



Drishti IAS Presents...

PT

SPRINT 2023

GEOGRAPHY

(March 2022 – March 2023)



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Earthquakes in Turkey and Causes

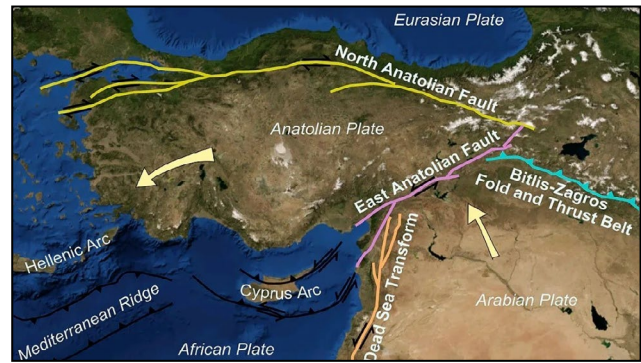
Why in News?

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?

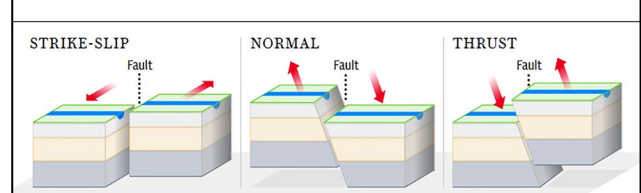
- In the Eastern Mediterranean region comprising **Turkey, Syria and Jordan**, tectonics are dominated by **complex interactions between the African, Arabian, and Eurasian tectonic plates**, and the **Anatolian tectonic block**.
- Turkey sits on the Anatolian tectonic plate, which borders two major faults, 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**.



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**.

THREE MAIN TYPES OF FAULTS CAUSING EARTHQUAKES



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.

Note:

- 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.
- **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.

Earthquakes In/Around India:

- India has experienced several significant earthquakes over the years, here are some examples:
 - **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.

What Steps can be Taken for Earthquake Preparedness in India?

- **Building Codes and Standards:** India has established **building codes and standards for earthquake-resistant construction**.
 - It is important to **strictly enforce these codes and standards to ensure that new buildings are built to withstand earthquakes**. This will also require regular inspections and enforcement of existing building codes.
- **Retrofitting and Reinforcement:** Older buildings may not meet current earthquake-resistant standards, and many of them **can be retrofitted or reinforced to improve their seismic performance**.
- **Emergency Response Planning:** Planning for emergency response is critical for minimising the impact of earthquakes. This includes **developing evacuation plans, establishing emergency shelters**, and training personnel on how to respond to earthquakes.
- **Research and Monitoring:** Investing in research and monitoring can help improve **our understanding of earthquakes and their causes**, and can also help to develop better methods for predicting and mitigating their impact.
- **Land-Use Planning:** It is important to consider the potential impacts of earthquakes when planning and developing land-use policies. This includes **limiting development in areas that are prone to earthquakes** and ensuring that new development is designed and constructed in a way that minimises the risk of damage.

Note:

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.
- 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.

Note:

- 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.

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 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**.
 - 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 cm year and 0.6 cm year, respectively.
- The impacts were more pronounced in **Rajasthan, Haryana and Delhi**, with average storage declines of roughly 14 cm year, 7.5 cm year and 7.2 cm year, 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.
- 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.

Note:

- 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 inhabits 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.

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.

What is the Issue?

- **Background:**
 - The opposition to the mining activities in Maliparbat dates back to 2003, when a public hearing was organized by the Odisha SPCB for environmental clearance.
 - After a lease was granted to Hindalco in 2007, **villagers had alleged that their grievances and objections to the project were ignored**.
 - According to activists, the company's **Environment Impact Assessment** report mentioned that **there was no water-body in Maliparvat**.
 - Villagers had, however, argued that 36 perennial streams flow down from the Maliparvat, which **was the source of water for villagers for their agricultural and drinking purposes** and the **bauxite mining project should be cancelled**.

- Till 2011 the company **failed to carry out mining and subsequently, its environmental clearance expired**. But, in 2012-2014 it **started mining illegally without going in for renewal of environmental clearance**.
- The industry has got a **fresh lease for 50 years for which the public hearing was necessitated**.
- **Concerns:**
 - Tribals residing in nearby villages have alleged that mining activities in Maliparbat would affect **around 42 villages under Sorishapodar, Dalaiguda and Pakhahjola panchayats**.
 - 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**.

Note:

- 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.

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.

What are the

Causes of Formation of Heat Dome?

- **Change in Ocean Temperature:** The **phenomenon begins when there is a strong change (or gradient) in ocean temperatures**.
 - In the process known as convection, the **gradient causes more warm air, heated by the ocean surface, to rise over the ocean surface**.

Note:

- As prevailing winds move the hot air east, the northern shifts of the jet stream trap the air and move it toward land, where it sinks, resulting in heat waves.
- **Change in Atmospheric Pressure:** Heat waves begin when high pressure in the atmosphere moves in and pushes warm air toward the ground. This effect is fueled by heat rising from the ocean, creating an amplification loop.
 - The high-pressure system pressing down on the ground expands vertically, forcing other weather systems to change course.
 - It even minimizes wind and cloud cover, making the air more stifling.
 - This is also why a heat wave parks itself over an area for several days or longer.
- **Climate Change:** The rising temperatures lead to hotter weather. Heat waves have been a regular phenomenon on land.
 - However, global warming has caused them to be hotter with a longer duration and an increased frequency.
 - Scientists studying the climate tend to agree that the heat waves occurring today are more likely to be a result of climate change for which humans are responsible.

Cold Wave

Why in News?

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

- The lowest minimum temperature recorded this month was **1.9 degrees Celsius on January 8**, the second-lowest minimum temperature in January in 15 years.
- Fog and **low cloud coverage brought severe cold day conditions to the region**, when temperatures remained below normal over parts of **Delhi, Punjab, Haryana, Chandigarh, Himachal Pradesh, Rajasthan, Uttar Pradesh and Madhya Pradesh**.

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 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,

Note:

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.

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 are the Benefits of Manufactured Sand (M-Sand)?

- **Cost-effectiveness:** Using manufactured sand can be **more cost-effective than using natural sand**, as it can be produced in large quantities at a lower cost.
- **Consistency:** Manufactured sand can have a **consistent grain size and shape**, which can be beneficial for construction projects that require a specific type of sand.
- **Environmental Benefits:** Using manufactured sand can help to **reduce the need for mining natural sand**, which can have negative environmental impacts.
 - Additionally, using the overburden from coal mines can help to repurpose materials that would otherwise be considered waste.
- **Reduced Water Consumption:** Using manufactured sand can help to reduce the amount of water required for construction projects, as it does not require washing before use.
- **Other Benefits:** Apart from commercial use, sand produced shall also be consumed for **sand stowing in Underground Mines** enhancing safety & conservation.
 - **Also, lesser Sand extraction from rivers** will reduce erosion of channel bed & banks and protect water habitat.

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.

Note:

- **Issues Related to Sand Mining in India:**
 - **Environmental Degradation:** Sand mining can lead to the destruction of habitats and ecosystems, as well as erosion of **river banks and coastal areas**.
 - **Water Scarcity:** Sand mining can **deplete the water table** and reduce the availability of water for **drinking and irrigation**.
 - For example, in the state of Rajasthan, sand mining has led to a **decline in the water level of the Luni River**, affecting the drinking water supply of nearby villages.
 - **Floods:** Excessive sand mining can cause the **riverbeds to become shallow**, which can increase the risk of floods.
 - For example, in the state of Bihar, sand mining has led to increased **flooding in the Kosi River**, causing damage to crops and property.
 - **Corruption:** Sand mining is a highly profitable activity, and there have been instances of **corruption and bribery** in the allocation of mining leases and the enforcement of regulations

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.
- **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.

Note:

- 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 needs**.
 - 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**.
- 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.

Note:

- **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 are the Highlights of the Research?

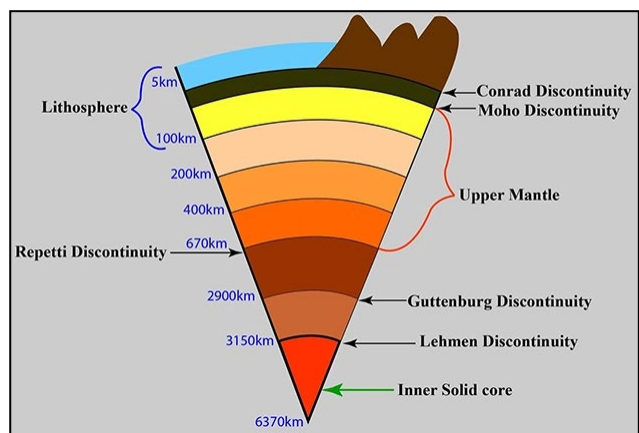
- **Methodology:**
 - The research analyzed **seismic waves from repeating earthquakes** over the last six decades.
 - By analysing changes in the time and propagation of these signals, they could estimate **the rotation of the inner core**, which is believed to move independently from the mantle and 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 **7,200–8,500°F (4,000–4,700°C)**.
- **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.



Note:

Western Disturbances

Why in News?

Recently, the daytime's temperatures in Delhi were above normal in December 2022 because of fewer **Western Disturbances (WD)**.

- In winter, WD brings rain and snow over the hills, and **more moisture to the plains**. The cloud cover results in **higher minimum temperatures at night and lower day-time or maximum temperatures**.

HIGHEST MAX TEMP IN DECEMBER

In degrees Celsius (°C)



What are Western Disturbances?

➤ About:

- 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)**.
- A Western Disturbance, 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.
- The disturbance travels **from the “western” to the eastern direction**.
 - These travel eastwards on high-altitude **westerly jet streams** - massive ribbons of fast winds traversing the earth from west to east.

- They **gradually travel across the middle-east from Iran, Afghanistan and Pakistan** to enter the Indian sub-continent.

- Disturbance means an area of **“disturbed” or reduced air pressure**.

- Equilibrium exists in nature due to which the air in a region tries to normalise its pressure.

➤ Impact in India:

- A WD is associated with **rainfall, snowfall and fog** in northern 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, hail storms and cold waves** killing people, destroying infrastructure and impacting livelihoods.
- During the summer months of April and May, **they move across North India and at times help in the activation** of monsoon in certain parts of northwest India.
- During the monsoon season, western disturbances **may occasionally cause dense clouding** and heavy precipitation.
- Weak western disturbances are **associated with crop failure** and water problems across north India.
- Strong western disturbances can help residents, farmers and governments avoid many of the problems associated with water scarcity.



Note:

What have been the Recent Instances/Impact of WD?

- Excess rainfall was recorded in January and February 2022. In contrast, there was no rainfall in **November 2021 and March 2022**, and the summer saw an **unusually early start with heat waves** setting in at the end of March 2022.
- Multiple western disturbances that brought cloud cover **had also kept the maximum temperature low in February 2022**, when the lowest maximum temperature in 19 years was recorded.
- Active western disturbances eluded northwest India in March 2022, and absence of cloud cover and rain allowed temperatures to remain high.
- The **frequency of western disturbances has increased**, but not the precipitation associated with them, partly due to a warming atmosphere (**Global Warming**).
- In 2021, western disturbances **brought rain to Delhi in the first week of December**.
 - Delhi is, however, **likely to get colder with the maximum temperature likely to fall to around 24 degrees** by December 15, 2022.

Cyclone Mandous

Why in News?

Recently, it has been reported that a **cyclone** may impact the Tamil Nadu and Puducherry coasts from 8th December 2022 onwards.

What is Cyclone Mandous?

- Mandous is a **slow-moving cyclone** that often absorbs a lot of moisture, carries a humongous amount of rainfall and gains strength in the form of wind speeds.
- The name has been **suggested by the United Arab Emirates**.
- **India Meteorological Department's (IMD)** predicted that the storm system **may move in the west and northwestward directions** and intensify into a depression by the evening of December 6.
 - It may subsequently strengthen further into a cyclone over southwest Bay of Bengal and move towards the Tamil Nadu and Puducherry coasts by the morning of December 8.

What is a Cyclone?

- **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.
- **There are two types of cyclones:**
 - **Tropical cyclones;**
 - **Extra Tropical cyclones** (also called Temperate cyclones or middle latitude cyclones or Frontal cyclones or Wave Cyclones).
- The **World Meteorological Organisation** 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**.
 - They are **large-scale weather systems** developing over tropical or subtropical waters, where they get organized into surface wind circulation.
 - **Extra tropical cyclones** occur in **temperate zones** and high latitude regions, though they are known to originate in the Polar Regions.

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)**. 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.

Note:



Coastal Red Sand Dunes

Why in News?

Recently, geologists have suggested to protect the site of **Coastal Red Sand Dunes**, of Visakhapatnam, Andhra Pradesh.

What are the Key Points of the Sites?

➤ About:

- **The Coastal Red Sand Dunes** is also known as 'Erra Matti Dibbalu'. It is one of the many sites of Visakhapatnam, which have **geological importance**.
- The site is located **along the coast and is about 20 km north-east of Visakhapatnam city** and about 4 km south-west of Bheemunipatnam.
- This site was declared as a **geo-heritage site by the Geological Survey of India (GSI)** in 2014 and the Andhra Pradesh government has listed it under the category of 'protected sites' in 2016.

➤ Distribution:

- Such sand deposits are rare and have **been reported only from three places** in the tropical regions in south Asia such as **Teri Sands in Tamil Nadu, Erra Matti Dibbalu in Visakhapatnam and one more site in Sri Lanka**.
- They do not occur in **equatorial regions or temperate regions** due to many scientific reasons.

What is the Uniqueness of these Sediments?

➤ Continuous Evolution:

- The **red sediments are a part of the continuation of the evolution of the earth** and represent the late **quaternary geologic age**.
 - The Quaternary Period is a period on the **Geologic Time Scale** that's known mainly for the spread of humanity and climate change. This period runs from about **2.6 million years ago to the Present Day**.

➤ Different Geomorphic Features:

- With a height of up to 30 m, they exhibit **badland topography with different geomorphic landforms and features**, including gullies, sand dunes, buried channels, beach ridges, paired terraces, the valley in the valley, wave-cut terrace, knick point and waterfalls.

- **Badland topography** is a dry terrain where softer sedimentary rocks and **clay-rich soils have been extensively eroded** by wind and water.

➤ Geochemically Unaltered:

- The top light-yellow sand unit, which is estimated to have been deposited around 3,000 years ago, **could not attain the red colouration as the sediments were geochemically unaltered**.
- These sediments are **unfossiliferous (not containing fossils) and deposited over the khondalite basement**.
 - **Khondalite** is a regional rock with high-grade metamorphism and granulite rock formation. It was named after the Khond tribe of Odisha.

What is the Significance of Protecting this Site?

- It is significant to protect this site, because its study can help understand the impact of climate change, as **Erra Matti Dibbalu has seen both the glacial and the warm periods**.
- The site is about 18,500 to 20,000 years old and **it can be related to the last glacial period**.
- It is a **lively scientific evolution site**, which depicts the real-time effects of climate change.
 - About 18,500 years ago, the sea (Bay of Bengal) was at least 5 km behind from the present coastline. Since then, it has been undergoing continuous active changes till about 3,000 years ago and still the changes are on.
- The site also has archaeological significance, as studies of artifacts indicate an **Upper Palaeolithic horizon and on cross dating assigned to Late Pleistocene epoch**, which is 20,000 BC.
- The site was home to the pre-historic man as the excavations at several places in the region revealed **stone implements of three distinctive periods and also the pottery of the Neolithic man**.

Semeru Volcano of Indonesia

Why in News?

Recently, **Semeru volcano** erupted in **Indonesia's Eastern Java Island**.

Note:

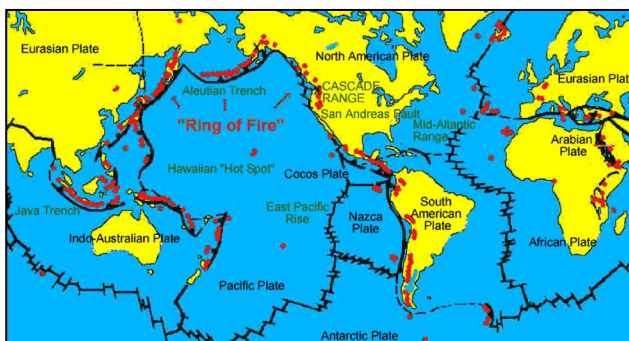


What is Semeru Volcano?

- Semeru - also known as “The Great Mountain” - is the **highest volcano** in Java and one of the most active.
- It previously erupted in December, 2021.
- Indonesia, with the maximum number of active volcanoes in the world, is **prone to seismic upheaval** due to its location on the **Pacific’s Ring of Fire**.
- Semeru volcano is also part of the **Island arcs** formed by the subduction of the **Indo-Australian plate** below **Sunda Plate** (part of the Eurasian Plate). The trench formed here is called the Sunda trench whose major section is the Java Trench.

What is Pacific Ring of Fire?

- **The Ring of Fire**, also referred to as the **Circum-Pacific Belt**, is a path along the Pacific Ocean characterized by **active volcanoes and frequent earthquakes**.
- It traces boundaries between several tectonic plates— including the Pacific, Cocos, Indian-Australian, Nazca, North American, and Philippine Plates.



What are Island Arcs?

- They are long, curved chains of **oceanic islands** associated with **intense volcanic and seismic activity and orogenic** (mountain-building) processes.

- An island arc typically has a **land mass or a partially enclosed, unusually shallow sea** on its concave side.
- Along the convex side there almost invariably exists a long, **narrow deep-sea trench**.
- The greatest ocean depths are found in these depressions of the seafloor, as in the case of the **Mariana (deepest trench in the world) and Tonga trenches**.
- Prime examples of this form of geologic feature include the **Aleutian-Alaska Arc** and the **Kuril-Kamchatka Arc**.

What are the Other Volcanoes?

- **Recently Erupted:**
 - **Sangay Volcano: Ecuador**
 - **Taal Volcano: Philippines**
 - **Mt. Sinabung, Merapi volcano: Indonesia**
- **Volcanoes in India:**
 - Barren Island, Andaman Islands (India’s only active volcano)
 - Narcondam, Andaman Islands
 - Baratang, Andaman Islands
 - Deccan Traps, Maharashtra
 - Dhinodhar Hills, Gujarat
 - Dhosi Hill, Haryana

Bomb Cyclone

Why in News?

Recently, a **Bomb cyclone** hit the **United States and Canada**, which triggered **road accidents** that results in the death of more than 30 people.

What is a Bomb Cyclone?

- **About:**
 - A bomb cyclone is a **large, intense midlatitude storm that has low pressure at its center**, weather fronts and an array of associated weather, from blizzards to severe thunderstorms to heavy precipitation.
 - Bomb cyclones put forecasters on high alert because **they can produce significant harmful impacts**.
- **Reasons for the Formation:**
 - Storms **form when a mass of low-pressure air (warm air mass) meets a high-pressure mass (cold air mass)**. The air flows from high pressure to low, creating winds.

Note:

- It occurs when a midlatitude cyclone rapidly intensifies, **dropping at least 24 millibars over 24 hours**.
 - A millibar measures atmospheric pressure.
- This quickly increases the pressure difference, or gradient, **between the two air masses, therefore making the winds stronger**.
 - The formation of this rapidly strengthening weather system is a process called **bombogenesis**.

How does a Bomb Cyclone Differ from a Hurricane?

- **Hurricanes** tend to form in tropical areas and are powered by warm seas. For this reason, they're **most common in summer or early fall**, when seawater is warmest.
- Bomb cyclones **generally occur during colder months** because cyclones occur due to cold and warm air meeting.
 - During the summer, there's generally not much cold air across the atmosphere; this means a bomb cyclone is much less likely to occur.
- Hurricanes **form in tropical waters**, while **bomb cyclones form over the northwestern Atlantic**, northwestern Pacific and sometimes the **Mediterranean Sea**.

Ganga Utsav 2022

Why in News?

Recently, the Ministry of Jal Shakti by the collaboration of The **National Mission for Clean Ganga (NMCG)** has organized **Ganga Utsav- The River Festivals 2022**.

What is Ganga Utsav 2022?

- **About:**
 - The **NMCG** celebrates the festival **every year to strengthen the Public – River Connection**.
 - NMCG is the implementation wing of **National Ganga Council**, set up in 2016, which replaced the National Ganga River Basin Authority (NRGBA).
 - The NMCG has been registered in the **Guinness Book of World Records on the first day of Ganga Utsav 2021** for the highest number of photos of handwritten notes that were uploaded on Facebook in an hour.
 - It highlights the significance of **Jan Bhagidari (People's Participation)** in the revival of Ganga, with a focus on encouraging stakeholder engagement

and public participation towards the rejuvenation of river Ganga.

➤ Ganga Utsav 2022:

- Dedicating the grand event to the 75 years of Indian Independence (Azadi ka Amrit Mahotsav), the aim is to **hold similar events at more than 75 locations in states to celebrate** the rivers of India.
- The festival will include a **blend of art, culture, music, knowledge, poetry, dialogue, and stories**.
- Several awareness activities will take place in districts to **establish a connection with the locals, and promote Namami Gange** as a mass movement.

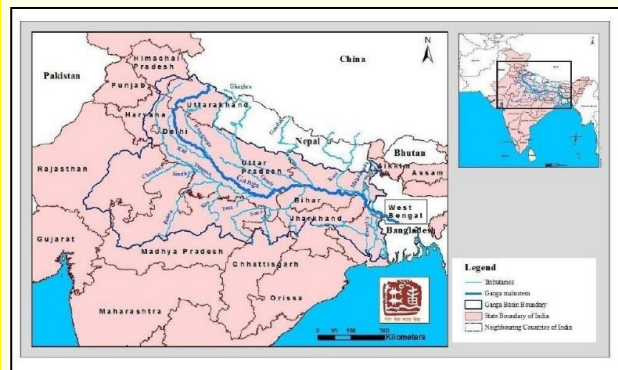
What are the

Government Initiatives on River Ganga?

- **Ganga Action Plan:** It was the first river action plan to improve the water quality by the interception, diversion and treatment of domestic sewage.
 - The National River Conservation Plan is an extension to this plan, which aims at cleaning the Ganga River under the Ganga Action Plan phase-2.
- **National River Ganga Basin Authority:** It was formed in the year 2009 under Section-3 of the **Environment Protection Act 1986**.
- **Clean Ganga Fund:** In 2014, it was formed for cleaning up of the Ganga, setting up of waste treatment plants and conservation of biotic diversity of the river.
- **Bhuvan-Ganga Web App:** It ensures the involvement of the public in the monitoring of pollution entering into the river Ganga.
- **Ban on Waste Disposal:** In 2017, the **National Green Tribunal (NGT)** banned the disposal of any waste in the Ganga.

What are the Key Points of River Ganga?

- 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 an area of 8,61,452 Sq.km which is 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 Ganga River basin is one of the most fertile and densely populated areas of the world and covers an area of 1,000,000 sq. km.
- The **Ganges River Dolphin** is an endangered animal that specifically habitats this river.
- The Ganga joins the Brahmaputra in Bangladesh and continues its run under the name Padma or Ganga.
- **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.

Earthquake

Why in News?

Recently, Powerful tremors were felt in India after an **earthquake** of magnitude 6.6 struck Nepal, which killed a few people and destroyed multiple houses.

What Caused these Tremors?

- According to the **United States Geological Survey (USGS)** the tremors are attributed to the continental collisions of **India and Eurasia Plates**, which is the dominating force for the Seismicity in the Himalayas.
- These plates are converging at a relative rate of 40-50 millimeters per year.

- Northward under thrusting of India beneath Eurasia generates numerous earthquakes and consequently **makes this area one of the most seismically hazardous regions on Earth.**

- The Himalayas and their vicinity have witnessed some of the most lethal earthquakes such as one of magnitude 8.1 Bihar in 1934, the 1905 magnitude 7.5 quake in Kangra and the 2005 magnitude 7.6 quake in Kashmir.

What is an Earthquake?

➤ About:

- An earthquake in simple words is the shaking of the earth. It is a natural event. It is caused due to release of energy, which generates waves that travel in all directions.
- The vibrations called **seismic waves** are generated from earthquakes that travel through the Earth and are recorded on instruments called seismographs.
- The location below the earth's surface where the earthquake starts is called the **hypocenter**, and the location directly above it on the surface of the earth is called the **epicenter**.
- **Types of Earthquake:** Fault Zones, Tectonic Earthquakes, Volcanic Earthquake, Human Induced Earthquakes.
- The earthquake events are scaled either according to the magnitude or intensity of the shock. The magnitude scale is known as the **Richter scale**. The magnitude relates to the energy released during the quake. The **magnitude is expressed in absolute numbers, 0-10**.
- The **intensity scale is named after Mercalli**, an Italian seismologist. The intensity scale takes into account the visible damage caused by the event. The **range of intensity scale is from 1-12**.
- **Distribution of Earthquake:**
 - **Circum-Pacific Seismic Belt:** The world's greatest earthquake belt, the circum-Pacific seismic belt, is found along the rim of the Pacific Ocean, where about **81% of our planet's largest earthquakes occur**. It has earned the nickname "**Ring of Fire**".
 - The belt exists along boundaries of tectonic plates, where plates of mostly oceanic crust are sinking (or subducting) beneath another plate. Earthquakes in these subduction zones are caused by slip between plates and rupture within plates.

Note:

- **Mid-Continental Belt:** The Alpine-Himalayan belt (mid-Continental belt) extends from Europe to Sumatra through the Himalayas, the Mediterranean, and out into the Atlantic.
 - This belt accounts for about 17% of the world's largest earthquakes, including some of the most destructive.
- **Mid-Atlantic Ridge:** Mid-Atlantic Ridge marks where two tectonic plates are spreading apart (a divergent plate boundary).
 - Most of the mid-Atlantic Ridge is deep underwater and far from human development.

What is the Seismic Hazard Map of India?

- India is one of the highly earthquakes affected countries because of the presence of technically active young fold mountains - Himalayas.
- India has been divided into **four seismic zones (II, III, IV, and V)** based on scientific inputs relating to seismicity, earthquakes that occurred in the past and tectonic setup of the region.
- Previously, earthquake zones were divided into five zones with respect to the severity of the earthquakes but the **Bureau of Indian Standards (BIS)** grouped the country into four seismic zones by unifying the first two zones.
 - BIS is the official agency for publishing the seismic hazard maps and codes.
- **Seismic Zone II:**
 - Area with minor damage earthquakes corresponding to intensities V to VI of MM scale (MM-Modified Mercalli Intensity scale).
- **Seismic Zone III:**
 - Moderate damage corresponding to intensity VII of MM scale.
- **Seismic Zone IV:**
 - Major damage corresponding to intensity VII and higher of MM scale.
- **Seismic Zone V:**
 - Area determined by the seismics of certain major fault systems and is seismically the most active region.
 - Earthquake zone V is the most vulnerable to earthquakes, where historically some of the country's most powerful shocks have occurred.
 - Earthquakes with magnitudes in excess of 7.0 have occurred in these areas, and have had intensities higher than IX.

Machchhu River

Why in News?

Recently, a suspension bridge collapsed **over the river Machchu, in Gujarat's Morbi district**, which killed almost 135 people.

- The suspension bridge, or **Jhulta Pul**, was built by the ruler of the princely state of Morbi, Sir Waghji Thakor, in 1877.
- It was made to reflect the '**progressive and scientific nature of the rulers of Morbi**'. It was inaugurated by the then-Bombay governor, Richard Temple, in 1879.

What is Suspension Bridge?

- A suspension bridge is a type of bridge in which **the deck is hung below suspension cables** on vertical suspenders.
- The basic structural components include stiffening girders, two or more main suspension cables, and towers and anchorages for cables at either end of the bridge.
- The main cables are suspended between the towers and are connected to the anchorage or the bridge itself. The vertical suspenders carry the weight of the deck and the commuter load on it.
- The design ensures that **the load on the suspension cables is transferred to the towers at the two ends**, which transfer them further by **vertical compression** to the ground by way of the anchorage cables.

What is Machchhu River?

- **About:** The Machchhu river **originates from Madla hills in the Surendranagar district of Gujarat and ends 141.75 km downstream in the Rann of Kutch.**
- **Tributaries:** Beti, Asoi, Jamburi, Benia, Machchhori, Maha are the tributaries of Machchhu river.
- **Dams:** It has two dams to augment irrigation to alleviate droughts in Saurashtra.

What is the Significance of Morbi District?

- It is famous for its **ceramic industry**. Around 70% of India's ceramics are produced in Morbi, and ceramic tiles manufactured here are exported to countries in the **Middle East, East Asia, and Africa**.

Note:

Key Points

- **Physical Geography:**
 - **Bordering Countries:** Ukraine, Russia, Georgia, Turkey, Bulgaria and Romania.
 - Also known as the **Euxine Sea**.
 - Surrounded by the **Pontic** (south), **Caucasus** (east), and **Crimean Mountains** (north).
 - The **Turkish straits system** - the **Dardanelles, Bosphorus and Marmara Sea** -
 - forms a transitional zone between the Mediterranean and the Black Sea.
 - **Sea of Azov** forms a **northern extension of the Black Sea** linked by the Strait of Kerch.
 - **Has anoxic water;** significant absence of oxygen in the water.
- **Russia – Ukraine Conflict:**
 - **Area of Russian Military Control in Ukraine:**
 - **Donbass region, comprising Donetsk and Luhansk** (2022)
 - **Crimea:** Russia annexed Crimea in 2014.
 - **Mariupol and Odessa:** Russia has its focus on:
 - Mariupol, **the Sea of Azov port in Donetsk.**
 - **Odessa, to the west of Crimea.**
 - **Bosphorus and Dardanelles Straits:** The Montreux convention gives Turkey certain control over the passage of warships from the Dardanelles and Bosphorus Straits that connect the Aegean, Marmara, and Black Sea.
 - **Naval Exercise ‘Sea Breeze’:** Involving NATO states and their allies.
- **Environmental Concern:**
 - **Turkey’s Sea of Marmara:** The largest outbreak of ‘sea snout’.

Mauna Loa Volcano

Why in News?

Mauna Loa, the largest active **volcano** in the world, may erupt in the near future.

Where is Mauna Loa?

- Mauna Loa is **one of five volcanoes** that together make up the Big Island of Hawaii.
- It is the **southernmost island in the Hawaiian archipelago.**

- It’s **not the tallest** (that title goes to Mauna Kea) but it’s the largest and makes up about half of the island’s land mass.
- It **sits immediately north of Kilauea volcano**, which is currently erupting from its summit crater.
 - Kilauea is **well-known for a 2018 eruption** that destroyed 700 homes and sent rivers of lava spreading across farms and into the ocean.
- Mauna Loa last erupted 38 years ago.

What about the Other Volcanoes?

➤ Recently Erupted:

- **Sangay Volcano: Ecuador**
- **Taal Volcano: Philippines**
- **Mt. Sinabung, Merapi volcano, Semeru volcano (Indonesia)**

➤ Volcanoes in India:

- Barren Island, Andaman Islands (India’s only active volcano)
- Narcondam, Andaman Islands
- Baratang, Andaman Islands
- Deccan Traps, Maharashtra
- Dhinodhar Hills, Gujarat
- Dhosi Hill, Haryana

How are Volcanoes

Distributed around the World?

- Volcanoes are distributed all around the world, mostly along the edges of **Tectonic Plates**, although there are intra-plate volcanoes that form from mantle Hotspots (e.g., Hawaii).
- Some volcanic regions, such as Iceland, happen to occur where there is both a hotspot and a plate boundary.
- **World Distribution of Volcano:**
 - **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.

Note:

- **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, Hindukush and Himalayas.
- **Mid Atlantic Ridge:**
 - The Mid-Atlantic Ridge separates the **North and South American Plate from the Eurasian and African Plate.**
 - 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.
- **Intra-Plate 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.**

Types of Eclipses

Why in News?

Recently, a **Total Lunar Eclipse (TLE)** occurred on 8th November, 2022.

- Earlier Indian witnessed a Partial Solar Eclipse in October 2022.

What is the Lunar Eclipse?

➤ **About:**

- Lunar eclipse takes **place when the Moon moves** into the Earth’s shadow. The Earth has to be **directly between the Sun and the Moon**, and a lunar eclipse can only take place during a full Moon.
- First, the Moon moves into the penumbra – the part of the Earth’s shadow where not all of the light from the Sun is blocked out. Part of the **Moon’s disc will look dimmer than a regular full Moon.**
- And then the Moon moves into the Earth’s umbra, where direct light from the Sun is totally blocked out by the Earth. This means the **only light reflecting off the Moon’s disc has already been refracted, or bent, by the Earth’s atmosphere.**

➤ **Total Lunar Eclipse:**

- A Total Lunar Eclipse happens when the **earth is positioned between the sun and the moon** and casts a shadow on the latter.
- During this, the whole of the lunar disc **enters the Earth’s umbra**, so the Moon appears reddish (Blood Moon).
- The moon takes on a reddish hue due to a phenomenon called **Rayleigh scattering.**
 - **Rayleigh scattering** is the scattering of light by particles in a medium **without a change in wavelength.** This is also the **reason why the sky appears blue.**
- The moon turns red during the eclipse since the only sunlight reaching it is passing through the earth’s atmosphere. The sunlight scatters due to the dust or clouds in the atmosphere producing the red colour.
- Total lunar eclipses occur, on average, about once every year and a half, according to **NASA (National Aeronautics and Space Administration).**

➤ **Partial lunar eclipse:**

- An imperfect alignment of Sun, Earth and Moon results in the Moon passing through only part of Earth’s umbra.
- The shadow grows and then recedes without ever entirely covering the Moon.

➤ **Penumbra eclipse:**

- The Moon travels through Earth’s penumbra, or the faint outer part of its shadow.

Note:

- The Moon dims so slightly that it can be difficult to notice.

What is Solar Eclipse?

➤ About:

- A solar eclipse happens when **the Moon passes between the Sun and Earth**, casting a shadow on Earth that either fully or partially blocks the Sun's light in some areas.

➤ Types:

○ Total Solar Eclipse:

- Total **solar eclipses** occur when the New Moon comes between the Sun and Earth and casts the darkest part of its shadow, the umbra, on Earth. A full solar eclipse, known as totality, is almost as dark as night.
- During a total eclipse of the Sun, the Moon covers the entire disk of the Sun.
- When the Moon completely covers the disk of the Sun, only the Sun's corona is visible.
- It is called Total eclipse because at the maximum point of the eclipse (midpoint of time of totality), the sky goes dark and temperatures can fall.

○ Annular Solar Eclipse:

- An annular solar eclipse happens when the **Moon passes between the Sun and Earth**, but when it is at or near its farthest point from Earth.
- Because the Moon is farther away from Earth, it appears smaller than the Sun and does not completely cover the Sun.
- As a result, the Moon appears as a dark disk on top of a larger, bright disk, creating what looks like a ring around the Moon.

○ Partial Solar Eclipse:

- A partial solar eclipse happens when the Moon passes between the Sun and Earth but the Sun, Moon, and Earth are not perfectly lined up.
- Only a part of the Sun will appear to be covered, **giving it a crescent shape**. During a total or annular solar eclipse, people outside the area covered by the Moon's inner shadow see a partial solar eclipse.

○ Hybrid Solar Eclipse:

- Because Earth's surface is curved, **sometimes an eclipse can shift between annular and total as the Moon's shadow** moves across the globe.
- This is called a hybrid solar eclipse.

Rare Earth Metals

Why in News?

Amid India's reliance on China for rare earth minerals imports, the **Confederation of Indian Industry (CII)** has urged the government to encourage private mining in the sector and diversify supply sources.

- Though 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.
- In 2018-19, for instance, **92% of rare earth metal imports by value and 97% by quantity were sourced from China**.

What are the Suggestions of CII?

- CII suggested that an **'India Rare Earths Mission'** be set up manned by professionals, similar to the **India Semiconductor Mission**, as a critical component of the **Deep Ocean Mission**.
- The industry group has also mooted **making rare earth minerals a part of the 'Make In India' campaign**, citing China's 'Made in China 2025' initiative that focuses on new materials, including permanent magnets that are made using rare earth minerals.

What are Rare Earth Metals?

- They are a **set of seventeen metallic elements**. These include the fifteen lanthanides on the **periodic table** in addition to scandium and yttrium that show similar physical and chemical properties to the lanthanides.
 - The 17 Rare Earths are cerium (Ce), dysprosium (Dy), erbium (Er), europium (Eu), gadolinium (Gd), holmium (Ho), lanthanum (La), lutetium (Lu), neodymium (Nd), praseodymium (Pr), promethium (Pm), samarium (Sm), scandium (Sc), terbium (Tb), thulium (Tm), ytterbium (Yb), and yttrium (Y).
- These minerals have **unique magnetic, luminescent, and electrochemical properties** and thus are used in many modern technologies, including consumer electronics, computers and networks, communications, health care, national defense, clean energy technologies etc.
- Even futuristic technologies need these REEs.
 - For example, high-temperature superconductivity, safe storage and transport of hydrogen for a post-hydrocarbon economy etc.

Note:



- They are called 'rare earth' because earlier it was difficult to extract them from their oxides forms technologically.
- They occur in many minerals but typically in low concentrations to be refined in an economical manner.

How China Monopolised Rare Earths?

- China has over time acquired global domination of rare earths, even at one point, it produced 90% of the rare earths the world needs.
- 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, and the US along with smaller units in Asia, Africa, and Latin America.
- Even so, the dominant share of processed Rare Earths lies with China.

What is India's Current Policy on Rare Earths?

- Exploration in India has been conducted by the **Bureau of Mines and the Department of Atomic Energy**. Mining and processing has been performed by some minor private players in the past, but is today concentrated in the hands of **IREL (India) Limited** (formerly Indian Rare Earths Limited), a Public Sector Undertaking under the Department of Atomic Energy.
- India has granted government corporations such as **IREL a monopoly** over the primary mineral that contains REEs: monazite beach sand, found in many coastal states.
- IREL produces rare earth oxides (low-cost, low-reward "upstream processes"), selling these to foreign firms that extract the metals and manufacture end products (high-cost, high-reward "downstream processes") elsewhere.
- IREL's focus is to provide thorium — extracted from monazite — to the Department of Atomic Energy.

What are the Related Steps taken?

- **Globally:**
 - The **Multilateral Minerals Security Partnership (MSP)** was announced in June 2022, with the goal of bringing together countries to build robust critical minerals supply chains needed for climate objectives.

- Involved in this partnership are the United States (US), Canada, Australia, Republic of Korea, Japan, and various European countries.
 - India is not included in the partnership.

➤ By India:

- Ministry of Mines has amended Mines and Minerals (Development and Regulation) (MMDR) Act, 1957 through the **Mines and Minerals (Development and Regulation) Amendment Act, 2021** for giving boost to mineral production, improving ease of doing business in the country and increasing contribution of mineral production to Gross Domestic Product (GDP).
- The amendment act provides that no mine will be reserved for particular end-use.

Trends in Demography

Why in News?

According to the projection by the **United Nations**, in 2022, **China will for the first time register an absolute decline in its population** and in 2023, India's population to reach 1,428.63 million, will surpass China's 1,425.67 million.

What are the Drivers of Population Change?

➤ Total Fertility Rate (TFR):

- TFR has fallen for India in the last three decades.
 - Between 1992-93 and 2019-21, it came down from **3.4 to 2**; the fall was especially significant in the rural areas.
 - In 1992-93, the average rural Indian woman produced one extra child compared to her urban counterpart (3.7 versus 2.7). By 2019-21, that gap had halved (2.1 versus 1.6).
 - A TFR of 2.1 is considered as "replacement-level fertility".
 - The TFR is the average number of births by women aged 15-49 based on surveys for a particular period/year.

➤ Fall in Mortality:

- **Crude Death Rate (CDR) fell to single digits for China first in 1974 (to 9.5) and for India in 1994 (9.8)**, and further to 7.3-7.4 for both in 2020.
 - The CDR was 23.2 for China and 22.2 for India in 1950.

Note:

- CDR is the **number of persons dying per year per 1,000 population**.
- Mortality falls with increased education levels, public health and vaccination programmes, access to food and medical care, and provision of safe drinking water and sanitation facilities.
- **Life Expectancy at Birth:**
 - Between 1950 and 2020, **life expectancy at birth went up from 43.7 to 78.1 years for China and from 41.7 to 70.1 years for India**.
 - Reduction in mortality normally leads to a rising population. A drop in fertility, on the other hand, slows down population growth, ultimately resulting in absolute declines.

What are the Implications of the Trends for China?

- China's **TFR was 1.3 births per woman, marginally up from the 1.2 in the 2010 and 2000 censuses**, but way below the replacement rate of 2.1.
- From 2016, **China officially ended its one-child policy** which was introduced in 1980.
- The UN, nevertheless, projects its total population at 1.31 billion in 2050, a 113 million-plus drop from the 2021 peak.
- The decline in China's population of prime working age is concerning as it **creates a vicious cycle wherein the number of working people to support dependent decreases but the number of dependents starts increasing**.
- The proportion of the **population aged between 20 and 59 years crossed 50% in 1987** and peaked at 61.5% in 2011.
- As the cycle reverses, China's working-age population will fall below 50% by 2045.
- Moreover, the average (median) age of the population, which was 28.9 years in 2000 and 37.4 years in 2020, is expected to soar to 50.7 years by 2050.

What are the Steps taken by India to Control Population?

- India **became one of the first developing countries** to come up with a state-sponsored family planning programme in the 1950s.
 - A population policy committee was established in 1952.

- In 1956, a Central Family Planning Board was set up and its focus was on sterilisation.
- In 1976, GOI announced the **first National Population Policy**.
- **National Population Policy, 2000** envisaged achieving a stable population for India.
 - The Policy aims to achieve stable population by 2045.
 - One of its immediate objectives is to address the unmet needs for contraception, health care infrastructure, and personnel and provide integrated service delivery for basic reproductive and child health care.
- **National Family Health Survey (NFHS)** is a large-scale, multi-round survey conducted in a representative sample of households throughout India.
 - NFHS has had two specific goals:
 - To provide essential data on health and family welfare needed for policy and programme purposes.
 - To provide information on important emerging health and family welfare issues.
- Realising the potential of education in tackling the problems of growing rate of population, the Ministry of Education launched a **Population Education Programme** with effect from 1980.
 - The Population Education programme is a central sector scheme designed to introduce Population Education in the formal education system.
 - It has been developed in collaboration with the **United Nations Funds for Population Activities (UNFPA)** and with the active involvement of the Ministry of Health and Family Welfare.

Maheshwar Dam: Narmada River

Why in News?

The Madhya Pradesh government has canceled all contracts with **Maheshwar Hydroelectric Project** almost three decades after it agreed to purchase power from it.

Note:

- It has been canceled due to its poor financial track record, several irregularities and graft allegations and **caused the submergence of 61 villages.**
- The Maheshwar dam is **one of the large dams of the Narmada Valley Development Project**, which envisages the construction of **30 large and 135 smaller dams** in the Narmada valley.

What are the Key Points of Narmada River?

- **About:**
 - Narmada is the **largest 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.
 - Narmada is flowing through the area where the land is not sloping **towards the west** from central India, but it is flowing west **because of the rift valleys only.**
 - It rises from **Maikala range near Amarkantak** in Madhya Pradesh.
 - It drains a large area in **Madhya Pradesh** besides some areas in the states of **Maharashtra and Gujarat.**
 - The river near Jabalpur (Madhya Pradesh) forms the Dhuandhar Falls.
 - There are **several islands in the estuary of Narmada** of which Aliabet is the largest.
- **Major Tributaries:** Hiran, Orsang, the Barna and the Kolar.
- **Hydro Power Projects:** Indira Sagar, Sardar Sarova, Maheshwar etc.
- **Narmada Bachao Andolan (NBA):**
 - It is an Indian social movement spearheaded by native tribes (adivasis), farmers, environmentalists and human rights activists against a number of large dam projects across the **Narmada River.**
 - **Sardar Sarovar Dam** in Gujarat is one of the biggest dams on the river and was one of the first focal points of the movement.

Fujiwhara Effect

Why in News?

With typhoon Hinnamnor and another tropical storm

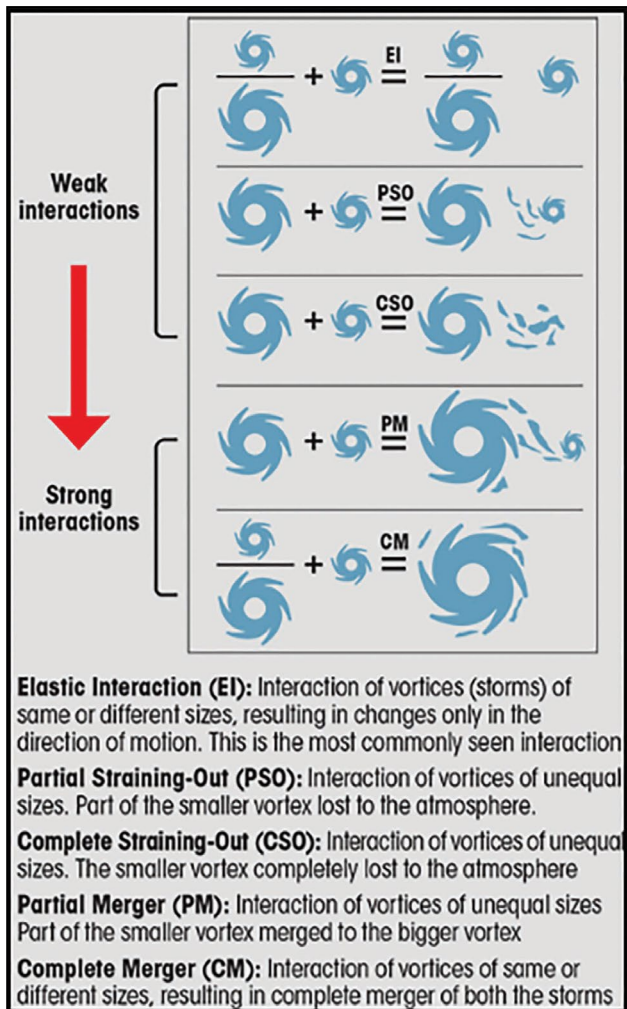
called Gardo, meteorologists observed a phenomenon called the Fujiwhara Effect.

- Typhoon Hinnamnor, known in the Philippines as Super Typhoon Henry, was a very large and powerful **tropical cyclone** in Pacific Ocean that impacted Japan and South Korea.

What is the Fujiwhara Effect?

- **About:**
 - The Fujiwhara Effect is any **interaction between tropical storms formed around the same time** in the same ocean region with their centres or eyes at a distance of less than 1,400 km, with intensity that could vary between a depression (wind speed under 63 km per hour) and a super typhoon (wind speed over 209 km per hour).
 - The **interaction could lead to changes in the track** and intensity of either or both storm systems.
 - In rare cases, the **two systems could merge**, especially when they are of similar size and intensity, to form a bigger storm.
- **Different ways in which Fujiwhara Effect can take place:**
 - **Elastic Interaction:**
 - In this interaction, **only the direction of motion of the storms changes** and is the most common case. These are also the cases that are difficult to assess and need closer examination.
 - **Partial straining out:**
 - In this interaction, a part of the smaller storm is lost to the atmosphere.
 - **Complete Straining Out:**
 - In this interaction, the smaller storm is completely lost to the atmosphere and the straining out does not happen for storms of equal strength.
 - **Partial Merger:**
 - In this interaction, the **smaller storm merges into the bigger one.**
 - **Complete Merger:**
 - In this interaction, **complete merger takes place between two storms of similar strength.**

Note:



Global Status of Multi-Hazard Early Warning Systems: Target G

Why in News?

Recently, the **United Nations Office for Disaster Risk Reduction (UNDRR)** and the **World Meteorological Organization (WMO)** released a report titled **Global Status of Multi-Hazard Early Warning Systems - Target G**, which warns that half of the countries globally are not protected by **Multi-Hazard Early Warning Systems (MHEWS)**.

- The report has been released to mark the **International Day for Disaster Risk Reduction (13th October)**.
- The analysis was made with data from the targets outlined in The **Sendai Framework (2015-2030)**. The framework is a global blueprint for disaster risk reduction and prevention.

- Of the seven targets in the framework, **Target G** aims to “substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to the people by 2030.

What is International Day for Disaster Risk Reduction?

- The International Day for Disaster Risk Reduction was **started in 1989, after a call by the United Nations General Assembly** for a day to promote a global culture of risk-awareness and disaster reduction.
- In 2015 at the **Third UN World Conference on Disaster Risk Reduction in Sendai, Japan**, the international community was reminded that disasters hit hardest at the local level with the potential to cause loss of life and great social and economic upheaval.

What are the Early Warning Systems?

- Early warning systems are a proven **means to reduce harm to people and damage to assets ahead of impending hazards**, including **storms, tsunamis, droughts**, and heatwaves, to name a few.
- Multi-hazard early warning systems address **several hazards that may occur alone, simultaneously, or cascadingly**.
- Many systems only cover one type of hazard - like floods or cyclones.

What are the Findings?

- **Failure at Investment:**
 - The world is failing to invest in protecting the lives and livelihoods of those on the front line.
 - Those who have done the least to cause the climate crisis are paying the highest price.
 - LDCs (Least developed countries), SIDS (Small Island Developing States), and countries in Africa, require the most investment to increase early warning coverage and adequately protect themselves against disasters.
 - Pakistan is dealing with its worst recorded climate disaster, with nearly 1,700 lives lost. Despite this carnage, the death toll would have been much higher **if not for early warning systems**.
- **Significant Gaps:**
 - Only half of the countries globally have MHEWS.

Note:

- The Number of recorded disasters has increased five-fold, driven in part by human-induced climate change and more extreme weather. This trend is expected to continue.
- Less than half of the Least Developed Countries and only one-third of Small Island Developing States have a multi-hazard early warning system.
- **Humanity is in the Danger Zone:**
 - As ever-rising greenhouse gas emissions are supercharging extreme weather events across the planet, **climate disasters are hurting countries and economies like never before.**
 - Increasing calamities are costing lives and hundreds of billions of dollars in loss and damage.
 - Three times more people are displaced by climate disasters than war and half of humanity is already in the danger zone.

What are the Recommendations?

- Called on all countries to invest in early warning systems.
- As climate change causes more frequent, extreme, and unpredictable weather events, investment in **early warning systems that target multiple hazards is more urgent than ever.**
- This is because of the need to warn not only against the initial impact of disasters, but also **second and third-order effects.** Examples include soil liquefaction following an earthquake or a landslide, and disease outbreaks following heavy rainfall.

What are India's Efforts in Managing Disaster?

- **Establishment of National Disaster Reaction Force (NDRF):**
 - India has increasingly mitigated and responded to all types of disasters, including with the establishment of its **National Disaster Reaction Force (NDRF)**, the world's largest rapid reaction force dedicated to disaster response.
- **India's Role as a Foreign Disaster Relief:**
 - India's foreign humanitarian assistance has increasingly included its military assets, primarily deploying naval ships or aircraft to deliver relief.
 - In line with its diplomatic policy of "**Neighbourhood First**," many of the recipient countries have been in the region of South and Southeast Asia.

- **Contribution to Regional Disaster Preparedness:**
 - Within the context of the **Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC)**, India has hosted DM Exercises that allow NDRF to demonstrate for counterparts from partner states the techniques developed to respond to various disasters.
 - Other NDRF and Indian Armed Forces exercises have brought India's first responders into contact with those from states in the **South Asian Association for Regional Cooperation (SAARC)** and the **Shanghai Cooperation Organisation (SCO)**.
- **Managing Climate Change related Disaster:**
 - India has adopted the **Sendai Framework for Disaster Risk Reduction, the Sustainable Development Goals (2015-2030), and the Paris Agreement** on Climate Change, all of which make clear the connections among DRR, Climate Change Adaptation (CCA), and sustainable development.

Cyclone Sitrang

Why in News?

- Bangladesh has been devastated by Cyclone Sitrang, which slammed into densely-populated, low-lying areas.
- Named by Thailand, Sitrang is the **first tropical cyclone** of the post-monsoon season of 2022.
 - In 2018, Titli was the last October cyclone in the Bay of Bengal.

What are the Tropical Cyclones?

- 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.

Note:

- **Storms rotate counterclockwise in the northern hemisphere** and clockwise in the southern hemisphere.
- 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 do Tropical Cyclones Form?

- The development cycle of tropical cyclones may be divided into three stages:
 - **Formation and Initial Development Stage:**
 - The formation and initial development of a cyclonic storm depends upon the transfer of water vapour and heat from the warm ocean to the overlying air, primarily by evaporation from the sea surface.
 - It encourages formation of massive vertical cumulus clouds due to convection with condensation of rising air above the ocean surface.
 - **Mature Stage:**
 - When a tropical storm intensifies, the air rises in vigorous thunderstorms and tends to spread out horizontally at the tropopause level. Once air spreads out, a positive pressure at high levels is produced, which accelerates the downward motion of air due to convection.
 - With the inducement of subsidence, air warms up by compression and a warm 'Eye' (Low pressure centre) is generated. The main physical feature of a mature tropical cyclone in the Indian Ocean is a concentric pattern of highly turbulent giant cumulus thundercloud bands.
 - **Modification and Decay:**
 - A tropical cyclone begins to weaken in terms of its central low pressure, internal warmth and extremely high speeds, as soon as its source of warm moist air begins to ebb or is abruptly cut off.

Thamirabarani River

Why in News?

The district administration of Tirunelveli in Tamil Nadu along with **Ashoka Trust for Research in Ecology and the Environment (ATREE)**, a non-profit Organisation, are using a 'hyper local' approach called TamiraSES to restore the **Thamirabarani River**.

What is the Project About?

- **Need:**
 - The Thamirabarani is of great importance to southern Tamil Nadu environmentally and historically. But it too has suffered, which is why the restoration project has been started.
 - While the Thamirabarani landscape, in general, appears water-rich, it **faced severe drought in 2016 despite** the diverse water storage systems in place.
 - Settlements have been on the rise, **which has led to the shrinkage of agricultural land** and water bodies.
- **TamiraSES project:**
 - It is a district level initiative, which aims to **restore the Social Ecological Systems of Tamiraparani river riverscape from head-waters to the estuary to enable conditions for native biodiversity to thrive** and maintain and enhance multiple ecosystem services to local stakeholders.
 - Five social ecological observatories will be set up **as part of the first phase of the project**. These will serve as pilots to scale up from the learnings from these sites.
 - The idea is to rejuvenate not just the **Thamirabarani but all the water bodies in the riverscape of Tirunelveli**.

What are the Key Points of Thamirabarani River?

- The Thamiraparani is the **only perennial** (continuous flow of water) **river in Tamil Nadu**.
- This is the shortest river in the state, the Thamirabarani **starts in Pothigai hills of the Western Ghats** in the Ambasamudram taluk, flows through Tirunelveli and Thoothukudi districts and empties at Korkai into the **Gulf of Mannar (Bay of Bengal)**. It thus **originates and ends in the same state**.

Note:



- The river supports wildlife such as the Nilgiri marten, **slender loris**, lion-tailed macaque, white spotted bush frog, galaxy frog, Sri Lankan Atlas moth and the **great hornbill**.
- Besides the ecosystem services it provides, the river also has **historical value for the people of the state**. It is mentioned extensively in **Sangam Era literature**.



Impact of Climate Change on Indian Monsoon

Why in News?

Recently, Research has shown that global warming, triggered by **Climate Change**, increases the fluctuations in the **monsoon**, resulting in **both long dry periods and short spells of heavy rains**.

- The Year 2022 has seen the **second highest extreme events since 1902**. An alarming case as incidents of **floods** and **droughts** have increased.

What are the Impacts of Climate Change on Indian Monsoon?

➤ Contrasting Rainfall Patterns:

- A shift in the track of monsoon systems has been seen such as low pressure and **depression travelling south of their position and flash floods**.
 - Monsoon depression originally refers to a low-pressure **system affecting the North Indian Ocean and the Bay of Bengal** in summer. It encompasses a **relatively large area and the diameter of closed isobar can be as wide as 1000 km**.

- Madhya Pradesh, Gujarat, Rajasthan and parts of Maharashtra have recorded excess rainfall in 2022, in contrast, **West Bengal, Jharkhand and Bihar did not receive normal rains**
- August 2022 too saw two back-to-back depressions forming in the Bay of Bengal and traveling across Central India.
- While summer monsoon rainfall each year is unique, there has been a **large regional and temporal variability in rainfall in 2022**.

➤ Causes:

- Persistence of intense **La Nina conditions**, the abnormal warming of East Indian Ocean, negative **Indian Ocean Dipole (IOD)**, southward movement of most of the monsoon depressions and lows and pre-monsoon heating over the **Himalayan region** and melting glaciers.
 - IOD is defined by the difference in sea surface temperature between two areas (or poles, hence a dipole) – a western pole in the Arabian Sea (western Indian Ocean) and an eastern pole in the eastern Indian Ocean south of Indonesia.
 - The IOD affects the climate of Australia and other countries that surround the **Indian Ocean Basin, and is a significant contributor to rainfall variability** in this region.

➤ Impacts:

○ Kharif Crops:

- One of the major impacts of changes in track of monsoon systems can be seen on kharif crops, particularly rice production. They form a significant share of more than 50% of total food grain production during this period.
- The fall in Kharif output **may keep rice prices at elevated levels**.
- Bihar, West Bengal and Uttar Pradesh, which account for a third of the country's total rice production, have been **highly deficit despite an active monsoon current in July and August**.

○ Quality of Grains:

- These uneven distribution rains may impact the quality of the grain as well as **the nutrition value may vary**.
 - According to a study, 'Climate change, the monsoon, and rice yield in India', very high temperatures (> 35°C) induce heat stress and

Note:

affect plant physiological processes, leading to **spikelet sterility, non-viable pollen and reduced grain quality**.

- **Food security:**
 - Monsoon rainfall became **less frequent but more intense in India** during the latter half of the 20th century.
 - Scientists and food experts believe that a better rainfall scenario could have helped increase the harvest.
 - However, India's hundreds of millions of rice producers and consumers are being affected negatively with these unprecedented changes which are also raising concerns over **food security**.

Aridity Anomaly Outlook Index: IMD

Why in News?

Recently, **Indian Meteorological Department (IMD)** has released the **Aridity Anomaly Outlook (AAO) Index** of July 2022, which says at least **85% of districts** face **arid conditions across India**.

What is the Aridity Anomaly Outlook Index?

- **About:**
 - The index monitors **agricultural drought, a situation when rainfall and soil moisture are inadequate to support healthy crop growth** till maturity, causing crop stress.
 - An anomaly from the normal value signifies a **water shortage in these districts that could directly impact agricultural activity**.
 - It is Developed by the **India Meteorological Department (IMD)**.
- **Characteristics:**
 - A **real-time drought index in which water balance is considered**.
 - The Aridity Index (AI) is computed for **weekly or two-week periods**.
 - For each period, **the actual aridity for the period is compared to the normal aridity for that period**.
 - Negative values indicate a surplus of moisture while positive values indicate moisture stress.

➤ **Parameters:**

- **Actual evapotranspiration and calculated potential evapotranspiration**, which require temperature, wind and solar radiation values.
 - **Actual evapotranspiration** is the quantity of water that is actually removed from a surface due to the processes of evaporation and transpiration.
 - **Potential evapotranspiration** is the maximum attainable or achievable evapotranspiration for a given crop due to evaporation and transpiration.

➤ **Applications:**

- Impacts of drought in agriculture, especially in the tropics where defined wet and dry seasons are part of the climate regime.
- Both winter and summer cropping seasons **can be assessed using this method**.

What are the Findings?

- Only 63 of 756 districts are non-arid, while 660 are facing different degrees of aridity — **mild, moderate and severe**.
- Some 196 districts are in the grip of a 'severe' degree of **dryness** and **65 of these are in Uttar Pradesh (highest)**.
 - **Bihar had the second highest number of districts (33) experiencing arid conditions**. The state also has a high rainfall deficit of 45%.
- Other districts facing '**severe arid**' conditions are Jharkhand, Haryana, Madhya Pradesh, Delhi, Telangana, Maharashtra, Andhra Pradesh, Jammu and Kashmir, Punjab, West Bengal, Rajasthan, Karnataka and Tamil Nadu.
- The SPI on the DEWS platform also **highlights a persisting rainfall deficit in these areas in the last six months**.
- Arid conditions have impacted the ongoing **kharif sowing**, as the area sown under different kharif crops as of July, 2022, was less by **13.26 million hectares compared to the corresponding period in 2021**.

What is the Standardised Precipitation Index (SPI)?

- The SPI is a widely used index to **characterize meteorological drought on a range of timescales**.
- On short timescales, the SPI is closely related to soil moisture, while at longer timescales, the SPI can be related to groundwater and reservoir storage.

Note:

- The SPI on the **Drought Early Warning System (DEWS)**, a **real-time drought monitoring platform** managed by the Indian Institute of Technology, Gandhinagar (IIT-G) platform **highlights a persisting rainfall deficit in these areas in the last six months.**
- UP, Jharkhand, Bihar, West Bengal and some parts of the North East are under extreme drought situation and agriculture of these regions might be affected.

What is the India Meteorological Department (IMD)?

- IMD was **established in 1875.**
- It is an agency of the **Ministry of Earth Sciences.**
- It is the principal agency responsible for meteorological observations, weather forecasting and seismology.

Pakistan's Devastating Floods

Why in News?

India will be extending humanitarian assistance to Pakistan to deal with the Devastating **Flood** that occurred because of Pakistan's Monster **Monsoon**.

- The climate crisis is the prime reason for the devastating scale of flooding in Pakistan, which has killed more than 1,000 people and affected 30 million.

What is the Indian Assistance to Pakistan?

- The aid will be the first time since 2014 that India will be extending aid to Pakistan on account of a natural disaster.
- In the past, India **extended assistance to Pakistan for the floods in 2010**, and for the earthquake in 2005.

How has been the Bilateral Trade between India and Pakistan?

- In 2021, Pakistan allowed the import of cotton and sugar from India, partially reversing a two-year old decision to suspend all trade with India.
- The decision to cancel trade was taken by the Pakistan government in August, 2019, days after the Indian government **amended Article 370 and reorganised Jammu and Kashmir.**
- Over the years, India has had a **trade surplus with Pakistan, with much less imports than exports** and trade has always been linked to politics.

- India's exports to Pakistan fell around 16% to USD 1.82 billion in 2016-17 as compared to 2015-16 after relations deteriorated **in the aftermath of the Uri terror attack and the Indian Army's surgical strikes** on militant launchpads in Pakistan-occupied Kashmir in 2016.

- Despite continuing tensions, trade between the two countries **grew marginally in subsequent years.**

What caused Severe Flood in Pakistan?

➤ Extremely Wet monsoon:

- The current flood is a **direct result of an extremely wet monsoon season** this year.
- The same southwest monsoon that brings the bulk of India's annual rainfall causes rain in Pakistan as well.
 - The monsoon season in Pakistan, however, is **a little shorter than in India.** That is because the **rain-bearing monsoon winds take time to travel northward from India into Pakistan.**

- There's been a **400% increase in average rainfall in areas like Baluchistan and Sindh**, which led to extreme flooding.

➤ Extreme Heat:

- In May 2022, Pakistan consistently saw temperatures **above 45 degrees Celsius (113 Fahrenheit).**
- Warmer air holds more moisture — about 7% more per degree Celsius (4% per degree Fahrenheit) — and that eventually comes down, in this case in torrents.
- Instead of just swollen rivers flooding from extra rain, **Pakistan is hit with another source of flash flooding.**
- The **extreme heat accelerates the long-term glacier melting** then water speeds down from the **Himalayas** to Pakistan in a dangerous phenomenon called glacial lake outburst floods.

➤ ENSO:

- The **El Niño-Southern Oscillation (ENSO)** appears to be in its La Niña phase.
- "La Niña is behaving very strongly in some metrics and is a significant factor for enhancing monsoonal rains.

Note:

Formation of Continents

Why in News?

According to a new study, **the earth's continents were formed by massive meteorite impacts** that were prevalent during the first billion years of our planet's four and a half billion-year history.

What are the Highlights of the Study?

➤ About:

- Meteorite impacts **generated massive energy to form oceanic plates**, which later evolved into continents.
- The theory that giant meteorite impacts formed continents had been around for decades, but until now, there was little solid evidence for its support.
- The most commonly accepted theory in place attributes continent formation to the movement of **Tectonic Plates**.

➤ Evidence for Meteorite Impact Theory:

- **Zircon crystals in Pilbara Craton:** The researchers looked for evidence in zircon crystals embedded in rocks from the Pilbara Craton in Western Australia. This craton is the remnant of an ancient crust that began forming more than three billion years ago.
 - **Zircons are formed by the crystallisation of magma** or are found in metamorphic rocks.
 - They act as tiny time capsules, recording the period of geologic activity. Newer zircon adds to the original crystal as time progresses.
 - The study of the variants or isotopes of oxygen within these crystals i.e., oxygen-18 and oxygen-16 and their ratio helped to estimate past temperatures.
 - Older grains of zircon possessed the lighter oxygen-16. The younger ones contained the heavier oxygen-18.
- **Cratons:** A craton is an old and stable part of the continental lithosphere, which consists of Earth's two topmost layers, the crust and the uppermost mantle.

➤ Need for Understanding the Formation of Continents:

- Understanding the formation and evolution of continents is important, as **it is the key to reserves of metals such as lithium, tin and nickel**.

- **Most of Earth's biomass and most humans live on these landmasses**, so understanding how continents form and evolve is crucial.

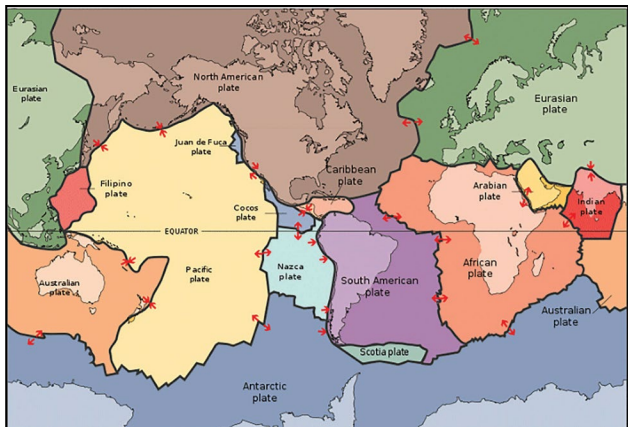
What are the Theories related to Continent Formation?

➤ Plate Tectonics Theory:

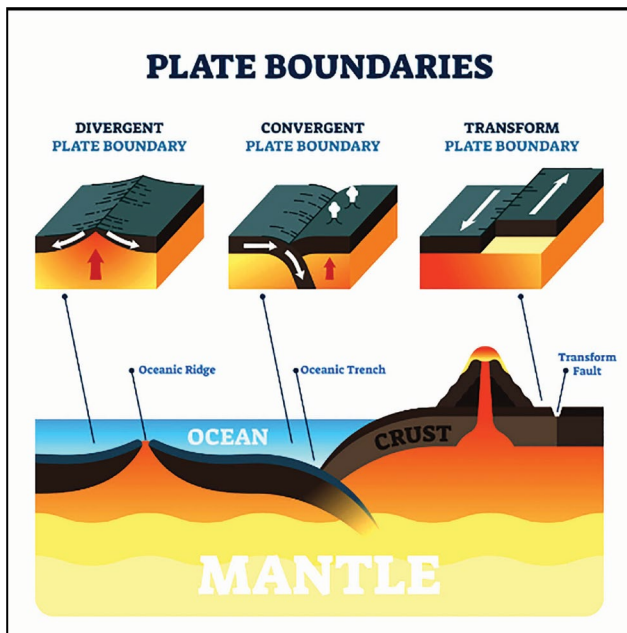
- Developed from the 1950s to the 1970s, the **theory of plate tectonics is the modern update to continental drift**, an idea first proposed by scientist Alfred Wegener in 1912 which stated that **Earth's continents had "drifted" across the planet over time**.
- **Wegener didn't have a correct explanation for how continents could move** around the planet, but researchers do now.
- Plate tectonics is the theory that **Earth's outer shell is divided into large slabs of solid rock**, called "plates," that glide over Earth's mantle, the rocky inner layer above Earth's core.
- Earth's solid outer layer, which includes the crust and the uppermost mantle, is called the **Lithosphere**.
- Below the lithosphere is the asthenosphere — a viscous layer kept malleable by heat deep within the Earth.
 - It lubricates the undersides of Earth's tectonic plates, allowing the lithosphere to move around.
- The Earth's Lithosphere is divided into seven major and some minor plates.
 - **Major Plates:**
 - The **Antarctic** (and the surrounding oceanic) Plate
 - The **North American Plate** (with western Atlantic floor separated from the South American plate along the Caribbean islands)
 - The **South American Plate** (with western Atlantic floor separated from the North American plate along the Caribbean islands)
 - The **Pacific Plate**
 - The **India-Australia-New Zealand Plate**
 - **Africa with the eastern Atlantic floor Plate**
 - **Eurasia and the adjacent oceanic Plate**
- Some important minor plates include:
 - **Cocos Plate:** Between Central America and Pacific plate

Note:

- **Nazca Plate:** Between South America and Pacific plate
- **Arabian Plate:** Mostly the Saudi Arabian landmass
- **Philippine Plate:** Between the Asiatic and Pacific plate
- **Caroline Plate:** Between the Philippine and Indian plate (North of New Guinea)
- **Fuji Plate:** North-east of Australia
- **Juan De Fuca Plate:** South-East of North American Plate

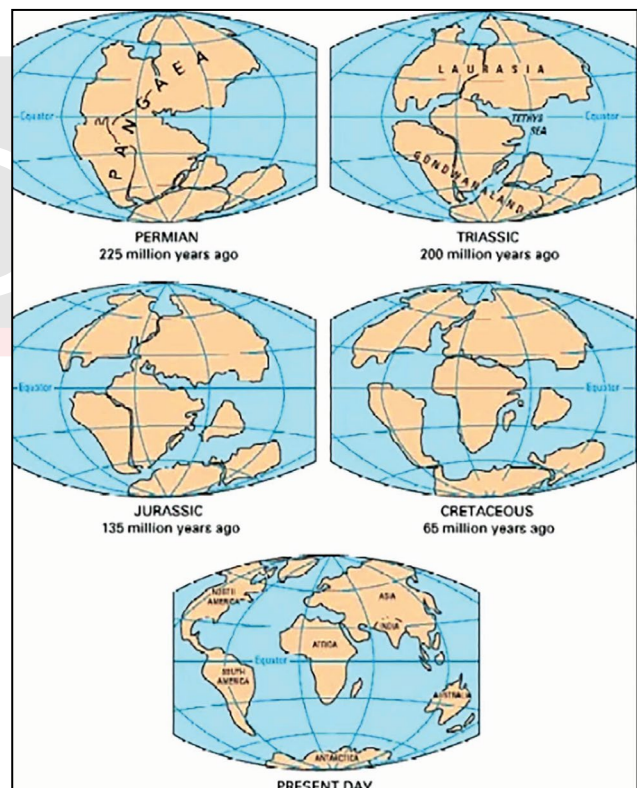


- The movement of the tectonic plates creates three types of tectonic boundaries:
 - **Convergent**, where plates move into one another.
 - **Divergent**, where plates move apart.
 - **Transform**, where plates move sideways in relation to each other.



➤ Continental Drift Theory:

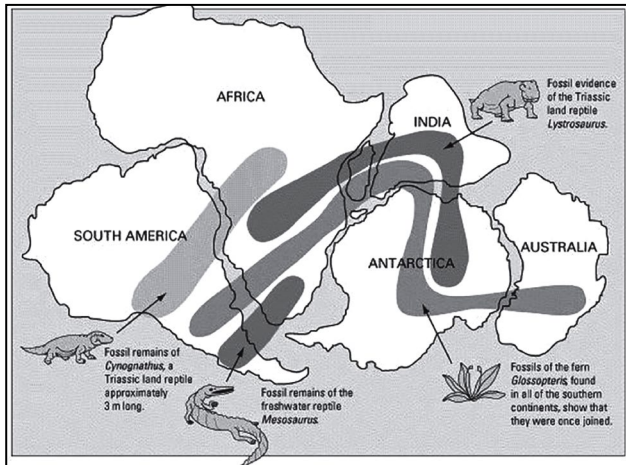
- Continental drift theory **deals with the distribution of the oceans and the continents**. It was first suggested by a German meteorologist, Alfred Wegener in 1912.
- According to the theory, all the continents formed a single continental mass- **Pangea** and mega ocean- **Panthalassa** surrounded it.
- Around 200 million years ago Pangea started splitting and **broke down into two large continental masses as Laurasia and Gondwanaland** forming the northern and southern components respectively.
- Subsequently, **Laurasia and Gondwanaland** continued to break into various smaller continents that exist today.



- **Prominent Evidence in Support of Continental Drift Theory**
 - **South America and Africa seem to fit in with each other**, especially the eastern bulge of Brazil fits into the Gulf of Guinea.
 - **Greenland seems to fit in with Ellesmere and Baffin islands.**
 - **The west coast of India, Madagascar and Africa seems to fit.**

Note:

- North and South America on one side and Africa and Europe on the other fit along the Mid-Atlantic Ridge.
- Alfred Wegner studied fossils of ancient plants and animals, geographical features on the borders of the continent and mineral resources and found similar results on the boundaries of the other continents.



Hunger Stones

Why in News?

Recently, Europe was suffering from the worst **drought**, therefore rivers have dried up and there is the emergence of **Hunger Stones**.



What are Hunger Stones?

- **About:**
 - They are the **common hydrological marker in central Europe** and date back to the **pre-instrumental era**.
 - They serve as **reminders to today's generation of previously dire water shortages**.
 - Usually found in Europe, they were embedded into rivers by our ancestors when rivers subsided to severe levels subsequently causing **famine and food shortages**.

- Many of the hunger stones found have unique carvings on them that seek to remind the next generation that if water levels get to this point, food availability will be affected.
- These stones were **embedded into the rivers in Germany & other German settlements from the 15th to 19th centuries**.

➤ Inscriptions:

- It expressed that drought had brought a bad harvest, lack of food, high prices, and hunger for poor people.

Drought in Europe

Why in News?

After the **record-breaking summer heat, 2022** may be the **worst drought year in Europe in 500 years**. Large rivers have been reduced to shallow streams, hitting power generation.

- **China and the US too are facing drought situations.**

What is a Drought?

➤ About:

- Drought is generally considered as a **deficiency in rainfall /precipitation over an extended period**, usually a season or more, resulting in a **water shortage causing adverse impacts on vegetation, animals, and/or people**.

➤ Causes:

- **Variability in rainfall**
- **Deviation in the route of monsoon winds**
- **Early withdrawal of the monsoon**
- **Forest fires**
- **Land degradation** in addition to **Climate change**

➤ Types:

- **Meteorological Drought:** It is based on the degree of dryness or rainfall deficit and the length of the dry period.
- **Hydrological Drought:** It is based on the impact of rainfall deficits on the water supply such as stream flow, reservoir and lake levels, and ground water table decline.
- **Agricultural Drought:** It refers to the impact on agriculture by factors such as rainfall deficits, soil water deficits, reduced groundwater, or reservoir levels needed for irrigation.

Note:

- **Socioeconomic Drought:** It considers the impact of drought conditions (meteorological, agricultural, or hydrological drought) on supply and demand of some economic goods such as fruits, vegetables, grains and meat.

How bad is the Drought Situation in Europe?

- **Present Scenario:**
 - The drought is considered the worst in 500 years. The European summer was this dry last in **1540**, when a **year-long drought killed tens of thousands of people**.
 - However, earlier European droughts such as those in **2003, 2010, and 2018** too were compared to the 1540 event.
 - Some of Europe's biggest rivers — **Rhine, Po, Loire, Danube** — which are usually formidable waterways, are unable to support even mid-sized boats.
 - As per an analytical report by the **Global Drought Observatory (GDO)**, an agency of the **European Commission**, about **64% of the continent's landmass was experiencing drought** conditions.
 - Nearly **90% of the geographical area in Switzerland and France**, about **83% in Germany**, and close to **75% in Italy**, was facing **agricultural drought**.
 - The **situation is unlikely to improve** substantially in the coming months.
- **Causes:**
 - Droughts are part of the natural climate system and are not uncommon in Europe. The extraordinary dry spell has been the result of a **prolonged and significant deviation from normal weather patterns**.
 - It is the **record-breaking heat waves** that have resulted in temperatures in many countries rising to historic highs.
 - Unusually high temperatures have led to **increased evaporation of surface water and soil moisture**.
 - The severity of the current drought can also be attributed, to an extent, to the fact that it occurred **so soon after the 2018 drought**.
 - **Many areas in Europe were yet to recover from the last drought**, soil moisture had also not been restored to normal.

What is Understood by Heat Waves?

- A heat wave is a **period of abnormally high temperatures** typically occurring between the months of March and June, and in some rare cases even extending till July.
- According to **India Meteorological Department (IMD)**, a heat wave is declared when the **maximum temperature of a station reaches at least 40°C for Plains and at least 30°C for Hilly regions**.

Impacts:

- **Transportation:** Europe depends heavily on its rivers to move cargo in an economical manner, including coal to power plants. With water levels down to less than a metre in some stretches, **most large ships have been rendered unusable**.
- **Power:** Power production has been hit, leading to **electricity shortages** and a further **increase in energy prices** which were already high due to the **war between Russia and Ukraine**.
 - Lack of adequate water has **affected the operation of nuclear power plants**, which use large amounts of water as coolant.
- **Food Security:** **Food has become sharply more expensive** in many countries, and **drinking water is being rationed** in some regions. **Agriculture** has also been affected badly.

What about the Drought Situations in the US and China?

Drought in China:

- Many parts of China too are headed towards a serious drought, **being described as the worst in 60 years**.
- The country's **longest river, Yangtze**, which caters to about a third of the Chinese population, is seeing water levels drop to record lows.
- Two of the country's biggest freshwater lakes, **Poyang and Dongting**, have reached their **lowest levels since 1951**.
- The water scarcity is leading to problems similar to those in Europe.
 - The drought has posed a **"serious threat" to China's autumn grain production** which makes up about 75% of the country's annual grain output.

Note:

- Power shortages in some areas have begun to **force factories to shut**, adding to the **strain on global supply chains**.

➤ Drought in the US:

- According to the US government, **over 40% of the area in the United States too is under drought conditions** currently, affecting about 130 million people.

How Drought is Declared in India?

- In India, there is **no single, legally accepted definition** of drought. The **State Government is the final authority** when it comes to declaring a region as drought affected.
- The Government of India has published two important documents in respect of managing a drought.
 - The first step is to **look at two mandatory indicators - rainfall deviation and dry spell**.
 - Depending on the extent of the deviation, and whether or not there is a dry spell, the manual specifies various situations that may or may not be considered a drought trigger.
 - The second step is to **look at four impact indicators — agriculture, vegetation indices** based on remote sensing, **soil moisture, and hydrology**.
 - The **States may consider any three of the four types** of the Impact Indicators (one from each) for assessment of drought, the intensity of the calamity and make a judgement.
 - If all three chosen indicators are in the 'severe' category, it amounts to **severe drought**; and if two of the three chosen impact indicators are in the 'moderate' class, it amounts to **moderate drought**.
 - The third step comes in after both previous triggers have been set off. In that event, **"States will conduct sample surveys for ground** in order to make a final determination of drought.
 - The finding of field verification exercise will be the final basis for judging the intensity of drought as 'severe' or 'moderate'.
- Once a drought is determined, the state government needs to **issue a notification specifying the geographical extent**. The **notification is valid for six months unless de-notified earlier**.

Mahanadi River

Why in News?

The **Indian Meteorological Department (IMD)** has forecast a heavy rainfall causing the **flood situation** in the Mahanadi River, Odisha.

- The low-pressure area is expected to form over the north Bay of Bengal and trigger **heavy rainfall** at a few places in Odisha and Chhattisgarh.

What is the India Meteorological Department (IMD)?

- IMD was **established in 1875**.
- It is an agency of the **Ministry of Earth Sciences**.
- It is the principal agency responsible for meteorological observations, weather forecasting and seismology.

What are the Key Points of Mahanadi River?

➤ About:

- The Mahanadi River system is the **third largest of peninsular India after Godavari and Krishna**, and the **largest river of Odisha** state.
- The catchment area of the river **extends to Chhattisgarh, Madhya Pradesh, Odisha, Jharkhand and Maharashtra**.
- Its basin is **bounded by the Central India hills** on the north, by the **Eastern Ghats** on the south and **east and by the Maikala range** in the west.

➤ Source:

- It originates from the **Amarkantak hills of the Bastar Plateau in Raipur district** of Chhattisgarh.

➤ Major Tributaries:

- The Seonath, the Hasdeo, the Mand and the Ib joins Mahanadi from **left** whereas **the Ong, the Tel and the Jonk joins it from right**.

➤ Mahanadi River Dispute:

- The Central Government constituted **Mahanadi Water Disputes Tribunal in 2018**.

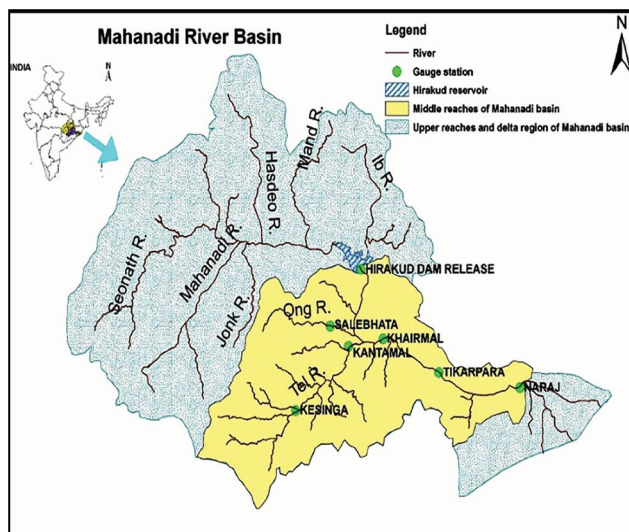
➤ Major Dams/Projects on Mahanadi:

- **Hirakud Dam**: This is the longest dam of India.
- Ravishankar Sagar, Dudhawa Reservoir, Sondur Reservoir, Hasdeo Bango and Tandula are other major projects.

Note:



- **Urban Centres :**
 - Three important urban centres in the basin are **Raipur, Durg and Cuttack.**
- **Industries:**
 - Mahanadi basin, because of its rich mineral resource and adequate power resource, **has a favourable industrial climate.**
 - **Iron and Steel plant** at Bhilai
 - **Aluminium factories** at Hirakud and Korba
 - **Paper mill** near Cuttack
 - **Cement factory** at Sundargarh.
 - Other industries based primarily on agricultural produce are **sugar and textile mills.**
 - **Mining of coal, iron and manganese** are other industrial activities.



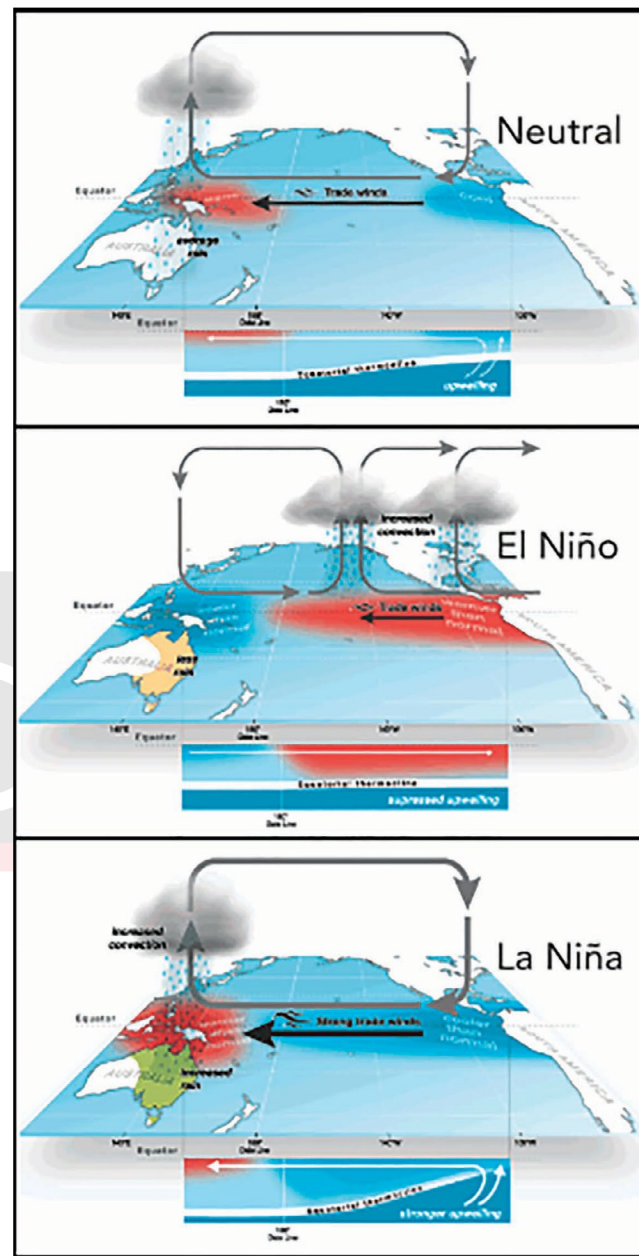
Third Consecutive La Nina Event

Why in News?

Recently, **Australia's Bureau of Meteorology (BOM)** predicted, that a third consecutive event of La Nina could be underway which could lead to unusual weather effects in various countries.

- There is an **extended period of La Nina in 2022.** It is the **first time that this has happened since the 1950s** when the event started to be recorded. The years 1973-76 and 1998-2001 were consecutive La Nina years.

What is La Nina and El Nino?



➤ Normal Condition:

- In the neutral state (neither El Niño nor La Niña) **trade winds blow east to west across the surface of the tropical Pacific Ocean, bringing warm moist air and warmer surface waters towards the western Pacific** and keeping the central Pacific Ocean relatively cool.
 - Warm sea surface temperatures in the western Pacific pump heat and moisture into the atmosphere above.

Note:

- In a process known as **atmospheric convection**, this **warm air rises high into the atmosphere and, if the air is moist enough, causes towering cumulonimbus clouds and rain.**
 - The pattern of **air rising in the west and falling in the east with westward moving air at the surface is referred to as the Walker Circulation.**

➤ La Nina:

- La Nina means the **Little Girl in Spanish. It is also sometimes called El Viejo, anti-El Nino, or simply "a cold event."**
- La Nina events represent periods of **below-average sea surface temperatures** across the **east-central Equatorial Pacific.**
 - It is indicated by **sea-surface temperature decreased by more than 0.9 for at least five successive three-month seasons.**
- La Nina event is observed when the **water temperature in the Eastern Pacific gets comparatively colder than normal**, as a consequence of which, there is a **strong high pressure over the eastern equatorial Pacific.**
- **Impacts:**
 - **Europe:** In Europe, El Nino reduces the number of autumnal hurricanes.
 - La Nina tends to lead to **milder winters in Northern Europe** (especially UK) and **colder winters in southern/western Europe** leading to snow in the Mediterranean region.
 - **North America:** It is continental North America where most of these conditions are felt. The wider effects include:
 - **Stronger winds along the equatorial region**, especially in the Pacific.
 - **Favourable conditions for hurricanes** in the Caribbean and central Atlantic area.
 - **Greater instances of tornados** in various states of the US.
 - **South America:** La Nina causes **drought in the South American countries of Peru and Ecuador.**
 - ◆ It usually has a **positive impact on the fishing industry** of western South America.
 - **Western Pacific:** In the western Pacific, La Nina increases the **potential for landfall** in those areas

most vulnerable to their effects, and especially into **continental Asia and China.**

- It also leads to **heavy floods in Australia.**
- There are **increased temperatures** in Western Pacific, Indian Ocean and off the Somalian coast.

➤ EL Nino:

- **El Nino** is a climate pattern that describes the **unusual warming of surface waters in the eastern tropical Pacific Ocean.**
 - It is the "warm phase" of a larger phenomenon called the **El Nino-Southern Oscillation (ENSO).**
 - It occurs more frequently than La Nina.
- **Impacts:**
 - **Impact on Ocean:** El Nino also impacts ocean temperatures, the speed and strength of ocean currents, the health of coastal fisheries, and local weather from Australia to South America and beyond.
 - **Increased Rainfall:** Convection above warmer surface waters brings increased precipitation.
 - Rainfall increases drastically in South America, contributing to coastal flooding and erosion.
 - **Diseases caused by Floods and Droughts:** Diseases thrive in communities devastated by natural hazards such as flood or drought.
- El Nino-related flooding is associated with increases in cholera, dengue, and malaria in some parts of the world, while drought can lead to wildfires that create respiratory problems.
 - **Positive impact:** It can sometimes have a positive impact too, for example, El Nino reduces the instances of hurricanes in the Atlantic.
 - **In South America:** As El Nino brings rain to South America, it brings droughts to Indonesia and Australia.
 - These droughts threaten the region's water supplies, as reservoirs dry and rivers carry less water. Agriculture, which depends on water for irrigation, is also threatened.
 - **In Western Pacific:** These winds **push warm surface water** towards the western Pacific, where it borders **Asia and Australia.**
 - Due to the warm trade winds, the sea surface is normally about **0.5 meter higher** and **4-5° F warmer in Indonesia than Ecuador.**

Note:



- The westward movement of warmer waters causes **cooler waters to rise up** towards the surface on the coasts of **Ecuador, Peru, and Chile**. This process is known as **upwelling**.
- ◆ Upwelling elevates cold, nutrient-rich water to the euphotic zone, the upper layer of the ocean.

➤ **El Nino-Southern Oscillation (ENSO):**

- The **combined phases of La Nina and El Nino** are termed **El Nino-Southern Oscillation (ENSO)** and affect rainfall patterns, global atmospheric circulation, and atmospheric pressure across the planet.

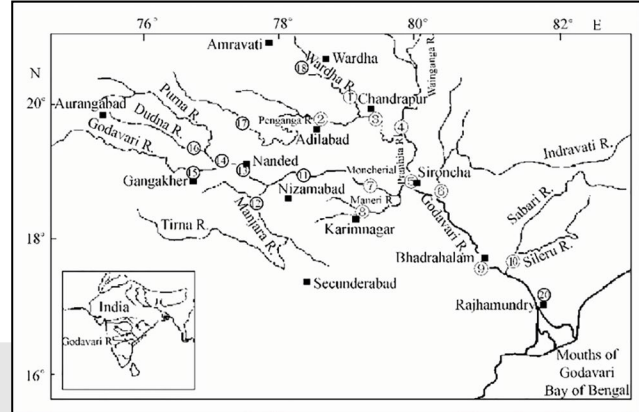
What will be the Impacts of Third Consecutive La Nina?

- The **India Meteorological India (IMD)** has stated in its report that La Nina conditions currently prevail over the equatorial Pacific Ocean.
- **Impacts on India:**
 - **Extreme weather:**
 - The India Meteorological India (IMD) has predicted that **some parts of India may witness heavy rains**.
 - The Western Ghats may receive average or below-average rain.
 - Winter rainfall is less than normal in North India.
 - Snowfall over Western Himalayas is less than normal.
 - Winter temperatures in the plains are less than normal.
 - Prolonged Winter Season over North India (extended winters).
 - More rain during the second half of the Northeast Monsoon.
 - **Negative Impact on Agriculture:**
 - Farmers will be at risk of **losing their standing Kharif crops** if it rains during this period.
 - As the **harvesting of the Kharif crops begins in September-end or early October** and any rain just before that would prove detrimental to the standing crops.
 - Farmers will suffer a double whammy if untimely rains coincide with the harvest.

Godavari River

Why in News?

Recently, Officials issued the second warning with the flood level crossing 50 feet in **Godavari River at Bhadrachalam, Telangana**, and the flow in the river crossing the 13-lakh cusecs mark.



Why is the River Overflowing?

- Due to **heavy rains in the catchment areas** in Upper Godavari Basin.
- Discharge of water from Medigadda Barrage, receding with inflow coming down into all reservoirs.
- Discharge of water from projects in the Krishna Basin, Almatti, Narayanpur, and Tungabhadra in Karnataka, which get most of the inflows into projects in Telangana and Andhra Pradesh.
 - **Further, Srisaialam reservoir (Hydro-electric Power plant)** was getting over 3.60 lakh cusecs flood and discharge was over 3.17 lakh cusecs.

What are the Key Points of Godavari River?

- **About:**
 - The Godavari is the **largest Peninsular River system**. It is also called the **Dakshin Ganga**.
 - The basin is bounded on the north by the **Satmala hills**, on the south by the **Ajanta range and the Mahadeo hills**, on the east by the Eastern Ghats and on the west by the Western Ghats.
- **Source:**
 - Godavari River rises from **Trimbakeshwar near Nasik** in Maharashtra and flows for a length of about 1465 km before **outfalling into the Bay of Bengal**.

Note:

- **Drainage Basin:**
 - The Godavari basin extends over states of **Maharashtra, Telangana, Andhra Pradesh, Chhattisgarh and Odisha** in addition to smaller parts in Madhya Pradesh, Karnataka and Union territory of Puducherry.
- **Tributaries:**
 - Pravara, Purna, Manjra, Penganga, Wardha, Wainganga, Pranhita (combined flow of Wainganga, Penganga, Wardha), Indravati, Maner and the Sabri.
 - The Pravara, Manjira and Maner are **right bank tributaries**.
 - The Purna, Pranhita, Indravathi and Sabari are important **left bank tributaries**
- **Cultural Significance:**
 - **Kumbh Mela** also takes place on the **banks of the Godavari River in Nashik**.
 - Other locations for Kumbh are the **Shipra River in Ujjain, the Ganges in Haridwar, and the confluence of the Ganges, Yamuna, and the mythical Saraswati River in Prayag**.
- **Urban Centers:**
 - Nagpur, Aurangabad, Nashik, Rajhmundry.
- **Industries:**
 - Nashik and Aurangabad have a large number of industries, especially **automobiles**.
 - The industries in the basin are mostly based on agricultural produce such as rice milling, cotton spinning and weaving, sugar and oil extraction.
 - Cement and some small engineering industries also exist in the basin.
- **Important Projects on Godavari:**
 - Polavaram Irrigation Project
 - Kaleshwaram.
 - Sadarmatt Anicut
 - Inchampalli project
 - Sriram Sagar Project (SRSP)

New Insights in Geology

Why in News?

A recent study by a team of scientists at Goa-based **National Centre for Polar and Ocean Research (NCPOR)** has brought new insights into the critical processes involved in the **movement of the earth's tectonic plates**.

What is NCPOR?

- NCPOR was established as an **autonomous Research and Development Institution** of the **Ministry of Earth Sciences** (formerly Department of Ocean Development) on the 25th May 1998.
- It is designated as the **nodal organization** for the co-ordination and implementation of the **Indian Antarctic Programme**, including the maintenance of India's permanent station in Antarctica.
- Year-round maintenance of the two Indian stations (**Maitri & Bharati**) in Antarctica is the primary responsibility of the Centre.
 - Maitri (1989) and Bharati (2011) were established, for carrying out research by the Indian scientists in all disciplines of polar research.

What do we need to know about the Study by NCPOR?

- **Background:**
 - The buoyant rising of **hot and low-density magma or plumes** from the Earth's interior towards the surface **leads to extensive volcanism** and the **creation of seamounts and volcanic chains** above the ocean floor.
 - However, many times, the magma's buoyant force is **not sufficient to pierce through the lithosphere**.
 - In such cases, plumes tend to dump the material at **sub-lithospheric depths**. When the tectonic plates that lie over the lithosphere move, **they tend to drag the ponded materials along with them**.
 - A fundamental question that remains outstanding in understanding earth's processes is **how far a tectonic plate can drag the plume material** at its base after its initial impact with the plume.
- **About Study:**
 - Scientists studied samples of **igneous rocks collected from near the Ninety East Ridge** in the **Indian Ocean** during an expedition under the **International Ocean Discovery Program (IODP)**.
 - The Ninety East Ridge is an **aseismic ridge located almost parallel** to 90 degrees east longitude in the Indian Ocean. It is approximately 5,000 km in length and has an average width of 200 km.

Note:

- Igneous rock, or magmatic rock, is one of the three main rock types, the others being sedimentary and metamorphic.
 - It is formed through the cooling and solidification of magma or lava.
- Investigation revealed that some **basaltic samples were highly alkaline** and had very **similar composition to those released by the Kerguelen hotspot** (volcanic hotspot at the Kerguelen Plateau in the Southern Indian Ocean).
 - In addition, **the minimum age of alkaline samples was about 58 million years**, much younger than the adjacent oceanic crust surrounding Ninety East Ridge (around 82-78 million years old)
- This study proposes that the Indian Tectonic Plate, which was **contemporaneously moving northward at a very high speed**, had dragged a considerable amount of Kerguelen plume material **for more than 2,000 km underneath the Indian lithosphere**.
- **Subsequent reactivation of deep fractures** may have triggered decompression melting of the underlying plume material and emplaced as **magmatic sills** and lava flows near the Ninety East Region around 58 million years ago.

What do we know about Earth's Crust?

- **Crust:**
 - The **outer superficial layer of the earth is called the "crust"**. In continental regions, the crust can be **divided into two layers**.
 - The **upper layer** which is less dense and granitic in character, is known as "**sial**", while the **lower layer** which is basaltic in character is known as "**sima**".
 - It extends down to **30 or 40 kilometer beneath continents and to about 10 km beneath ocean basins**
- **Mantle:**
 - The **mantle is located beneath the earth's crust** and has a thickness of about 2900 km.
 - It has been divided into two layers: **(i) upper mantle, and (ii) lower mantle**.
 - The boundary between these is at about 700 km depth.
 - The upper mantle contains a most important zone called the "**asthenosphere**". It is located at depths between 50 to 100 km.

- This zone **provides lava for volcanic eruptions**.
- **Core:**
 - The **core** (inner core and the outer core) accounts for just about **16%** of the earth's volume but **33% of earth's mass**.
 - Like Mantle, core can also be distinguished into two layers namely **outer core and inner core**.
 - The outer core is composed of **iron** mixed with **nickel** and trace amounts of lighter elements.
 - The outer core is **not under enough pressure to be solid**, so it is **liquid** even though it has a composition similar to the inner core.

Derecho

Why in News?

- Recently, a few States of US were hit by a storm system called a **Derecho**, turning Sky Green.
- They mostly **occur across central and eastern parts** of the United States. In 2009 "**Super Derecho**" was **one of the "most intense and unusual derechos ever observed"** in the US as it swept from Kansas to Kentucky (US States) with wind speeds reaching up to 170 km/hr.
- In 2010, **Russia witnessed its first documented derecho**. They have also swept through **Germany and Finland, and more recently in Bulgaria and Poland**.

What is Derecho?

- **About:**
 - A Derecho is "**a widespread, long-lived, straight-line windstorm**" that is associated with a "**band of rapidly moving showers or thunderstorms**".
 - The name comes from the Spanish word '**la derecha**' which means 'straight'.
 - Straight-line storms are those **in which thunderstorm winds have no rotation unlike a tornado**. These storms travel hundreds of miles and cover a vast area.
 - It is a **warm-weather phenomenon** that generally occurs in June and July.
 - They are a **rare occurrence as compared to other storm systems** like tornadoes or **hurricanes**.
- **Types:**
 - **Progressive:**

Note:

- A progressive derecho is associated with a **short line of thunderstorms that may travel for hundreds of miles** along a relatively narrow path.
- It is a summer phenomenon.
- **Serial:**
 - A serial derecho, on the other hand, **has an extensive squall line – wide and long – sweeping across a large area.**
 - It usually occurs during spring or fall.
- **Hybrid:**
 - Hybrid ones have the **features of both progressive and serial derechos.**

What Makes Sky Green Amid Derecho?

- Severe thunderstorms result in a 'green sky' **due to light interacting with the huge amount of water they hold.**
- The **big raindrops and hail scatter away all but the blue wavelengths** due to which primarily blue light penetrates below the storm cloud.
- This blue then combines with the red-yellow of the afternoon or the evening sun to produce green.

Sakurajima Volcano: Japan

Why in News?

Recently, the Sakurajima Volcano erupted on Japan's major western island of Kyushu.



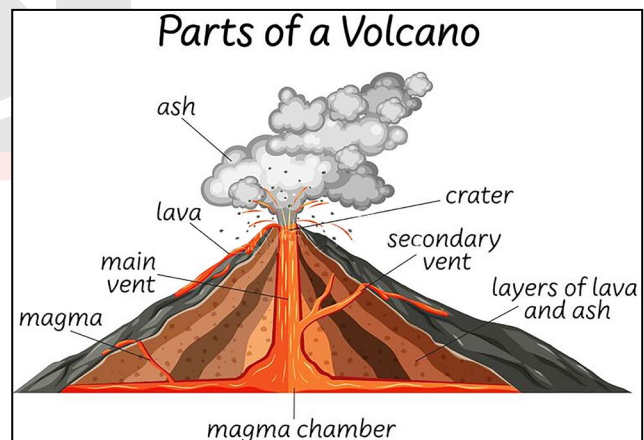
- In 2021, the **Fukutoku-Okanoba Submarine Volcano** exploded in the **Pacific Ocean**, off Japan.

What is Sakurajima Volcano?

- Sakurajima is **one of Japan's most active volcanoes** and eruptions of varying levels take place on a regular basis.
- It is an **active stratovolcano.**
- The largest historical eruptions of Sakurajima took place during 1471-76 and in 1914.
- Its eruption has been recorded since the 8th Century.
- Due to its frequent deposition of ash on Kagoshima, and due to its explosive potential, it is considered as **one of the very dangerous volcanoes.**

What is a Volcano?

- **About:**
 - A volcano is **an opening on the surface of a planet or moon that allows material warmer than its surroundings to escape from its interior.**



- When this material escapes, it causes an eruption. An eruption can be explosive, sending material high into the sky. Or it can be calmer, with gentle flows of material.
- On Earth, the erupted material can be liquid rock ("lava" when it's on the surface, "magma" when it's underground), ash, cinders, and/or gas.
- **Reasons for Magma Rise:**
 - Magma can rise when pieces of **Earth's crust called tectonic plates slowly move away from each other.** The magma rises to fill in the space. When this happens, underwater volcanoes can form.
 - Magma also rises when these **tectonic plates** move toward each other. When this happens, part of

Note:

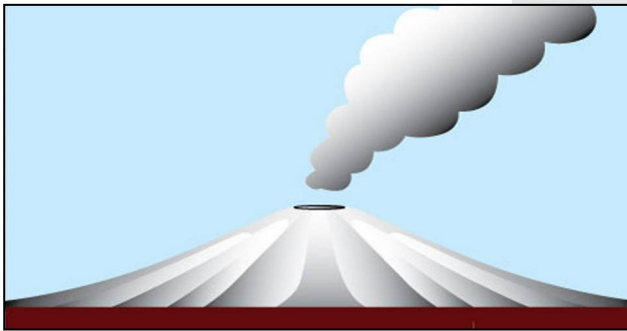
Earth's crust can be forced deep into its interior. The high heat and pressure cause the crust to melt and rise as magma.

- The final way that magma rises is over **hot spots**. Hot spots are the hot areas inside of Earth. These areas heat up magma. The magma becomes less dense. When it is less dense it rises. Each of the reasons for rising magma are a bit different, but each can form volcanoes.

➤ **Types:**

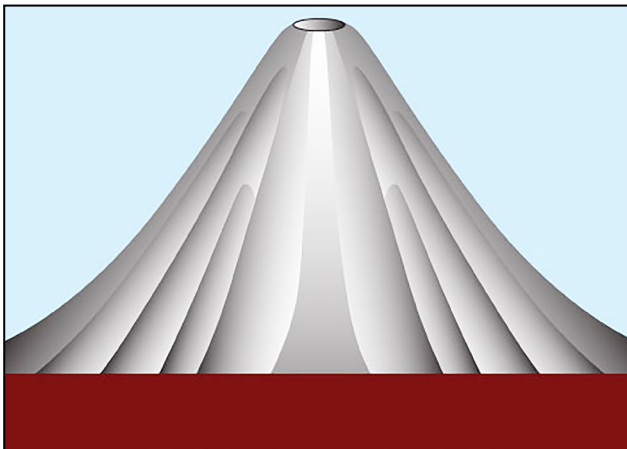
○ **Shield volcanoes:**

- A volcano **produces low viscosity, runny lava, it spreads far from the source and forms a volcano with gentle slopes.**
- Most shield volcanoes are formed **from fluid, basaltic lava flows.**
 - **Mauna Kea and Mauna Loa are shield volcanoes.** They are the world's largest active volcanoes around the island of Hawai'i.



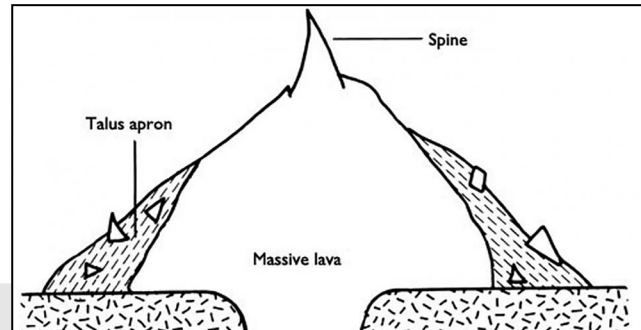
○ **Stratovolcano:**

- Stratovolcanoes have **relatively steep sides and are more cone-shaped than shield volcanoes.**
- They are formed from viscous, sticky lava that does not flow easily.



➤ **Lava dome:**

- The Soufrière Hills volcano, on the Caribbean island of Montserrat, is well known for its lava dome complex at the summit of the volcano, which has gone through phases of growth and collapse. As viscous lava is not very fluid, it cannot flow away from the vent easily when it is extruded. Instead it piles up on top of the vent forming a large, dome-shaped mass of material.



○ **Caldera:**

- Magma is **stored beneath a volcano in a magma chamber.** When a very large, explosive eruption occurs that empties the magma chamber, the roof of the magma chamber can collapse to form a depression or bowl with very steep walls on the surface.
- These are calderas and can be tens of miles across.



What about the Volcanoes in India?

- Barren Island, Andaman Islands (India's only active volcano)
- Narcondam, Andaman Islands
- Baratang, Andaman Islands
- Deccan Traps, Maharashtra
- Dhinodhar Hills, Gujarat
- Dhosi Hill, Haryana

Note:

Unified Geologic Map of the Moon

Why in News?

Recently, the **United States Geological Survey (USGS)** in partnership with **National Aeronautics and Space Administration (NASA)** and the Lunar Planetary Institute has released a new comprehensive map of the Moon, called the '**Unified Geologic Map of the Moon**'.

- The **new map showcases the Moon in a 1:50,00,000-scale size**, and is claimed to come handy to researchers, scientists, students and the general public.
- The map has been **created with the help of the information gathered** from six **Apollo-era regional maps**.
 - It also uses data from **recently held satellite missions to the Moon**.

What is the Significance of this New Map?

- **Blueprint for Future Human Mission:**
 - This new map will serve as the "**definitive blueprint of the Moon's surface geology for future human missions**."
- **Help in understanding the Moon Surface:**
 - It will come handy to **understand the surface of the Moon**.
 - The map will also **help researchers learn the history behind the formations** located on the Moon's surface.
 - Earlier, a leftover piece of a spacecraft flying (of Chang'e 5-T1 – a lunar mission of China) through space reportedly hit the surface of the moon creating a new crater that may be around 65 feet wide (**lunar crater**).

What are the key

Highlights about the Moon?

- **About:**
 - The Moon is **Earth's only natural satellite** and the fifth largest moon in the solar system.
 - The Moon's presence **helps stabilize our planet's wobble** and moderate our climate.
 - The Moon's distance from Earth is about 240,000 miles.

- The Moon has a **very thin atmosphere called an exosphere**.

➤ Phases of the Moon:

- The Moon displays four main phases: new, first quarter, full, and last quarter.
 - **New Moon:** It occurs when the **Moon is between Earth and the Sun**, and thus the side of the Moon that is in shadow faces Earth.
 - **Full Moon:** It occurs when the **Moon is on the opposite side of Earth from the Sun**, and thus the side of the Moon that is illuminated faces Earth.
 - **First and Last Quarter:** In this phase, half the Moon appears illuminated, occurring when the Moon is at a right angle with respect to the Sun when viewed from Earth. (Earth, as seen from the Moon, shows the same phases in opposite order—e.g., Earth is full when the Moon is new.)

➤ Related Missions:

- **Chandrayaan-3 Mission (India)**
- **Artemis I moon mission (USA)**
- **Chang'e-5 Mission (China)**

Residual Flood Damage under Intensive Adaptation

Why in News?

According to a new Study published, **Residual Flood Damage under Intensive Adaptation**, the risk of river flooding is expected to increase with **climate change** and socioeconomic development.

- Residual flood damage under intensive adaptation tries to **estimate the global cost of employing adaptive flood measures** depending on local economic scenarios and cost adaptation measures by trying to quantify the cost of **Residual Flood Damage (RFD)**.

What is RFD?

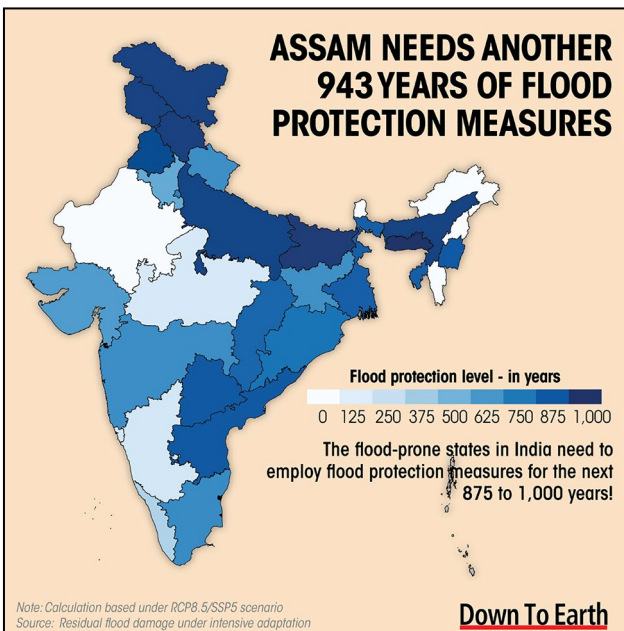
- RFD refers to the unavoidable increases in flood damage even under an adaptation strategy based on feasible adaptation costs.
 - Adaptation strategy in the context of floods includes infrastructural measures employed to mitigate flood risks.

Note:

- RFD is the part of total **Expected Annual Damage (EAD)**.
 - The expected annual damage is the average of flood damages calculated over a number of events.
- It is calculated by subtracted past EAD (1970-2000) and future EAD estimates (set to 1000 years).

What are the Findings?

- **Assam will need 943 years of flood protection measures to prevent a crisis like the one it is witnessing** if its pace of preparedness and climate adaptation doesn't increase.
 - In 2022, the flooding started as early as May, with 62% above average rainfall from March-May — a 10-year high.
 - Currently, 33 of Assam's 35 districts have been affected due to flooding along the Brahmaputra basin. Over 4.2 million people have been affected by floods this year, while over 100,000 hectares of cropland have been damaged as of June 20.
- Other **flood-prone states like Bihar, Uttar Pradesh and Meghalaya** will need 966, 935 & 996 years respectively.
 - In India, **riverine floods — considered one of the major natural disasters — have become synonymous with economic losses**. The total flood-related losses in the country were estimated to be over Rs 37 lakh crores from 1953-2017, according to the **Central Water Commission**.



- RFD in South Asia is estimated to be around USD 4 million and adaptive costs around USD 3 million.
- RFD (as a part of the **gross domestic product**) **remained high in eastern China, northern parts of India and the central regions of the African continent**.
- RFD can be reduced with shorter construction periods or lower adaptation costs, implying the **need for immediate and appropriate adaptation actions, including enhanced financial support for high-risk regions**.

What is Flood?

- **About:**
 - It is an **overflow of water onto land that is normally dry**. Floods can happen during **heavy rains, when ocean waves come on shore**, when snow melts quickly, or when dams or levees break.
 - Damaging flooding may happen with only a few inches of water, or it may cover a house to the rooftop. **Floods can occur within minutes or over a long period**, and may last days, weeks, or longer. Floods are the most common and widespread of all weather-related natural disasters.
 - **Flash floods are the most dangerous kind of floods**, because they combine the destructive power of a flood with incredible speed.
- Flash floods occur when **heavy rainfall exceeds the ability of the ground to absorb it**.
- They also occur when water fills normally dry creeks or streams or enough water accumulates for streams to overtop their banks, causing rapid rises of water in a short amount of time.
- They can happen **within minutes of the causative rainfall**, limiting the time available to warn and protect the public.
- **Measures:**
 - **National Disaster Management Authority (NDMA)**
 - **Sandai Framework for Disaster Risk Reduction**
 - **National Flood Commission**
 - **Disaster Management Act, 2005**
 - **Flood Plain Zoning**

Note:

Snake Island

Why in News?

Ukraine has caused significant losses to the Russian military in airstrikes on Zmiinyi Island, also known as **Snake Island**, in the **Black Sea**.

- The hit on the island is believed to be the second major military success using missiles given to Ukraine by the West.



Where is Snake Island?

- **Features:**
 - **Zmiinyi Island**, also known as **Snake or Serpent Island**, is a small piece of rock less than 700 metres from end to end, that has been described as being **X-shaped**.
- **Location:**
 - It is located 35 km from the coast in the **Black Sea**, to the east of the mouth of the **Danube** and roughly southwest of the **port city of Odesa**.
 - The Danube is the **second longest river in Europe after the Volga**. It rises in the Black Forest mountains of western Germany and flows for some 2,850 km to its mouth on the Black Sea.
 - The island is marked on the map by the tiny village of Bile that is located on it, belongs to **Ukraine**.

Where is the Black Sea?



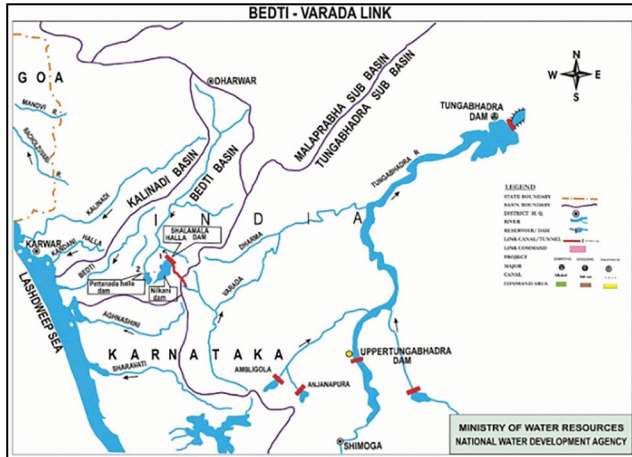
- **Surrounded by:**
 - Black Sea is bound by **Ukraine to the north and northwest, Russia and Georgia to the east, Turkey to the south, and Bulgaria and Romania to the west**.
- **Straits:**
 - **Black Sea links to the Sea of Marmara through the Bosphorus and then to the Aegean Sea through the Dardanelles**, has traditionally been Russia's warm water gateway to Europe.
 - The Black Sea is also connected to the **Sea of Azov** by the **Strait of Kerch**.
- **Significance for Russia:**
 - **Strategic Buffer:**
 - **Black Sea** is both a stepping stones to the **Mediterranean** as well as a **strategic buffer** between **NATO** Countries and Russia.
 - **Geostrategic Significance:**
 - **Domination of the Black Sea region is a geostrategic imperative for Moscow, both to project Russian power in the Mediterranean and to secure the economic gateway to key markets in southern Europe.**
 - **Russia** has been making efforts to **gain complete control over the Black Sea since the Crimean crisis of 2014**.
 - The domination of the Black Sea has been a major Russian objective of the ongoing war, along with the land bridge to connect Russia and Crimea.
 - **Cutting Ukrainian access to the Black Sea** will reduce it to a **landlocked country** and deal a crippling blow to its trade logistics.

Note:

Bedti-Varada River Interlinking Project

Why in News?

Environmental groups in Karnataka have criticised the project to link the **Bedti and Varada rivers in Karnataka**, calling it unscientific and a waste of public money.



What is the Bedti-Varada Project?

- The **Bedti-Varada project** was envisaged in **1992** to **supply drinking water**.
- The plan aims to link the **Bedti**, a river flowing west into the **Arabian Sea**, with the **Varada**, a tributary of the **Tungabhadra River**, which flows into the **Krishna**, which in turn flows into the **Bay of Bengal**.
- A **massive dam** will be erected at **Hirewadatti in Gadag district**.
- A **second dam** will be built on the **Pattanahalla river at Menasagoda in Sirsi, Uttara Kannada district**.
- **Both dams will take water to the Varada** via tunnels.
- The water will reach **Kengre** and will then go down a **6.88 km tunnel to Hakkalumane**, where it will join the **Varada**.
- The project thus envisages taking water from the water surplus **Sirsi-Yellapura region of Uttara Kannada district** to the arid **Raichur, Gadag and Koppal districts**.
- A total of **302 million cubic metres** of water from **Pattanahalla and Shalmalahalla tributaries of the Bedti and Varada rivers**, while **222 million cubic metres** of water will be drawn from the **barrage at Suremane built against the Bedti river**.

- The Project would need **61 megawatts** of power to pull the water all the way to **Gadag**. Even after this, it is unknown whether the water would reach **Gadag**.

What are the Issues associated with this Project?

- **Difficult to Redirect:**
 - It is difficult to redirect a westward-flowing river to flow eastward.
- **Rain-fed Rivers:**
 - In early summer, the **Bedti and Varada rivers** begin to dry up.
 - It is a **sad irony that government scientists plan to interconnect these rivers** under the pretext of providing drinking water despite knowing well that **they do not flow all year**.
- **Project Report not Accurate:**
 - The **Detailed Project Report (DPR)** drawn up by the irrigation department is **not accurate** as it was drawn without assessing the availability of water and quoting the observation of the **National Water Development Agency (NWDA)** report on the interconnection of the **Bedti-Aghanashini and Varada rivers**.
- **Environmental Impact:**
 - Over **500 acres of forests will be lost**. The end result will be that **there will still be no water**.
 - Flora and fauna will also suffer due to this project.
 - The **Bedti valley** has been designated as an **active biodiversity zone** by the **International Union for Conservation of Nature**.
 - The area is home to **1,741 types of flowering plants as well as 420 species of birds and animals**.
 - The nutrients that the river carries with it are responsible for sustaining fish **stocks, especially in the Bedti's estuary in Dedi**.
 - The river valley serves as a corridor for around **35 different animal species**. The **Bedti is known as Gangavali** in the estuary region.
- **Affect Lifelines for Thousands:**
 - The **Bedti and Varada rivers are also lifelines for thousands of farmers** in the **Malenadu region**, the foothills of the **Western Ghats**, in addition to fishing communities along the coast.

Note:

Summer Solstice: 21st June

Why in News?

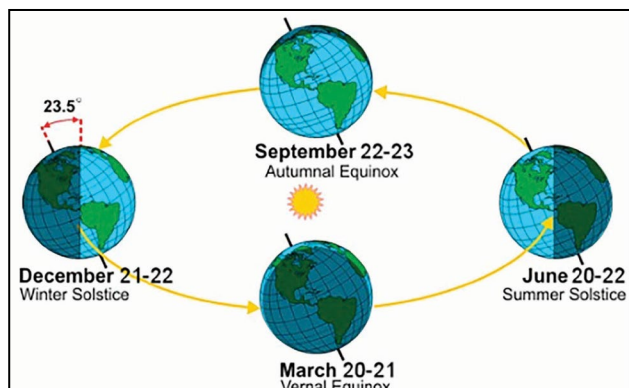
21st June is the day of the **Summer Solstice** in the northern hemisphere.

- The day is observed as the **International Day of Yoga**.

What is the Summer Solstice?

➤ About:

- **Solstice** is a **Latin word that means 'stalled sun'**. It is a natural **phenomenon that occurs twice every year**, once in the summer and again during winter, in each hemisphere of the earth - Summer and **Winter Solstice**.
- It is the **longest day and shortest night of the year in the Northern Hemisphere**.
- During this, **countries in the Northern Hemisphere are nearest to the Sun** and the Sun shines overhead on the Tropic of Cancer (23.5° North).
 - At latitudes of 23.5° are the Tropics of Cancer and Capricorn, north and south of the Equator.
 - At 66.5° are the Arctic and Antarctic Circles, to the north and south.
 - Latitudes are a measure of a location's distance from the Equator.
- During the solstice, **the Earth's axis — around which the planet spins, completing one turn each day — is tilted in a way that the North Pole is tipped towards the sun and the South Pole is away from it**.
- Typically, this imaginary axis passes right through the middle of the Earth from top to bottom and is always tilted at 23.5 degrees with respect to the sun.



➤ Greater Amount of Energy:

- This day is characterised by a greater amount of energy received from the sun. According to **NASA (National Aeronautics and Space Administration)**, the amount of incoming energy the Earth received from the sun on this day is 30% higher at the North Pole than at the Equator.
- The **maximum amount of sunlight received by the Northern Hemisphere during this time is usually on June 20, 21 or 22**. In contrast, the Southern Hemisphere receives most sunlight on December 21, 22 or 23 when the northern hemisphere has its longest nights— or the winter solstice.

What is the Geography Behind the Solstice?

- The reason behind it is the **changing lengths of the days is the Earth's tilt**.
- The Earth's **axis of rotation is tilted at an angle of 23.5°** to its orbital plane. This tilt, combined with factors such as Earth's spin and orbit, leads to variations in the duration of sunlight, due to which any location on the planet receives different lengths of days.
 - The Northern **Hemisphere spends half the year tilted in the direction of the Sun**, getting direct sunlight during long summer days. During the other half of the year, it tilts away from the Sun, and the days are shorter.
- The tilt is **also responsible for the different seasons on Earth**. This phenomenon causes the movement of the Sun from the northern to the southern hemisphere and vice versa bringing in seasonal changes in the year.

What is the Equinox?

- Twice each year, **during the equinoxes ("equal nights")**, Earth's axis is not pointed toward our Sun, but is perpendicular to the incoming rays.
- It results in a **"nearly" equal amount of daylight and darkness** at all latitudes.
- The vernal or spring equinox occurs in the northern hemisphere on March 20 or 21. September 22 or 23 marks the northern hemisphere **autumnal or fall equinox**.

Note:

Theri Desert

Why in News?

There are couple of theories that are being debated regarding the formation of Theri desert, the most plausible being the role of **south west monsoonal winds**.

What is the Theri Desert?

- It is a **small desert** situated in the state of **Tamil Nadu**. It consists of **red sand dunes** and is confined to **Thoothukudi district**.
- The red dunes are called **theri** in Tamil. They consist of sediments dating back to the **Quaternary Period** (began 2.6 million years ago) and are made of marine deposits.
- They **have very low water and nutrient retention capacity**. The dunes are susceptible to aerodynamic lift. This is the push that lets something move up. It is the force that is the opposite of weight.

What is the Mineral Composition of Theri?

- The petrographical study (petrography is the study of composition and properties of rocks) and X-ray diffraction analysis (a method used to determine a material's crystallographic structure) of the red sand dunes reveal the presence of heavy and light minerals.
- These include: Ilmenite, Magnetite, Rutile, Garnet, Zircon, Diopside, Tourmaline, Hematite, Goethite, Kyanite, Quartz, Feldspar and Biotite.
- The iron-rich heavy **minerals like ilmenite, magnetite, garnet, hypersthene and rutile present in the soil had undergone leaching by surface water** and were then oxidised because of the favourable semi-arid climatic conditions.
- It was **due to these processes** that the **dunes** near Tiruchendur, a coastal town of Thoothukudi district are **red-coloured**.
How Theri Dunes Were formed?
- Theri appears as gentle, undulating terrain. The **lithology** (the study of general physical characteristics of rocks) **that the area might have been a paleo (ancient) coast in the past**. The presence of limestone in many places indicates marine transgression.
- The present-day theris might have been formed by the confinement of beach sand locally, after regression of the sea. When high velocity winds from the Western

Ghats blew east, they induced migration of sand grains and accumulation of dunes.

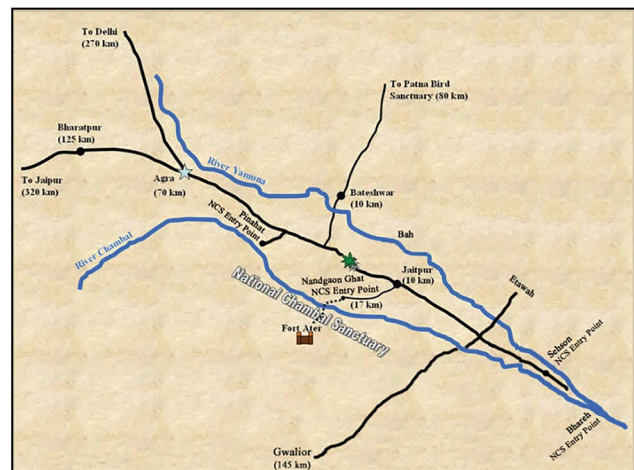
- **Another view is that these are geological formations** that appeared in a period of a few hundred years.
- There is a lot of red sand spread over these *theris*. The **red sand is brought from the surface of a broad belt of red loam in the plains** of the Nanguneri region (about 57 kilometres from this area in Tirunelveli district) **by south west monsoon winds** during May-September.
- Deforestation and absence of vegetative cover are considered to be the major causes of wind erosion.
- When the dry monsoon wind blows with high velocity, the red loam is churned and driven east in huge columns of red sand, till they are met by sea breeze near the coastal tract of Tiruchendur and get deposited there.
- These **processes of erosion, transport and deposit of sediments** that are **caused by wind** at or near the surface of the earth, are called **Aeolian processes**. They lead to continual sand redistribution.

National Chambal Sanctuary

Why in News?

Recently, the Madhya Pradesh government has proposed to open 292 hectares for mining in five stretches on **Chambal and its tributary Parvati rivers**.

- The step is taken to free its forest department from devoting too much time, resources, and efforts in fighting illegal mining in the **National Chambal Sanctuary**.
- Sand mining has been banned in the sanctuary since 2006.



Note:

Where is National Chambal Sanctuary?

➤ About:

- It was set up in 1979 as a riverine sanctuary along an approximately 425 km length of the Chambal River.
- Its ravines stretches over 2-6 km wide along the **Chambal River** near the tri-point of Rajasthan, Madhya Pradesh and Uttar Pradesh.
- The National Chambal Sanctuary is listed as an **Important Bird Area (IBA)** and is a proposed **Ramsar site**.

What are Important Bird Areas (IBAs)?

- **Birds are excellent indicators of ecosystem health.**
- The **IBA programme of Birdlife International** aims to identify, monitor and protect a global network of IBAs for **conservation of the world's birds and associated biodiversity**.
- The **Bombay Natural History Society** and **Birdlife International** have identified **554 IBAs in India**.
- 40% of these IBAs fall outside the Protected Area network and thus form an important tool for landscape-level conservation planning.
- According to Birdlife International, designation of IBAs is based on standardized criteria, namely:
 - **A: Global**
 - **A1. Species of Global Conservation Concern:**
 - The site regularly holds significant numbers of a **globally threatened species**, or other species of global conservation concern.
 - **A3. Biome-Restricted Species:**
 - The site is known or thought to hold a significant assemblage of the species whose breeding distributions are largely or wholly **confined to one biome**.
 - **A4. Congregations**
 - i. The site is known or thought to hold, on a regular basis, **≥ 1% of the biogeographic population of a congregatory waterbird species**.
 - ii. The site is known or thought to hold, on a regular basis, **≥ 1% of the global population of a congregatory seabird or terrestrial species**.
 - iii. The site is known or thought to hold, on a regular basis, **≥ 20,000 waterbirds or ≥ 10,000 pairs of seabird of one or more species**.

➤ Ecological Significance:

- The National Chambal Sanctuary is **home to critically endangered Gharial (small crocodiles), the red-crowned roof turtle** and the endangered **Ganges River dolphin**.
 - Chambal supports the largest population of Gharials in the wild.
- Only known place where nesting of **Indian Skimmers** is recorded in large numbers.
- Chambal supports **8 rare turtle species** out of the 26 found in the country.
- Chambal is one of the **cleanest rivers in the country**.
- Chambal supports more than **320 resident and migrant birds**.

➤ Economic Support:

- Locals directly depended on various resources of the Sanctuary. They **farm along the river**, extract river water for **irrigation**, practice **sustenance and commercial fishing**, and **quarry sand**.

What are the Other Sanctuaries and National Parks of Madhya Pradesh?

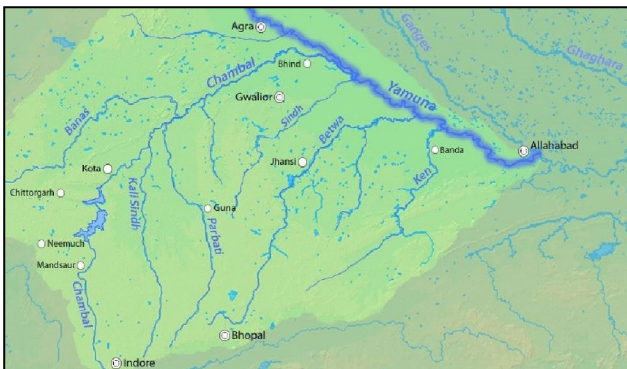
- Madhya Pradesh has **9 National Parks and 25 Sanctuaries** spread over an area of 10,862 square km constituting 11.40% of the total forest area and 3.52% of the geographical area of the state.
- At present, the state has **5 Project Tiger** areas in the state namely –
 - **Kanha National Park**
 - **Panna National Park**
 - **Bandhavgarh National Park**
 - **Pench National Park**
 - **Satpura National Park**
- It is also known as the '**Tiger State**' as it occupies around 19% of India's Tiger Population and 10% of the world's tiger population.

Chambal River

- It is one of the most **pollution-free rivers** of India.
- It's a 960 km. long river that originates at the **Singar Chouri peak** in the northern slopes of the **Vindhya** mountains (Indore, Madhya Pradesh). From there, it flows in **North direction** in Madhya Pradesh for a length of about 346 km and then follows a **north-easterly direction** for a length of 225 km through Rajasthan.

Note:

- It enters U.P. and flows for about 32 km before joining the **Yamuna River** in Etawah District.
- It is a **rainfed river** and its basin is bounded by the **Vindhyan** mountain ranges and the **Aravallis**. The Chambal and its tributaries drain the **Malwa region** of northwestern Madhya Pradesh.
- **Tributaries:** Banas, Kali Sindh, Parbati.
- **Main Power Projects/ Dam:** Gandhi Sagar Dam, Rana Pratap Sagar Dam, Jawahar Sagar Dam, and Kota Barrage.
- The **National Chambal Sanctuary** is located along river Chambal on the tri-junction of Rajasthan, Madhya Pradesh and Uttar Pradesh. It is known for **critically endangered gharial, the red-crowned roof turtle, and the endangered Ganges river dolphin.**



High-grade lithium discovered in Nigeria

Why in News?

Recently, **High-grade Lithium** has been discovered in Nigeria.

- **Greenbushes mine** in **Western Australia** is the **largest hard-rock Lithium mine** in the world.
- The largest importers of lithium are **South Korea, China, Japan, US and Belgium.**

What are the Key Highlights of Lithium?

- **About:**
 - Lithium is an element and in nature tends to concentrate sufficiently in the two minerals, **spodumene and lepidolite.**
 - They are usually **found in specialised rocks called rare Cand greisens.**

- The **Geological Agency** described lithium as **high grade** because it is found with 1-13% oxide content. Normally exploration begins at levels as low as 0.4%.
- **Grade (in %)** is a **measure of the concentration of lithium in the minerals and or rocks that contain it.**
- Therefore, the **higher the grade the more the economic viability.** Higher grades are very rare for metals like lithium.
- **Applications:**
 - **Special Glasses and Ceramics:**
 - **Lithium disilicate ($\text{Li}_2\text{Si}_2\text{O}_5$)** is a chemical compound that is a glass ceramic.
 - It is widely used as a dental ceramic due to its **strength, machinability and translucency.**
 - **Alloy Making:**
 - Lithium metal is used to make useful alloys.
 - For example, with lead to make **'white metal'** bearings for motor engines, with aluminium to make aircraft parts, and with magnesium to make Armour plates.

➤ Rechargeable batteries:

- **Lithium is used in rechargeable batteries for mobile phones, laptops, digital cameras and electric vehicles.** Lithium is also used in some non-rechargeable batteries for things like heart **pacemakers, toys and clocks.** The different types of batteries are:
 - **Lithium-cobalt oxide battery:** It is used in **consumer electronics** and is being applied in **electric vehicles.** It is relatively **cheap.**
 - **Lithium-nickel-manganese-cobalt:** It is a newer, higher performing range of battery chemistry. It is mainly developed for the electronic vehicle market but is finding a wider use because of its increasing cost effectiveness.
 - **Lithium iron phosphate:** It is the safest technology with relatively **high performance but relatively expensive.** It is very popular in China.
 - **Lithium-nickel-cobalt-aluminium oxide:** It is developed **to reduce cobalt consumption** and is known as a **solid performer** and of reasonable cost. It is also **becoming popular outside China.**
- **High Demand:**
 - Due to the growing interest in **clean energy,** the **demand for lithium has skyrocketed as most**

Note:

countries draw plans to phase out fossil fuel and switch to zero emission electric vehicles.

- Lithium production globally grew from 28,100 metric tonnes in 2010 to 86,000 in 2019. The challenge will be in supplying the market with enough lithium.

➤ **Lithium in India:**

- Researchers at the **Atomic Minerals Directorate (under India's Atomic Energy Commission)** have estimated **lithium reserves of 14,100 tonnes** in a small patch of land surveyed in **Southern Karnataka's Mandya district**.
- Also, to be **India's first ever Lithium deposit site**.

What are the Steps taken by India to reduce import of Lithium?

- India has adopted a **multi-modal strategy to reduce its dependence on imported lithium** and give fresh impetus to the growth of the **local electric vehicles (EV) industry**.
- State-run **Khanij Bidesh India Ltd (KABIL)** is working with the authorities in **Argentina, Chile, Australia and Bolivia** for acquiring lithium and cobalt mines overseas.
 - These nations are rich in lithium reserves.
- The country is also working on **urban mining** where recycled materials remain in circulation and this reduces the dependency on fresh lithium inputs. This will further bring down the requirement for imports.

Cyclone Asani

Why in News?

The **India Meteorological Department (IMD)** has predicted the **Cyclone Asani** to intensify into a **'severe cyclone'** over Southeast regions of Bay of Bengal.

- The name **Cyclone Asani** has been given by **Sri Lanka**. It means 'wrath' in Sinhalese.
- Cyclones that Hit India in 2020-21: **Tauktae, Yaas, Nisarga, Amphan**.

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.

- Cyclone Gulab became the third cyclone of the 21st century to make landfall over the east coast in September, after tropical cyclone Daye in 2018 and Pyarr in 2005.

- Typically, **tropical 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.

What is Classification?

- The IMD classifies cyclones **on the basis of the Maximum Sustained Surface Wind Speed (MSW)** they generate.
- The cyclones are classified as severe (MSW of 48-63 knots), very severe (MSW of 64-89 knots), extremely severe (MSW of 90-119 knots) and super cyclonic storm (MSW of 120 knots or more). One knot is equal to 1.8 kmph (kilometers per hour).

What are the Tropical Cyclones?

- 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 South East 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.
- 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.

Note:

Pre-Monsoon Devastation in Assam

Why in News?

While the **Monsoons** are yet to arrive, Assam has already been beset by **Floods and Landslides** that have left 15 people dead and more than 7 lakh affected.

- The hill district of **Dima Hasao**, in particular, has been ravaged by flash floods and landslides, with connectivity to the rest of the state snapped.

What are the Factors behind this Unprecedented Devastation?

- **Excess Pre-Monsoon Rainfall:**
 - The average rainfall for the period of 1st March to 20th May in Assam is 434.5 mm, the corresponding number for this year is 719 mm which amounts to a 65 % excess.
 - The neighbouring state of Meghalaya has recorded an even greater excess of 137%.
- **Climate Change:**
 - The Timing and the Scale of Rainfall can be attributed to Climate Change.
 - Because of climate change, **there are more and more concentrated rain and heavy rainfall episodes.**

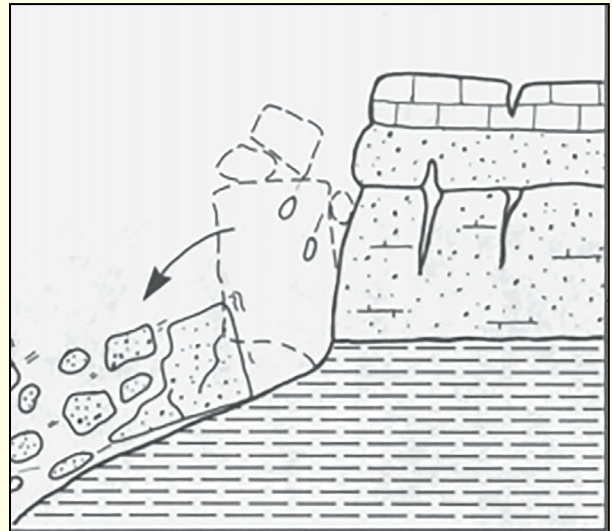
What is Causing the Landslides During Pre-monsoon?

- It is because of “**undesirable, unpragmatic, unplanned structural intervention on the fragile landscape** of hills.
- Over the years, there has **not only been massive deforestation for the extension of the railway line and the four-line highway**, but there has also been **rampant riverbed mining often done in collusion** with the district authorities.
- Many roads are being built over streams and spring water sources and hastily carried out infrastructure developmental work in assam and Nearby States has led to an **increase in landslides in the state in recent years.**

What is Landslide?

- **About:**
 - 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.**



➤ Related Steps:

- The **Geological Survey of India (GSI)** has done a **national landslide susceptibility mapping** for 85% of the entire 4,20,000 square km landslide-prone area in the country. The **areas have been divided into different zones according to the propensity of the disaster.**
 - **Improvement in early warning systems, monitoring and susceptibility zoning** can reduce the damage caused by landslides

Twin Cyclones

Why in News?

Recent satellite images have Captured Twin Cyclones **in the Indian Ocean region**, one in the northern hemisphere and one in the southern hemisphere, named cyclone Asani and cyclone Karim respectively.

What are Cyclone Karim and Asani?

- Karim is classified as a **category II hurricane**, with a wind speed of 112 kilometers per hour (kmph).
- Asani remains a **Severe Cyclonic Storm over the Bay of Bengal**, with wind speeds of 100-110 kmph gusting to 120 kmph.

Note:

- Both were formed in the **Indian Ocean region**.
- Both cyclones **originated in the same longitude and now drifting apart**.
- Cyclone Karim has **created a path in the open seas west of Australia**.
- The name Karim was given by the **South African country Seychelles**. The name Cyclone Asani was suggested by Sri Lanka.

What are Twin Cyclones?

- The interplay of the wind and the **monsoon system** combined with the Earth system produces these synchronous cyclones.
- The twin tropical cyclones are caused by what are called **equatorial Rossby waves**.
 - **Rossby waves are huge waves in the ocean with wavelengths of around 4,000–5,000 kilometres**.
 - Rossby waves are named for famous meteorologist Carl-Gustaf Rossby who was the first to explain that **these waves arose due to the rotation of the Earth**.
- This **system has a vortex in the northern hemisphere and another in the southern hemisphere**, and each of these is a mirror image of the other.
- The vortex in the **north spins counterclockwise and has a positive spin, while the one in the southern hemisphere spins clockwise in the clockwise direction and therefore has a negative spin**.
- Both have a **positive value of the vorticity which is a measure of the rotation**.
- Very often **twin cyclones are formed from these Rossby waves**.

How do Cyclones Form?

- When the vorticity is positive in both Northern and Southern hemispheres, as is the case with Rossby waves, the air in the boundary layer, which is moist, is lifted slightly.
- That is **enough to set off a feedback process**.
- When the air is lifted slightly, the water vapour condenses to make clouds. As it condenses, **it lets out the latent heat of evaporation**.
- The atmosphere warms, this parcel of air rises, and positive feedback is set off by this process. The warmer parcel of air can rise further because it is lighter than the surrounding air, and it can form deeper clouds.

Meanwhile, moisture comes in from both sides. This leads to the formation of a cyclone if certain conditions are present.

- The ocean's surface temperature has to be 27 degrees or warmer; the wind shear in the atmosphere must not be too high.
 - For example, if you have westerly winds at the lower level and easterly winds at the upper level, if the difference between them is too high, **cyclones will not form**.
 - But **if the difference is modest, cyclones will still form**.
- There will be a big, tall vortex with all sorts of clouds inside. Once they are stronger, they will spin faster and faster and organise themselves into the big storms.

Will the Two Cyclones Necessarily Move to Different Hemispheres?

- Yes, once formed they will generally move west. In the Northern Hemisphere, they will have a slightly northerly component of motion, while in the southern hemisphere they usually have a slightly southern component to their movement.
- So, this means that in the northern hemisphere the cyclone is moving north and west, while the southern one is moving south and west.

Does Madden-Julian Oscillation (MJO) Give Rise to Twin Cyclones?

- The MJO is a **large cluster of clouds and convection**, about 5,000-10,000 kilometers in size.
- It is **composed of a Rossby wave and a Kelvin wave**, which is a type of wave structure that we see in the ocean. On the eastern side of the MJO is the Kelvin wave, while on the western, trailing edge of the MJO is the Rossby wave, again with two vortices on either side of the equator.
- However, **not all tropical cyclones are born from the MJO**. Sometimes it's just a Rossby wave with two eddies on either side.

Flood Plain Zoning

Why in News?

Recently, the Ministry of Jal Shakti has informed the **Rajya Sabha** that the states of Manipur, Rajasthan,

Note:



Uttarakhand and erstwhile State of Jammu & Kashmir had enacted the **National Floodplains Zoning Policy**.

- However, **delineation and demarcation of flood plains is yet to be undertaken**.
- Earlier, the **Comptroller and Auditor General of India (CAG)** presented a report on preparedness and response to floods in the Kerala assembly.
 - The report pointed out that the state is yet to enact flood plain zoning legislation, 45 years after the Union Government circulated to all states a **model draft bill for flood plain zoning legislation**.

What is Flood Plain Zoning?

- **About:**
 - Flood Plain Zoning has been recognized as an effective non-structural measure for **flood management**.
 - The basic concept of flood plain zoning is to **regulate land use in the flood plains to restrict the damage** caused by floods.
- **Features:**
 - **Determining Developmental Activities:** It aims at **determining the locations and the extent of areas** for developmental activities in such a fashion that the damage is reduced to a minimum.
 - **Adds Limitations:** It envisages **laying down limitations on development of both the unprotected as well as protected areas**.
 - In the unprotected areas, boundaries of areas in which developmental activities will be banned, are to be established to prevent indiscriminate growth.
 - In the protected areas, only such developmental activities can be allowed, which will not involve heavy damage in case the protective measures fail.
 - **Utility:** Zoning cannot remedy existing situations, although, **it will definitely help in minimising flood damage in new developments**.
 - Flood plain zoning is not only necessary in the case of floods by rivers but it is also useful in reducing the damage caused by drainage congestion particularly in urban areas.

What is India's Status of Vulnerability to Floods?

- India's **high risk and vulnerability is highlighted** by the fact that 40 million hectares out of a geographical area of 3290 lakh hectares is prone to **floods**.

- On an average every year, **75 lakh hectares of land is affected, 1600 lives are lost and the damage caused to crops**, houses and public utilities is Rs. 1805 crores due to floods.

What is a Model Bill for Flood Plain Zoning?

- **About:** The Bill provides **clauses about flood zoning authorities, surveys and delineation of flood plain area, notification of limits of flood plains, prohibition of the use of the flood plains**, compensation and most importantly removing obstructions to ensure free flow of water.
 - It **seeks to replace dwellings in low-lying areas** by parks and playgrounds as absence of human settlement in those areas would cut down loss of lives and property.
- **Challenges in Implementation:**
 - There has been **resistance on the part of the states to follow-up the various aspects** of floodplain management including possible legislation.
 - The reluctance of the states is mainly due to population pressure and want of alternative livelihood systems.
 - The lukewarm response of the states towards the enactment and enforcement of the floodplain regulations has **fuelled a significant increase in the encroachments into the flood plains**, sometimes authorised and duly approved by the town planning authorities.

What are the Related Constitutional Provisions and Other Measures?

- Based on the inclusion of drainage and embankments as **entry 17 of List II (State List)**, **flood control has been seen to fall under the purview of the state government**, except in the case of "regulation and development of inter-state rivers and river valleys," which is mentioned in **entry 56 of List I (Union List)**.
 - Floodplain zoning is firmly **within the state government's ambit** as it deals with the land along the riverbanks and land is a state subject under entry 18 of List II.
 - The central government's role can only be to issue advisories and prescribe guidelines.
- Flood control and mitigation are not directly mentioned in any of the three legislative lists included in the **seventh schedule Constitution**.

Note:

- The **National Disaster Management Authority (NDMA)** in 2008 has issued guidelines for states for floodplain zoning as an important “non-structural measure” to mitigate floods.
 - It suggested that areas likely to be affected by floods in a frequency of 10 years should be reserved for green areas like parks, gardens and others while concrete structures should not be allowed there.
 - It also talked about other zones in the floodplain like in areas of flooding in a 25-year frequency and asked states to make plans accordingly in those areas.

Tapi-Par-Narmada Link Project

Why in News?

Recently, some tribals have **intensified their protest against the Par-Tapi-Narmada river linking project** after it was mentioned in the **budget speech (2022-23)** of the finance minister.



What is the Background?

- These projects had been **sanctioned in 2010**, when a **tripartite agreement** was signed between the Union government, Gujarat and Maharashtra.
- The Finance Minister in her **Budget Speech** said that **five river linking projects will be taken up** after consensus among states.

- The projects are **Damanganga-Pinjal, Par-Tapi-Narmada, Godavari-Krishna, Krishna-Pennar and Pennar-Cauveri**.
- The **Ken-Betwa** is the **first project** under the government's **National Perspective Plan for river inter-linking**.
 - The **National River Linking Project (NRLP)** formally known as the National Perspective Plan, envisages the transfer of water from water 'surplus' basins where there is flooding, to water 'deficit' basins where there is drought/scarcity, through inter-basin water transfer projects.

What is the Par-Tapi Narmada River Linking Project?

- Par Tapi Narmada Link proposes to **transfer water from the water surplus regions of Western Ghats to the water deficit regions of Saurashtra and Kutch (Gujarat)**.
- The link project includes seven reservoirs **proposed in north Maharashtra and south Gujarat**.
- The water from the **seven proposed reservoirs would be taken through a 395 km long canal** to take over a part of the command of the on-going Sardar Sarovar Project (on Narmada), while irrigating small enroute areas.
 - The **seven dams proposed in the scheme** are Jheri, Mohankavchali, Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan.
- This would save **Sardar Sarovar water** which will be used to extend irrigation in Saurashtra and Kutch region.
- The link mainly **envisages construction of seven dams, three diversion weirs, two tunnels, 395 km long canal, 6 power houses** and a number of cross-drainage works.

What will be the Benefits of the Project?

- Besides providing **irrigation benefits to the enroute command** and Narmada command, the link will **generate hydropower** of the order of 93.00 Mkw through the power houses installed at four dam sites.
- The reservoirs will **also provide flood relief to the people** residing in downstream areas.

Note:

India to Receive Normal Monsoon: IMD

Why in News?

Recently, the **India Meteorological Department (IMD)** released its **first Long Range Forecast (LRF)** for 2022 which says that the **country is likely to receive a normal monsoon for the fourth consecutive year.**

- While forecasting a 'normal' southwest monsoon for this year, IMD also **revised downwards the definition** of what constitutes average rainfall.
- Every year, the **IMD issues a two-stage forecast:** the first one in April and the second one in the last week of May, which is a more detailed forecast and also illustrates how the monsoon will spread over the country.

What is the India Meteorological Department (IMD)?

- IMD was **established in 1875.**
- It is **an agency of the Ministry of Earth Sciences.**
- It is the principal agency responsible for meteorological observations, weather forecasting and seismology.

What are the Key Highlights of the Forecast?

- **India will get Normal Monsoon:**
 - India would get **99% of the Long Period Average (LPA) rainfall** — changed from 89 cm to 88 cm in 2018, and in the periodic update in 2022, again revised to 87 cm.
 - A monsoon is **considered "normal"** when rainfall falls between **96% and 104% of the LPA.**
- **EL Nino not Expected:**
 - The IMD does **not expect an El Nino** but currently **La Nina conditions are prevailing over the equatorial Pacific** which will continue during the monsoon.
 - El Nino is a **phenomenon associated with a warming of the Central Pacific** and drying up of the rains over northwest India, the coming monsoon.
 - La Nina events represent periods of **below-average sea surface** temperatures across the east-central Equatorial Pacific.

- It is **indicated by sea-surface temperature** decreased by more than 0.9°C for at least five successive three-month seasons.

“Normal” to “above Normal” Rainfall:

- Current **indications suggest “normal” to “above normal” rainfall** in the northern parts of peninsular India, central India and the Himalayan foothills.
- Many **parts of northeast India and southern parts of South India** are expected to see a subdued monsoon.

What is the Long Period Average (LPA)?

- According to the IMD, the **“LPA of rainfall is the rainfall recorded over a particular region** for a given interval (like month or season) averaged over a long period like 30 years, 50 years, etc”.
 - The **IMD predicts a “normal”, “below normal”, or “above normal” monsoon** in relation to a benchmark **“Long Period Average” (LPA).**
- The IMD has in the **past calculated the LPA at 88 cm for the 1961-2010 period**, and at 89 cm for the 1951-2000.
 - It calculated the LPA at 87 cm **for the 1971-2020 period.**
- While this quantitative benchmark refers to the average rainfall recorded from June to September for the entire country, the amount of rain that falls every year varies from region to region and from month to month.
- Therefore, along with the countrywide figure, the **IMD also maintains LPAs for every meteorological region of the country.**
 - This **number ranges from around 61 cm** for the drier Northwest India to more than 143 cm for the wetter East and Northeast India.

Mullaperiyar Dam Issue

Why in News?

Recently, the **Supreme Court** ordered the reconstitution of the **Mullaperiyar dam’s supervisory committee.**

- The committee will include **one technical expert each from Tamil Nadu and Kerala**, the two States involved in the dispute concerning safety of the dam.

Note:



What was the Supreme Court Ruling?

- The court has **empowered the panel with functions and powers** on par with that of the **National Dam Safety Authority (NDSA)**.
 - NDSA is a body envisaged under the **Dam Safety Act, 2021**.
- For any act of failure, “appropriate action” will be taken against the persons concerned not only for having violated the directions of the court but also under the Act
 - The act **talks of one year imprisonment or fine or both for refusal** to comply with directions of bodies formed under the law.
- As per the Supreme Court latest order, the **two States are expected to nominate, within two weeks**, one representative each to the supervisory committee, in addition to one nominee each.

What do we Know about the Mullaperiyar Dam?

- The Mullaperiyar, a **126-year-old dam**, is located on the **confluence of the Mullayar and Periyar rivers** in Kerala’s Idukki district.
- The dam stands at the height of 53.66 metres and 365.85 metres in length.

- The **dam** is owned, operated and maintained by Tamil Nadu.
 - **Tamil Nadu maintained it for several purposes**, including irrigation, drinking water supply and hydro-power generation.

What are the Key Highlights about Periyar River?

- The Periyar River is the **longest river in the state of Kerala** with a length of 244 km.
- It is also known as ‘**Lifeline of Kerala**’ as it is one of the few perennial rivers in the state.
- Periyar River originates from **Sivagiri hills of Western Ghats**, in Tamil Nadu and flows through the Periyar National Park.
- The **main tributaries** of Periyar are Muthirapuzha, **Mullayar**, Cheruthoni, Perinjankutti.

What is the Dispute?

- In late 1979, after the eruption of the controversy over the structural stability of the dam, it was **decided at a tripartite meeting** chaired by K. C. Thomas, the then Chairman of the **Central Water Commission** that the **water level be lowered to 136 feet** against the full reservoir level of 152 feet so that Tamil Nadu could take up strengthening measures.
- In 2006 and 2014 the **Supreme Court held that the water level be raised to 142 feet**, up to which Tamil Nadu stored water even last year (2021).
- The court’s judgment of 2014 also **provided for the formation of the supervisory committee** and the completion of the remaining work by Tamil Nadu.
 - But, **there has been no end to litigation over the dam** with Kerala witnessing **landslides** in recent years.
- Though **there had been no reports of landslides in the vicinity of the dam site**, the events in other parts of the **State led to a renewed campaign against the dam**.
- The Kerala government **proposed that the existing dam be decommissioned** and a fresh one be built
 - These **options are not completely acceptable to Tamil Nadu** which wants to complete the remaining strengthening work and restore the level to 152 feet.

What is Dam Safety Act?

- **About:**
 - The Dam Safety Act, 2021 came into **force in December 2021**.

Note:

- The act is aimed at addressing the long-felt need for addressing issues concerning the safety of major dams all over the country.
- It provides for surveillance, inspection, operation, and maintenance of certain dams for prevention of disasters related to dam failure, apart from institutional mechanisms to ensure their safe functioning.
- The Act covers those dams having a height of over 15m and between 10m and 15m with certain stipulations.
- **Create two National Institutions:**
 - **National Committee on Dam Safety (NCDS):** It seeks to evolve dam safety policies and recommend necessary regulations, and the
 - **National Dam Safety Authority (NDSA):** It seeks to implement policies and address unresolved issues between the two States. The NDSA will be the regulatory body.
- **Create two State Level Institutions:**
 - The legislation also envisages the formation of **State Dam Safety Organisations and State Committees on Dam Safety.**
 - **Dam owners will be held responsible** for the construction, operation, maintenance, and supervision of dams.

How does the Dam Safety Act Affect Mullaperiyar?

- Since the act provides that the **NDSA will perform the role of the State Dam Safety Organisation for a dam located in one State and used by another**, the Mullaperiyar dam, strictly speaking, comes under the purview of the NDSA.
- Besides, the Supreme Court, which has been hearing petition after petition after its judgment in 2014, **mooted the idea of extending the powers of its supervisory committee** to take over charge of the safety and maintenance of the structure.

Kwar Hydroelectric Project

Why in News?

The Cabinet Committee on Economic Affairs (CCEA) has approved the **540-megawatt Kwar hydroelectric project on the Chenab in Kishtwar district of Jammu and Kashmir.**

What is the Kwar Project?

- This is part of the **Indus basin** and would be one of at least four projects coming up in the district, including the 1,000 MWs **Pakal Dul hydroelectric project** and 624 MWs run-of-the-river **Kiru hydroelectric project.**
- Under the 1960 vintage **Indus Water Treaty (IWT)** between India and Pakistan, the two countries share the waters of six rivers in the Indus basin that flow through India towards Pakistan.
 - Of these, India has complete rights over three eastern rivers - Sutlej, Beas and Ravi, while Pakistan has rights over the western rivers - Chenab, Jhelum, and Indus.
- The Kwar project will be implemented by Chenab Valley Power Projects Private Ltd (CVPPPL), a joint venture company between NHPC Ltd and Jammu & Kashmir State Power Development Corporation (JKSPDC).
- The project is expected to generate 1975.54 million units in a 90% dependable year.
- The construction activities of the Project would result in direct and indirect employment of about 2,500 people.

What are the Key Points of Chenab River?

- **Source:** It rises in the upper Himalayas in the Lahaul and Spiti district of Himachal Pradesh state.
 - The river is formed by the confluence of two rivers, Chandra and Bhaga, at Tandi, 8 km southwest of Keylong, in the Lahaul and Spiti district.
 - The Bhaga river originates from Surya taal lake, which is situated a few kilometers west of the Bara-lacha la pass in Himachal Pradesh.
 - The Chandra river originates from glaciers east of the same pass (near Chandra Taal).
- **Flows Through:** It flows through the Jammu region of Jammu and Kashmir into the plains of Punjab, Pakistan, before flowing into the Indus River.
- **Some of the important projects/dams on Chenab:**
 - **Ratle Hydro Electric Project**
 - Salal Dam- hydroelectric power project near Reasi
 - Dul Hasti Hydroelectric Plant- power project in Kishtwar District
 - Pakal Dul Dam (under construction)- on a tributary Marusadar River in Kishtwar District.
 - Kiru Hydroelectric Project (Kishtwar District)

Note:



Seafloor Spreading

Why in News?

According to a study that analyzed data from the last 19 million years, **Seafloor spreading rates have slowed down by roughly 35% globally.**

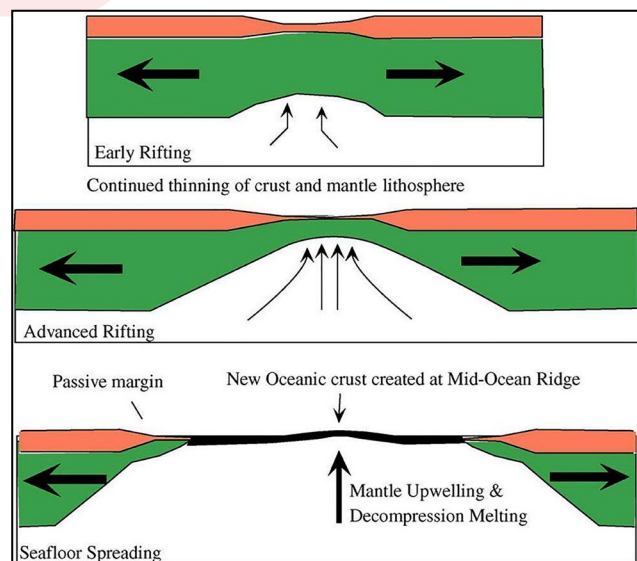
What are the Highlights of the Study?

- For this study, researchers **selected 18 of the world's largest spreading ridges** (mid-ocean ridges).
 - A ridge or a mountain ridge is a **geographical feature consisting of a chain of mountains or hills** that form a continuous elevated crest for an extended distance.
- By **studying magnetic records in the rocks on the oceanic crust**, they calculated how much oceanic crust had formed over the last 19 million years.
 - **Basalt rocks** on the oceanic crust contain magnetic properties.
 - Their **magnetism is influenced by the Earth's magnetic field** when the magma reaches the surface and begins cooling to form the crust.
- But the records are incomplete **because the crusts get destroyed at subduction zones.**

- **Subduction zone is a point where two tectonic plates collide**, causing one of them to sink into the Earth's mantle beneath the other plate.

What is Seafloor Spreading?

- The seafloor spreading hypothesis was proposed by the **American geophysicist Harry H. Hess in 1960.**
- Seafloor spreading is the **process of magma welling up in the rift** as the old crust pulls itself in opposite directions. **Cold seawater cools the magma**, creating a new crust.
- The **upward movement and eventual cooling of this magma** has created high ridges on the ocean floor over millions of years.
 - However, the seafloor is destroyed in subduction zones, where oceanic crust slides under continents and sinks back into the mantle, and is reformed at seafloor spreading ridges.
- The **East Pacific Rise is a site of major seafloor spreading** in the Ring of Fire.
 - It is located on the **divergent boundary of the Pacific Plate, the Cocos Plate** (west of Central America), the Nazca Plate (west of South America), the North-American Plate and the Antarctic Plate.



What are the Reasons behind the Decline of Seafloor Spreading?

- **Growing mountains on the continents** might be one of the factors driving the slowdown (as it causes resistance to seafloor spreading).

Note:

- About 200 million years ago, when the **supercontinent Pangea start breaking**, there weren't any major plate collisions or related mountain chains.
- The continents were fairly flat back then.
- **Mature Stage of the Supercontinent Breakup:** As **Pangea progressively broke apart**, new ocean basins formed and eventually, the widely fragmented continents started running into each other.
 - This happened, for instance, **between India and Eurasia**, the Arabian Peninsula and Eurasia as well as Africa and Eurasia.
 - This is a **natural consequence of a 'mature' stage** of supercontinent breakup and dispersal.
- **Changes in mantle convection** could also be playing a role as **mantle convection transports heat** from the earth's interior to the surface.
 - A mantle is a **layer inside a planetary body** bounded below by a **core and above by a crust**.
 - Mantle convection describes the **movement of the mantle as it transfers heat** from the white-hot core to the brittle lithosphere.
 - The **mantle is heated from below, cooled from above**, and its overall temperature decreases over long periods of time.

What can be the Impact of Seafloor Spreading?

- Seafloor spreading influences **sea level** and **carbon cycle**.
 - **Sea Level:**
 - Increasing the rate of seafloor spreading inflates the ridge. Hot, young lithosphere is forming and moving away from the ridge at a faster rate and moving a greater distance from the ridge before it cools and contracts. So sea level rises.
 - **Carbon Cycle:**
 - **Faster rates mean more volcanic activity**, which injects **greenhouse gases** into the atmosphere.

Pre-Eruption Warning Signals at Volcanoes

Why in News?

Recently, new research detected pre-eruption warning signals at Whakaari White Island and other active volcanoes, majorly from New Zealand.

What is the New Research About?

- Every volcano behaves differently: some have crater lakes while others are "dry", they have diverse magmas and rise to different elevations.
- Despite these differences volcanoes such as **Whakaari, Ruapehu and Tongariro in New Zealand could be driven to eruption by common processes** in the shallow subsurface below their craters.
- In the new research, **machine learning** was used to sift through 40 years of seismic data from the New Zealand volcanoes and three others around the world, listening for frequencies that track the depth **where gas, magma or water are moving or building up**.
- Researchers **saw one pattern repeatedly in the days before all the known Whakaari eruptions over the past decade**, and most Ruapehu and Tongariro ones.
 - This pattern is a slow strengthening of a quantity called **Displacement Seismic Amplitude Ratio (DSAR)**, which peaks a few days before each event.
 - **DSAR is a ratio that compares the "activity" of fluids (gas, hot water, steam) at the volcano's surface to those several hundred metres deep**. When DSAR increases, surface fluids are quiet, but deep ones are still actively moving and circulating vigorously below ground.
 - **Seismic waves** are the waves of energy caused by earthquakes or an explosion. They are the energy that travels through the earth and is recorded on seismographs.
- This type of analysis is so new that the researchers have not had many chances to **test how reliable the DSAR and other automated measures are for forecasting**.

What are Whakaari and Ruapehu?

- **Whakaari:**
 - Whakaari/White Island is in the **Bay of Plenty**, 43 miles west of **Cape Runaway**, eastern North Island, New Zealand is an active volcano.
 - It is the **top of a submarine vent at the northern end of the Taupō-Rotorua Volcanic Zone**. With a total land area of about 1,000 acres, it rises to 1,053 feet at Mount Gisborne. Scrub vegetation is common on much of the island.
 - The island was sighted and named by Capt. James Cook in 1769. It has numerous hot springs, geysers, and fumaroles, **its last eruption, which took place in December 2019**.

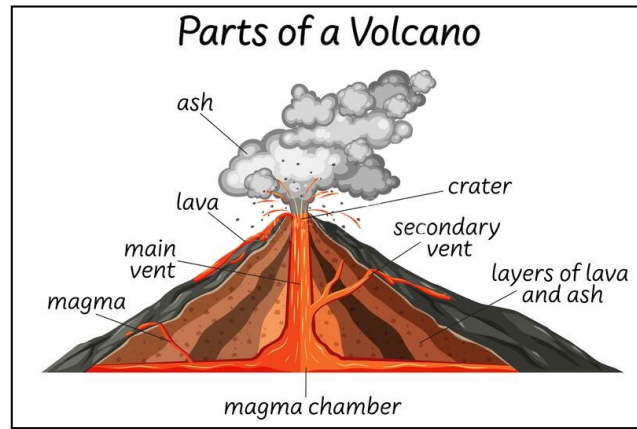
Note:

➤ Ruapehu:

- Mount Ruapehu is **2800m stratovolcano in New Zealand's central North Island.**
- It is also **capped by a hydrothermal system and a warm crater lake** (Te Wai a Moe).
- The volcano is forested below its line of permanent snow cover. Above the line, glaciers flow from the peak. **Within the crater lies a lake**, which is drained by the **Whangaehu River.**
- The temperature and level of its lake is known to vary in cycles, responding to changes in gas released into its base, local weather or the occasional formation of a gas seal.
- The lake is so large it hides the surface activity that is useful for diagnosing volcanoes like Whakaari.

What is a Volcano?

- A **volcano is an opening on the surface of a planet or moon** that allows material warmer than its surroundings to escape from its interior.
- When this material escapes, it causes an eruption. An eruption can be explosive, sending material high into the sky. Or it can be calmer, with gentle flows of material.
- On Earth, the erupted material can be liquid **rock** ("lava" when it's on the surface, "magma" when it's underground), **ash, cinders, and/or gas.**



- There are **three reasons why magma might rise** and cause eruptions onto Earth's surface
 - Magma can rise when pieces of **Earth's crust called tectonic plates slowly move away from each other.** The magma rises to fill in the space. When this happens, underwater volcanoes can form.
 - Magma also rises when these **tectonic plates move toward each other.** When this happens, part of Earth's crust can be forced deep into its interior. The high heat and pressure cause the crust to melt and rise as magma.
 - The final way that magma rises is over hot spots. **Hot spots are the hot areas inside of Earth.** These areas heat up magma. The magma becomes less dense. When it is less dense it rises. Each of the reasons for rising magma are a bit different, but each can form volcanoes.



Note:



Key Points

Details

Blank area for Key Points.

Lined area for Details.

Summary

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