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“ GS SCORE has been really helpful in my preparation. I had used the Mains Test Series and the Feedback and guidance was really awesome. GS SCORE was the only mock which I gave and the feedback motivated and helped me alot. ”

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“ Answer Writing is always considered as a vital part for success in UPSC. GS SCORE helped me in building a strong and solid foundation for development of Answer Writing skills. Thank you! ”

and many more...

AISHWARYAM
AIR-10 (CSE-2023)



“ GS SCORE helped me during the preparation I practised lot of mock test on the GS Score platform to understand the structure of answer writing. I am grateful to this platform for providing such guidance to me and many more aspirants. ”

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AIR-23 (CSE-2023)



“ Mains Tests at GS SCORE in the simulated environment helped me thoroughly complete my preparation with discipline. I would like to thank GSSCORE. ”

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“ UPSC Style mock papers coupled with evaluation by faculty members of GS SCORE themselves enhanced my confidence to write answers as per the demand. I am thankful. ”

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CONTENT

1. PHYSICAL GEOGRAPHY 01-35

- ▶ Subaerial volcanic Eruption: Phenomena and Impact..... 1
- ▶ Supervolcanos: Concept and Impact..... 4
- ▶ Volcanoes of Island Arcs: Recent eruptions of Indonesia 6
- ▶ Fissure Volcanic Eruption: Impact and Consequences 7
- ▶ Geomagnetic Storm and Auroras: Origin and Impact 10
- ▶ Indian ocean warming and Climate Change..... 12
- ▶ Pacific Weather Changing: More Multi-Year El Nino and La Nina 13
- ▶ Volcanic Vortex Rings: Formation and Impact..... 15
- ▶ Oceanic Nino Index: Indication and Application..... 16
- ▶ Pacific 'Ring of Fire' and Earthquakes: Geophysical Hazard Zone 18
- ▶ Sea swells and their impact on Human Settlements 19
- ▶ Rip currents: Significance for beaches 21
- ▶ Alpenglow: A Rare Phenomena..... 22
- ▶ Earthquakes and Ionosphere: Interrelated Geophysical Phenomena..... 24
- ▶ Impact of climate change on ocean currents 25
- ▶ Cryosphere and Climate change 26
- ▶ Lightning in India: Phenomena, Impact and Challenges 28
- ▶ Marine Heatwave and its Impacts 30
- ▶ The Slowdown in Overturning Circulation: Reasons and Impact 32
- ▶ Africa's Rift Valley and the Creation of a New Ocean Basin 33

2. INDIAN GEOGRAPHY36-53

- ▶ Cyclones of Bay of Bengal and Climate Change 36
- ▶ El Nino and Indian Monsoon..... 38
- ▶ Dam construction on Indus Rivers: Prospects and challenges 39
- ▶ Receding glaciers in Himalayas: Issues and Challenges..... 40

▶ Indian Ocean Dipole: Impact on Indian weather	41
▶ Increasing landslides in Himalayan region	43
▶ Tectonic Deformation in Northern Plains	44
▶ Land Subsidence in Chenab Valley	45
▶ Heat Waves, Anticyclones and Global Warming in India	47
▶ Expanding Glacial Lakes in the Himalayas.....	48
▶ Integrated River Basin Management: Prospects and Challenges	50
▶ Changing Western Disturbances: Reasons and Consequences.....	52

3. ECONOMIC GEOGRAPHY 54-87

▶ Tunnel development and Regional connectivity.....	54
▶ Food security in Sub-Saharan region of Africa	57
▶ Mineral resources of Antarctica – A Mineral hub of Gondwanaland	59
▶ Minerals of Mid-oceanic ridges.....	60
▶ Exclusive economic zones and Minerals Deposits.....	61
▶ Hydrocarbon extraction: Prospects and Challenges.....	63
▶ Indian Ports and Economic development	65
▶ Shrinking water in reservoirs in India.....	67
▶ Geopolitics of South China Sea: Challenges for India.....	69
▶ Multipurpose project and Regional development	71
▶ Wind Energy in India: Potential and Challenges	73
▶ Petroleum oil production: Opportunities and Challenges	75
▶ Critical Minerals: Distribution, Prospects and challenges	77
▶ Eastern Maritime Corridor (EMC): Prospects and challenges	78
▶ Declining Groundwater in India: Issues and challenges	80
▶ Increased Coal demand and Net Carbon Neutrality	83
▶ Rare Earth Metals: Prospects and Challenges.....	84

4. HUMAN GEOGRAPHY 88-109

▶ Indian Demography: Largest, Youngest and Underdeveloped	88
▶ Urban Flooding: Issues and Challenges	91
▶ Menace of Illegal Migration in India and World	93
▶ Surge in Human Settlements in Flood-Prone Areas	94
▶ Issues with Tribal habitat in India.....	97
▶ Migration in India: Changing pattern and dynamics	100
▶ Low Human Development in India: Reasons and Consequences.....	102

- ▶ **Climate change and North-South Divide in India103**
- ▶ **Social Capital in India: Issues and Challenges104**
- ▶ **Quality of Life and Standard of Living in India: A Paradoxical case106**
- ▶ **Population compositing of India: Changing Dynamics108**

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PHYSICAL GEOGRAPHY

1. SUBAERIAL VOLCANIC ERUPTION: PHENOMENA AND IMPACT

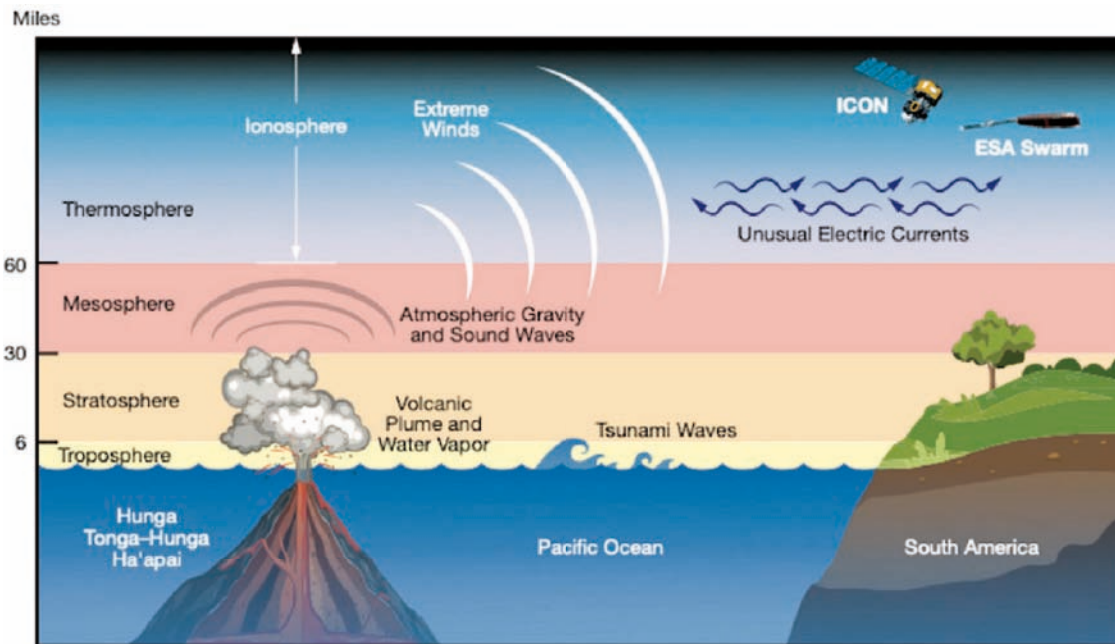
CONTEXT: Subaerial volcanic eruptions, occurring on the earth's surface, profoundly influence the environment, climate, and human societies. Recently subaerial volcanic eruption occurred in Tonga, New Zealand.

▢ Phenomena of Subaerial Volcanic Eruptions:

- Subaerial volcanic eruptions are surface eruptions where magma escapes through vents, resulting in the expulsion of lava, ash, gases, and volcanic rocks. These eruptions can be explosive or effusive, influenced by magma composition, viscosity, and gas content. The primary phenomena associated with these eruptions include:
 - **Lava Flows:** Molten rock that flows from the volcano.
 - **Pyroclastic Flows:** Fast-moving currents of hot gas and volcanic matter.
 - **Volcanic Ash:** Fine particles of rock and volcanic glass propelled into the atmosphere.
 - **Volcanic Gases:** Emissions including water vapor, carbon dioxide, sulfur dioxide, and other gases.

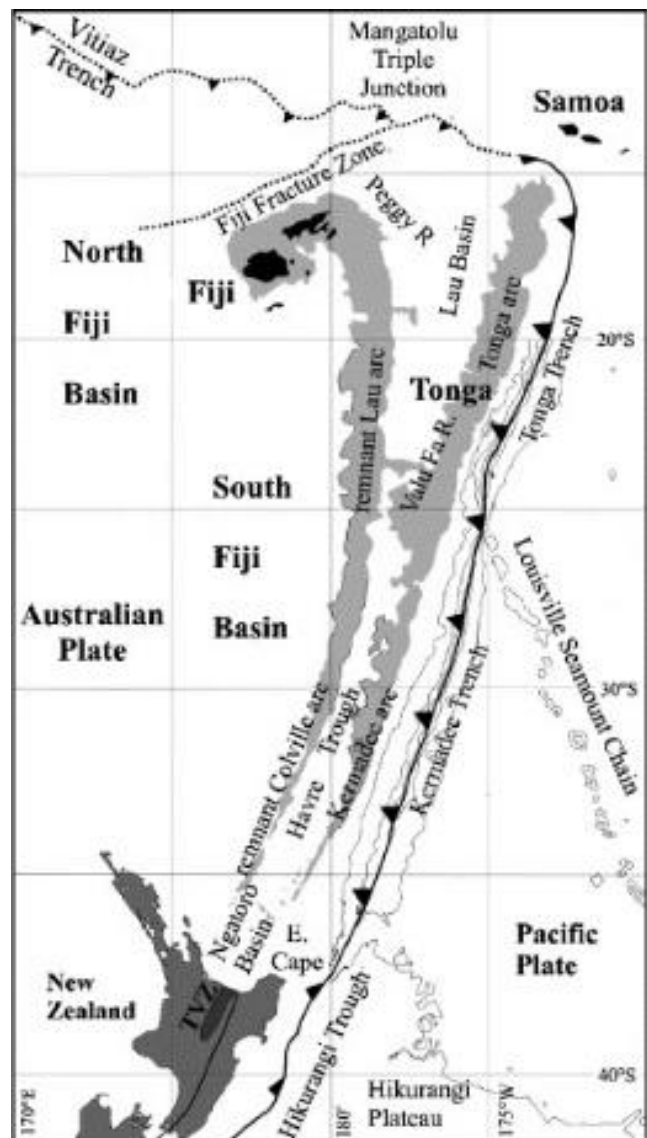
Case Study: Kermadec Arc

The Kermadec Arc in the SW Pacific provides an excellent case study for understanding the dynamics of subaerial and submarine explosive silicic volcanism. The research conducted here focuses on the microtextures of bubbles in pumice, revealing that submarine pumice-forming eruptions are surprisingly common. The study also highlights the influence of eruption rate and water depth on eruption dynamics.



Impact

- Environmental Impact:** Eruptions can create new landforms, such as lava plateaus and volcanic islands. *For e.g.* The 2018 eruption of Kīlauea in Hawaii significantly altered the landscape, creating new land masses. Volcanic eruptions can devastate local ecosystems through ashfall and lava flows. *For e.g.* The Mount St. Helens eruption in 1980 destroyed vast tracts of forest and habitat.
- Climatic Impact:** Volcanic ash and sulfur dioxide can reflect sunlight, causing temporary global cooling. *For e.g.* The 1991 eruption of Mount Pinatubo led to a global temperature drop of about 0.6°C. Emissions of sulfur dioxide can combine with water vapor, forming acid rain that affects soil and water bodies. *For e.g.* The Laki eruption in Iceland in 1783 caused severe acid rain, impacting agriculture across Europe.
- Socio-Economic Impact:** Ashfall can cause respiratory issues and contaminate water supplies. *For e.g.* The Eyjafjallajökull eruption in 2010 led to widespread health advisories due to ash dispersion. Eruptions can disrupt air travel, agriculture, and local economies. *For e.g.* The same Eyjafjallajökull eruption halted air travel across Europe, causing significant economic losses.
- Disaster Management:** Effective monitoring and early warning systems are crucial for mitigating the impact of eruptions. *For e.g.* Japan's advanced volcanic monitoring system provides timely warnings, minimizing casualties.



Case Studies: Eyjafjallajökull (Iceland, 2010)

- The volcanic eruption resulted in extensive ashfall affected local ecosystems. It resulted in minor but notable cooling effect due to ash in the atmosphere. It also caused major disruption of air travel in Europe, highlighting the far-reaching impact of volcanic eruptions on global trade and travel.



White Island Volcano

- The eruption of New Zealand's Whakaari/White Island volcano on December 9, 2019, serves as a poignant example of the impacts of subaerial volcanic eruptions. The eruption resulted in the death of 18 people and left 26 seriously injured. The eruption was identified as a phreatic eruption, involving the release of steam and volcanic gases, which caused an explosion, launching rock and ash 3km into the air.



PRACTICE QUESTION

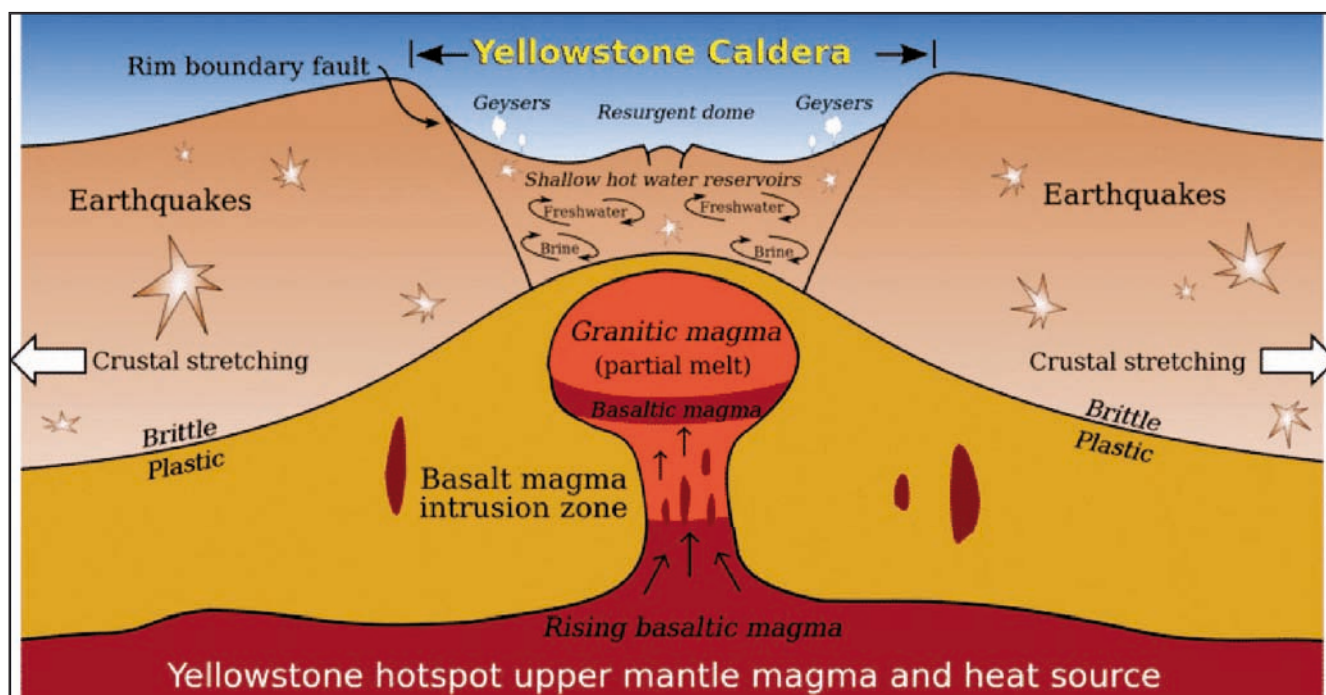
- Q. Explain the various phenomena associated with subaerial volcanic eruptions. How do these phenomena affect the local environment and human settlements?

2. SUPERVOLCANOS: CONCEPT AND IMPACT

CONTEXT: The Long Valley Caldera based in the California, US is a super volcano, with a high level classification of VEI 8, and has not erupted in the last 760,000 years, and has a potential chance of erupting in the near future.

Super Volcano:

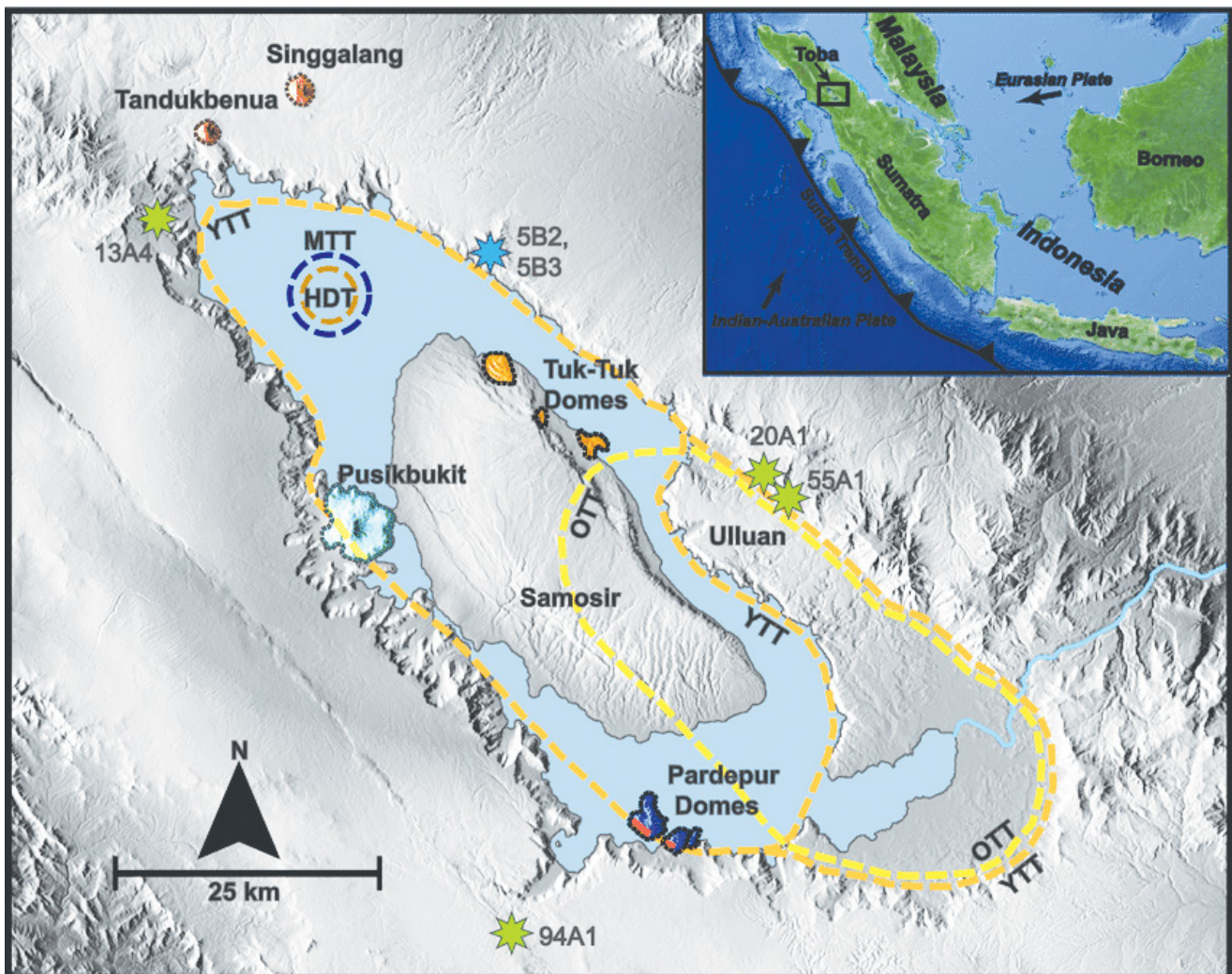
- ▶ Supervolcanoes are capable of producing eruptions with a volcanic explosivity index (VEI) of 8, the largest recorded value on the index. This means the volume of deposits for such an eruption is greater than 1,000 cubic kilometers (240 cubic miles), thousands of times larger than normal volcanic eruptions.
- ▶ **Phenomena:** Supervolcanoes occur when magma in the mantle rises into the crust but is unable to break through it.
 - Pressure builds in a large and growing magma pool until the crust is unable to contain the pressure and ruptures.
 - This can occur at hotspots (for example, Yellowstone Caldera) or at subduction zones (for example, Toba).
- ▶ **Yellowstone Caldera:** One of the most famous supervolcanoes is the Yellowstone Caldera in the United States. The Yellowstone supervolcano has experienced three major eruptions in the last 2.1 million years, with the most recent occurring approximately 640,000 years ago. These eruptions created massive calderas and released immense quantities of ash and volcanic gases into the atmosphere.
- ▶ **Toba Caldera:** The Toba Caldera, situated in Indonesia on the island of Sumatra, is renowned for hosting one of the most colossal volcanic eruptions in Earth's history. Approximately 74,000 years ago, this supervolcano unleashed an apocalyptic explosion, registering at a magnitude of 8 on the Volcanic Explosivity Index (VEI).



Analysis of Impact

- ▶ **Environmental Impact:** Supervolcanoes can drastically reshape the landscape, creating vast calderas and affecting geological structures. *For e.g.* The Yellowstone eruptions created the Yellowstone Caldera, altering the topography of the region and affecting river systems. The massive outpouring of volcanic material can destroy ecosystems and lead to long-term environmental changes. *For e.g.* The Toba supereruption, around 74,000 years ago, is believed to have caused a volcanic winter, drastically affecting global ecosystems.

- ▶ **Climatic Impact:** Supervolcanoes can inject vast amounts of ash and sulfur dioxide into the stratosphere, blocking sunlight and causing significant cooling of the Earth's surface. *For e.g.* The Toba supereruption is hypothesized to have triggered a volcanic winter, leading to a dramatic drop in global temperatures and contributing to a severe bottleneck in human population.
 - **Long-term Climate Effects:** The aerosols from supervolcano eruptions can remain in the atmosphere for years, affecting weather patterns and global climate. *For e.g.* The effects of the Toba eruption possibly contributed to a millennium-long cooling period known as the "Younger Dryas."
 - **Socio-Economic Impact:** The ashfall from supervolcanoes can have severe health impacts, including respiratory problems and water contamination. *For e.g.* In a modern context, an eruption at Yellowstone could potentially blanket much of North America in ash, causing widespread health crises.
 - **Economic Disruption:** The ash and aerosols can disrupt agriculture, transportation, and infrastructure, leading to economic losses. *For e.g.* A significant eruption today could cause agricultural collapse in affected regions, disrupt air travel globally, and necessitate massive disaster relief efforts.



- ▶ **Disaster Management:** Developing effective monitoring systems is crucial for predicting supervolcano eruptions and mitigating their impact. *For e.g.* The Yellowstone Volcano Observatory monitors seismic activity, ground deformation, and gas emissions to provide early warnings of potential eruptions.
 - **Emergency Preparedness and Response:** Comprehensive disaster preparedness plans are essential to manage the aftermath of a supervolcano eruption. *For e.g.* Governments and international organizations must coordinate to develop strategies for evacuation, healthcare, and economic recovery in the event of a supervolcanic eruption.

PRACTICE QUESTION

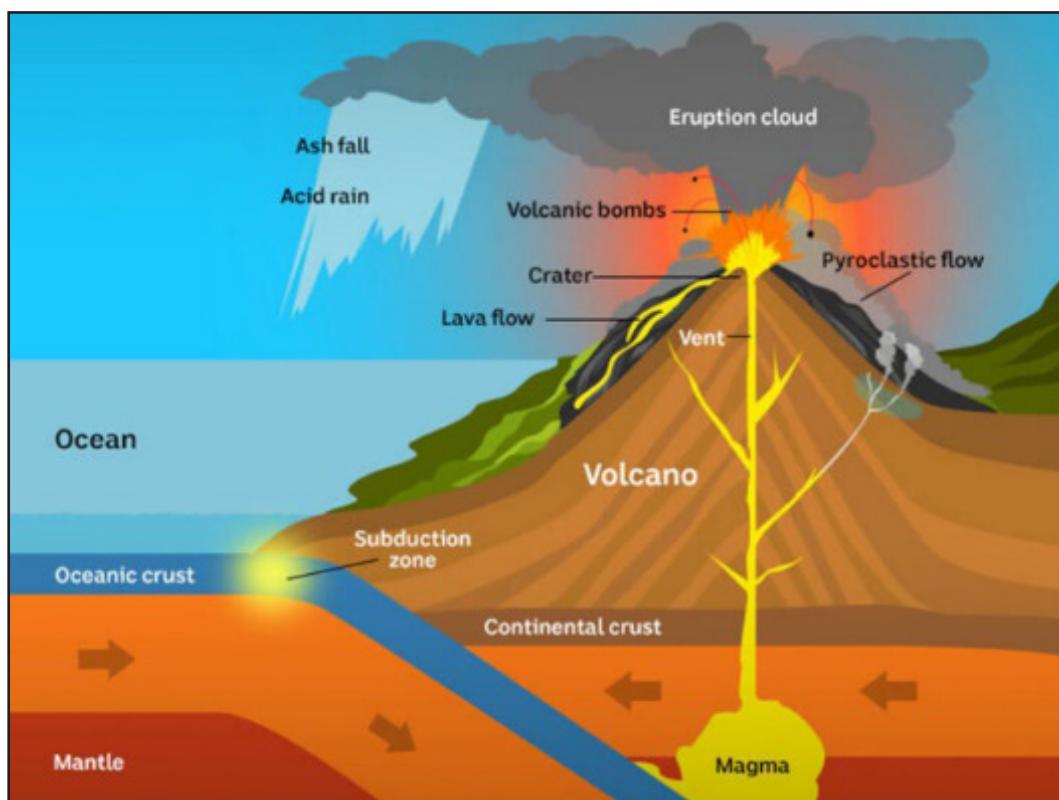
Q. Define the concept of a supervolcano and distinguish it from regular volcanic eruptions. What geological features characterize a supervolcano?

3. VOLCANOES OF ISLAND ARCS: RECENT ERUPTIONS OF INDONESIA

CONTEXT: According to a recent report, there were a total of 46 eruptions and 66 blasts observed from the volcano's observation in Indonesia in 2023. The eruptions included Mount Marapi and Ruang volcano located in Indonesia.

Volcanoes of Island Arcs:

- ▶ Island arcs are long chains of active volcanoes with intense seismic activity found along convergent tectonic plate boundaries. They originate on oceanic crust and result from the descent of the lithosphere into the mantle along the **subduction zone**.
- ▶ **Indonesia and Volcanic Arc:** Indonesia, situated on the **Pacific Ring of Fire**, is home to numerous active volcanoes, many of which are part of island arcs. These volcanic chains result from tectonic processes and have significant geological and environmental implications.
 - **Example: Mariana Islands:** The Mariana Islands, located in the western Pacific Ocean, form a curved line of islands, known as an island arc, that is **parallel to the trench**. These islands are a prime example of the phenomena associated with **volcanoes of island arcs**.
- ▶ **Phenomena of Island Arc and Volcanic Eruptions:** Island arc volcanoes form along convergent tectonic plate boundaries where an oceanic plate subducts beneath another oceanic or continental plate. The descending plate melts due to high temperatures and pressures, generating magma that rises to form volcanic arcs. Indonesia's complex tectonics involve the subduction of the **Indo-Australian Plate** beneath the **Eurasian Plate**, creating a prolific chain of volcanoes.
 - **Example: Mount Sumeru:** The 2021 eruption of Mount Semeru, Indonesia's tallest volcano, exemplifies the island arc volcanic activity. Located on the island of Java, Semeru's eruptions are characterized by pyroclastic flows, ash plumes, and lava flows. On December 4, 2021, Semeru erupted violently, spewing ash up to 15 kilometers into the atmosphere and generating pyroclastic flows that devastated nearby villages.



❏ Impact

- ▶ **Environmental Impact:** Volcanic eruptions reshape landscapes, creating new landforms and altering existing ones. *For e.g.* The 2018 eruption of Anak Krakatau led to the collapse of a large portion of the volcano, significantly altering its shape and triggering a deadly tsunami.
- **Ecosystem Disruption:** Eruptions can destroy habitats and alter ecosystems, affecting flora and fauna. *For e.g.* The eruption of Mount Sinabung has repeatedly devastated local ecosystems, displacing wildlife and altering forest composition.
- ▶ **Climatic Impact:** Volcanic ash and sulfur dioxide can temporarily cool the atmosphere by reflecting sunlight. *For e.g.* The 1815 eruption of Mount Tambora in Indonesia caused the “Year Without a Summer,” leading to global temperature drops and agricultural failures.
- **Acid Rain:** Volcanic emissions of sulfur dioxide can lead to acid rain, impacting soil and water bodies. *For e.g.* Recent eruptions of Mount Agung have led to localized acid rain, affecting crops and water sources in Bali.
- ▶ **Socio-Economic Impact:** Ashfall from eruptions can cause respiratory issues, eye irritation, and skin problems. *For e.g.* The 2021 eruption of Mount Semeru resulted in significant health problems for nearby residents due to ash inhalation.
- **Economic Disruption:** Eruptions can disrupt agriculture, tourism, and infrastructure, leading to economic losses. *For e.g.* The 2017 eruption of Mount Agung led to the evacuation of tens of thousands of people and disrupted Bali’s tourism industry, causing economic hardships for local communities.
- ▶ **Disaster Management:** Effective monitoring and early warning systems are crucial for mitigating the impact of volcanic eruptions. *For e.g.* Indonesia’s Center for Volcanology and Geological Hazard Mitigation (PVMBG) monitors volcanic activity and provides early warnings, as seen with the successful evacuation before the 2010 eruption of Mount Merapi.

PREVIOUS YEAR QUESTION

- Q. Mention the global occurrence of volcanic eruptions in 2021 and their impact on regional environment. (2021)
- Q. Define mantle plume and explain its role in plate tectonics. (2018)

PRACTICE QUESTION

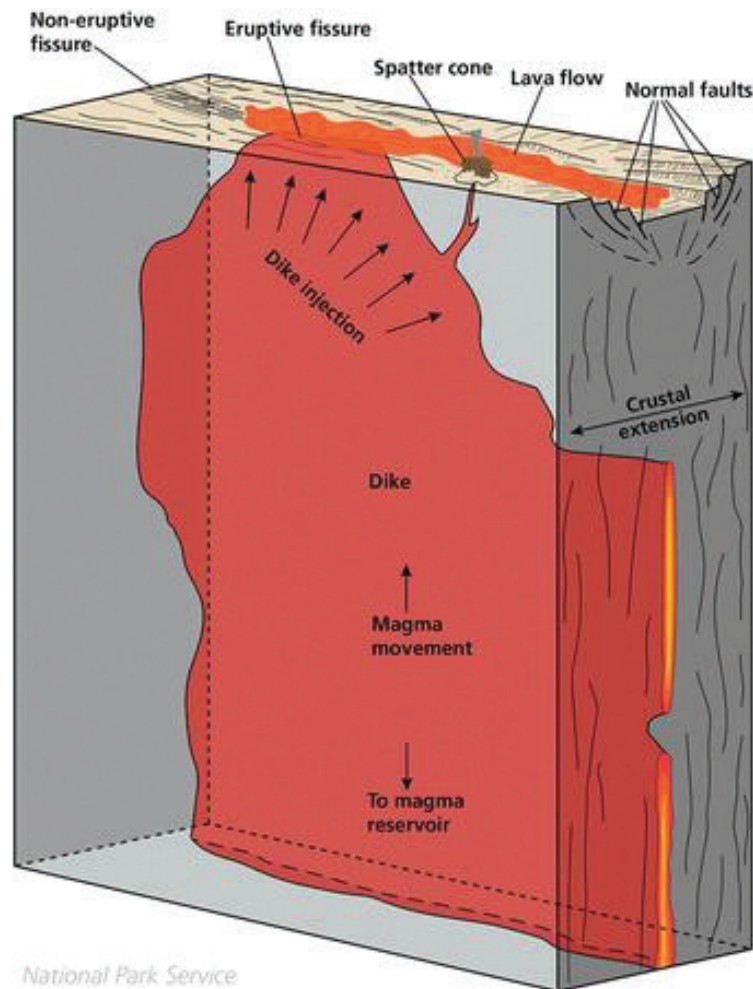
- Q. Describe the geological processes that lead to the formation of island arc volcanoes. How do these processes contribute to the frequent volcanic activity in Indonesia?

4. FISSURE VOLCANIC ERUPTION: IMPACT AND CONSEQUENCES

CONTEXT: A volcanic fissure on Iceland’s Reykjanes peninsula reawakened in late May 2024. This eruption, the latest in a series that began in December 2023, was notable for its vigorous start.

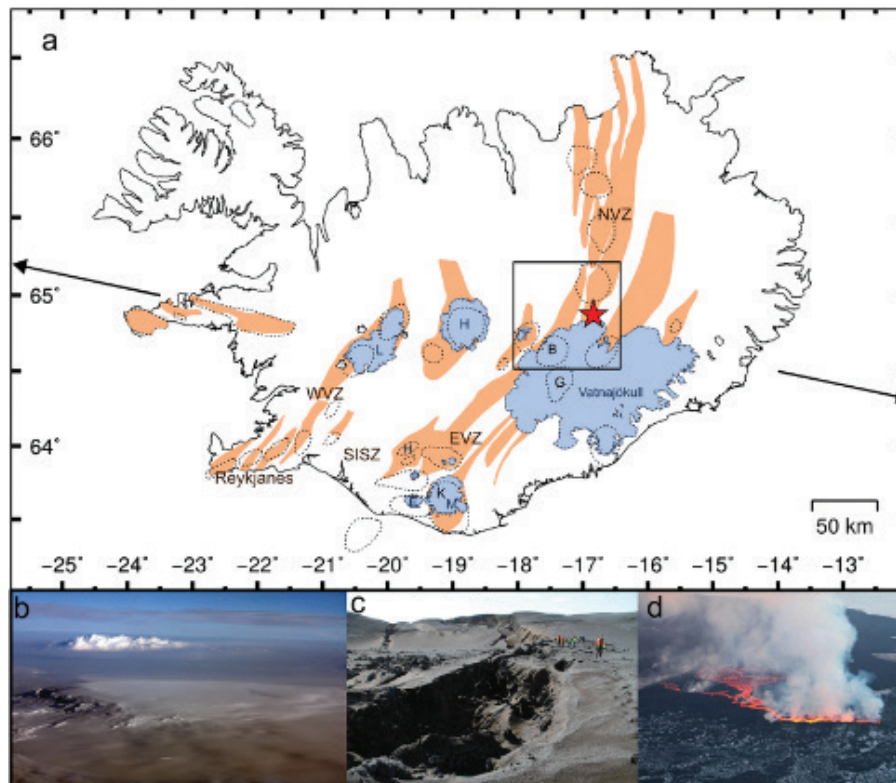
❏ Fissure Volcanic Eruption:

- ▶ A fissure volcanic eruption is a **natural phenomenon** where lava erupts through a **linear volcanic vent**, often a few meters wide and many kilometers long.
- This type of eruption is usually non-explosive and can cause large **flood basalts**, which initially run in lava channels and later in lava tubes. Fissure vents are typically found in or along rifts and rift zones, such as Iceland and the East African Rift.
- For instance, the **Laki fissures**, part of the **Grímsvötn volcanic system** in Iceland, produced one of the biggest effusive eruptions on earth in historical times, releasing 12–14 km³ of lava in 1783.
- Another significant example is the eruption in Hawaii, where radial fissure vents produce “curtains of fire” as lava fountains erupt along a portion of a fissure.



■ Analysis of Impact

- ▶ **Environmental Impact:** Fissure eruptions can drastically alter landscapes by creating new landforms and lava fields. *For e.g.* The Laki eruption created extensive lava fields in southern Iceland, permanently altering the region's topography.
 - **Ecosystem Disruption:** Lava flows can destroy ecosystems, and the emission of volcanic gases can lead to long-term environmental changes. *For e.g.* The 1783 Laki eruption released significant amounts of sulfur dioxide, leading to acid rain that devastated Iceland's pastures and livestock.
- ▶ **Climatic Impact:** The aerosols and gases emitted during fissure eruptions can lead to short-term global cooling. *For e.g.* The Laki eruption caused a volcanic winter, leading to a drop in global temperatures and contributing to the harsh winters of 1783-1784.
 - **Acid Rain:** Sulfur dioxide emissions from fissure eruptions can combine with water vapor, forming acid rain that affects soil and water bodies. *For e.g.* The acid rain from the Laki eruption damaged crops and vegetation across Europe, impacting agriculture and food supply.
- ▶ **Socio-Economic Impact:** Volcanic gases, particularly sulfur dioxide, can cause respiratory problems and other health issues. *For e.g.* The Laki eruption's "Haze Famine" resulted in widespread health problems and mortality in Iceland due to toxic gas exposure.
 - **Economic Disruption:** Eruptions can disrupt agriculture, infrastructure, and livelihoods, leading to significant economic losses. *For e.g.* The Laki eruption caused massive agricultural failure in Iceland, leading to a famine that killed a significant portion of the population and caused long-term economic hardship.



- **Disaster Management:** Effective monitoring and early warning systems are crucial for mitigating the impact of fissure eruptions. *For e.g.* Modern technology, such as satellite monitoring and seismographs, helps provide early warnings and track volcanic activity.
- **Emergency Response and Evacuation:** Comprehensive disaster response plans are essential to manage the aftermath of fissure eruptions. *For e.g.* In recent Icelandic eruptions, such as the 2014 **Holuhraun fissure eruption**, coordinated emergency response and evacuation efforts helped minimize human casualties and property damage.

Case Study: Fissure Eruption of Reykjanes peninsula in Ireland

- Volcanic activity reawakened on the Reykjanes peninsula in southwestern Iceland with a pulse of eruptions in mid-January 2024.



- Over the course of about two days, new fissures released lava near the town of Grindavík.
- A human-constructed barrier diverted some of the flow from one fissure away from town, but lava from one closer to Grindavík engulfed several homes.
- The eruption occurred less than a month after another fissure opened several kilometers to the northeast.
- It was the fifth eruption on the peninsula since 2021.

PRACTICE QUESTION

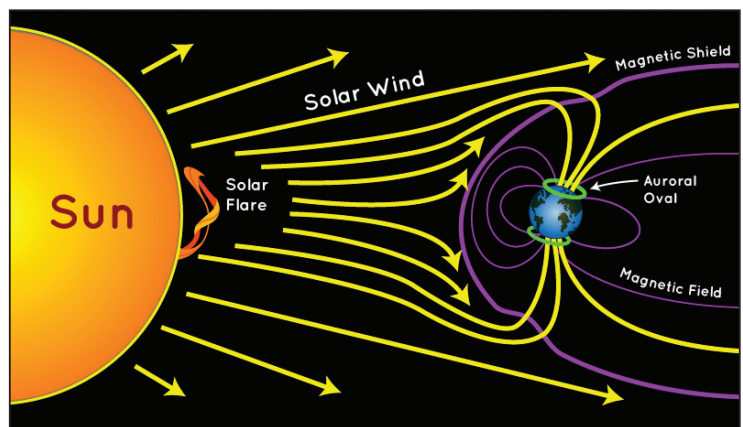
Q. Explain the mechanisms behind fissure volcanic eruptions. Also explain their typical characteristics?

5. GEOMAGNETIC STORM AND AURORAS: ORIGIN AND IMPACT

CONTEXT: In March 2024, a powerful solar flare followed by a coronal mass ejection (CME) struck Earth's magnetic field, triggering one of the most intense geomagnetic storms in recent years. This event produced spectacular auroral displays visible as far south as Texas and Spain, affecting various technological systems and raising awareness about the importance of monitoring space weather.

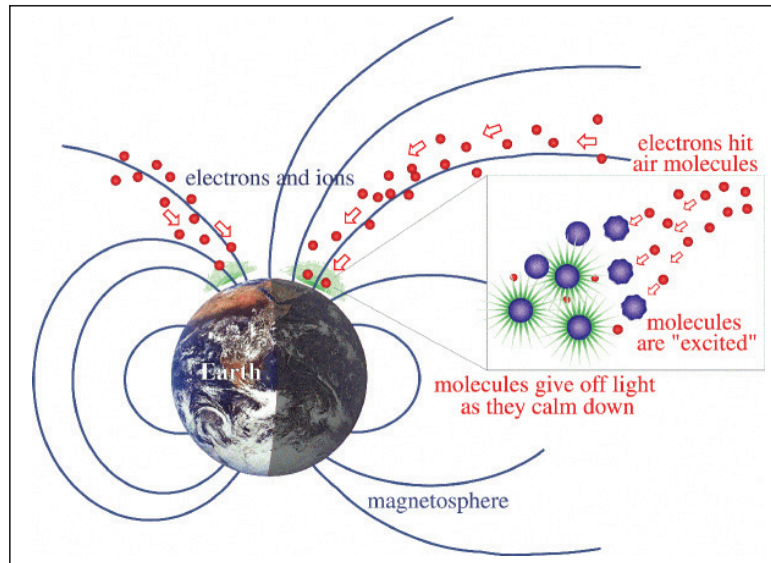
▢ Geomagnetic Storm and Auroras Phenomena

- **Geomagnetic Storms:** Geomagnetic storms are disturbances in Earth's magnetosphere caused by solar wind shock waves and CMEs interacting with Earth's magnetic field. These disturbances can enhance the flow of charged particles into the magnetosphere, leading to various effects, including the intensification of auroras.
- **Auroras:** Auroras, known as the Northern and Southern Lights, occur when charged particles from the sun collide with Earth's atmosphere. These particles excite atmospheric gases, causing them to emit light. Auroras are typically seen near polar regions but can extend to lower latitudes during strong geomagnetic storms.
- **Example:** The 2024 event began with an X-class solar flare, the most intense category, followed by a CME that traveled towards Earth at high speed. Upon impact, it compressed Earth's magnetosphere, causing a geomagnetic storm rated G4 (severe) on the geomagnetic storm scale.



▢ Impact

- **Environmental Impact:** Geomagnetic storms enhance auroral activity, providing a spectacular natural light show. *For e.g.* The 2024 storm produced auroras visible across Europe and North America, delighting observers and contributing to citizen science projects tracking auroral activity.
- **Radiation Exposure:** Increased radiation in the polar regions can impact high-altitude flights. *For e.g.* Airlines rerouted polar flights during the 2024 storm to protect passengers and crew from increased radiation levels.



- ▶ **Technological Impact:** Geomagnetic storms can disrupt satellite communications and navigation systems. *For e.g.* During the 2024 event, several satellites experienced temporary communication blackouts and minor orbital adjustments due to increased atmospheric drag.
 - **Power Grids:** Induced electric currents from geomagnetic storms can overload and damage power grids. *For e.g.* In 1989, a geomagnetic storm caused a blackout in Quebec. While the 2024 storm did not cause major blackouts, power companies took precautionary measures to safeguard the grid.
- ▶ **Economic Impact:** Flight rerouting and delays can result in significant costs. *For e.g.* The rerouting of transpolar flights during the 2024 event led to increased fuel consumption and operational costs for airlines.
 - **Telecommunications:** Disruptions to communication systems can affect various sectors, including finance and emergency services. *For e.g.* During the 2024 storm, some regions experienced disruptions in GPS services, affecting logistics and transportation.
- ▶ **Scientific and Societal Impact:** Geomagnetic storms offer valuable data for studying space weather and its effects on Earth. *For e.g.* The 2024 storm provided researchers with crucial data to improve predictive models of geomagnetic storms and their impacts on technological systems.
 - **Public Awareness and Education:** High-profile geomagnetic storms raise public awareness about space weather. *For e.g.* The widespread visibility of auroras in 2024 led to increased interest in space weather science and greater public understanding of the need for monitoring solar activity.

Recent Case Study: 2024 Geomagnetic Storm

The 2024 geomagnetic storm serves as a recent and vivid example of the impact of solar activity on Earth. The event began with a massive X-class solar flare on March 9, 2024, followed by a CME that reached Earth on March 11. The resulting geomagnetic storm, rated G4, was one of the most intense in the past decade.

PRACTICE QUESTION

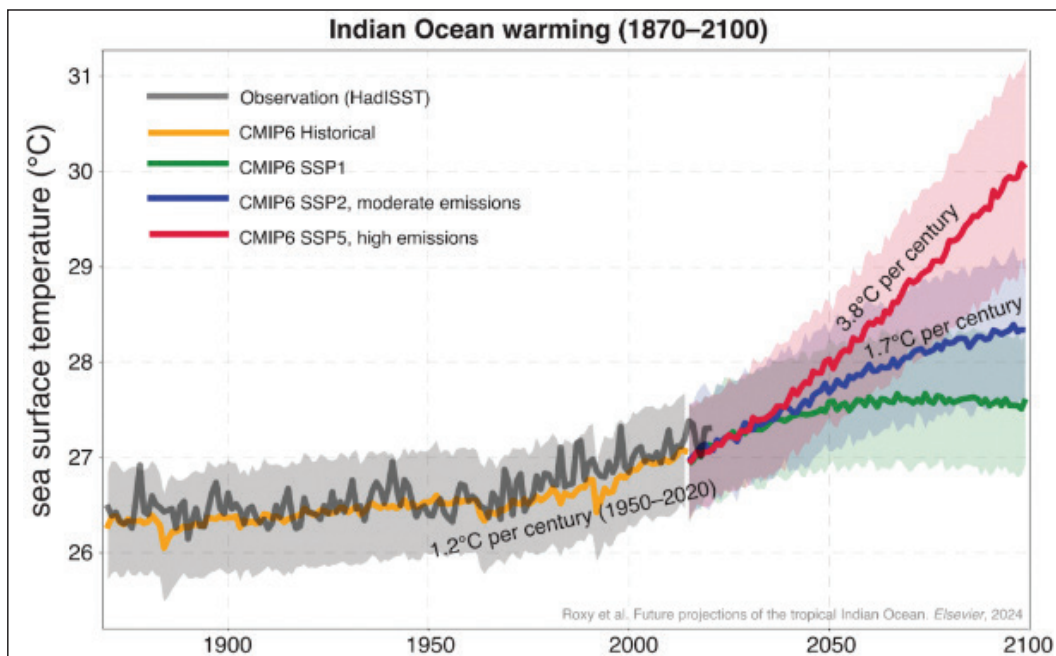
Q. What are geomagnetic storms? How do solar activities such as solar flares and coronal mass ejections (CMEs) lead to geomagnetic disturbances on Earth?

6. INDIAN OCEAN WARMING AND CLIMATE CHANGE

CONTEXT: Indian Ocean is heating up much faster than we think, at a rate of 1.7-3.8°C per century. In early 2024, the Indian Ocean experienced sea surface temperatures reaching record highs. This warming trend is attributed to a combination of anthropogenic climate change and natural variability, including the Indian Ocean Dipole (IOD) and El Niño-Southern Oscillation (ENSO).

Explaining the Phenomena:

- ▶ Indian Ocean warming refers to the increase in sea surface temperatures over time. This warming is influenced by greenhouse gas emissions trapping heat in the atmosphere, which is then absorbed by the ocean. Events like a positive IOD, characterized by warmer waters in the western Indian Ocean, exacerbate this warming.
- ▶ **Example:** In 2024, a strong positive IOD phase contributed to sea surface temperatures rising by over 1°C above average, leading to significant climatic anomalies.



Analysis of Impact

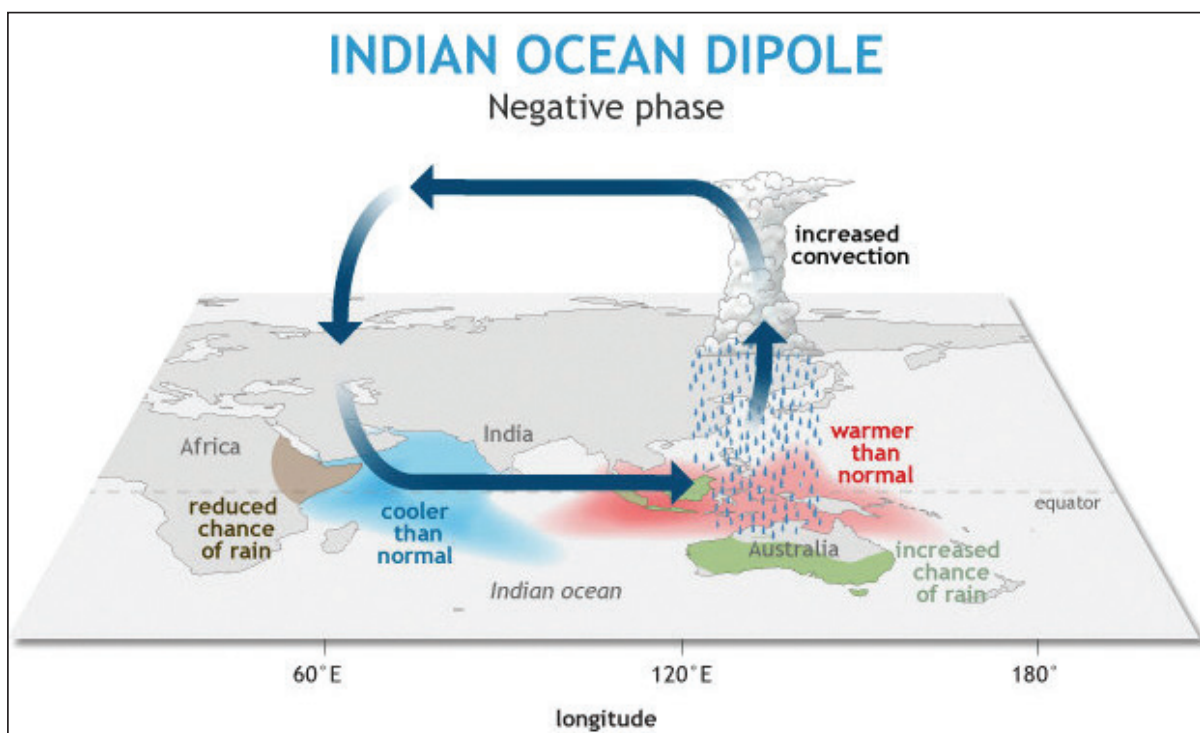
- ▶ **Environmental Impact:** Warming seas can lead to coral bleaching and loss of marine biodiversity. *For e.g.* In 2024, extensive coral bleaching was observed in the Maldives, with over 60% of coral reefs affected.
 - **Weather Patterns:** Warmer waters can intensify cyclones and alter monsoon patterns. *For e.g.* The 2024 cyclonic season saw unusually severe cyclones, such as Cyclone Mocha, which was intensified by the warm waters, causing extensive damage in coastal regions of India and Bangladesh.
- ▶ **Climatic Impact:** Indian Ocean warming can disrupt the South Asian monsoon, leading to irregular rainfall patterns. *For e.g.* In 2024, India experienced a 20% deficit in monsoon rainfall in some regions, impacting agriculture and water resources.
- ▶ **Socio-Economic Impact:** Altered marine ecosystems affect fish stocks, impacting livelihoods. *For e.g.* In 2024, the warming led to a 30% decline in fish catch in the Bay of Bengal, affecting local fishing communities.
 - **Agriculture:** Changes in monsoon patterns affect crop yields, threatening food security. *For e.g.* The reduced monsoon rains in 2024 led to a significant drop in rice and wheat production in India, raising concerns over food supply and prices.

- **Disaster Management:** Increased frequency and intensity of extreme weather events necessitate improved disaster preparedness. *For e.g.* The Indian government enhanced cyclone preparedness measures in 2024, including better forecasting and early warning systems, which helped mitigate the impacts of Cyclone Mocha.

Recent Case Study: 2024 Positive IOD Event

The 2024 positive IOD event exemplifies the impact of Indian Ocean warming. Sea surface temperatures rose sharply, contributing to severe weather anomalies and ecological disturbances. This event underscored the urgent need for climate adaptation and mitigation strategies to address the multifaceted impacts of ocean warming.

Australian national weather agency Bureau of Meteorology (BoM) indicates a positive IOD is developing earlier than usual event. According to BoM the Indian Ocean Dipole (IOD) index for the week ending April 28, 2024, was $+0.68^{\circ}\text{C}$, above the positive IOD threshold ($+0.40^{\circ}\text{C}$).



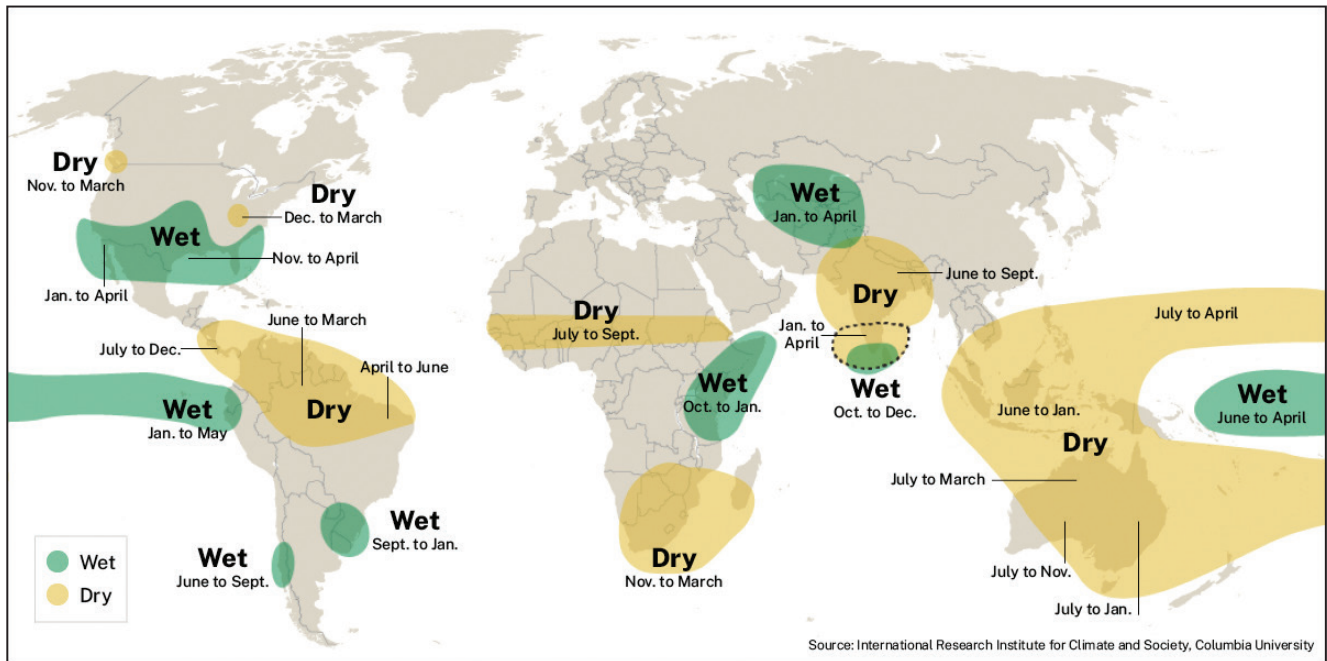
PRACTICE QUESTION

- Q. Analyze the causes and consequences of Indian Ocean warming. How does this phenomenon interact with global climate systems?

7. PACIFIC WEATHER CHANGING: MORE MULTI-YEAR EL NINO AND LA NINA

CONTEXT: The years 2023-24 witnessed a persistent La Niña phase in the Pacific Ocean, characterized by cooler-than-average sea surface temperatures in the central and eastern equatorial Pacific. This followed a series of strong La Niña events starting from 2020, indicating a trend towards more prolonged ENSO phases.

- ▶ **Explaining the Multi-Year El Niño and La Niña Phenomena:** El Niño and La Niña are phases of the ENSO cycle, driven by interactions between ocean temperatures and atmospheric circulation patterns in the tropical Pacific.
 - **El Niño:** Warmer-than-average sea surface temperatures in the central and eastern Pacific, influencing global climate patterns.
- ▶ **La Niña:** Cooler-than-average sea surface temperatures in the central and eastern Pacific, with opposite climate impacts to El Niño. The La Niña event of 2023-24 persisted for over a year, affecting global weather patterns, including increased hurricane activity in the Atlantic and drier conditions in parts of Asia and Australia.

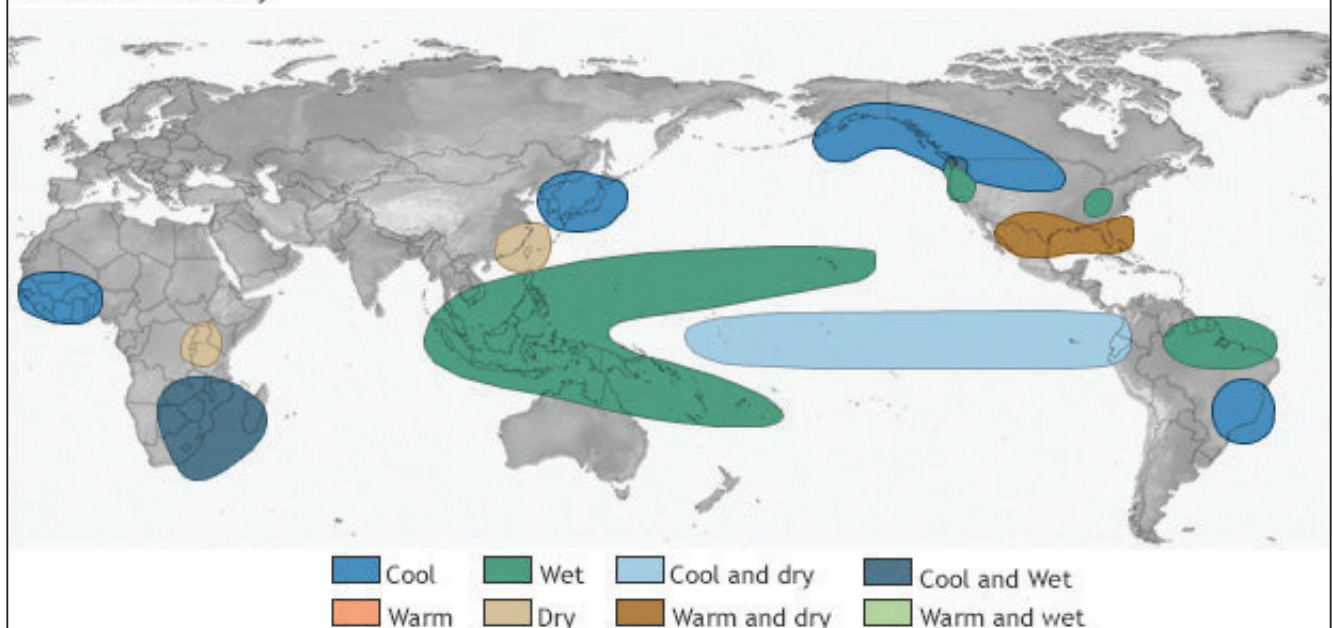


Impact

- ▶ **Environmental Impact:** La Niña can enhance hurricane and typhoon activity in the Atlantic and Pacific basins. The 2023 Atlantic hurricane season saw above-average activity, with 19 named storms, including several major hurricanes.
- **Droughts and Floods:** El Niño and La Niña can lead to extreme weather events such as droughts in some regions and floods in others. *For e.g.* La Niña in 2023-24 contributed to severe drought conditions in Southeast Asia and parts of Africa, impacting agriculture and water resources.
- ▶ **Climatic Impact:** ENSO phases influence global temperatures, contributing to variability in regional climate. The persistence of La Niña in 2023-24 led to below-average temperatures in the eastern Pacific and above-average temperatures in the western Pacific.
- **Precipitation Patterns:** ENSO affects rainfall patterns, influencing agricultural productivity and water availability. *For e.g.* Australia experienced below-average rainfall during the La Niña of 2023-24, affecting crop yields and water reserves.
- ▶ **Socio-Economic Impact:** ENSO phases can disrupt agricultural production through changes in rainfall and temperature patterns. *For e.g.:* In 2024, Argentina faced reduced soybean yields due to drier-than-normal conditions associated with La Niña.
- **Economic Sectors:** Industries such as fisheries, tourism, and energy production are vulnerable to ENSO-related impacts. *For e.g.* The Pacific fishing industry struggled with fluctuating fish stocks and changing ocean conditions during the prolonged La Niña phase.

LA NIÑA CLIMATE IMPACTS

December-February



- **Disaster Management:** Governments and organizations implement measures to mitigate the impact of ENSO events on vulnerable communities. *For e.g.* In the Philippines, early warning systems and disaster preparedness plans were enhanced ahead of the 2023-24 La Niña to minimize the impact of floods and landslides.

Recent Case Study: 2023-24 La Niña Event

The 2023-24 La Niña event illustrates the prolonged and impactful nature of ENSO phases on global weather patterns. Persisting for over a year, this event influenced climate conditions worldwide, highlighting the need for adaptive strategies to manage its diverse impacts.

PRACTICE QUESTION

- Q. Discuss the mechanisms driving the El Niño and La Niña phenomena. How do multi-year occurrences of these events affect global weather patterns?

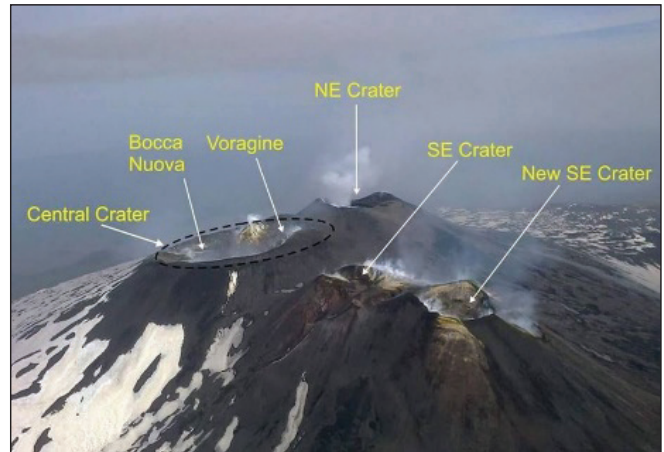
8. VOLCANIC VORTEX RINGS: FORMATION AND IMPACT

CONTEXT: In 2024, during the eruption of Mount Etna in Italy, volcanic vortex rings were observed and studied intensively. These rings are formed when gas and ash are expelled from the volcanic vent in a circular or ring-like pattern due to the interaction of volcanic plumes with the surrounding atmosphere.

- **About Volcanic Vortex:** Volcanic vortex rings occur during explosive eruptions when bursts of gas and ash are ejected from the vent. The expulsion of these materials in a coherent ring-like structure is facilitated by the volcanic plume's buoyancy and the surrounding atmospheric conditions.
- **Eruption of Mount Etna:** During the 2024 eruption of Mount Etna, several vortex rings were observed rising above the volcano, reaching heights of several kilometers. These rings are visually striking and offer valuable data for understanding volcanic dynamics.

Impact

- ▶ **Scientific Impact:** Studying vortex rings helps scientists analyze the force and structure of volcanic plumes. For e.g. Data from Mount Etna's 2024 eruption provided insights into the energy release and gas dynamics within volcanic eruptions.
- ▶ **Environmental Impact:** Vortex rings can affect the dispersion of volcanic ash and gases, influencing regional air quality. The 2024 Mount Etna eruption led to temporary closures of nearby airports due to ash dispersal from vortex rings.
- ▶ **Technological Impact:** Advanced monitoring systems can utilize vortex ring observations to improve volcanic eruption forecasting. For e.g. Seismic networks and satellite imagery detected the formation of vortex rings during the 2024 eruption, enhancing early warning capabilities.
- ▶ **Educational and Public Engagement:** Vortex rings capture public interest and raise awareness about volcanic processes. For e.g. The media coverage of Mount Etna's vortex rings in 2024 sparked interest in volcanic phenomena and geoscience education.



Recent Case Study: 2023-24 Mount Etna Eruption

The 2023-24 eruption of Mount Etna serves as a recent and notable case study of volcanic vortex rings. As one of the most active volcanoes in the world, Mount Etna's eruptions often exhibit diverse and dynamic volcanic behaviors, including the formation of vortex rings during explosive events.

PRACTICE QUESTION

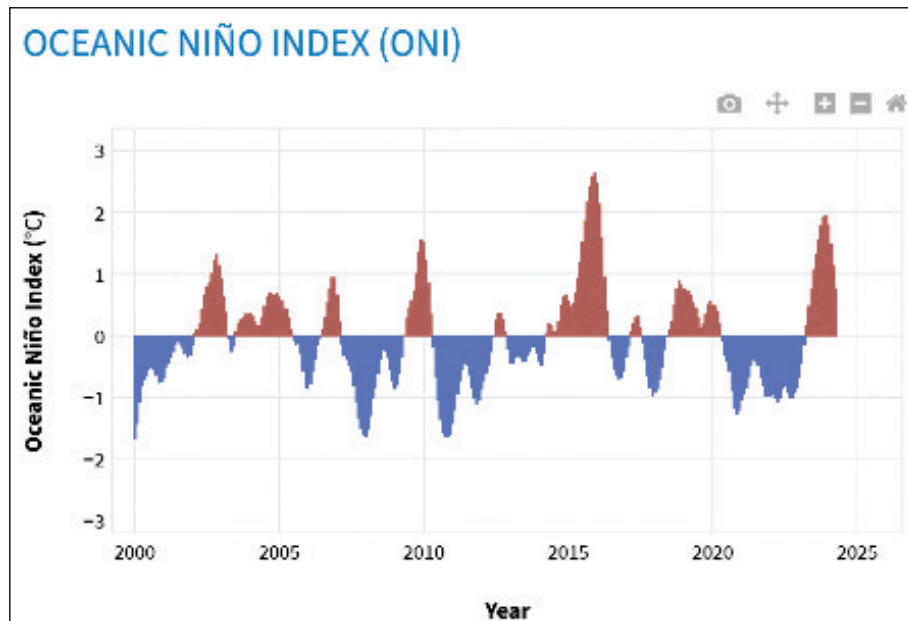
- Q. Explain the phenomenon of volcanic vortex rings. How are they formed during volcanic eruptions, and what principles underlie their formation?

9. OCEANIC NINO INDEX: INDICATION AND APPLICATION

CONTEXT: In 2024, the Oceanic Niño Index indicated a transition from a La Niña phase to neutral conditions in the Pacific Ocean. This shift followed a prolonged period of La Niña, influencing global weather patterns throughout 2023-24.

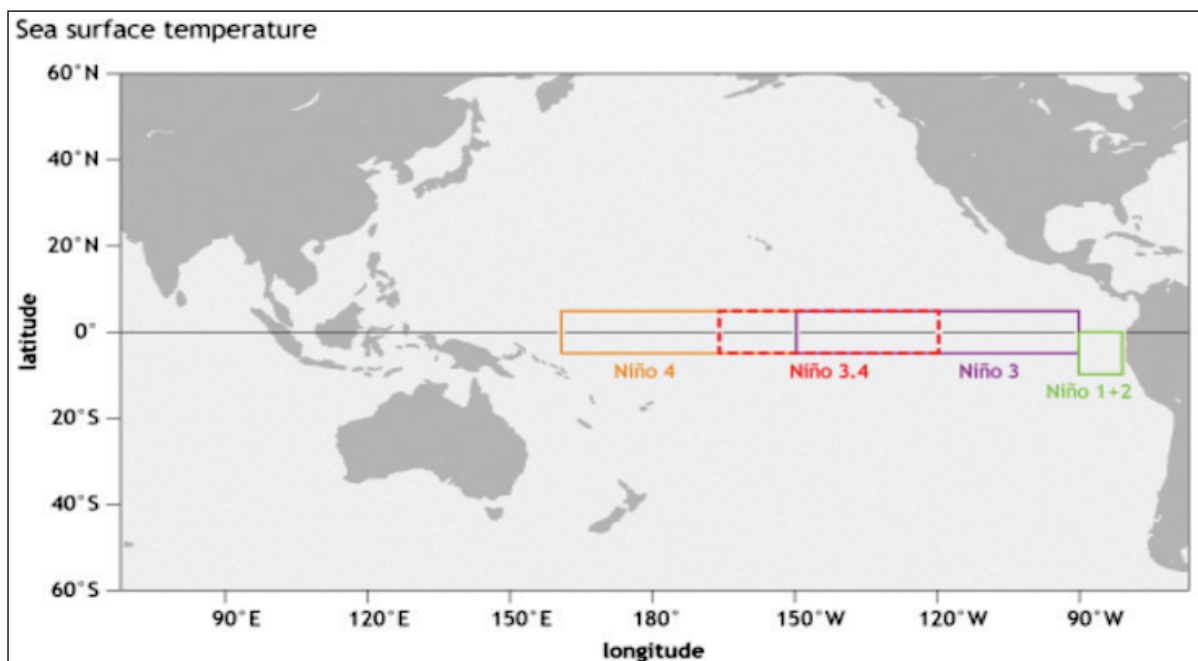
Phenomena:

- ▶ The Oceanic Niño Index (ONI) is a key indicator used to monitor and classify El Niño and La Niña events in the equatorial Pacific Ocean. This index plays a crucial role in understanding global climate variability, impacting weather patterns, agriculture, and economies worldwide.
- ▶ The Oceanic Niño Index measures sea surface temperature anomalies in the central and eastern equatorial Pacific Ocean. It categorizes conditions into:
 - **El Niño:** Warmer-than-average sea surface temperatures.
 - **La Niña:** Cooler-than-average sea surface temperatures.
 - **Neutral:** Near-average sea surface temperatures.
- ▶ **Example:** During the 2023-24 period, a strong La Niña phase persisted, leading to below-average sea surface temperatures in the eastern Pacific and impacting global climate patterns.



Analysis of Impact

- **Environmental Impact:** El Niño and La Niña influence the frequency and intensity of tropical cyclones worldwide. In 2023, La Niña contributed to an active Atlantic hurricane season, with above-average storm formation and intensity.
- **Droughts and Floods:** ENSO phases affect precipitation patterns, leading to droughts in some regions and floods in others. *For e.g.* La Niña in 2024 intensified drought conditions in parts of Southeast Asia, impacting agriculture and water resources.
- **Economic Impact:** ENSO events disrupt global agricultural production through changes in rainfall and temperature patterns. The 2023-24 La Niña led to reduced crop yields in Australia and parts of South America, affecting global food prices.



- **Fisheries and Marine Ecosystems:** Warmer or cooler ocean temperatures influence fish stocks and marine biodiversity. *For e.g.* La Niña conditions in 2023-24 affected fisheries in the Pacific, leading to shifts in fish migration patterns and catch volumes.

- ▶ **Social Impact:** ENSO-related weather extremes impact public health through heatwaves, vector-borne diseases, and respiratory illnesses. *For e.g.* Heatwaves associated with El Niño events in Southeast Asia in 2024 led to increased cases of heat-related illnesses and deaths.
- **Migration and Displacement:** Extreme weather events linked to ENSO can trigger population displacement and migration. *For e.g.* Flooding in parts of South America during La Niña events displaced communities and disrupted livelihoods.
- ▶ **Policy and Governance:** Governments implement policies and strategies to mitigate the impact of ENSO-related disasters. *For e.g.* In 2023-24, countries in the Pacific region enhanced disaster preparedness and early warning systems to minimize the impact of cyclones and floods associated with La Niña.

Recent Case Study: 2023-24 Oceanic Niño Index

The Oceanic Niño Index for 2023-24 highlighted the prolonged and impactful nature of La Niña conditions on global weather and climate. This period underscored the importance of monitoring ENSO events and implementing adaptive strategies to mitigate their diverse socio-economic and environmental impacts.

PRACTICE QUESTION

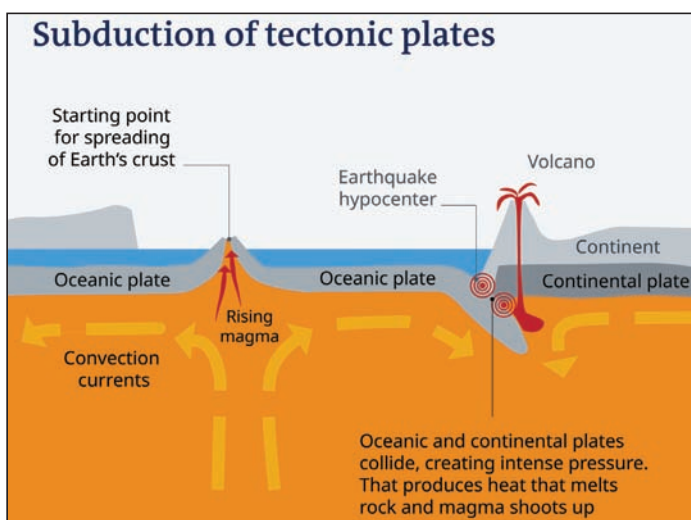
- Q. Define the Oceanic Niño Index (ONI) and explain its significance in monitoring and understanding El Niño and La Niña events. How is the ONI calculated and what thresholds are used to classify these events?

10. PACIFIC 'RING OF FIRE' AND EARTHQUAKES: GEOPHYSICAL HAZARD ZONE

CONTEXT: In 2024, the Pacific 'Ring of Fire' experienced several notable seismic events, including earthquakes and volcanic eruptions. These events underscored the dynamic and hazardous nature of the tectonic interactions along this region.

▢ Pacific 'Ring of Fire' and Earthquakes Phenomena:

- ▶ The Pacific 'Ring of Fire' is a horseshoe-shaped zone of intense seismic and volcanic activity encircling the Pacific Ocean basin. This activity is driven by the subduction of oceanic plates beneath continental plates and the interaction of multiple tectonic plates.
- ▶ **Example:** In 2024, the region saw significant seismic activity, including a series of earthquakes in Japan and Indonesia, along with volcanic eruptions in the Philippines and Kamchatka.



Analysis of Impact

- ▶ **Environmental Impact:** The 'Ring of Fire' is home to numerous active volcanoes whose eruptions can impact climate and air quality. *For e.g.* The eruption of Mount Semeru in Indonesia in 2024 led to ashfall and air quality issues in nearby regions.
 - **Tsunamis:** Submarine earthquakes along subduction zones can trigger tsunamis, impacting coastal communities. The 2024 earthquake off the coast of Japan generated a tsunami that affected coastal areas, prompting evacuation measures.
- ▶ **Socio-Economic Impact:** Earthquakes and volcanic eruptions can cause significant damage to infrastructure, disrupting daily life and economic activities. *For e.g.* The 2023 earthquake in the Philippines damaged roads and bridges, hampering relief efforts and access to affected areas.
 - **Loss of Lives and Livelihoods:** Natural disasters in the 'Ring of Fire' can result in loss of lives and displacement of communities. The 2024 earthquake in Indonesia caused casualties and displaced thousands, highlighting vulnerabilities in disaster preparedness.
- ▶ **Global Impact:** Major volcanic eruptions can release ash and gases into the atmosphere, affecting global climate patterns. *For e.g.* The 2024 eruption of Mount Etna in Italy sent ash plumes into the atmosphere, influencing regional weather patterns.
 - **International Cooperation:** Countries in the 'Ring of Fire' region collaborate on disaster preparedness and response to mitigate transboundary impacts. *For e.g.* Following the 2024 earthquakes in Japan and Indonesia, international aid and cooperation facilitated relief efforts and recovery.
- ▶ **Scientific and Technological Response:** Advanced seismic and volcanic monitoring systems help predict and mitigate the impacts of earthquakes and eruptions. *For e.g.* The deployment of early warning systems in Japan alerted residents to the 2024 earthquake, reducing casualties and damage.

Case Study: 2023-24 Seismic Activity

The 2023-24 period witnessed significant seismic activity along the Pacific 'Ring of Fire', highlighting the region's susceptibility to earthquakes and volcanic eruptions. These events underscore the importance of preparedness, mitigation, and international cooperation in managing natural hazards in the tectonically active zone.

PREVIOUS YEAR QUESTION

Q. Discuss the geophysical characteristics of Circum-Pacific Zone. (2020)

PRACTICE QUESTION

Q. Explain the features and tectonic processes that characterize the Pacific 'Ring of Fire'. How do these features contribute to the high frequency of earthquakes in this region?

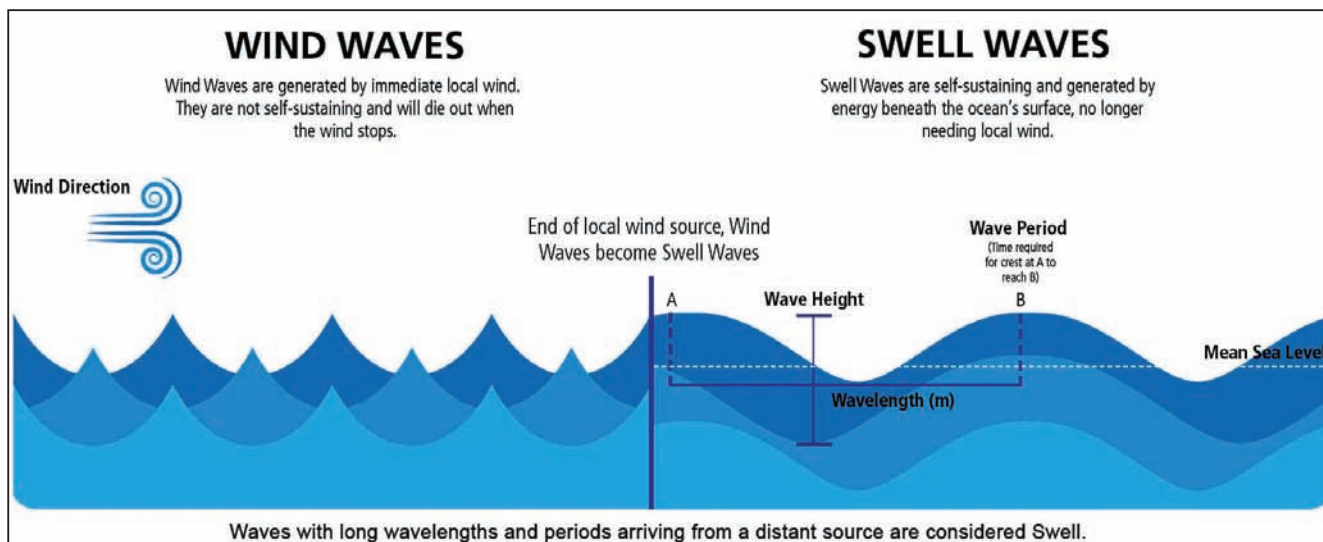
11. SEA SWELLS AND THEIR IMPACT ON HUMAN SETTLEMENTS

CONTEXT: Of Recent Event in 2024: In 2024, several coastal regions experienced heightened sea swell activity, attributed to strong storm systems and unusual oceanographic conditions. These events highlighted the vulnerability of coastal communities to the impacts of long-period waves.

Sea swells Phenomena:

- ▶ Sea swells, also known as ocean swells, are long-period waves that travel across the ocean surface, often generated by distant weather systems or undersea earthquakes. These swells can significantly impact coastal regions, affecting human settlements, infrastructure, and marine ecosystems.

- ▶ Sea swells are characterized by their long wavelengths and relatively uniform shape, distinct from wind-generated waves. They can travel thousands of kilometers across open ocean before reaching shorelines, where they manifest as powerful surges.
- ▶ **Example:** In 2024, the Pacific coast of North America witnessed elevated sea swells caused by a series of winter storms, leading to coastal erosion and flooding in some areas.



Impact

- ▶ **Environmental Impact:** Sea swells contribute to erosion of coastal cliffs and beaches, altering shoreline morphology. The 2023-24 winter season saw accelerated erosion along the California coastline, exacerbated by large swells generated by distant storms.
 - **Marine Ecosystems:** Swells can disrupt marine habitats and species, affecting breeding grounds and migration patterns. *For e.g.* Elevated sea swells in 2024 disturbed nesting sites of sea turtles in the Caribbean, impacting conservation efforts.
- ▶ **Socio-Economic Impact:** Coastal infrastructure, including homes, roads, and utilities, is vulnerable to damage from swells and coastal flooding. *For e.g.* In 2024, sea swells caused flooding and property damage along low-lying coastal areas in Florida, necessitating emergency response measures.
 - **Tourism and Recreation:** Beach closures and hazardous surf conditions during periods of high swells can impact tourism and local economies. Hawaiian resorts experienced cancellations and reduced visitor numbers in 2024 due to dangerous surf conditions from large swells.
- ▶ **Human Health and Safety:** Increased swells can lead to dangerous rip currents and rough surf conditions, posing risks to swimmers and water sports enthusiasts. *For e.g.* Lifeguards reported numerous rescues in 2024 along the Australian coast due to strong currents and powerful swells.
 - **Community Resilience:** Coastal communities must develop resilience strategies to mitigate the impact of sea swells, including early warning systems and coastal defense measures. New Zealand implemented community evacuation drills in 2024 following swells that threatened low-lying coastal towns.
- ▶ **Policy and Adaptation Strategies:** Governments enact policies to manage coastal erosion and mitigate the impact of sea swells on infrastructure and communities. *For e.g.* The Netherlands employs innovative coastal engineering techniques, such as dikes and beach nourishment, to protect against sea swells and storm surges.
 - **Climate Change Adaptation:** As sea levels rise and storm intensities increase, adaptation strategies are crucial for enhancing coastal resilience. The Maldives implemented shoreline protection projects in 2024 to safeguard against swells exacerbated by climate change.

Recent Case Study: 2023-24 Coastal Impacts

The 2023-24 period illustrated the diverse impacts of sea swells on coastal regions worldwide. From erosion and infrastructure damage to disruptions in marine ecosystems and tourism, these events underscored the need for integrated coastal management and adaptation strategies.

PRACTICE QUESTION

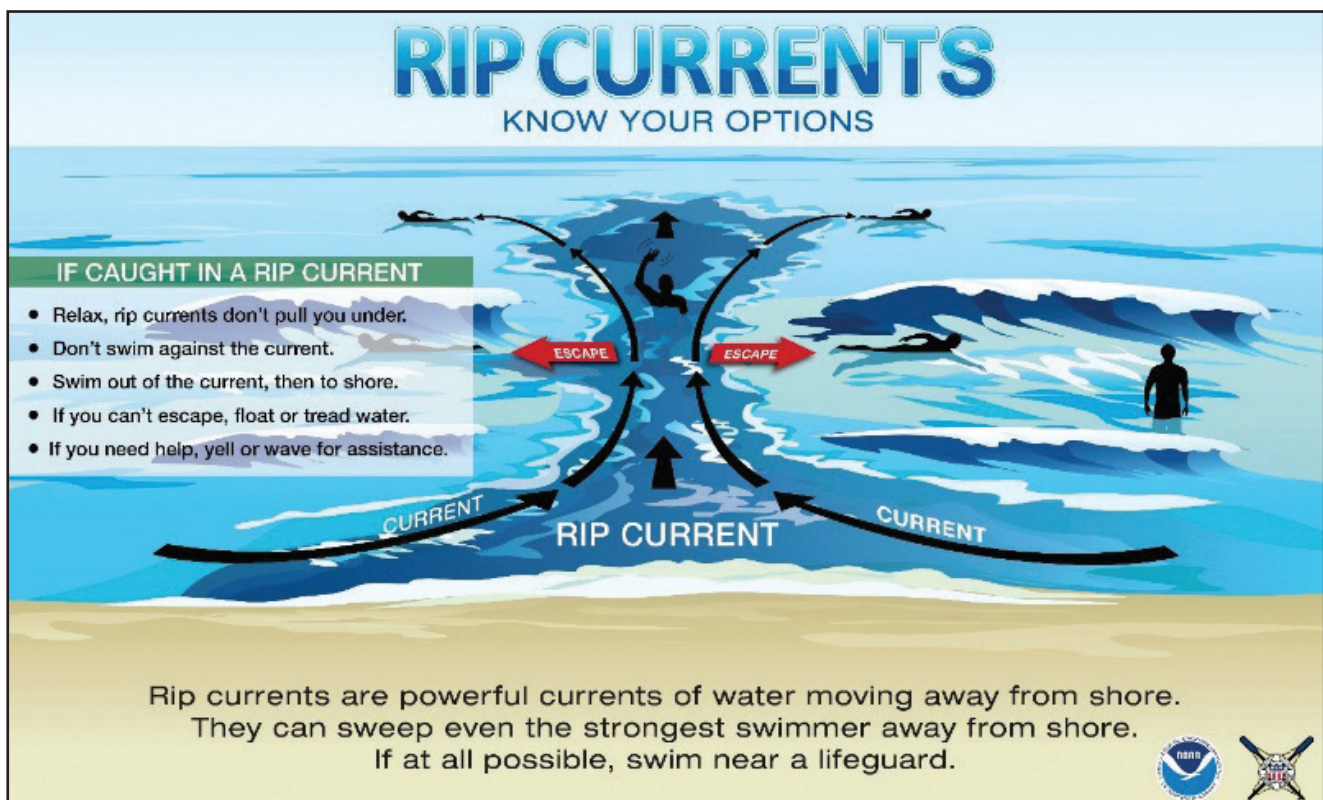
Q. Explain the phenomenon of sea swells and their causes. How do sea swells differ from other oceanic phenomena like waves and tides?

12. RIP CURRENTS: SIGNIFICANCE FOR BEACHES

CONTEXT: In 2024, several coastal regions experienced heightened rip current activity, exacerbated by strong storm systems and oceanographic conditions. These events underscored the persistent dangers rip currents pose to beach safety and public awareness efforts.

▢ Rip currents:

- Rip currents are powerful, narrow channels of water that flow rapidly away from the shore, posing significant risks to beachgoers worldwide. Understanding the dynamics and impacts of rip currents is crucial for beach safety and coastal management.
- Rip currents form when water pushed onto the shore by breaking waves returns seaward in concentrated channels. These currents can reach speeds of up to 8 feet per second, faster than an Olympic swimmer. They are typically caused by variations in shoreline topography, tidal conditions, and wave patterns.
 - **Example:** In 2024, beaches along the southeastern coast of the United States, including Florida and North Carolina, reported numerous incidents of rip current rescues and fatalities due to increased surf and storm activity.



▢ Impact

- **Human Safety:** Rip currents are responsible for the majority of beach-related drownings globally. In 2023-24, the U.S. Lifesaving Association reported over 100 fatalities attributed to rip currents, emphasizing their lethal potential.

- **Public Awareness and Education:** Effective communication of rip current risks is critical to reducing incidents and enhancing beach safety. *For e.g.* Beach safety campaigns in Australia in 2024 emphasized identifying rip currents and proper response protocols, reducing drowning incidents.
- **Environmental Impact:** Rip currents can contribute to erosion by transporting sand offshore, affecting coastal stability. Increased rip current activity in 2024 led to accelerated erosion along vulnerable stretches of beachfront in parts of Europe and Australia.
- **Marine Life:** Rip currents influence marine habitats and species distribution, impacting biodiversity. *For e.g.* Marine protected areas in South Africa experienced altered ocean circulation patterns in 2024, affecting coastal ecosystems.
- **Socio-Economic Impact:** Rip currents can disrupt beach tourism and recreational activities, impacting local economies. *For e.g.* The closure of popular beaches in Spain and Portugal in 2024 due to dangerous rip currents resulted in financial losses for coastal businesses.
- **Emergency Response Costs:** Managing rip current-related emergencies imposes significant costs on public services and healthcare systems. Emergency response expenditures related to rip current incidents in California in 2024 exceeded \$1 million, highlighting the economic burden.
- **Policy and Management Strategies:** Governments and organizations implement measures such as lifeguard patrols and warning systems to mitigate rip current risks. *For e.g.* The installation of rip current signage and rescue equipment along California's coastline in 2024 enhanced beach safety protocols.
- **Coastal Planning:** Integrated coastal management strategies include rip current monitoring and beach nourishment projects to enhance resilience. The Netherlands' coastal management plan in 2024 integrated rip current mapping to safeguard against erosion and enhance coastal sustainability.

Recent Case Study: 2023-24 Rip Current Incidents

The 2023-24 period highlighted the ongoing challenges rip currents pose to beach safety and coastal management efforts globally. From public safety initiatives to environmental impacts, addressing rip current risks requires coordinated efforts across scientific research, policy development, and community engagement.

PRACTICE QUESTION

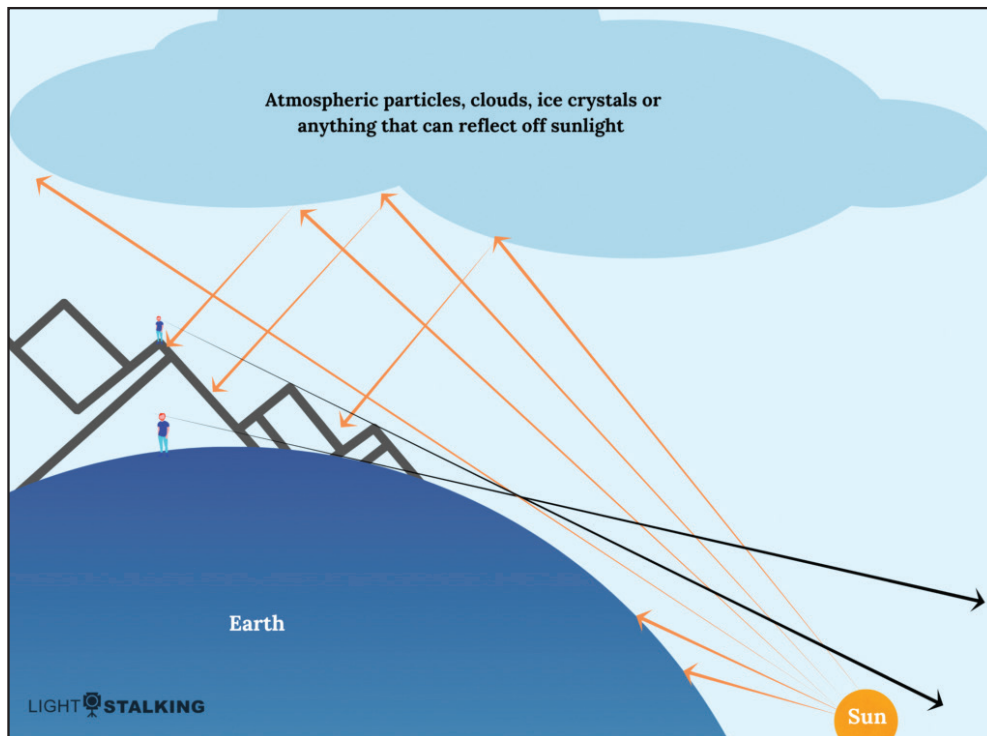
Q. Explain the formation and characteristics of rip currents. How do rip currents pose risks to coastal ecosystem and what factors influence their strength and occurrence?

13. ALPENGLOW: A RARE PHENOMENA

CONTEXT: In January 2024, a stunning display of the Alpenglow phenomenon was captured near the Hindu Kush mountain range by astronaut Lora O'Hara, who was stationed aboard the International Space Station (ISS). This event brought the Alpenglow phenomenon into the limelight, sparking interest and curiosity worldwide.

Alpenglow Phenomenon:

- Alpenglow is a natural phenomenon where mountain slopes are illuminated by the sun as it rises or sets. The slopes turn a rosy, reddish, or orange hue depending on the angle of the sun and atmospheric conditions. It occurs during the twilight hours before sunrise or after sunset, and can also occur in the first minutes after the sun rises or sets.



- The phenomenon typically occurs in the range of colors between red, pink, and orange. This is because these are the longest warm rays of **electromagnetic wave (light)** — they reach various surfaces, while cold rays are shorter and disappear faster in the atmosphere.

▢ Conditions and Impact

- ▶ **Atmospheric Conditions:** The vibrancy and color of Alpenglöhen depend on the location of the sun, the angle of the light, and other atmospheric conditions like clouds, humidity, and particulates. It can change quickly depending on how fast the sun sets on any given day.
- ▶ **Geographical Location:** The occurrence and visibility of Alpenglöhen are influenced by the geographical location. Mountainous regions, such as the Hindu Kush, provide ideal conditions for observing this phenomenon.
- ▶ **Seasonal Variations:** Seasonal variations can also affect the occurrence and intensity of Alpenglöhen. Longer twilight periods during the summer months can enhance the visibility and duration of this phenomenon.
- ▶ **Impact of Climate Change:** Climate change, with its potential to alter atmospheric conditions, could potentially impact the occurrence and visibility of Alpenglöhen. Further research is needed to understand this dimension fully.

Case Study: Alpenglöhen in the Hindu Kush (2023-24)

The Hindu Kush mountain range, which stretches over 800 kilometers and winds through Afghanistan, reaching into Northern Pakistan and Tajikistan, provided a spectacular display of Alpenglöhen in 2023-24. The region, home to approximately two billion people, is experiencing alarming rates of warming, which is three times the global average. Despite these challenges, the region continues to offer breathtaking natural phenomena like Alpenglöhen, reminding us of the beauty and fragility of our planet.

PRACTICE QUESTION

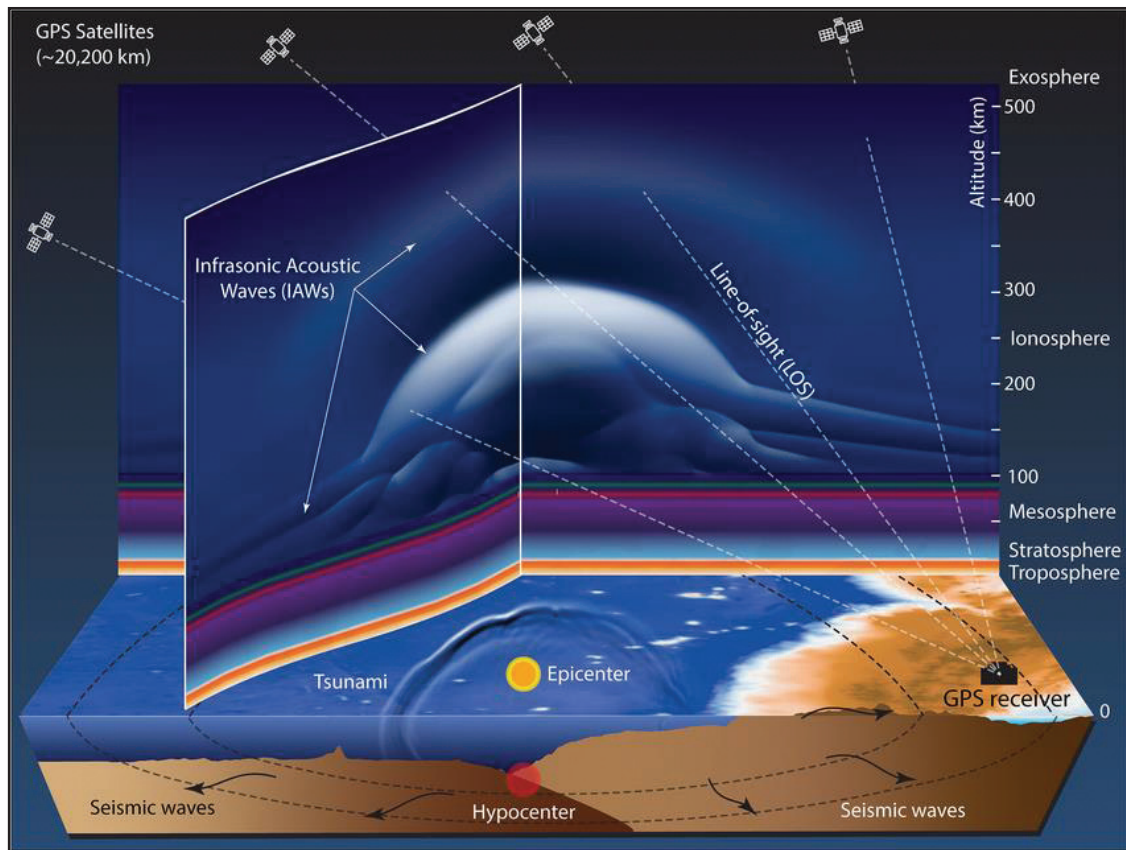
- Q. Describe the Alpenglöhen phenomenon and explain the atmospheric conditions that contribute to its occurrence.

14. EARTHQUAKES AND IONOSPHERE: INTERRELATED GEOPHYSICAL PHENOMENA

CONTEXT: In 2024, the world witnessed a significant event that highlighted the interrelation between earthquakes and the ionosphere. A powerful earthquake with a magnitude of 7.5 struck the Ishikawa region of Japan on January 1st. This event sparked interest in the scientific community, leading to further exploration of the connection between seismic activities and ionospheric changes.

▢ Phenomena:

- ▶ Earthquakes are seismic activities resulting from the movement of tectonic plates in the Earth's lithosphere. The ionosphere, on the other hand, is a layer of the Earth's atmosphere filled with ions and free electrons.
- Research suggests that seismic activities can cause changes in the ionosphere. For instance, the crushing of rock crystalline structures during an earthquake can release electromagnetic signals, causing ionospheric changes.



▢ Analysis of the Phenomena

- ▶ **Seismic Activities:** Seismic activities can cause changes in the ionosphere. For example, the density and flow of electrons in the ionosphere can change due to shifts in the Earth's tectonic plates.
- ▶ **Ionospheric Changes:** Ionospheric changes can serve as potential precursors to earthquakes. For instance, variations in the shape of electron concentrations along earthquake longitudes have been observed.
- ▶ **Geographical Location:** The geographical location of an earthquake can influence the extent of ionospheric changes. For example, earthquakes occurring near the equator can have a more pronounced effect on the ionosphere.
- ▶ **Time of Occurrence:** The time of occurrence of an earthquake can also influence ionospheric changes. For instance, ionospheric perturbations have been observed 5 days before and after the main shock of an earthquake.

Case Study:

The seismic events of 2023-24 underscored the dynamic interactions between earthquakes and the ionosphere, advancing scientific understanding and technological applications in earthquake forecasting and disaster management. By leveraging these insights, researchers and policymakers can enhance global resilience to seismic hazards and improve early warning capabilities.

PREVIOUS YEAR QUESTION

Q. Troposphere is a very significant atmosphere layer that determines weather processes. How? (2022)

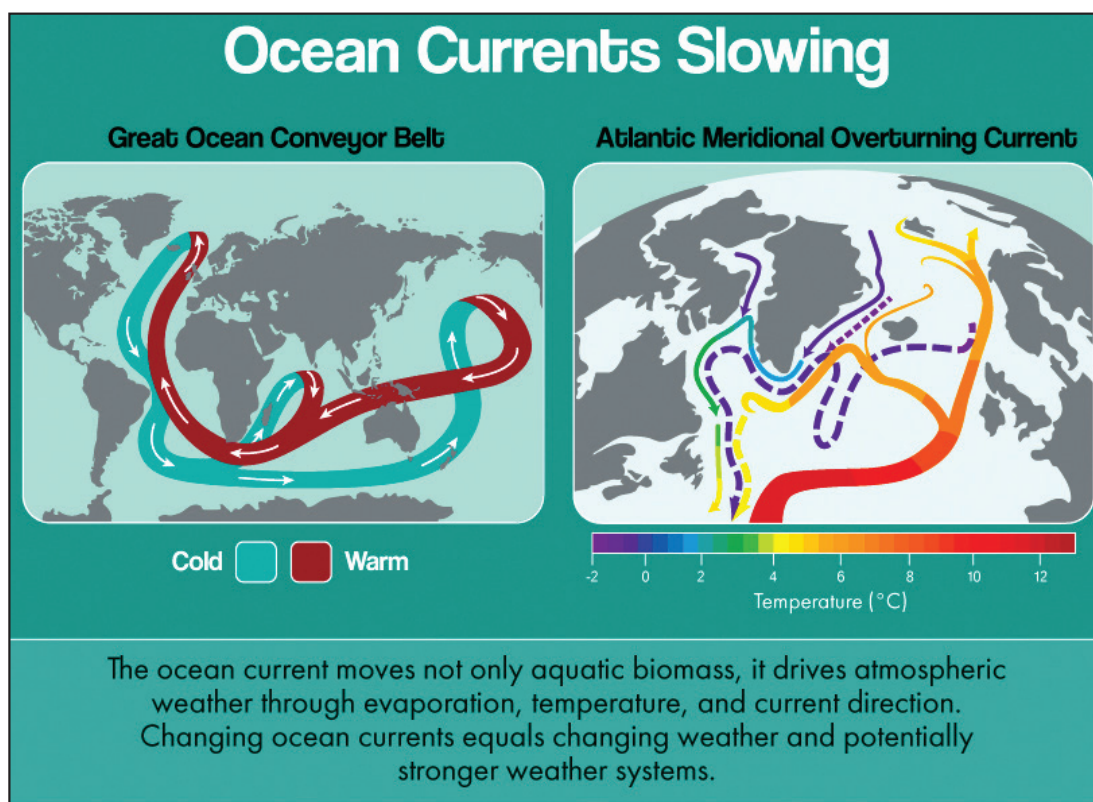
PRACTICE QUESTION

Q. Explain the interrelation between earthquakes and the ionosphere. How do seismic activities influence ionospheric disturbances, and what scientific methods are used to study this phenomenon?

15. IMPACT OF CLIMATE CHANGE ON OCEAN CURRENTS

CONTEXT: In 2024, UNESCO's State of the Ocean Report revealed alarming data on threats facing the ocean, including ocean warming, rising sea levels, pollution, acidification, de-oxygenation, blue carbon, and biodiversity loss. The report indicated that the rate of ocean warming has doubled in the past 20 years, leading to significant shifts in ocean currents.

- **Impact of climate change on ocean currents:** Ocean currents, driven by wind, temperature, and salinity differences, play a key role in distributing heat around the globe.
 - Climate change, primarily caused by increased greenhouse gas emissions, is disrupting these currents.
 - As the ocean absorbs about 90% of the excess heat released into the atmosphere, the rising temperatures are causing changes in ocean currents.



❏ Impact:

- **Ocean Warming:** The ocean has absorbed about 90% of the heat generated by rising emissions. This excessive heat warms the ocean, leading to changes in ocean currents.
- **Sea-Level Rise:** As the ocean warms, it expands, leading to a rise in sea levels. This rise, along with melting ice, affects the salinity of the ocean, further influencing ocean currents.
- **Changes in Ocean Currents**
 - ❖ Climate change is causing ocean currents to become more energetic. These changes in currents alter the distribution of heat in the ocean, impacting local weather and marine ecosystems.
- **Impact on Marine Life:** Changes in ocean currents can lead to shifts in marine ecosystems. For instance, changes in ocean color, a reflection of the organisms in its waters, indicate shifts in marine ecosystems.

Case Study: Overturning circulation

In 2023-24, researchers detected a slowdown of the deep “overturning circulation” that carries carbon, heat, oxygen, and nutrients from Antarctica around the globe. At the same time, surface ocean currents were becoming more energetic. These changes, likely driven by human-induced climate change, have far-reaching impacts on marine life and global climate patterns.

PREVIOUS YEAR QUESTION

- Q. What are the forces that influence ocean currents? Describe their role in fishing industry of the world. (2022)
- Q. Defining blue revolution, explain the problems and strategies for pisciculture development in India. (2018)

PRACTICE QUESTION

- Q. Explain the mechanisms through which climate change influences ocean currents. Substantiate with suitable examples.

16. CRYOSPHERE AND CLIMATE CHANGE

CONTEXT: In 2024, the world's attention was drawn to the alarming rate at which the cryosphere is changing. A UNESCO report revealed that the rate of ocean warming has doubled in the past 20 years, leading to significant shifts in the cryosphere.

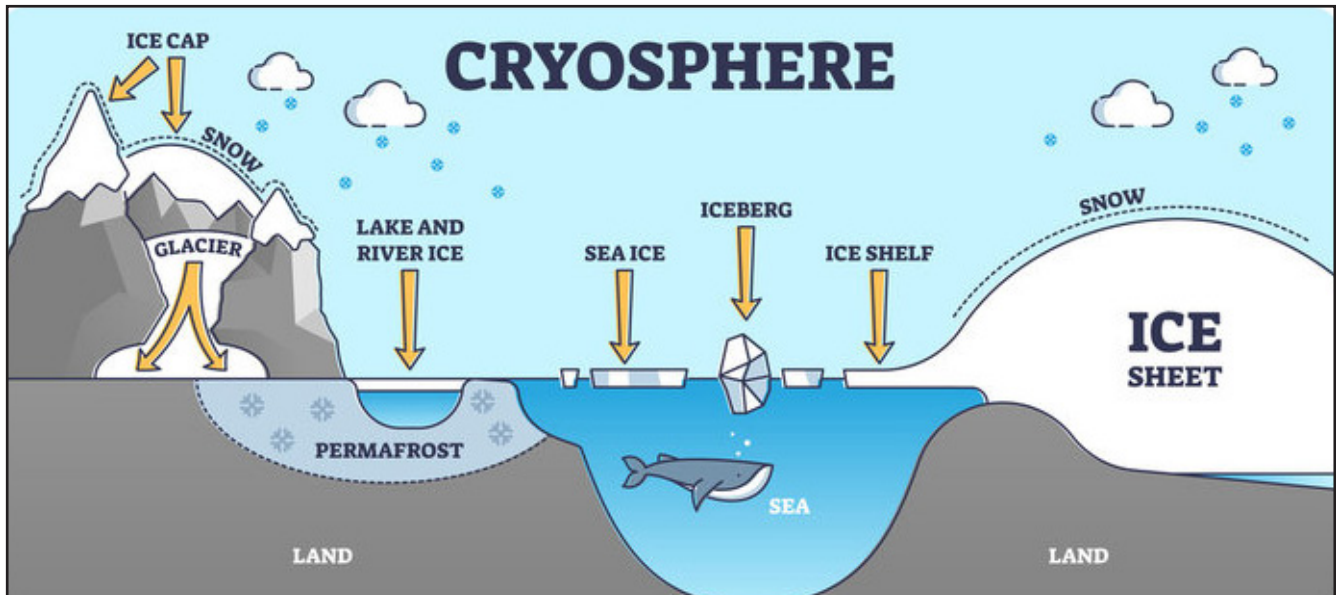
❏ Understanding the Phenomena:

- The cryosphere refers to the frozen parts of the Earth, including snow, ice caps, glaciers, permafrost, and sea ice.
 - ❖ It plays a crucial role in maintaining Earth's climate by reflecting incoming solar radiation back into space. However, as the world warms due to increasing greenhouse gases, the snow and ice are melting.
 - ❖ This exposes more of the dark ocean below the ice and the dark vegetation below on land, which absorb the solar radiation, causing more melting.
 - ❖ This creates a positive feedback loop, exacerbating the impacts of climate change.

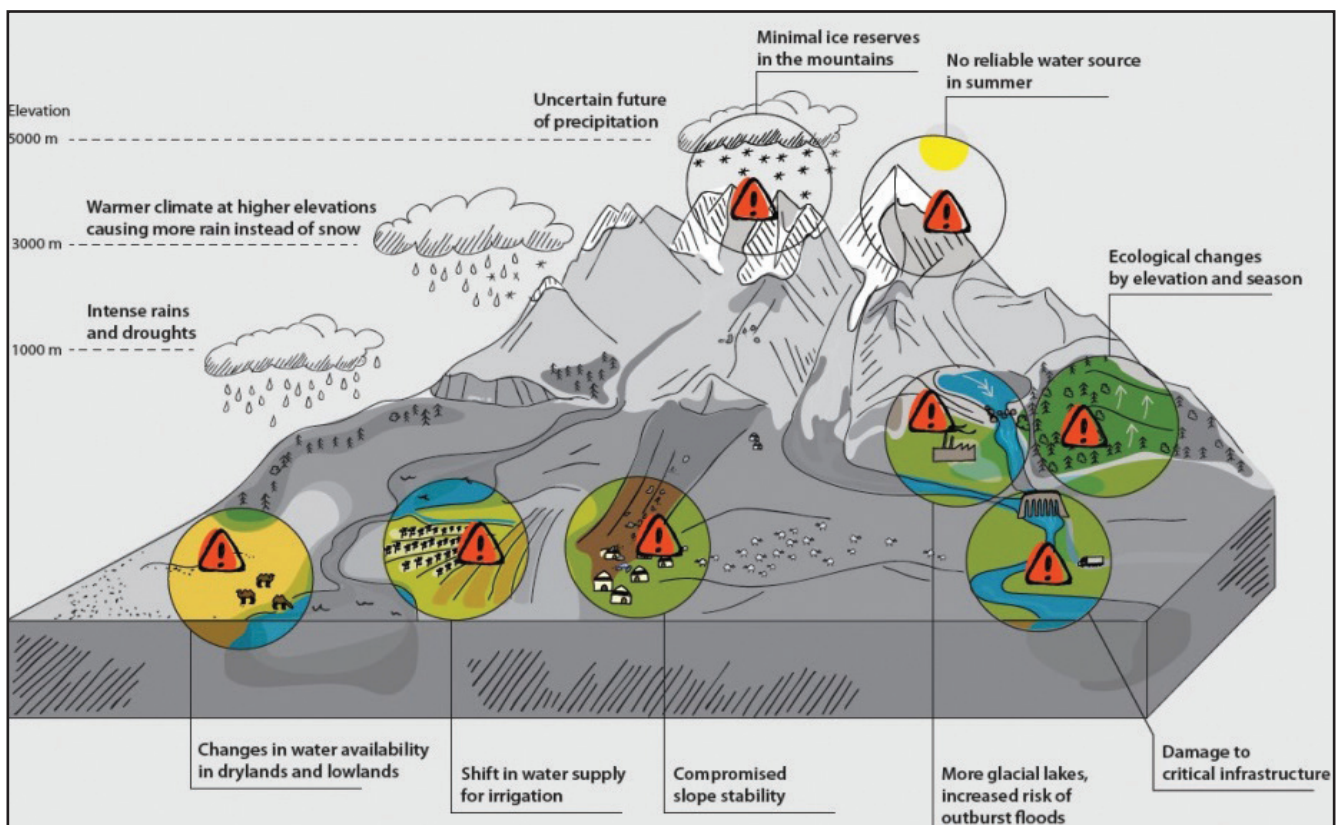
❏ Impact of Climate change on Cryosphere

- **Cryosphere Degradation:** The degradation of the cryosphere is a key indicator of climate change. For instance, the Arctic is warming at two to four times the rate of the rest of the planet.

- **Sea-Level Rise:** As the cryosphere melts, it contributes to sea-level rise. About 69 percent of total fresh water on Earth is stored in ice sheets, ice caps, and glaciers. When this ice melts and its water runs into the ocean, sea level rises.
- **Impact on Ecosystems:** Changes in the cryosphere can lead to shifts in ecosystems. Many animals and plants are uniquely adapted to snowy environments, and these changes can threaten their survival.



- **Impact on Human Communities:** Human communities, particularly those in high mountain areas and the Arctic, are heavily dependent on the cryosphere for their water supply. Changes in the cryosphere can impact water availability, access, and management.



Case Study: Cryosphere Changes in Central Asia

In 2023-24, UNESCO implemented two projects in Central Asia to address the cryospheric changes impacting water availability and to provide adaptation strategies to climate change for communities living in the region. The projects highlighted the importance of community-based adaptation strategies in mitigating hazards in Central Asia.

PRACTICE QUESTION

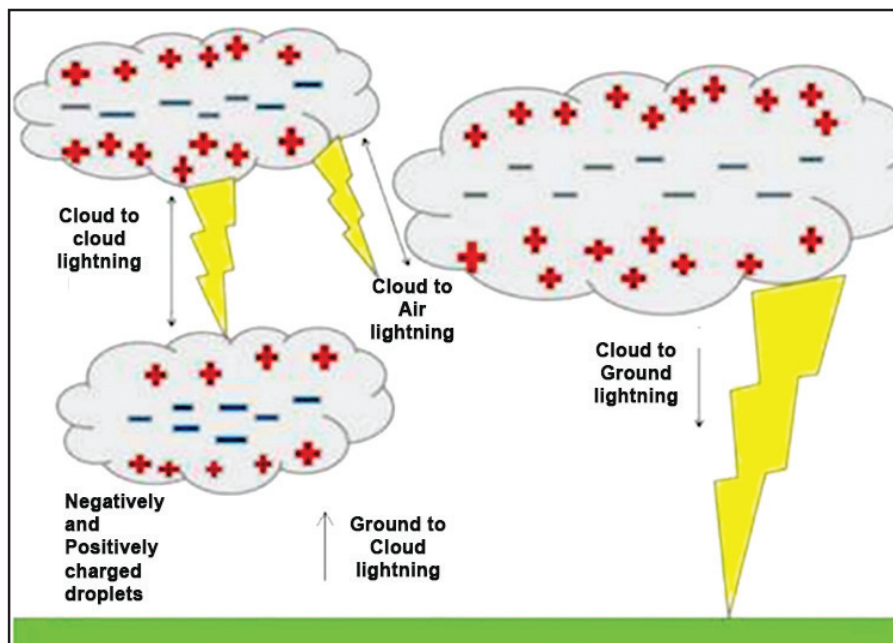
Q. Explain the significance of the cryosphere in regulating global climate patterns. How is climate change affecting different components of the cryosphere?

17. LIGHTNING IN INDIA: PHENOMENA, IMPACT AND CHALLENGES

CONTEXT: In 2024, India witnessed a significant increase in lightning strikes, with a 53% rise between 2019 and 2023. This surge in lightning activity has been attributed to climate change and has led to a growing concern for public safety.

Lightening Phenomena:

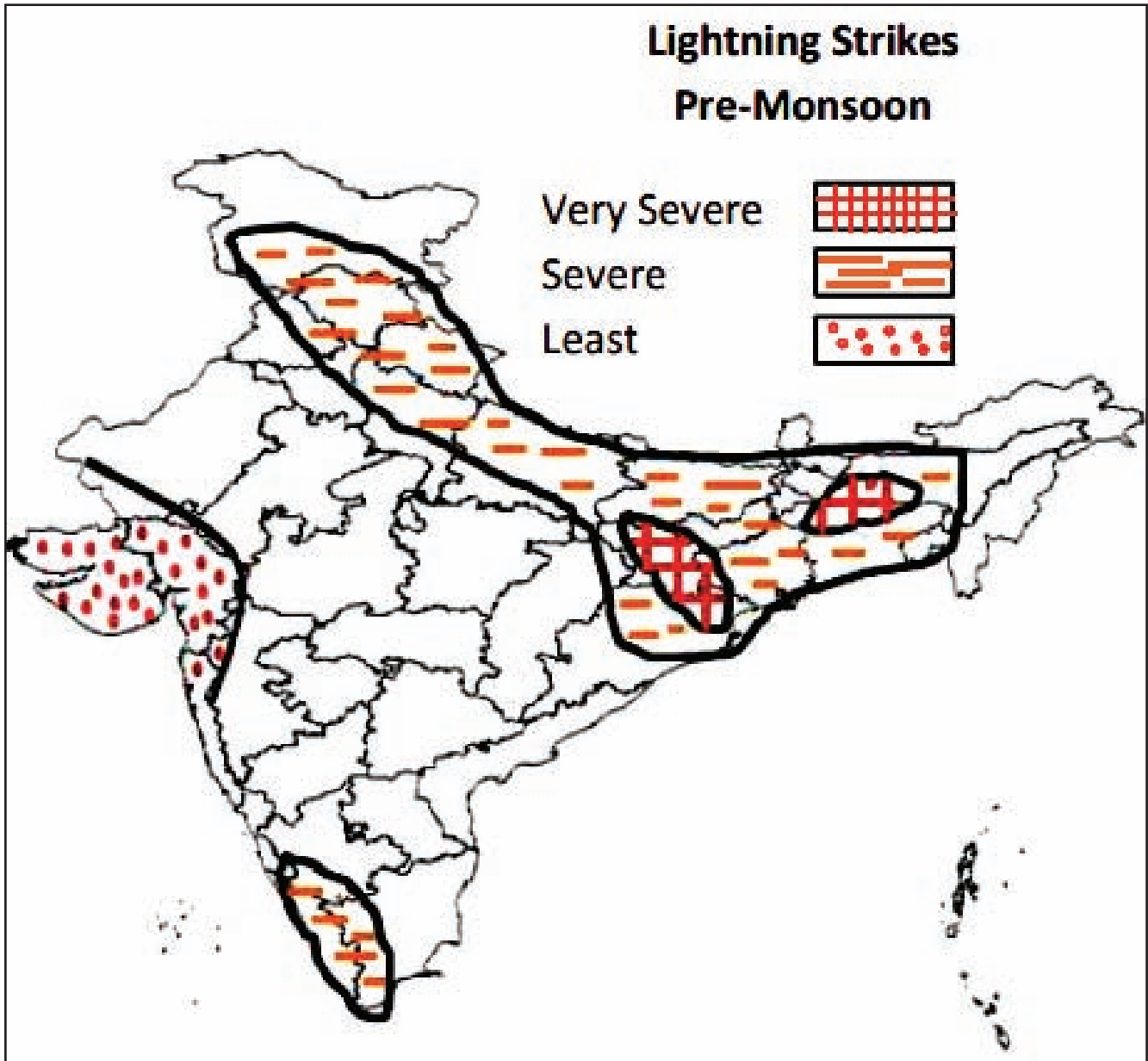
- ▶ Lightning is a powerful and visible electrical phenomenon that occurs due to a buildup of electrical charges within clouds and between clouds and the ground. A typical lightning flash measures about 300 million volts and 30,000 amps, enough to cause fatalities. It can heat the air around it to temperatures five times that on the surface of the sun.



Impact of Lightening Strike

- ▶ **Frequency and Intensity:** India recorded more than 18 million lightning strikes between April 2020 and March 2021. The frequency and intensity of these strikes have been increasing, posing a significant threat to life and property.
- ▶ **Geographical Distribution:** Lightning frequency is highest in northeastern states and West Bengal, Sikkim, Jharkhand, Odisha, and Bihar. However, the number of lightning-related deaths is higher in central Indian states like Madhya Pradesh, Maharashtra, Chhattisgarh, and Odisha.

- ▶ **Seasonal Variations:** The occurrence of lightning is influenced by seasonal variations. Monsoon seasons often see a spike in lightning activity due to the increased atmospheric instability.
- ▶ **Impact on Human Life:** Lightning strikes have resulted in a significant number of fatalities each year. More than 2,500 Indians lose their lives to lightning every year. Survivors might have to live with symptoms such as weakness, dizziness, and memory loss.



Case Study: Lightning Strikes in Bihar

In 2023-24, Bihar, one of the most vulnerable states to lightning strikes, recorded 107 deaths due to lightning. The state has been witnessing a rise in both lightning strikes and mortality. Most of the casualties take place among tribals, especially in Madhya Pradesh, Jharkhand, and Odisha, due to their housing patterns and subsistence on the land.

PREVIOUS YEAR QUESTION

Q. How do the melting of the Arctic ice and glaciers of the Antarctic differently affect the weather patterns and human activities on the Earth? Explain. (2021)

PRACTICE QUESTION

Q. Examine the phenomena of lightening with its formation and characteristics? What advancements are needed to enhance early warning systems and reduce the impacts of lightning strikes?

18. MARINE HEATWAVE AND ITS IMPACTS

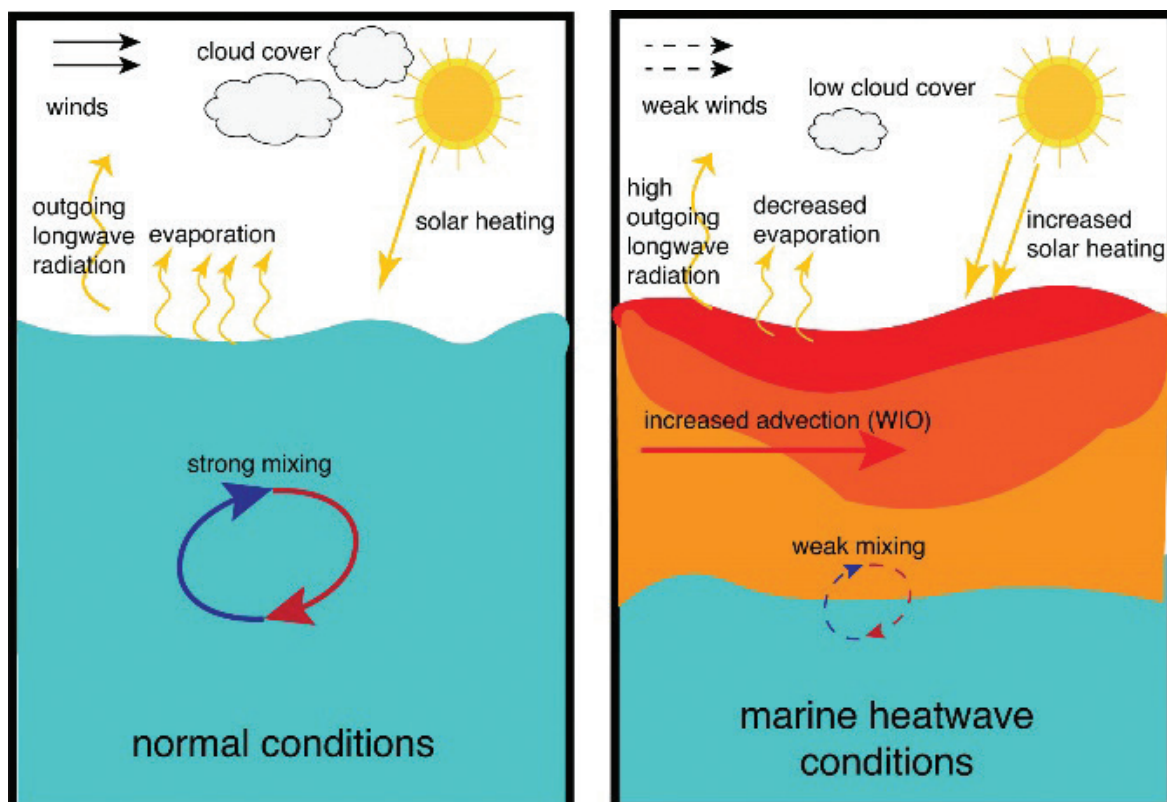
CONTEXT: In 2024, the world witnessed a significant surge in marine heatwaves (MHWs), with the northern Bay of Bengal experiencing an intense MHW since June 28th. This event has led to extreme rainfall in India's usually arid northwest.

Understanding Marine Heatwaves:

- ▶ Marine heatwaves are prolonged periods of anomalously high sea surface temperatures. These events are linked to coral bleaching, seagrass destruction, loss of kelp forests, and adverse effects on the fisheries sector.
 - The most common drivers of MHWs include **ocean currents**, which can build up areas of warm water, and **air-sea heat flux**, or warming through the ocean surface from the atmosphere.

Impact

- ▶ **Frequency and Intensity:** The frequency and intensity of MHWs have been increasing globally. For instance, the northern Bay of Bengal has been experiencing an intense MHW since June 28th, 2023.
- ▶ **Geographical Distribution:** MHWs have been recorded in all major ocean basins. Certain regions, such as the Bay of Bengal, are particularly vulnerable due to their unique oceanographic conditions.
- ▶ **Impact on Marine Ecosystems:** MHWs can lead to severe biodiversity changes such as coral bleaching, sea star wasting disease, harmful algal blooms, and mass mortality of benthic communities.
- ▶ **Socioeconomic Impacts:** MHWs can cause economic losses through impacts on fisheries and aquaculture. They also pose a threat to human health and economies.

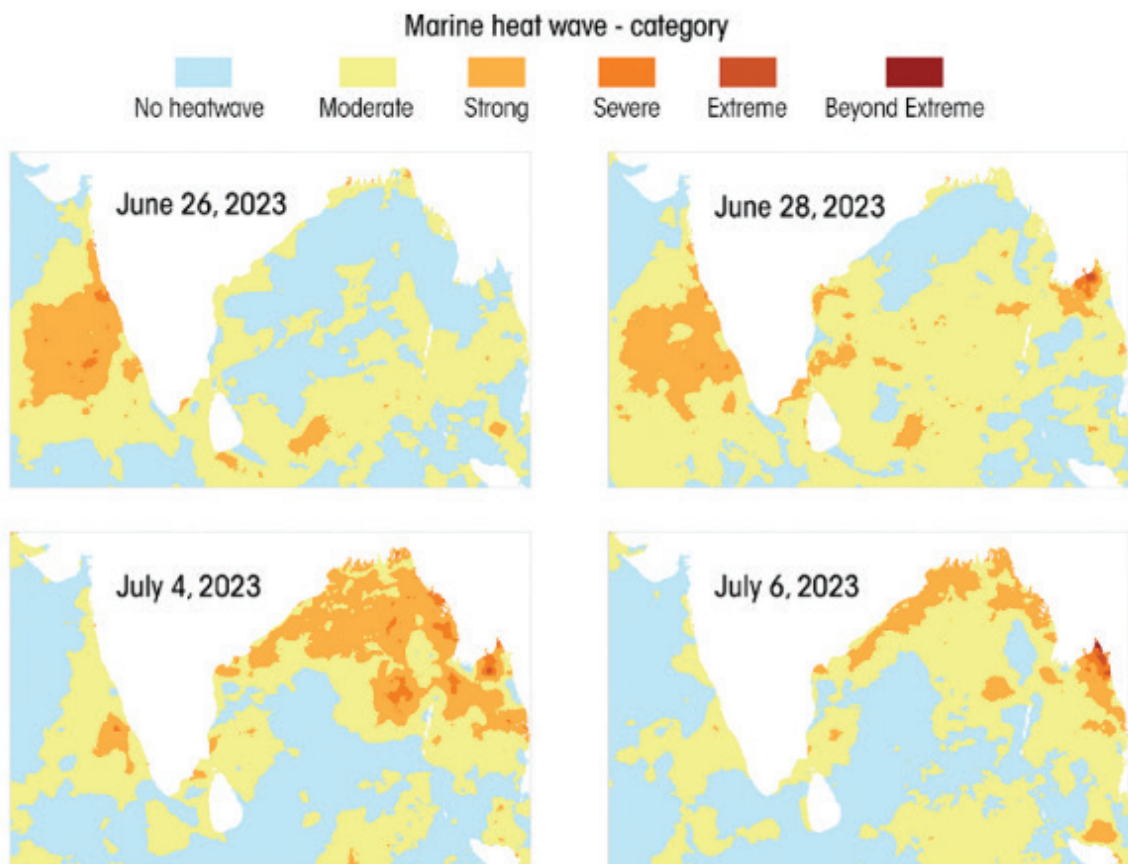


Case Study: Marine Heatwaves in the Bay of Bengal

In 2023-24, the northern Bay of Bengal experienced an intense MHW, leading to India's usually arid northwest receiving extreme rainfall. The MHW increased sea surface temperatures, causing higher evaporation rates and a greater moisture supply in the atmosphere. This surplus of moisture contributed to above-average rainfall in northwest India.

BoB: SCORCHED

Marine heatwaves, according to the National Oceanic and Atmospheric Administration, "prolonged periods of anomalously high sea surface temperature". But marine heatwaves are also part of the weather phenomenon. The maps below show the increase in intensity over the Bay of Bengal (BoB) and the Andaman Sea region from June 26 to July 6, 2023. A warmer-than-usual BoB also means extreme rainfall days in various parts of the country.



Source: NOAA

Down To Earth

PREVIOUS YEAR QUESTION

Q. What are the consequences of spreading of 'Dead Zones' on marine ecosystems? 2018

PRACTICE QUESTION

Q. Define marine heatwaves (MHW) and discuss their causes and characteristics. How do marine ecosystems and fisheries respond to prolonged periods of elevated sea surface temperatures?

19. THE SLOWDOWN IN OVERTURNING CIRCULATION: REASONS AND IMPACT

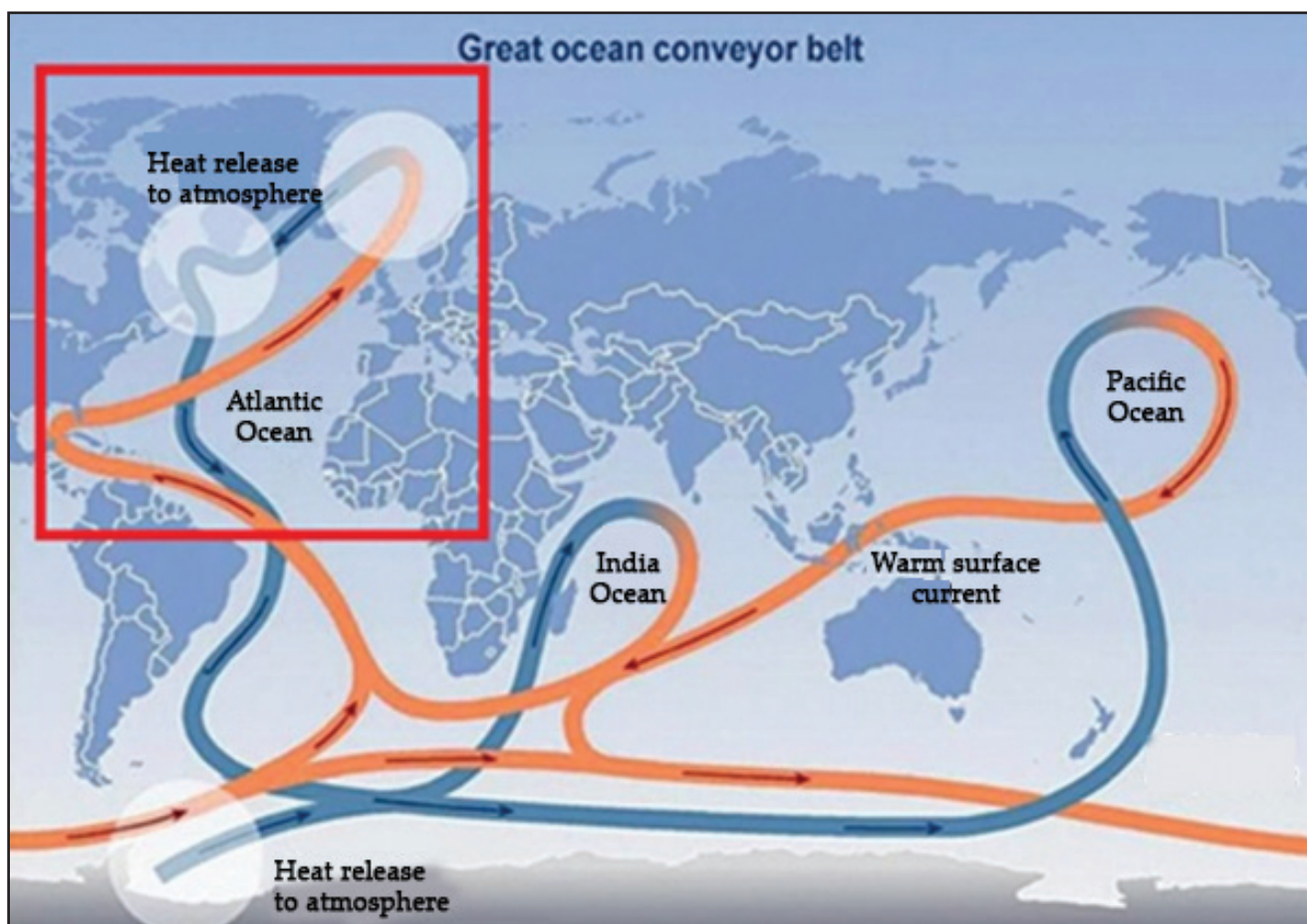
CONTEXT: In 2024, the world's attention was drawn to the alarming slowdown in the Overturning Circulation. This event has led to significant changes in the Antarctic deep ocean over the past three decades.

❏ Overturning Circulation:

- Overturning Circulation refers to the global network of ocean currents that redistribute heat, carbon, and nutrients across the world's oceans. In Antarctica, it involves the sinking of dense, oxygen-rich water from the surface, its spread along the sea floor, and slow rise in distant regions.

❏ Significance and Impact

- **Frequency and Intensity:** The observed slowdown of deep ocean currents in Antarctica, occurring earlier than anticipated, raises concerns about climate stability.
- **Geographical Distribution:** The slowdown in circulation and declining oxygen levels in the deep ocean have been observed, indicating significant changes in the Antarctic deep ocean over the past three decades.
- **Impact on Marine Ecosystems:** A reduced flow of bottom water results in a decline in oxygen supply to the deep ocean, impacting oxygen-dependent organisms.
- **Impact on Climate Change:** The slowdown amplifies global warming as the ocean's capacity to store carbon dioxide and heat diminishes, intensifying the greenhouse effect.



Case Study: Overturning Circulation

In 2023-24, studies showed that the Atlantic Meridional Overturning Circulation (AMOC) has already weakened as a result of anthropogenic climate change and is possibly moving towards a tipping point. This current has a significant influence on climate, particularly in Europe.

PRACTICE QUESTION

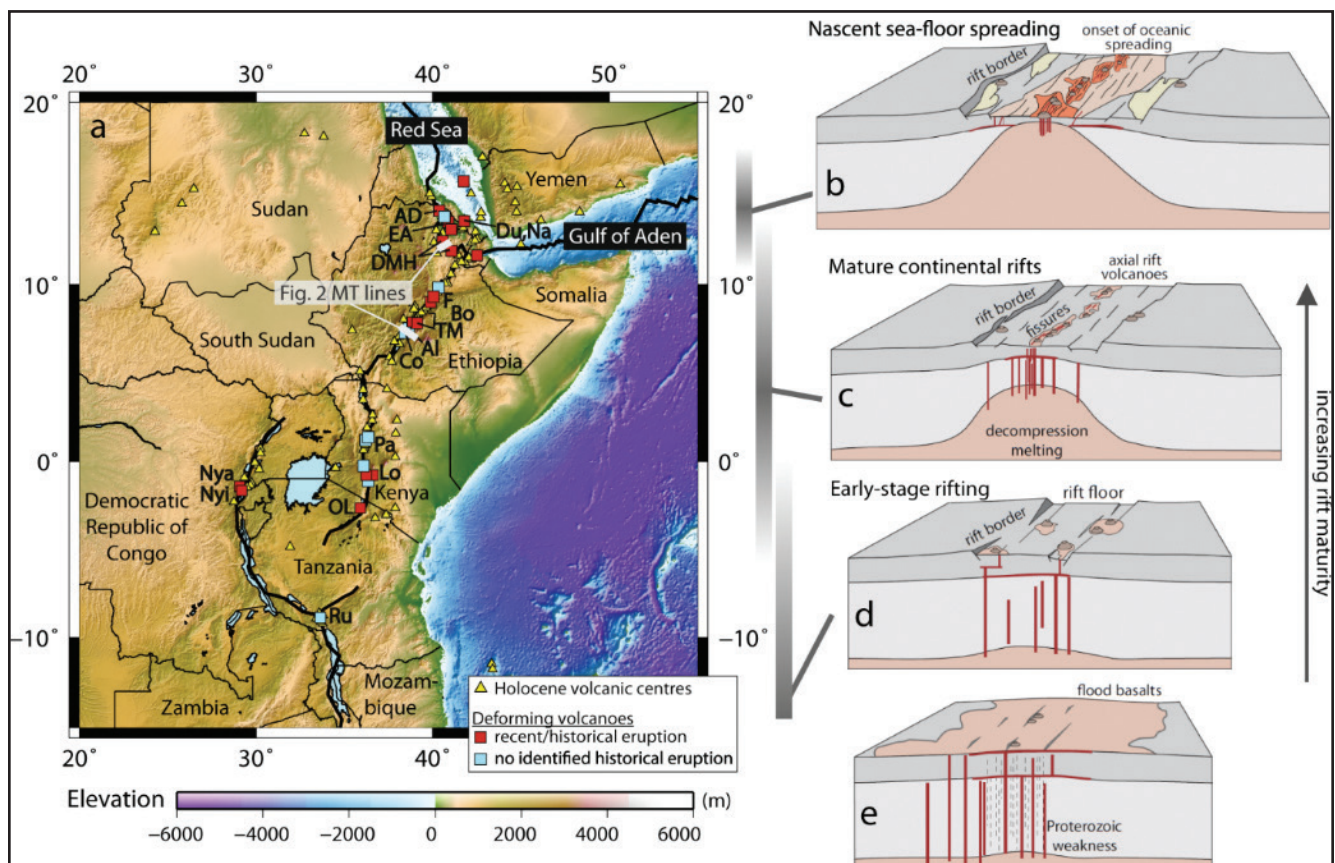
Q. Discuss the impact of the slowdown in Overturning Circulation on the global climate and marine ecosystems. Substantiate with suitable examples.

20.AFRICA'S RIFT VALLEY AND THE CREATION OF A NEW OCEAN BASIN

CONTEXT: In 2024, the world's attention was drawn to the significant geological changes occurring in Africa's Rift Valley. A study revealed that the gradual separation of the African continent is leading to the formation of a new ocean basin.

Rifting of African Continent:

- ▶ The East African Rift, also known as the **Great Rift Valley**, is a crack that stretches 56 kilometers and appeared in the desert of Ethiopia in 2005. This rift is triggering the formation of a new sea. The division of the continent is connected to the movement of three plates — the **Nubian African Plate**, **Somalian African Plate**, and **Arabian Plate**.



■ Analysis of the Continental Rifting

- ▶ **Tectonic Movement:** The Arabian Plate is moving away from Africa at a rate of about an inch per year, while the two African plates are separating even slower, between half an inch to 0.2 inches per year.
- ▶ **Geographical Changes:** In the past 30 million years, the Arabian Plate has been gradually moving away from Africa, which has already led to the creation of the Red Sea and the Gulf of Aden.
- ▶ **Future Predictions:** As the Somali and Nubian tectonic plates continue to pull apart from each other, a smaller continent will be created from the rift, which will include present-day Somalia and parts of Kenya, Ethiopia, and Tanzania.
- ▶ **Formation of a New Ocean:** The Gulf of Aden and the Red Sea will eventually flood into the Afar region in Ethiopia and the East African Rift Valley, leading to the formation of a new ocean. This new ocean will result in East Africa becoming a separate small continent with its own unique geographic and ecological characteristics.

Case Study: Rift Valley

While the rifting process has been occurring for some time, the potential division made headlines worldwide in 2018 when a large crack emerged in the Kenyan Rift Valley. The necessary separation of the Somali and Nubian tectonic plates will take 5 to 10 million years to create a new ocean basin.

PRACTICE QUESTION

Q. Discuss the geological phenomena leading to the creation of a new ocean basin in Africa's Rift Valley. Also analyze the potential impacts of these changes.

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2

INDIAN GEOGRAPHY

1. CYCLONES OF BAY OF BENGAL AND CLIMATE CHANGE

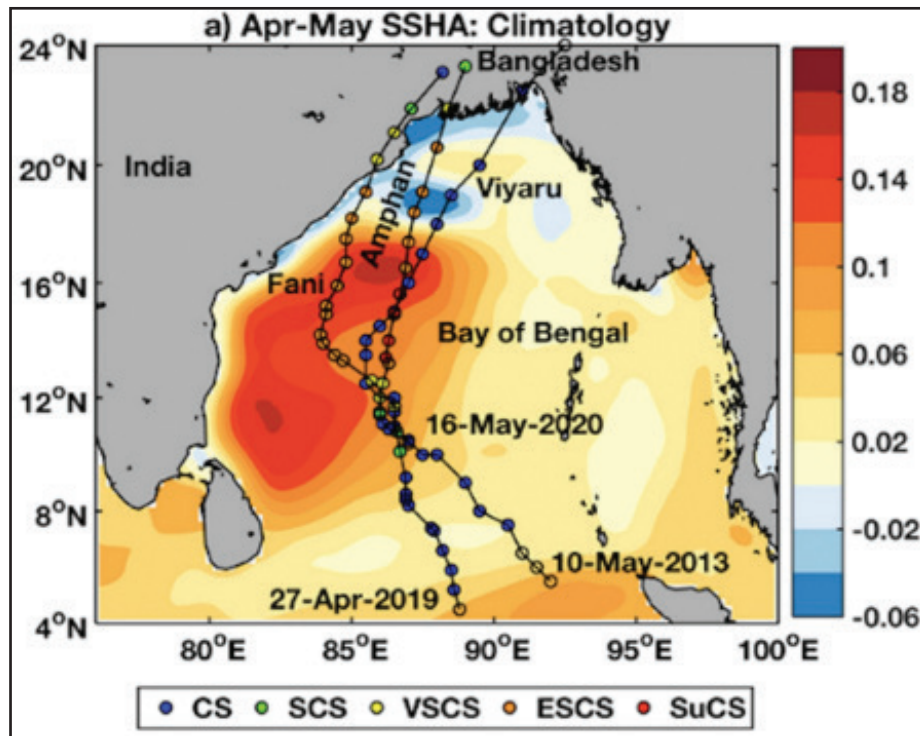
CONTEXT: The Bay of Bengal, a basin prone to cyclones, has witnessed significant climatic shifts in recent times. The year 2023-24 saw notable cyclonic activities, such as Cyclone Hamoon and Cyclone Midhili, which brought about considerable discourse on climate change's impact on cyclonic patterns.

▣ Cyclone Phenomena:

- ▶ Cyclones are large-scale air masses that rotate around a strong center of low atmospheric pressure. They are formed over warm tropical waters, with the Bay of Bengal being particularly conducive due to its high sea surface temperatures and ample moisture.

▣ Cyclone Impact:

- ▶ **Intensity:** Cyclone Hamoon (October 2023) reached wind speeds up to 143 km/h, becoming a severe cyclonic storm as it made landfall in Bangladesh.
- ▶ **Frequency:** Close on Hamoon's heels, Cyclone Midhili (November 2023) put West Bengal and Odisha on alert, indicating an increased frequency of cyclonic events.
- ▶ **Preparedness:** The prediction and tracking of Tropical Cyclone Mocha (May 2023) demonstrated advancements in early warning systems, crucial for timely evacuations and preparations.
- ▶ **Mitigation Efforts:** The back-to-back formation of low-pressure areas in November 2023 highlighted the need for improved disaster management strategies to mitigate cyclone impacts.
- ▶ **Climate Change Impact:** Studies predict a decrease in the overall number of cyclones but an increase in post-monsoon intensity due to warming sea surface temperatures and changing atmospheric conditions.



Case Studies: Cyclone Hamoon

Cyclone Hamoon's landfall in Bangladesh and subsequent Cyclone Midhili's alert for West Bengal and Odisha illustrate the escalating threat from such natural disasters. The rapid intensification of these cyclones points towards a worrying trend likely exacerbated by climate change.

Categories of Cyclones:

- **Category 1:** Wind speed of 90-125 kph, negligible house damage, some damage to trees and crops.
- **Category 2:** Destructive winds of 125-164 kph. Minor house damage, significant damage to trees, crops and caravans, risk of power failure.
- **Category 3:** Very destructive winds of 165-224 kph. Some roof and structural damage, some caravans destroyed power failure likely.
- **Category 4:** Very destructive winds of 225-279 kph. Significant roofing loss and structural damage, caravans destroyed, blown away, widespread power failures.
- **Category 5:** Very destructive winds gusts of more than 280 kph. Extremely dangerous with widespread destruction.

- **Climate Change Connection:** Studies suggest that while the overall number of cyclones may decrease, their intensity post-monsoon could increase due to climate change. Warmer temperatures enable storms to hold more moisture, causing more damage with increased precipitation over land.
- **Hazards associated with Cyclones:** There are three hazards associated with a cyclone, which cause destruction
 - **Storm surge:** A storm surge is an abnormal rise of sea level near the coast caused by a severe tropical cyclone; as a result, seawater inundates low lying areas of coastal regions drowning human beings and livestock, eroding agricultural land, beaches and embankments, destroying vegetation and reducing soil fertility.
 - **Strong wind:** The most destructive force of a cyclone comes from fierce winds. These winds are strong enough to easily topple fences, sheds, trees, power poles and communication systems, while hurling helpless people through the air. Many people are killed when the cyclone winds cause buildings and houses to collapse and completely blow away resulting in loss of life and property.

- **Flood:** Heavy and prolonged rains due to cyclones may cause floods and submergence of low-lying areas causing loss of life and property. Floods and coastal inundation due to storm surges pollute drinking water sources causing outbreak of epidemics. Long after a cyclone has passed, road and rail transport can still be blocked by floodwaters. Water often becomes contaminated from dead animals or rotten food, and people are threatened with diseases like diarrhoea and other infections.
- The Bay of Bengal's cyclonic activities in 2023-24 highlight an urgent need for robust disaster management strategies and climate action plans to mitigate future risks.

PREVIOUS YEAR QUESTION

Q. Discuss the meaning of colour-coded weather warnings for cyclone prone areas given by India Meteorological Department. (2022)

PRACTICE QUESTION

Q. Examine the impact of climate change on the frequency and intensity of cyclonic storms in the Bay of Bengal region. Discuss with reference to recent events and suggest measures for effective disaster management.

2. EL NINO AND INDIAN MONSOON

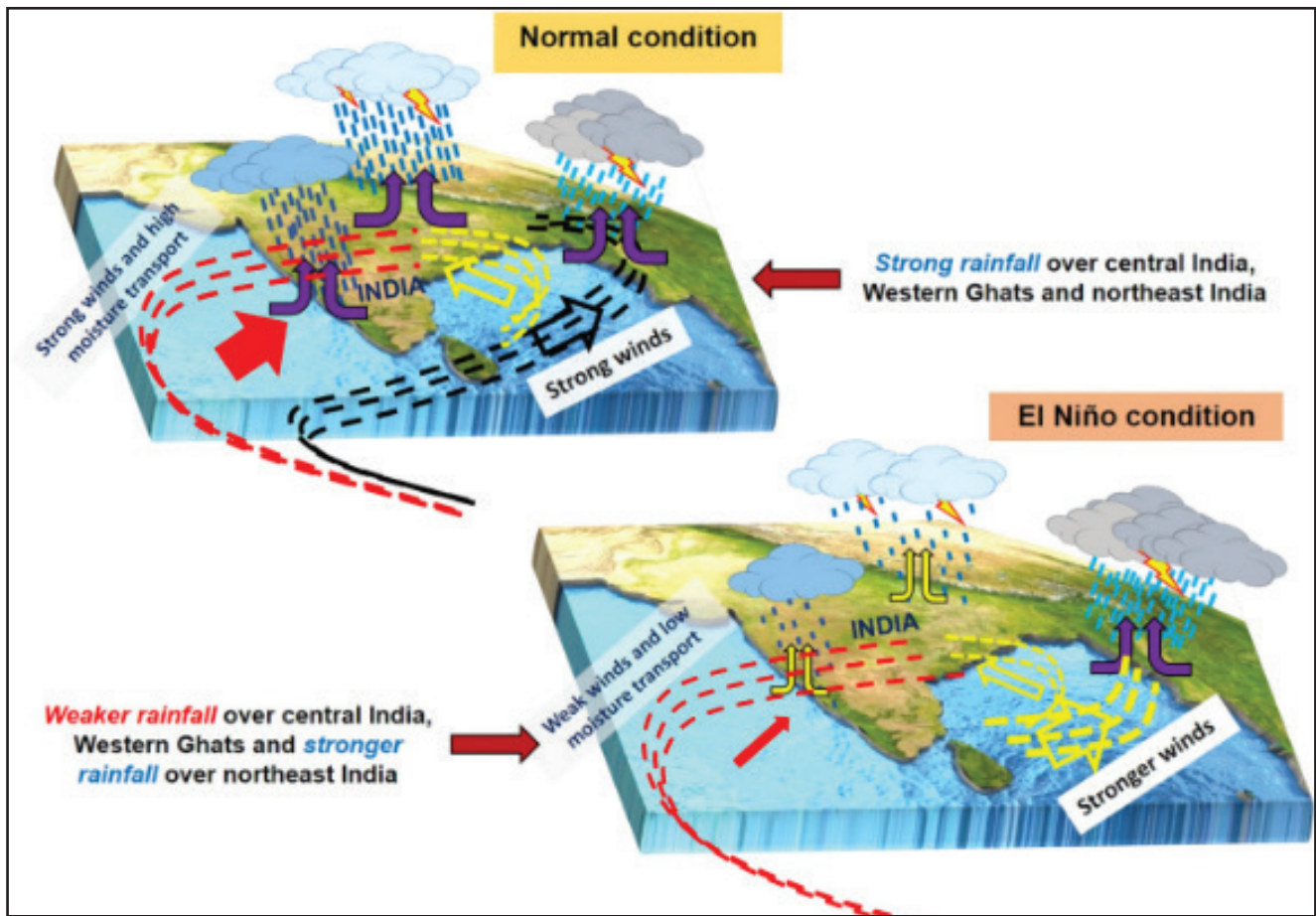
CONTEXT: The Indian subcontinent's climate rhythm is intricately linked to the monsoon season, a pattern that has been disrupted in recent times due to El Niño events. The period of 2023-24 has been particularly significant in studying this phenomenon's impact on the Indian monsoon.

▢ Explaining the Phenomena:

- El Niño is a climate pattern that describes the unusual warming of surface waters in the eastern tropical Pacific Ocean. It influences global weather patterns and has a profound effect on the Indian monsoon by altering the normal patterns of wind and rainfall.

▢ Examples

- **Weather Models:** In 2023, models predicted over a 95% likelihood of El Niño persisting through winter, suggesting a moderate-to-strong event that could adversely affect monsoon rainfall.
- **Monsoon Predictions:** Despite El Niño's presence, Indian experts remained optimistic about the 2024 monsoon, citing that its peak may not significantly disrupt the season.
- **IMD Forecast:** The India Meteorological Department (IMD) indicated that El Niño's impact might wane in 2024, offering hope for a normal monsoon season.
- **WMO Statement:** The World Meteorological Organization (WMO) reported that the strong 2023-24 El Niño was weakening, increasing chances for normal conditions during the April-June period.
- **Transition to La Niña:** Predictions for a transition from El Niño to La Niña conditions raised hopes for above-normal precipitation during India's peak monsoon months in 2024.



Case Studies: El Nino and Impact on India

The impact of El Niño on India's agriculture and economy is significant, as seen in 2023 when predictions of a strong El Niño led to concerns over drought conditions. However, the weakening of El Niño and potential transition to La Niña by mid-2024 brought relief and hopes for better monsoon rains.

PREVIOUS YEAR QUESTION

Q. Why is South-West Monsoon called 'Purvaiya' (easterly) in Bhojpur Region? How has this directional seasonal wind system influenced the cultured ethos of the region? (2023)

PRACTICE QUESTION

Q. Assess the impact of El Niño on the Indian monsoon system with reference to recent developments in Pacific Ocean.

3. DAM CONSTRUCTION ON INDUS RIVERS: PROSPECTS AND CHALLENGES

CONTEXT: In 2023-24, India's efforts to harness the waters of the Indus Rivers through dam construction have been marked by strategic initiatives and challenges.

Need For Dam Construction on Indus River System:

- ▶ **Water Utilization:** India aims to maximize its share under the Indus Water Treaty.

- ▶ **Energy Security:** Hydro projects are critical for meeting India's growing energy demands.
- ▶ **Regional Development:** Dams are seen as a means to spur economic growth in Jammu & Kashmir.
- ▶ **Environmental Management:** Balancing ecological concerns with development is a priority.
- ▶ **Diplomatic Relations:** Dam construction has implications for India-Pakistan water-sharing dynamics.

❏ Impact of Dam Construction on Region:

- ▶ **Indus Water Treaty:** Projects like Shahpur Kandi and Ujh aim to utilize water currently flowing to Pakistan.
- ▶ **Multipurpose Projects:** The Ujh multipurpose project faces roadblocks but is key to utilizing Indus waters.
- ▶ **Hydroelectric Projects:** Small dams like Nimoo Bazgo are part of India's sustainable energy strategy.
- ▶ **Kashmir's Development:** New dams in Kishtwar aim to boost local economy and energy supply.
- ▶ **Water Conflict:** India's hydroelectric plans have escalated tensions with Pakistan.

Case Studies: The Ujh project

The Ujh project, despite facing challenges, represents India's commitment to utilizing its river waters for irrigation and power generation. However, it also underscores the delicate balance between development and environmental sustainability.



PRACTICE QUESTION

Q. Discuss the prospects and challenges of dam construction on the Indus rivers in India within the context of 2023-24. Provide an analysis across five dimensions with recent examples, and assess the impact on regional geopolitics, economy, and environment.

4. RECEDING GLACIERS IN HIMALAYAS: ISSUES AND CHALLENGES

CONTEXT: Studies conducted by the Indian Space Research Organization (ISRO) show that approximately 75 percent of the Himalayan glaciers are retreating at an alarming rate. These retreats will increase the variability of water flows to downstream areas and endanger the sustainability of water use in the earth's most crowded basins. Receding glaciers would also have an impact on the rates of groundwater recharge in some areas.

Reasons for Glacial Retreat:

- ▶ **Climate Change:** Warmer global temperatures are the primary driver of glacier melt. Glaciers in the Hindu Kush Himalayas have lost about 40% of their area since the Little Ice Age maximum 400-700 years ago.
- ▶ **Accelerated Melt:** Recent decades have witnessed faster ice melt in the Himalayas compared to other mountainous regions. Even previously stable glaciers in Pakistan's Karakoram range are now retreating.
- ▶ **Examples:** Rigorous research has provided insights into glacier dynamics, including mass loss and area reduction. These findings inform policy planning for the future.

Consequences and Impact:

- ▶ **Water Security:** Glaciers serve as natural reservoirs, supplying meltwater to rivers. Over a billion people in South Asia rely on this water for survival. As glaciers shrink, water availability becomes uncertain, leading to potential crises.
- ▶ **Increased Flooding:** Glacier retreat contributes to the formation of proglacial glacial lakes. When these unstable lakes breach their dams, catastrophic glacier lake outburst floods (GLOFs) occur, endangering communities downstream.

Case Studies:

- **Sabai Glacier, Nepal:** The Shisper Glacier in Gilgit-Baltistan, Pakistan, recently burst through an ice dam, causing widespread destruction. Glacial lake outburst floods pose a significant hazard.
- **Uttarakhand Flash Floods (2021):** Retreating glaciers contributed to the disaster in India's Uttarakhand state, highlighting the need for monitoring and mitigation.

Required Measures

- ▶ **Early Warning Systems:** Implement robust monitoring systems to detect glacial lake changes and potential GLOFs.
- ▶ **Infrastructure Resilience:** Strengthen infrastructure (roads, bridges, power plants) in vulnerable regions.
- ▶ **Climate Action:** Aggressive global efforts to limit warming can slow glacier retreat.
- ▶ **Local Initiatives:** Promote sustainable water management, afforestation, and community-based adaptation.
- ▶ **International Cooperation:** Collaborate across borders to address transboundary water issues.

PREVIOUS YEAR QUESTION

Q. How will the melting of Himalayan glaciers have a far-reaching impact on the water resources of India? (2020)

PRACTICE QUESTION

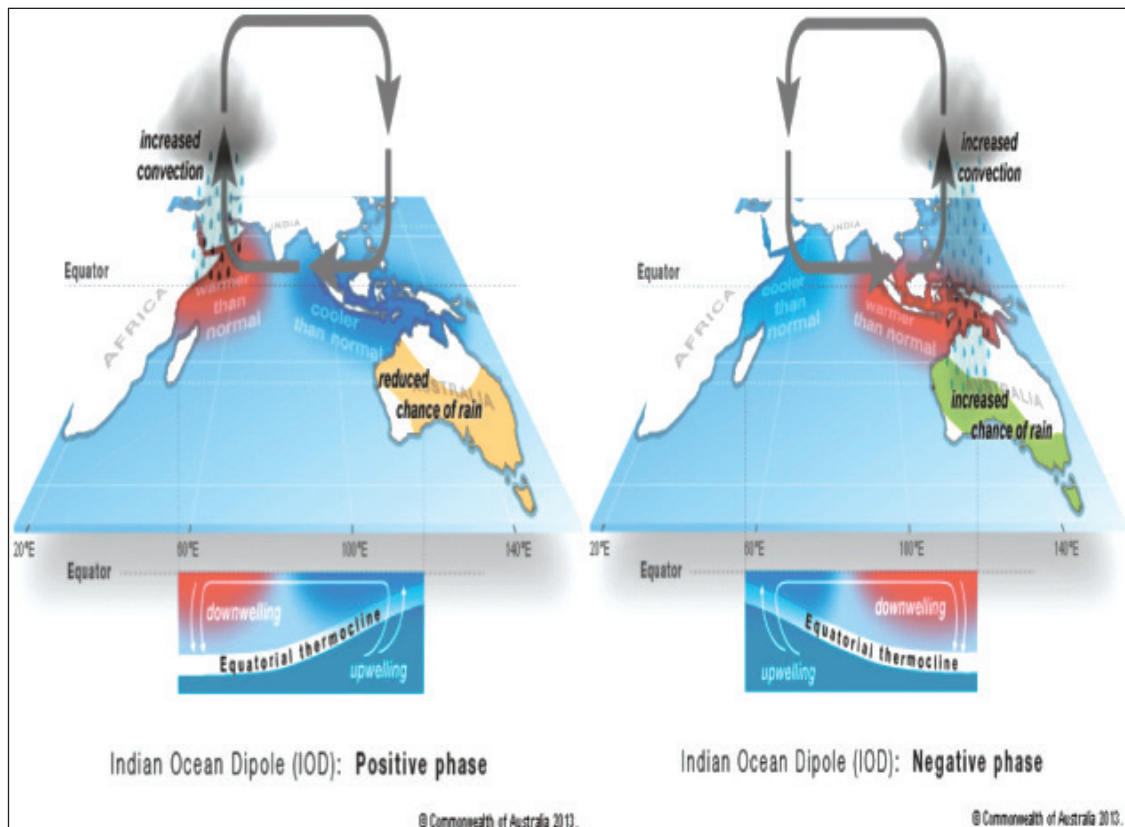
Q. What are the causes and consequences of receding of Himalayan glaciers on the South Asian Region. Substantiate with suitable examples.

5. INDIAN OCEAN DIPOLE: IMPACT ON INDIAN WEATHER

CONTEXT: In recent years, the Indian Ocean Dipole (IOD) has emerged as a critical climatic phenomenon influencing weather patterns across the Indian subcontinent. The IOD, characterized by the difference in sea surface temperatures between the western and eastern Indian Ocean, plays a pivotal role in modulating the monsoon rains and weather extremes experienced in India.

Understanding Indian Ocean Dipole:

- ▶ The Indian Ocean Dipole manifests in two phases: positive and negative. During a positive phase, warmer-than-average sea surface temperatures prevail in the western Indian Ocean near Africa, while cooler waters are observed in the eastern Indian Ocean near Indonesia. This gradient sets up a pattern of atmospheric circulation that can enhance moisture transport towards the Indian subcontinent, typically resulting in above-normal monsoon rains over India.
- ▶ Conversely, a negative phase of the IOD is characterized by cooler waters in the western Indian Ocean and warmer waters in the eastern Indian Ocean. This configuration can weaken the monsoon winds, leading to below-normal rainfall and even drought conditions in parts of India.



Impact of Indian Ocean Dipole:

- ▶ The years 2023-24 witnessed notable impacts of the Indian Ocean Dipole on Indian weather patterns. During the positive IOD phase observed in late 2023, regions of South India experienced heavy rainfall and flooding, particularly in Kerala and Karnataka. This surplus rainfall was attributed to the enhanced moisture inflow from the Arabian Sea, influenced by the positive IOD conditions.
- ▶ Conversely, the negative IOD phase in early 2024 coincided with below-average monsoon rains over northern and central India, exacerbating concerns over agricultural productivity and water availability. States like Rajasthan and Madhya Pradesh faced drought-like conditions, affecting crop yields and livelihoods.

Case Studies

- In 2023, the excessive rainfall triggered landslides in hilly regions, leading to loss of lives and infrastructure damage. Conversely, water scarcity in 2024 strained urban water supply systems and forced agricultural communities to adopt water conservation measures.
- In Kerala, a case study highlighted the vulnerability of coastal communities to extreme weather events exacerbated by the IOD. Flooding in low-lying areas disrupted daily life and posed challenges to relief and rehabilitation efforts.

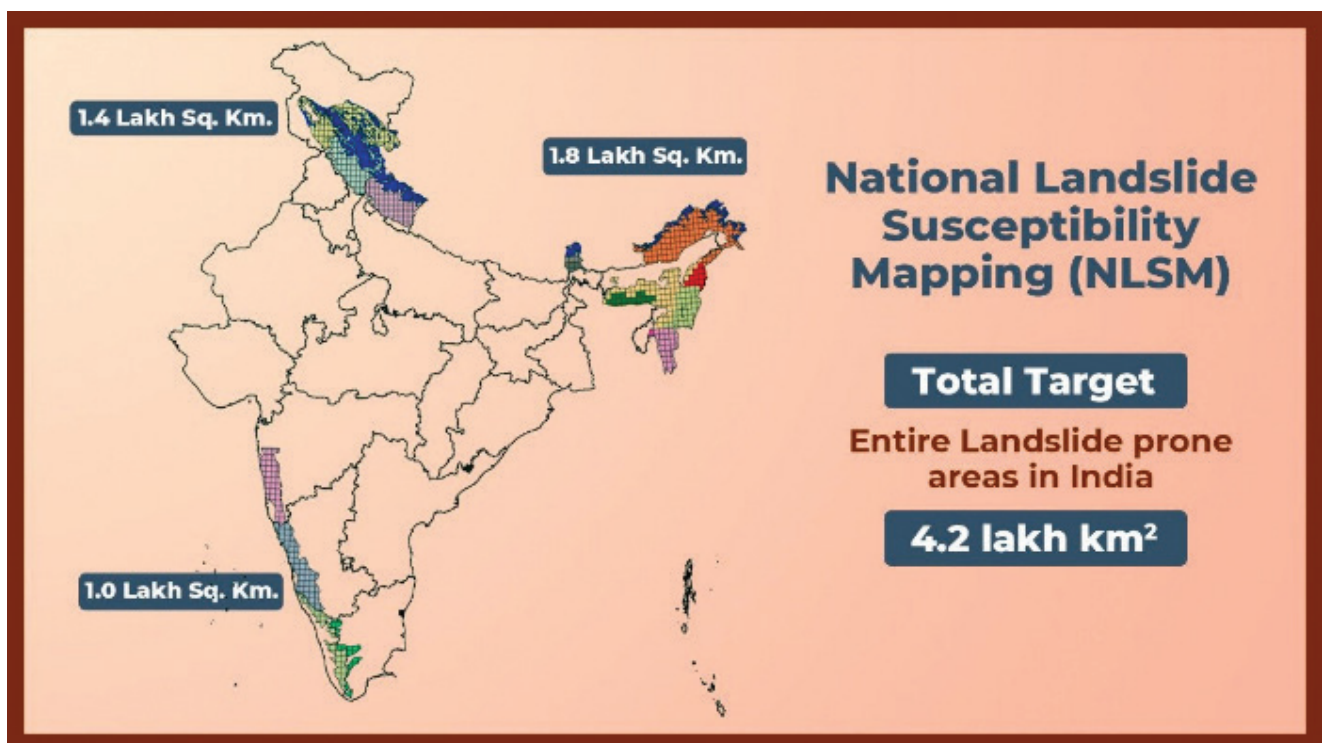
PRACTICE QUESTION

Q. Explain the role of the Indian Ocean Dipole (IOD) in modulating Indian weather patterns. Discuss its recent impacts on the monsoon rains and regional climate variability.

6. INCREASING LANDSLIDES IN HIMALAYAN REGION

CONTEXT: Recent reports have highlighted a series of devastating landslides across the Himalayan states. In 2023, Himachal Pradesh witnessed unprecedented landslide activity following intense monsoon rains that were 436% above the normal average. These events have brought attention to the escalating climate risks in this fragile ecosystem.

▢ Landslides in Himalayan Region:



- ▶ The Himalayan region, known for its majestic peaks and diverse ecosystems, is facing an alarming increase in landslide incidents.
- ▶ Landslides are complex geological processes where slopes fail and materials such as rock, earth, or debris flow downhill. In the Himalayas, they are often triggered by heavy rainfall, seismic activity, rapid snowmelt, or anthropogenic factors like deforestation and construction.

▢ Reasons for Landslides

- ▶ **Rainfall-Induced Landslides:** The intense rainfall events of June to September 2023 led to numerous landslides in Shimla.
- ▶ **Seismic Activity:** The region's seismicity contributes to slope instability.
- ▶ **Human Activities:** Expanding infrastructure and deforestation destabilize slopes.
- ▶ **Climate Change:** Rising temperatures increase atmospheric evaporation and humidity levels, leading to sudden extreme rains.

Impact of landslides

- ▶ **Humanitarian Disaster:** In Himachal Pradesh alone, landslides claimed 223 lives.
- ▶ **Infrastructure Damage:** Over 1,300 roads were closed, including five national highways during landslides of 2023.
- ▶ **Economic Losses:** The estimated losses amounted to \$1.2 billion due to landslides in 2023.

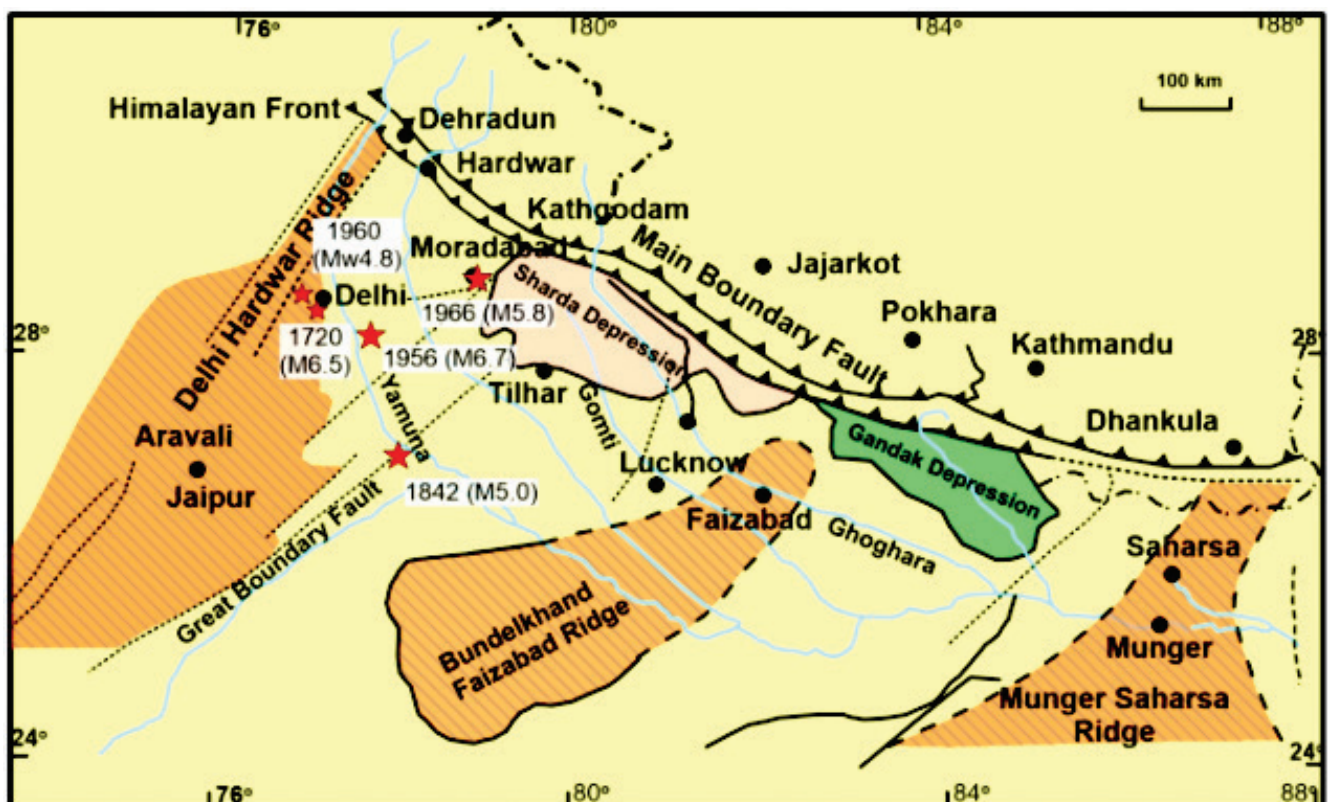
PRACTICE QUESTION

Q. Assess the causes and consequences of increasing landslide events in the Himalayan region. Discuss the role of climate change and human activities in exacerbating these incidents.

7. TECTONIC DEFORMATION IN NORTHERN PLAINS

CONTEXT: The Northern Plains of India Including regions of Haryana, Uttar Pradesh, etc. are undergoing significant tectonic deformation, raising concerns over potential seismic hazards.

- ▶ **Tectonic Deformation and Plate Tectonics:** Tectonic deformation occurs when the Earth's lithosphere is subjected to stress, leading to structural changes. This can result from plate movements, causing earthquakes, mountain building, and other geological phenomena. The Northern Plains, generally considered tectonically stable, have shown signs of deformation, raising concerns about the underlying causes and potential risks.
- ▶ **Reasons for Tectonic Deformation:** The tectonic deformation in the Northern Plains can be linked to several factors:
 - ▶ **Himalayan Influence:** The ongoing collision between the Indian Plate and the Eurasian Plate results in the uplift of the Himalayas. This tectonic stress is transmitted to the adjacent plains, causing deformation.



- ▶ **Ancient Faults:** The Northern Plains harbor several ancient fault lines that can be reactivated by distant tectonic forces. These faults, although dormant for long periods, can become active, leading to seismic activities.
 - ▶ **Human Activities:** Urbanization, groundwater extraction, and other anthropogenic factors can exacerbate tectonic stresses, contributing to ground subsidence and minor tremors.
- **Impact of Tectonic Deformation:** The impacts of tectonic deformation in the Northern Plains are multifaceted:
- ▶ **Infrastructure Damage:** Even minor tremors can cause significant damage to buildings, roads, and other infrastructure, especially in densely populated areas like Delhi and Patna.
 - ▶ **Groundwater Contamination:** Ground subsidence and changes in the groundwater table can lead to contamination of water resources, posing health risks.
 - ▶ **Agricultural Disruption:** Changes in soil structure and water availability can adversely affect agriculture, which is a critical livelihood source in the Northern Plains.

Recent Examples (2023-24)

- **Delhi-NCR Earthquake Swarms (2023):** The Delhi-NCR region experienced a series of low to moderate-intensity earthquakes in early 2023. These swarms, although not devastating, highlighted the active tectonic setting beneath the seemingly stable plains. Seismologists attributed these events to the reactivation of ancient faults due to distant tectonic stresses.
- **Bihar Seismic Activity (2024):** In early 2024, parts of Bihar witnessed unusual seismic activities. Minor tremors and ground subsidence in areas like Patna and Gaya pointed towards underlying tectonic adjustments. Researchers are investigating the role of the Himalayan tectonic movements and their impact on the Gangetic plains.

PREVIOUS YEAR QUESTION

- Q. Differentiate the causes of landslides in the Himalayan region and Western Ghats. (2021)
- Q. Briefly mention the alignment of major mountain ranges of the world and explain their impact on local weather conditions, with examples. (2021)

PRACTICE QUESTION

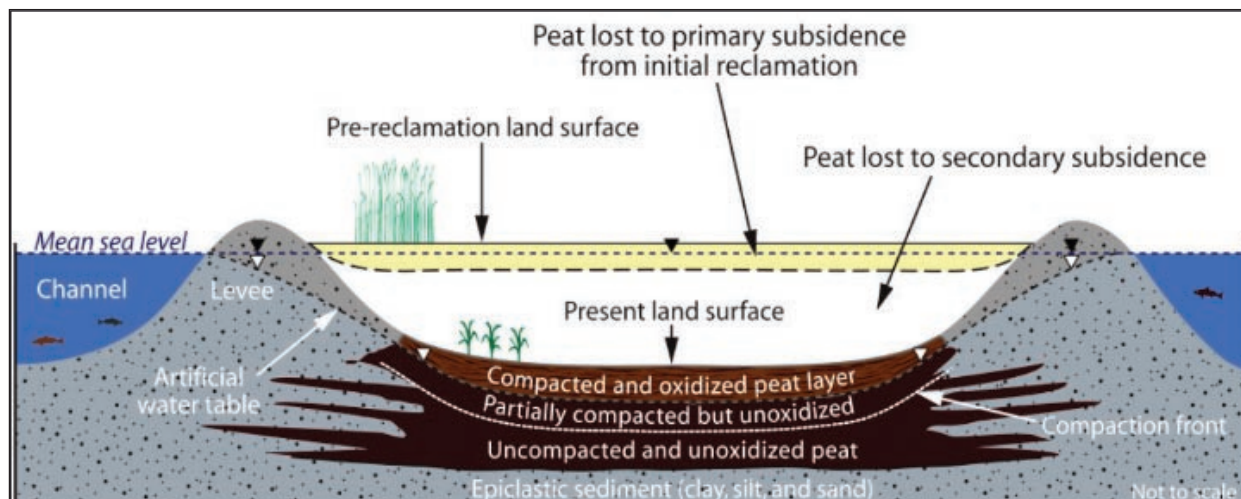
- Q. Discuss the recent instances of tectonic deformation in the Northern Plains of India. Analyze the underlying causes and evaluate the impacts on the local environment and infrastructure.

8. LAND SUBSIDENCE IN CHENAB VALLEY

CONTEXT: Land subsidence, the gradual sinking or sudden collapse of the Earth's surface, has emerged as a significant issue in the Chenab Valley, situated in the Jammu and Kashmir region of India.

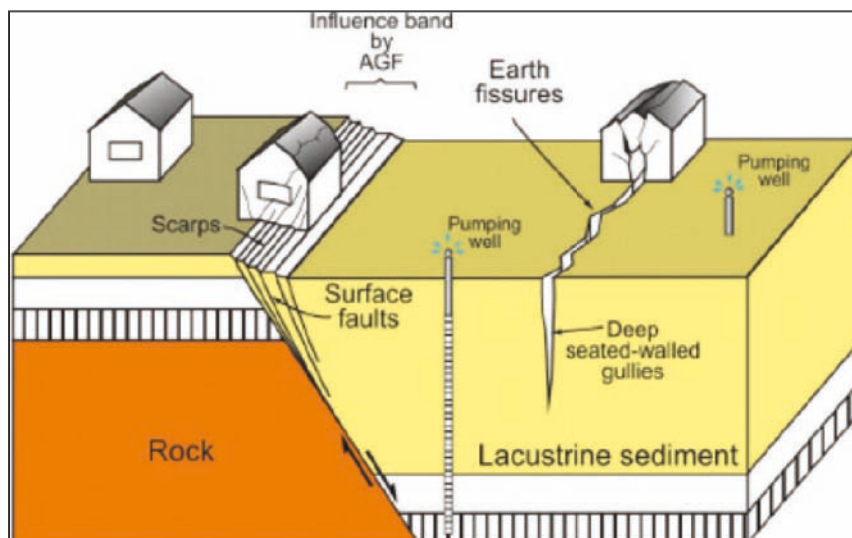
■ **Understanding Land Subsidence:**

- ▶ Land subsidence occurs when the ground sinks due to the removal or displacement of subsurface materials. This can result from natural processes such as the dissolution of underground rocks (e.g., limestone), volcanic activities, or human activities like groundwater extraction, mining, and construction. The Chenab Valley, known for its rugged terrain and tectonic activity, is particularly susceptible to such changes.



Reasons for land subsidence: Several factors contribute to land subsidence in the Chenab Valley:

- ▶ **Geological Factors:** The Chenab Valley is geologically young and tectonically active. The region's fragile rock formations, combined with seismic activity, create a predisposition to subsidence.
- ▶ **Hydropower Projects:** The construction of large dams and reservoirs alters the natural water flow and can lead to the saturation of soil, weakening the ground and causing it to sink.
- ▶ **Mining Activities:** Extensive mining for minerals and stones disturbs the underground stability. The removal of large volumes of earth materials can lead to voids, which eventually collapse, causing the surface to sink.



- ▶ **Groundwater Extraction:** Over-extraction of groundwater for agriculture and domestic use depletes the aquifers, leading to a reduction in subsurface support and subsequent land subsidence.
- Impact of Land Subsidence: The consequences of land subsidence in the Chenab Valley are profound and multifaceted:
- ▶ **Infrastructure Damage:** Buildings, roads, and bridges are susceptible to cracks and collapses, necessitating costly repairs and posing risks to human safety.
 - ▶ **Agricultural Disruption:** Subsidence affects soil structure and water availability, disrupting farming activities, which are a primary livelihood for many residents.
 - ▶ **Environmental Degradation:** Changes in the landscape can alter natural drainage patterns, leading to increased erosion and loss of arable land.
 - ▶ **Social Displacement:** Persistent subsidence can render areas uninhabitable, forcing people to relocate and causing socio-economic stress.

Case Studies

- **Doda District (2023):** The Doda district subsidence prompted a series of government actions, including the temporary relocation of affected families and a halt to certain construction activities. Detailed geological surveys were initiated to assess and mitigate future risks.
- **Ramban District (2024):** In response to the subsidence events, the Ramban district administration conducted emergency assessments and provided financial assistance to affected farmers and homeowners. Measures to regulate groundwater extraction and monitor mining activities were also implemented.

PRACTICE QUESTION

Q. Examine the causes and impacts of land subsidence in the Chenab Valley of Jammu and Kashmir.

9. HEAT WAVES, ANTICYCLONES AND GLOBAL WARMING IN INDIA

CONTEXT: In recent years, India has experienced increasingly severe heat waves, a phenomenon closely linked to global warming and anticyclonic conditions. The summer of 2023-24 was particularly notable for its extreme temperatures, leading to widespread health and environmental impacts.

Understanding Heat Waves and Anticyclones

- ▶ **Heat Waves** are prolonged periods of excessively high temperatures, often accompanied by high humidity. They are typically defined relative to the usual climate of a region and can be deadly.
- ▶ **Anticyclones**, large-scale weather systems characterized by high atmospheric pressure, play a crucial role in the formation of heat waves. These systems cause air to descend, leading to clear skies and high temperatures as the air compresses and warms.
- ▶ **Global Warming**, driven by the increase in greenhouse gases like carbon dioxide, exacerbates these conditions. Warmer global temperatures mean that heat waves are becoming more frequent, intense, and prolonged.

Analysis of Heat waves in India:

- ▶ The summer of 2023-24 witnessed several extreme heat events across India. For instance, in May 2023, parts of northern India, including Delhi, recorded temperatures exceeding 45°C (113°F). Such extreme temperatures are becoming more common due to the combined effects of global warming and persistent anticyclonic systems.
- ▶ The Indian Meteorological Department (IMD) reported that the number of heat wave days in 2023 was significantly higher than the long-term average. Cities like Jaipur, Lucknow, and Patna experienced sustained high temperatures, leading to severe water shortages and health crises.
- ▶ In addition to the direct heat, anticyclones also contribute to poor air quality. During heat waves, stagnant air traps pollutants near the surface, exacerbating respiratory problems, particularly in urban areas.

Impact on Health and Environment

- ▶ The impact of these heat waves is multifaceted. Health-wise, the extreme temperatures in 2023 led to an increase in heat-related illnesses and fatalities. Hospitals in affected regions reported a surge in cases of heatstroke and dehydration. Vulnerable populations, such as the elderly, children, and those with pre-existing health conditions, were particularly hard-hit.

- ▶ Environmentally, heat waves have devastating effects on agriculture. The 2023-24 season saw significant crop losses due to heat stress, affecting food security and farmers' livelihoods. The heat also intensified the demand for water and electricity, leading to resource strains and power outages.

Case Studies

- **Delhi:** The capital experienced one of its hottest summers on record, with temperatures regularly surpassing 45°C. The city's infrastructure struggled to cope, with frequent power cuts and water supply issues exacerbating the situation.
- **Rajasthan:** In Jaipur, temperatures soared to 47°C in June 2023. The state implemented emergency measures, including water rationing and cooling centers, to protect its residents.
- **Bihar:** Patna faced prolonged heat waves, leading to a public health emergency. The state government launched awareness campaigns and set up temporary shelters to provide relief to those without access to cooling.

PREVIOUS YEAR QUESTION

- Q. The process of desertification does not have climate boundaries. Justify with examples. (2020)

PRACTICE QUESTION

- Q. Discuss the relationship between anticyclones, heat waves, and global warming with specific reference to recent events in India.

10. EXPANDING GLACIAL LAKES IN THE HIMALAYAS

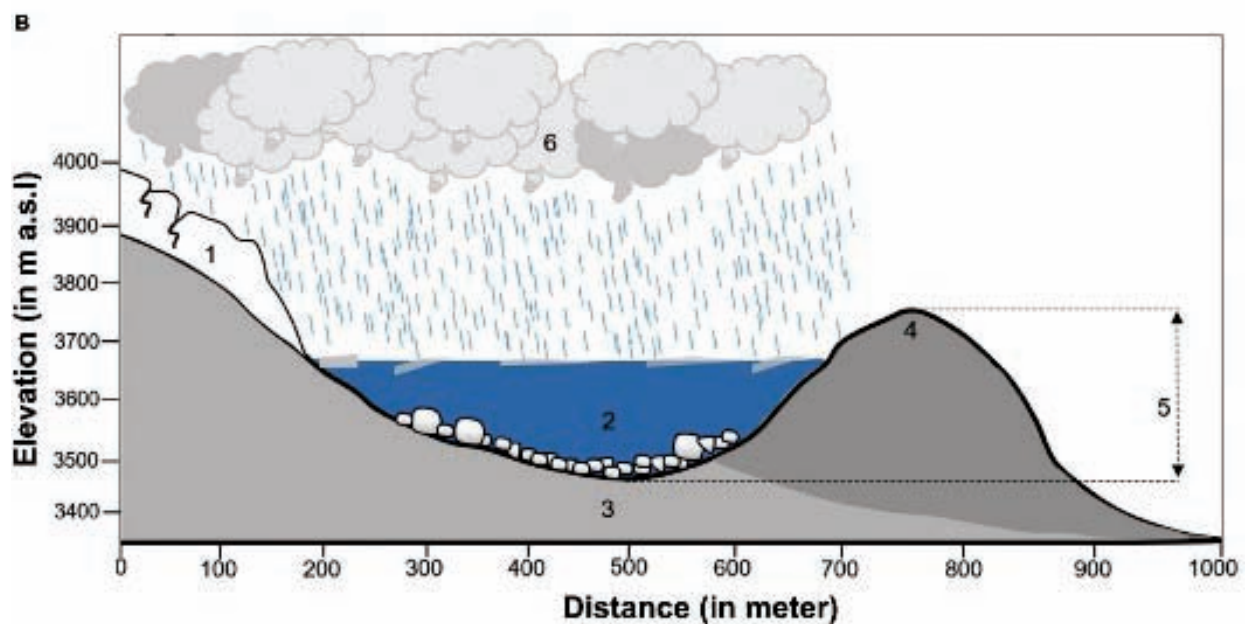
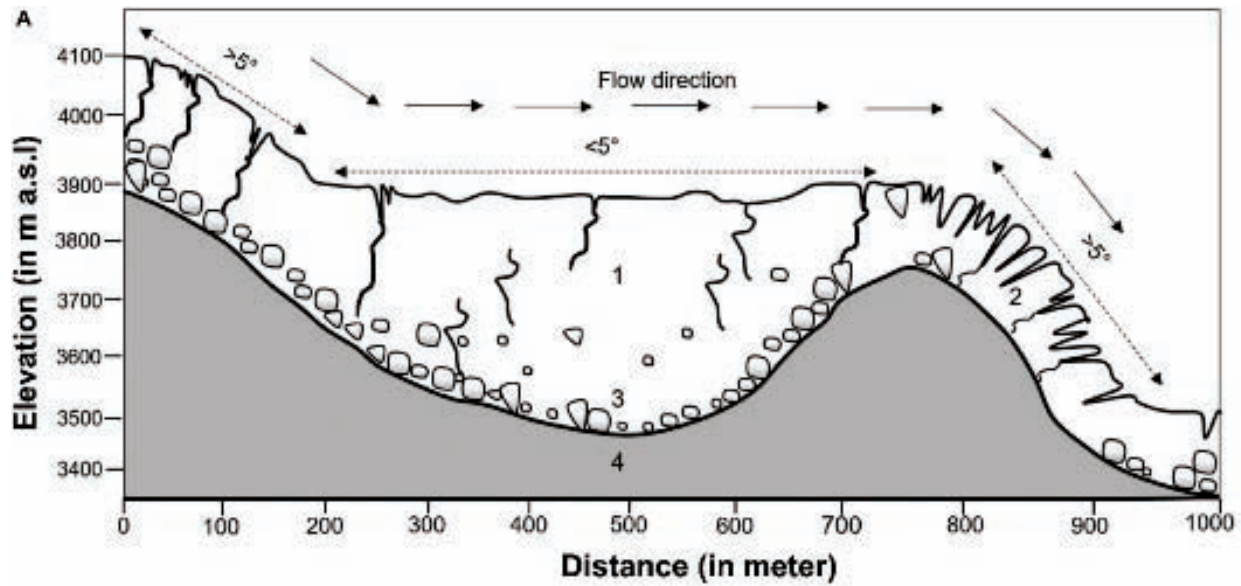
CONTEXT: According to ISRO data, long-term changes in the Ghepang Ghat glacial lake (Indus River Basin) at an elevation of 4,068 m in Himachal Pradesh, India, show a 178% increase in size from 36.49 to 101.30 hectares between 1989 and 2022.

Understanding Glacial Lakes:

- ▶ Glacial lakes are bodies of water formed by melting glaciers. They are typically found at high altitudes, dammed by ice or moraines (accumulations of glacial debris). As global temperatures rise, glaciers retreat, and meltwater accumulates, leading to the expansion of these lakes. This process is exacerbated by the accelerated melting rates observed in recent years due to climate change.
- ▶ **Glacial Lake Expansion in Himalayan Region:** The primary driver of glacial lake expansion is global warming. Increased temperatures cause glaciers to melt at unprecedented rates, resulting in larger volumes of meltwater. Additionally, changes in precipitation patterns, such as increased rainfall and decreased snowfall, contribute to this phenomenon. The weakening of ice and moraine dams due to hydrostatic pressure further increases the risk of glacial lake outburst floods (GLOFs).

Glacial Lake Expansion in India:

- ▶ In India, the South Lhonak Lake in Sikkim has been under close observation.
- ▶ In 2024, reports indicated a substantial increase in its water volume, heightening the risk of a potential outburst.
- ▶ The situation prompted the local government to initiate emergency preparedness measures, including the installation of early warning systems and the construction of protective barriers.



❏ Impact on Communities and Ecosystems

- ▶ The expansion of glacial lakes poses multiple threats. The most immediate danger is the potential for GLOFs, which can have catastrophic impacts on downstream communities. These floods can destroy infrastructure, homes, and agricultural land, leading to significant economic losses and displacement of populations. In 2023, the outburst of the Lhonak Lake resulted in severe flooding in parts of Sikkim, causing extensive damage to property and forcing hundreds of people to evacuate.
- ▶ Ecologically, the sudden influx of glacial meltwater can disrupt river systems, affecting aquatic habitats and biodiversity. The increased water flow can also lead to soil erosion and sedimentation, impacting agriculture and water quality.

Case Studies:

- **Nepal (Imja Tsho and Tsho Rolpa):** In 2023-24, these lakes experienced notable expansions. The Nepalese government, in collaboration with international agencies, has been working on risk mitigation strategies, including lake drainage and strengthening of moraine dams.
- **India (South Lhonak Lake, Sikkim):** The significant growth of this lake in 2024 led to the implementation of early warning systems and infrastructure reinforcement to prevent potential GLOFs. The state government has also engaged in community awareness programs to prepare locals for possible emergencies.

PRACTICE QUESTION

Q. Discuss the phenomenon of expanding glacial lakes in the Himalayas in the context of global warming. Analyze their impact and suggest measures to mitigate their adverse effects.

11. INTEGRATED RIVER BASIN MANAGEMENT: PROSPECTS AND CHALLENGES

CONTEXT: The recent report by the International Centre for Integrated Mountain Development (ICIMOD) and the Australian Water Partnership (AWP) pointed out climate change as the “urgent catalyst” for collaboration over three key river basins in Asia: the Indus, the Ganga, and the Brahmaputra.

Understanding Integrated River Basin Management

- IRBM views a river basin as a single unit for management.
- This approach takes into account the interconnections between water quality, water quantity, land use, and ecosystem health.
- It involves collaboration among various stakeholders, including governments, local communities, industries, and environmental organizations, ensuring that all interests are considered in decision-making processes.

Prospects of IRBM:

The prospects of IRBM are promising, particularly in terms of sustainable water management, conflict resolution, and environmental protection.

- **Sustainable Water Management:** IRBM promotes efficient use and equitable distribution of water resources, ensuring that water needs for agriculture, industry, and domestic purposes are met without compromising the environment. This approach helps maintain water quality by addressing pollution sources comprehensively.
- **Conflict Resolution:** By involving all stakeholders, IRBM helps resolve conflicts over water usage. Collaborative decision-making ensures that the needs and concerns of different groups are balanced, reducing tensions and fostering cooperation.

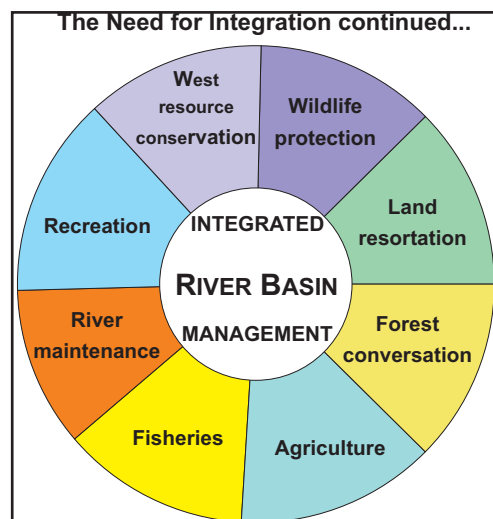


Figure: Concept of Integrated approach in river basin management.

- ▶ **Environmental Protection:** IRBM emphasizes the protection and restoration of natural ecosystems. Healthy river basins support biodiversity, provide natural flood defenses, and enhance resilience to climate change.

Case Studies: South Asian Rivers

- **Ganga River Basin, India:** The National Mission for Clean Ganga (NMCG) continued its efforts in 2023 to clean and rejuvenate the Ganga. This program integrates sewage treatment, industrial pollution control, and community participation. Recent reports indicate improvements in water quality and aquatic life, though challenges remain in ensuring sustained local involvement.
- **Mekong River Basin, Southeast Asia:** Countries in the Mekong River Basin have intensified their cooperation under the Mekong River Commission (MRC). In 2023, initiatives focused on shared data collection and flood management. However, disputes over dam constructions and water usage rights continue to pose significant challenges.

Challenges of IRBM

- ▶ **Institutional Fragmentation:** Effective IRBM requires strong coordination among various administrative and political entities. Fragmented governance structures can hinder the implementation of integrated strategies.
- ▶ **Data and Knowledge Gaps:** Comprehensive data on water resources, land use, and ecological health are crucial for IRBM. However, many regions lack the necessary monitoring and data collection systems.
- ▶ **Stakeholder Engagement:** Ensuring meaningful participation from all stakeholders, particularly local communities and marginalized groups, is essential but often challenging. Resistance to change and differing priorities can impede collaborative efforts.
- ▶ **Funding and Resources:** Implementing IRBM requires substantial investment in infrastructure, monitoring systems, and capacity building. Securing adequate funding and resources remains a significant barrier.

Case Studies: International Rivers

- **Rhine River Basin, Europe:** The International Commission for the Protection of the Rhine (ICPR) continued to address pollution and flood risks in 2023. Successes include improved water quality and fish populations, though industrial discharges remain a concern.
- **Colorado River Basin, USA:** In 2024, stakeholders in the Colorado River Basin worked on agreements to manage severe drought conditions. While progress has been made in water sharing and conservation, climate change impacts present ongoing challenges.

PREVIOUS YEAR QUESTION

Q. The interlinking of rivers can provide viable solutions to the multi-dimensional inter-related problems of droughts, floods, and interrupted navigation. Critically examine. 2020

PRACTICE QUESTION

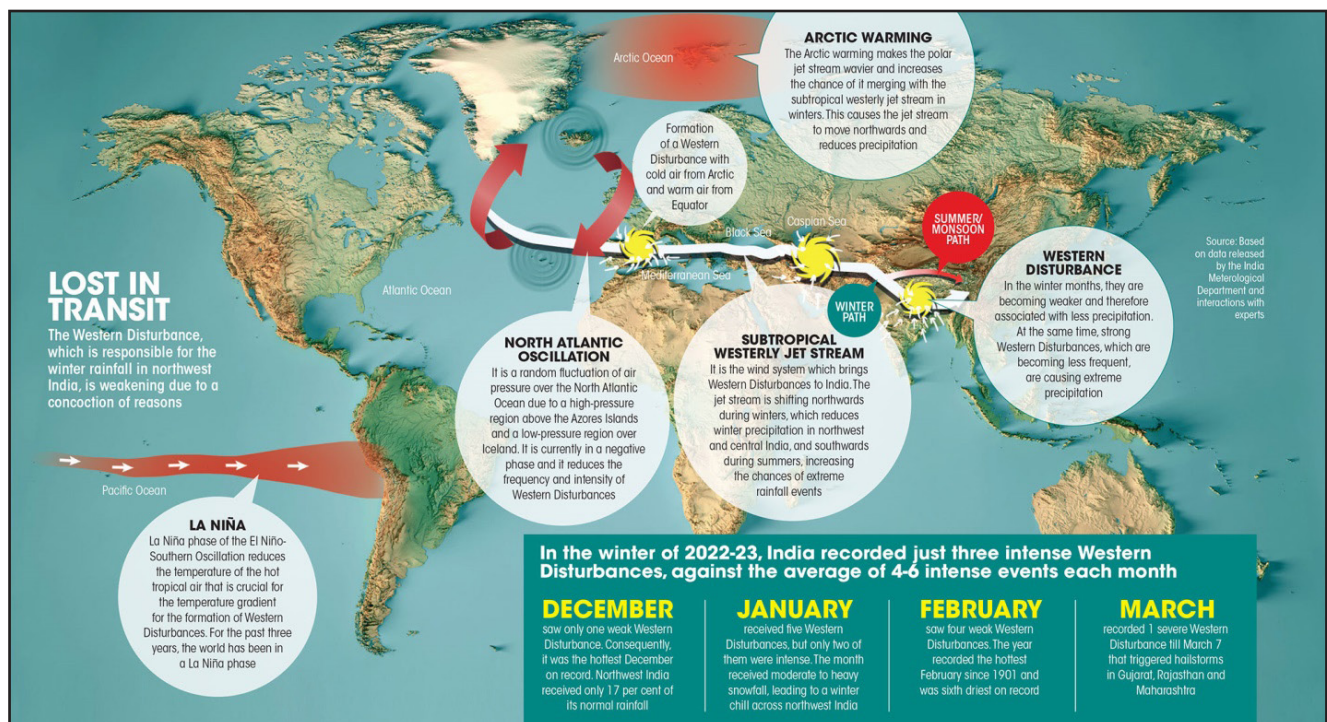
Q. Discuss the prospects and challenges of Integrated River Basin Management (IRBM) with recent examples from 2023-24. Analyze its impact on sustainable water management and conflict resolution.

12. CHANGING WESTERN DISTURBANCES: REASONS AND CONSEQUENCES

CONTEXT: The warming of the Arctic and the Mediterranean Sea mean that Western Disturbances are striking India less in winter and more in summer; with catastrophic consequences.

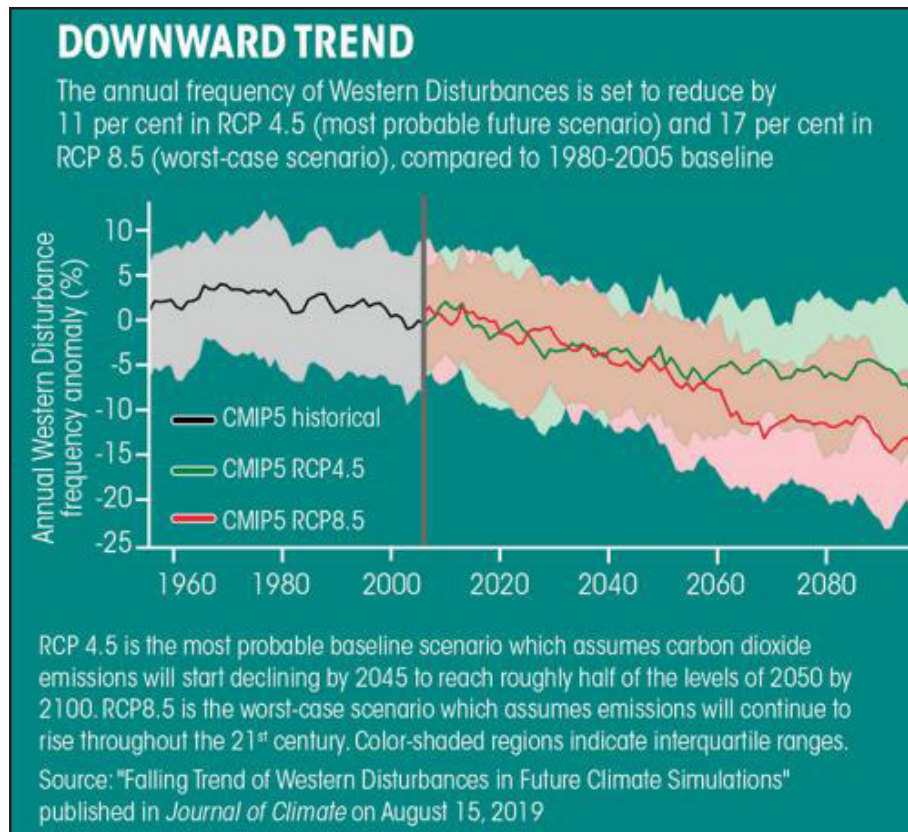
Understanding Western Disturbances

- ▶ Western disturbances are extratropical storms characterized by a low-pressure system that moves from the west to the east.
- ▶ They typically carry moisture from the Mediterranean Sea, the Atlantic Ocean, and even the Caspian Sea.
- ▶ As these systems travel across Iran, Afghanistan, and Pakistan, they gather additional moisture before reaching India.
- ▶ Upon arrival, they bring rainfall and snowfall, particularly affecting the states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Punjab, Haryana, and parts of Rajasthan and Uttar Pradesh.



Changing Patterns of Western Disturbances

- ▶ **Frequency and Intensity:** The 2023-24 winter season saw only three intense western disturbances, significantly fewer than the average of 16 to 24 events from December to March. December and February passed without any significant disturbances, leading to an 83% and 76% rainfall deficit in the northwest region, respectively.
- ▶ **Shift in Timing:** Traditionally active between December and February, recent disturbances have been delayed or weakened. For instance, January 2024 experienced near-normal conditions, while February broke records as the hottest month since 1901.
- ▶ **Path Alterations:** The trajectory of these disturbances has shifted northward, reducing their impact on India and increasing their influence on higher latitudes such as the Tibetan Plateau and China.



❏ Impact of Changing Western Disturbances

- **Agriculture:** The timing and intensity of western disturbances are crucial for the Rabi crop season. In 2023-24, the lack of winter rains adversely affected wheat crops. The India Meteorological Department (IMD) warned of potential yield losses due to higher temperatures in February, reminiscent of the 2022 damage that affected 30-40% of the wheat crop in key agricultural states.
- **Water Resources:** Western disturbances replenish Himalayan glaciers, crucial for the flow of major rivers like the Ganga, Indus, and Yamuna. Reduced snowfall due to weaker disturbances threatens the water security of the region.
- **Temperature Extremes:** Without the moderating effect of clouds formed by western disturbances, northern India experienced severe cold waves in December and January, followed by an unusually hot February. For example, parts of Gujarat and Rajasthan saw temperatures reach 39°C on February 20, 2024.

Case Studies:

- **Punjab and Haryana:** These regions faced significant agricultural challenges due to reduced rainfall in winter. The prolonged dry spell impacted wheat and other Rabi crops, leading to fears of reduced yields and economic losses for farmers.
- **Himachal Pradesh:** Typically reliant on western disturbances for snowfall, the state experienced severe disruptions in tourism and water availability due to the lack of significant snow events in December and January.
- **Rajasthan:** The state saw a high-pressure area formation in February, leading to unusually high temperatures and necessitating IMD advisories for farmers to mitigate crop damage risks.

PRACTICE QUESTION

Q. Discuss the changing patterns of western disturbances and their impact on India. Analyze the implications for agriculture and water resources, and suggest adaptive measures.

3

ECONOMIC GEOGRAPHY

1. TUNNEL DEVELOPMENT AND REGIONAL CONNECTIVITY

CONTEXT: Shinku La Tunnel is 4.1-kilometer long tunnel, situated on the Nimu-Padam-Darcha road link, aims to provide all-weather connectivity to the border areas of Ladakh, significantly enhancing security measures with unhindered access for the Indian Army to regions bordering China and Pakistan.

▢ Tunnel Development

- ▶ **Tunnel development** has emerged as a crucial component of infrastructure projects aimed at enhancing **regional connectivity**.
- ▶ With the potential to **overcome geographical barriers**, tunnels facilitate smoother, faster, and more reliable transportation links.
- ▶ Tunnels are **engineering marvels** designed to pass through mountains, under rivers, and beneath urban landscapes.
- ▶ They are constructed using **various methods**, including drill and blast, tunnel boring machines (TBMs), and cut-and-cover techniques.
- ▶ The **strategic importance** of tunnels lies in their ability to provide **all-weather connectivity**, reduce travel time, and promote economic integration of remote regions.

▢ Impact of Tunnel Development

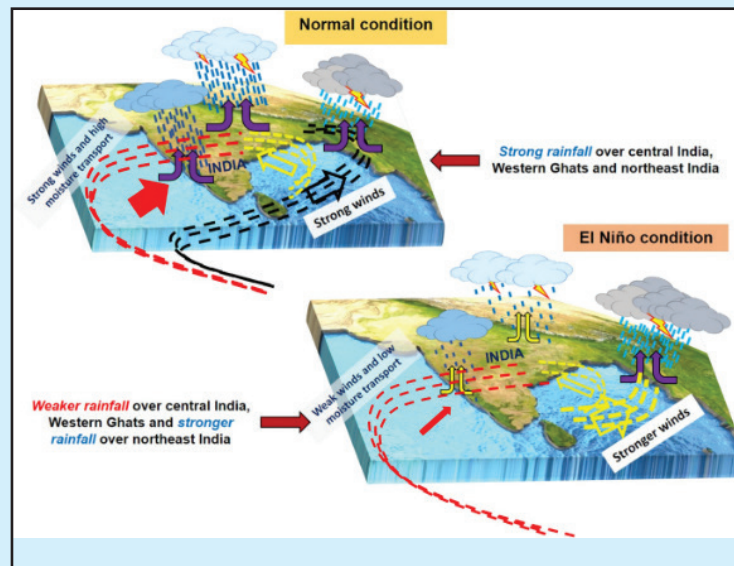
- ▶ **Economic Growth:** Tunnels contribute to economic growth by improving access to markets, reducing transportation costs, and facilitating trade. The enhanced connectivity can attract investments, boost tourism, and create job opportunities.



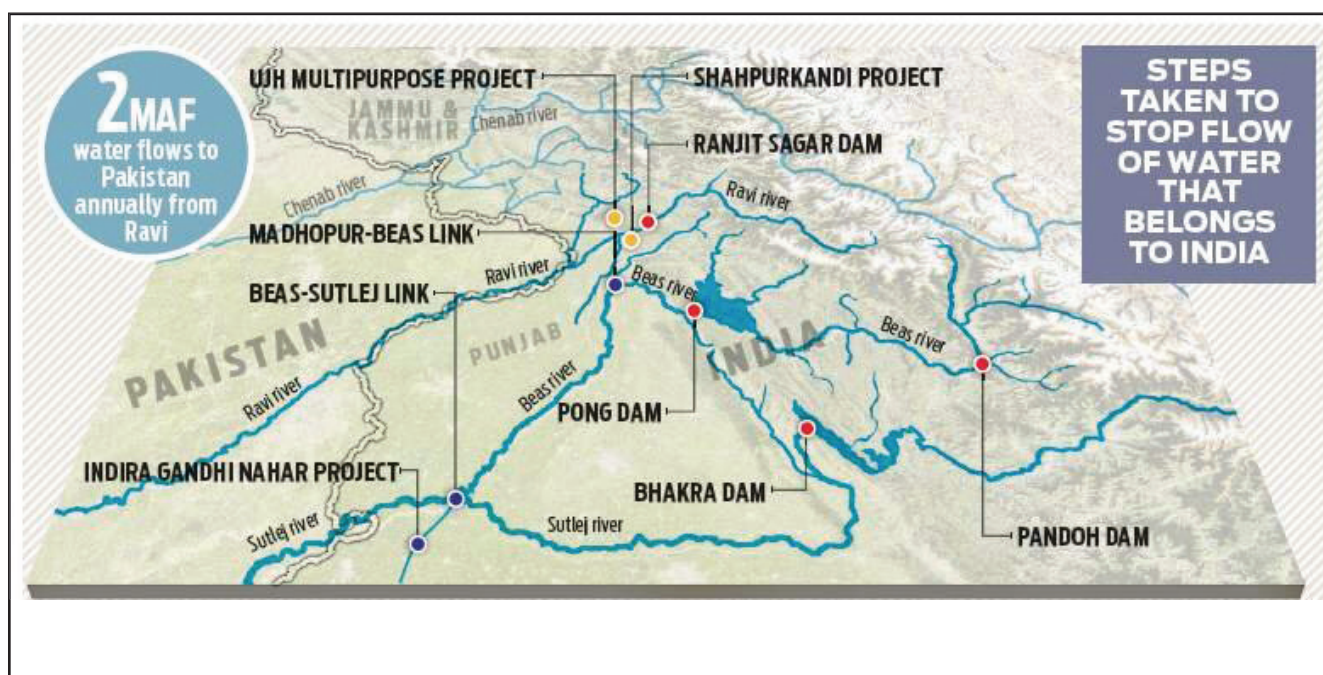
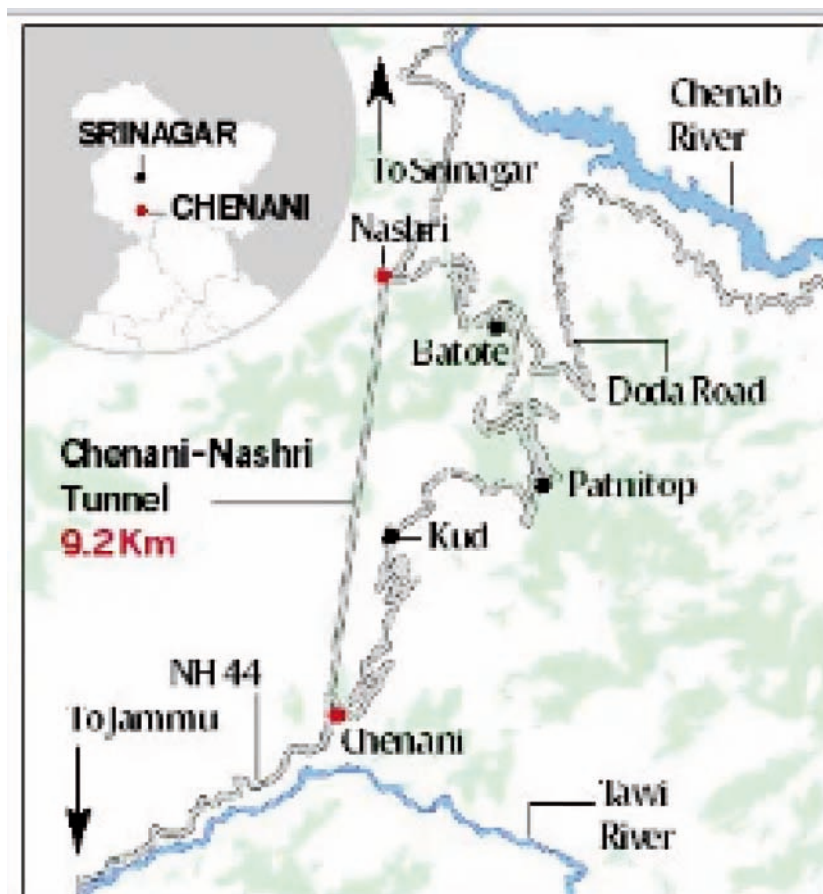
- ▶ **Strategic Importance:** Tunnels play a critical role in national security, especially in border areas. They enable rapid troop movement and supply logistics, enhancing the operational capabilities of the armed forces.
- ▶ **Social Development:** Improved connectivity brings educational, medical, and social services within reach of remote and isolated communities. This fosters inclusive development and enhances the quality of life.
- ▶ **Environmental Benefits:** By reducing travel distances and times, tunnels help in lowering fuel consumption and vehicular emissions, contributing to environmental sustainability.

Case Studies:

- **Zojila Tunnel:** The ongoing construction of the Zojila Tunnel is expected to transform the socio-economic landscape of Ladakh. It will provide uninterrupted access to essential goods and services during the harsh winter months, boosting the local economy and tourism.



- **Sela Tunnel:** The Sela Tunnel's development is set to revolutionize connectivity in Arunachal Pradesh. This will not only facilitate civilian movement but also ensure that military logistics remain unhindered, thereby bolstering India's strategic interests in the northeast.
- **Chenani-Nashri Tunnel:** Since its inauguration, the Chenani-Nashri Tunnel has significantly improved the connectivity between Jammu and Srinagar. In 2023-24, it has continued to support increased tourist inflows and economic activities, showcasing the long-term benefits of tunnel infrastructure.



PRACTICE QUESTION

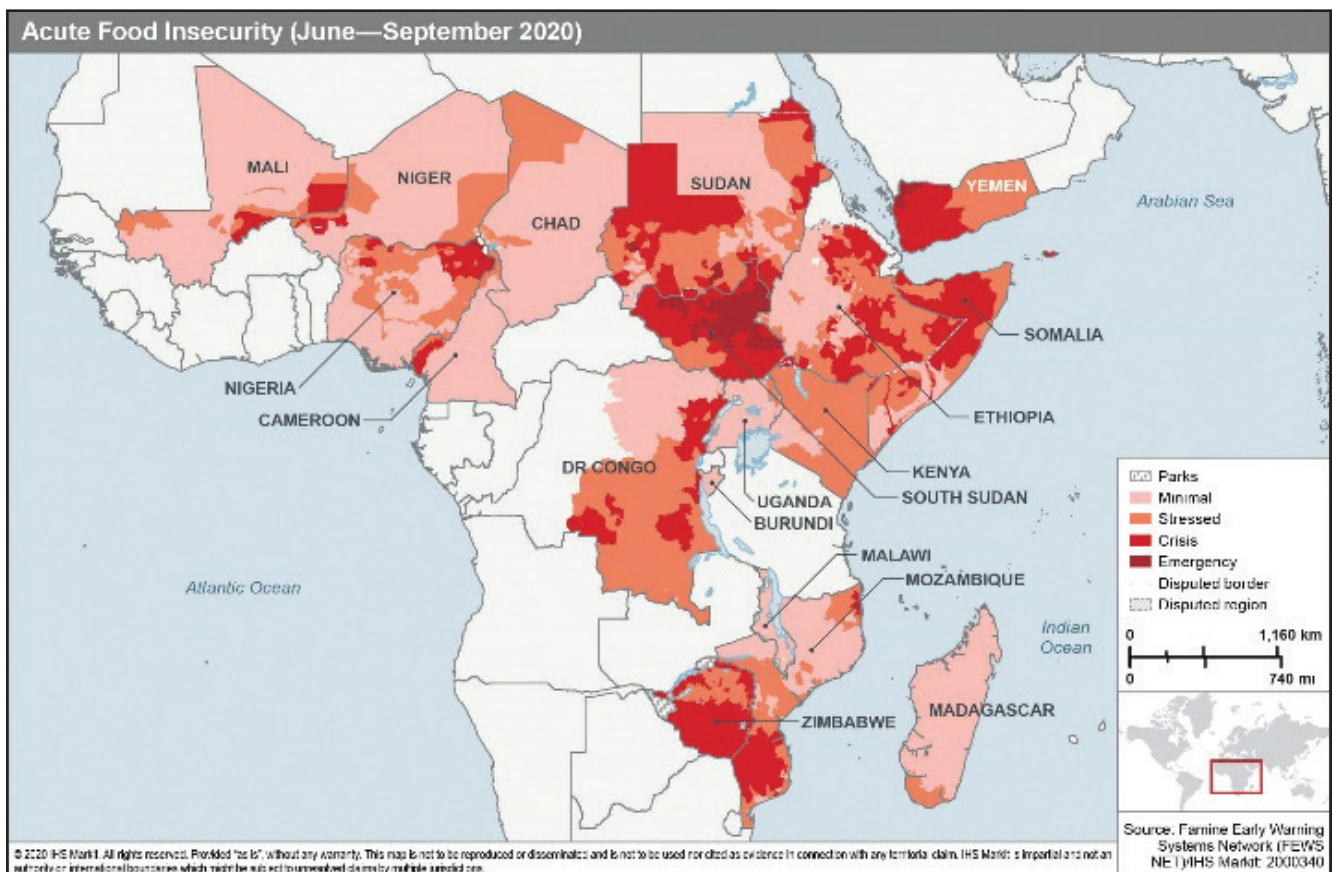
Q. Discuss the role of tunnel development in enhancing regional connectivity with reference to recent projects in India.

2. FOOD SECURITY IN SUB-SAHARAN REGION OF AFRICA

CONTEXT: Sub-Saharan Africa faces a profound challenge with food insecurity, exacerbated by a combination of factors including climate change, poverty, rapid population growth, and inadequate infrastructure. This region has the highest proportion of people unable to afford a healthy diet globally, highlighting systemic issues that hinder access to nutritious food and exacerbate malnutrition.

Food Insecurity in Sub-Saharan Africa:

- Food insecurity is defined as the lack of consistent access to enough food for an active, healthy life. In sub-Saharan Africa, multiple factors contribute to this problem. Climate change has led to unpredictable weather patterns, affecting crop yields. High levels of poverty limit the ability of families to purchase sufficient food. Rapid population growth strains already limited resources. Inadequate infrastructure hampers the distribution of food, and conflicts disrupt agricultural activities and food supply chains.
- Food security a major issue:** In 2023-24, several initiatives have been highlighted as potential solutions to food insecurity in sub-Saharan Africa. These projects demonstrate the importance of community-led approaches, direct cash transfers, and climate-smart agricultural practices.



- Senegal's Community-Led Total Sanitation (CLTS):** This initiative mobilizes communities to improve sanitation practices, reducing waterborne diseases and enhancing food safety. Improved

sanitation directly impacts food security by ensuring healthier populations capable of engaging in agricultural activities.

- ▶ **Rwanda's Agricultural Transformation Agenda:** Rwanda has focused on sustainable agricultural practices and connecting smallholder farmers to markets. This has led to increased agricultural productivity, improved food security, and rural development. The initiative underscores the importance of sustainable farming methods in enhancing food availability.
- ▶ **Malawi's Social Cash Transfer Programme:** The Mtukula Pakhomo Programme provides unconditional direct cash transfers to impoverished households. These transfers enable families to purchase a more varied and nutritious diet. In 2023-24, the program has continued to alleviate poverty and improve food security among the most vulnerable populations.
- ▶ **Zambia's Conservation Agriculture:** Conservation agriculture practices, such as minimal soil disturbance and permanent soil cover, have improved soil health and crop yields. This approach has helped rural families grow diverse crops, increasing their resilience to climate change and enhancing food security.
- ▶ **Ethiopia's Sasakawa Africa Association:** This program provides training and access to markets and improved agricultural practices for smallholder farmers. By increasing crop production and promoting sustainable farming techniques, the initiative has significantly improved food availability and farmer incomes.

▢ Impact

- ▶ The impact of these initiatives is evident in the improved food security and economic conditions of participating communities. For instance, in Senegal, better sanitation has led to healthier communities with increased agricultural productivity. Rwanda's agricultural agenda has not only boosted food production but also improved market access for farmers, enhancing their incomes.
- ▶ Malawi's cash transfer program has enabled families to access diverse and nutritious foods, improving overall health and wellbeing.
- ▶ In Zambia, conservation agriculture has increased resilience to climate change, ensuring food availability despite adverse weather conditions. Ethiopia's farmer training programs have led to substantial increases in crop yields, directly contributing to food security.

▢ Required Measures

- ▶ To achieve food security in sub-Saharan Africa, governments must recognize **food as a basic human right** and take comprehensive steps to ensure its availability.
- ▶ This includes **promoting sustainable food production**, ensuring **equal access to food** distribution, and addressing gender imbalances and environmental degradation.
- ▶ Investing in **climate-smart agriculture**, improving water management systems, and integrating traditional knowledge with innovative technologies are critical.
- ▶ Governments should work with **communities and civil society organizations** to create resilient food systems and involve individuals in decision-making processes related to food and agriculture.
- ▶ Achieving food sufficiency in sub-Saharan Africa requires a comprehensive approach that integrates scientific advancements, robust policies, and inclusive socio-economic strategies. The successes observed in recent initiatives underscore the importance of tailored interventions that address the unique challenges faced by different communities.

PREVIOUS YEAR QUESTION

Q. Discuss the consequence of Climate change on the food security in tropical countries. (2023)

Q. From being net food importer in 1960, India has emerged as a net food exporter to the world. Provide reasons. (2023)

PRACTICE QUESTION

Q. Discuss the key factors contributing to food insecurity in sub-Saharan Africa and evaluate the effectiveness of recent interventions aimed at addressing this issue.

3. MINERAL RESOURCES OF ANTARCTICA – A MINERAL HUB OF GONDWANALAND

CONTEXT: Antarctica, often regarded as a pristine continent dedicated to scientific research and environmental conservation, also holds significant potential as a repository of mineral resources. In recent years, advancements in technology and climate change have renewed interest in Antarctica's mineral resources. The continent's strategic importance and the potential economic benefits of resource extraction have prompted several nations to explore possibilities despite existing environmental concerns.

▢ Significance of Antarctica as Mineral Hub:

- **Mineral Resources Overview:** Antarctica holds substantial reserves of minerals such as coal, iron ore, copper, gold, and oil. These resources are largely unexplored and untapped due to the Antarctic Treaty System (ATS), which prohibits mining until at least 2048 under the Protocol on Environmental Protection to the Antarctic Treaty.
- **Geological Significance:** Antarctica was once part of the supercontinent Gondwanaland, which suggests geological continuity with resource-rich regions like South America, Africa, India, and Australia. This historical linkage underscores the potential for valuable mineral deposits.



- ❑ **Global Interest in Antarctic Mineral:** Recent developments and initiatives related to Antarctica's mineral resources highlight ongoing debates and challenges:
 - **International Interest and Diplomatic Tensions:** Several countries, including China, Russia, and India, have conducted geological surveys and explorations in Antarctica, raising geopolitical concerns about resource ownership and environmental stewardship.
 1. In 2023, China announced plans for its fifth Antarctic scientific research station, emphasizing scientific research but also hinting at long-term strategic interests in the continent's resources.
 - **Environmental Concerns:** The fragile Antarctic ecosystem, characterized by unique biodiversity and pristine landscapes, faces significant risks from potential mining activities. Environmentalists advocate for strict adherence to the Antarctic Treaty's environmental protocols to prevent irreversible damage.
- ❑ **Impact of Mineral Exploration in Antarctic region:** The exploration and potential exploitation of Antarctica's mineral resources have far-reaching implications:
 - **Environmental Impact Assessments (EIAs):** Rigorous EIAs are essential to assess the potential ecological consequences of mineral extraction. Case studies from other regions underscore the importance of mitigating environmental risks while maximizing economic benefits.
 - **Scientific Research and Sustainability:** Antarctica's scientific research stations serve dual purposes of scientific exploration and environmental monitoring. Initiatives like the Madrid Protocol highlight efforts to balance resource utilization with environmental preservation.

PREVIOUS YEAR QUESTION

- Q. Despite India being one of the countries of Gondwanaland, its mining industry contributes much less to its Gross Domestic Product (GDP) in percentage. Discuss. (2021)
- Q. Why is India taking keen interest in resources of Arctic region? (2018)

PRACTICE QUESTION

- Q. Discuss the potential and challenges associated with mineral resource exploration in Antarctica which is a part of Gondwanaland. Evaluate the international regulatory frameworks and environmental concerns that shape current debates on Antarctica's mineral wealth.

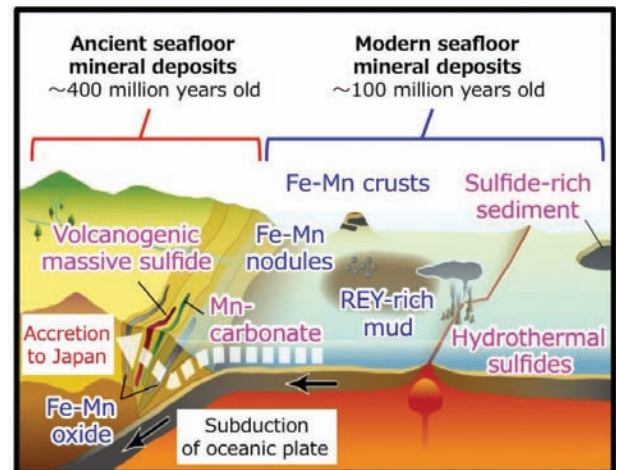
4. MINERALS OF MID-OCEANIC RIDGES

CONTEXT: Mid-oceanic ridges, hidden beneath the vast expanses of the world's oceans, have increasingly become focal points for mineral exploration due to their unique geological formations and mineral-rich compositions. In recent years, discussions surrounding mid-oceanic ridges have intensified, driven by technological advancements enabling deeper exploration and extraction capabilities. The global shortage of critical minerals essential for high-tech industries, coupled with rising geopolitical tensions over mineral resources, has underscored the strategic importance of these undersea geological features.

- ❑ **Mid-Oceanic Regions:**
 - **Mid-Oceanic Ridges Overview:** Mid-oceanic ridges are underwater mountain ranges formed by tectonic activity where new oceanic crust is created through volcanic processes. These ridges span thousands of kilometers across various ocean basins, including the Atlantic, Indian, and Pacific Oceans.
 - **Mineral Composition and Resources:** The ridges are known for their rich deposits of minerals such as copper, zinc, cobalt, manganese, and rare earth elements (REEs). These minerals are critical for modern technologies including electronics, renewable energy systems, and electric vehicles.

Key trends and challenges in exploring mid-oceanic ridges:

- ▶ **Technological Advancements:** Advances in deep-sea exploration technologies, including remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs), have enabled more precise mapping and sampling of mineral-rich areas on mid-oceanic ridges.
- ▶ **Environmental Concerns:** Mining operations in deep-sea environments pose significant environmental risks, including habitat destruction and disruption of unique ecosystems. Regulatory frameworks and international agreements such as the International Seabed Authority (ISA) aim to balance mineral extraction with environmental protection.
- ▶ **Economic Opportunities:** Developing nations and technology-dependent economies are keenly interested in securing access to critical minerals from mid-oceanic ridges to reduce dependency on terrestrial sources and geopolitical risks.



Case Study

Clarion-Clipperton Zone (CCZ): Located in the Pacific Ocean, the CCZ is known for its vast deposits of polymetallic nodules rich in cobalt, nickel, copper, and manganese. Research expeditions and environmental impact assessments are ongoing to evaluate sustainable mining practices.

PRACTICE QUESTION

Q. Discuss the potential and challenges associated with mining minerals from mid-oceanic ridges.

5. EXCLUSIVE ECONOMIC ZONES AND MINERALS DEPOSITS

CONTEXT: India applied for Rights to Explore the Indian Ocean Seabed Beyond its territorial Jurisdictions, including Cobalt-Rich Afanasy Nikitin Seamount (AN Seamount).

Exclusive economic zones and minerals deposits:

- ▶ **Exclusive Economic Zones (EEZs)** are maritime zones extending up to 200 nautical miles from a coastal state's baselines, where the state has sovereign rights for exploring, exploiting, conserving, and managing natural resources. In recent years, EEZs have become significant areas of interest for exploring mineral deposits due to their potential for rich resources and geopolitical implications.
- ▶ **Definition and Scope of EEZs:** EEZs are established based on the United Nations Convention on the Law of the Sea (UNCLOS), granting coastal states sovereign rights over natural resources within these zones, including mineral deposits on the seabed and subsoil.
- ▶ **Mineral Deposits in EEZs:** EEZs are known for their diverse mineral deposits, including polymetallic nodules, hydrothermal vents rich in minerals like copper, zinc, cobalt, and rare earth elements (REEs), and oil and gas reserves. These resources are crucial for technological advancements and economic growth.

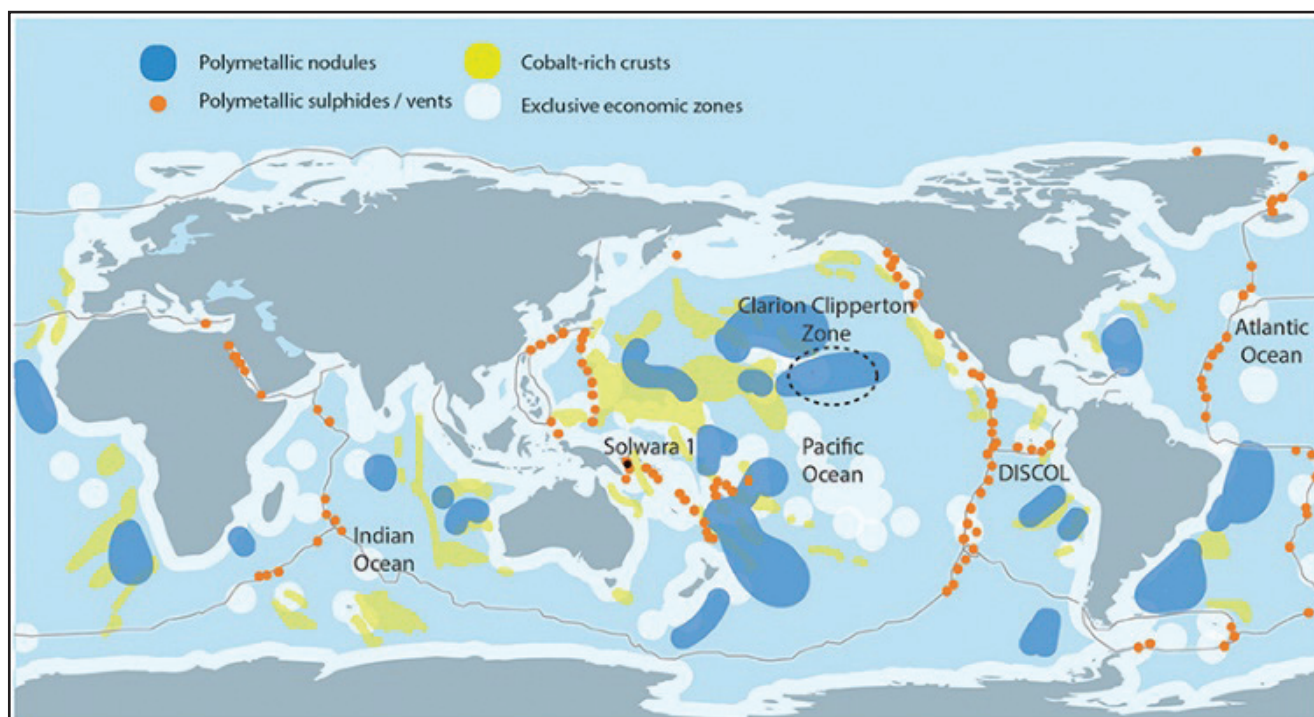
Recent developments and trends in EEZs mineral exploration and exploitation:

- **Technological Advancements:** Advancements in deep-sea exploration technologies, such as autonomous underwater vehicles (AUVs) and remotely operated vehicles (ROVs), have enhanced the capability to survey and extract minerals from deep-sea environments within EEZs.
- **Geopolitical Dynamics:** EEZs often overlap with disputed maritime boundaries, leading to geopolitical tensions and conflicts over resource ownership and exploitation rights. Countries are strategically positioning themselves to assert sovereignty and secure mineral resources within their EEZs.

India and Mineral Exploration in EEZs:

India has staked a claim for its **continental shelf up to 350 nautical miles** from its border but has yet to be awarded so. It has previously garnered **exploration rights to two other large basins** in the **Central India Ocean** and has undertaken surveys.

- India applied to the **International Seabed Authority (ISBA), Jamaica**, for rights to explore two vast tracts in the Indian Ocean seabed that aren't part of its jurisdiction. The application to explore one of these regions, a cobalt-rich crust long known as the **Afanasy Nikitin Seamount (AN Seamount)**, is a gambit by India.
- The AN Seamount is a structural feature (400 km-long and 150 km-wide) in the Central Indian Basin, located about 3,000 km away from India's coast. From an oceanic depth of about 4,800 m it rises to about 1,200 metre and — as surveys from about two decades establish — rich in deposits of cobalt, nickel, manganese and copper.
- These rights are specific to areas that are part of the open ocean, meaning ocean — whose air, surface and sea-bed — where no countries can claim sovereignty. Around 60% of the world's seas are open ocean and though believed to be rich in a variety of mineral wealth, the costs and challenges of extraction are prohibitive.



Exploring the impact of mineral deposits in EEZs:

- **Case Study - Polymetallic Nodules in the Clarion-Clipperton Zone (CCZ):** The CCZ in the Pacific Ocean is rich in polymetallic nodules containing cobalt, nickel, copper, and manganese. Research and mining activities are underway, balancing economic benefits with environmental concerns.

- ▶ **Economic Opportunities:** EEZs offer significant economic opportunities for coastal states by providing access to critical minerals that are essential for renewable energy technologies, electronics, and infrastructure development.

PREVIOUS YEAR QUESTION

- Q. Comment on the resource potentials of the long coastline of India and highlight the status of natural hazard preparedness in these areas. (2023)

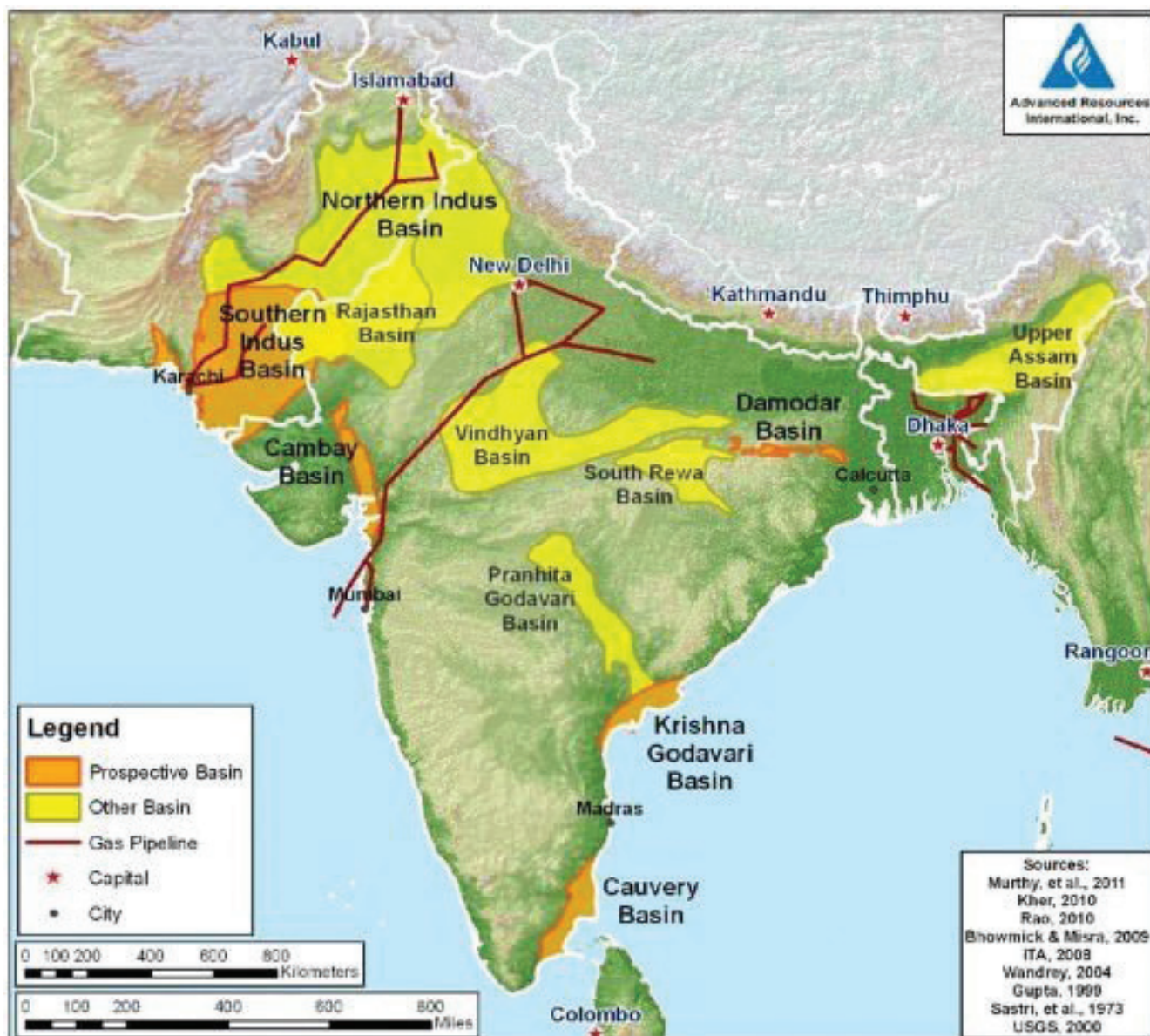
PRACTICE QUESTION

- Q. Discuss the significance of Exclusive Economic Zones (EEZs) in the context of mineral deposits. Analyze the technological advancements, geopolitical challenges, and environmental considerations associated with exploring and exploiting minerals within EEZs.

6. HYDROCARBON EXTRACTION: PROSPECTS AND CHALLENGES

CONTEXT: In 2023-24, hydrocarbon extraction has been a subject of significant discourse due to geopolitical tensions, technological advancements, environmental concerns, and shifting global energy demands. Countries continue to balance energy security with environmental sustainability amid evolving regulatory frameworks.

- ▢ **Hydrocarbon extraction:** Hydrocarbon extraction, encompassing both oil and natural gas, remains a cornerstone of global energy supply despite growing emphasis on renewable sources.
 - ▶ **Types of Hydrocarbon Resources:**
 - **Oil:** Extracted primarily from onshore and offshore fields, oil remains a crucial energy source for transportation, industries, and petrochemicals.
 - **Natural Gas:** Found in conventional reservoirs and increasingly in unconventional sources like shale formations, natural gas serves as a cleaner alternative to coal for electricity generation.
 - ▶ **Global Energy Landscape:**
 - Hydrocarbons, particularly oil and natural gas, contribute significantly to global energy consumption, fulfilling over 50% of the world's energy needs despite the rise of renewables.
- ▢ **Recent developments and trends in hydrocarbon extraction:**
 - ▶ **Technological Advancements:**
 - Advanced drilling technologies, including horizontal drilling and hydraulic fracturing (fracking), have expanded access to previously inaccessible hydrocarbon reserves, such as shale oil and gas.
 - Digitalization and automation are optimizing extraction processes, enhancing efficiency and reducing operational costs.
 - ▶ **Geopolitical Dynamics:**
 - Geopolitical tensions and conflicts often revolve around hydrocarbon-rich regions, influencing global energy markets and strategies.



- Shifts in global energy policies, such as sanctions and trade agreements, impact hydrocarbon extraction and trade routes.

Exploring the impact of hydrocarbon extraction:

- Case Study - U.S. Shale Revolution:** The U.S. shale boom transformed global energy dynamics, making the country a major producer and exporter of oil and natural gas, reducing its dependence on imports.
- Environmental Concerns:** Extraction techniques like fracking raise concerns about water contamination, seismic activity, and methane emissions, necessitating stringent regulatory frameworks and environmental safeguards.

PREVIOUS YEAR QUESTION

Q. Discuss the multi-dimensional implications of uneven distribution of mineral oil in the world. (2021)

PRACTICE QUESTION

Q. Discuss the prospects and challenges associated with hydrocarbon extraction in the context of global energy security and environmental sustainability.

7. INDIAN PORTS AND ECONOMIC DEVELOPMENT

CONTEXT: In 2023-24, Indian ports have been pivotal amidst global supply chain disruptions, infrastructure upgrades, and policy reforms aimed at enhancing maritime trade efficiency and competitiveness.

Indian ports are vital nodes of the country's economic infrastructure, facilitating trade, commerce, and industrial growth.

■ Indian Ports and Economic development:

► Role of Indian Ports:

- Indian ports handle over 90% of the country's international trade by volume and serve as crucial gateways for imports and exports.
- Major ports include Jawaharlal Nehru Port Trust (JNPT), Chennai Port, Kolkata Port, and ports in Gujarat like Kandla and Mundra.
- **Recent Developments:**
- **Infrastructure Upgrades:** Investments in port infrastructure, including dredging, container terminals, and connectivity enhancements, to accommodate larger vessels and increase handling capacity.
- **Policy Reforms:** Initiatives such as Sagarmala and Bharatmala aimed at integrated development of port-led infrastructure and enhancing multimodal connectivity.

■ Recent trends and challenges in Indian ports:

► Technological Integration:

- Adoption of digital technologies like RFID, automated cranes, and blockchain for cargo tracking and operational efficiency.
- Implementation of green initiatives to reduce carbon footprint and improve sustainability.

► Global Supply Chain Dynamics:

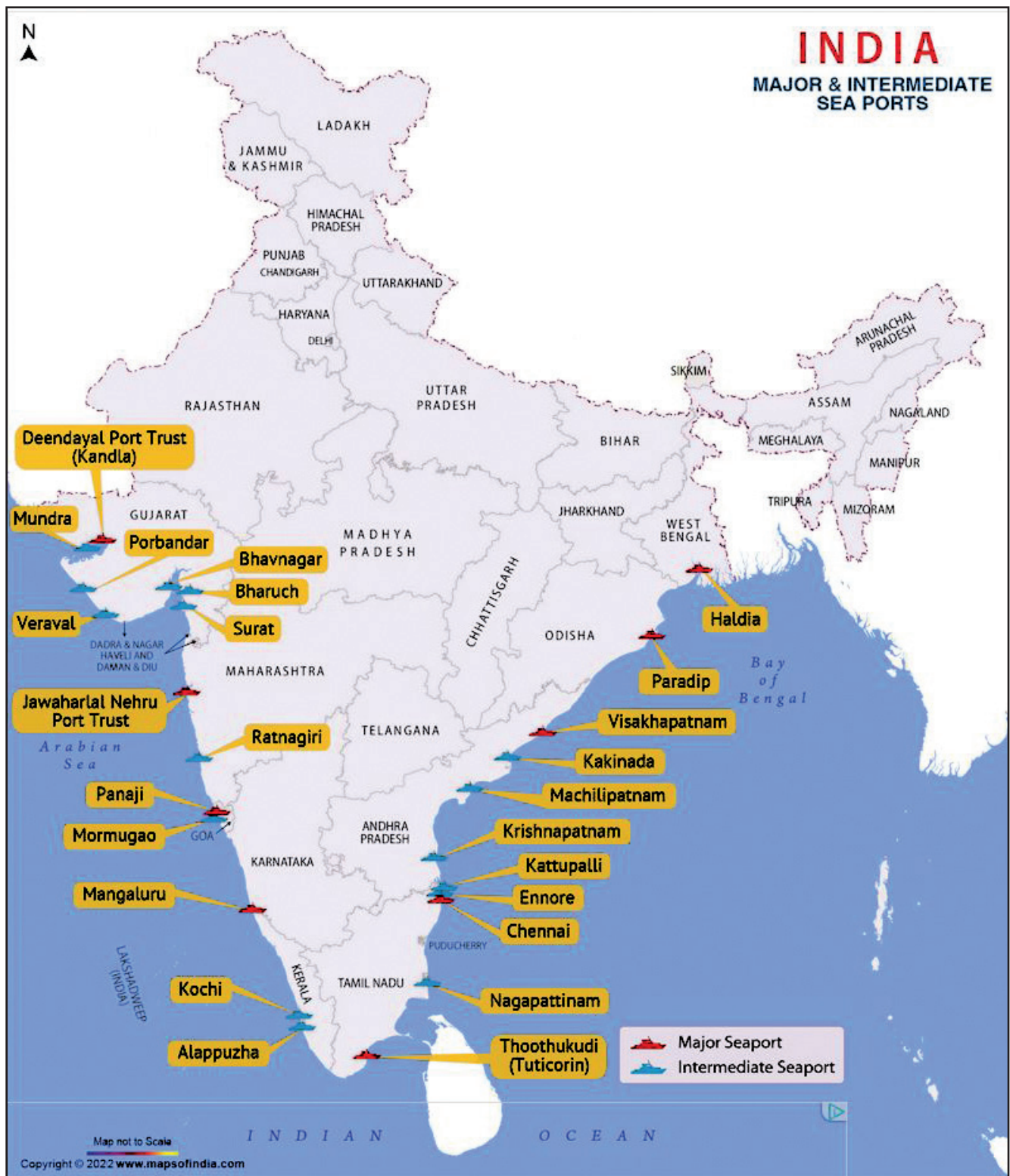
- Impact of global supply chain disruptions, such as COVID-19, on port operations and logistics.
- Resilience measures and adaptive strategies adopted by ports to mitigate disruptions and ensure uninterrupted trade flows.

■ Understanding the impact and strategic initiatives:

- **Case Study - JNPT:** Expansion projects at JNPT to increase container handling capacity and streamline operations, supporting India's trade growth aspirations.
- **Economic Contribution:** Ports contribute significantly to GDP through employment generation, revenue generation, and facilitation of industrial growth in port hinterlands.

PRACTICE QUESTION

Q. Discuss the role of Indian ports in economic development, highlighting recent trends, challenges, and strategic initiatives.

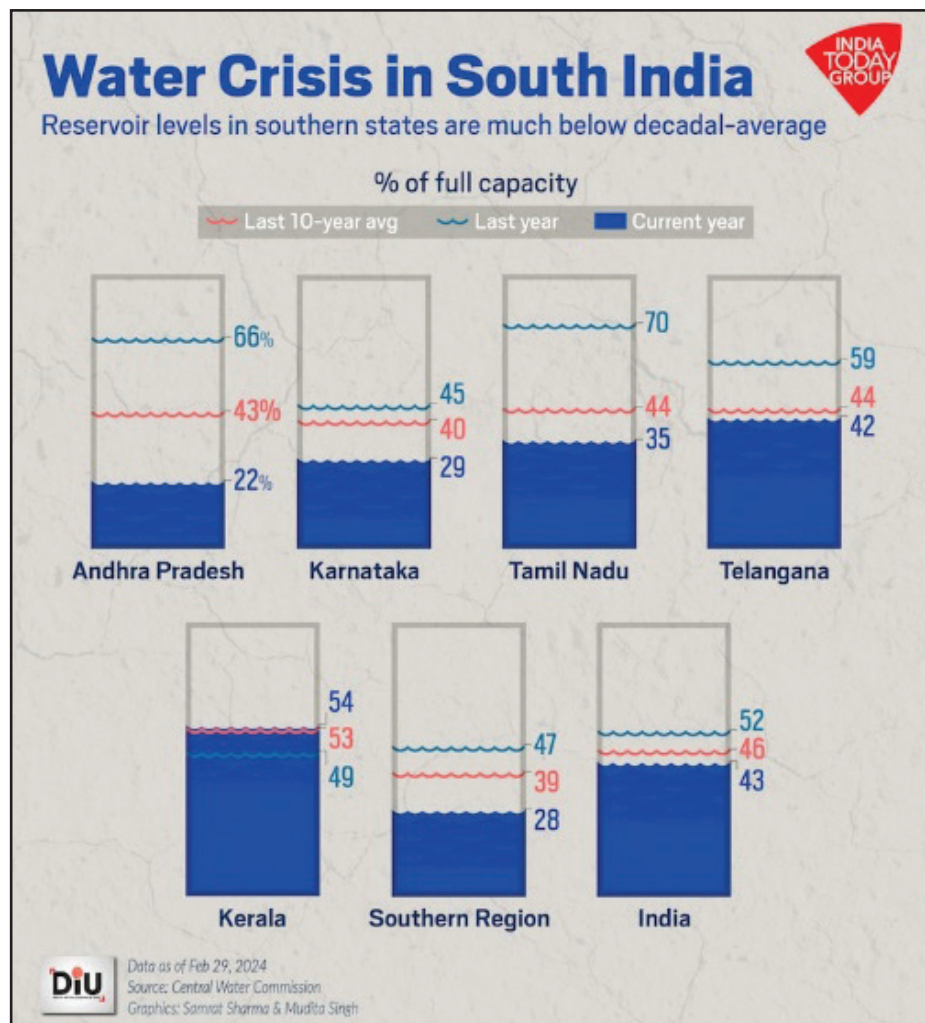


8. SHRINKING WATER IN RESERVOIRS IN INDIA

CONTEXT: In March 2024, India's main reservoirs hit their lowest levels in five years, signaling a potential water crisis. The situation is particularly dire in major cities like Bengaluru, where water supply is already being curtailed. Hot weather and the aftermath of a poor monsoon in 2023 have exacerbated the problem, affecting at least 16 states and shrinking hydro-power generation to a record low.

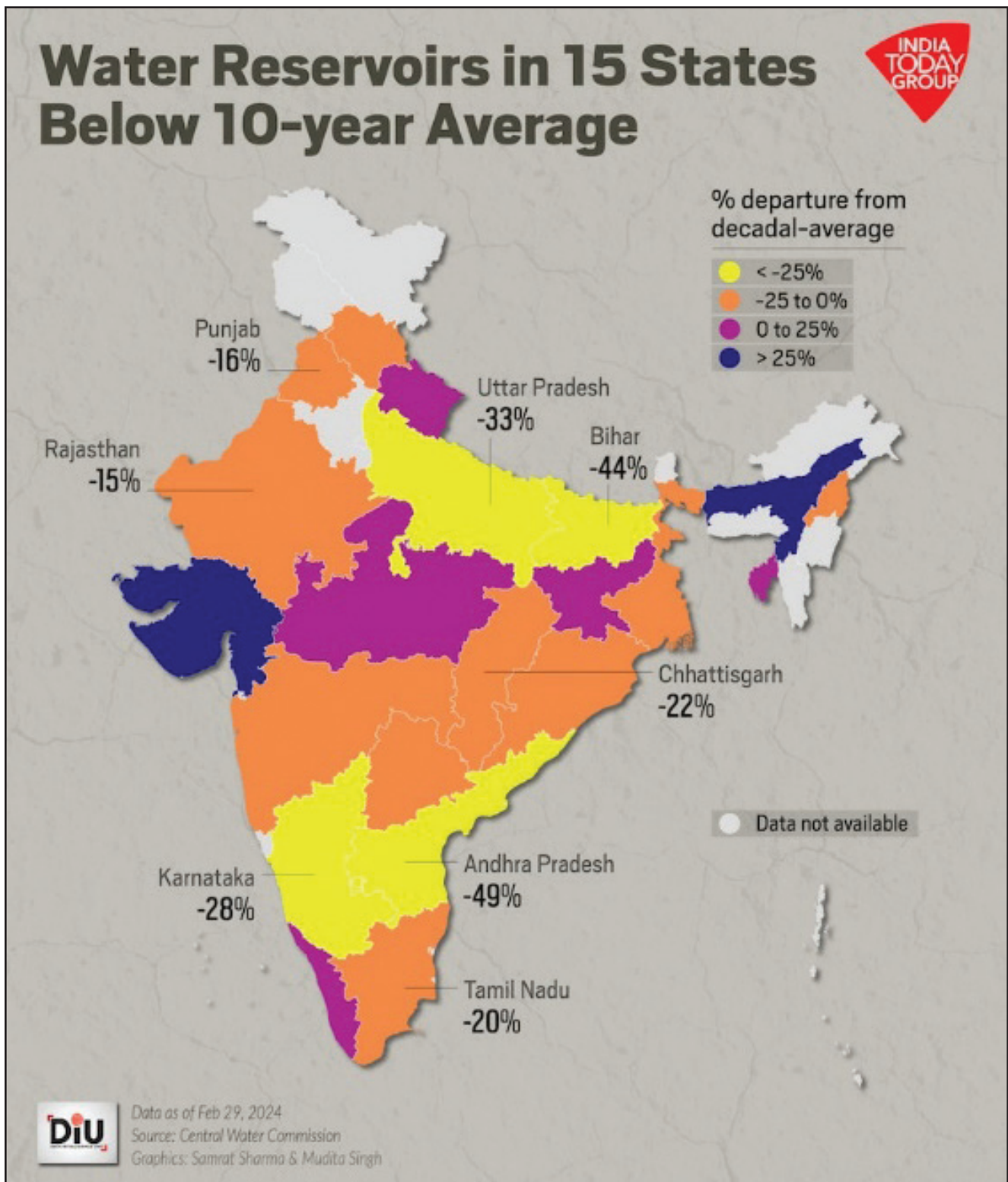
Water Scarcity in India

- ▶ **Reservoir Levels:** The 150 federally monitored reservoirs, crucial for drinking water and irrigation, were filled to just 40% of capacity last week. In Karnataka, home to Bengaluru, the main reservoir plummeted to 16% capacity.
- ▶ **Hydropower Generation:** India's hydro generation has dropped 17% in the current financial year despite strong electricity demand.
- ▶ **Regional Disparities:** Uneven monsoons led to varying water levels across regions, exacerbating shortages.
- ▶ **Risk of Water Wars:** Without immediate action, water scarcity could escalate into conflicts between states.
- ▶ **Climate Change Impact:** Erratic monsoons and El Niño patterns contribute to the crisis.



▢ Solutions to Water Scarcity Problem:

- **Rainwater Harvesting:** Promote rooftop rainwater harvesting to recharge groundwater.
- **Efficient Irrigation:** Adopt drip irrigation and precision farming techniques.
- **Water Pricing:** Implement tiered pricing to encourage conservation.
- **Desalination Plants:** Explore desalination technologies for coastal cities.
- **Interlinking Rivers:** Strategically connect rivers to redistribute water.



Case Studies:

- **Chennai, 2019:** Reservoirs hit 35% capacity, leading to severe water shortages.
- **Maharashtra, 2020:** Drought conditions affected agriculture and livelihoods.
- **Bengaluru, 2024:** Water supply curtailed due to critically low reservoir levels.
 - India faces an urgent challenge to manage its water resources effectively. Immediate action, sustainable practices, and inter-state cooperation are essential to avert a full-blown crisis.

PREVIOUS YEAR QUESTION

- Q. What are the environmental implications of the reclamation of the water bodies into urban land use? Explain with examples. (2021)
- Q. Account for the present location of iron and steel industries away from the source of raw material, by giving examples. (2020)

PRACTICE QUESTION

- Q. Discuss the impact of climate change on India's water resources, highlighting the role of monsoons and reservoir management. Suggest measures to mitigate water scarcity in the country.

9. GEOPOLITICS OF SOUTH CHINA SEA: CHALLENGES FOR INDIA

CONTEXT: In recent months, the South China Sea has emerged as a geopolitical flashpoint. China's assertiveness in the region, marked by its Nine-Dash Line claim, challenges the concept of freedom of navigation and the rule-based international order. India, with growing interests in the Indo-Pacific, faces complex challenges as it navigates this strategic arena.

▢ Navigating Geopolitical Dynamics of South China Sea

- **Trade Routes and Energy Security:**
 - Over 55% of India's total trade passes through the South China Sea. India's economic interests are closely tied to the stability of these vital sea lanes.
 - India's joint hydrocarbon exploration project with Vietnam in the Phu Khanh Basin underscores its strategic energy security concerns.
- **Strategic Engagement with ASEAN:**
 - India's maritime engagement with Southeast Asian states has intensified. The Indian Navy's visits to the region have increased four-fold since 2013.
 - The 20th ASEAN-India summit emphasized economic complementarities, trade, and connectivity. Negotiations to enhance the ASEAN-India Trade in Goods Agreement are underway.
- **Balancing Act with China:**
 - India maintains neutrality on sovereignty disputes in the South China Sea. However, it has become more vocal about regional stability and adherence to international law.
 - The challenge lies in balancing economic interests, strategic partnerships, and avoiding direct confrontation with China.

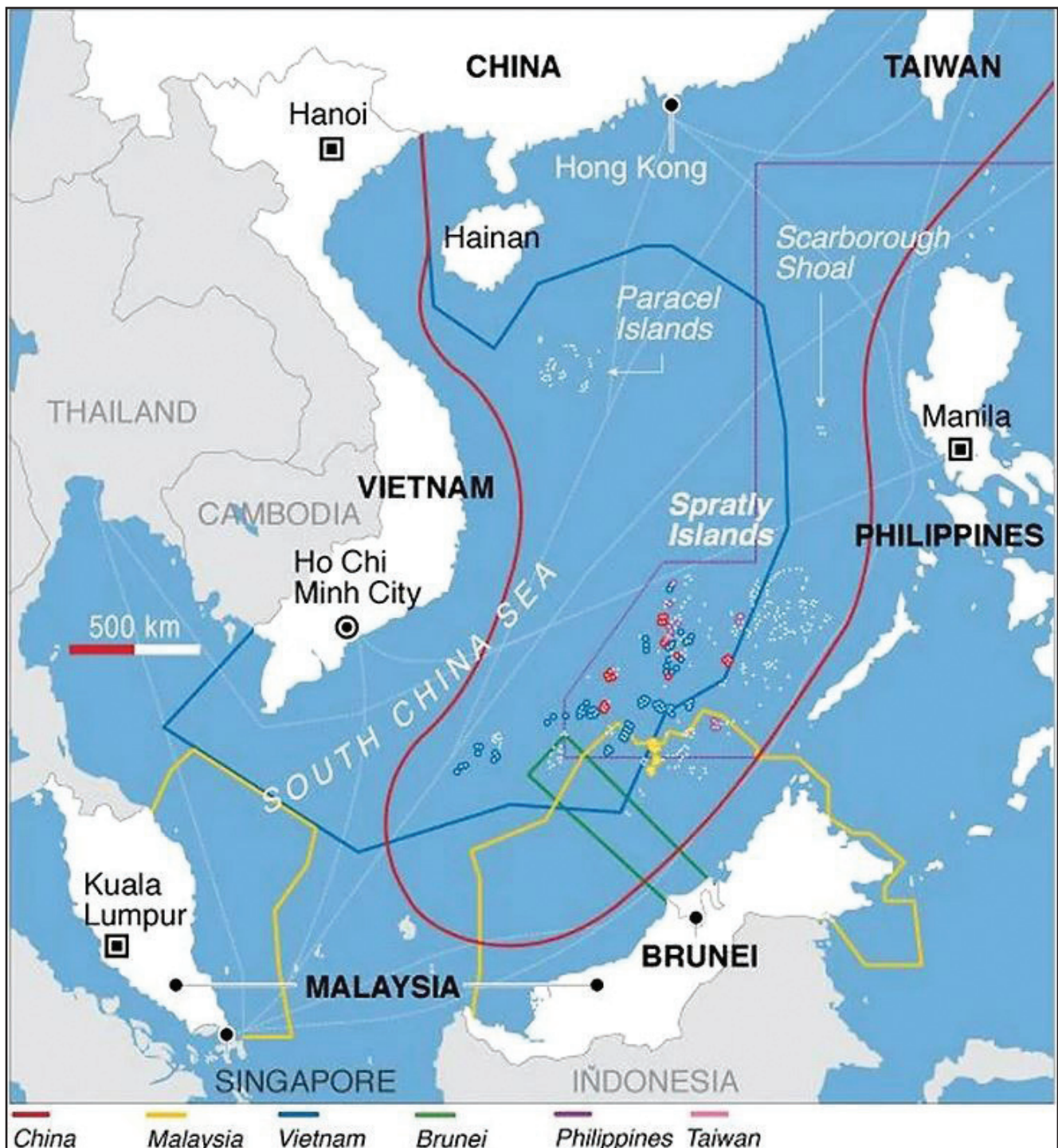
▢ Solutions to Geopolitical Issues:

► Multilateral Cooperation:

- India should strengthen partnerships with ASEAN nations, emphasizing shared interests in maritime security, trade, and connectivity.
- Collaborative efforts can promote stability and counterbalance China's influence.

► Legal Framework and UNCLOS:

- Uphold the United Nations Convention on the Law of the Sea (UNCLOS) principles. Encourage adherence to international norms.
- Advocate for a code of conduct in the South China Sea that respects the rights of all stakeholders.



Case Studies:

- **Indian Navy's Deployment:** The recent operational deployment of the Indian Navy's Eastern Fleet to the South China Sea demonstrates India's commitment to regional security and cooperation.
- **Vietnam-India Hydrocarbon Project:** Despite China's objections, India's joint exploration project with Vietnam highlights its strategic interests in the region.
- **ASEAN-India Summit:** The 20th summit showcased India's intent to deepen economic ties and connectivity with Southeast Asia.

PREVIOUS YEAR QUESTION

Q. Why is India considered as a subcontinent? Elaborate your answer. (2021)

PRACTICE QUESTION

Q. Discuss India's evolving stance on the South China Sea disputes, considering economic interests, strategic partnerships, and the need for a balanced approach.

10. MULTIPURPOSE PROJECT AND REGIONAL DEVELOPMENT

CONTEXT: As we step into 2024, India eagerly anticipates the inauguration of five groundbreaking infrastructure projects. These ventures promise to revolutionize urban landscapes, particularly in the Delhi-National Capital Region (NCR) and the Mumbai Metropolitan Region (MMR).

▢ Multipurpose Projects and Regional Development

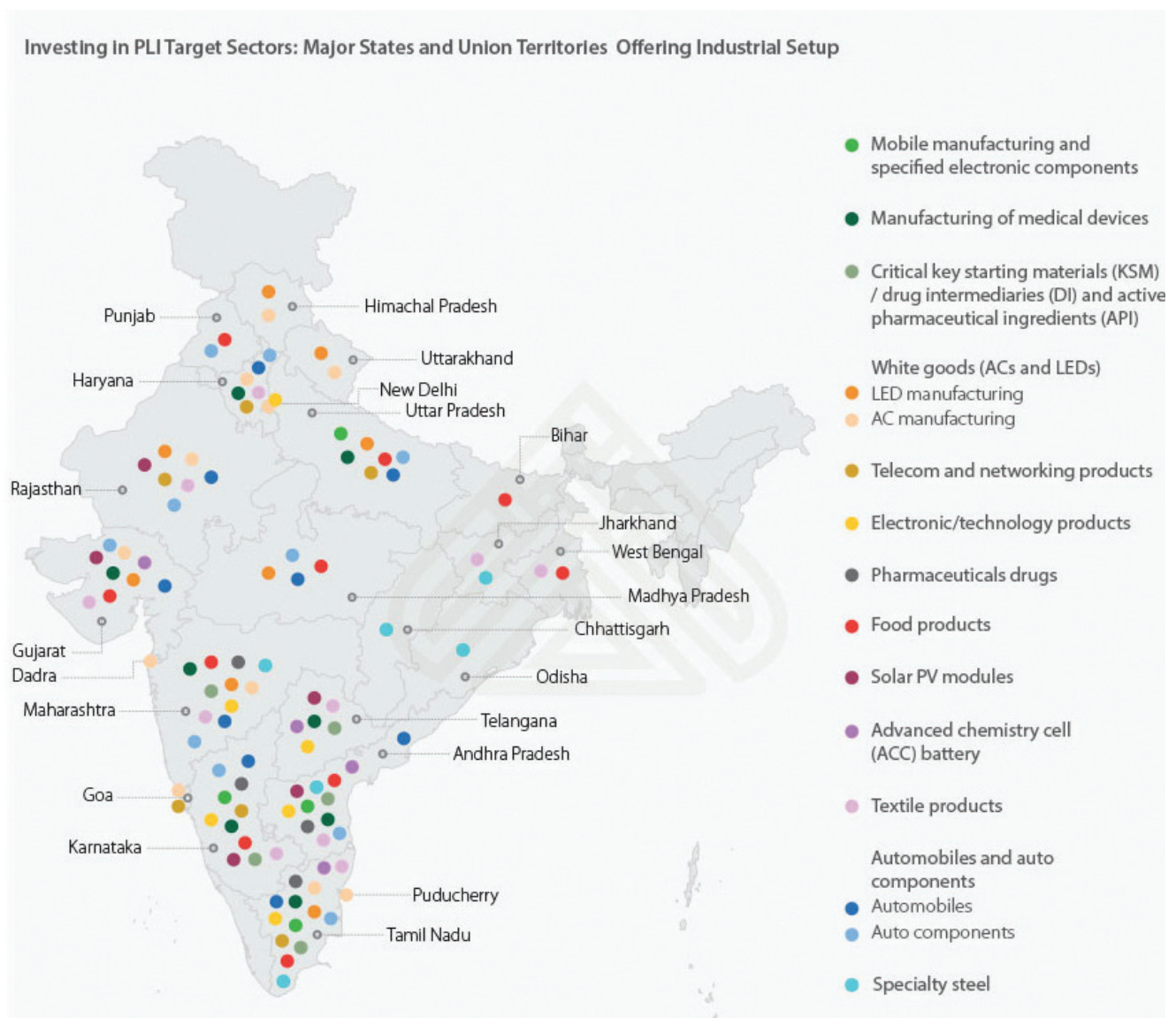
► Mumbai Trans Harbour Link (MTHL):

- **Overview:** The MTHL is an engineering marvel, spanning nearly 22 km. It will connect Mumbai city with mainland Navi Mumbai.
- **Significance:** Scheduled for inauguration by Prime Minister Narendra Modi on January 12, 2024, the six-lane sea bridge aims to enhance connectivity and economic development.
- **Benefits:**
 - Economic upliftment of Navi Mumbai and parts of Raigad District.
 - Faster access to the upcoming Navi Mumbai International Airport.
- **Cost:** Approximately ₹18,000 crore.
- **Impact:** The MTHL is poised to transform the Mumbai Metropolitan Region's transportation landscape.

► Navi Mumbai International Airport (NMIA):

- **Overview:** NMIA, operated by Adani Airports Holdings Ltd., addresses capacity constraints in the MMR.
- **Phase 1 (Completion by 2024):**
 - Capacity: 20 million passengers per annum.
 - Cargo handling: 800,000 tons per annum.
- **Total Capacity (Upon Completion):**
 - Passengers: 60 million per annum.
 - Cargo: 800,000 tons per annum.

- **Cost:** Around ₹17,000 crore.
- **Importance:** NMIA will boost air connectivity and economic growth in the region.
- **NOIDA International Airport:**
 - **Status:** Under development.
 - **Location:** Jewar, Uttar Pradesh.
 - **Capacity:** Expected to handle 12-16 million passengers annually.
 - **Purpose:** To ease congestion at Delhi's Indira Gandhi International Airport.
 - **Impact:** Enhanced regional connectivity and economic opportunities.



▢ Solutions:

- **Multilateral Cooperation:** Strengthen partnerships with ASEAN nations for shared interests in maritime security, trade, and connectivity. Collaborate to promote stability and counterbalance China's influence in the Indo-Pacific region.
- **Adherence to International Norms:** Uphold UNCLOS principles. Advocate for a code of conduct in the South China Sea that respects the rights of all stakeholders.

Case Studies:

- **Indian Navy's Deployment:** Operational presence in the South China Sea demonstrates India's commitment to regional security and cooperation.
- **Vietnam-India Hydrocarbon Project:** Despite objections, India's joint exploration project with Vietnam highlights strategic interests in the region.
- **ASEAN-India Summit:** Emphasizes deepening economic ties and connectivity with Southeast Asia.

India's strategic decisions regarding these mega projects will shape its role in the Indo-Pacific landscape. Balancing economic interests, partnerships, and regional stability remains crucial. As we move forward, these transformative initiatives hold the promise of a more connected and prosperous India.

PREVIOUS YEAR QUESTION

Q. What is the significance of Industrial Corridors in India? Identifying industrial corridors, explain their main characteristics. (2018)

PRACTICE QUESTION

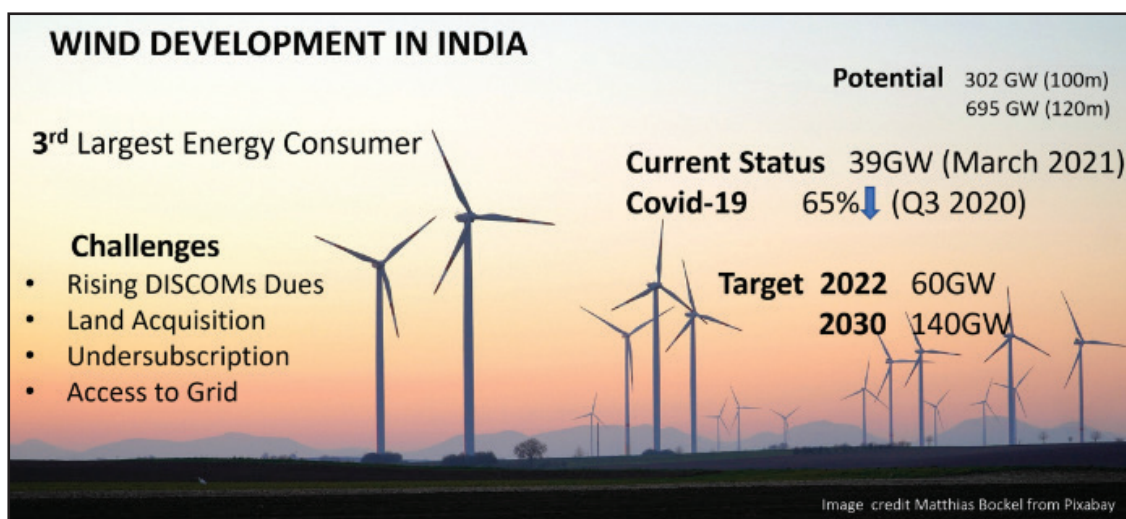
Q. Discuss the implications of multipurpose projects on regional development in India?

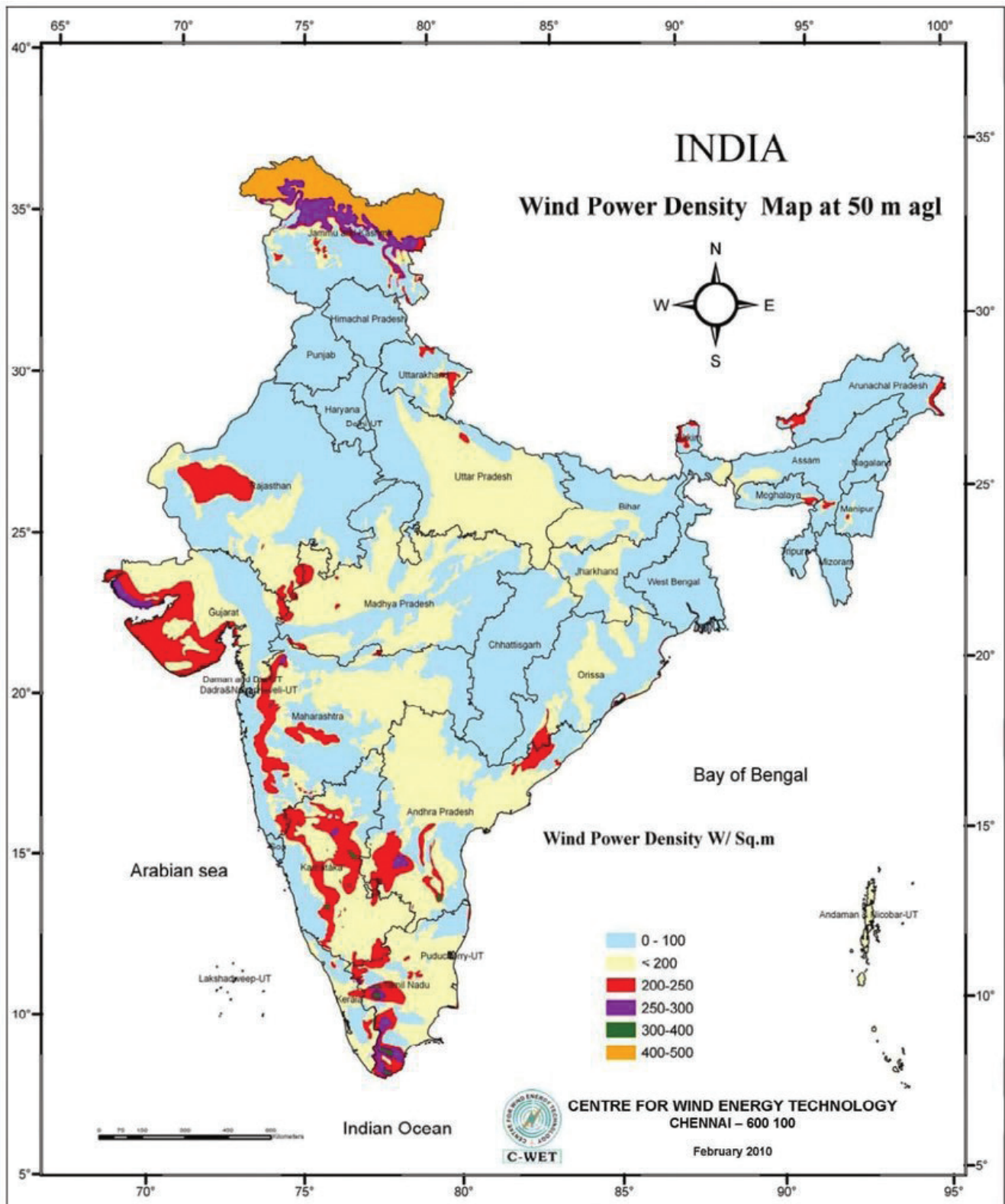
11. WIND ENERGY IN INDIA: POTENTIAL AND CHALLENGES

CONTEXT: India, with its diverse landscapes and vast coastline, stands at the forefront of renewable energy adoption. Among these sources, wind energy plays a pivotal role in the nation's sustainable development and energy security.

Historical Context and Growth of Wind Energy

- India's journey in wind energy began in the early 1990s with the establishment of the first wind farms, primarily in Tamil Nadu. These pioneering developments laid the foundation for a burgeoning industry. Key factors, including favorable policies and cutting-edge technology, fueled substantial growth in installed wind capacity across the country.





❏ Milestones in India's Wind Energy Journey

► Installed Capacity Surge:

- India boasts a cumulative installed wind power capacity of 46.4 GW by May 2024, making it the fourth-largest globally.
- Noteworthy achievements include the development of large wind farms and advancements in turbine technology.

► **Integration with the Grid:**

- Wind power seamlessly integrates into India's national grid, contributing to the energy mix.
- The rise of wind energy has been a collaborative effort involving government initiatives, foreign investments, and technological advancements.

► **Challenges Faced:**

- Despite growth, challenges persist:
- **Infrastructure:** Developing adequate infrastructure for wind projects.
- **Investment:** Attracting sufficient investment for expansion.
- **Grid Integration:** Ensuring smooth integration with the grid.

▢ **Solutions to Wind Energy Development Challenges:**

- **Policy Continuity:** Sustained government support is crucial for long-term growth. Clear policies encourage private sector participation.
- **Technological Innovations:** Continued R&D to enhance turbine efficiency. Smart grid solutions for seamless integration.
- **Payment Mechanisms:** Timely payments to wind power generators. Streamlined processes for project execution.

Case Studies:

- **Tamil Nadu's Success:** The state's early focus on wind energy led to significant capacity growth.
- **Gujarat's Vibrant Market:** Gujarat's favorable policies attracted investments and boosted wind projects.
- **Andhra Pradesh's Challenges:** Grid instability affected wind power utilization.

PREVIOUS YEAR QUESTION

- Q. Examine the potential of wind energy in India and explain the reasons for their limited spatial spread. (2022)
- Q. India has immense potential of solar energy though there are regional variations in its developments. Elaborate. (2020)

PRACTICE QUESTION

- Q. Discuss potential and challenges of wind energy harnessing in varied regions of India?

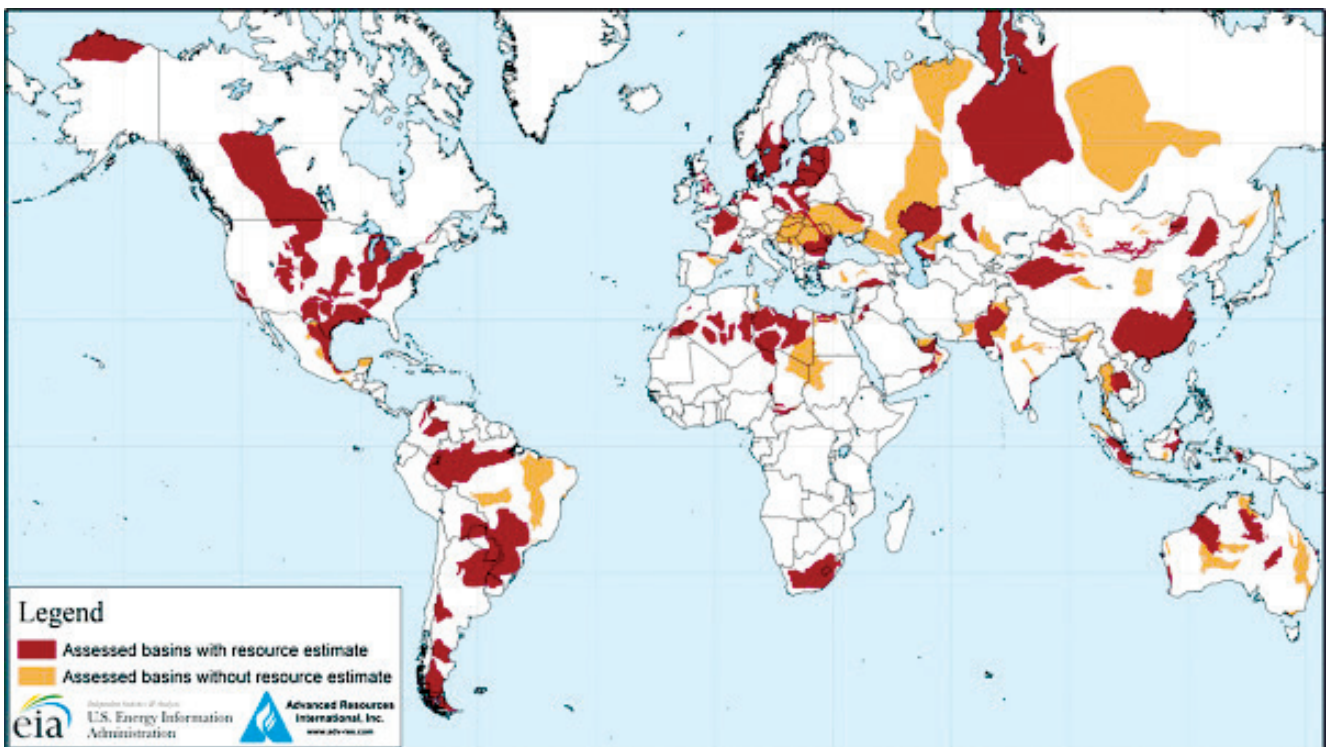
12. PETROLEUM OIL PRODUCTION: OPPORTUNITIES AND CHALLENGES

CONTEXT: In 2024, the global oil industry faces a dynamic landscape. Structural shifts, technological advancements, and geopolitical tensions shape the trajectory of petroleum production.

▢ **Contemporary Issue: Five Dimensions**

- **Divergent Demand Trajectories:**
 - **Asia's Growth:** Emerging economies, particularly China and India, drive global oil demand growth.
 - **Advanced Economies:** Contrarily, oil demand in advanced economies declines sharply.

- ▶ **Rising Oil Supplies:**
 - **Non-OPEC+ Producers:** World oil supplies are set to surpass forecast demand from 2025 onward.
 - **Capacity Buildup:** A front-loaded increase in oil production capacity may lose momentum.
- ▶ **Petrochemicals and NGLs:**
 - **NGL Surge:** Natural gas liquids (NGLs) and condensates account for 45% of new capacity increases.
 - **Refining Challenges:** Refiners face displacement of refined products by non-refined fuels like NGLs and biofuels.
- ▶ **Energy Transition Impact:**
 - **EVs and Distillates:** Electric vehicles (EVs) reduce distillate demand, affecting road transport fuels.
 - **Product Slate Reconfiguration:** Refiners must adapt to changing consumption patterns.
- ▶ **Uncertainties and Adaptability:**
 - **Macroeconomic Factors:** Weaker expectations.
 - **Regulatory Changes:** Energy transition policies.
 - **Investment in Efficiency:** Scaling up technologies.



Solutions: Three Case Studies

- **Tamil Nadu's Wind Energy Success:** Early focus on wind farms led to significant capacity growth. Strategic planning yields results.
- **Gujarat's Vibrant Market:** Favorable policies attracted investments in renewables. Clear policies drive adoption.
- **Andhra Pradesh's Grid Challenges:** Grid instability affected wind power utilization. Strengthen grid infrastructure for reliable energy supply.

PRACTICE QUESTION

Q. Discuss the impact of structural shifts on global oil markets, emphasizing demand patterns, supply dynamics, and strategies for a sustainable energy transition.

13. CRITICAL MINERALS: DISTRIBUTION, PROSPECTS AND CHALLENGES

CONTEXT: Critical minerals, also known as critical raw materials, are essential for modern technologies and the global energy transition. These minerals are indispensable for producing high-tech devices, renewable energy systems, and defense applications. The significance of critical minerals has surged in 2024, driven by the increasing demand for green technologies and geopolitical tensions influencing global supply chains.

▣ Importance of Critical Minerals

- Critical minerals such as lithium, cobalt, rare earth elements, and nickel are fundamental to the manufacture of batteries, electric vehicles (EVs), wind turbines, and solar panels.
- Their importance extends to national security, as they are crucial for defense technologies.
- The global shift towards renewable energy sources has heightened the urgency to secure a stable supply of these minerals.

▣ Global Distribution of Critical Minerals

- The distribution of critical minerals is geographically uneven, posing challenges for supply chain stability:
- **Lithium:** Predominantly found in Australia, Chile, and Argentina.
- **Cobalt:** The Democratic Republic of Congo (DRC) dominates global production.
- **Rare Earth Elements:** China accounts for over 60% of global production.
- **Nickel:** Indonesia, the Philippines, and Russia are major producers.

▣ Prospects in the Global Context

- The demand for critical minerals is projected to rise significantly.
- The International Energy Agency (IEA) estimates that to meet global climate goals, the supply of minerals like lithium and cobalt needs to increase by over 40 times by 2040.
- Innovations in recycling and substitution, along with new mining technologies, are being explored to meet this demand sustainably.

▣ Challenges in the Global Context Several challenges hinder the stable supply of critical minerals:

- **Geopolitical Tensions:** Dependence on a few countries for critical minerals makes supply chains vulnerable to geopolitical conflicts.
- **Environmental Concerns:** Mining and processing critical minerals often have significant environmental impacts, including habitat destruction and pollution.
- **Ethical Issues:** Child labor and poor working conditions in countries like the DRC raise ethical concerns about mineral sourcing.
- **Critical Minerals in India:** India, aspiring to become a global manufacturing hub and achieve energy self-sufficiency, faces unique challenges and opportunities in securing critical minerals.
- **Prospects in the Indian Context:** India is investing in exploration and development of domestic resources. Initiatives like the National Mineral Policy 2019 and the establishment of KABIL (Khanij Bidesh India Ltd) aim to ensure a stable supply of critical minerals through joint ventures with resource-rich countries.

▣ Challenges in the Indian Context

- **Resource Scarcity:** India has limited reserves of many critical minerals, making it dependent on imports.

- ▶ **Technological Gaps:** The country needs advanced technology for efficient extraction and processing of critical minerals.
- ▶ **Regulatory Hurdles:** Complex regulatory frameworks can delay the development of mining projects.

Case Study: Lithium in Australia:

Australia is a leading producer of lithium, essential for EV batteries. The Greenbushes lithium mine, one of the largest in the world, highlights the country's role in the global supply chain. Australia's stable political environment and robust regulatory framework make it a reliable source of lithium.

Cobalt in the Democratic Republic of Congo

The DRC supplies over 60% of the world's cobalt. However, the mining industry is plagued by issues such as child labor and environmental degradation. Companies like Tesla and Apple are working towards ethical sourcing initiatives to address these concerns, but challenges persist.

PRACTICE QUESTION

- Q. Discuss the significance of critical minerals in modern technologies and the challenges India faces in balancing its geological diversity with China's market dominance.

14. EASTERN MARITIME CORRIDOR (EMC): PROSPECTS AND CHALLENGES

CONTEXT: The Eastern Maritime Corridor (EMC) has emerged as a significant development in global trade and logistics. This corridor aims to enhance maritime connectivity between the eastern coast of India and Russia's Far East, offering a faster alternative to traditional routes via the Suez Canal. In 2024, the EMC has garnered substantial attention due to its potential to revolutionize trade dynamics, foster regional cooperation, and enhance economic growth.

■ Importance of the Eastern Maritime Corridor

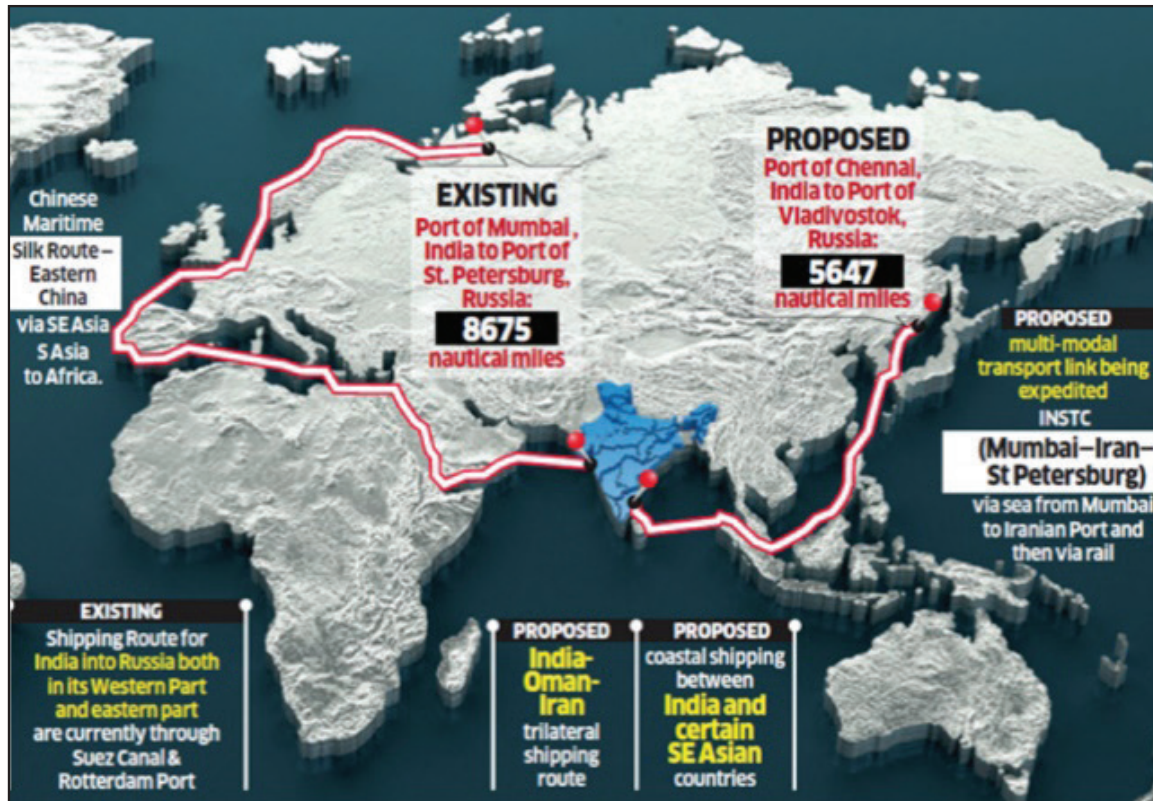
- ▶ **Trade Efficiency:** Reduces travel time between India and Russia by approximately 40%, boosting trade efficiency.
- ▶ **Economic Growth:** Enhances economic integration and development in the regions it connects.
- ▶ **Strategic Significance:** Strengthens geopolitical ties and diversifies trade routes, reducing dependency on traditional passages like the Suez Canal.

■ Global Distribution and Connectivity

- ▶ The EMC connects major ports on India's eastern coast, such as Chennai, Visakhapatnam, and Kolkata, with the Russian ports of Vladivostok and Vostochny. This route traverses the South China Sea and the Sea of Japan, linking Southeast Asia, East Asia, and the Russian Far East.

■ Prospects in the Global Context

- ▶ **Enhanced Trade:** The EMC is expected to facilitate increased trade volumes between Asia and Europe, particularly benefiting countries in the Indo-Pacific region.
- ▶ **Economic Diversification:** Provides an alternative to the heavily congested and geopolitically sensitive Suez Canal route, offering a more resilient trade pathway.
- ▶ **Regional Development:** Promotes economic development in the Russian Far East and India's eastern states through improved connectivity and investment opportunities.



❑ Challenges in the Global Context

- **Geopolitical Tensions:** The route passes through sensitive maritime regions, potentially facing geopolitical disputes and security concerns.
- **Infrastructure Development:** Significant investment is required to develop port infrastructure and logistics capabilities along the corridor.
- **Environmental Impact:** Increased maritime traffic poses environmental risks, including marine pollution and ecological disruption.
- **Eastern Maritime Corridor in India:** India plays a pivotal role in the EMC, with its eastern ports serving as critical nodes in the corridor.

❑ Prospects in the Indian Context

- **Economic Boost:** The EMC can stimulate economic growth in India's eastern states by enhancing trade and attracting investments.
- **Infrastructure Development:** Encourages the modernization of port infrastructure, logistics, and transportation networks.
- **Strategic Leverage:** Strengthens India's strategic position in the Indo-Pacific region, enhancing its influence in regional trade dynamics.

❑ Challenges in the Indian Context

- **Infrastructure Gaps:** India's eastern ports require substantial upgrades to handle increased trade volumes and larger vessels.
- **Regulatory Hurdles:** Complex regulatory frameworks and bureaucratic red tape can delay infrastructure projects and trade facilitation.
- **Maritime Security:** Ensuring the security of maritime routes against piracy and geopolitical conflicts remains a critical challenge.

Case Study: Chennai Port

Chennai Port, one of India's major ports on the eastern coast, is poised to play a central role in the EMC. Recent investments in modernizing its infrastructure and enhancing connectivity with hinterland regions have made it a key hub for trade along the corridor. The port's strategic location and capabilities are expected to significantly boost trade efficiency and economic activities in the region.

Vladivostok Port

Vladivostok, a major Russian port, is crucial for the EMC. The port has undergone significant upgrades to accommodate larger vessels and increased cargo volumes. Russia's Far East Development Program aims to attract foreign investments and promote economic activities in the region, leveraging the port's enhanced connectivity with Asian markets.

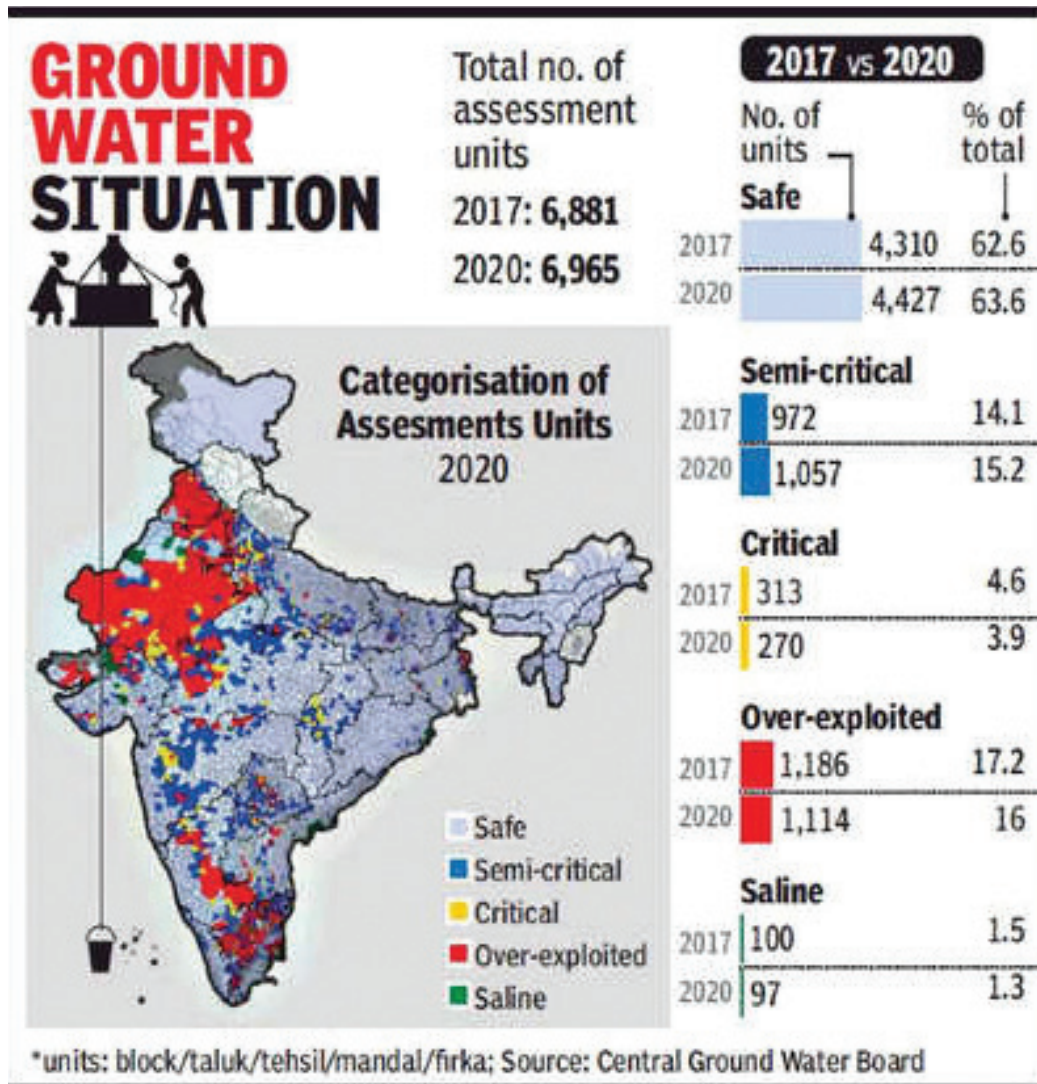
PRACTICE QUESTION

Q. Discuss the significance of the proposed Eastern Maritime Corridor (EMC) between Chennai and Vladivostok, its potential benefits for India, and the challenges in its implementation.

15. DECLINING GROUNDWATER IN INDIA: ISSUES AND CHALLENGES

CONTEXT: Groundwater is a critical resource in India, supporting agriculture, drinking water supply, and industrial activities. However, the country is facing a severe groundwater crisis, with depletion rates escalating at an alarming pace. According to the Central Ground Water Board (CGWB), over 70% of India's groundwater resources are in a critical or over-exploited state.

- ❑ **Importance of Groundwater in India:** Groundwater plays a pivotal role in India's water supply:
 - **Agriculture:** Approximately 60% of irrigated agriculture relies on groundwater.
 - **Drinking Water:** About 85% of rural and 50% of urban drinking water needs are met through groundwater.
 - **Industrial Use:** Industries also depend heavily on groundwater for their operations.
- ❑ **Current Status of Groundwater in India:** The CGWB's 2020 report highlights the dire state of India's groundwater resources:
 - **Critical Regions:** States like Punjab, Haryana, Rajasthan, and Tamil Nadu are experiencing acute groundwater depletion.
 - **Declining Water Levels:** In several regions, groundwater levels are falling by over 1 meter per year.
 - **Over-exploitation:** Nearly 256 out of 700 districts are classified as over-exploited or critical.
- ❑ **Issues Contributing to Groundwater Depletion**
 - **Over-extraction:** Excessive withdrawal of groundwater for agriculture, primarily for water-intensive crops like rice and sugarcane, is a major cause of depletion.



- **Inefficient Irrigation Practices:** Traditional irrigation methods like flood irrigation lead to significant water wastage.
- **Urbanization and Industrialization:** Rapid urban growth and industrial activities increase demand for groundwater.
- **Climate Change:** Altered rainfall patterns and increased frequency of droughts reduce groundwater recharge rates.
- **Policy Gaps:** Lack of effective groundwater management policies and enforcement exacerbates the crisis.

❏ Challenges in Addressing Groundwater Depletion

- **Data and Monitoring:** Inadequate and inconsistent data on groundwater levels hampers effective monitoring and management.
- **Regulatory Framework:** Existing regulations are often poorly enforced, and there is a need for stricter groundwater extraction laws.
- **Public Awareness:** Lack of awareness about sustainable water use practices among farmers and the general public.
- **Technological Adoption:** Slow adoption of water-efficient technologies and practices in agriculture.
- **Inter-State Coordination:** Groundwater management requires coordinated efforts across state boundaries, which is often lacking.

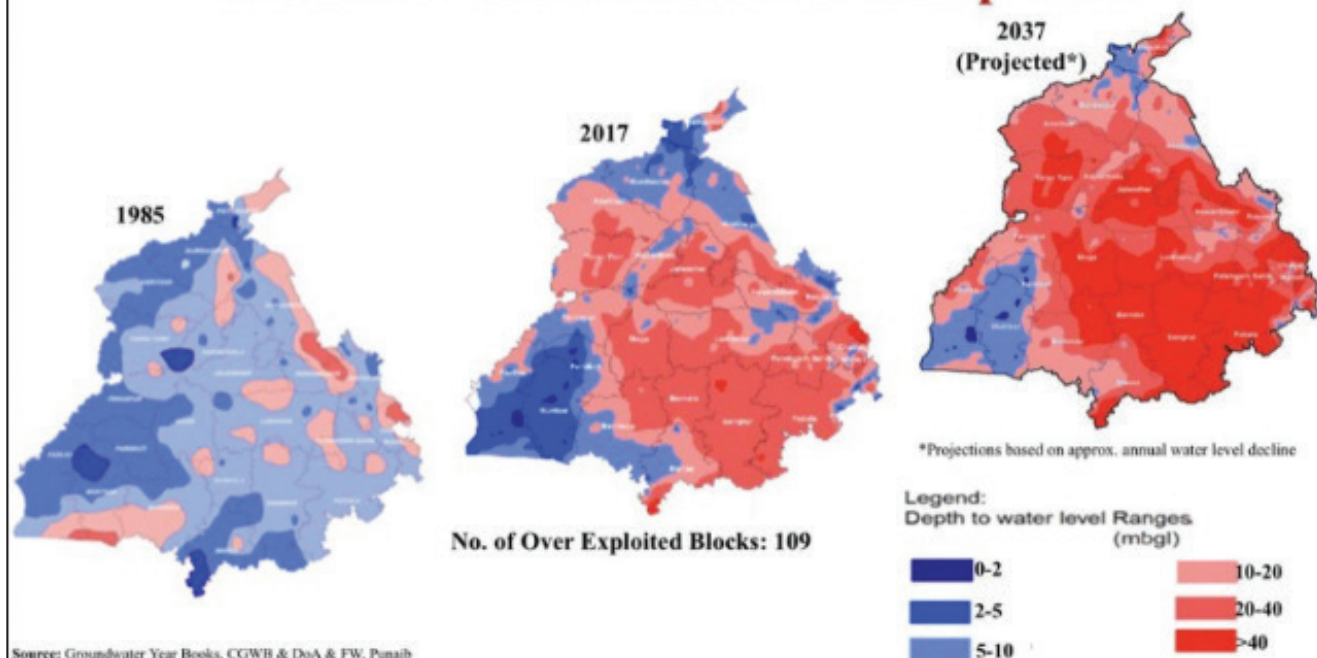
Case Study: Punjab's Groundwater Crisis

Punjab, India's breadbasket, faces severe groundwater depletion due to the cultivation of water-intensive crops like rice. The state government's groundwater data indicates that water levels in many districts are declining by over 2 meters annually. Efforts such as crop diversification and the promotion of micro-irrigation systems are underway but face resistance from farmers due to economic dependencies on rice cultivation.

Tamil Nadu's Groundwater Management

Tamil Nadu has implemented several initiatives to address groundwater depletion, including the Tamil Nadu Water Resources Consolidation Project. The state has promoted rainwater harvesting and the creation of artificial recharge structures. According to the state's groundwater department, these measures have led to a stabilization of groundwater levels in some regions, though challenges remain in achieving widespread impact.

Trend of Ground Water Table Depletion



Government Initiatives and Policies

- ▶ **Atal Bhujal Yojana (ABY):** A \$450 million World Bank-funded project aimed at sustainable groundwater management in priority areas.
- ▶ **Jal Shakti Abhiyan:** A campaign focusing on water conservation and rainwater harvesting in water-stressed districts.
- ▶ **Pradhan Mantri Krishi Sinchayee Yojana (PMKSY):** Promotes micro-irrigation and efficient water use in agriculture.

PREVIOUS YEAR QUESTION

- Q. Why is the world today confronted with a crisis of availability of and access to freshwater resources? (2023)
- Q. "The ideal solution of depleting ground water resources in India is water harvesting system". How can it be made effective in urban areas? (2018)

PRACTICE QUESTION

- Q. Discuss the causes of groundwater depletion in India and suggest policy measures to address this critical issue.

16. INCREASED COAL DEMAND AND NET CARBON NEUTRALITY








CONTEXT: As the world grapples with the urgent need to address climate change, balancing increased coal demand and the commitment to net carbon neutrality presents a formidable challenge for India. Coal remains a dominant energy source in the country, driving economic growth and energy security. However, this reliance on coal is at odds with global and national climate goals.

❑ **Importance of Coal in India:** Coal is crucial for India's energy landscape:

- **Energy Security:** Coal accounts for about 55% of India's total energy consumption.
- **Economic Growth:** It fuels major industries such as steel, cement, and power generation.
- **Employment:** The coal sector provides jobs to millions, directly and indirectly.

COAL CONSUMPTION & PRODUCTION IN INDIA							
MT	2020	2021	2022	2025 (expected)	2020 -21	2021 -22	CAGR 2022-25
Coal Consumption	905	1033	1103	1220	14.10%	6.80%	3.40%
Coal Production	758	805	893	1021	6.30%	10.90%	4.60%
Coal Imports	220	207	221	209	-5.90%	7.10%	-1.90%

Source: IEA

❑ **Current Trends in Coal Demand:** Despite global pressure to reduce fossil fuel dependency, India's coal demand has been on the rise:

- **Power Generation:** Coal-fired power plants contribute to about 70% of India's electricity.
- **Industrial Use:** Industries like steel and cement are heavily dependent on coal.
- **Economic Growth:** As India strives to become a \$5 trillion economy, energy demand is projected to grow, further boosting coal consumption.

❑ **Challenges to Net Carbon Neutrality:** India's commitment to achieving net carbon neutrality by 2070 faces several challenges:

- **Energy Transition:** Shifting from coal to renewable energy sources is a complex and gradual process.
- **Infrastructure:** Significant investment in renewable energy infrastructure is required.
- **Technological Barriers:** Advanced technologies for carbon capture and storage (CCS) and renewable energy integration need to be scaled up.
- **Economic Impact:** Transitioning away from coal may have economic repercussions, including job losses in the coal sector.

❑ **Government Policies and Initiatives:** The Indian government is taking steps to address these challenges while promoting sustainable growth:

- **National Action Plan on Climate Change (NAPCC):** Emphasizes increasing the share of renewable energy and enhancing energy efficiency.

- ▶ **Renewable Energy Targets:** India aims to achieve 500 GW of renewable energy capacity by 2030.
- ▶ **Coal Gasification:** Promotes cleaner coal technologies to reduce emissions from coal use.
- ▶ **Carbon Pricing:** Exploring mechanisms like carbon trading to incentivize emission reductions.
- ▶ **Balancing Increased Coal Demand with Climate Goals**
- ▶ **Renewable Energy Expansion:** Accelerating the deployment of solar, wind, and hydro energy projects to reduce reliance on coal.
- ▶ **Energy Efficiency:** Implementing energy-efficient technologies in industries and power generation to lower overall coal consumption.
- ▶ **Carbon Capture and Storage (CCS):** Investing in CCS technologies to capture and store carbon emissions from coal-fired plants.
- ▶ **Diversification:** Diversifying the energy mix by integrating bioenergy, nuclear, and hydrogen alongside renewables.

Case Study: Solar Power Expansion in Rajasthan

Rajasthan, with its vast desert landscapes, has become a hub for solar power. The Bhadla Solar Park, one of the largest in the world, showcases India's commitment to renewable energy. This massive project not only contributes significantly to the national grid but also provides a model for large-scale renewable energy deployment. However, integrating such large-scale renewables into the grid presents challenges in terms of storage and distribution.

Coal Gasification in Odisha

The Talcher Fertilizer Plant in Odisha is pioneering coal gasification technology. This process converts coal into syngas, which can be used to produce fertilizers and chemicals with lower carbon emissions compared to conventional coal use. This initiative represents a step towards cleaner coal utilization, aligning with the need to reduce emissions while meeting industrial demand.

PREVIOUS YEAR QUESTION

- Q. Discuss the natural resource potentials of 'Deccan Trap'. (2021)
- Q. Examine the status of forest resources of India and its resultant impact on climate change. (2020)

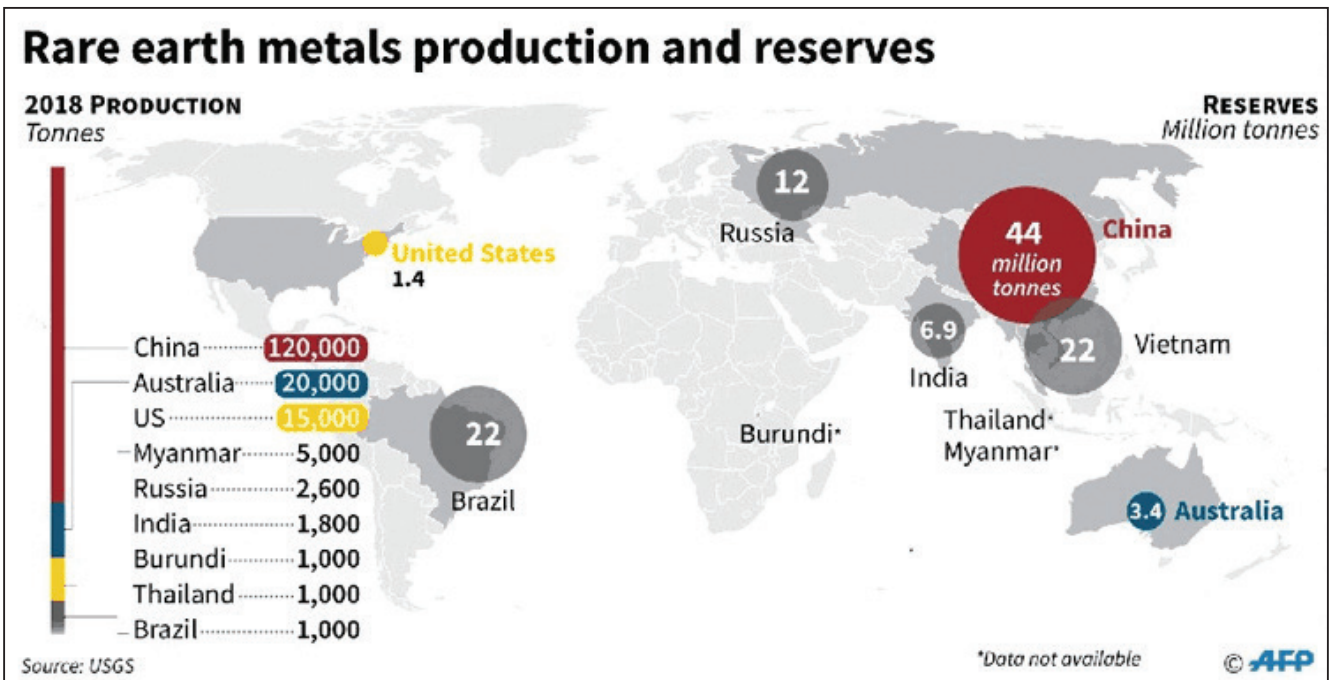
PRACTICE QUESTION

- Q. Discuss the issues arising with increased use of coal for production of power in times of global warming and climate change.

17. RARE EARTH METALS: PROSPECTS AND CHALLENGES

CONTEXT: New discovery of Rare Earth Elements in USA, South America, India, etc. will help in reducing Chinese hegemony over the control of Rare Earth Elements in world.

- **Rare Earth Metals:** Rare earth metals, a group of 17 elements critical for modern technology, are essential for various high-tech applications, including electronics, renewable energy, and defense systems.
 - ▶ As the global demand for these metals increases, understanding their prospects and challenges becomes crucial.



- ❑ **Importance of Rare Earth Metals:** Rare earth metals are indispensable in the production of numerous high-tech devices:
 - **Electronics:** Used in the manufacture of smartphones, computers, and other electronic devices.
 - **Renewable Energy:** Essential for the production of wind turbines and electric vehicle (EV) batteries.
 - **Defense:** Critical for advanced defense technologies, including radar systems and guided missiles.
 - **Healthcare:** Utilized in medical imaging devices and other healthcare technologies.
- ❑ **Global Distribution of Rare Earth Metals:** The distribution of rare earth metals is highly concentrated, with a few countries dominating production and reserves:
 - **China:** Accounts for over 60% of global rare earth production and holds significant reserves.
 - **United States:** Possesses substantial reserves and is ramping up production efforts.
 - **Australia:** Another key player with large reserves and increasing production capacity.
 - **Other Countries:** Canada, Brazil, India, and Vietnam also have notable reserves and are potential sources of rare earth metals.
- ❑ **Prospects in the Global Context**
 - **Rising Demand:** The global demand for rare earth metals is expected to surge due to the expansion of renewable energy, EVs, and high-tech industries.
 - **Technological Advancements:** Innovations in extraction and processing technologies are likely to make rare earth metal production more efficient and environmentally friendly.
 - **Geopolitical Significance:** Countries are seeking to diversify their supply chains to reduce dependence on dominant producers like China, enhancing global supply security.
- ❑ **Challenges in the Global Context**
 - **Environmental Impact:** The extraction and processing of rare earth metals can cause significant environmental damage, including habitat destruction and pollution.
 - **Supply Chain Vulnerabilities:** Concentration of production in a few countries makes the supply chain susceptible to geopolitical tensions and trade restrictions.
 - **Economic Barriers:** High costs associated with mining and processing rare earth metals can be prohibitive, particularly for developing countries.

- ▶ **Regulatory Hurdles:** Strict environmental regulations can delay or impede the development of new mining projects.

❏ Rare Earth Metals in India

- ▶ India, with its substantial reserves found in J&K, Jharkhand, etc., has the potential to become a significant player in the rare earth metals market.

❏ Prospects in the Indian Context

- ▶ **Resource Potential:** India possesses considerable reserves of rare earth metals, particularly in states like Andhra Pradesh, Tamil Nadu, and Kerala.
- ▶ **Strategic Initiatives:** The Indian government is focusing on boosting domestic production through initiatives like the National Mineral Policy and collaboration with international partners.
- ▶ **Economic Growth:** Development of rare earth metal resources can contribute to economic growth, job creation, and technological advancement in India.

❏ Challenges in the Indian Context

- ▶ **Technological Gaps:** India needs to invest in advanced technologies for efficient extraction and processing of rare earth metals.
- ▶ **Infrastructure Development:** Significant infrastructure improvements are required to support large-scale mining and processing activities.
- ▶ **Regulatory Framework:** Streamlining regulations and ensuring environmental safeguards is crucial for sustainable development.
- ▶ **Market Integration:** Integrating domestic production with global supply chains remains a challenge, requiring strategic partnerships and investment.

Case Study: China's Rare Earth Dominance

China's dominance in the rare earth metals market provides a critical case study. With vast reserves and a well-developed supply chain, China has become the world's largest producer and exporter of rare earth metals. This dominance allows China to influence global prices and supply chains, highlighting the geopolitical significance of these resources. Efforts by other countries to diversify supply chains are a direct response to China's market control.

Lynas Corporation in Australia

Lynas Corporation, an Australian rare earth mining company, represents a successful non-Chinese source of rare earth metals. Lynas operates the Mount Weld mine in Western Australia, one of the richest rare earth deposits globally. The company's processing plant in Malaysia further enhances its capability to supply rare earth metals to global markets, showcasing the potential for countries outside China to contribute significantly to the global supply.

PRACTICE QUESTION

- Q. Analyze the significance of rare earth elements (REEs), their applications, environmental concerns, and geopolitical challenges.

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4

HUMAN GEOGRAPHY

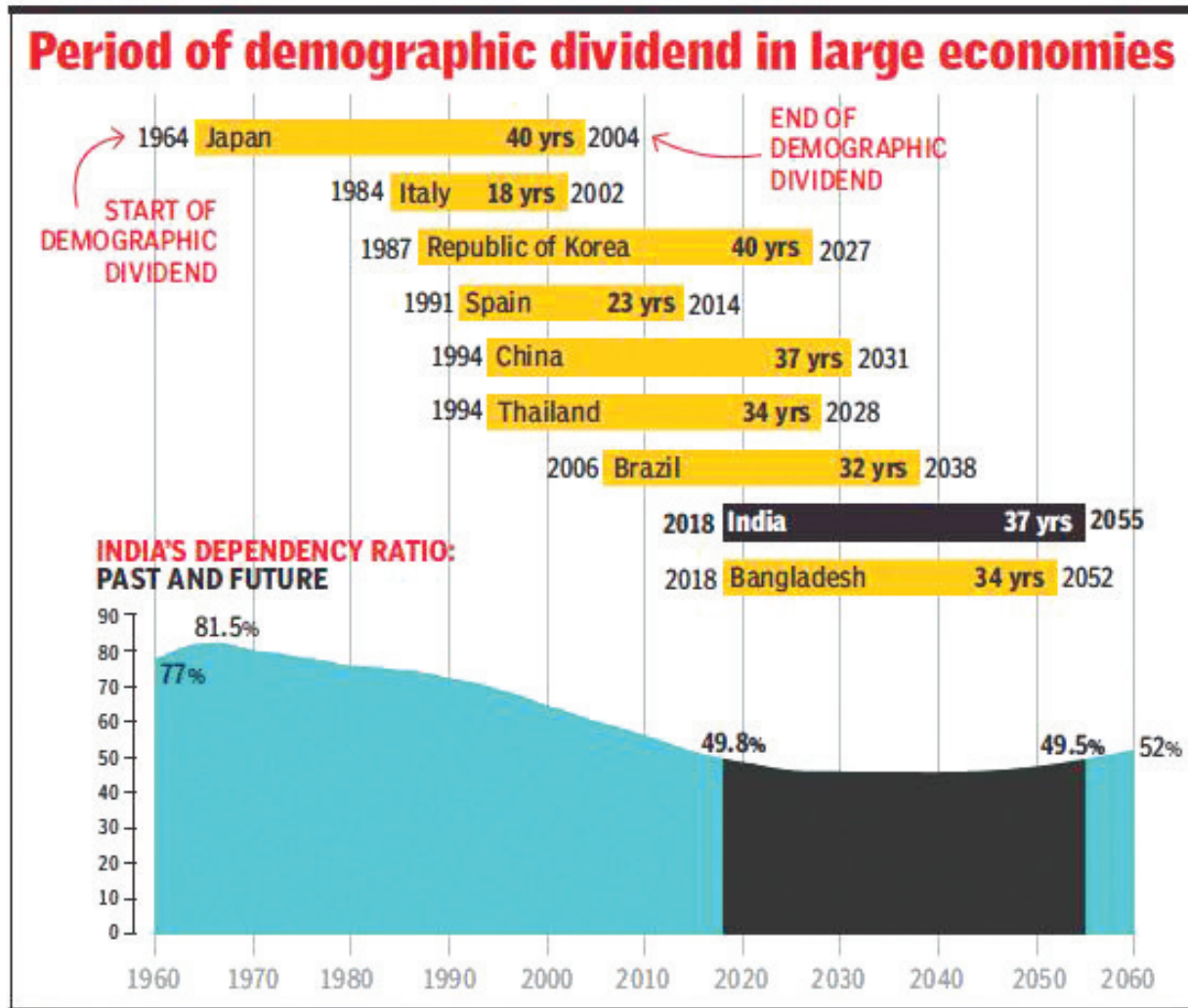
1. INDIAN DEMOGRAPHY: LARGEST, YOUNGEST AND UNDERDEVELOPED

CONTEXT: As of 2024, India has overtaken China as the world's most populous country, with a population exceeding 1.4 billion. This demographic milestone is driven by high birth rates and declining mortality rates.

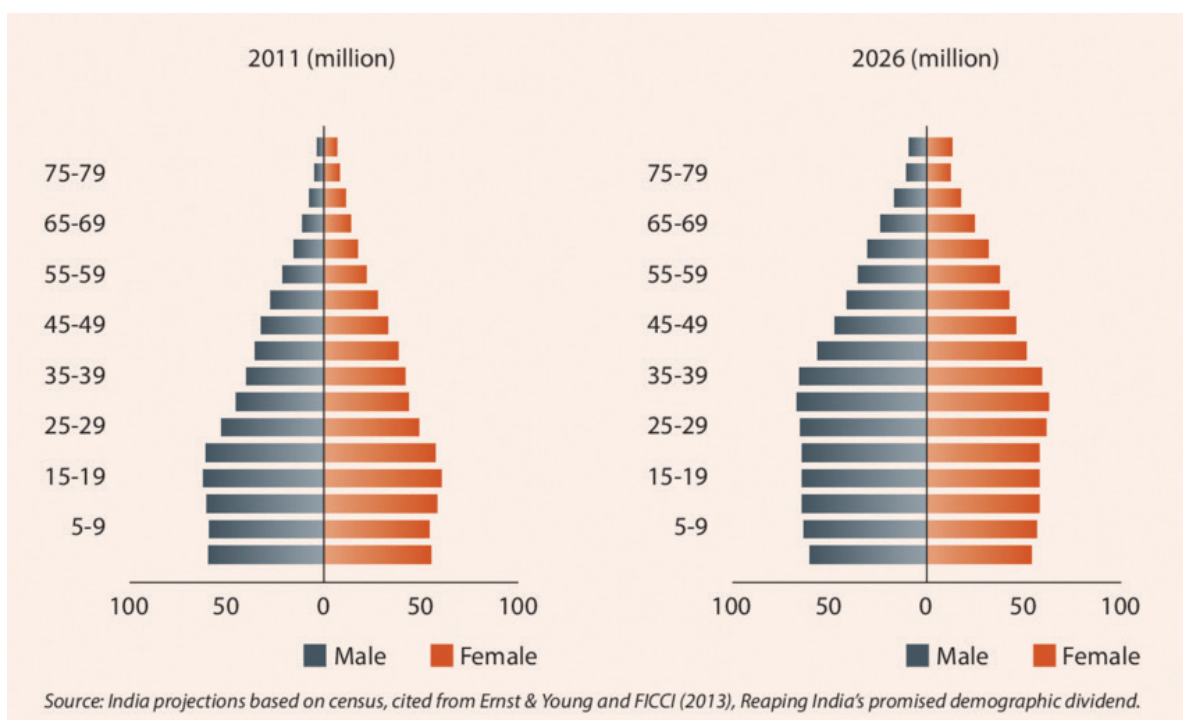
- ▶ **Largest Population:** India's demographic landscape in 2024 presents a unique and complex scenario characterized by three primary features: its massive population, a predominantly youthful demographic, and significant underdevelopment. These aspects create a multifaceted challenge with far-reaching implications for the country's socio-economic fabric.
- ▶ **Issues with India**
 - **Resource Strain:** The sheer size of the population exerts immense pressure on natural resources, public infrastructure, and social services. **Example:** Water scarcity in metropolitan cities like Delhi and Bangalore, where the demand far outstrips the supply.
 - **Unemployment:** With more people entering the job market, the country faces the challenge of providing adequate employment opportunities. **Example:** The unemployment rate among graduates has surged, with many young Indians struggling to find jobs that match their qualifications.

■ Consequences of High Population

- ▶ **Economic Stress:** The increased population demands higher government spending on health, education, and welfare. **Example:** The government's budget allocation for health has increased, but per capita spending remains insufficient.



- **Urban Overcrowding:** Cities are becoming overcrowded, leading to the proliferation of slums and inadequate housing. Example: Mumbai's Dharavi remains one of the largest slums in Asia, highlighting the chronic housing problem.



❑ India: Youngest Demographic Dividend

- India boasts one of the world's youngest populations, with a median age of around 28 years. This demographic dividend has the potential to propel economic growth if harnessed properly.

❑ Issues of Young Population

- **Education Quality:** While access to education has improved, the quality remains inconsistent, with significant disparities between urban and rural areas. **Example:** Rural schools often lack basic infrastructure and qualified teachers, leading to lower educational outcomes compared to urban schools.
- **Skill Mismatch:** There is a growing gap between the skills possessed by the youth and the needs of the job market. **Example:** The IT sector faces a shortage of skilled professionals despite a large number of engineering graduates each year.

❑ Consequences of Underdevelopment of Population

- **Underemployment:** Many young people are employed in jobs that do not utilize their skills or offer adequate wages. A large number of engineering graduates end up working in unrelated fields or in low-paying jobs.
- **Social Unrest:** The frustration stemming from unemployment and underemployment can lead to social instability. Protests and movements by unemployed youth demanding better job opportunities and government intervention.

❑ Under development in India:

- Despite being one of the fastest-growing economies, significant parts of India remain underdeveloped, with stark contrasts between urban and rural areas and among different states.

❑ Issues

- **Poverty:** A significant portion of the population lives below the poverty line, with rural areas being the hardest hit. **Example:** States like Bihar and Uttar Pradesh have high poverty rates, with inadequate access to healthcare, education, and employment.
- **Healthcare:** The healthcare infrastructure is insufficient, particularly in rural areas, leading to poor health outcomes. **Example:** Maternal and child mortality rates remain high in rural regions due to lack of access to quality healthcare services.

❑ Consequences

- **Stunted Development:** The lack of development in key areas hinders overall economic progress and perpetuates the cycle of poverty. **Example:** The persistent rural-urban divide, where rural areas lag significantly behind in terms of infrastructure and economic opportunities.
- **Migration:** High rates of migration from rural to urban areas as people seek better opportunities, often leading to overburdened urban infrastructure. **For e.g.** The influx of migrants to cities like Mumbai and Delhi contributes to the strain on housing, sanitation, and public services.

Case Study 1: Kerala's Human Development Model

Kerala, despite being a smaller state with limited industrial output, has achieved remarkable progress in human development indicators such as literacy, life expectancy, and healthcare. The state's focus on education and healthcare has resulted in a relatively high quality of life and social stability. However, Kerala also faces challenges such as high unemployment rates among its educated youth, highlighting the need for balanced development that includes job creation.

Case Study 2: Bihar's Struggle with Poverty and Development

Bihar remains one of India's most underdeveloped states with high poverty rates, low literacy levels, and inadequate healthcare facilities. Despite recent improvements in infrastructure and governance, the state continues to grapple with systemic issues that hinder its progress. Programs aimed at enhancing education and skill development have shown some promise, but significant challenges remain in lifting the population out of poverty and ensuring sustainable development.

PRACTICE QUESTION

Q. What are the opportunities and challenges posed by India's youthful population, considering India's demography as the youngest in the world.

2. URBAN FLOODING: ISSUES AND CHALLENGES

CONTEXT: In 2024, multiple Indian cities, including Mumbai, Chennai, and Bangalore, experienced severe flooding due to intense monsoon rains. According to the India Meteorological Department (IMD), this year's monsoon season recorded 15% more rainfall than the long-term average. Additionally, a report by the National Disaster Management Authority (NDMA) highlighted that urban flooding affected over 20 million people across various metropolitan areas, causing extensive damage to property, infrastructure, and livelihoods.

▢ Urban Floods:

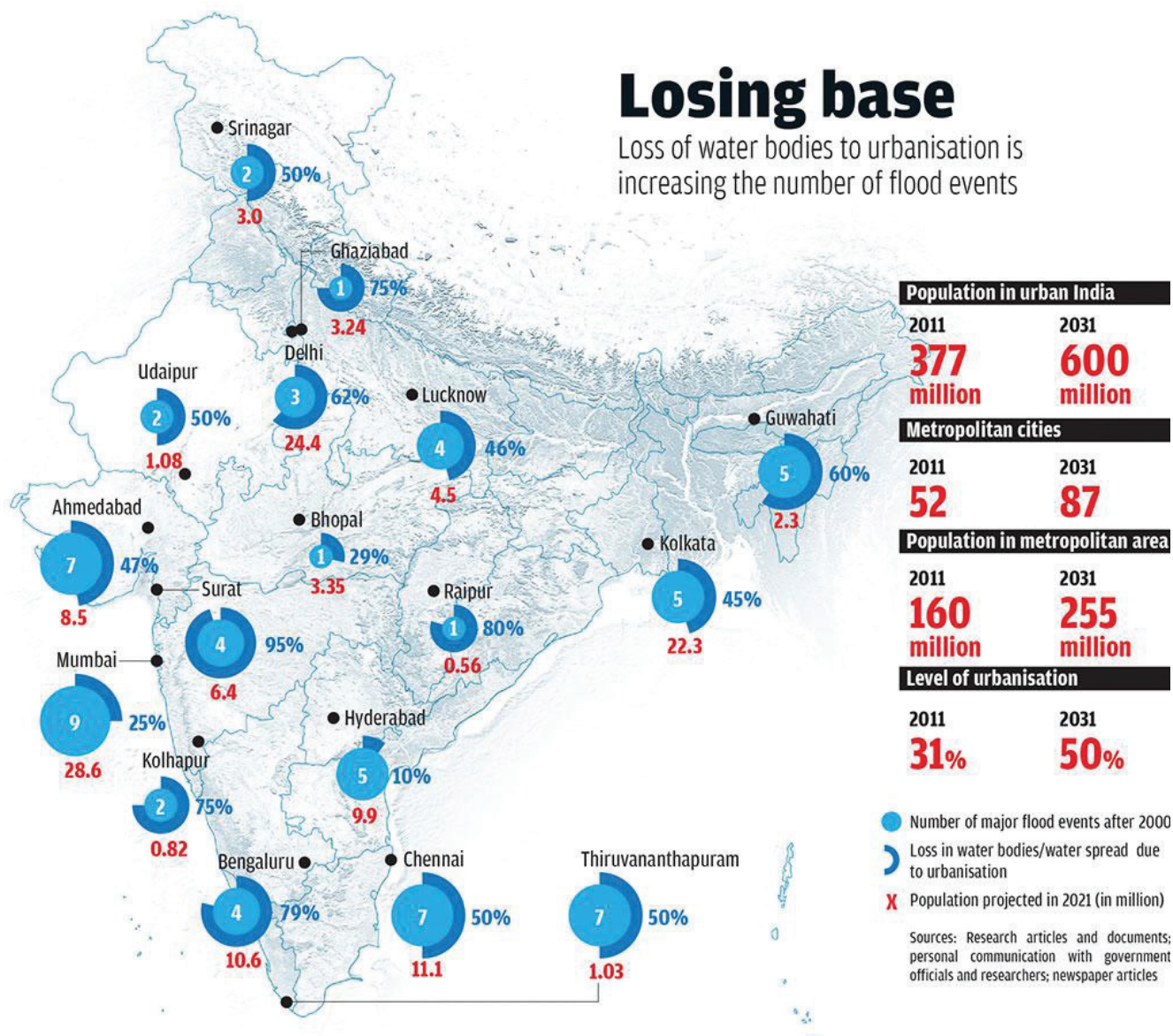
- Urban flooding has emerged as a significant and recurring problem in many of India's cities.
- With climate change intensifying and rapid urbanization outpacing infrastructure development, the frequency and severity of urban floods have increased, leading to widespread disruption and damage.
- The year 2024 has already seen several instances of severe urban flooding, emphasizing the urgent need for effective solutions.

▢ Issues with Urban Floods

- **Inadequate Drainage Systems:** Mumbai's drainage system, designed during the British era, is ill-equipped to handle the modern city's runoff. During heavy rains, waterlogging is common, causing severe disruptions.
- **Unplanned Urbanization:** Bangalore's rapid expansion has led to the encroachment of natural water bodies and wetlands, reducing the city's ability to absorb rainfall and increasing flood risks.
- **Climate Change:** Chennai experienced unprecedented rainfall in November 2024, attributed to changing weather patterns linked to climate change, overwhelming the city's preparedness and response mechanisms.
- **Poor Waste Management:** In Delhi, clogged drains due to plastic and other waste materials exacerbated flooding during the monsoon, highlighting the need for better waste management practices.

▢ Consequences of Urban Floods

- **Economic Losses:** The floods in Mumbai in July 2024 caused an estimated \$1.5 billion in damages, affecting businesses, homes, and public infrastructure.
- **Public Health Crises:** Post-flooding in Kolkata, there was a significant outbreak of waterborne diseases such as cholera and dengue, straining the city's healthcare system.
- **Displacement and Social Disruption:** The flooding in Chennai led to the displacement of over 100,000 residents, many of whom were forced to seek temporary shelter in overcrowded conditions.
- **Environmental Degradation:** The encroachment on Bangalore's wetlands has not only increased flood risk but also led to a loss of biodiversity and natural habitats.



Case Study 1: Mumbai's Monsoon Woes

The city's drainage system, originally designed for much lower population densities and rainfall volumes, is now inadequate. In July 2023, Mumbai experienced one of its worst floods in decades, with 400 mm of rain falling in just 24 hours. The flooding caused extensive damage, shutting down the local train network, which is the city's lifeline, and submerging low-lying areas.

The government has been working on the Brihanmumbai Stormwater Disposal System (BRIMSTOWAD) project to upgrade the drainage system, but progress has been slow due to bureaucratic delays and funding issues. This case underscores the need for modernizing urban infrastructure to cope with extreme weather events.

Case Study 2: Chennai's Flood Management Efforts

Chennai has faced repeated flooding issues, with major floods occurring in 2015, 2021, and now in 2024. The city's geography, combined with rapid urbanization and poor planning, has exacerbated its flood risk. After the devastating floods of 2015, the Tamil Nadu government initiated several flood management projects, including the restoration of waterways and construction of new stormwater drains. However, these measures proved insufficient during the heavy rains in November 2024.

PREVIOUS YEAR QUESTION

Q. Account for the huge flooding of million cities in India including the smart ones like Hyderabad and Pune. Suggest lasting remedial measures. (2020)

PRACTICE QUESTION

Q. What are the reasons for increasing incidences of flooding in million plus cities of India? Substantiate with suitable examples.

3. MENACE OF ILLEGAL MIGRATION IN INDIA AND WORLD

CONTEXT: In 2024, illegal migration remains a contentious issue worldwide, exacerbated by conflicts, economic disparities, and climate change. According to the International Organization for Migration (IOM), an estimated 272 million international migrants existed globally in 2021, with a significant proportion categorized as irregular or illegal migrants. In India, the issue is multifaceted, involving border security, economic opportunities, and geopolitical considerations.

❑ Illegal Migration

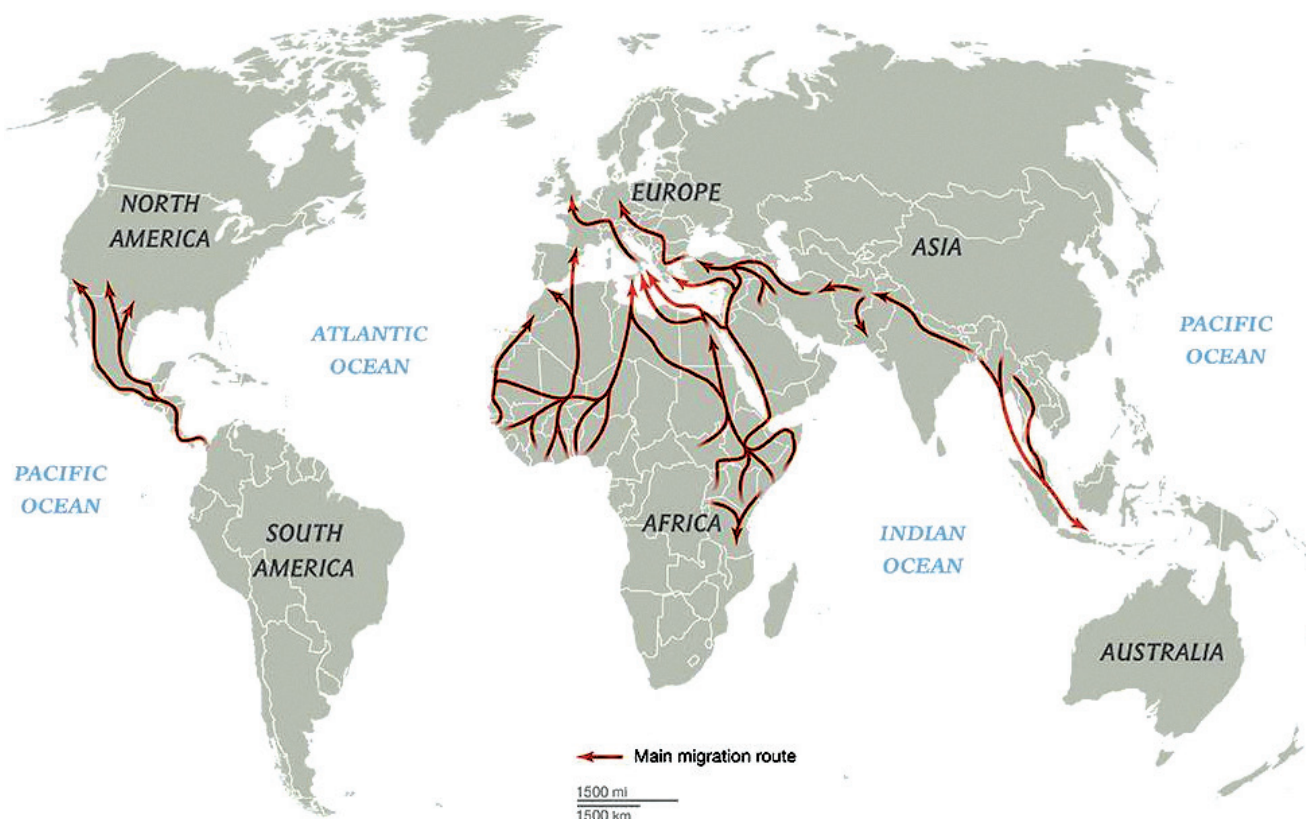
- Illegal migration continues to be a pressing issue globally, including in India, with significant socio-economic and political implications. As of 2024, the challenges posed by illegal migration have intensified due to various factors, prompting governments to adopt stringent measures while grappling with humanitarian concerns.

❑ Issues with Illegal Migration

- **Border Security Challenges:** India faces challenges in securing its borders, particularly in regions prone to illegal crossings such as the Indo-Bangladesh border in West Bengal and Assam.
- **Economic Impact:** Illegal migrants often take up low-wage jobs, leading to competition with local labor and affecting wage levels in sectors such as construction and agriculture.
- **Social Integration:** Integration of illegal migrants into society poses challenges related to access to education, healthcare, and social services.
- **Humanitarian Concerns:** Many illegal migrants face exploitation and abuse, including trafficking and unsafe working conditions.

❑ Consequences of Illegal Migration

- **Strain on Resources:** In states like Assam and Delhi, the influx of illegal migrants has strained resources, leading to overcrowding in urban areas and pressure on public services.
- **Security Risks:** Illegal migration has been linked to security threats, including terrorism and organized crime, necessitating enhanced border surveillance and intelligence operations.
- **Political Tensions:** Issues related to illegal migration often become politicized, leading to tensions between communities and affecting diplomatic relations with neighboring countries.
- **Environmental Impact:** The concentration of illegal migrants in ecologically sensitive areas can lead to environmental degradation and strain on natural resources.



Case Study 1: Rohingya Refugees in India

The Rohingya refugee crisis has led to significant illegal migration into India, particularly in states bordering Myanmar such as Mizoram and Manipur. The Rohingya, fleeing persecution in Myanmar, have sought refuge in India, often crossing the border illegally. This influx has strained local resources and led to tensions with local communities. The Indian government has faced challenges in managing the influx while balancing humanitarian concerns with national security interests.

Case Study 2: Mexico-US Border Crisis

The Mexico-US border remains a focal point of illegal migration, with thousands of Central American migrants attempting to enter the United States illegally each year. Issues of poverty, violence, and lack of economic opportunities in countries like Honduras and Guatemala drive this migration. The US government has implemented various measures, including border walls and stricter immigration policies, to curb illegal crossings.

PRACTICE QUESTION

Q. What are the causes, consequences, and legal framework related to illegal migration in India?

4. SURGE IN HUMAN SETTLEMENTS IN FLOOD-PRONE AREAS

CONTEXT: In 2024, rapid urbanization and population growth have led to an increasing number of people settling in flood-prone areas worldwide.

- According to the United Nations, urban populations are expected to grow significantly in the coming decades, with a substantial portion of this growth occurring in low-lying coastal and riverine areas prone to flooding.



- ▶ In India, cities like Mumbai, Chennai, and Kolkata have witnessed rapid expansion into flood-prone zones due to limited available land and increasing housing demands.

❏ Issues

- ▶ **Risk of Flooding:** Settlements along riverbanks and low-lying coastal areas are particularly vulnerable during monsoon seasons or in regions prone to storm surges.
- ▶ **Infrastructure Vulnerability:** Inadequate infrastructure in flood-prone areas exacerbates the impact of flooding, affecting roads, bridges, and utilities such as water and electricity.
- ▶ **Economic Losses:** Flood events can result in significant economic losses, damaging homes, businesses, and agricultural lands, and disrupting local economies.
- ▶ **Humanitarian Impact:** Floods can lead to displacement, loss of livelihoods, and humanitarian crises, especially in densely populated urban areas with poor housing conditions.

❏ Consequences

- ▶ **Loss of Lives and Property:** In 2024, floods in Mumbai led to several fatalities and displaced thousands of residents, highlighting the human toll of settling in flood-prone areas.
- ▶ **Environmental Degradation:** Rapid urbanization in flood-prone zones often results in habitat destruction, loss of biodiversity, and increased pollution levels.
- ▶ **Insurance and Financial Burden:** Insuring properties in flood-prone areas becomes costly and challenging, affecting both homeowners and insurers.
- ▶ **Long-term Resilience:** Building resilience in flood-prone areas requires investments in flood management infrastructure, urban planning reforms, and community awareness.

Case Studies

Case Study 1: Houston, Texas, USA

Houston has experienced significant urban sprawl into flood-prone areas, exacerbated by its flat terrain and susceptibility to hurricanes and heavy rainfall. In 2017, Hurricane Harvey caused catastrophic flooding, inundating neighborhoods built in floodplains and highlighting vulnerabilities in the city's development practices. The disaster prompted reevaluations of zoning laws, floodplain management, and infrastructure investments to enhance resilience against future flood events.

Case Study 2: Uttarakhand, India

Uttarakhand, a state in northern India known for its Himalayan foothills and river valleys, has witnessed rapid growth in human settlements in flood-prone areas. In 2013, devastating floods and landslides caused extensive damage and loss of life in the region, exacerbated by unchecked development along riverbanks and steep slopes. The disaster underscored the consequences of unregulated urbanization in environmentally sensitive zones and prompted calls for sustainable development practices and disaster risk reduction strategies.

The surge in human settlements in flood-prone areas poses significant risks and challenges globally and in countries like India. Addressing this issue requires a coordinated approach involving urban planning reforms, improved infrastructure, community resilience-building efforts, and enhanced environmental protection measures.

PRACTICE QUESTION

- Q. Analyze the reasons behind the increase in human settlements in flood-prone regions and propose strategies to mitigate the associated risks.

5. ISSUES WITH TRIBAL HABITAT IN INDIA

CONTEXT: As of 2023-24, India is home to over 700 tribal groups, representing diverse cultures, languages, and traditions. Many of these communities reside in forested and remote areas, facing increasing pressures from infrastructure projects, mining activities, urbanization, and conservation policies. According to the Ministry of Tribal Affairs, these communities constitute approximately 8.6% of India's population, with varying degrees of access to basic amenities and government services.

▢ Issues of Tribal Habitat loss and Displacement in India

- ▶ **Displacement and Land Acquisition:** Tribal communities often face displacement due to large-scale infrastructure projects such as dams, mining operations, and highways.
- ▶ **Loss of Traditional Livelihoods:** Economic development projects can disrupt traditional livelihoods based on agriculture, hunting, gathering, and forestry.
- ▶ **Marginalization and Socio-economic Inequality:** Tribal communities often experience socio-economic marginalization, lack of access to education, healthcare, and employment opportunities.
- ▶ **Environmental Impact:** Deforestation, mining, and industrial activities in tribal areas can lead to environmental degradation, affecting biodiversity and ecosystem services.

▢ Consequences of Tribal Displacement

- ▶ **Cultural Erosion:** Displacement and modernization often lead to the erosion of traditional knowledge, languages, customs, and cultural practices.
- ▶ **Health and Well-being:** Limited access to healthcare facilities and clean water sources contributes to poor health outcomes among tribal populations.
- ▶ **Social Unrest and Conflict:** Disputes over land rights and natural resources can lead to social unrest and conflicts between tribal communities, governments, and private entities.
- ▶ **Legal and Human Rights Concerns:** Violations of indigenous land rights and inadequate implementation of protective laws undermine the human rights of tribal communities.

Case Study 1: Dongria Kondh Tribe, Odisha

The Dongria Kondh tribe in Odisha's Niyamgiri hills faced significant threats to their habitat due to proposed bauxite mining by a multinational corporation. The project would have displaced the tribe and disrupted their sacred lands and traditional way of life. The Dongria Kondh resisted the mining project through sustained protests, legal challenges, and international advocacy. Ultimately, in 2013, the Supreme Court of India ruled in favor of the tribe's rights and rejected the mining proposal, highlighting the importance of indigenous land rights and environmental conservation.

Case Study 2: Adivasis in Central India

Adivasi communities in central India, including states like Chhattisgarh, Jharkhand, and Madhya Pradesh, have faced displacement and marginalization due to industrial development, particularly mining and infrastructure projects. The rapid expansion of coal mining and steel industries has encroached upon tribal lands, leading to conflicts over land rights and environmental degradation.

Efforts to implement the Forest Rights Act (2006) and empower tribal communities with greater control over their lands have been crucial in addressing these challenges.

The preservation of tribal habitats in India is essential for safeguarding indigenous cultures, promoting environmental sustainability, and upholding human rights. Addressing the issues faced by tribal communities requires a holistic approach that includes respecting land rights, promoting sustainable development practices, enhancing access to education and healthcare, and fostering inclusive governance.

% Scheduled Tribe, District wise,
Census 2011

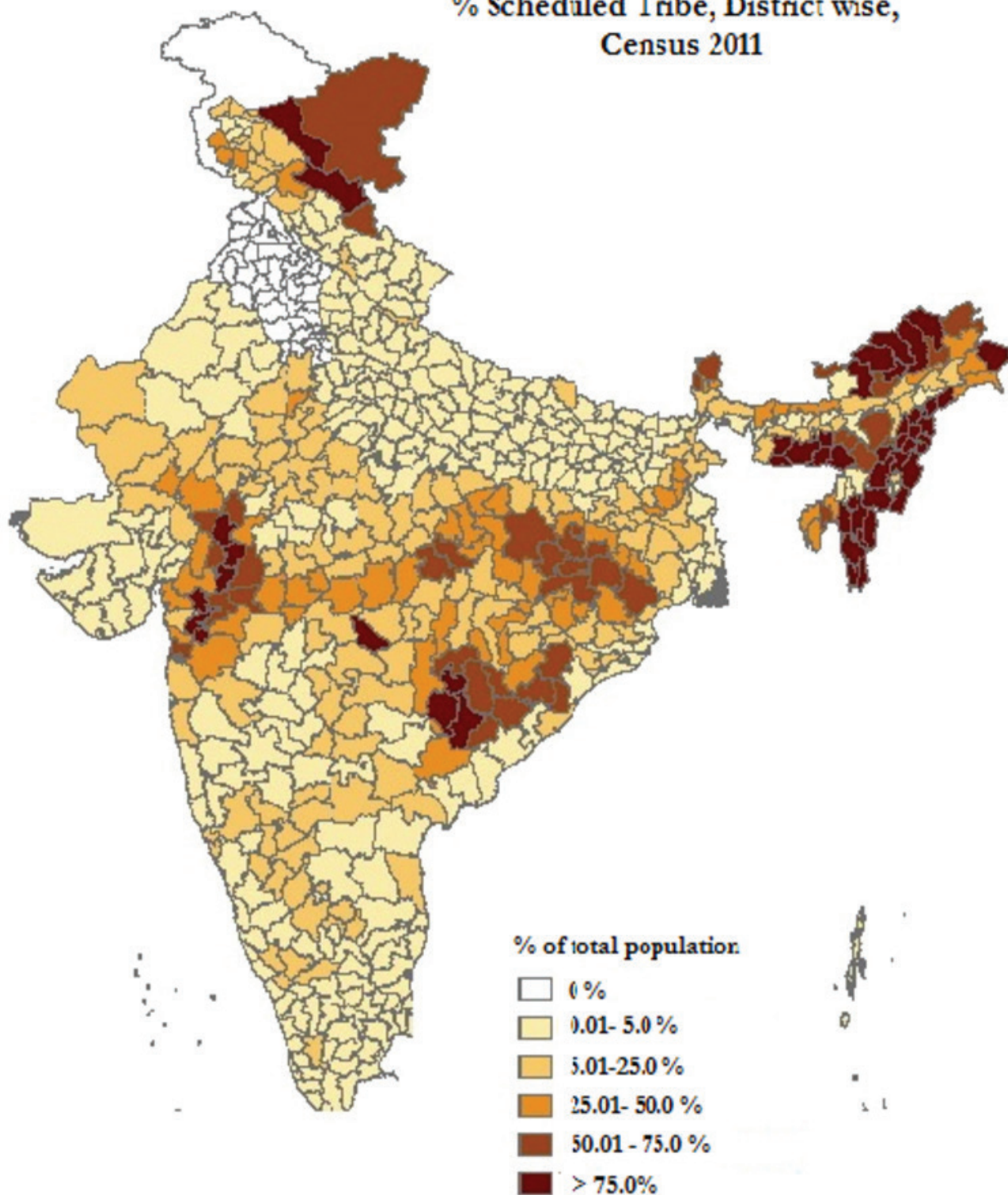




Figure: Tribe and Forest distribution in India.

PRACTICE QUESTION

Q. Analyze the challenges faced by tribal communities in preserving their habitats, cultural heritage, and livelihoods. Suggest inclusive policies for their well-being.

6. MIGRATION IN INDIA: CHANGING PATTERN AND DYNAMICS

CONTEXT: India has a long history of internal migration, driven by factors such as economic opportunities, education, marriage, and displacement due to natural disasters or conflicts. According to the Census of India 2011, there were over 450 million internal migrants in the country, indicating the scale and diversity of migration patterns. In recent years, several trends have emerged that highlight the evolving dynamics of migration within India.

▢ Migration in India

- Migration in India has undergone significant changes in patterns and dynamics over the years, influenced by socio-economic factors, demographic shifts, and policy interventions. As of 2024, these changes reflect a complex interplay of urbanization, employment opportunities, and regional disparities, shaping the movement of people across the country.

▢ Changing Patterns

- **Rural to Urban Migration:** There continues to be a significant flow of people from rural areas to urban centers in search of better job opportunities, education, and improved living standards. Cities like Delhi, Mumbai, Bangalore, and Hyderabad have witnessed substantial migration from rural hinterlands, leading to rapid urbanization.
- **Urban to Urban Migration:** Migration between urban areas, often termed as intra-urban migration, is increasing due to job changes, educational pursuits, lifestyle preferences, and family considerations. Professionals moving from smaller cities to metropolitan areas like Mumbai or Delhi for career advancement and better amenities.
- **Seasonal and Circular Migration:** Seasonal migration for agricultural work, construction projects, and other temporary employment remains prevalent, particularly in rural areas. Farmers and laborers from states like Uttar Pradesh and Bihar migrate seasonally to Punjab and Haryana for harvesting crops.
- **Reverse Migration:** The COVID-19 pandemic highlighted the phenomenon of reverse migration, where urban migrants returned to their rural hometowns due to job losses, health concerns, and lockdown-induced hardships. Thousands of migrant workers left cities like Mumbai and Delhi to return to their villages during the nationwide lockdown in 2020.

▢ Dynamics and Drivers

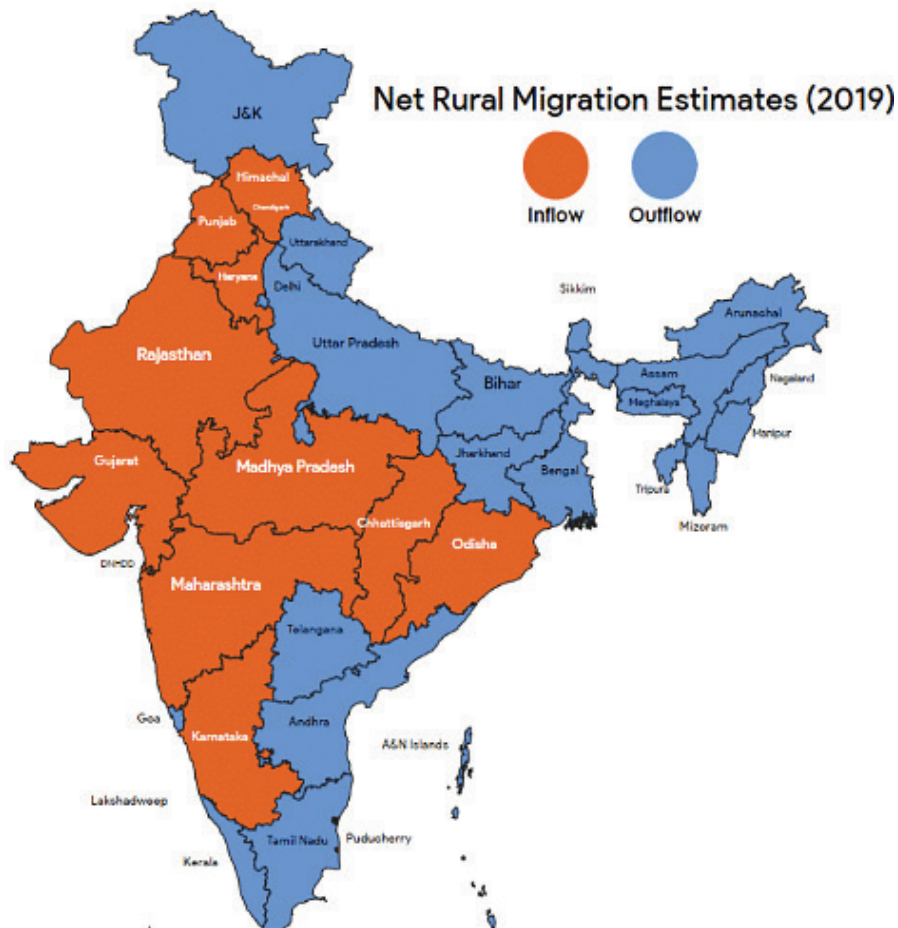
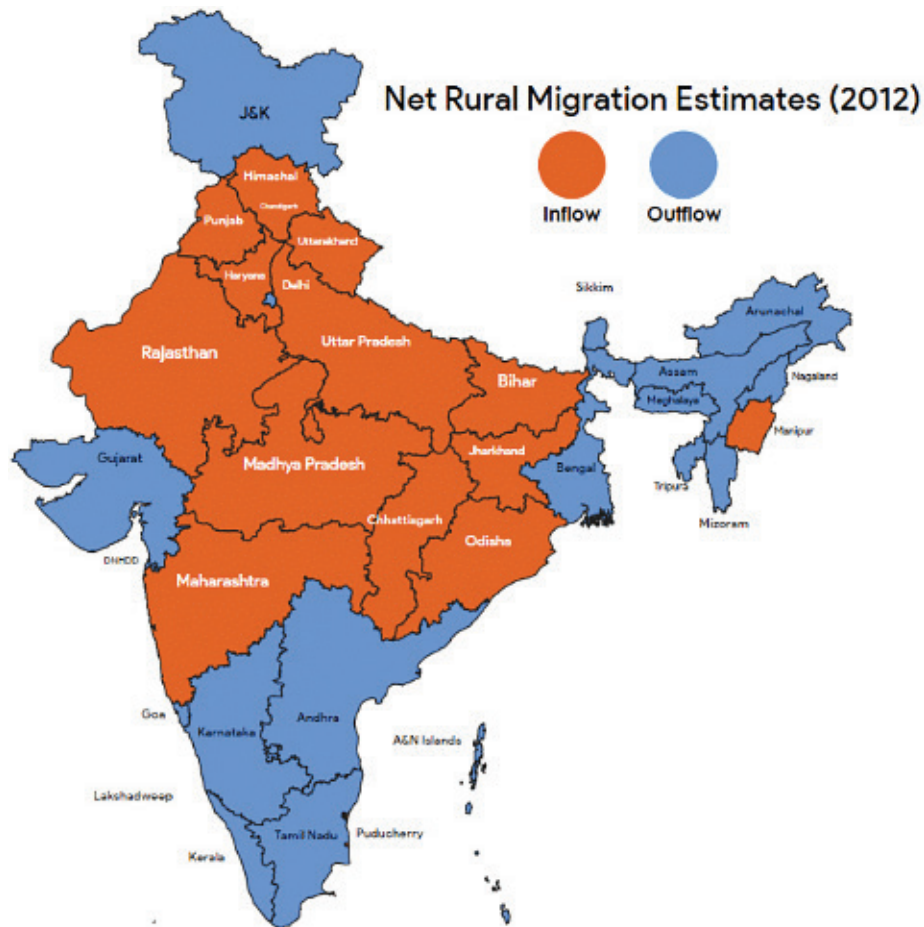
- **Economic Factors:** Employment opportunities and wage differentials between rural and urban areas continue to be primary factors driving migration. Skilled workers migrating to urban tech hubs like Bangalore and Hyderabad for jobs in the IT sector.
- **Social and Cultural Factors:** Marriage, family reunification, education, and access to healthcare are significant social drivers influencing migration patterns. Young adults moving to urban centers for higher education or marriage prospects.
- **Policy Interventions:** Government policies and initiatives aimed at rural development, employment generation, and infrastructure improvements impact migration trends. Programs like MGNREGA (Mahatma Gandhi National Rural Employment Guarantee Act) aim to create jobs in rural areas to reduce migration to cities.

▢ Implications and Future Directions

- **Urbanization and Infrastructure Challenges:** Rapid urbanization strains infrastructure in cities, leading to issues such as housing shortages, traffic congestion, and environmental degradation. Cities like Bangalore and Chennai face infrastructure challenges due to the influx of migrants.
- **Social Integration and Inclusivity:** Ensuring social integration and inclusivity for migrants in urban areas remains crucial for their well-being and productivity. Initiatives promoting inclusive growth and community engagement in urban planning.

PRACTICE QUESTION

- Q. Discuss the changing patterns of internal migration in India, including the factors driving it and its impact on urbanization.



7. LOW HUMAN DEVELOPMENT IN INDIA: REASONS AND CONSEQUENCES

CONTEXT: India's human development is assessed annually by the United Nations Development Programme (UNDP) through its Human Development Index (HDI), which considers factors such as life expectancy, education (literacy and school enrollment rates), and per capita income.

As of the latest data, India ranks 131st out of 189 countries in the HDI rankings, reflecting significant room for improvement in key areas of human development.

Reasons for Low Human Development

- ▶ **Education:** Unequal access to quality education, particularly in rural and marginalized communities, contributes to low literacy rates and educational attainment levels. Government schools in remote villages lacking basic infrastructure and trained teachers, leading to poor learning outcomes.
- ▶ **Healthcare:** Inadequate healthcare infrastructure and services, especially in rural areas, result in high maternal and child mortality rates and limited access to essential health services. Limited availability of hospitals, clinics, and medical professionals in remote regions like tribal areas.
- ▶ **Income Inequality:** Persistent income disparities exacerbate socio-economic inequalities, limiting opportunities for social mobility and overall human development. Disparities between urban and rural incomes and within urban areas based on socio-economic status.
- ▶ **Gender Disparities:** Gender inequality in access to education, healthcare, and employment opportunities hinders women's empowerment and overall human development. Lower female literacy rates and higher maternal mortality rates in comparison to men.

Consequences of Low Human Development

- ▶ **Economic Impact:** Low human development limits productivity and economic growth potential, impacting overall national development. Inefficient workforce due to lack of education and health outcomes affecting labor productivity.
- ▶ **Social Challenges:** Social unrest and inequalities perpetuate as a result of inadequate access to education, healthcare, and basic amenities. Protests and movements demanding better infrastructure and services in underserved communities.
- ▶ **Healthcare Burden:** High burden of preventable diseases and healthcare costs due to poor health outcomes and inadequate healthcare infrastructure. Outbreaks of diseases like tuberculosis and malaria affecting vulnerable populations disproportionately.
- ▶ **Global Competitiveness:** Low human development impacts India's global competitiveness and standing in international indices related to quality of life and sustainable development. India's ranking in global health and education indices reflecting its human development challenges.

Case Study 1: Bihar's Educational Challenges

Bihar, one of India's most populous states, faces significant educational challenges with low literacy rates and poor educational outcomes. Factors such as inadequate school infrastructure, teacher shortages, and socio-economic disparities contribute to the state's low human development index. Efforts to improve educational quality and access through government initiatives like the "Bihar Education Project" have shown some progress but highlight the ongoing struggle to bridge educational gaps.

Case Study 2: Healthcare in Uttar Pradesh

Uttar Pradesh, India's most populous state, grapples with healthcare deficiencies characterized by a shortage of medical facilities, healthcare professionals, and essential medicines. Maternal and child mortality rates are among the highest in the country, reflecting inadequate access to maternal and child healthcare services. Government initiatives such as the National Health Mission aim to address these challenges through the provision of healthcare infrastructure and services. However, the state continues to face challenges in improving health outcomes and overall human development indicators.

PREVIOUS YEAR QUESTION

Q. Why did human development fail to keep pace with economic development in India? (2023)

PRACTICE QUESTION

Q. Comment on the reasons behind India's low human development and propose strategies for its improvement.

8. CLIMATE CHANGE AND NORTH-SOUTH DIVIDE IN INDIA

CONTEXT: India is experiencing the effects of climate change differently across its northern and southern regions, influenced by geographical factors, socio-economic conditions, and adaptive capacities.

The Intergovernmental Panel on Climate Change (IPCC) reports that India's average temperature has risen by 0.7°C over the past century, leading to altered precipitation patterns, extreme weather events, and environmental degradation.

Issues

- ▶ **Vulnerability to Extreme Weather Events:** Northern India, including states like Uttarakhand and Himachal Pradesh, faces increased vulnerability to extreme weather events such as floods, landslides, and glacial lake outburst floods (GLOFs) due to melting glaciers and erratic rainfall patterns. The devastating floods in Uttarakhand in 2013 resulted in significant loss of life and infrastructure damage, highlighting the region's susceptibility to climate impacts.
- ▶ **Agricultural Impacts:** Southern India, characterized by states like Tamil Nadu and Andhra Pradesh, experiences challenges related to droughts, water scarcity, and heatwaves, impacting agricultural productivity and livelihoods. Severe droughts in Tamil Nadu have led to crop failures, farmer distress, and migration from rural areas in search of alternative livelihoods.
- ▶ **Health Risks:** Both regions face health risks exacerbated by climate change, including vector-borne diseases like malaria and dengue fever, as well as heat-related illnesses. Outbreaks of dengue fever in northern states during the monsoon season have been linked to increased rainfall and stagnant water.
- ▶ **Economic Disparities:** The North-South divide in economic development amplifies the impacts of climate change, with northern states often having lower adaptive capacities and fewer resources for resilience-building measures. Limited access to technology and financial resources for climate adaptation in rural communities of northern states compared to more developed southern regions.

Consequences

- ▶ **Environmental Degradation:** Climate change exacerbates environmental degradation, including deforestation, soil erosion, and loss of biodiversity, impacting ecosystems differently across northern and southern India. Deforestation in the Himalayan region accelerates soil erosion and reduces the region's resilience to floods and landslides.

- ▶ **Water Stress:** Water stress intensifies in both regions, with northern states facing challenges related to glacial melt and southern states experiencing groundwater depletion and salinization. Groundwater depletion in states like Rajasthan and Gujarat leads to conflicts over water resources and affects agricultural sustainability.
- ▶ **Migration and Displacement:** Climate-induced migration increases in both regions, with communities from environmentally vulnerable areas seeking relocation to more resilient regions, exacerbating urbanization pressures. Climate refugees from coastal areas of Kerala migrating to urban centers in Karnataka due to sea-level rise and coastal erosion.
- ▶ **Policy and Governance Challenges:** Addressing the North-South climate divide requires coordinated policy frameworks, adaptive strategies, and governance mechanisms tailored to regional contexts. Varied state-level responses to climate change adaptation and mitigation efforts reflect the need for cohesive national policies that consider regional disparities.

Case Study 1: Floods in Uttarakhand

Uttarakhand, located in the northern Himalayan region, is prone to flash floods and landslides exacerbated by climate change. The devastating floods in June 2013, triggered by heavy rainfall and glacial melt, resulted in thousands of deaths and extensive damage to infrastructure. The event underscored the region's vulnerability to climate impacts and the need for improved early warning systems, disaster preparedness, and sustainable development practices.

Case Study 2: Drought in Tamil Nadu

Tamil Nadu, situated in southern India, faces recurring droughts and water scarcity exacerbated by climate variability. Severe drought conditions in recent years have severely affected agriculture, particularly in regions dependent on monsoon rains and groundwater. The state government has implemented drought relief measures and water management strategies to mitigate the impacts on farmers and rural communities, emphasizing the importance of climate-resilient agricultural practices and sustainable water management.

PREVIOUS YEAR QUESTION

- Q. Identify and discuss the factors responsible for diversity of natural vegetation in India. Assess the significance of wildlife sanctuaries in rain forest regions of India. (2023)

PRACTICE QUESTION

- Q. Critically analyze the impact of climate change on India's regional disparities, focusing on the North-South divide. Suggest measures for equitable adaptation.

9. SOCIAL CAPITAL IN INDIA: ISSUES AND CHALLENGES

CONTEXT: In India, social capital encompasses trust, reciprocity, and cooperation among individuals and groups within communities. It is instrumental in enhancing governance effectiveness, improving public service delivery, and facilitating collective action for socio-economic development. However, the dynamics of social capital vary significantly across regions and demographic groups, influenced by cultural diversity, historical legacies, and socio-political factors.

■ Issues

- ▶ **Trust and Civic Engagement:** Declining levels of trust and civic engagement in society impact the formation of social capital, hindering collective efforts for community development and public welfare. Decreased participation in local governance activities such as community meetings or volunteering for social causes.

- ▶ **Inequality and Exclusion:** Social capital tends to be unevenly distributed, with marginalized groups, including lower castes, religious minorities, and women, facing barriers to accessing networks and resources. Limited social capital among Dalit communities affecting their ability to access economic opportunities and political representation.
- ▶ **Urban-Rural Divide:** Urban areas often exhibit different patterns of social capital compared to rural regions, characterized by higher mobility, diversity of networks, and access to formal institutions. Strong social capital networks among urban professionals influencing career advancement and business opportunities.
- ▶ **Technological Disruption:** The advent of digital platforms and social media can both enhance and diminish social capital, depending on how they are utilized to foster community engagement and social interactions. Online communities supporting social causes vs. spreading misinformation and polarization.

▣ Consequences of the Topic

- ▶ **Community Resilience:** Strong social capital enhances community resilience during crises such as natural disasters, economic downturns, or health emergencies. Communities in Kerala demonstrating resilience and effective disaster response during the floods in 2018 through local networks and volunteer efforts.
- ▶ **Economic Development:** Social capital facilitates entrepreneurship, innovation, and economic cooperation, contributing to local economic development and poverty reduction. Self-help groups in rural India promoting micro-enterprises and collective savings to empower women and improve livelihoods.
- ▶ **Political Participation:** High levels of social capital can lead to increased political engagement, transparency, and accountability in governance processes. Voter turnout and active participation in grassroots movements like the **Chipko Movement in Uttarakhand** for environmental conservation.
- ▶ **Social Cohesion:** Strengthened social capital fosters social cohesion, tolerance, and inclusivity, reducing social divisions and promoting a sense of belonging. Interfaith harmony initiatives in diverse communities promoting peace and understanding.

Case Study 1: Self-Help Groups in Tamil Nadu

Self-help groups (SHGs) in Tamil Nadu have leveraged social capital to empower women from marginalized communities, providing them with access to financial resources, skill development training, and social support networks. These groups have promoted economic independence, improved healthcare access, and enhanced community solidarity, demonstrating the transformative impact of social capital on women's empowerment and socio-economic development.

Case Study 2: Panchayati Raj Institutions in Kerala

Kerala's decentralized governance system, anchored by vibrant Panchayati Raj Institutions (PRIs), exemplifies strong social capital at the grassroots level. PRIs have facilitated community participation in decision-making, equitable resource allocation, and effective implementation of local development projects. This bottom-up approach has enhanced social inclusion, public service delivery, and sustainable development outcomes, showcasing the role of social capital in fostering participatory democracy and inclusive governance.

PRACTICE QUESTION

- Q. Discuss the significance of social capital, its types, and its role in governance. Highlight the need for inclusion of vulnerable sections.

10. QUALITY OF LIFE AND STANDARD OF LIVING IN INDIA: A PARADOXICAL CASE

CONTEXT: India's economic growth over recent decades has positioned it as one of the fastest-growing major economies globally. However, this growth has not uniformly translated into improved quality of life indicators such as health outcomes, education, environmental sustainability, and social well-being. Understanding this paradox requires examining the nuanced factors influencing people's everyday experiences and overall life satisfaction.

- ▶ In 2024, India presents a paradoxical scenario where the standard of living, often measured by economic indicators, contrasts sharply with the quality of life experienced by its diverse population. This disparity underscores the multifaceted challenges and complexities in achieving holistic well-being and sustainable development across the country.

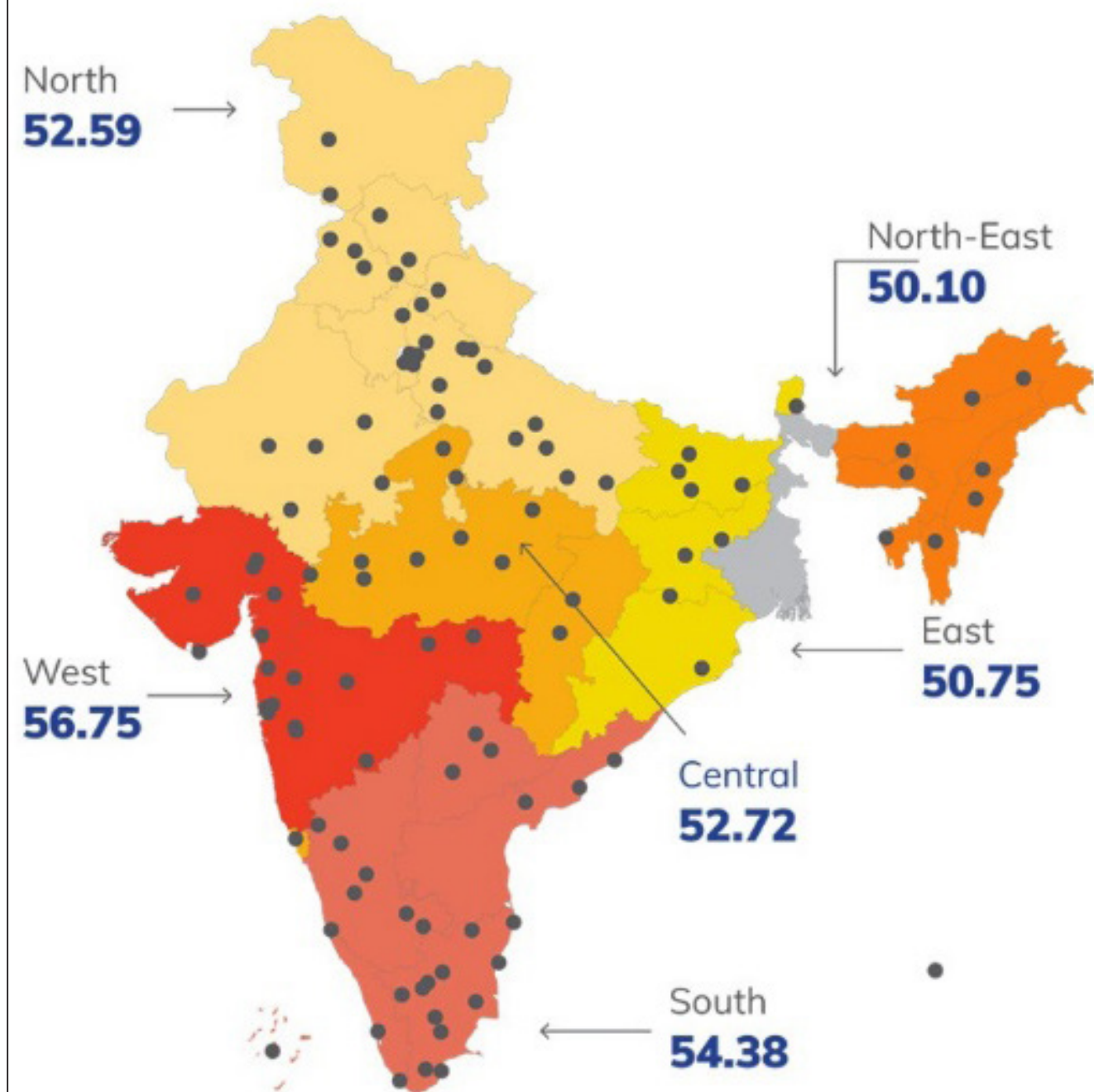
▢ Issues of the Topic

- ▶ **Economic Growth vs. Inequality:** Despite economic progress, income and wealth disparities persist, exacerbating socio-economic inequalities and limiting access to essential services and opportunities. **For example:** High-income inequality between urban and rural areas, as well as within urban centers, affecting access to education, healthcare, and infrastructure.
- ▶ **Health and Well-being:** Challenges in healthcare infrastructure, sanitation, and public health contribute to poor health outcomes and lower life expectancy rates in certain regions and demographic groups. **For example:** Disparities in maternal and child mortality rates between states like Kerala and Bihar highlight gaps in healthcare access and quality.
- ▶ **Environmental Sustainability:** Rapid urbanization, industrialization, and agricultural practices contribute to environmental degradation, affecting air and water quality, as well as ecosystem health. **For example:** Pollution levels in cities like Delhi impacting respiratory health and overall quality of life for residents.
- ▶ **Social Indicators:** Social indicators such as education attainment, gender equality, and social cohesion vary significantly across states and communities, influencing overall well-being. **For example:** Variations in literacy rates and access to sanitation facilities between states like Goa and Uttar Pradesh.

▢ Consequences

- ▶ **Human Development:** Disparities in quality of life indicators hinder overall human development potential, impacting productivity, social mobility, and inclusive growth. **For example:** Lower Human Development Index (HDI) rankings in states with poorer health and education outcomes compared to more developed regions.
- ▶ **Social Cohesion and Inclusion:** Widening gaps in quality of life indicators contribute to social tensions, exclusion, and disparities in opportunities, undermining social cohesion. **For example:** Communal tensions and conflicts over resources exacerbated by socio-economic inequalities and perceptions of injustice.
- ▶ **Sustainable Development:** Unsustainable development practices driven by economic priorities threaten environmental sustainability and long-term well-being for future generations. **For example:** Deforestation and water scarcity issues impacting rural communities dependent on agriculture for livelihoods.
- ▶ **Global Perception and Competitiveness:** Disparities in quality of life indicators affect India's global reputation and competitiveness in indices measuring livability, sustainability, and social progress. **For example:** Varied perceptions of India's development achievements based on regional disparities in quality of life.

Regional Distribution of Ease of Living scores



Case Study 1: Mumbai's Slums vs. Affluent Neighborhoods

Mumbai, India's financial capital, exemplifies stark contrasts in quality of life. Affluent neighborhoods like South Mumbai boast modern infrastructure, high-quality healthcare facilities, and educational institutions, offering residents a high standard of living. In contrast, slum areas such as Dharavi face overcrowding, inadequate sanitation, limited access to clean water, and healthcare challenges. Efforts to improve living conditions in slums through community development programs and infrastructure upgrades highlight ongoing efforts to address these disparities.

Case Study 2: Kerala's Human Development Achievements

Kerala stands out for its exemplary achievements in human development despite lower economic indicators compared to other states. The state prioritizes investments in education, healthcare, and social welfare programs, resulting in high literacy rates, low maternal and child mortality rates, and longer life expectancy. Kerala's focus on equitable development and social inclusion underscores the importance of holistic approaches to improving quality of life and well-being, serving as a model for other regions in India.

PREVIOUS YEAR QUESTION

- Q. What are the main socio-economic implications arising out of the development of IT industries in major cities of India? (2021)
- Q. Mention core strategies for the transformation of aspirational districts in India & explain the nature of convergence, collaboration & Competition for its success. (2018)

PRACTICE QUESTION

- Q. Discuss the paradoxical relationship between quality of life and standard of living in India, considering socio-economic disparities and well-being indicators.

11. POPULATION COMPOSITING OF INDIA: CHANGING DYNAMICS

CONTEXT: India, the second most populous country globally, faces complex demographic shifts. By 2030, it is projected to surpass China in population size, becoming the most populous nation. Here are key insights:

Reasons for Change in Population Composition:

- **Demographic Transition:** India has transitioned from high fertility and mortality rates to lower levels. Improved healthcare, family planning, and socioeconomic changes have influenced this shift.
- **Urbanization:** Rapid urban growth has altered population distribution. Urban areas now house over 30% of India's population, impacting age structure and lifestyle.
- **Government Policies:** Initiatives like the National Health Mission and family planning programs have contributed to declining birth rates.

Consequences and Impact:

- **Youth Bulge:** India's median age is around 28 years, creating a "youth bulge." While this can drive economic growth, it also poses challenges in education, employment, and social stability.
- **Aging Population:** As life expectancy increases, India faces an aging population. Healthcare, pensions, and elder care become critical.

Case Studies:

- **Kerala:** With a low fertility rate, Kerala's population growth is slowing. It serves as a model for effective family planning and healthcare.
- **Uttar Pradesh:** High fertility rates persist in Uttar Pradesh, impacting resources and development.

Way Forward:

- **Education and Awareness:** Promote family planning, reproductive health, and gender equality.
- **Invest in Youth:** Skill development, job creation, and education for the youth are essential.
- **Elderly Care:** Develop policies for senior citizens' well-being.
- **Sustainable Urbanization:** Plan cities for efficient resource use.

PRACTICE QUESTION

Q. Analyze the population composition of India with its impact of the Economic development of the country?



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