
5	Kangra	> 20,000	06:10, April 4th, 1905	7.8	Himalayas
6	Latur	> 7.748	22:25, September	6.4	Killari, Latur

Note:



Surge in Human Settlements in Flood-Prone Areas

Why in News?

According to a recent study conducted by the **World Bank, human settlements** in some of the **world's riskiest flood zones** have increased by a staggering **122% since 1985**, contributing to the vulnerability of millions to water disasters induced by **climate change**. And, this growth is **predominantly observed in middle- and low-income countries.**

- On the other hand, the most secure regions experienced an **80% increase in growth in human settlements**.

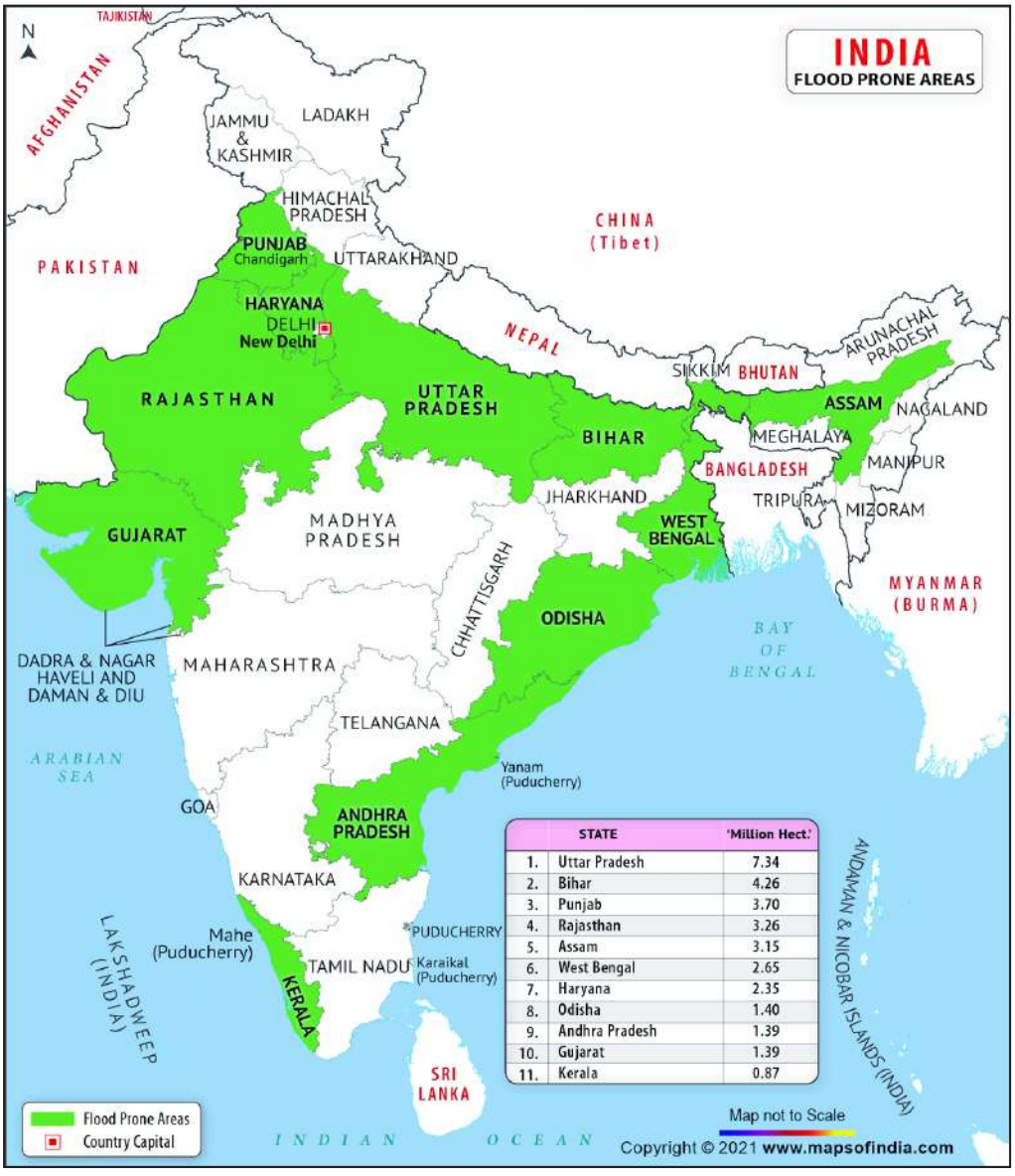
Note:

What are the Major Takeaways from the Study?

- **Global Landscape of Settlement Expansion:**
  - Most countries, **especially in East Asia,** saw more settlements in **regular flood zones and ultra-high flood zones** than in dry areas.
  - **Libya**, which suffered from devastating flooding in **September 2023**, had an 83% increase in settlement extent in the worst flood zones.
  - **Pakistan**, experiencing **catastrophic flooding both in 2022 and 2023**, witnessed an 89% increase in settlements in prone areas.
- **Notable Exceptions:**
  - **Dry settlements in the United States increased by 76%**, while the highest flood settlements rose by only 46%.
  - Other countries with more dry settlements than ultra-wet areas include **India, France, Sweden, Austria, Finland, Japan and Canada.**

Note: Settlement expansion into flood zones **does not negate the significance of climate change.** The two issues are **intertwined**, compounding risks and vulnerabilities. People might **prioritize immediate needs for shelter and livelihoods over long-term climate risks.**

- This can lead to decisions that are more focused on short-term survival.



	STATE	'Million Hect.'
1.	Uttar Pradesh	7.34
2.	Bihar	4.26
3.	Punjab	3.70
4.	Rajasthan	3.26
5.	Assam	3.15
6.	West Bengal	2.65
7.	Haryana	2.35
8.	Odisha	1.40
9.	Andhra Pradesh	1.39
10.	Gujarat	1.39
11.	Kerala	0.87

Note:

More Frequent Cyclones in Eastern Arabian Sea

Why in News?

Recently, a study has been published in the Nature Journal, which highlights the concerns related to **Climate Change** causing frequent **Tropical Cyclones (TC)** in the **Eastern Arabian Sea.**

- The study is part of the **"Forecasting with Fisher's" project**, by the **Advanced Centre for Atmospheric Radar Research (ACARR**) at Cochin University of Science and Technology (CUSAT).

What are the Key Findings of the Study?

- **Increasing Frequency and Severity of Cyclones:**
  - Changes in ocean and atmosphere **warming patterns are leading to more frequent and severe tropical** cyclones in the Eastern Arabian Sea, adjacent to India's west coast.
    - Typically, tropical cyclones in the Arabian Sea occur a**t the start of the southwestern monsoon between March and June,** as well as after the season, between October and December.
  - The Arabian Sea accounts for about 2% of the annual global mean of tropical cyclones but **poses a considerable threat due to its densely populated coastlines**.
- **Impact of Indian Ocean Dipole (IOD):**
  - The positive phase of **IOD**, where one part of the ocean gets warmer than the other, leads to **warmer sea surface temperatures** and increased precipitation in the western Indian Ocean region.
    - **IOD, sometimes referred to as the Indian Nino**, is similar to the **El Nino** phenomenon, occurring in the relatively smaller area of the **Indian Ocean** between the Indonesian and Malaysian coastline in the east and the African coastline near Somalia in the west.
- **Anthropogenic Influence:**
  - The recent increase in the frequency of extremely severe cyclonic storms over the Arabian Sea during the post-monsoon season is **attributed to anthropogenic (human-caused) influence** rather than natural variability.
  - Human-induced climate change is contributing to the **intensification and higher frequency of cyclones** in the Arabian Sea.
- **Impact on Western Indian Coastline:**
  - The intensification and increase in cyclone frequency pose a significant threat to the **densely populated coastal regions** along the western coast of **India, from Gujarat to Thiruvananthapuram**, facing higher risks, including strong winds, storm surges, heavy rainfall, and other associated hazards.
- **Concerns for Coastal Communities:**
  - The changing cyclone patterns are expected to **significantly affect** the lives and livelihoods of **indigenous coastal communities** and artisanal fishers, necessitating a need for further studies and adaptation strategies.

Note:

- Cyclones in the Bay of Bengal (BOB) are relatively **more frequent and intense than those of the Arabian Sea.**
  - The Bay of Bengal typically sees multiple cyclonic events during the tropical cyclone season, which is primarily from April to December.
- The BOB usually has **higher sea surface temperatures**, especially during the pre-monsoon and post-monsoon seasons, providing the **necessary energy and moisture for cyclone formation** and intensification.
- The convergence of winds in the BOB, combined with the Coriolis Force (resulting from the Earth's rotation), creates an **environment suitable for cyclone genesis.** These converging winds **form areas of low pressure,** which can develop into tropical disturbances and cyclones.

Note:

What are Cyclones?

CYCLONE

Drishti IAS

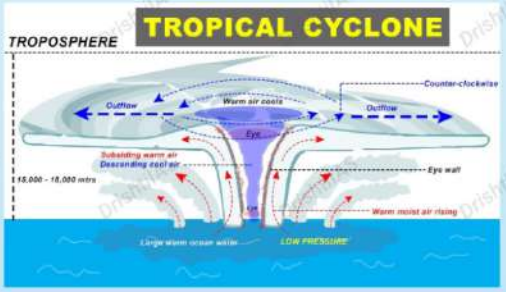
Cyclones are rapid **inward** air circulation around a **low-pressure** area.

Cyclone v/s Anticyclone

Pressure System	Pressure Condition at the Center	Pattern of Wind Direction	
		Northern Hemisphere	Southern Hemisphere
Cyclone	Low	Anticlockwise	Clockwise
Anticyclone	High	Clockwise	Anticlockwise

Classification

- **Tropical Cyclones;** originate between the **Tropics of Capricorn and Cancer**
- **Extra Tropical/ Temperate Cyclones;** originate in the **Polar Regions**



Conditions for Formation

- Large sea surface with temperature >27° C.
- Presence of the **Coriolis force**
- Small **variations in the vertical wind speed**
- **A pre-existing weak low- pressure area**
- **Upper divergence** above the sea level system

Nomenclature

- Nodal Authority - **World Meteorological Organization (WMO)**
- Indian Ocean Region - **Bangladesh, India, Maldives, Myanmar, Oman, Pakistan, Sri Lanka** and **Thailand** contribute to naming cyclones that occur in this region.

Different Names for Tropical Cyclones

- **Typhoons** - Southeast Asia and China
- **Hurricanes** - North Atlantic and eastern Pacific
- **Tornados** - West Africa and southern USA
- **Willy-willies** - Northwest Australia
- **Tropical Cyclones** - Southwest Pacific and Indian Ocean

Cyclones in India

- **Bi-annual Cyclone Season** - March to May and October to December
- Recent Cyclones - **Tauktae, Vayu, Nisarga and Mekanu** (in Arabian Sea) and **Asani, Amphan, Fani, Nivar, Bulbul, Titli, Yaas and Sitrang (in Bay of Bengal)**

Note:

Glacial Lake Outburst Flood in Sikkim

Why in News?

Sikkim recently experienced a **Glacial Lake Outburst Flood (GLOF)**. The **South Lhonak Lake, a glacial lake** located at an altitude of 17,000 feet in the state's northwest, experienced a **rupture as a result of continuous rainfall.**

- Consequently, water was discharged into the downstream regions, causing flooding in the **Teesta River** and impacting four districts of Sikkim: Mangan, Gangtok, Pakyong, and Namchi, as reported by the Sikkim State Disaster Management Authority (SSDMA).
- This flooding also caused the **Chungthang Hydro-Dam in Sikkim (on Teesta river) to breach**, worsening the overall situation.

What is Glacial Lake Outburst Flood?

- **About:**
  - A **GLOF (Glacial Lake Outburst Flood)** is a sudden and potentially catastrophic flood that occurs when water stored behind a glacier or a **moraine (a natural accumulation of ice, sand, pebbles, and debris)** is released rapidly.
    - These floods happen when glacial lakes formed by melting ice accumulate water behind weak moraine dams.
    - Unlike sturdy earthen dams, these moraine dams can fail abruptly, releasing large volumes of water in minutes to days, leading to **devastating downstream flooding.**
  - The **Himalayan terrain**, with its **steep mountains**, is particularly vulnerable to GLOFs.
    - **Climate change,** accompanied by **rising global temperatures**, has expedited the process of glacier melting in the **Sikkim Himalayas.**
      - The region now boasts more than 300 glacial lakes, with **ten identified as susceptible to outburst floods.**
  - GLOF can be triggered by several reasons, including **earthquakes, extremely heavy rains and ice avalanches.**
- **Impact:**
  - GLOFs can result in catastrophic **downstream flooding**. They have the potential to release millions of cubic meters of water in a short period of time.

Note:

- Peak flows during GLOFs have been recorded as high as **15,000 cubic meters per second (as per National Disaster Management Authority).**

How Susceptible is South Lhonak Lake to GLOFs?

- The **South Lhonak lake** in northern Sikkim is situated about 5,200 meters above sea level.
  - Scientists have previously warned that the **lake had been expanding over years**, possibly from the melting of the ice at its head.
  - Notably, seismic activities, including a **2011 magnitude 6.9 earthquake,** escalated the GLOF risk in the area.
- In 2016, the **Sikkim State Disaster Management Authority** and other stakeholders launched a critical plan to drain excess water from South Lhonak Lake.
  - Visionary innovator **Sonam Wangchuk** led the effort, employing **High Density Polyethylene (HDPE) pipes** to siphon off water from the lake.
  - This initiative successfully reduced the lake's water volume by approximately 50%, mitigating the risk to some extent.
- However, the recent tragedy is believed to be caused by an **avalanche originating from the ice-capped feature surrounding the lake.**

What are the Other Recent GLOF Incidents in India?

- In **June 2013,** Uttrakhand had received an **unusual amount of rainfall leading to the melting of the Chorabari glacier** and the eruption of the **Mandakini river.**
- In **August 2014**, a glacial lake outburst flood hit the village of **Gya in Ladakh**
- In **February 2021**, **Chamoli** district in Uttarakhand witnessed flash floods which are suspected to have been caused by GLOFs.

International Migration Outlook 2023

Why in News?

Recently, **International Migration Outlook 2023,** a report on international migration patterns was released by the **Organisation for Economic Co-operation and Development (OECD)** to analyze the migration trends worldwide.

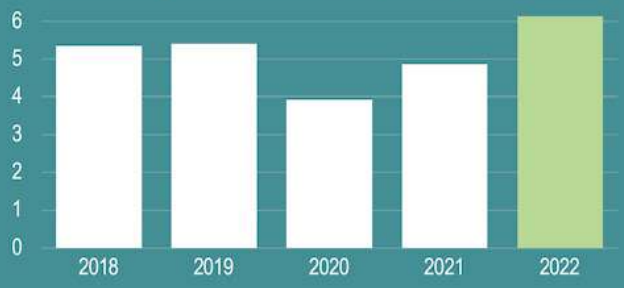
What are the Highlights of the Report?

- **India Leads in Migration to OECD Countries:**
  - In 2021 and 2022, India became the primary source of migration to OECD countries, surpassing China. India consistently topped the list **with 0.41 million new migrants in both years, while China had 0.23 million new migrants,** followed by Romania with approximately 200,000 new migrants.
- **Climate-Induced Displacement and Policy Responses:**
  - The report sheds light on the **increasing focus on policy responses to climate-induced displacement in recent years.** Few OECD countries have explicit policies to address this issue.
  - Notably, **Colombia began discussing a pioneering bill in April 2023**, aiming to recognize and support climate-displaced individuals, with a broad definition and provisions for housing, healthcare, education, and a national register.
- **Record Refugee Inflows and Worker Migration:**
  - The **OECD region experienced record refugee inflows due to the Russia-Ukraine war**, with over 10 million people becoming internally displaced or refugees. Worker migration saw significant increases from India, Uzbekistan, and Turkey, making them prominent source countries following Ukraine.
- **Recent Trends in International Migration:**
  - All top four destination countries **(The United States, Germany, the United Kingdom and Spain)** registered large year-on-year increases, between 21% and 35%. The increase was smaller in Canada (8%) the fifth destination country.
  - The United States **alone accounted for 1.05 million new permanent-type migrants,** and the other four countries for between 440 000 and 650 000 each.
- **Permanent-Type Migration by Main Categories:**
  - In 2022, **family migration** remained the primary category of entry for new permanent-type migrants, **representing 40%** of all permanent-type migration, a relatively stable share over time.
  - The share of **labour migration** has increased over time. While in 2022, **labour migration represented 21% of permanent-type migration, it accounted for only 16% in 2019**.
  - Conversely, the share of **free movement migration** (within the EU-EFTA and between Australia and New Zealand) has decreased since 2020. It accounted for **21% of permanent-type migration in 2022, compared with 28% in 2019.**

Note:

Migration to OECD countries is at a record high

Permanent migration to the OECD, 2018-22, in millions



With more than 6 million new permanent immigrants (not including Ukrainian refugees), permanent-type migration to OECD countries reached a record level in 2022.

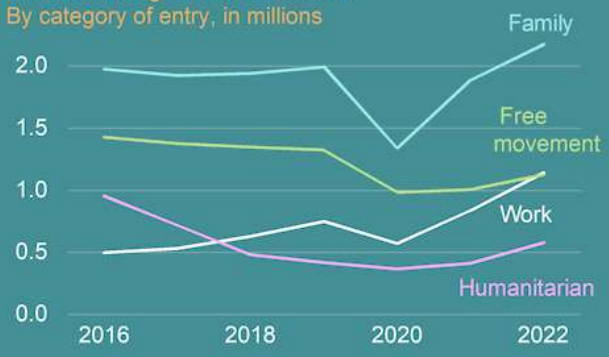
The Ukrainian refugee crisis is the largest displacement in Europe since WWII

Total number of refugees from Ukraine, June 2023, millions

OECD countries have provided refuge to about 5 million people fleeing Ukraine.

Increase in labour migration in response to labour shortages in many countries

Permanent migration to the OECD
By category of entry, in millions



Labour migration comprised 21% of all migration in 2022, a rise of 36% since 2021. Family migration also increased by 15%.

Migrant employment rates are at the highest levels in over two decades

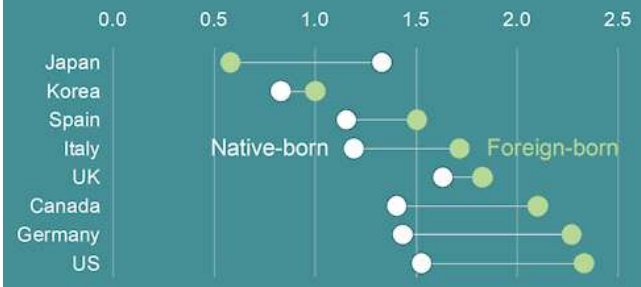
Migrant employment rates are at their highest ever levels in more than half of OECD countries and the gap with the native-born is also narrowing.

Employment rates, 2022

	Foreign-born	Native-born
New Zealand	82.7	78.3
Australia	77.2	77.6
UK	75.8	75.5
Canada	75.2	75.8
US	72.6	69.4
Korea	67.8	69.3
EU 27	66.8	70.3

Migrant fertility has little effect on overall population levels in majority of countries

Total Fertility Rate (TFR), 2020 or latest year available



The fertility rate among migrant women is higher than among native-born women in most OECD countries, but below the replacement rate (2.1) in two-thirds of them.

Immigrant mothers face greater challenges compared to native-born mothers

Employment rates across OECD countries, 2021

Across OECD countries, the gap in employment rates between immigrant and native-born mothers is 20 percentage points.

Note:

What is OECD?

- **About:**
  - The OECD is an **intergovernmental economic organisation,** founded to stimulate economic progress and world trade.
  - Most OECD members are high-income economies with a very high **Human Development Index (HDI)** and are regarded as developed countries.
- **Foundation:**
  - It was founded in 1961 with its **Headquarters at Paris, France and total membership is 38 countries.**
  - The most recent countries to join the OECD were Colombia, in April 2020, and Costa Rica, in May 2021.
  - **India is not a member, but a key economic partner.**
- **Reports and Indices by OECD:**
  - Government at a Glance
  - OECD Better Life Index.

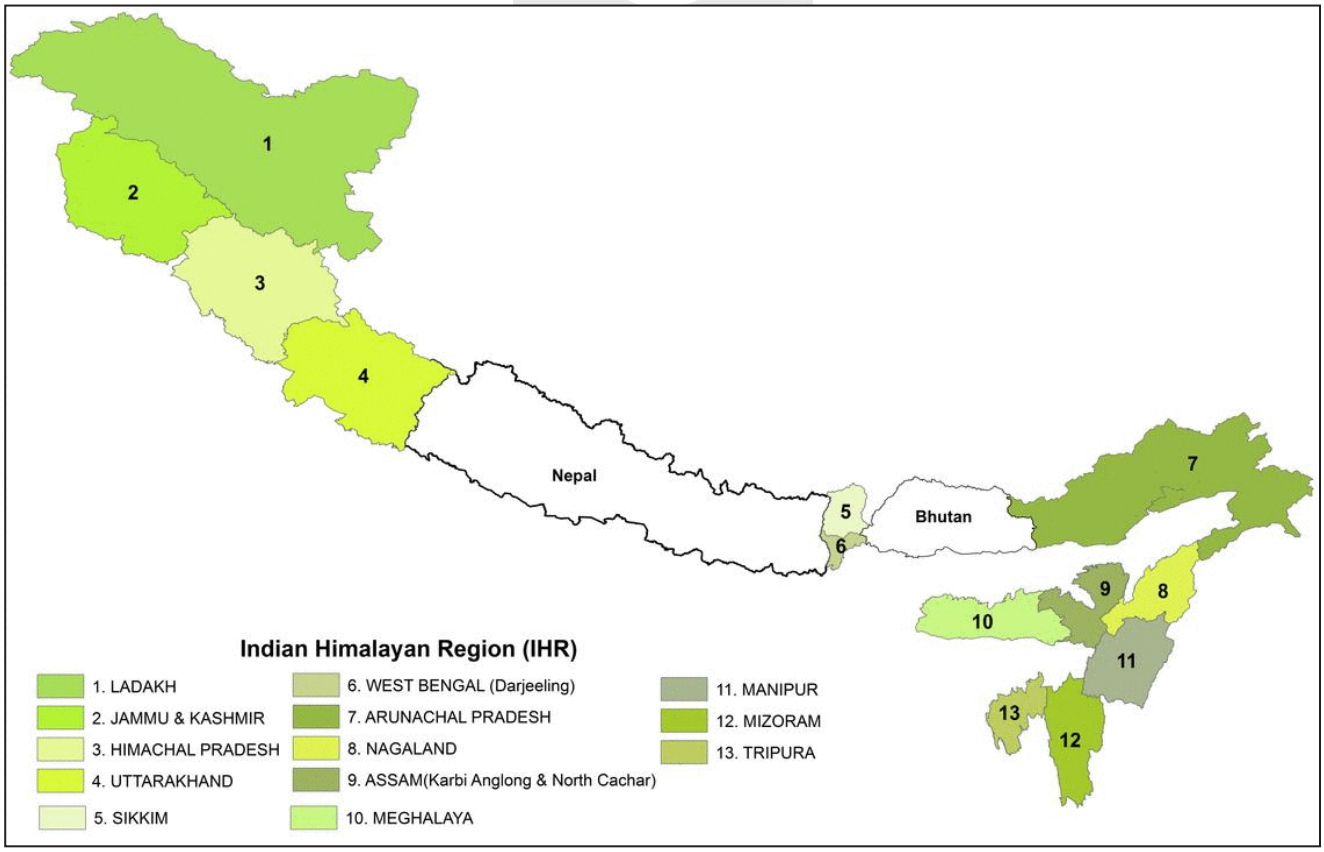
Fragility of Indian Himalayan Region

Why in News?

The **Teesta dam** breach in Sikkim led to **floods** and also the recent **landslides** in Himachal Pradesh are stark reminders of the toll our development model is taking on the environment and ecology, especially in the mountainous **Indian Himalayan Region.**

The Indian Himalayan Region (IHR):

- It refers to the **mountainous area in India** that encompasses the entire Himalayan range within the country. It stretches from the **northwestern part of India in Jammu and Kashmir to the northeastern states along the border with countries like Bhutan, Nepal, and Tibet (China).**
- It **covers 11 states** (Himachal Pradesh, Uttarakhand, Sikkim, all northeast states, and West Bengal) **and 2 UTs** (Jammu & Kashmir and Ladakh).



Note:

EIA in India

- **About:**
  - The Indian experience with **Environmental Impact Assessment** began over 20 years back. It started in 1976-77 when the **Planning Commission** asked the Department of Science and Technology to examine the river-valley projects from an environmental angle.
- **EIA 1994 Notification:**
  - In 1994, the then Union Ministry of Environment and Forests, **under the Environmental (Protection) Act 1986,** promulgated an **EIA notification making Environmental Clearance (EC) mandatory for expansion or modernisation** of any activity or for setting up new projects listed in **Schedule 1** of the notification.
- **EIA 2006 Notification:**
  - The Ministry of Environment, Forests and Climate Change (MoEFCC) notified new **EIA legislation in September 2006**.
  - The notification **makes it mandatory for various projects such as mining, thermal power plants, river valley, infrastructure** (road, highway, ports, harbors and airports) and industries including very small electroplating or foundry units to get environment clearance.
  - However, **unlike the EIA Notification of 1994, the new legislation has put the onus of clearing projects on the state government** depending on the size/capacity of the project.

Subansiri Lower Hydroelectric Project

Why in News?

The **Subansiri Lower Hydroelectric Project,** India's largest hydel project under construction, faced a setback when a **landslide blocked** the only functional diversion tunnel and stopped the flow of water downstream of the dam into the **Subansiri River, a major tributary of the Brahmaputra.**

- This resulted in the **river bed drying up and endangering aquatic life.** The incident also raised questions about the safety and viability of the project, which has faced multiple delays and opposition since its inception in 2005.

What is the Subansiri Lower Hydroelectric Project?

- The Subansiri Lower Hydroelectric Project is a **run-of-river scheme** that aims to **generate 2,000 MW of power** by harnessing the potential of the Subansiri River, which flows along the border of Arunachal Pradesh and Assam.
  - A run-of-river dam is one in which the **flow of water in the river downstream of the dam** is the **same as the flow of water upstream** of the dam.
- The project is being executed by the **National Hydroelectric Power Corporation (NHPC)**.
- The project involves the construction of a 116-metre-high **concrete gravity dam,** a 34.5-km-long reservoir, five diversion tunnels, eight spillways, and a powerhouse with eight 250-MW units.
  - **Gravity dam** is constructed from concrete or cement, it is designed to **hold back water by primarily utilizing the weight** of the material alone to resist the horizontal pressure of water pushing against it.
- The project is expected to generate around 7,500 million units of power annually in a 90% dependable year.
- The project is also expected to provide flood moderation, irrigation, and drinking water benefits to the downstream areas.
- NHPC Limited commenced construction work of Subansiri Lower Hydroelectric Project in January 2005.
  - However, **due to agitations and protests by local stakeholders,** the project construction work was stalled from December 2011 to October 2019. The project construction resumed from October 15, 2019, after the clearance by **National Green Tribunal.**

Note:

Subansiri River

- Subansiri, or "Gold River" is the largest tributary of the Upper Brahmaputra river.
- Emerging from the Tibetan Himalayas, the river flows into India through the **Miri Hills of Arunachal Pradesh**. The significant variation in its topography presents an opportunity for harnessing hydropower potential in the region.

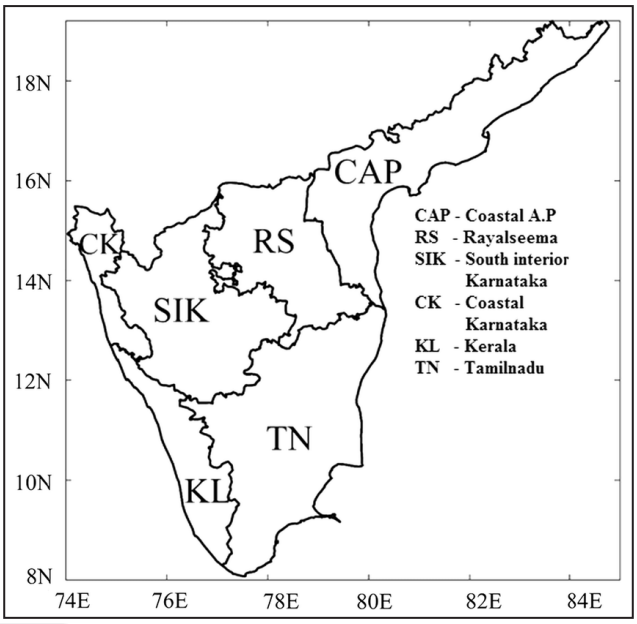
Rainfall Deficiency in Southern Peninsular India

Why in News?

The India Meteorological Department (IMD) recent analysis regarding the rainfall patterns in Southern peninsular India, spanning 123 years of records, **exposed that the region encountered its sixth driest October in its meteorological history.**

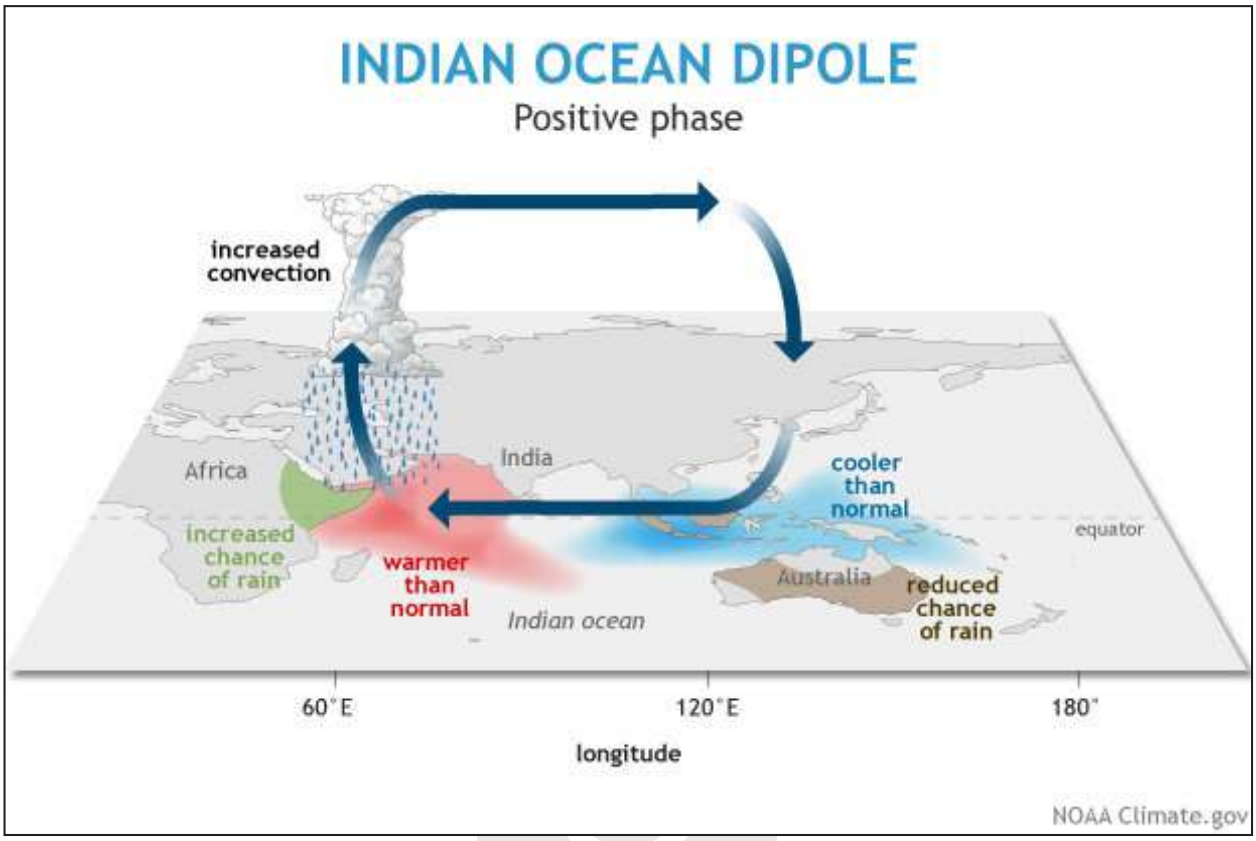
What are the Major Factors Influencing Rainfall Deficiency in Southern Peninsular India?

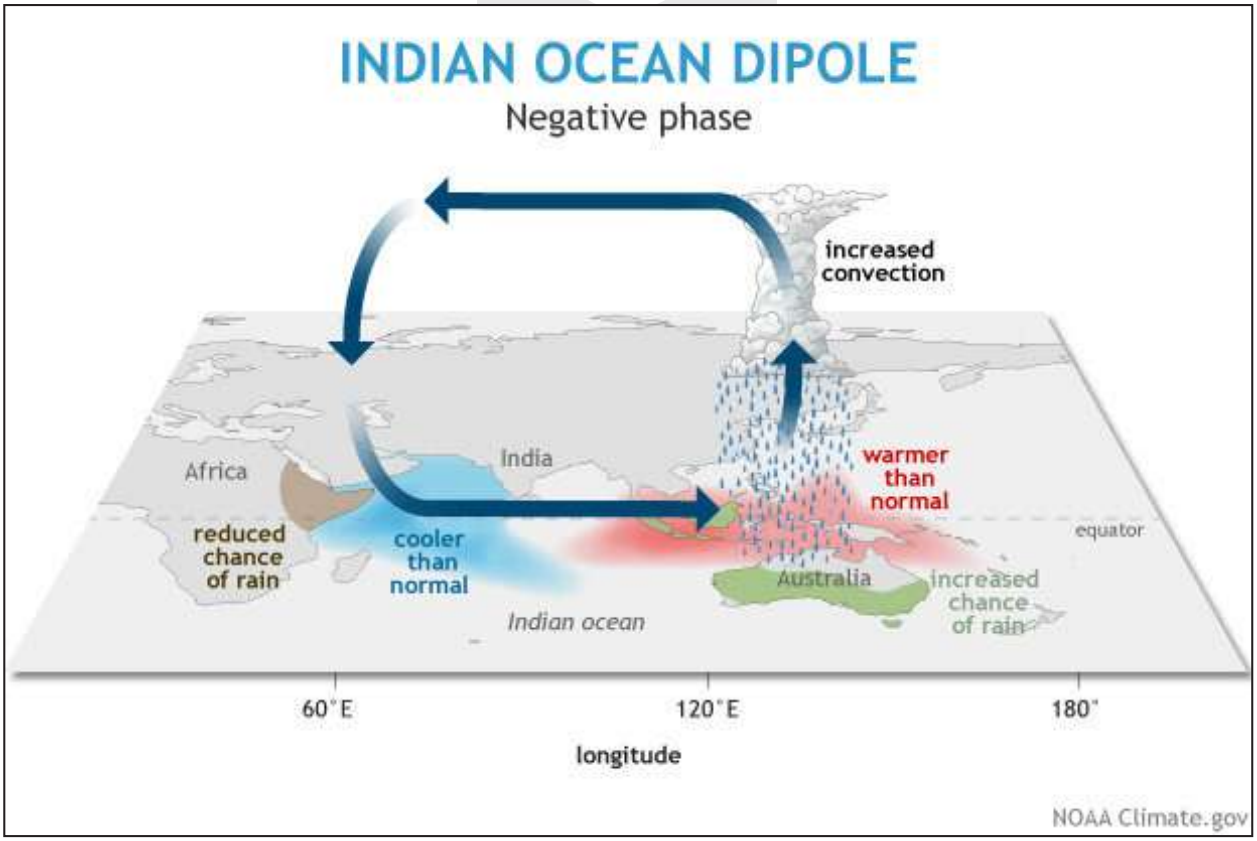
- **About:**
  - The Southern Peninsular region encompassing **Kerala, Mahe, South Interior Karnataka, Tamil Nadu, Karaikal, Puducherry, coastal Andhra Pradesh, Yanam and Rayalaseema** received only 74.9mm of rain in October, **which was over 60% below normal.**
- **Factors Influencing Rainfall Deficiency:**
  - **Confluence of Northeast Monsoon and Cyclone Hamoon:** The **commencement of the northeast monsoon** coincided with the **genesis of Cyclone Hamoon,** causing a **diversion of moisture away from southern peninsular India.**
    - This altered wind flow patterns and weakened the onset of the northeast monsoon.
  - **El Nino and Indian Ocean Dipole (IOD):** 2023 is an **El Nino year** combined with a **positive phase of the Indian Ocean Dipole (IOD).**
    - In such conditions, there is **less rainfall over northern Tamil Nadu** and adjoining areas.
- Whereas, the southernmost areas of Tamil Nadu and Kerala receive good rainfall in October.



- **Cyclone Hamoon**:
  - It was a very severe tropical cyclone that made landfall in Bangladesh on 25th October, 2023.
    - The cyclone formed from a **low-pressure area over the west-central Bay of Bengal**.
  - It was **named by Iran,** and the **word "Hamoon"** is a Persian word that refers to **inland desert lakes or marshlands.**
- **El Nino:**
  - It is a natural phenomenon that involves a **periodic warming of the surface waters in the equatorial Pacific Ocean.**
    - The word "**El Niño" means "Little Boy" in Spanish.**
    - It is one of the two phases of a climate pattern called El Niño-Southern Oscillation (ENSO)
  - Over India, **it has the effect of suppressing the monsoon rainfall.**
- **Indian Ocean Dipole (IOD):**
  - The **IOD** is an **atmosphere-ocean phenomenon** that occurs in the Indian Ocean.
  - It's characterized by a **disparity in sea surface temperatures** between the eastern and western Indian Oceans.

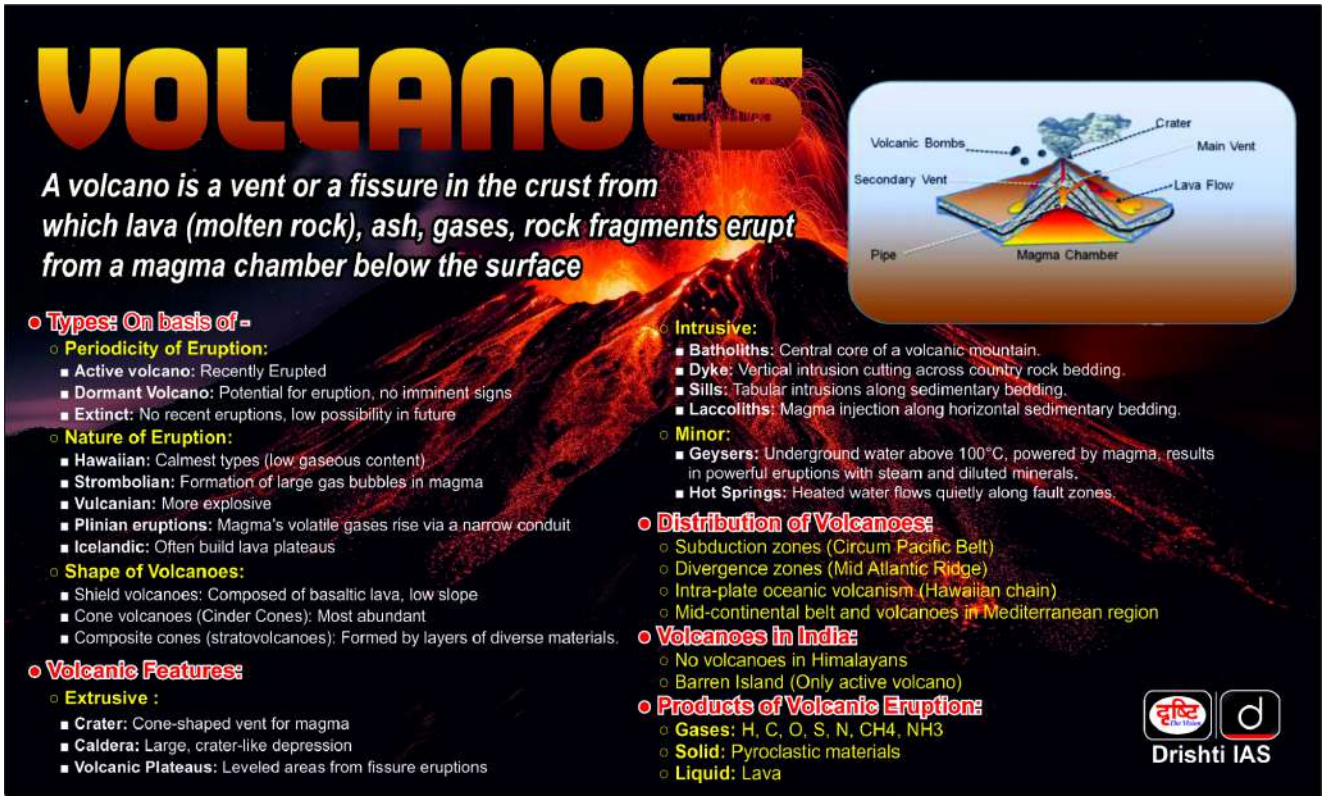
Note:


INDIAN OCEAN DIPOLE
Positive phase
increased convection
Africa
India
cooler than normal
equator
increased chance of rain
warmer than normal
Australia
reduced chance of rain
Indian ocean
60°E
120°E
180°
longitude
NOAA Climate.gov


INDIAN OCEAN DIPOLE
Negative phase
increased convection
Africa
India
warmer than normal
equator
reduced chance of rain
cooler than normal
Australia
increased chance of rain
Indian ocean
60°E
120°E
180°
longitude
NOAA Climate.gov

Note:

- **India Meteorological Department:**
  - It was established in 1875.
  - It is the **National Meteorological Service** of the country and the principal government agency in **all matters relating to meteorology and allied subjects.**



Global Energy Monitor's Global Coal Plant Tracker

Why in News?

Recently, Global Energy Monitor (GEM), a not-for-profit cataloging coal projects worldwide, has released its quarterly update of **GEM's Global Coal Plant Tracker,** highlighting several key findings regarding the **status of coal power projects worldwide.**

What are the Key Findings of the GEM Report?

- **Global Trends in Coal Construction:**
  - More than 95% of coal plant capacity beginning construction in 2023 is in China, showcasing a dominance in new coal projects.
  - A decline is observed in new coal power capacity construction for the **second consecutive year,** signaling a shift away from coal in many regions.
- **Coal Capacity Under Consideration:**
  - 110 GW of coal power capacity is under consideration in 32 countries, indicating a significant amount of Coal projects are still being deliberated.
  - India, Bangladesh, and Indonesia lead, **comprising 83% of the proposed coal capacity outside China.**
- **Trends in Project Status:**
  - 18.3 GW of coal capacity **moved from proposed to shelved or canceled status** in the first nine months of 2023 across several countries.
  - Despite cancellations, 15.3 GW of entirely new **proposals emerged in India,** Indonesia, Kazakhstan, and Mongolia.
  - India, Indonesia, Bangladesh, and Vietnam represent 84% of the 67 GW of coal power capacity under construction outside China as of July 2023.

Note:

- **Indian Scenario:**
  - India plans to increase coal-fired power plant capacity significantly by 2032, aiming for **80 GW compared to the previously stated 27 GW in the National Electricity Plan 2022-32 (NEP).**
  - Specific states in India have seen advancements in coal plant projects, with permits granted and progress reported in states like Chhattisgarh, Gujarat, Jharkhand, Madhya Pradesh, Odisha, and Uttar Pradesh.
- **Recommendations:**
  - Amidst global efforts to combat climate change, the report emphasizes the urgent need to cease the construction of new unabated coal power plants to limit global warming effectively.

What is Global Energy Monitor (GEM)?

- **About:**
  - GEM develops and shares i**nformation in support of the worldwide movement for clean energy.**
  - By studying the evolving international energy landscape and creating databases, reports, and interactive tools that enhance understanding, **GEM seeks to build an open guide to the world's energy system**.
  - Users of GEM's data and reports include the International Energy Agency, United Nations Environment Programme, **the** World Bank, and the Bloomberg Global Coal Countdown.
- **Global Coal Plant Tracker:**
  - It is an online database that identifies and **maps every known coal-fired generating unit** and every new unit proposed since 2010 (30 megawatts and larger).
  - Developed by GEM the tracker uses footnoted wiki pages to document each plant and is updated biannually, around January and July.

What is Coal?

- **About:**
  - It is a type of fossil fuel found in a form of **sedimentary rocks and is often known as 'Black Gold'.**
  - It is a conventional source of energy and is widely available.I**t is used as a domestic fuel,** in industries such as iron and steel, steam engines and to generate electricity. Electricity from coal is called thermal power.
  - The leading coal producers of the world include China, US, Australia, Indonesia, India.
- **Distribution of Coal in India:**
  - **Gondwana Coal Fields (250 million years old):**
    - Gondwana coal makes **up to 98 % of the total reserves and 99 %** of the production of coal in India.
    - Gondwana coal forms India's metallurgical grade as well as superior quality coal.
    - It is found in Damodar (Jharkand-West Bengal), Mahanadi (Chhattisgarh-Odisha), Godavari (Maharashtra), and Narmada valleys.
  - **Tertiary Coal Fields (15 – 60 million years old):**
    - Carbon content is very low but is rich in moisture and sulphur.
    - Tertiary coalfields are **mainly confined to extra-peninsular regions**
    - Important areas include Assam, Meghalaya, Nagaland, Arunachal Pradesh, Jammu and Kashmir, Himalayan foothills of Darjeeling in West Bengal, Rajasthan, Uttar Pradesh, and Kerala.
- **Classification:**
  - **Anthracite** (80 - 95% carbon content, found in small quantities in J&K).
  - **Bituminous** (60 - 80% of carbon content and is found in Jharkhand, West Bengal, Odisha, Chhattisgarh and Madhya Pradesh).
  - **Lignite** (40 to 55% carbon content, high moisture content and is found in Rajasthan, Lakhimpur (Assam) and Tamil Nadu).
  - **Peat** (less than 40% carbon content and it is in the first stage of transformation from organic matter (wood) to coal).

Survival of Rainforests Around 50 Million Years Ago

Why in News?

Recently, a team of Scientists of **Birbal Sahni Institute of Palaeosciences (BSIP)** has revealed the **Equatorial (Tropical) Rainforests**' climate of around 50 million years ago (during the Early Eocene Climate Optimum (EECO)), which survived when the earth was globally warm.

Note:

- The research **utilized innovative techniques**, employing **Plant Proxies** to quantify **terrestrial equatorial climate data** from the past. These methods helped uncover mechanisms that enabled ancient rainforests to withstand adverse conditions.

What are Plant Proxies?

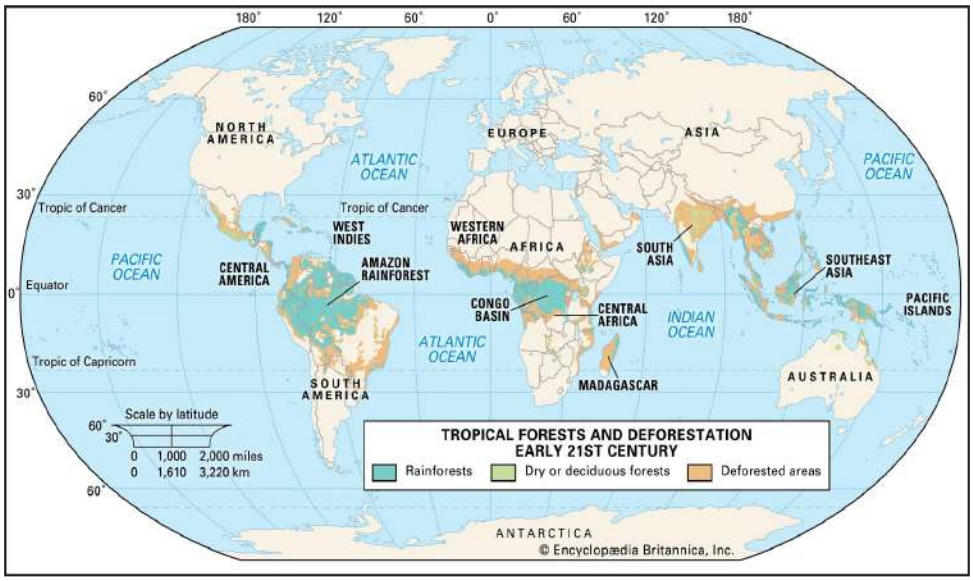
- In the context of **environmental science or Paleontology (the study of the history of life on Earth as based on fossils)**, "plant proxies" refer to indirect evidence or **indicators that scientists use to understand past environmental conditions,** particularly related to plant life.
- These proxies serve as substitutes or stand-ins for direct evidence that might not be **available or easily accessible.**
- **For Example,** Pollen grains are highly resistant and can be preserved in sediments for thousands or even millions of years. By studying the types and abundance of pollen in sediment cores or layers, **scientists can infer the types of plants that existed in a particular region during a specific period**.
- These plant proxies help scientists reconstruct ancient ecosystems, understand long-term environmental changes, and track shifts in climate and vegetation over geological timescales.

What are the Key Highlights of the Study?

- **Equatorial Rainforest Resilience:**
  - Despite global warmth and soaring atmospheric carbon dioxide levels approximately 50 million years ago, equatorial rainforests not only survived but thrived.
  - It was earlier known that the **Earth was around 13°C warmer** than present and carbon dioxide concentration was **more than 1000 ppmv during this time.**
  - This drastically affected the survival of mid- and high latitude forests due to changes in the hydrological cycle, but the equ**atorial forests survived successfully.**
- **High Rainfall's Role:**
  - The study highlights significantly **high rainfall as a crucial factor enabling the survival and thriving** of equatorial rainforests.
  - This elevated rainfall likely **enhanced plant water use efficiency,** allowing the flora to function in extreme warmth and high carbon dioxide levels.
- **Implications of This Study:**
  - Understanding the climate dynamics and resilience of equatorial rainforests during warm periods like the EECO holds significance for future climate predictions and provides insights into the survival strategies of tropical ecosystems under extreme climatic conditions.

What are Equatorial Rainforests?

- **About:**
  - Equatorial rainforests are lush, biodiverse forests found near the **equator in tropical regions.**
  - These forests typically lie **within 10 degrees latitude north or south of the equator** and are characterized by **high temperatures and heavy rainfall** throughout the year.



Note:

- **Key Features:**
  - **Climate:** They experience **a hot and humid climate** with temperatures consistently high year-round, usually averaging **around 25-27°C (77-81°F). Rainfall is abundant,** often exceeding 2,000 millimeters (80 inches) annually, leading to the term "rainforest."
  - **Biodiversity:** Equatorial rainforests are **among the most diverse ecosystems** on Earth, housing an incredibly rich variety of plant and animal species.
    - These forests contain a myriad of **species of trees, plants, insects, birds,** mammals, and other organisms, many of which are endemic to these regions.
  - **Flora and Fauna:** The vegetation in equatorial rainforests is **characterized by tall trees forming a dense canopy** that shades the forest floor, creating a multi-layered ecosystem.
    - A variety of plant species, including epiphytes (plants growing on other plants), lianas (climbing vines), and numerous species of trees, contribute to the rich biodiversity.
  - **Importance:** Equatorial rainforests play a **crucial role in regulating the Earth's climate** and carbon cycle. They absorb carbon **dioxide through photosynthesis and act as carbon sinks**, helping mitigate climate change. Additionally, they provide habitat for countless species, support indigenous communities, and are centers of medicinal plant resources.
  - **Threats:** Unfortunately, these rainforests face significant threats from deforestation, **logging, agriculture, mining, a**nd other human activities.
    - The loss of equatorial rainforests not only endangers the vast array of species that **call these forests home but also contributes to climate change** and the disruption of global ecosystems.

Flood in Somalia

Why in News?

Recently, the **U.N. Office for the Coordination of Humanitarian Affairs (OCHA)**, has described **Floods** that uprooted hundreds of thousands of people in Somalia and neighbouring countries in East Africa following a historic drought as a **Once-in-a-Century event.**

- The primary cause of the floods in Somalia has been attributed to torrential rainfall, exacerbated by **climatic phenomena like El Niño** and the **Indian Ocean Dipole.**
- The impact isn't confined to Somalia alone; neighbouring Kenya has also been affected, with the death toll reaching 15 and regions like Mombasa, Mandera, and Wajir experiencing significant challenges due to the floods.

What is the Office for the Coordination of Humanitarian Affairs (OCHA)?

- OCHA is the part of the United Nations Secretariat **responsible for bringing together humanitarian actors** to ensure a coherent response to emergencies.
- OCHA also ensures there is a framework within which each actor can contribute to the overall response effort.

What is the Indian Ocean Dipole (IOD)?

- **IOD or Indian Nino:**
  - IOD, sometimes referred to as the **Indian Nino, is similar to the El Nino phenomenon**, occurring in the relatively smaller area of the Indian Ocean between the Indonesian and Malaysian coastline in the east and the African coastline near Somalia in the west.
    - The El Nino is the warmer-than-normal phase of the **El Nino Southern Oscillation (ENSO) phenomenon**, during which there are generally warmer temperatures and less rainfall than normal in many regions of the world, including India.
  - One side of the ocean, along the equator, gets warmer than the other.
  - IOD is said to be positive when the western side of the Indian Ocean, near the **Somalia coast, becomes warmer** than the eastern Indian Ocean.
  - It is negative when the western Indian Ocean is cooler.
- **Mechanism:**
  - **Neutral Phase:**
    - The air circulation in the Indian Ocean basin moves from **west to east,** that is from the African coast towards the Indonesian islands, near the surface, and in the opposite direction at the upper levels. That means the surface waters in the Indian Ocean get pushed from west to east.

Note:

What is El Nino?

El Nino Southern Oscillation (ENSO)

Describes the fluctuations in temperature between the ocean and atmosphere **in the east-central Equatorial Pacific**

Significance:

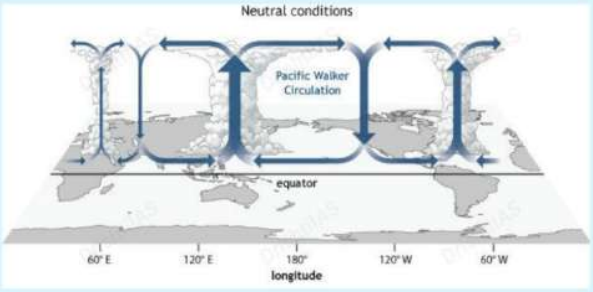
- **Ability to change the global atmospheric circulation, influencing temperature and precipitation** worldwide

States of ENSO:

- The two opposite phases - **El Niño** and **La Niña**
- The middle of the continuum - **Neutral**

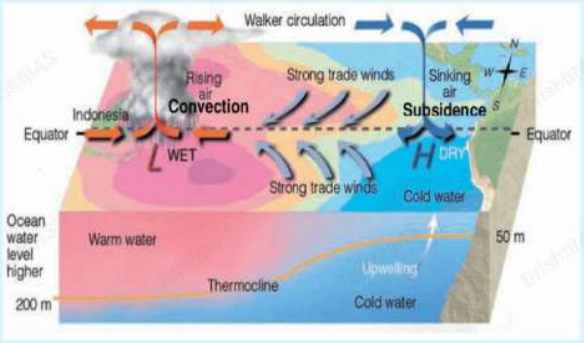
Walker Circulation (WC)

- An **atmospheric system of air flow** in the equatorial Pacific Ocean
  - The trade winds across the tropical Pacific flow from east to west: air rises above the warm waters of the western Pacific, flows eastward at high altitudes, and descends over the eastern Pacific
- WC and ENSO:
  - **A weak/reverse WC produces El Niño**
  - **Stronger WC results in La Niña**



Normal (non ENSO) Conditions in the Pacific Ocean

NEUTRAL ENSO



- **Trade winds (easterlies) blow west** along the equator, taking warm water from S. America towards Asia
- To replace that warm water, **cold water rises from the depths** — a process called **upwelling**
  - **El Niño and La Niña** are two climate patterns that **break these normal conditions**
- During an El Niño, sea level pressure tends to be lower in the eastern Pacific and higher in the western Pacific while the opposite tends to occur during a La Niña
  - This see-saw in atmospheric pressure between the eastern and western tropical Pacific is called the **Southern Oscillation (SO)**

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Note:

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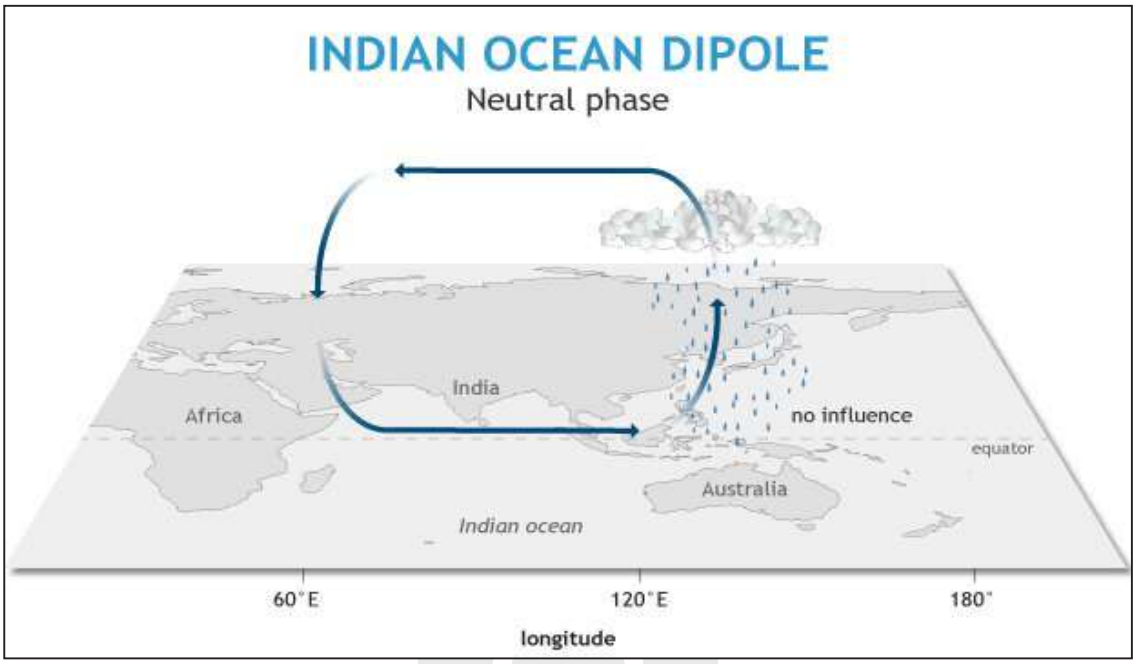
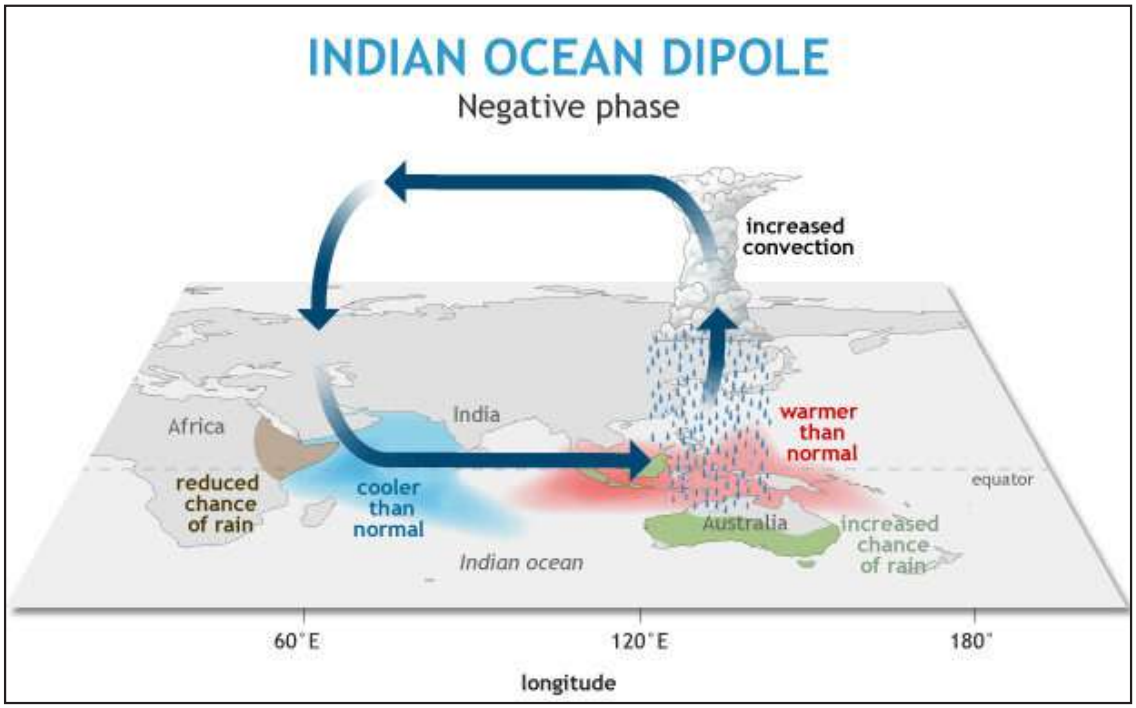
- In a normal year, warmer waters in the western Pacific near Indonesia cross over into the Indian Ocean and make **that part of the Indian Ocean slightly warmer.** That causes the air to rise and helps the prevailing air circulation.



➢ **Negative IOD:**

- In the years when the air circulation becomes stronger, more warm surface waters from the African coast are pushed towards the Indonesian islands, making that region warmer than usual. This causes hotter air to rise, and the cycle reinforces itself.
- This is the state of negative IOD.

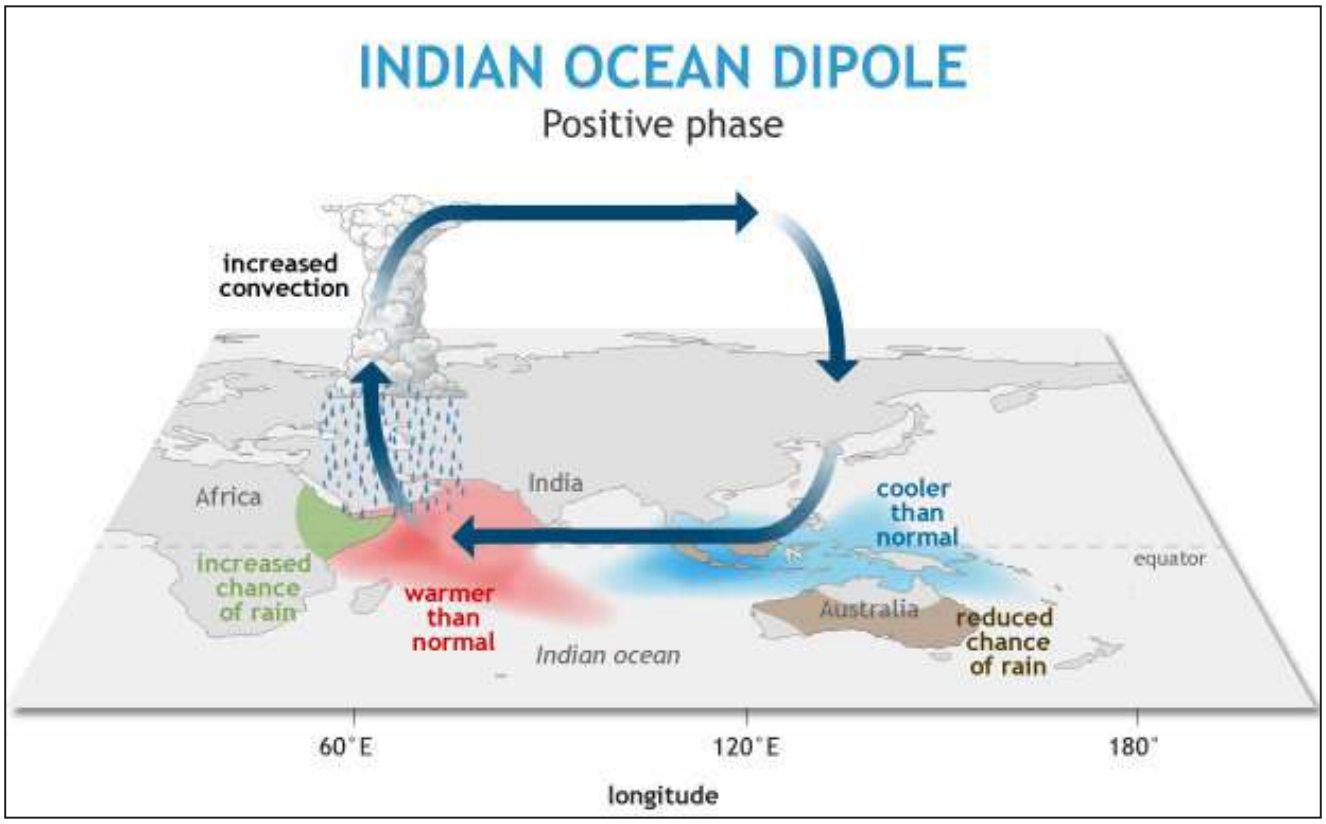


Note:

➢ **Positive IOD:**

- ❍ Air circulation becomes slightly weaker than normal. In some rare cases, the air circulation even reverses direction. The consequence is that the African coast becomes warmer while the Indonesian coastline gets cooler.

- A positive IOD event is often seen developing at times of an El Nino, while a negative IOD is sometimes associated with La Nina.
- During El Nino, the Pacific side of Indonesia is cooler than normal because of which the Indian Ocean side also gets cooler. That helps the development of a positive IOD.



➢ **Impact of IOD:**

- ❍ In the Indian Ocean, IOD exhibits an ocean-atmosphere interaction that closely resembles the fluctuations observed during El Niño events in the Pacific Ocean. However, the IOD is considerably less powerful compared to El Niño, resulting in relatively minimal impacts.
- ❍ A positive IOD helps rainfall along the African coastline and also over the Indian sub-continent while suppressing rainfall over Indonesia, southeast Asia and Australia. The impacts are opposite during a negative IOD event.

What are the Key Facts About Somalia?

➢ **Location:**

- ❍ Somalia is situated in the Horn of Africa, bordered by the Gulf of Aden to the north, the Indian Ocean to the east, Kenya and Ethiopia to the west, and Djibouti to the northwest.

➢ **Capital:**

- ❍ Mogadishu is the capital and largest city in Somalia.

➢ **Terrain:**

- ❍ The country features **diverse landscapes including arid plains**, plateaus, highlands, and mountain ranges.
- ❍ The northern part of Somalia includes the Golis Mountains, while the southern region is characterized by savannas and grasslands.

Note:

- **Climate:**
  - Somalia experiences a **predominantly arid to semi-arid climate with hot temperature**s and limited rainfall. The coastal areas have a more moderate climate due to the influence of the Indian Ocean.

- **Islands:**
  - Somalia has several islands off its coast, including the Bajuni Islands and the Socotra Archipelago, which includes islands like Socotra, Abd al Kuri, and Samha. However, the Socotra Archipelago is administered by Yemen.

Mount Etna

Why in News?

Mount Etna, Europe's most **active volcano** and one of the largest in the world, has been **erupting frequently** since February 2023, sending plumes of ash and fountains of lava into the sky.

What are the Key Facts About Mount Etna?

- Mount Etna is a **stratovolcano,** which means it is composed of layers of lava, ash, and rocks that have accumulated over thousands of years of eruptions.
- It is located on the **east coast of Sicily,** an island in the Mediterranean Sea that belongs to Italy.
  - It stands about 3,300 metres above sea level and covers an area of about 1,200 square kilometres.
- Mount Etna has four summit craters and hundreds of lateral vents that can produce different types of eruptions, such as explosive, effusive, or mixed.
- Mount Etna **has been erupting almost continuously since 1500 BC,** making it one of the most active volcanoes in the world.

Note:

What is a Volcano?

- **About:**
  - **Volcanoes** are openings or vents where lava, rocks, and steam erupt onto the Earth's surface.
  - They result from both their own eruptions and the general formation of the planet through the movement and collision of tectonic plates.
- **Types of Volcanoes:**
  - **Based on Frequency of Eruption:**
    - **Active Volcanoes:**
      - They **erupt frequently** and are mostly located in the **Pacific Ring of Fire,** which includes New Zealand, Southeast Asia, Japan and the western coast of the Americas.

Note:

- About **90% of all earthquakes worldwide strike within this region.**
- Volcanic activity is linked to the movement and collision of **tectonic plates.**
- Examples include **Kilauea in Hawaii** and **Santa Maria in Guatemala**.

- **Dormant Volcano:**
  - These are **not extinct but have not erupted in recent history.** The dormant volcanoes may erupt in future.
  - Example: **Mount Kilimanjaro,** located in Tanzania, also the highest mountain in Africa, is known to be a dormant Volcano.
- Extinct or Inactive Volcanoes:
  - These have **not worked in the distant geological past.**
  - Example: **Dhinodhar hill, Gujarat.**

➢ Based on Geological Formations:

Characteristic	Cinder Cones	Composite or Stratovolcanoes	Shield Volcanoes	Lava Domes
Formation	Small, steep-sided structures	Large, conical structures	Broad, gently sloping structures	Volcanic mountains formed by slow extrusion
Composition	Formed from ejected volcanic particles	Layers of lava, ash, and rocks	Created by low-viscosity lava flows	Formed by the slow extrusion of highly viscous lava
Lava Characteristics	Dark-colored basaltic lava	Viscous lava	Fluid lava	Highly viscous lava
Geological Location	Commonly found near other types of volcanoes	Associated with subduction zones	Divergent plate boundaries and hot spots	Typically found at subduction zones

- **Based on the Type of Eruption:**
  - **Basic:**
    - The basic magma is **dark-coloured like basalt**, rich in iron and magnesium but poor in silica. They travel far and generate broad shield volcanoes.
  - **Acidic:**
    - These are **light-coloured, of low density,** and have a high percentage of silica therefore they make a familiar cone volcano shape.

➢ **Tools and Methods to Predict Volcanic Eruptions:**

- **Seismic Data:**
  - Monitoring earthquakes and tremors as potential precursors to volcanic eruptions.
- **Ground Deformation:**
  - Observing changes in the ground, indicating magma movement.
- **Gas Emissions and Gravity Changes:**
  - Analyzing volcanic gas emissions, gravity, and magnetic field alterations.

Note:

Thousands of Earthquakes Rock Iceland

Why in News?

Iceland has declared a **state of emergency** following a series of **800 earthquakes** that struck the **southwestern Reykjanes peninsula** in less than 14 hours.

- Approximately 1,400 earthquakes were detected in a day, and the peninsula has experienced over **24,000 seismic events** since late October. The strongest of these earthquakes, with a magnitude of 5.2, occurred approximately 40 km from Reykjavík, Iceland's capital.

What is Happening in Iceland?

- **About Iceland:**
  - Iceland is located on the **Mid-Atlantic Ridge**, technically the longest mountain range in the world, but on the floor of the Atlantic Ocean. The ridge separates the Eurasian and North American tectonic plates — making it a hotbed of seismic activity.
    - The **Mid-Atlantic Ridge is a divergent or constructive plate boundary** where tectonic plates move away from each other, leading to the **creation of new** oceanic crust
  - This geological setting makes the region prone to frequent earthquakes, with an annual average of approximately 26,000, as reported by Perlan, a natural history museum based in Reykjavik.
  - While most of these tremors go unnoticed, the occurrence of **earthquake swarms**, characterized by **numerous small earthquakes** without a discernible mainshock, raises concerns about the **possibility of an impending volcanic eruption.**
    - **These earthquake swarms indicate heightened tectonic stress in specific areas.**
- **Notable Icelandic Volcanoes:**
  - Iceland boasts a total of 33 active volcanoes.

Note:

- Eyjafjallajökull, one of Iceland's most famous volcanoes, erupted in 2010, causing a widespread ash cloud.
- Other notable volcanoes include Hekla, Grímsvötn, Hóluhraun, and Litli-Hrútur, part of the Fagradalsfjall system.

MONSOON

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Monsoons are seasonal winds that reverse their direction with the change of season.

Origin of Monsoon

- Thermal Concept
- Dynamic Concept

Thermal Concept by Halley

- **Monsoon result of:**
  - Heterogenous character of globe (Unequal distribution of land and water)
  - Differential seasonal heating and cooling of continents and oceans

South-West (Summer) Monsoon

- Sun shines over Tropic of Cancer
- Brings low-pressure centres (Near Baykal Lake and Peshawar) due to High temperature
- Low temperature in Southern hemisphere brings High pressure centre over Australia and Indian Ocean
- Winds Blow from high (ocean) to low pressure in Asia (land)
- Ferrel's law and Coriolis force turn these wind in south-westerly (SW) direction
- They bring moisture from Indian oceans to Indian subcontinent yielding heavy rainfall

North-East (Winter) Monsoon

- Sun shines over Tropic of Capricorn
- Brings High Pressure centers (near Baykal Lake and Peshawar) due to low temperatures
- High temperature in Southern hemisphere brings Low pressure centre over Australia and Indian Ocean
- Winds Blow from high (land) to low pressure (ocean) in north-easterly (NE) direction called Retreating Monsoon

Dynamic Concept by Flohn

- Monsoon originated due to shifting of pressure and wind belts
- Intertropical Convergence (ITC) formed due to convergence of NE and SE trade winds near equator
- Northern and Southern branches of the ITC, known as NITC and SITC respectively, create a belt of doldrums marked by equatorial westerlies

South-West (Summer) Monsoon

- Sun shines over Tropic of Cancer
- NITC extended up to 30° N latitude covering south and SE-Asia and establishes Equatorial westerlies
- It brings atmospheric depressions (cyclones) with heavy rainfall

North-East (Winter) Monsoon

- Sun shines over Tropic of Capricorn
- Due to Southward shifting of Sun, pressure and wind belts also shifts
- Western cyclonic disturbances (from Mediterranean Sea) enter India from west in winter due to Westerly Jet stream
- Northeast trade winds reestablished over south and SE Asia
- These NE trades become winter monsoons called Retreating Monsoon and rains in Andhra and Tamil Region

Note:

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Indian Meteorological Department

Why in News?

The **Indian Meteorological Department (IMD)** recently got a new logo ahead of the commencement of its **150th year of providing weather and climate services to the country.**

- The new logo, in a mix of orange and green colours, depicts numerical 150 embedded with the present logo showing the **Indian monsoon winds** crossing over India**.**

What is the India Meteorological Department?

- **About**:
  - IMD was **established in 1875**. It is the **National Meteorological Service** of the country and the principal government agency in all **matters relating to meteorology and allied subjects.**
    - It works as an **agency of the Ministry of Earth Sciences** of the Government of India.
  - It is headquartered in **New Delhi.**
  - IMD is also one of the **six Regional Specialized Meteorological Centres** of the **World Meteorological Organization**.

What are the Major Initiatives Related to Meteorology in India?

- **National Monsoon Mission (NMM):** Government of India launched NMM in 2012 with a vision to develop a state-of-the-art dynamical prediction system for monsoon rainfall on different time scales.
- **Mausam App:** Tool for dissemination of weather information and warnings in an attractive and user friendly manner.
- **Doppler Weather Radars:** Based on Doppler principle, the **radar is designed to improve precision in long-range weather forecasting and surveillance** using a parabolic dish antenna and a foam sandwich spherical radome.
  - DWR has the equipment to measure **rainfall intensity, wind shear and velocity and locate a storm center** and the direction of a tornado or gust front.

Land of Fire and Ice: Iceland

Why in News?

Recently, the **Government of Iceland** has confirmed that the **volcanic eruption** near the capital **Reykjanes** poses no threat to human life.

- Iceland is located on thes **Mid-Atlantic Ridge,** technically the longest mountain range in the world, but on the floor of the **Atlantic Ocean.**
- The eruption began between **Sýlingarfell** and **Hagafell**, just north of the fishing town of **Grindavik** which is located on the **Reykjanes Peninsula.**

What are the Key Facts about Iceland (Land of Fire and Ice)?

- Iceland is located on the **Mid-Atlantic Ridge**, technically the longest mountain range in the world, but on the **floor of the Atlantic Ocean**.

Note:

- The ridge separates the **Eurasian** and **North American tectonic plates** making it a hotbed of **seismic activity**.It is mostly a submarine, running along the length of the **Atlantic** from **north to south**.
- However, in the North Atlantic, it rises over the ocean surface in the form of the island of Iceland. This feature of its geology has given rise to **Iceland's unique landscape** made up of **geysers (hot springs), glaciers, mountains, volcanoes** and **lava fields.**

➢ Iceland is home to **33 active volcanoes**, the **highest in Europe**. This unique landscape has given Iceland the epithet, **'Land of Fire and Ice'**.

- **Eyjafjallajökull,** one of **Iceland's most famous volcanoes**, erupted in **2010**, causing a widespread **ash cloud.**
  - Other notable volcanoes include **Hekla, Grímsvötn, Hóluhraun,** and **Litli-Hrútur,** part of the Fagradalsfjall system.

What are the Other Volcano-Prone Regions in the World?

➢ Volcanoes are distributed all around the world, mostly along the edges of **Tectonic Plates**, although there are intraplate volcanoes that form from **mantle Hotspots** .

➢ **Circum-Pacific Belt:**

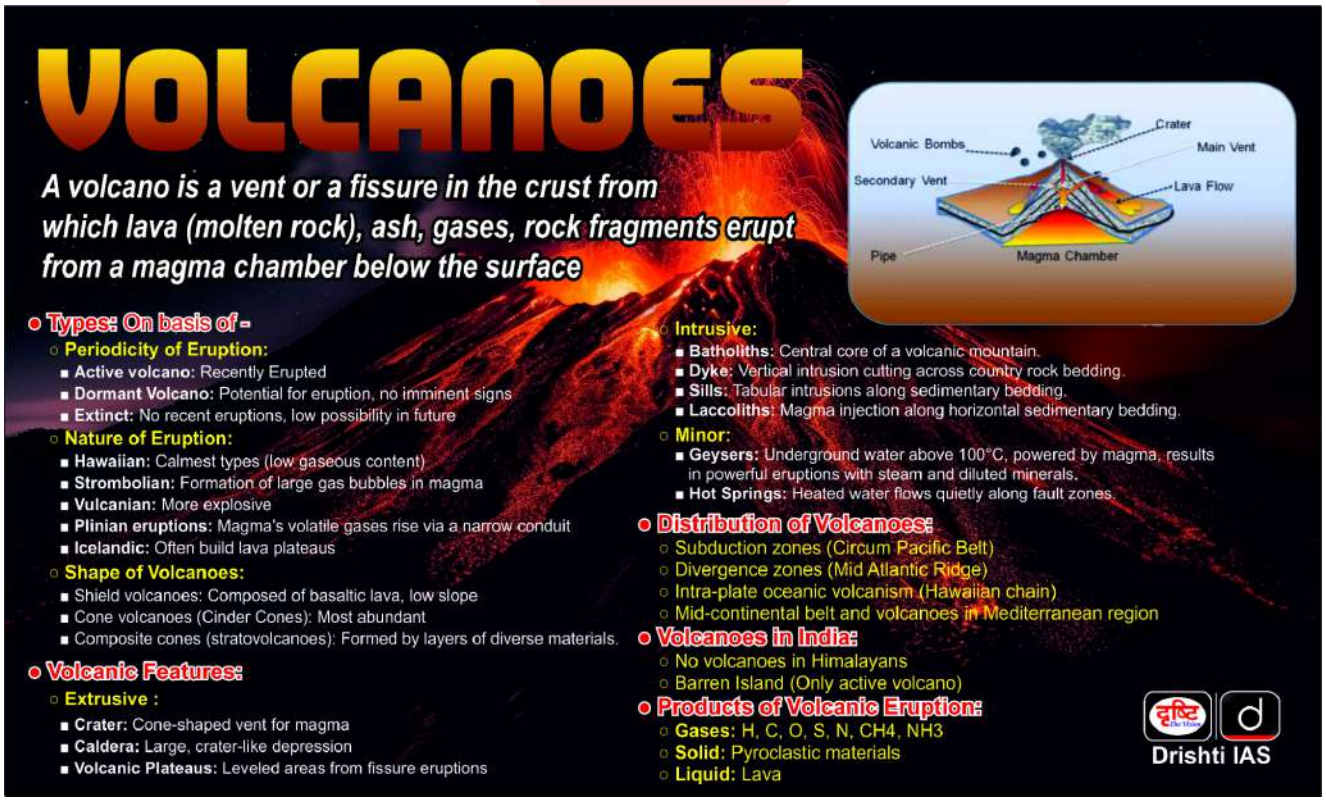
- The **Pacific "Ring of Fire"** is a **string of volcanoes** and sites located on most of the **Earth's subduction zones** having **high seismic activity**, around the **edges of the Pacific Ocean.**
- The **Pacific Ring of Fire** has a total of **452 volcanoes.**
- Most of the active volcanoes are found on its western edge, from the **Kamchatka Peninsula** in **Russia**, through the **islands of Japan** and **Southeast Asia**, to **New Zealand**.

➢ **Mid-Continental Belt:**

- This volcanic belt extends along the **Alpine Mountain system** of **Europe**, **North America**, through **Asia Minor**, **Caucasia, Iran, Afghanistan** and **Pakistan** to the **Himalayan Mountain system**, including **Tibet**, the **pamir, Tien-Shan**, **Altai**, and the mountains of **China, Myanmar** and **eastern Siberia**.
- This belt includes the **volcanoes of Alps mountains, Mediterranean Sea** (Stromboli, Vesuvius, Etna, etc.), **volcanoes of Aegean Sea, Mt. Ararat** (Turkey), **Elburz, Hindu Kush** and **Himalayas**.

➢ **Mid Atlantic Ridge:**

- The Mid-Atlantic Ridge **separates** the **North and South American Plate from the Eurasian and African Plate.**



Note:

- Magma rises through the cracks and leaks out onto the ocean floor like a long, thin, undersea volcano. As magma meets the water, it cools and solidifies, adding to the edges of the sideways-moving plates.
- This process along the divergent boundary has created the **longest topographic feature in the form of Mid oceanic ridges** under the Oceans of the world.

➢ **Intraplate Volcanoes:**

- The **5%** of known volcanoes in the world that are not closely related to plate margins are generally regarded as **intraplate**, or **"hot-spot," volcanoes**.
  - A hot spot is believed to be related to the rising of a **deep-mantle plume**, which is caused by very slow convection of highly viscous material in Earth's mantle.
- It can be represented by a **single oceanic volcano** or **lines of volcanoes** such as the **Hawaiian-Emperor seamount chains.**

Persistence of Synchronized Extreme Rainfall in Changing Climates

Why in News?

Recently, a new study has been published by Advancing Earth and Space Sciences (AGU) titled- ***Geographical Trapping of Synchronous Extremes Amidst Increasing Variability of Indian Summer Monsoon Rainfall***, highlighting that Indian Monsoon has undergone significant alterations due to **Global Warming**.

➢ The study investigates **synchronous extreme rainfall events** during the **Indian Summer Monsoon Rainfall (ISMR) from 1901 to 2019**. It highlights the consistent presence of interconnected extreme hubs in Central India, suggesting the geographical concentration of these concurrent events in the region.

How have been the Rainfall Trends in India?

➢ **Consistent Spatial Concentration:**

- Despite the rising variability in Indian **Summer Monsoon** Rainfall (ISMR) over the past century, synchronous extreme rainfall events **have consistently concentrated within a specific geographical region**, primarily in **Central India (CI) that extends from parts of West Bengal and Odisha to parts of Gujarat and Rajasthan.**
  - This corridor has remained unchanged from 1901 to 2019!
  - This indicates a **stable pattern of synchronized extreme** events despite overall increased variability.

➢ **Network Cohesiveness:**

- There is a **persistent network of highly interconnected extreme rainfall hubs** in CI. These hubs exhibit strong local connections, emphasizing a stable synchronization of extreme events in this region over the long term.

➢ **Correlation with Climatic Patterns:**

- India's monsoon forecasts rely heavily on its relation to the **El Niño and the La Niña phenomena,** although this relation holds only about 60% of the time.
- Indian Rainfall events are correlated with **El Niño Southern Oscillations (ENSO)**, with more **synchronization during strong El Niño periods** and less during La Niña conditions.

➢ **Implications for Predictability:**

- The findings suggest that despite the increasing variability and complexity of ISMR, understanding the persistent nature of extreme rainfall synchronization in CI provides insights crucial for predicting synchronous extremes.
- This knowledge can aid in developing effective adaptation strategies and risk management during the monsoon season.

What are the Factors Affecting the Indian Monsoon?

➢ **Himalayan Mountains:**

- The **Himalayas** are a **major factor in the formation of the monsoon winds** in India.
- During the **summer months, the landmass over the Indian subcontinent heats up** rapidly, leading to the formation of a low-pressure system.
  - The Himalayas, which act as a barrier, prevent the cool, dry air from the north from flowing into the region, resulting in a pressure gradient that draws in warm, moist air from the Indian Ocean.

Note:

- **Thar Desert:**
  - The Thar Desert, also known as the **Great Indian Desert**, is a crucial factor in the formation of monsoon winds in India.
  - It **acts as a rain shadow area for the Bay of Bengal branch of the monsoon,** meaning that it receives very little rainfall due to the barrier created by the **Aravalli Mountain range.**
    - Thus, the Arabian branch of the monsoon, which moves parallel to the Thar Desert, also leads to very little rainfall in the nearby regions.
      - **This lack of rainfall can have significant impacts on agriculture and the local economy in the region.**
    - The hot and dry air from the desert creates a low-pressure zone in the whole northwest parts of India, which draws in moisture-laden winds from the Indian Ocean, resulting in heavy rainfall during the summer months.
- **Indian Ocean:**
  - The **Indian Ocean** is a significant contributor to the formation of monsoon winds in India.
    - The ocean's warm and moist air interacts with the low-pressure system over the Indian subcontinent, resulting in the formation of the monsoon winds.

150 Years of India Meteorological Department

Why in News?

India Meteorological Department (IMD) with the mandate of providing public weather services will complete 150 years of presence on 15th January, 2025.

- To mark this milestone, IMD plans a nationwide celebration in all sub-offices from January 15, 2024, to January 15, 2025.

What is India Meteorological Department (IMD)?

- **About:**
  - It is the **National Meteorological Service** of the country and the principal government agency in **all matters relating to meteorology** and allied subjects.
  - It is an agency of the **Ministry of Earth Sciences**, Government of India.
- **Objectives:**
  - To take **meteorological observations** and to provide current and forecast meteorological information for optimum operation of weather-sensitive activities like agriculture, irrigation, shipping, aviation, offshore oil explorations, etc.
  - To **warn against severe weather phenomena** like tropical cyclones, norwesters, duststorms, heavy rains and snow, cold and heat waves, etc., which cause destruction of life and property.
  - To **provide meteorological statistics** required for agriculture, water resource management, industries, oil exploration and other nation-building activities.
  - To **conduct and promote research** in meteorology and allied disciplines.

How has the IMD Evolved Over The Years?

- **Historical Background:**
  - In 1864, two devastating cyclones hit Kolkata and the Andhra coast, causing significant loss of life.
  - The severity of these calamities highlighted the absence of a system to monitor atmospheric parameters, leading to the **establishment of the India Meteorological Department (IMD) in 1875.**
- **Evolution of IMD**:
  - The IMD commenced its official operations with the appointment of just one individual, **HF Blanford**, an Englishman recognized as the Imperial Meteorological Reporter.
  - Under the leadership of **Gilbert Walker**, appointed as the head of IMD in 1903, significant progress was made in understanding monsoons.
    - Walker identified large-scale oscillations in atmospheric circulations, laying the foundation for modern comprehension of the **El Niño phenomenon**.
  - Over 150 years, IMD has grown into a **massive organization with permanent observatories** and automatic weather stations across the country.
- **Advancements in Cyclone Forecasting:**
  - The IMD experienced a pivotal moment in **1999 during the Odisha super cyclone,** prompting

Note:

significant investments in technology and manpower. Since then, **cyclone-related casualties have notably decreased**, attributed to IMD's effective forecasts.

- IMD's cyclone forecasts now serve not just India but **the entire neighbourhood, with as many as 13 countries** in the region operating their cyclone management systems using these forecasts.

➢ **Diversified Roles :**

- Initially focused on weather forecasting, IMD now provides specialized services for elections, sporting events, space launches, and various sectors.

➢ **Global Role and Recognition :**

- IMD's enhanced capabilities have led to its recognition **as the Regional Climate Centre for South Asia.**
- IMD has partnered to contribute to the United Nations' **'Early Warning for All'** programme, for which 30 countries have been identified.

What are the Major Initiatives Related to Meteorology in India?

➢ **National Monsoon Mission (NMM)**

➢ **Mausam App**

➢ **Doppler Weather Radars**

Rock Glaciers

Why in News?

A recent study has shed light on the presence of over **100 active permafrost structures in the Jhelum basin of the Kashmir** Himalayas. These structures, known as **rock glaciers,** have significant implications for the region's hydrology and pose potential risks as the **climate warms**.

What are Rock Glaciers?

➢ **About:**

- Rock glaciers are a type of landform that consists of a **mixture of rock fragments and ice**.
- Rock glaciers typically form in **mountainous regions** where there is a combination of **permafrost, rock debris, and ice.**
  - **Permafrost** is a permanently frozen layer on or under Earth's surface. It consists of **soil, gravel, and sand, usually bound together by ice.**
  - One common scenario involves a **pre-existing glacier** that accumulates debris and rocks as it moves. Over time, if the glacier recedes or thaws, the debris-covered ice can transform into a rock glacier.
- These rock glaciers occur in highly elevated regions with steep slopes.
- To the **naked eye, the rock glaciers look like regular ground,** they require a geomorphological view for proper identification.

➢ **Classification:**

- They are classified as **active or relict,** depending on whether they have ice and movement or not. **Active rock glaciers are more dynamic** and hazardous, while **relict rock glaciers are more stable and inert.**

➢ **Importance:**

- Rock glaciers are important indicators of **mountain permafrost**, which is the permanently frozen ground that underlies many high-altitude regions.
- Rock glaciers also store **significant amounts of water** in their frozen cores, which could be a valuable resource in the face of **water scarcity and glacial retreat.**

Jhelum Basin of the Kashmir Himalayas

➢ The Jhelum basin is drained by the **upper Jhelum River**, which originates from a deep spring at **Vernag at Anantnag,** situated at the base of the **Pir Panjal range in the Kashmir Valley,** the river passes through **Srinagar and Wular Lake** before entering Pakistan.

➢ As a tributary of the Indus River, the Jhelum contributes to the larger river system in the Indian subcontinent.

- The river flows through Jammu and Kashmir and into Pakistan, where it joins the Chenab River.

➢ The primary tributary is the **Kishenganga (Neelum) River**. The **Kunhar River,** another significant tributary, connects Pakistan-occupied Kashmir and Pakistan via the Kohala Bridge in the Kanghan Valley.

Note:

Implications of No Snowfall In Kashmir

Why in News?

The absence of Snowfall in Kashmir during the winter season is not **only affecting the region's tourism industry,** particularly in popular destinations like Gulmarg, but it also has significant implications for various aspects of the local environment and economy.

What Causes No Snowfall In Kashmir?

- **Climate and Weather Patterns:**
  - The entire Jammu and Kashmir and Ladakh regions have seen a **lack of rains or snow this winter**, with a notable **80% rainfall deficit in December 2023** and 100% (no rain) deficit in January 2024 so far.
  - Winter precipitation in these regions, crucial for the local climate, is mainly in the form of snowfall.
- **Decline in Western Disturbance:**
  - The overall trend of decreasing snowfall has been attributed to a decline in **Western Disturbance** events and a **gradual rise in temperature**s, likely influenced by **Climate Change.**
  - Western Disturbances are the **primary source of winter precipitation** in the **Himalayan region.**
    - The number of Western Disturbance events has been showing a declining trend, contributing to less overall precipitation during the winter months.
    - Western Disturbance are large **eastward-moving rain-bearing wind systems** that originate beyond Afghanistan and Iran, picking up moisture from as far as **the Mediterranean Sea and even the Atlantic Ocean.**
- **Role of Climate Change and El Nino:**
  - Climate change is considered a contributing factor to the declining snowfall in Kashmir, as indicated by various studies.
  - The rate of temperature increase is higher in upper elevation areas than in the **plains, further impacting snowfall.**
  - The current **El Nino** event in the eastern Pacific Ocean is suggested as an **additional factor affecting global atmospheric circulation** and contributing to the deficit precipitation in the region.
    - There have been several years in the last one decade — 2022, 2018, 2015 — when winters have been relatively dry in Jammu and Kashmir, and snowfall has been very low.

Atlantic Meridional Overturning Circulation

Why in News?

The **Atlantic Meridional Overturning Circulation (AMOC)** is at risk of imminent collapse, with recent studies indicating that **anthropogenic emissions** could expedite this between **2025 and 2095.**

What is AMOC?

- **About**:
  - AMOC is a large-scale oceanic circulation system that transports **warm surface waters from the tropics** to the northern latitudes and returns cold, deep waters from the **North Atlantic** back towards the equator.
    - It plays a crucial role in redistributing heat globally, influencing regional and global climates, especially moderating temperatures in Europe, North America, and near the Equator.
- **Mechanism:**
  - Warm water from the tropics moves towards the northern latitude, carrying heat energy which warms places like Europe.
  - As it travels, the warm water cools down due to contact with the colder air of northern latitude and mixes with cold freshwater from **melting Arctic ice.**
  - This cooler, denser water sinks to deeper layers of the ocean, mainly in the **North Atlantic,** and then flows back southwards along the ocean floor.
  - This southward flow, known as the **deep limb of the AMOC,** helps to distribute heat and nutrients across the ocean.
  - Eventually, the water resurfaces in the tropics and warms up again, completing the circulation cycle of the AMOC.

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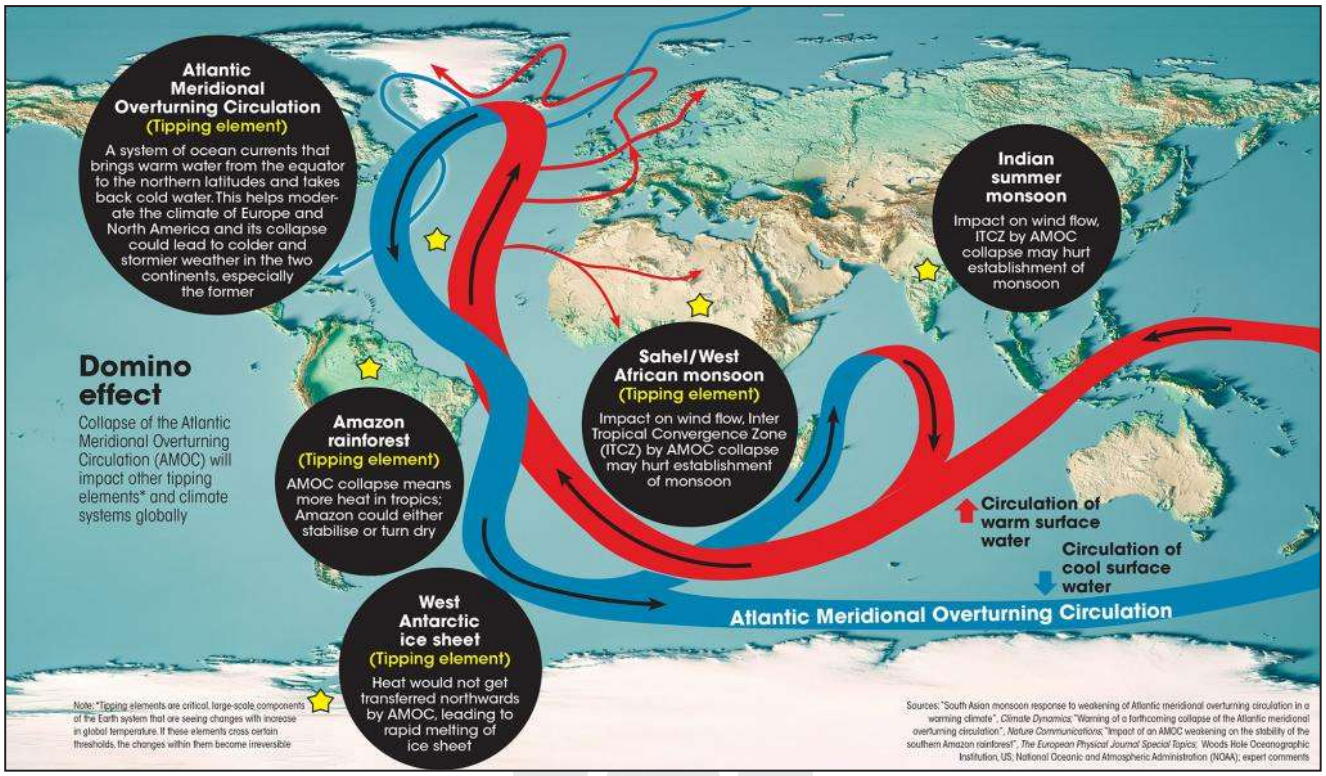

- **Role of Indian Ocean:** As the **Indian Ocean warms** faster and faster, it **generates additional precipitation**. This **draws more air** from other parts of the world to the Indian Ocean, including the Atlantic. With so much precipitation in the Indian Ocean, there will be **less precipitation in the Atlantic** Ocean.
  - Less precipitation will **lead to higher salinity in the waters of the tropical portion of the Atlantic** — because there won't be as much rainwater to dilute it.
  - This saltier water in the Atlantic, as it comes north via AMOC, will get cold much quicker than usual and sink faster.
  - This would act as a jump start for AMOC, intensifying the circulation.
- **Contribution to Global Climate:** This cycle acts like a **heat conveyor belt,** warming the northern latitudes and cooling the southern latitudes, contributing to the overall stability of the Earth's climate.
- **Threat:** Rising precipitation and accelerated melting of the **Greenland ice sheet** have introduced more cold freshwater into the North Atlantic.
  - This influx has lowered water salinity and density, causing the colder ocean layer to expand while the warmer layer contracts.
  - Consequently, the AMOC is slowing down, posing a risk of collapse.
  - Also, anthropogenic activities, such as **greenhouse gas emissions**, can influence ocean temperatures and circulation patterns, further affecting the AMOC.
- **Potential Cascading Effects:**
  - AMOC collapse may **alter precipitation patterns**, potentially destabilizing the **southern Amazon rainforest** and transforming it into a savannah-like ecosystem.
  - Increased ocean heat in the southern hemisphere could accelerate the melting of the **West Antarctic ice sheet**, exacerbating sea-level rise.
  - Weakening of monsoon circulation in regions like South Asia and Africa could have far-reaching consequences for **agriculture, water resources, and regional climates.**

Atmospheric River

Why in News?

California, US is currently grappling with an extraordinary weather phenomenon known as an **Atmospheric River** also called Pineapple Express Storm, which has the potential to unleash up to 8 **trillion gallons of rain over the state.**

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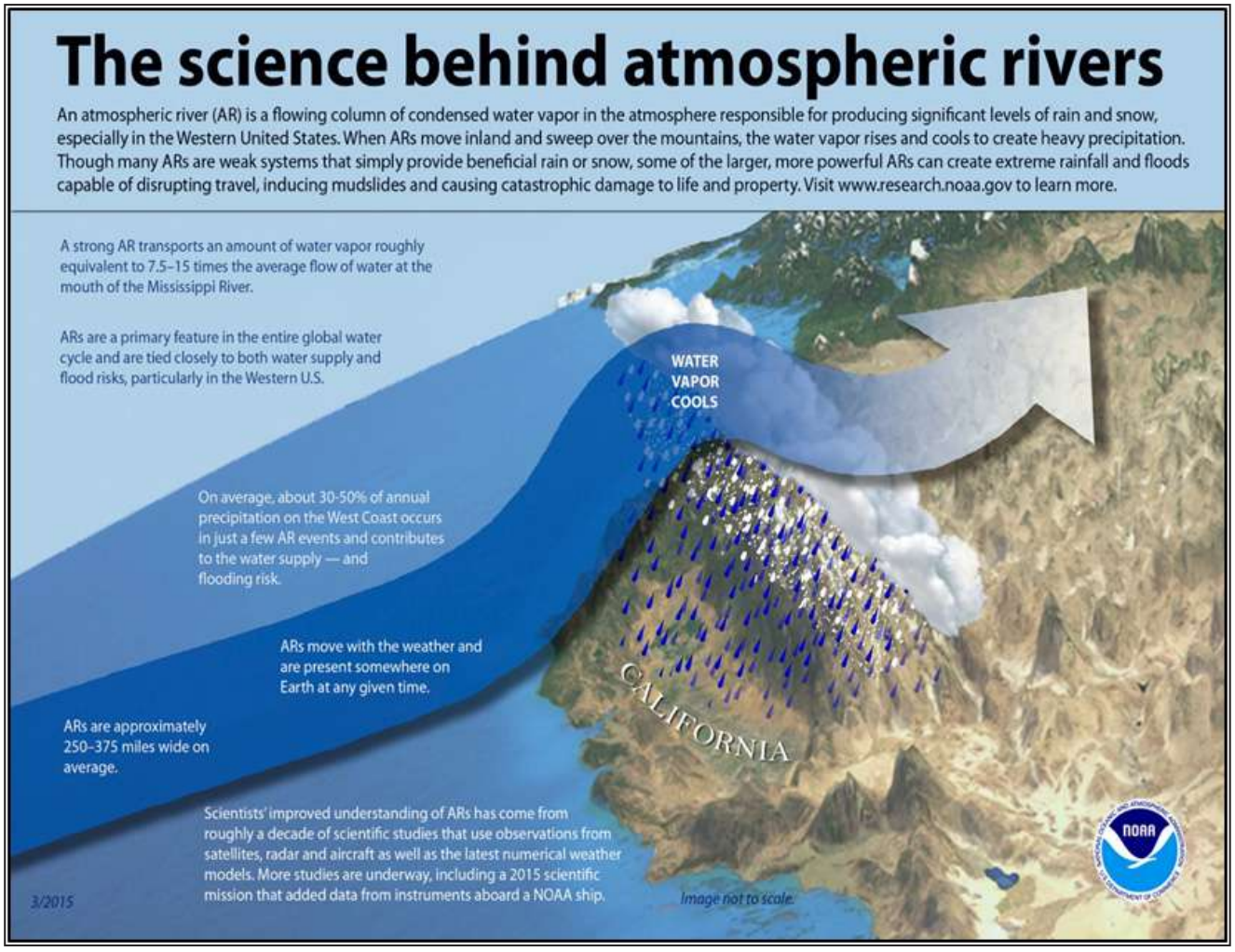
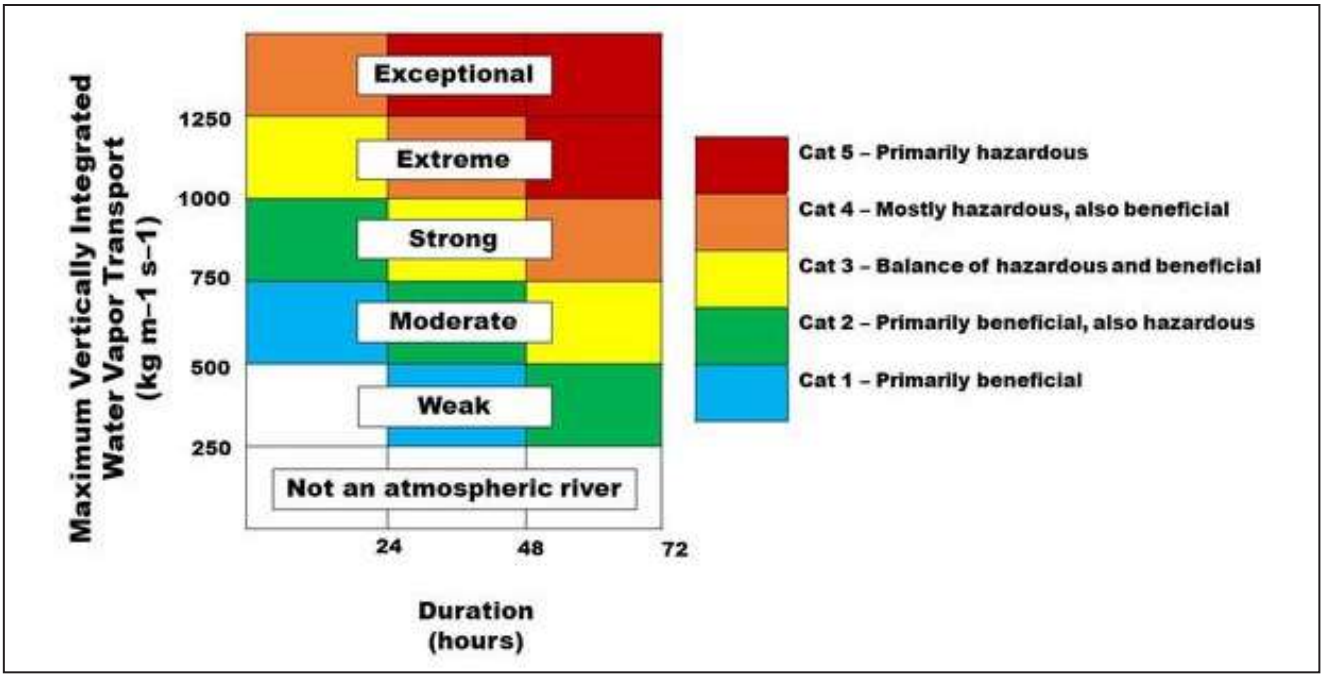


What is an Atmospheric River?

- **About:**
  - The atmospheric river is a **long, narrow band of moisture-filled air that** transports significant amounts of water vapor from the tropics to higher latitudes.
    - The Atmospheric River is often associated with **mT (Maritime Tropical)** air mass.
  - When these rivers make landfall, they release **this moisture as intense precipitation**, which can manifest as **either rain or snow** depending on the altitude and temperature.
    - According to the **National Oceanic and Atmospheric Administration (NOAA)**, the water vapor they carry is **roughly equivalent to the average flow of water** at the mouth of the Mississippi River.
  - So, when they make landfall and release all that water, they can cause extreme flooding.
- **Pineapple Express:**
  - The "Pineapple Express" is a well-known example of atmospheric river storms that bring **heavy rainfall to the US West Coast**, particularly California.
  - This name originates from the fact that these storms draw moisture from the tropical waters near the Hawaiian Islands, **resembling a "express" train of moisture originating** from the vicinity of Hawaii, which is often associated with pineapples.
    - This atmospheric river is driven by a **strong southern branch of the polar jet stream** and transports humid, warm mT air from as far away as the Hawaiian Islands.
- **Categories:**
  - **Category 1 (Weak):** A Category 1 atmospheric river would be a milder and briefer weather event with **primarily beneficial effects, like 24 hours of modest rainfall.**

Note:

- **Category 2 (Moderate):** A Category 2 atmospheric river is a moderate storm with mostly beneficial effects, but **also somewhat hazardous.**
- **Category 3 (Strong):** A Category 3 atmospheric river is **more powerful and longer lasting**, with a balance of beneficial and hazardous impacts. For example, a storm in this category could bring 5-10 inches of rain over 36 hours, enough to **help replenish reservoirs but also pushing some rivers close to flood stage.**
- **Category 4 (Extreme):** A Category 4 atmospheric river is mostly hazardous, though also with some beneficial aspects. A storm of this rating could dump enough heavy rain over several days to bring many rivers to flood stage.
- **Category 5 (Exceptional):** A Category 5 atmospheric river is primarily hazardous.
  - An atmospheric river that lasted over 100 hours over the Central California coast during the 1996-97 New Year's holiday period. The heavy rain and runoff caused over USD 100 billion in damage.



Note: An atmospheric river should not be confused with a traditional river found on the Earth's surface. Unlike a visible water body, an atmospheric river is an invisible, elongated corridor in the sky that carries large amounts of water vapor, influencing weather patterns and precipitation.

How Common are Atmospheric Rivers, and Where do They Occur?

- They're not limited to the US West Coast; they can occur worldwide. These rivers of moisture can stretch thousands of miles and affect regions **like the UK, Ireland, Norway, and China.**
  - Atmospheric rivers often make the rainy season in China, known as **Mei-Yu season, even worse.**
- While they only account for 17% of storms on the US West Coast, atmospheric rivers contribute significantly to California's precipitation, snowpack, and major floods. They're predictable and can be forecasted up to a week in advance.

What is Air Mass?

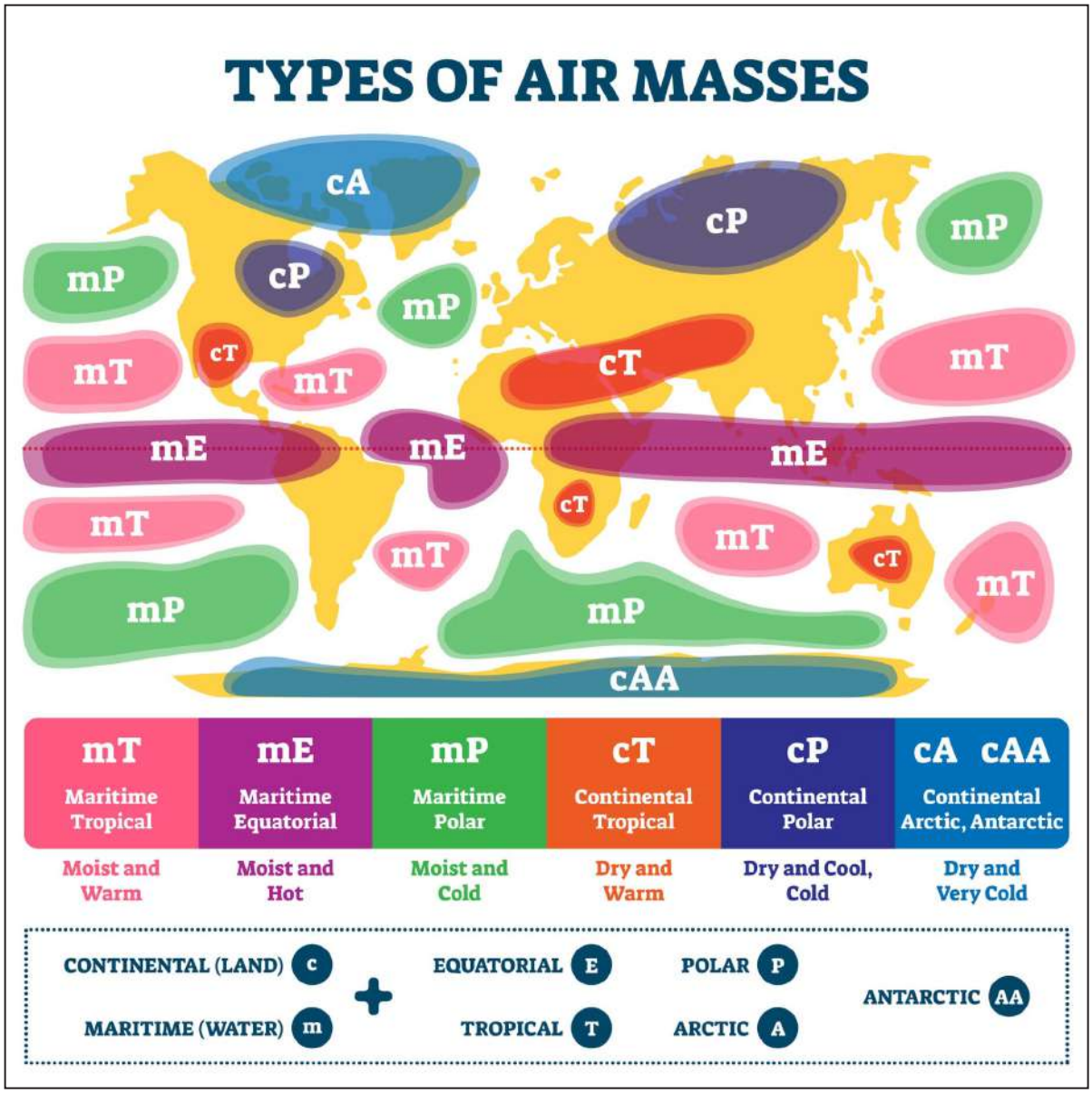
- **About:**
  - An air mass is **a large body of air with relatively uniform temperature**, humidity, and pressure characteristics. These masses of air form over source regions, where they take on the characteristics of the surface below due to low wind speeds.

Note:

- When air masses move, they can **influence weather patterns in the region**s they move into, potentially leading to the formation of storms when they interact with other air masses.

➢ **Types of Air Masses:**

- **Continental Tropical (cT):** These air masses originate over hot and dry continental regions. They are characterized by h**igh temperatures and low humidity.**
- **Continental Polar (cP):** Originating **over cold and dry continenta**l regions, cP air masses are ch**aracterized by cold temperatures** and low humidity.
- **Maritime Tropical (mT)**: These air masses form over **warm and moist oceanic regions.** They are characterized by warm temperatures and high humidity.
- **Maritime Polar (mP):** Originating over cold oceanic regions, mP air masses are characterized by cool temperatures and high humidity.
- **Continental Arctic (cA):** cA air masses originate over extremely cold Arctic regions. They are characterized by frigid temperatures and very low humidity.



Note:

- **Characteristics of Air Masses:**
  - Air masses originate over vast flat surfaces having uniform temperature and humidity.
  - Air masses travel slowly over hundreds of kilometers from their source regions.
  - As the air masses move away from source regions their chief characteristics of temperature and humidity undergo large-scale changes.
  - They affect the weather conditions of the areas visited by them.
  - When two air masses of different temperature and humidity approach each other, they do not intermingle but **a front is formed** between them.
    - Weather conditions change abruptly at the front.
    - The front keeps two approaching air masses separate from each other.

Hindu Kush Himalayas

Why in News?

The **International Centre for Integrated Mountain Development (ICIMOD)** has issued a warning, calling for **"bold action" and "urgent finance"** to prevent the collapse of nature in High Mountain Asia.

- It stated that the **Hindu Kush Himalaya (HKH),** one of the most biodiverse regions on Earth, is a **'biosphere on the brink'.**

What is the Hindu Kush Himalaya?

- **About**: Stretching over **3500 kilometres** and across eight countries: **Afghanistan, Bangladesh, Bhutan, China, India, Nepal, Myanmar and Pakistan**, HKH is one of the largest volumes of ice and snow outside of the Arctic and Antarctica.
  - **4 of the world's 36 global biodiversity hotspots** are in this region.
    - Himalaya, Indo-Burma, Mountains of Southwest China, and Mountains of Central Asia
- **Water Tower of Asia:** It is called the **'Water Tower of Asia'**. At least 12 rivers fan out in every direction across the Asian continent from HKH:
  - The **Indus, Ganga and Brahmaputra** towards the **Arabian Sea** and **Bay of Bengal**
  - **Syr Darya and Amu Darya** towards the now-dead **Aral Sea**
  - The **Tarim** toward the Taklamakan
  - The Yellow river towards the Gulf of Bohai
  - The Yangtze towards the East China Sea
  - The Mekong towards the South China Sea
  - The Chindwin, Salween and Irrawaddy towards the Andaman Sea

Note: **High Mountain Asia** comprises mountain ranges such as the Tian Shan, Kunlun Shan, Pamir, Karakoram, Hindu Kush, Tibetan Plateau and the Himalayas.

What is the International Centre for Integrated Mountain Development?

- **About**: ICIMOD is a regional intergovernmental organisation established in **1983** and working towards a **greener, more inclusive, and climate resilient Hindu Kush Himalaya.**

La Nina Links with Air Quality

Why in News?

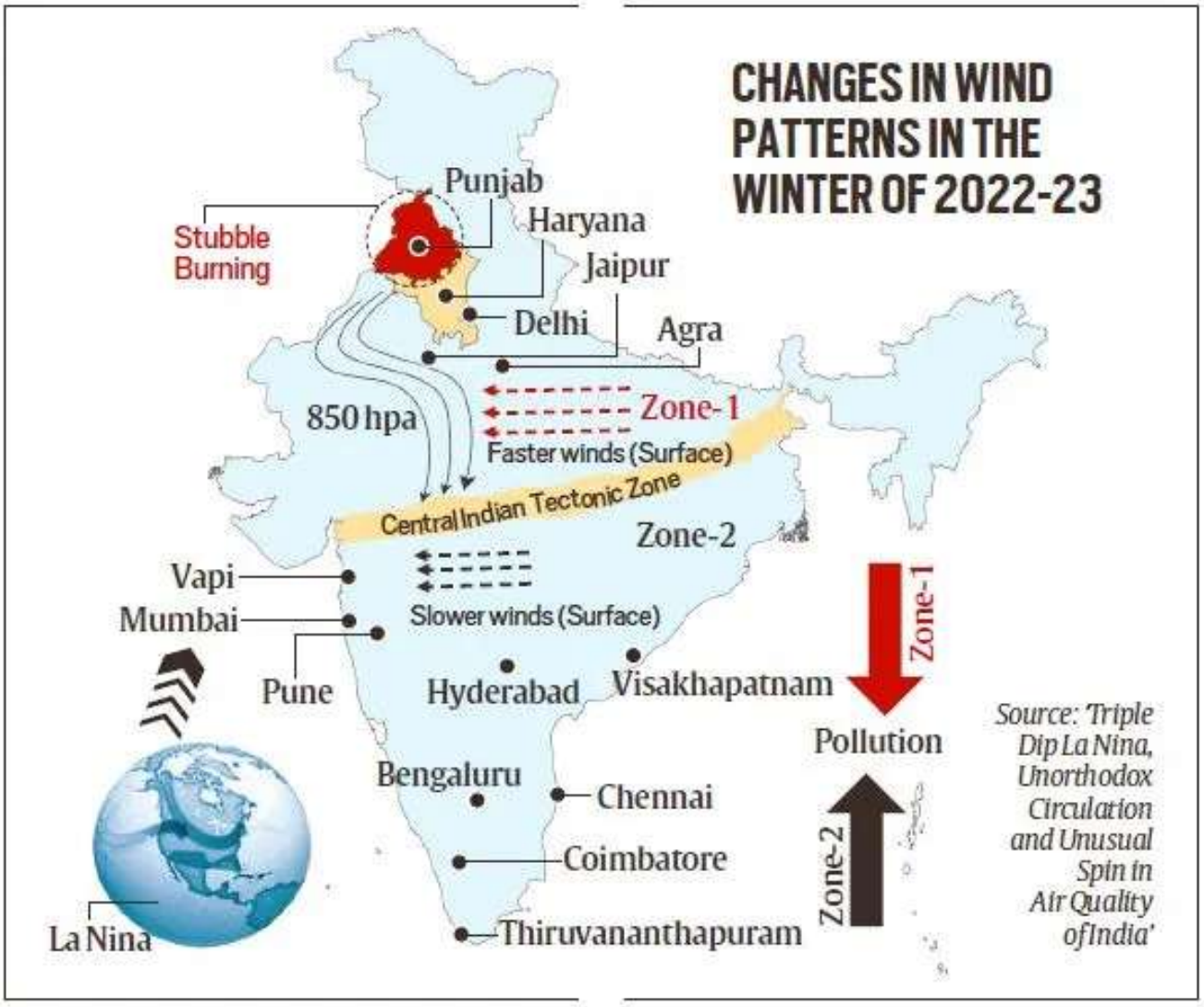
Recently, a new study has been published by researchers at the Pune-based **Indian Institute of Tropical Meteorology** and the Bengaluru-based National Institute of Advanced Studies**,** suggesting that even air quality in India could be influenced by **El Nino and La Nina events.**

- The study has suggested that the unusual air quality in some Indian cities in the winter of 2022 could be attributed to the record-breaking spell of **La Nina prevailing at that time.**

Note:

What are the Key Findings of the Study?

- **Link between Pollution and Winter Months in India:**
  - During October to January, northern Indian cities, like Delhi, typically have high **levels of PM2.5 due to various meteorological factors** and pollution transport from regions like Punjab and Haryana.
  - The western and southern parts of the country have always had **relatively lower levels of pollution**, because of their proximity to oceans.
  - The **winter of 2022,** however, showed a significant deviation from this normal.
    - **Northern Indian cities,** including Delhi, were **cleaner** than usual, while cities in the west and the south, like Mumbai, Bengaluru and **Chennai, experienced worse-than-usual air quality**.



- **Anomalous Behaviour in Winter 2022:**
  - PM2.5 concentrations in Ghaziabad and Noida reduced significantly, while Delhi saw a slight reduction. In contrast, Mumbai and Bengaluru experienced rises in PM2.5 levels.
    - Northern Indian cities had cleaner air than western and southern cities.
- **Factors Causing Anomaly:**
  - The most crucial **factor in explaining the anomaly of winter 2022** was a change in the normal wind direction.
  - During winter, the wind usually **blows in the northwesterly direction**. For example, from Punjab towards Delhi and further into the **Gangetic plains.**

Note:

- It is a reason for transporting agricultural waste pollutants from Punjab and Haryana into Delhi.

❍ In the winter of 2022, however, the **wind circulation was in the north-south direction**.

- The pollutants being carried from Punjab and Haryana **bypassed Delhi** and surrounding areas and **flew over Rajasthan and Gujarat** to southern regions.

➢ **La Nina's Influence:**

❍ Extended **La Nina persisted for** an unusually long **three years** by the winter of 2022, impacting wind patterns.

- The three consecutive years of La Niña conditions (2020-23) — **a rare "Triple-Dip" phenomenon** — had widespread impacts on the ocean and climate across the globe.

❍ Not all La Nina events might produce noticeable changes in wind circulation over India.

❍ The 2022 event is particularly strong. And the impact on air circulation became evident only in the third year of La Nina. So, there may be an accumulative effect.

- The study suggests an **unclear impact of El Nino on air quality in India.**

Fig. 1 - Depiction of El Niño Phenomenon

Fig. 2 - Depiction of La Niña Phenomenon

Note:

El Nino Southern Oscillation (ENSO)

Describes the fluctuations in temperature between the ocean and atmosphere **in the east-central Equatorial Pacific**

Significance:

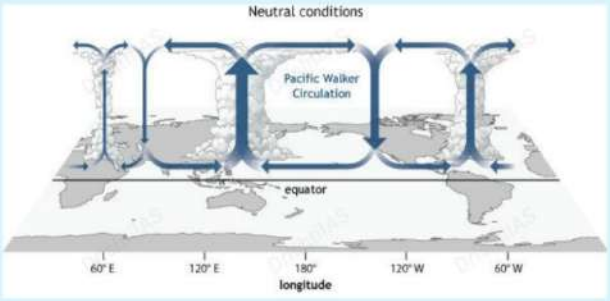
- **Ability to change the global atmospheric circulation, influencing temperature and precipitation** worldwide

States of ENSO:

- The two opposite phases - **El Niño** and **La Niña**
- The middle of the continuum - **Neutral**

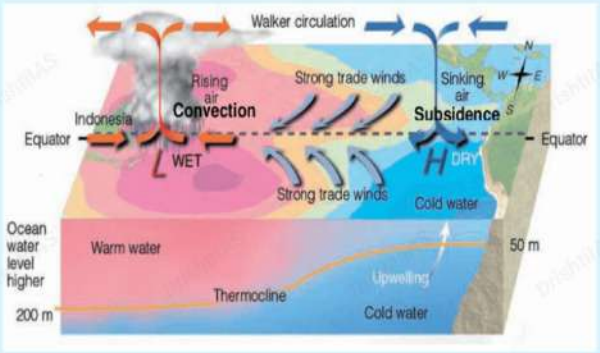
Walker Circulation (WC)

- An **atmospheric system of air flow** in the equatorial Pacific Ocean
  - The trade winds across the tropical Pacific flow from east to west: air rises above the warm waters of the western Pacific, flows eastward at high altitudes, and descends over the eastern Pacific
- WC and ENSO:
  - **A weak/reverse WC produces El Niño**
  - **Stronger WC results in La Niña**



Normal (non ENSO) Conditions in the Pacific Ocean

NEUTRAL ENSO



- **Trade winds (easterlies) blow west** along the equator, taking warm water from S. America towards Asia
- To replace that warm water, **cold water rises from the depths** — a process called **upwelling**
  - **El Niño and La Niña** are two climate patterns that **break these normal conditions**
- During an El Niño, sea level pressure tends to be lower in the eastern Pacific and higher in the western Pacific while the opposite tends to occur during a La Niña
  - This see-saw in atmospheric pressure between the eastern and western tropical Pacific is called the **Southern Oscillation (SO)**

Drishti IAS

Note:

Indian Institute of Tropical Meteorology (IITM)

- IITM is a **scientific institution** based in Pune, Maharashtra. It specializes in expanding research related to tropical meteorology, with a **special focus on the tropical Indian Ocean.**
- Key areas of study include monsoon meteorology and air-sea interactions in the South Asian climate.
- IITM operates **as an autonomous institute under the Ministry of Earth Sciences,** Government of India.

National Institute of Advanced Studies (NIAS)

- NIAS is an **autonomous research institution** located in Bengaluru, India. It was established in 1988 with the vision and initiative of the late Mr. J.R.D. Tata.
- The institute **aims to nurture a broad base of scholars**, managers, and leaders who can address complex societal challenges through interdisciplinary approaches.
- NIAS conducts advanced multidisciplinary research in various fields, including humanities, social sciences, natural sciences, engineering, and conflict and security studies.

Surge in Demand of Copper

Why in News?

As demand for **copper** grew by 16% yearly-on-year in **FY23**, policymakers and corporations have increasingly turned their attention to the **critical role of copper in spurring economic growth.**

What are the Key Points Related to Copper?

- **About:** Copper is a **malleable, ductile metal** known for its excellent heat and electricity conductivity. It possesses corrosion resistance and antimicrobial properties.
  - **Malleability** refers to the ability of a material to be pressed, or **rolled into thin sheets without breaking or cracking.**
  - **Ductility** is the property of a material that allows it to be stretched or **drawn out into a thin wire without losing** its strength or breaking.
- **Applications:** It is widely utilised in **construction, consumer durables, transportation, and industrial manufacturing.**
  - It is also Integral to clean energy technologies such as **solar panels, electric vehicles (EVs)**, and energy-efficient motors.
  - It is a **100%** recyclable metal (allows for a **circular economy**).
- **Occurrence and Composition:** It is naturally found in various forms in the Earth's crust.
  - It can be found in sulphide deposits (as **chalcopyrite, bornite, chalcocite, covellite**), in carbonate deposits (as **azurite and malachite**), in silicate deposits (as **chrysycolla and dioptase**) and as pure native copper.
  - Most commercial copper ore deposits contain an average grade of 0.8% copper, while copper ore in India has an average copper content of **around 1%**.
- **Mining Methods:** There are two primary methods of copper mining: **open-pit and underground mining.**
  - Open-pit mining dominates, constituting **80% of global copper mining operations**.
- **Copper Deposits in India:** Mainly located in **Singhbhum (Jharkhand), Balaghat (Madhya Pradesh), and Jhunjhunu and Alwar (Rajasthan) districts.**
  - Minor deposits are found in Agnigundala (Andhra Pradesh), Chitradurg and Hasan (Karnataka), and South Arcot (Tamil Nadu) districts.
- **India's Copper Appetite:** India's demand for copper is soaring due to rising infrastructure projects, renewable energy initiatives, and urbanisation.
  - Despite this, the country heavily relies on copper imports due to limited domestic reserves.
  - To address this, the government is promoting investments in smelters and refineries while **Indian companies are acquiring copper mines abroad** to secure a stable supply and reduce dependence on international markets.
    - Recently, the **Ministry of Mines** has proposed sending an Indian industry delegation to **copper-rich Zambia** to discuss potential copper exploration and mining projects in the southern African country
  - Recognizing copper's criticality, the government has included it in its list of **critical minerals,** highlighting the need to reduce import dependence.

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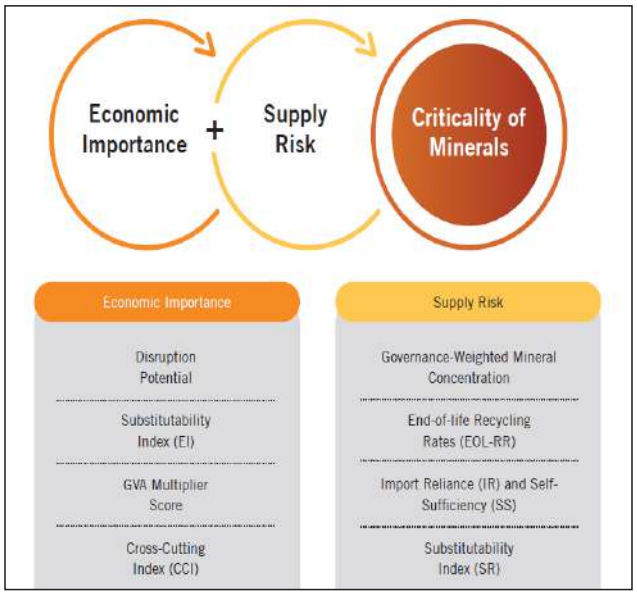
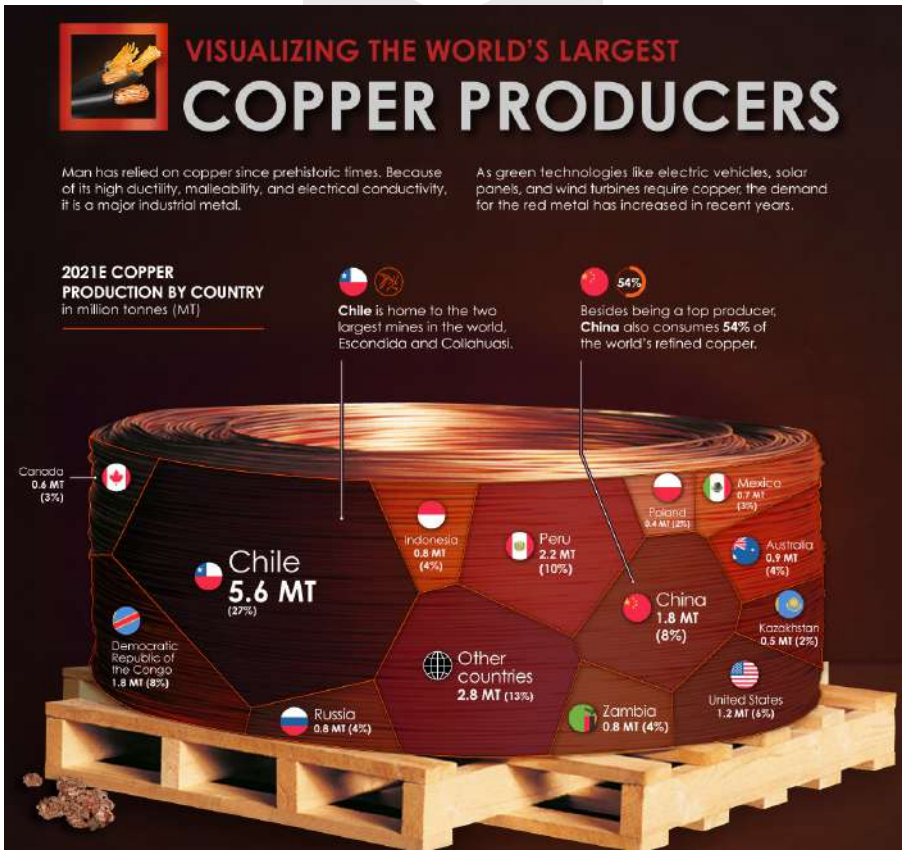


- **Hindustan Copper Limited (HCL):** Established in 1967 under the Companies Act, It is a **Miniratna Category-I enterprise** operating under the **Ministry of Mines, Government of India.**
  - It was formed to consolidate all copper exploration and exploitation projects from the **National Mineral Development Corporation Ltd**.
  - HCL is India's **only vertically integrated copper producing company.**
- **Copper's Key Importance:**
  - **Copper as an Economic Barometer:** Copper prices reflect **demand/supply dynamics,** monetary markets, and speculation, making it a global economic indicator.
    - Unlike sector-specific commodities, copper is integral across all economic sectors.
  - **Copper for Energy Efficiency:** Copper plays a vital role in promoting energy efficiency in buildings.
  - Its excellent thermal and electrical conductivity make it ideal for **wiring, heat exchangers, and roofing**, leading to reduced energy consumption for heating, cooling, and lighting.
  - By minimising energy losses throughout a building's lifespan, copper contributes to a more sustainable future.

Note:

- **Chile is the top copper producer** in the world, with 27% of global copper production. In addition, the country is home to the two largest mines in the world, **Escondido and Collahuasi.**



Note:

India Joins Sri Lanka in Seabed Mining Race

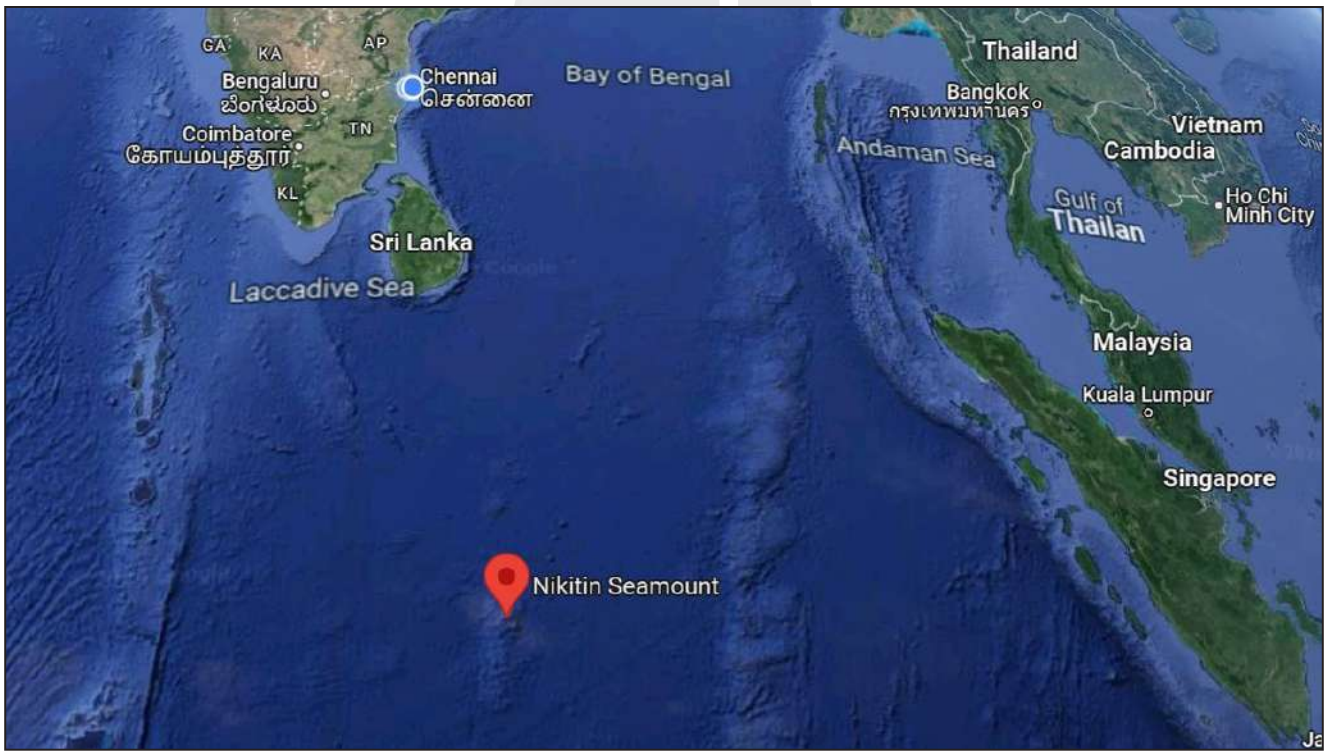
Why in News?

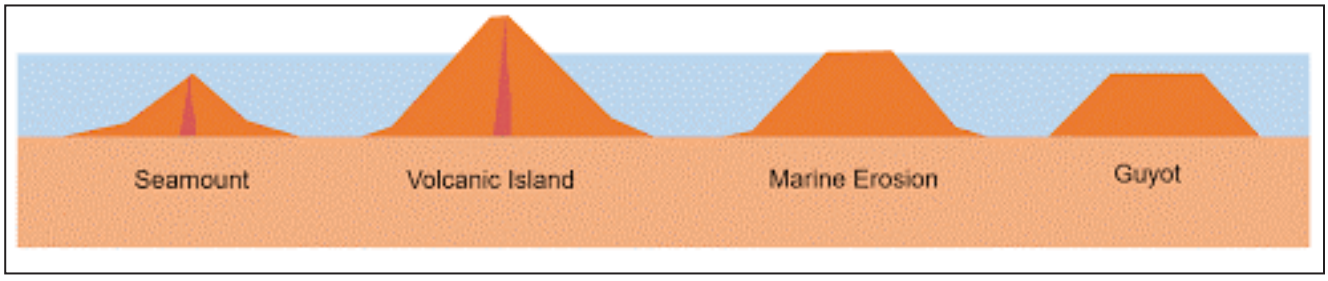
Recently, India applied for Rights to Explore the Indian Ocean Seabed Beyond its Jurisdiction, Including **Cobalt-Rich Afanasy Nikitin Seamount (AN Seamount).** India's interest is fueled by concerns over Chinese vessels conducting reconnaissance there.

- Rights to the region have already been claimed by **Sri Lanka** under a separate set of laws.

What is Afanasy Nikitin Seamount (AN Seamount)?

- The **AN Seamount** is a structural feature (400 km long and 150 km wide) in the Central Indian Basin, located about 3,000 km away from India's coast.
- From an oceanic depth of about 4,800 km, it rises to about 1,200 meters and it is rich in deposits of **cobalt, nickel, manganese and copper.**
- To proceed with extraction, interested parties/ countries must first apply for an exploration license to the **International Seabed Authority (ISBA).** This organisation operates autonomously under the **United Nations Convention on the Law of the Sea (UNCLOS).**
- These rights are specific to areas that are part of the open ocean. **Around 60% of the world's seas are open ocean** and though believed to be rich in a variety of mineral wealth, the costs and challenges of extraction are prohibitive.

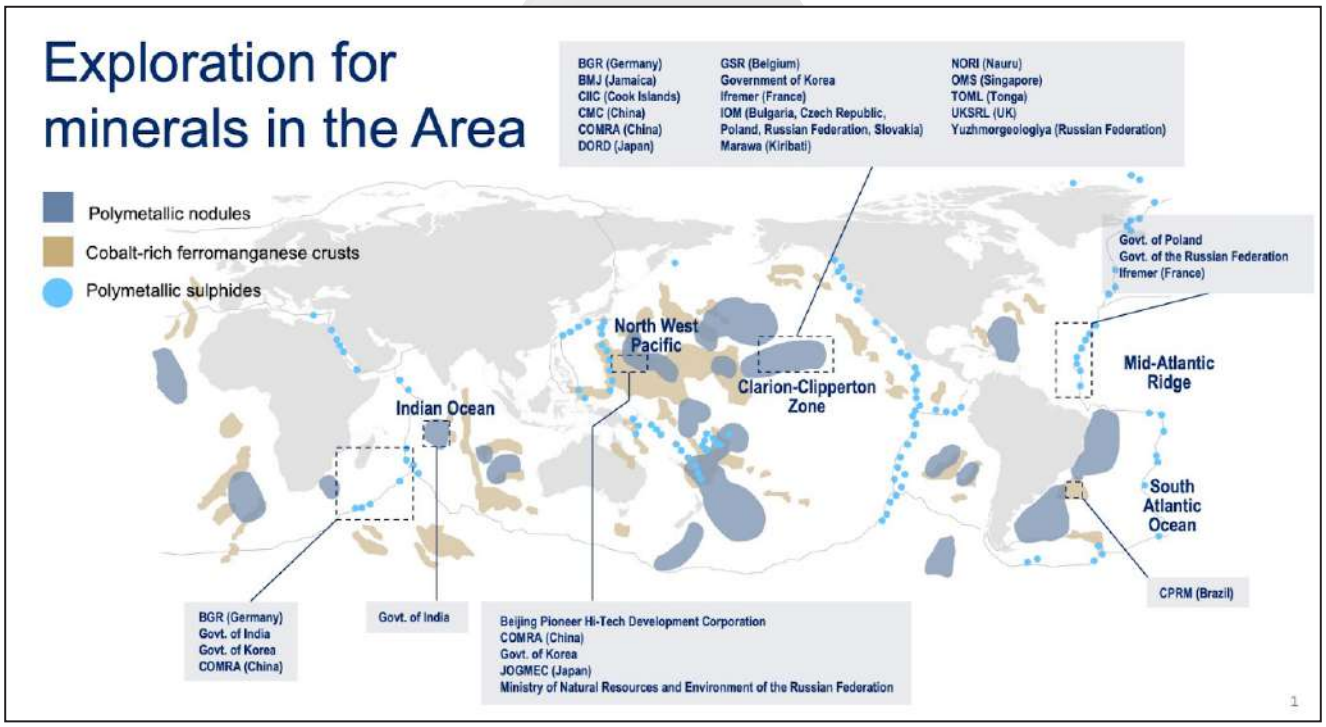




Note:

Which Countries have been Provided with Exploration Licences?

- Both state-owned and government-sponsored companies from **India, France, Russia, Germany, China, Singapore** and the **UK** had sought permission for minerals prospecting in the high seas.
- **Licence Granted:**
  - Four licences have been granted for the **Pacific Ocean**, the **Clarion Clipperton Zone** between **Hawaii** and **Mexico** and the **Magellan Seamount** in the **northwest Pacific**.
  - Two licences are for the **Indian Ocean Ridge**, while one for **Rio Grande Rise** in the **southern Atlantic.**
- **India's Exploration Applications:** Along with the application for AN Seamount, India has also applied for permission to explore another region, spanning **3,00,000 square km,** called the **Carlsberg Ridge** in the **Central Indian Ocean** to investigate for **polymetallic sulphides**, which are **large smoking mounds** near **hydrothermal vents** that are reportedly rich in **copper, zinc, gold** and **silver.**
- **Previous Exploration Efforts:** India has previously secured exploration rights to two other large basins in the **Central Indian Ocean** and has undertaken surveys in these regions, demonstrating its commitment to marine exploration and resource assessment.
  - India has been studying the seabed and carrying out test mining for about two decades through institutes like **National Institute of Oceanography (NIO) and National Institute of Ocean Technology (NIOT) .**



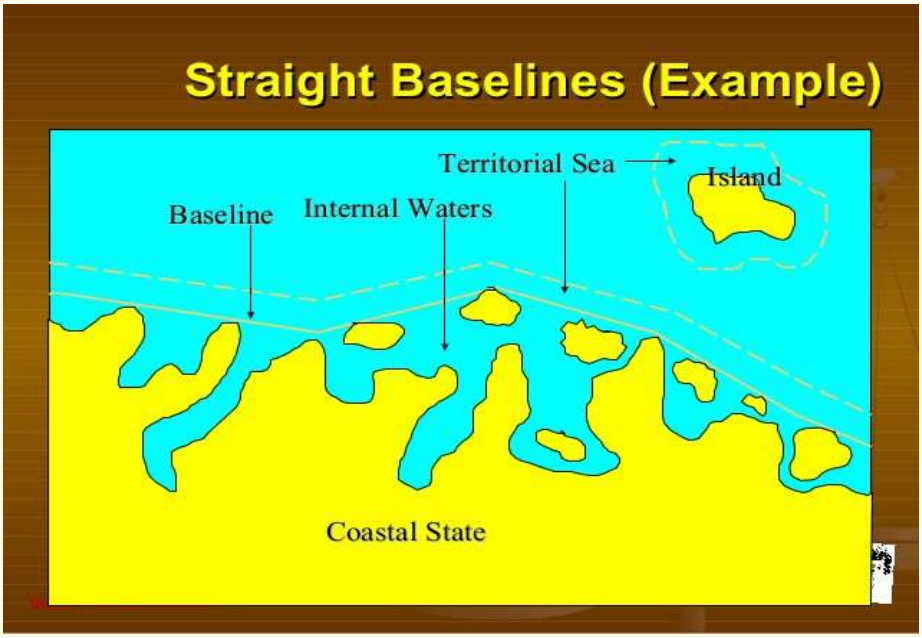
What is Deep Sea Bed Mining?

- **Deep-sea mining** involves extracting valuable mineral deposits from the ocean floor at depths ranging from **200** to **6,500 meters** below the surface.
  - These mineral deposits include materials such as **copper, cobalt, nickel, zinc, silver, gold,** and **rare earth elements.**
  - **NIO** has tested deep-sea mining systems up to **512 meters depth** and is working on systems for up to **6,000 meters.**
- Establishing **deep-sea mines** was earlier considered more expensive than **land-based mining.**
- Innovations in **underwater robotics** from the **petroleum industry** have improved prospects for **deep-sea mining.**

Note:

What are the Different Maritime Zones?

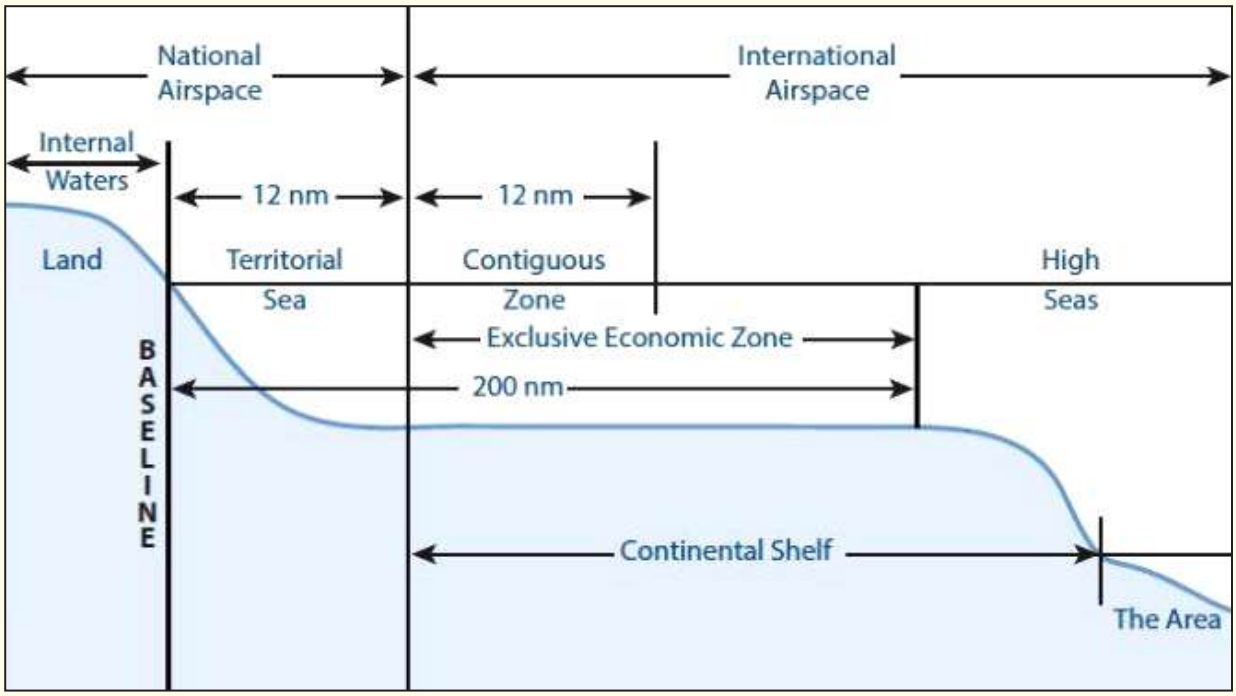
- **Baseline:**
  - A **baseline refers** to a line, **often along the coastline**, serving as a reference point for measuring the outer boundaries of a state's territorial sea and other maritime zones, such as its exclusive economic zone.
  - Typically, this baseline mirrors the low-water mark of the coastal state. In cases where the **coastline is deeply indented, contains islands close to the shore,** or exhibits significant instability, straight baselines may be established instead.
- **Internal Waters:**
  - Internal waters are **waters on the landward side of the baseline** from which the breadth of the territorial sea is measured.
  - **Each coastal state has full sovereignty over its internal waters** as like its land territory. **Examples** of internal waters include bays, ports, inlets, rivers and even lakes that are connected to the sea.
  - There is **no right to innocent passage** through internal waters.
    - **The innocent passage refers** to the passing through the waters which are not prejudicial to peace and security. However, the nations have the right to suspend the same.
- **Territorial Sea:**
  - The territorial sea **extends seaward up to 12 nautical miles (nm) from its baselines.**
    - The coastal states have **sovereignty and jurisdiction over the territorial sea.** These rights extend not only to the surface but also to the seabed, subsoil, and even airspace.
  - However, the coastal states' rights are **limited by the innocent passage** through the territorial sea.



- **Contiguous Zone:**
  - The **contiguous zone** adjacent to and beyond its **territorial sea** that extends seaward up to **24 nm** from its baselines.
  - It is **an intermediary zone between the territorial sea and the high seas.**
  - The coastal state has the right to both prevent and punish infringement of fiscal, immigration, sanitary, and customs laws within its territory and territorial sea.
    - From the break, the shelf descends toward the **deep ocean floor** in what is called the **continental slope.**

Note:

- **High Seas:**
  - The ocean surface and the water column beyond the EEZ are referred to as the high seas.
  - It is **considered as "the common heritage of all mankind"** and is beyond any national jurisdiction.
  - States can conduct activities in these areas as long as they are for peaceful purposes, such as transit, marine science, and undersea exploration.



What are the Continental Shelf Claims and Exploration Rights?

- **Exclusive Rights to Continental Shelf:** Countries possess exclusive rights up to 200 nautical miles from their borders, including the underlying seabed. This jurisdiction extends to the exploration and potential exploitation of resources within this zone.
- **Continental Shelf Extension:** Some ocean-bound states may have a natural land formation connecting their border to the edge of the deep ocean, extending beyond the 200-nautical-mile limit. This extension is known as the continental shelf.
- **Special Provisions:** There is a provision allowing countries along the **Bay of Bengal** to apply a different set of criteria for making claims on the extent of their continental shelf.
  - **Example:** Utilising a special provision, Sri Lanka has asserted a claim for an extension of its continental shelf up to **500 nautical miles,** exceeding the usual limit of **350 nautical miles.**
- **Rational Support to Claim:** To claim exclusive rights to the continental shelf beyond 200 nautical miles, a country must **provide a detailed scientific rationale supported by underwater maps and surveys.** This information is submitted to a scientific commission appointed by the **International Seabed Authority (ISBA).**
  - If the claim is approved by the commission, the country gains primacy to explore and potentially exploit both living and non-living resources within the extended continental shelf.

United Nations Convention on the Law of the Sea 1982

- **About:**
  - The UNCLOS is an **international treaty** that provides a **regulatory framework for the use of the world's seas and oceans**.
  - It lays down a **comprehensive regime of law and order** in the world's oceans and seas establishing rules governing all uses of the oceans and their resources.

Note:

- It enshrines the notion that **all problems of ocean space are closely** interrelated and need to be addressed as a whole.

➢ **Ratification:**

- The Convention was **opened for signature in December 1982** in Montego Bay, Jamaica.
- The convention has been **ratified by 168 parties**, which includes 167 states (164 United Nations (UN) member states plus the UN Observer state Palestine, as well as the Cook Islands and Niue) and the European Union. An additional 14 UN member states have signed, but not ratified the convention.
- While **India ratified UN Law of the Seas in 1995,** the **US has failed to do it so far**.

➢ **Indian Law:**

- As per India's **Territorial Waters, Continental Shelf, Exclusive Economic Zone and Other Maritime Zones Act, 1976**:
  - All foreign ships (other than warships including submarines and other underwater vehicles) shall enjoy the **right of innocent passage** through the territorial waters.
    - **Innocent passage:** It is the passage that is not prejudicial to the peace, good order or security of India.

What are other Blue Economy Initiatives?

➢ **India-Norway Task Force on Blue Economy for Sustainable Development:**

➢ **Sagarmala project**

➢ **O-SMART**

➢ **Integrated Coastal Zone Management**

➢ **National Fisheries policy**

Integrated River Basin Management

Why in News?

A recent report authored by the Kathmandu-based International Centre for Integrated Mountain Development (ICIMOD) and the Australian Water Partnership has emphasized the **need for multilateral treaties for effective integrated river basin management of the Indus, Ganga, and Brahmaputra rivers.**

What are the Key Highlights of the Report?

➢ **Integrated River Basin Management:**

- The report emphasizes the importance of **integrated river basin management,** which involves a basin-wide approach to river planning, backed by quality data sharing on water availability, biodiversity, and pollution among all stakeholders.

➢ **Need for Multilateral Treaties:**

- Despite **existing bilateral treaties and agreements on water data sharing,** there is a **notable absence of multilateral agreements** for river management in the region, posing a challenge to effective governance.
  - It emphasizes the necessity for establishing multilateral treaties to manage the Indus, Ganga, and Brahmaputra rivers effectively.

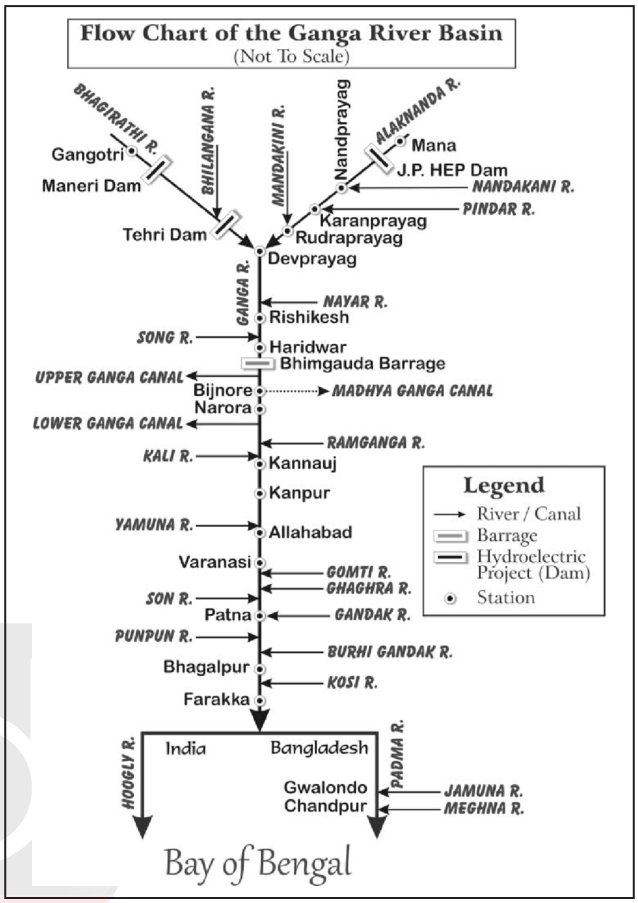
➢ **Dependence on Critical Rivers:**

- Millions of people in India, Tibet (China), Pakistan, Afghanistan, Nepal, and Bhutan rely on the Indus, Ganga, and Brahmaputra rivers for **food and water security,** making comprehensive management strategies imperative.
  - All three basins are part of the larger **Indus-Ganga-Brahmaputra (IGB)** Plain, a vast alluvial plain that spans across parts of India, Pakistan, Bangladesh, and Nepal.
- **Ganga River Basin:**
  - 600 million Indians, 29 million Nepalese, and millions in Bangladesh live in this basin area.
  - No agreement involving Nepal, India, and Bangladesh.
- **Indus River Basin:**
  - Lifeline for 268 million people living in its basin.
- **Brahmaputra River Basin:**
  - Approximately 114 million people depend on it for water, electricity, food, agriculture, and fishing.

Note:

What are the Key Facts About the Ganga, Indus and Brahmaputra River Basin?

- **Ganga River Basin:**
  - **Source and Headwaters:**
    - The Ganga originates as **Bhagirathi from Gangotri Glacier, Uttarakhand** at an elevation of 3, 892 m.
    - Many small streams comprise the headwaters of Ganga. The important among these are **Alaknanda, Dhauliganga, Pindar, Mandakini and Bhilangana.**
- At Devprayag, where **Alaknanda joins Bhagirathi,** the river acquires the name **Ganga.** It traverses 2525 km before flowing into the Bay of Bengal.
  - **Course and Major Tributaries**
    - Flows through the states of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, and West Bengal in India, before entering Bangladesh.
    - Nearly 80% of the Ganges river basin is in India, the rest is in Nepal, Tibet (China) and Bangladesh.
    - Major tributaries include the **Yamuna, Gomti, Ghagra, Gandak, and Kosi rivers.**
    - Known for its fertile alluvial plains, which have supported agriculture and human settlements for centuries.
  - **Delta and Outflow**
    - After a journey of around 2,510 kilometres, the Ganga River merges with the **Brahmaputra River in Bangladesh, forming the Padma River.**
- The Padma River then joins the Meghna River and flows into the **Bay of Bengal** through the **Meghna Estuary.**



- **Indus River Basin:**
  - **Source:**
    - The Indus (Tibetan-Sengge Chu, 'Lion River'), a major river in South Asia, originates in **Tibet near Mansarovar Lake in the Trans-Himalaya**.
    - The river flows through **Tibet, India and Pakistan** and about 200 million people live in the area of its drainage basin.
    - The **Indus Waters Treaty is a treaty between India and Pakistan** that was signed in 1960, to define the rights and responsibilities of each country regarding the use of the **Indus River system's waters.** The treaty was brokered by the **World Bank.**
  - **Course and Major Tributaries:**
    - It enters **India through Ladakh** and flows through Jammu and Kashmir before reaching **Pakistan's Gilgit-Baltistan region.**

Note:

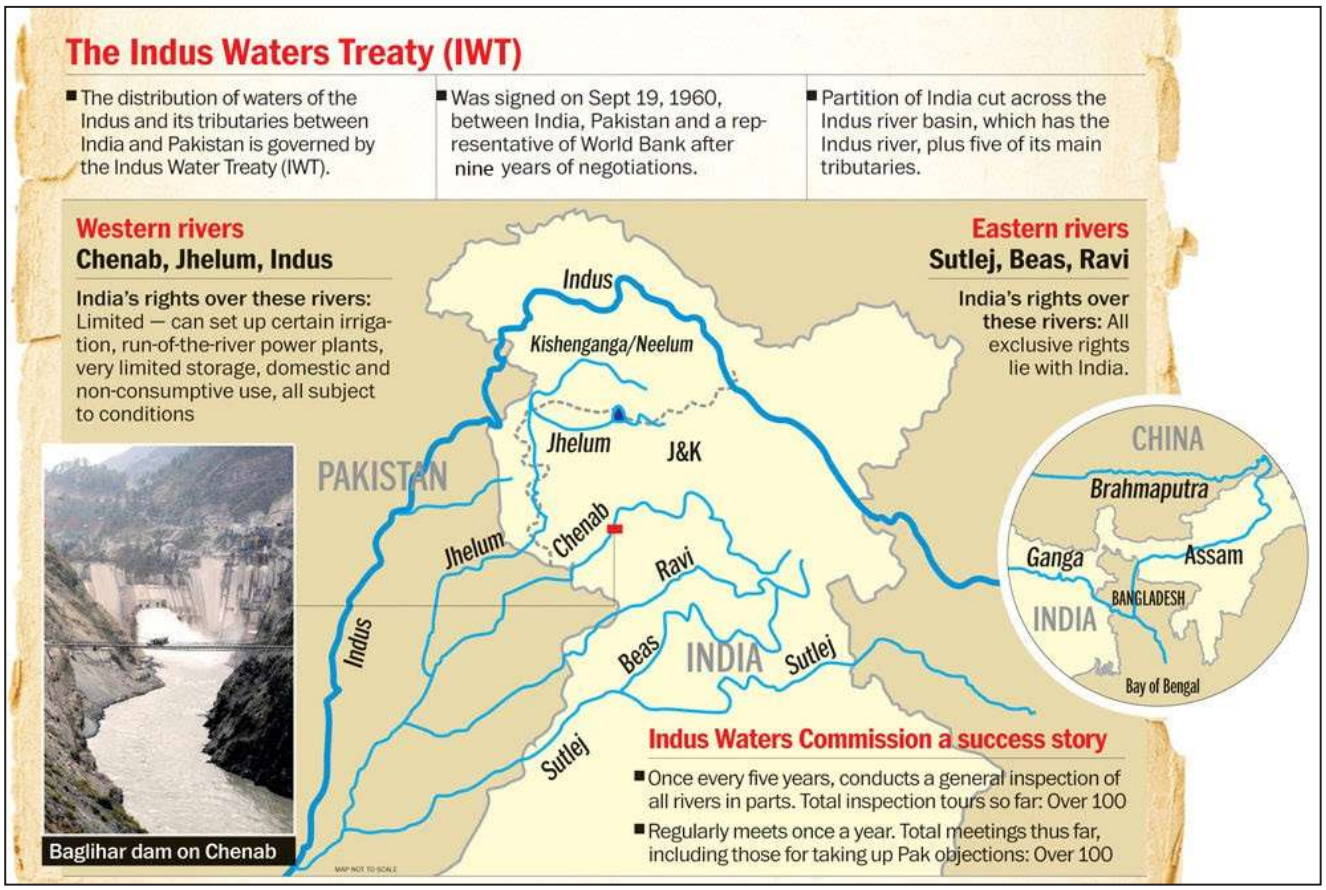
- The major left-bank tributaries of the Indus River are the Zaskar, Suru, Soan, Jhelum, Chenab, Ravi, Beas, Satluj, and Panjnad rivers. The major right-bank tributaries are Shyok, Gilgit, Hunza, Swat, Kunnar, Kurram, Gomal, and Kabul rivers.
- The Indus River and its tributaries are vital for agriculture and water supply in the region, particularly in Pakistan, where it serves as the lifeline for the country's economy.

❍ **Delta and Outflow:**

- The Indus River empties into the **Arabian Sea** near the city of Karachi in southern Pakistan.

➢ Forms a vast delta known as the **Indus Delta**.

- The delta is home to numerous creeks, marshes, and mangrove forests.



➢ **Brahmaputra River Basin:**

❍ **Source:**

- It originates under the name of **Siang or Dihang,** from the **Chemayungdung glacier of the Kailash range** near the Mansarovar Lake, the Brahmaputra ranks fifth in the world in terms of average discharge.
- The basin covers an area of around 580,000 square kilometers spanning parts of Tibet (China), India, Bhutan, and Bangladesh.
- The Brahmaputra River and its tributaries are important for agriculture, **hydropower generation,** and transportation in the region.

❍ **Course and Major Tributaries:**

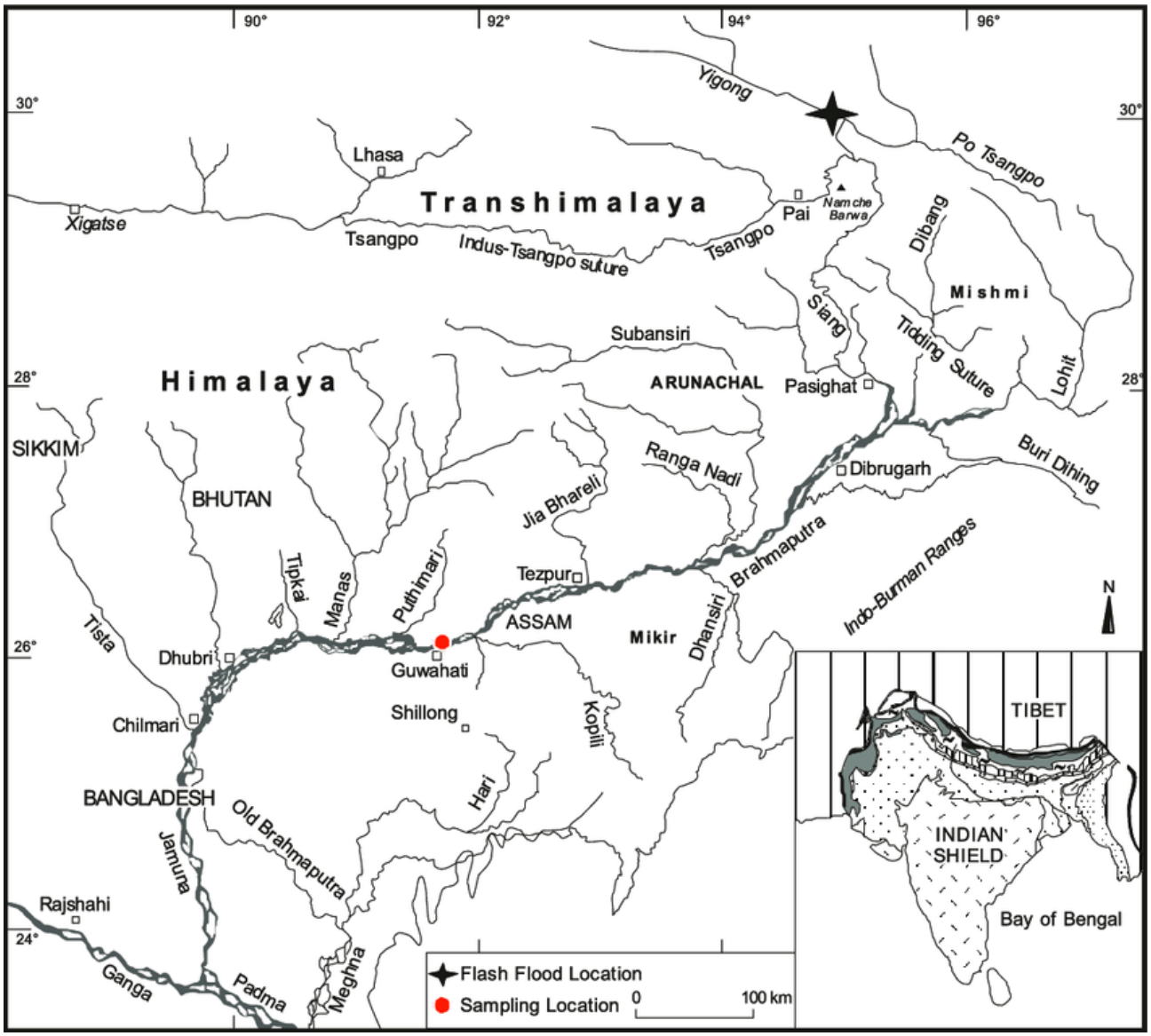
- Known as the **Yarlung Tsangpo in Tibet,** flows eastward through the Himalayas and enters the Indian state of Arunachal Pradesh.

Note:

- Continues its journey through the states of Assam and West Bengal in India, before entering Bangladesh.
- Major tributaries include the Subansiri, Kameng, Manas, and Dhansiri rivers in India, and the Teesta River in Bangladesh.

❍ **Delta and Outflow:**

- The Brahmaputra River joins the Ganga River in Bangladesh, forming the **Padma River.**
  - The **Padma River then merges with the Meghna River** and flows into the Bay of Bengal through the **Meghna Estuary.**



Menace of Illegal Migration

Why in News?

Recently, the **International Organization for Migration (IOM)** has stated that a total of 8,565 **migrants** died on land and sea routes worldwide in 2023.

- IOM reported that the number of migrant deaths in 2023 increased by almost **20%** compared to 2022.
- The "**Missing Migrants**" project by IOM, established in 2014, tracks these figures and was initiated after a surge in deaths in the Mediterranean and an influx of migrants on the Italian island of Lampedusa.

Note:

What is the International Organization for Migration?

- **About:**
  - The **International Organization for Migration** originated in 1951 as the Provisional Intergovernmental Committee for the Movement of Migrants from Europe (PICMME) after **World War II's** upheavals.
  - It underwent name changes from PICMME to the **Intergovernmental Committee for European Migration (ICEM)** in 1952, to the **Intergovernmental Committee for Migration (ICM)** in 1980, and finally to the **International Organisation for Migration** in 1989, reflecting its evolution into a migration agency.
  - In 2016, IOM entered into an agreement with the **United Nations**, becoming a related organization.
- **Members**: It currently has 175 Member States and 8 states with Observer status.
  - **India** became an IOM Member State on 18th June 2008.
- **Crisis Management:** Throughout its history, IOM has responded to various crises such as Hungary in 1956, Czechoslovakia in 1968, Chile in 1973, Vietnamese Boat People in 1975, Kuwait in 1990, Kosovo and Timor in 1999, and the **Asian tsunami and Pakistan earthquake** of 2004/2005.

What is the Status of Migration Across the Globe?

- **About**: Migration refers to the movement of people from one place to another, typically involving a change in residence.
  - This movement can be within a country **(internal migration)** or between countries **(international migration).**
  - It can be temporary or permanent, depending on the individual's intentions and circumstances.
  - According to the International Organization for Migration, migrants currently **constitute 3.6% of the global population.**

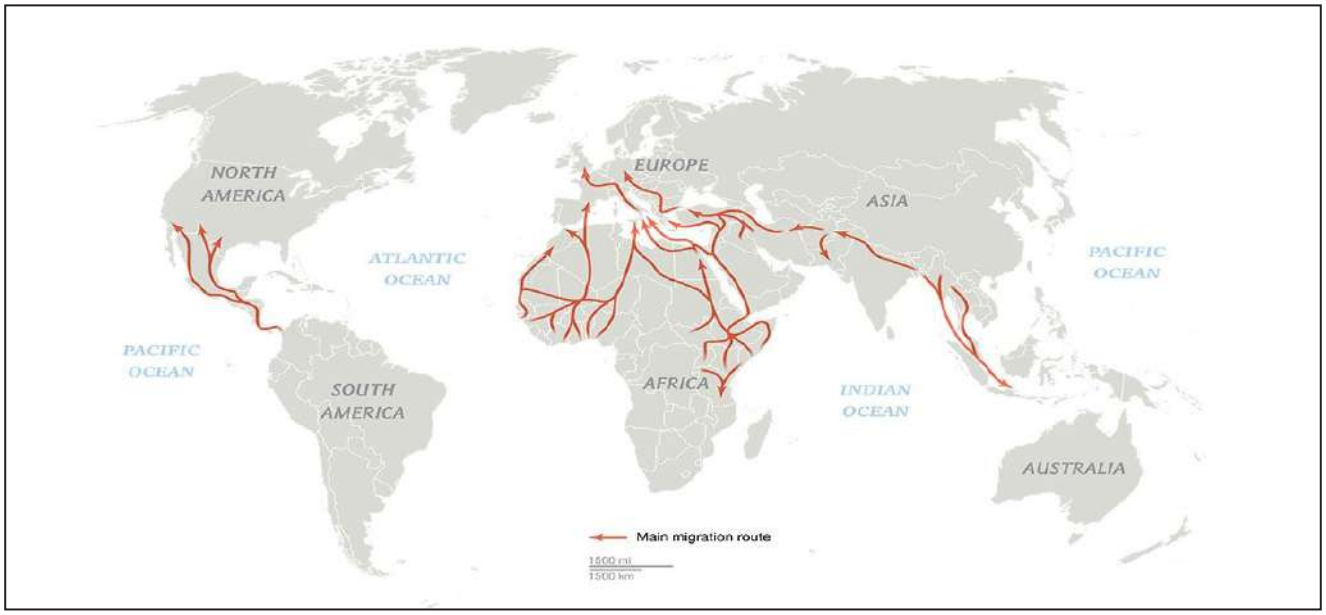
Note:

Donkey flight:

- Donkey flight is a term used to describe an illegal immigration technique employed by people seeking unauthorised entry into countries like the **United States, Canada, the United Kingdom, and Australia.**
  - According to the **US Customs and Border Protection (USCBP),** Indians are the 5th largest source of illegal migrants entering the US from the southwest border.
  - 96,917 Indians were caught illegally crossing borders into the US between **October 2022 and September 2023.**

Darién Gap:

- A **geographic region** in the **Isthmus of Darién or Isthmus of Panama** connecting the **American continents within Central America,** consisting of a large watershed, forest, and mountains in Panama's Darién Province and the northern portion of Colombia's Chocó Department.



Note:

Black Sea

Why in News?

Russia appointed **Admiral Alexander Moiseev** as the new acting head of its Navy following a series of successful **Ukrainian attacks on Russia's Black Sea Fleet**, which has sustained significant losses.

What are the Key Facts About the Black Sea?

- **About:**
  - The Black Sea, also known as **the Euxine Sea**, is one of the major water bodies and a famous inland sea of the world.
  - This marginal sea of the Atlantic Ocean is located between Eastern Europe and Western Asia.
- **Geographical Location:**
  - **Land Boundary**: The Black Sea is bordered by Ukraine to the north and northwest, Russia and Georgia to the east, Türkiye to the south, and Bulgaria and Romania to the west.

Note: The bordering countries of the Black Sea can be remembered as **BURGeR-T:** Bulgaria, Ukraine, Russia, Georgia, Romania and Türkiye).

  - **Maritime Boundary**: It is linked to the **Sea of Marmara** through the **Bosphorus Strait** and then to the **Aegean Sea** (an elongated embayment of the Mediterranean Sea) through the **Dardanelles Strait.**
    - **The Turkish straits system** (the Dardanelles, Bosphorus and the Marmara Sea) forms **a transitional zone between the Mediterranean and the Black Sea.**
- The Black Sea is also connected to the **Sea of Azov by the Strait of Kerch.**
  - **Surrounding Mountains:** The Black Sea is surrounded by the Pontic in the South, the Caucasus in the East, and the Crimean Mountains in the North.
- **Inflowing Rivers:**
  - The Black Sea is supplied by major rivers, principally the **Danube** (the second-longest river in Europe, after the Volga in Russia), **Dnieper and Dniester.**

Read more - Russia-Ukraine Conflict, Mediterranean Sea

Note: