IYACHAMY ACADEMY

UPSC PRELIMS

CURRENT AFFAIRS

GEOGRAPHY

Strategic Current Affairs for UPSC Prelims

What's Inside

- Map Based Questions
- Places in News
- Physical Geography
- Environment Linkages
- India & World Geography
- Concept + Current Affairs Integration

Prepared by

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JANUARY 2025 – FEBRUARY 2026 | INDEX OF TOPICS

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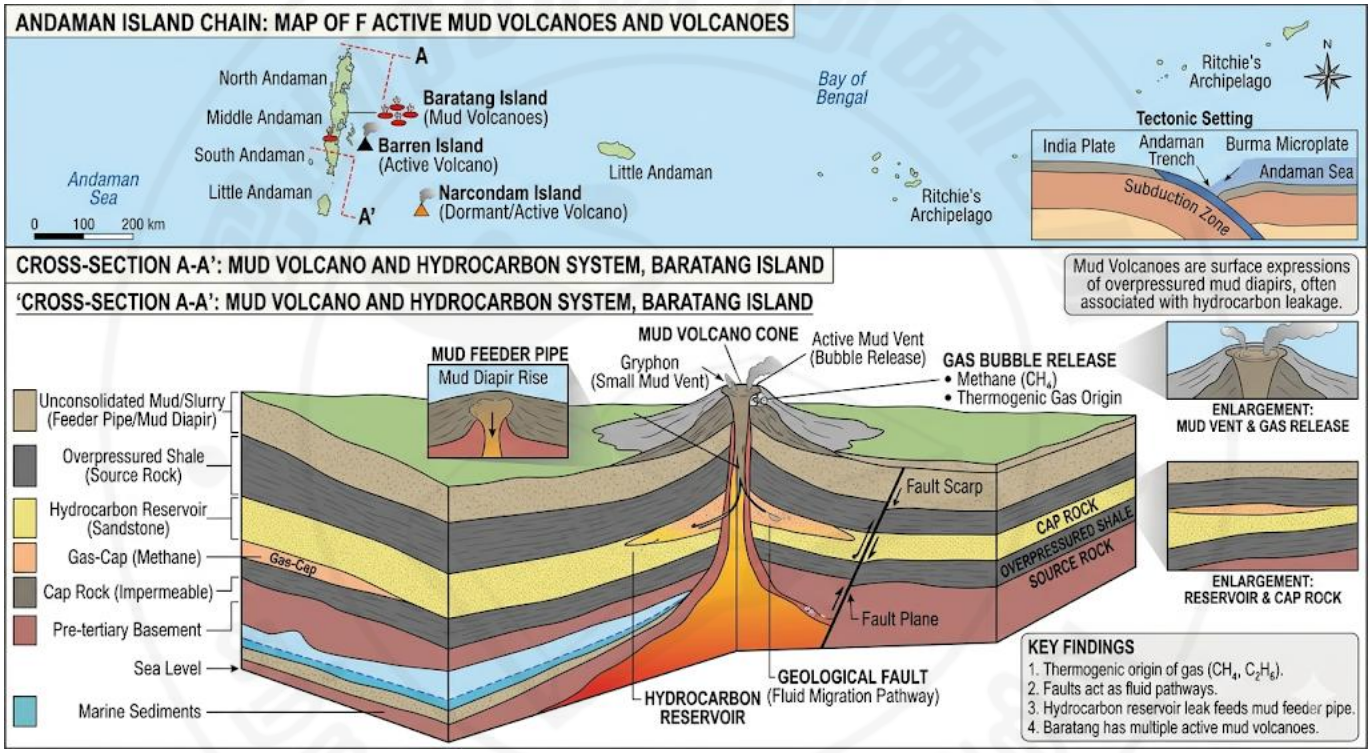
PHYSICAL GEOGRAPHY

BARATANG MUD VOLCANO ERUPTS — INDIA'S ONLY MUD VOLCANO (ANDAMAN)

The Baratang mud volcano in the Andaman & Nicobar Islands erupted twice in 2025 — in October 2025 and again in February 2026 — after being dormant for over a year. Located on Baratang Island, about 100 km north of Port Blair, it is India's only mud volcano and one of the rare mud-volcano sites in Asia. Mud volcanoes are not volcanoes in the classical sense; they release methane, carbon dioxide and water-laden slurry rather than molten lava.



News in Brief

- Baratang Island lies in the Middle Andaman group, separated from South Andaman by the narrow Humphrey Strait.
- Mud volcanoes are surface expressions of deep hydrocarbon accumulations — they release pressurised mud, water, brines and gases (mostly methane) along fault lines.
- Baratang's mud volcanoes were first recorded by the British in 1803 and are locally called 'Jalki' by the indigenous Jarawa tribe.
- Other famous mud volcano fields are in Azerbaijan (which hosts ~400 — the world's highest concentration), Trinidad, Indonesia (Sidoarjo) and Pakistan's Hingol National Park.

Prelims Connect

Volcanoes — Classification by Activity

Type	Definition	Examples
Active	Erupted in past 10,000 years / currently erupting	Kilauea (USA), Stromboli (Italy), Mt Etna
Dormant	Not erupted recently but can reawaken	Mt Fuji (Japan), Popocatépetl (Mexico)
Extinct	No eruption in Holocene and no magma chamber	Mt Kenya, Deccan Traps (India)
Submarine	Occur on ocean floor along MOR	Axial Seamount, Kick'em Jenny
Mud volcano	Release slurry (not lava); linked to hydrocarbons	Baratang (India), Lokbatan (Azerbaijan)

India also has the extinct Barren Island volcano in the Andaman Sea — India's only classical (magma-based) active volcano — which last erupted in 2017.

Prelims Pointers

- Barren Island is **India's only active (magma) volcano**, a stratovolcano in the Andaman Sea; Baratang's mud volcano is a separate, gas-driven feature.
- Andaman & Nicobar lies on the **Sunda arc / Indo-Burman subduction zone**; the 2004 Indian Ocean earthquake and tsunami originated here.
- Mud volcanoes are closely linked to **hydrocarbon seeps** — they are used as natural indicators for oil & gas exploration.
- Azerbaijan's **Caspian Sea basin** hosts over 400 mud volcanoes — **the world's highest density**.

MOUNT DUKONO VOLCANO ERUPTS IN NORTH MALUKU, INDONESIA

Mount Dukono, located in North Maluku province of Indonesia's Halmahera Island, erupted in February 2025 — continuing its record of near-continuous activity since 1933. Dukono is one of Indonesia's most persistent volcanoes, spewing ash plumes several kilometres into the sky almost daily for nearly a century.

News in Brief

- Mount Dukono (1,229 m) is a complex stratovolcano on Halmahera Island, Indonesia.
- It has been in near-continuous eruption since 1933, making it one of the longest continuously active volcanoes in the world.
- Indonesia sits on the Pacific Ring of Fire and has over 130 active volcanoes — the highest number of any country.
- The Indonesian volcano monitoring agency is PVMBG (Centre for Volcanology and Geological Hazard Mitigation).

Prelims Connect

Indonesia — Volcanism and Tectonic Setting

Element	Details

Tectonic zone	Convergent boundary — Indo-Australian plate subducting below Sunda plate
Volcanoes count	130+ active volcanoes; ~76 have erupted in historic time
Major volcanoes	Merapi (Java), Krakatau, Tambora (1815 VEI-7), Sinabung, Semeru, Dukono
Monitoring agency	PVMBG (Centre for Volcanology & Geological Hazard Mitigation)
Part of	Pacific Ring of Fire — 75% of world's volcanoes & 90% of earthquakes

Mount Tambora (1815) had a VEI of 7 — the largest historic eruption. Its ejected ash caused 'The Year Without a Summer' in 1816 across the Northern Hemisphere.

Prelims Pointers

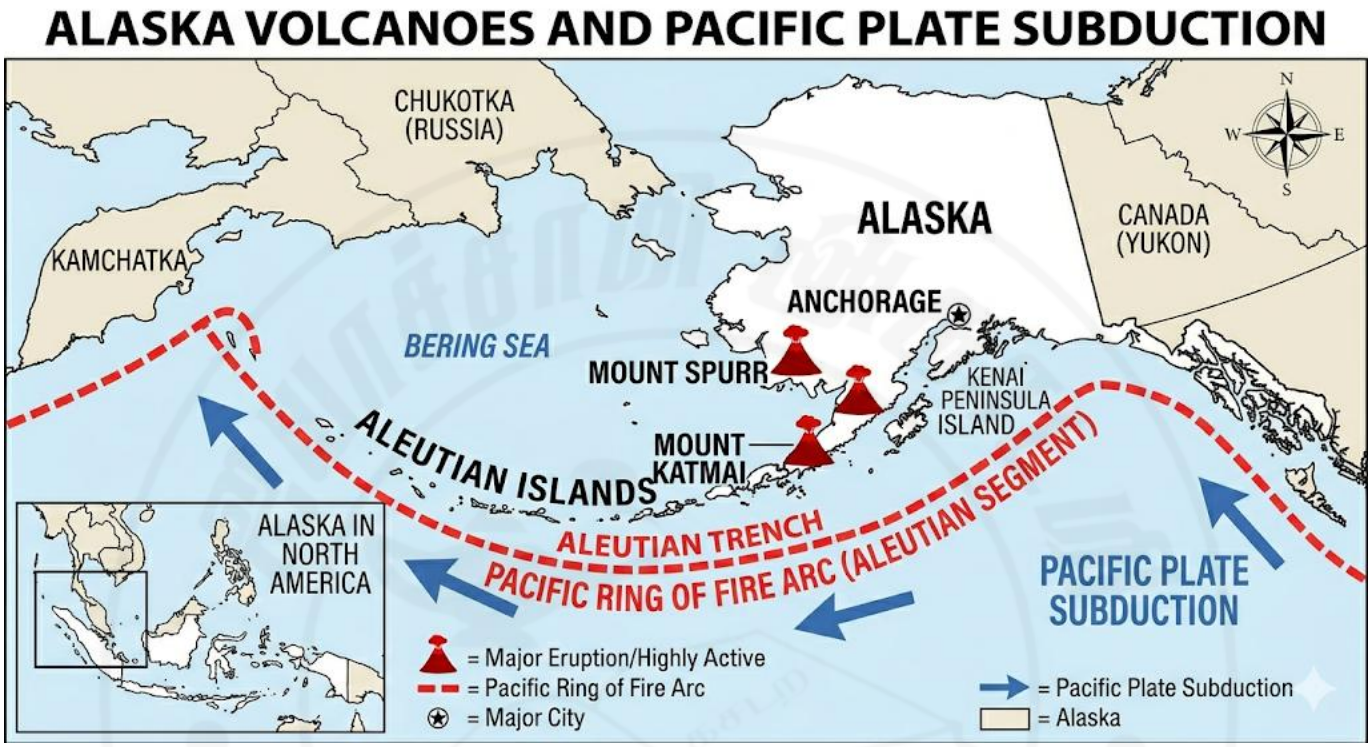
- The **Pacific Ring of Fire** is a 40,000 km horseshoe-shaped belt containing **~75% of the world's volcanoes** and 90% of earthquakes.
- The **Volcanic Explosivity Index (VEI)** is a 0–8 logarithmic scale for eruption magnitude; Mt Tambora (1815) and Krakatau (1883) reached VEI 7 and 6.
- Indonesia's Merapi on Java, the **most active**, is a **stratovolcano with andesitic lava**; it is monitored 24/7 due to population density.
- Halmahera Island is part of the **Maluku Islands (Spice Islands)** — historically important for clove and nutmeg trade.

MOUNT SPURR — ALASKAN VOLCANO SHAKEN BY MINI-EARTHQUAKE SWARM

Mount Spurr, an active stratovolcano in Alaska's Aleutian Volcanic Arc, was rattled by dozens of mini-earthquakes in April 2025, prompting the Alaska Volcano Observatory to raise its alert level. Scientists warn that the seismic swarms are characteristic precursors to eruption, with magma potentially on the move beneath the summit.

News in Brief

- Mount Spurr (3,374 m) is an ice-capped stratovolcano about 130 km west of Anchorage, Alaska, in the Aleutian Range.
- It last erupted in 1992, when three eruptions of its Crater Peak vent spread ash over Anchorage — the first US airport to be closed by volcanic ash.
- Earthquake swarms (many small quakes in quick succession) often indicate magma intrusion into shallow crust.
- The Alaska Volcano Observatory (AVO) is a joint USGS–UAF–ADGGS programme monitoring 130 Alaskan volcanoes.



Prelims Connect

Volcano–Earthquake Nexus: Precursor Signals

Precursor	Meaning
Earthquake swarms	Magma fracturing rock on its way to the surface
Ground deformation	Inflation of magma chamber; measured via GPS / InSAR
Gas emissions (SO_2)	Volatile release from rising magma
Thermal anomalies	Hot spots detected via satellite IR sensors
Harmonic tremor	Sustained vibration caused by magma movement

India uses GPS-based volcano monitoring for Barren Island; the Deccan Volcano Observatory (DVO) at IIT-Kharagpur studies India's intraplate volcanism legacy.

Prelims Pointers

- The **Aleutian Arc** is a 3,000 km volcanic arc formed where the Pacific Plate subducts under the North American Plate.
- Mount Spurr's 1992 eruption closed Anchorage International Airport — the first time a **US airport was shut by volcanic ash**.
- Ice-capped volcanoes are dangerous because eruptions trigger **jökulhlaups (glacial outburst floods) and lahars** (volcanic mudflows).

UTURUNCU — BOLIVIA'S 'ZOMBIE VOLCANO' RISES AT 1 CM/YEAR

Uturuncu, a stratovolcano in the Central Andes of Bolivia, has been dubbed a 'zombie volcano' by scientists because it continues to show signs of unrest despite not having erupted for 2,50,000 years. Recent studies published in 2025 show the volcano is inflating at roughly 1 cm per year — one of the largest ground deformation signals on Earth — fuelled by a hot fluid reservoir 10–15 km deep.

News in Brief

- Uturuncu (6,008 m) lies in the Altiplano–Puna Volcanic Complex (APVC) of southwestern Bolivia near the Chilean border.
- It has been inactive for 2,50,000 years but is currently inflating — a phenomenon detected through InSAR satellite imagery.
- Beneath it lies the Altiplano–Puna Magma Body (APMB) — the largest known magma body in Earth's continental crust.
- It is considered a 'zombie' because it shows vital signs (deformation, gas emissions, seismicity) without being truly alive.

Prelims Connect

World's Major Volcanic Provinces

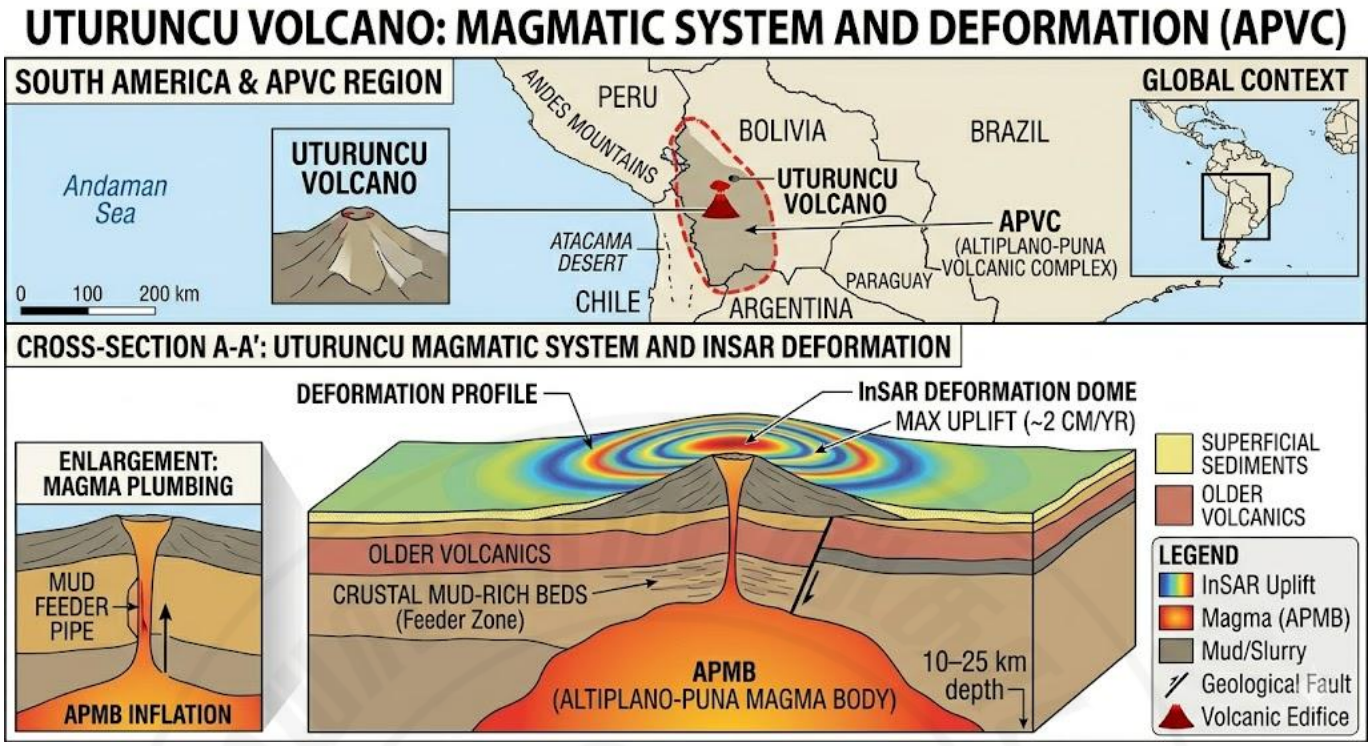
Province	Location	Key Feature
Pacific Ring of Fire	Pacific Rim	~452 volcanoes; 75% of world total
Mid-Atlantic Ridge	Atlantic Ocean	Divergent; includes Iceland, Azores
East African Rift	Kenya–Ethiopia	Continental rifting; Ol Doinyo Lengai, Mt Kilimanjaro
Mediterranean–Alpine	S. Europe	Vesuvius, Etna, Stromboli, Santorini
Central Andes (APVC)	Bolivia–Chile–Argentina	Uturuncu; world's largest crustal magma body

The Central Andean Volcanic Zone (CVZ) has 69 Holocene volcanoes — including Ojos del Salado (6,893 m), the world's highest active volcano, on the Chile–Argentina border.

Prelims Pointers

- InSAR (Interferometric Synthetic Aperture Radar) is used to measure **millimetre-scale ground deformation** via satellite.
- The Altiplano–Puna Magma Body (APMB) underlies parts of **Bolivia, Chile and Argentina** at depths of 10–25 km.
- 'Zombie volcanoes' are long-dormant volcanoes that show **low-level seismic and deformation activity** despite no recent eruption.

- The **Andes mountain range** is the world's longest continental mountain chain (7,000 km) and a classic **ocean–continent convergent boundary**.



ANAK KRAKATAU — UNNOTICED GROUND DEFORMATION AFTER 2018 COLLAPSE

A new study published in May 2025 reveals that in the years following Anak Krakatau's deadly 2018 flank collapse and tsunami, the volcano experienced widespread ground deformation that went largely undetected. The 2018 event killed 437 people along Indonesia's Sunda Strait coasts — a reminder that flank collapses can trigger tsunamis without any classical warning signs.

News in Brief

- Anak Krakatau ('Child of Krakatoa') is a volcanic island that emerged in 1927 from the caldera of the 1883 Krakatau eruption in Indonesia's Sunda Strait.
- On 22 December 2018, a portion of the volcano's south-west flank collapsed into the sea, generating a tsunami that struck Java and Sumatra without warning.
- The 1883 Krakatau eruption (VEI 6) was one of the most violent in history — its sound was heard 4,800 km away and it killed over 36,000 people.
- The 2018 event highlighted the gap in tsunami warning systems — existing systems are tuned for earthquakes, not volcanic flank collapses.

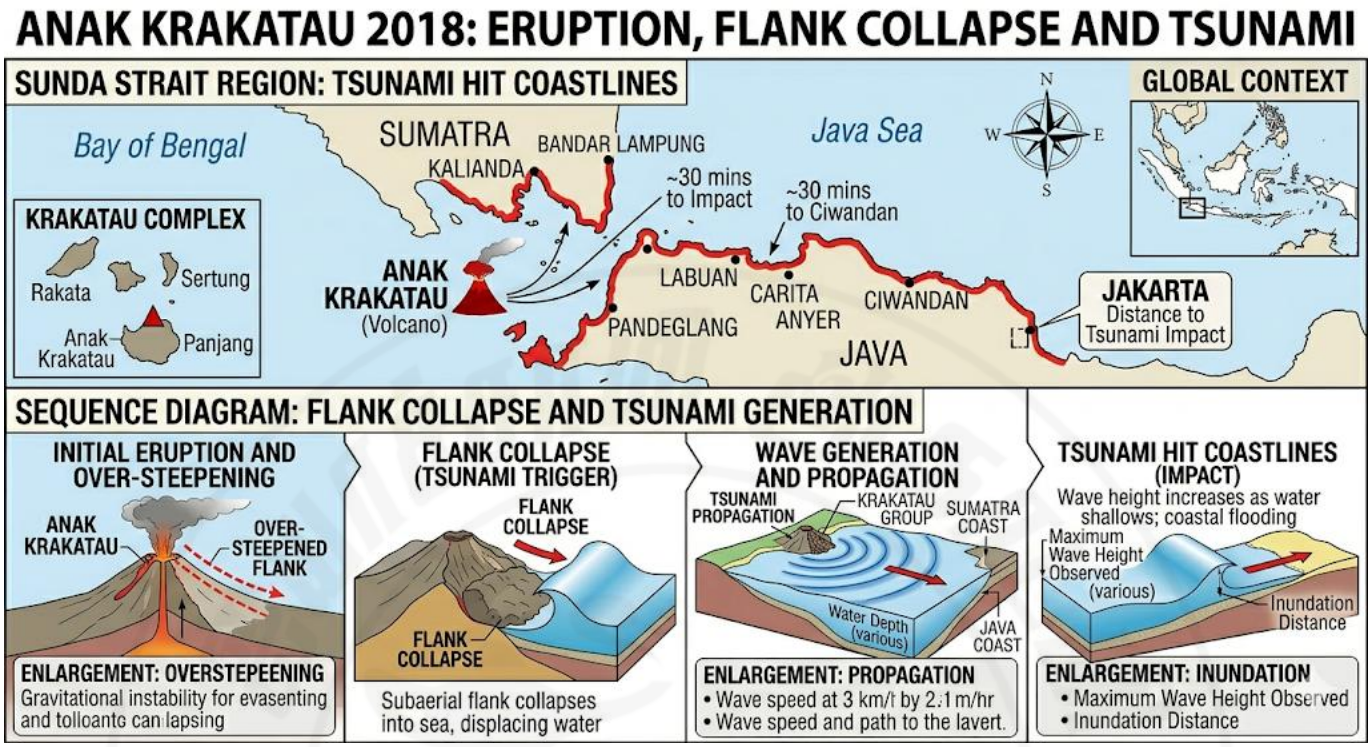
Prelims Connect

Types of Tsunamis — Triggers

Trigger	Frequency	Examples
Submarine earthquake	~80% of tsunamis	2004 Sumatra–Andaman (Mw 9.1), 2011 Tōhoku
Volcanic eruption/collapse	~5%	Krakatau (1883, 2018), Hunga Tonga (2022)

Underwater landslide	~8%	Papua New Guinea (1998) — 2,200 deaths
Meteor impact	<1%	Chicxulub (~66 Ma BP); theoretical

The Sunda Strait separates Java from Sumatra and is one of the world's most tectonically active zones — the India–Australian plate dives under the Sunda plate.



Prelims Pointers

- The **Indian Tsunami Early Warning System (ITEWS)** is run by INCOIS, Hyderabad — established after the **2004 Indian Ocean tsunami**.
- The **2022 Hunga Tonga–Hunga Haʻapai eruption** was the largest of the 21st century so far; it generated a tsunami detected across the Pacific.
- Anak Krakatau reduced in height from **338 m to 110 m** after the 2018 collapse.

KILAUEA VOLCANO, HAWAII — NEW ERUPTIVE EPISODES AT HALEMA'UMA'U CRATER

Hawaii's Kilauea volcano experienced new eruptive episodes in December 2025, with lava fountaining within the Halemaʻumaʻu crater at the summit. Kilauea is one of the most active and most studied volcanoes on Earth and is considered a classic example of hotspot volcanism — not associated with any plate boundary but fed by a deep mantle plume.

News in Brief

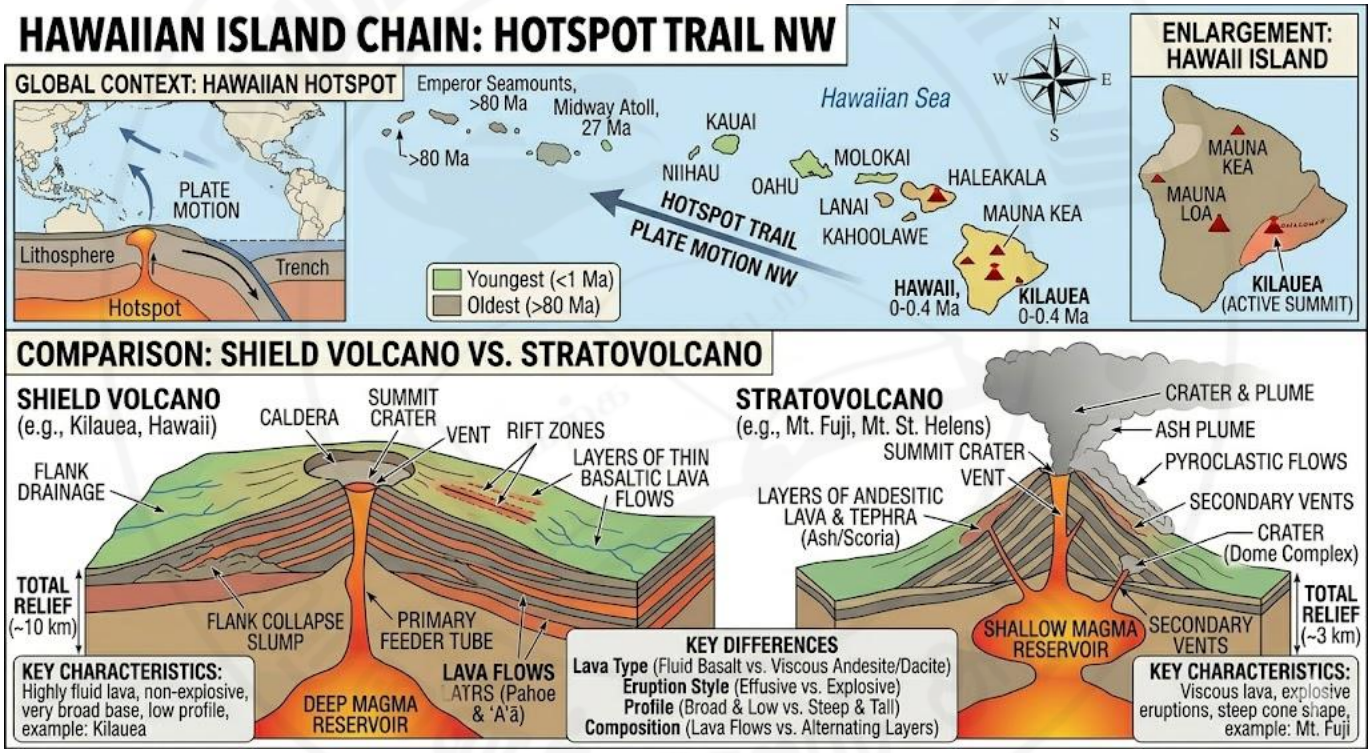
- Kilauea (1,247 m) lies on the south-eastern flank of Mauna Loa on the Big Island of Hawaii.
- It is a shield volcano — built up by successive low-viscosity basaltic lava flows — and is considered one of the most active volcanoes in the world.
- The Halemaʻumaʻu crater, within the summit caldera, is the mythological home of Pele — the Hawaiian goddess of volcanoes.
- Kilauea's 2018 eruption destroyed over 700 homes and the ongoing 2021–2025 summit episodes continue to expand the lava lake.

Prelims Connect

Types of Volcanoes by Structure

Type	Shape	Lava	Examples
Shield	Broad, gentle slopes	Basaltic (low viscosity)	Mauna Loa, Kilauea, Fernandina
Stratovolcano (composite)	Steep, conical	Andesitic–rhyolitic	Fuji, Vesuvius, Krakatau, Etna
Cinder cone	Small, steep	Pyroclastic ash & scoria	Paricutin (Mexico)
Caldera	Collapsed summit depression	Explosive	Yellowstone, Toba, Santorini
Fissure	Long cracks	Flood basalt	Laki (Iceland), Deccan Traps

India's Deccan Traps (West-central India) formed 66 Mya by massive fissure eruptions at the time of the Cretaceous–Paleogene mass extinction.



Prelims Pointers

- Kilauea sits on the **Hawaiian hotspot** — a mantle plume unrelated to any plate boundary; the Hawaiian chain formed as the Pacific Plate moved NW over the stationary plume.
- Mauna Loa, also on the Big Island, is the **world's largest shield volcano by volume** (80,000 km³).
- Shield volcanoes erupt **basaltic lava** which is **fluid and non-explosive**; stratovolcanoes erupt andesitic/rhyolitic lava which is viscous and explosive.

MOUNT BUR NI TELONG ALERT RAISED — ACEH, INDONESIA

Indonesia raised the alert level for Mount Bur Ni Telong, an active stratovolcano in the Bener Meriah regency of Aceh province, in January 2026 after rising seismic activity and gas emissions. Bur Ni Telong (2,624 m) last erupted in 1924 and sits along the Sunda Arc — the tectonic belt that runs from the Andamans through Sumatra and Java to the Lesser Sunda Islands.

News in Brief

- Mount Bur Ni Telong is in Aceh province, northern Sumatra, on the Barisan mountain range running the length of Sumatra.
- It is a stratovolcano formed by the subduction of the Indo-Australian plate under the Eurasian (Sunda) plate along the Sunda Trench.
- The Sunda Arc is one of Earth's most active subduction systems — it produced the 2004 Indian Ocean earthquake (Mw 9.1) that generated the devastating Boxing Day tsunami.
- Indonesia's PVMBG monitors Bur Ni Telong along with over 60 other active Indonesian volcanoes.

Prelims Connect

The Sunda Arc — Tectonic Structure

Element	Details
Tectonic setting	Indo-Australian Plate subducts NE under Sunda/Eurasian Plate
Sunda Trench depth	Up to 7,725 m (Java Trench)
Length of arc	~5,600 km from Andaman to Banda arc
Active volcanoes	~130 — densest arc system in the world

Key volcanoes	Barren Island, Sinabung, Merapi, Krakatau, Tambora, Bromo

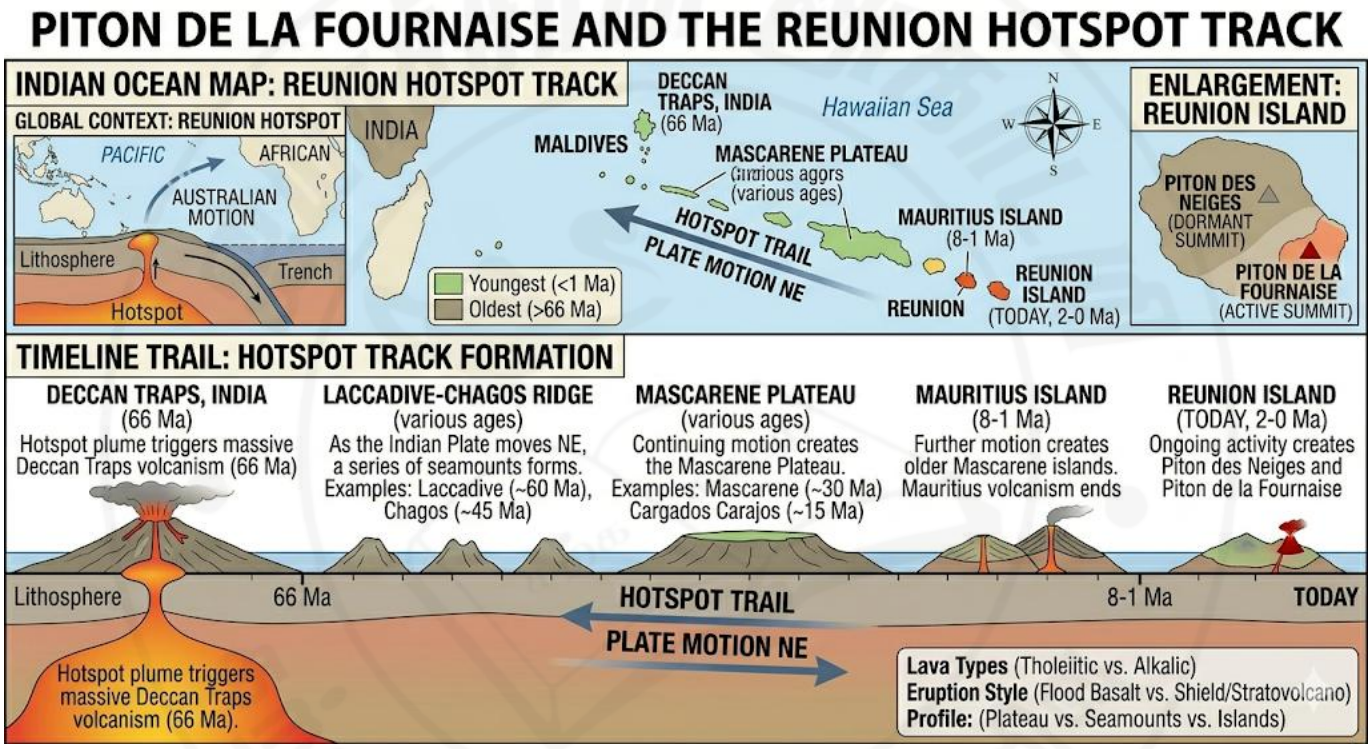
The Andaman and Nicobar arc is the north-western continuation of the Sunda Arc — India's only active volcanoes (Barren and Narcondam) lie along it.

Prelims Pointers

- The **Sunda Trench (Java Trench)** is the deepest trench in the Indian Ocean (7,725 m).
- Barisan Mountains form the **backbone of Sumatra** and house multiple active volcanoes including Sinabung and Kerinci (Sumatra's highest peak at 3,805 m).
- Aceh province, at Sumatra's northern tip, was **worst affected by the 2004 tsunami**, losing over 1,67,000 lives.

PITON DE LA FOURNAISE — ONE OF WORLD'S MOST ACTIVE VOLCANOES ERUPTS

Piton de la Fournaise on Réunion Island in the Indian Ocean erupted again in February 2026. Known as one of the most active volcanoes on Earth, it has erupted nearly 200 times since 1640 and is a classic example of hotspot volcanism — formed by the Réunion mantle plume, the same plume thought to have created India's Deccan Traps around 66 million years ago.



News in Brief

- Piton de la Fournaise (2,632 m) is a shield volcano on the eastern side of Réunion Island in the Indian Ocean.
- Réunion Island is an overseas department of France, located east of Madagascar.
- The Réunion hotspot is a persistent mantle plume that has been active for 65+ million years.
- The same hotspot created the Deccan Traps in India 66 Mya when the Indian plate was drifting north over it, contributing to the K-Pg extinction event.

Prelims Connect

Réunion Hotspot — Geological Trail

Feature	Age (Ma)	Location

Deccan Traps (India)	~66	Maharashtra–Gujarat–MP
Laccadive Plateau	~60	NW of Maldives
Maldives–Chagos Ridge	~55–45	Indian Ocean
Mascarene Plateau	~45–35	NE of Madagascar
Mauritius volcanism	~8–0.03	Mauritius
Réunion (Piton de la Fournaise)	~2–present	Réunion Island

The Réunion hotspot trail is one of the strongest evidences for continental drift and plate tectonics — showing a clear age progression as the Indian plate moved north.

Prelims Pointers

- The **Deccan Traps** are one of the largest volcanic features on Earth, originally covering **~1.5 million km²** of western and central India.
- Hotspots are **stationary mantle plumes** — as tectonic plates move over them, a chain of volcanoes is formed (e.g., Hawaiian, Réunion, Yellowstone chains).
- Piton de la Fournaise is **closely monitored by OVPF (Observatoire Volcanologique du Piton de la Fournaise)** — one of the most instrumented volcanoes on Earth.

MOUNT ETNA ERUPTION — EUROPE'S LARGEST ACTIVE VOLCANO

Europe's largest active volcano, Mount Etna in Sicily, produced a major explosive eruption — characterised by Strombolian activity with moderately explosive bursts ejecting rocks and cinders hundreds of metres into the air.

News in Brief

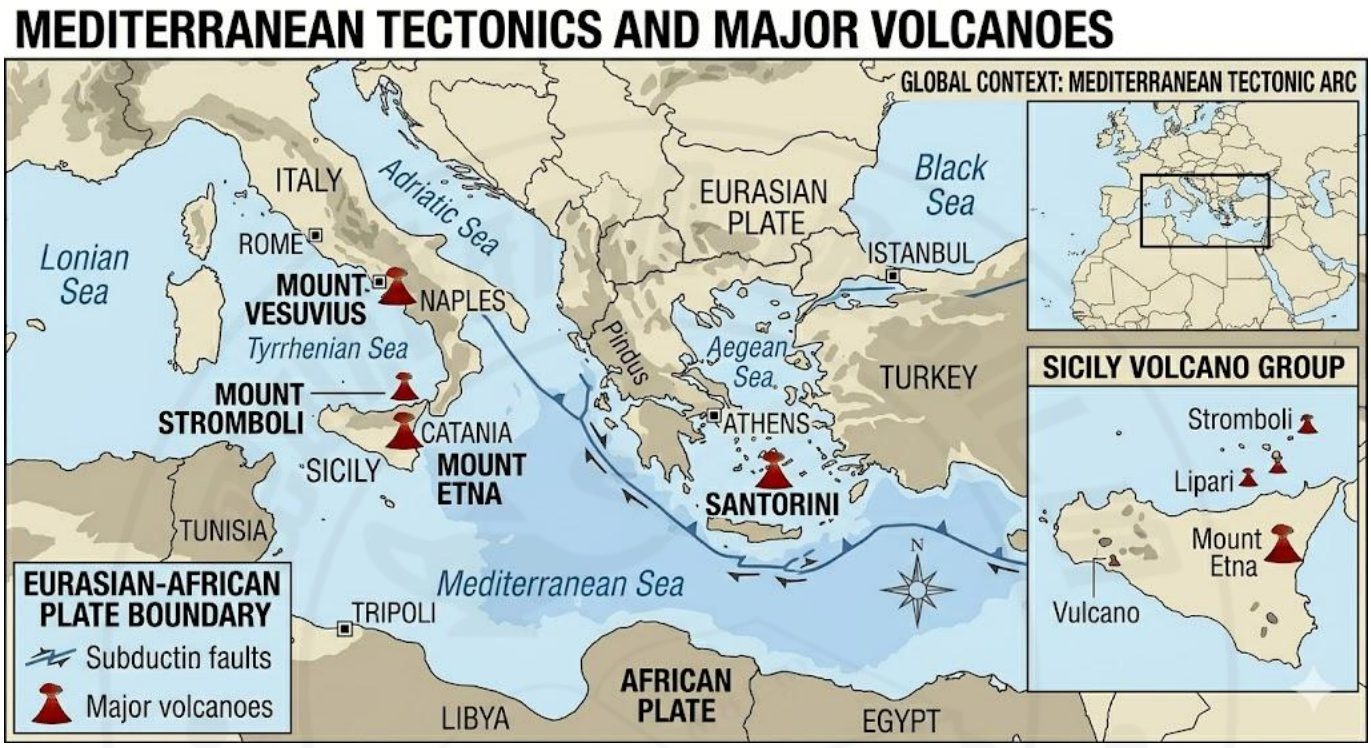
- Etna is located on the **east coast of Sicily**, the largest island in the **Mediterranean Sea**, off the toe of the Italian 'boot'.
- Etna's peak is the **highest in Italy south of the Alps** and the **largest of Europe's active volcanoes**; its summit has **five craters** responsible for most eruptions; flank eruptions occur at 300-odd vents on its slopes.
- Volcano is in **near-constant activity**, with at least **60 flank eruptions** and many summit eruptions since 1600.
- **Mount Etna** has been a **UNESCO World Heritage Site since 2013**, with eruptions traceable back **5 lakh years**.
- **Strombolian eruption**: characterised by moderately explosive bursts ejecting rocks and cinders; occurs due to the **presence of gas in the magma chamber**.
- India has **one active volcano** (Barren Island — South Asia's only active volcano), **one dormant volcano** (Narcondam Island), and other features such as mud volcanoes and extinct volcanic regions.

Prelims Connect

Why Volcanoes Erupt — Mechanism

Factor	Explanation
Magma formation	Deep beneath Earth's surface, temperature and pressure melt mantle and crust forming magma; being less dense than solid rock, it rises.

Gas bubble pressure	Volatile compounds like water vapour, CO2, SO2 remain trapped under pressure; near surface, pressure drops, gases form bubbles, increasing internal pressure.
Tectonic pathways	At tectonic plate boundaries or mantle plumes, fractures allow magma and gases to escape violently.
Types	Stratovolcanoes (steep, cone-shaped) vs shield volcanoes (low profile); type depends on magma viscosity, gas content, and eruption style.



Prelims Pointers

- **Zombie volcanoes** like Uturuncu emit gases and cause quakes despite no eruption in **2.5 lakh years** — long thought extinct but showing unexpected signs of life (gas emissions, earthquakes, ground deformation).
- **Magma** is liquid rock underground; **lava** is magma that breaks through the surface. Volcanoes form when magma, ash, gases erupt onto Earth's surface.
- Volcanoes rise when tectonic plates **move apart** (creating underwater volcanoes), when plates **converge** (part of crust melts), or via **hotspots** — hot areas inside Earth where magma becomes less dense and rises.

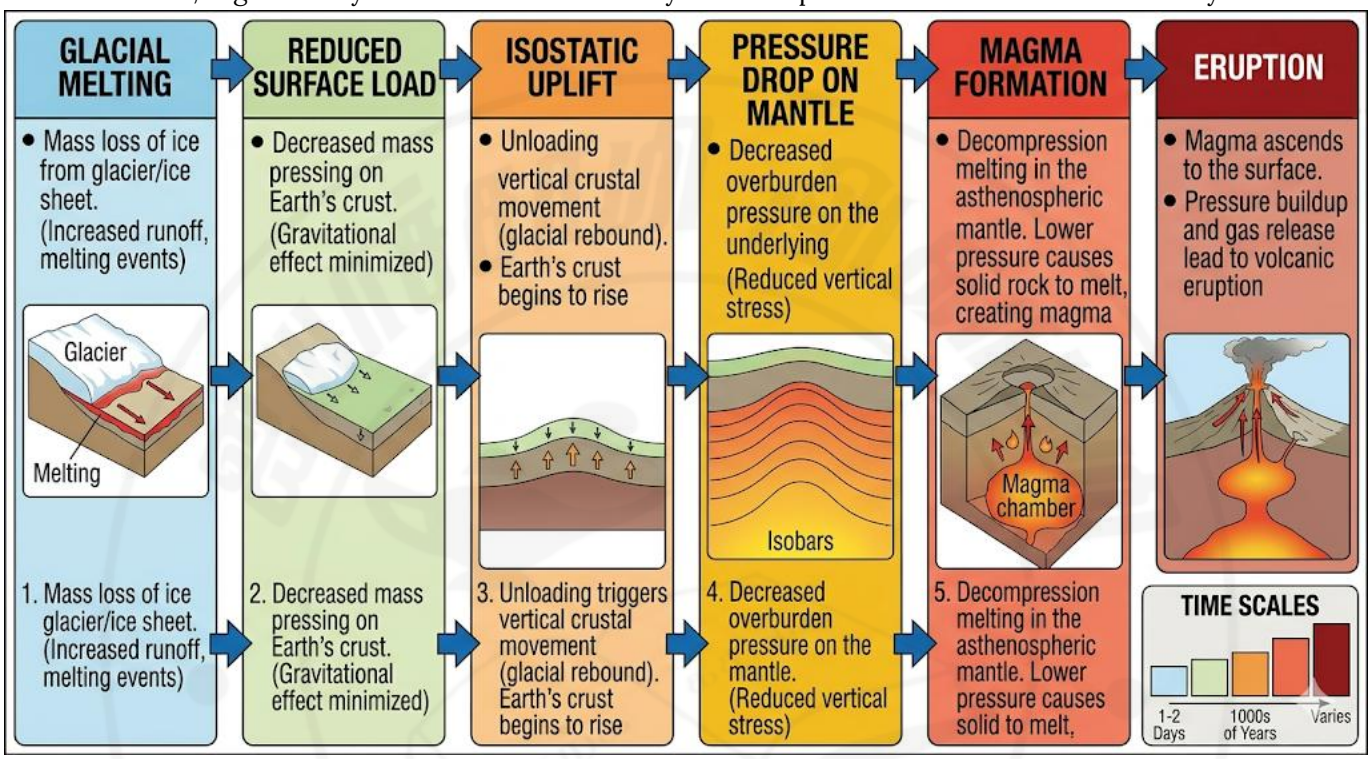
MELTING GLACIERS — LINK TO MORE FREQUENT VOLCANIC ERUPTIONS

Research presented at the 2025 Goldschmidt Conference in Prague reveals that the rise in melting glaciers and ice caps can lead to more frequent and explosive volcanic eruptions worldwide.

News in Brief

- The greatest risk of renewed volcanic eruptions is in **West Antarctica**, where about **100 volcanoes** are buried under thick ice; North America, New Zealand, and Russia also face increased risk.

- **Weight of ice** exerts pressure on underground magma chambers; when glaciers or ice caps melt, the pressure reduces, allowing gases and magma to expand — causing explosive eruptions.
- In **Iceland**, during major deglaciation, volcanic eruption rates were **30–50 times higher**. Ice loss lowers pressure and triggers magma production; rocks at lower pressure tend to melt at lower temperatures.
- A study on **Chile's Mocho Choshuenco volcano** found that a thick ice sheet suppressed eruption volumes between **26,000 and 18,000 years ago**, building a large magma reservoir **10–15 km below** the surface.
- When the ice sheet melted about **13,000 years ago**, explosive eruptions occurred.
- Volcanic eruptions can cause **temporary cooling** by releasing **sulfur dioxide** into the stratosphere, where it forms **sulfuric acid aerosols** that reflect incoming solar radiation, cooling the Earth's surface.
- The **2025 Goldschmidt Conference** was held in Prague — the largest international geochemistry conference, organised by the Geochemical Society and European Association of Geochemistry.



Prelims Connect

Volcanic Climate Effects — Key Examples

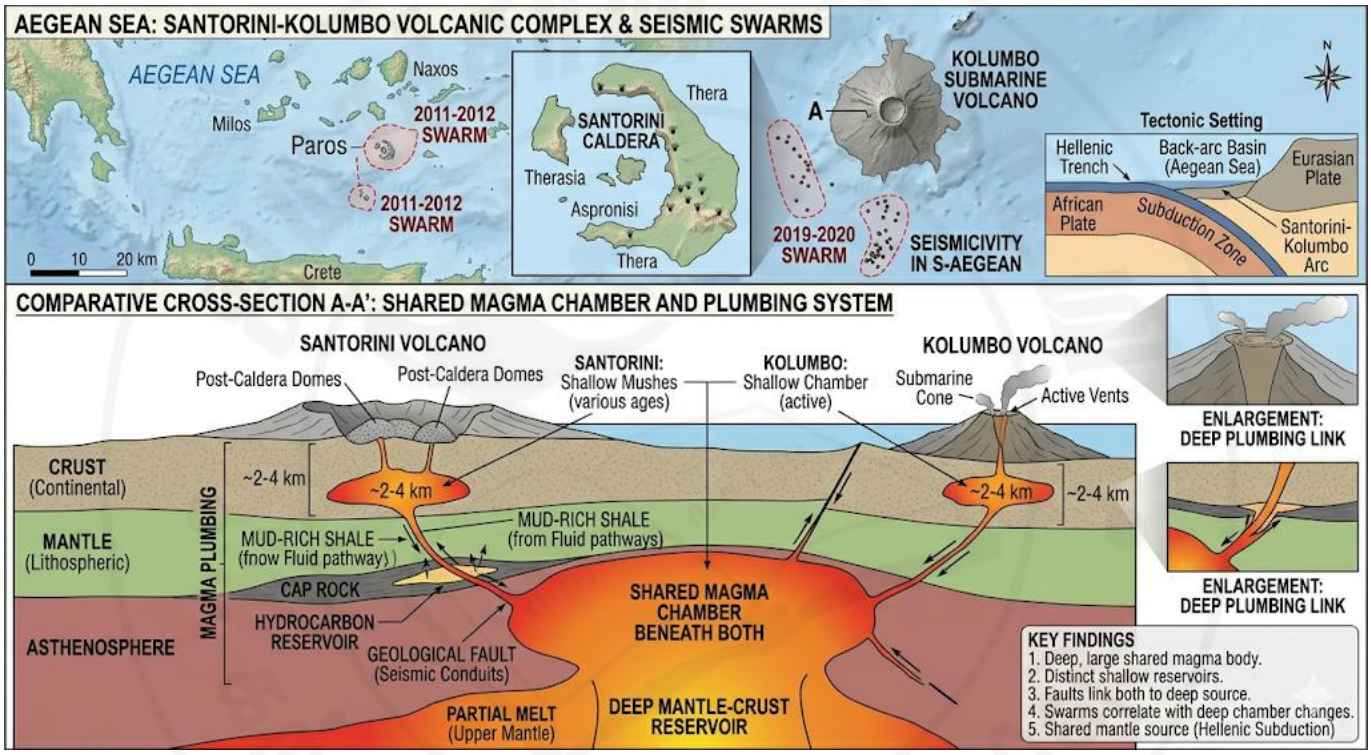
Effect	Mechanism	Historical Example
Temporary global cooling	SO2 forms sulfuric acid aerosols in stratosphere, reflecting sunlight	1815 Tambora eruption — 'Year Without a Summer' 1816
Short-term ash darkening	Ash and dust block sunlight (short-term)	Krakatau 1883 — global temperature drop 1.2°C
Ice-volcano feedback	Glacier melt reduces overburden pressure, triggering more eruptions	Iceland during Younger Dryas deglaciation
Long-term climate driver	Large-scale CO2 emissions from flood basalts	Deccan Traps (66 Mya) — linked to K-Pg extinction

Prelims Pointers

- This **ice-volcano feedback loop** has implications for future eruption risk as global warming accelerates glacier melt — a critical intersection of climate change and geohazards.
- Sulfur dioxide is **more effective than ash** at cooling the climate — it rises into the stratosphere and reacts with water to form sulfuric acid aerosols that reflect incoming solar radiation.
- The **Goldschmidt Conference** is the world's foremost gathering on geochemistry — relevant for UPSC Science & Technology and Environment sections.

SANTORINI–KOLUMBO EARTHQUAKE SWARMS — SHARED MAGMA CHAMBER

In 2025, Greece experienced swarms of earthquakes over a month. Research using satellites, seismometers, and ground sensors found that activity was driven by two neighbouring volcanoes — Santorini (Thira Island) and Kolumbo — sharing a magma chamber.



News in Brief

- **Magma reservoir beneath Kolumbo** (in the Aegean Sea) **lost volume**, while ground at **Santorini swelled upward** — revealing both volcanoes are **connected deep underground**.
- The study explains simultaneous seismic activity — pressure changes in one volcano's system directly affect the other.
- **Aegean Sea** is bordered by Greece to the west and north, and Turkey to the east — forming a key part of the Mediterranean between the Balkan Peninsula and Anatolia.
- Santorini's ancient eruption (~1600 BCE, **Minoan eruption**) is believed to have contributed to the collapse of the Minoan civilization — one of history's most debated volcanic–civilizational links.

Prelims Connect

Earthquake Precursors and Monitoring Tools

Precursor	What It Indicates
Earthquake swarms	Magma fracturing rock on its way up — intrusion into shallow crust
Ground deformation (InSAR)	Magma chamber inflation or deflation — cm-scale ground movement detected from satellite
Gas emissions (SO2, CO2)	Volatile release from rising magma — measurable increase before eruptions
Harmonic tremor	Sustained vibration caused by fluid (magma/gas) movement in volcanic conduit
Thermal anomalies	Hot spots detected via satellite IR sensors — surface heating above intrusions

Prelims Pointers

- **InSAR** (Interferometric Synthetic Aperture Radar) measures **millimetre-scale ground deformation** via satellites — critical tool for monitoring volcanic unrest.
- The Aegean Sea region has some of **Europe's most seismically active zones** — lying on the boundary of the Eurasian and African tectonic plates.
- This study highlights that **volcano networks can share underground plumbing systems** — seismic activity at one signals pressure changes at another. Important for disaster preparedness.

DELHI EARTHQUAKE & NEW SEISMIC ZONE MAP — IS 1893:2025

A 4.4 magnitude earthquake struck Delhi, prompting fresh attention on India's seismic vulnerability. The Bureau of Indian Standards (BIS) released a revised Earthquake Design Code 2025 (IS 1893) introducing a new highest-risk Zone VI — the first major revision in India's seismic zonation in decades.

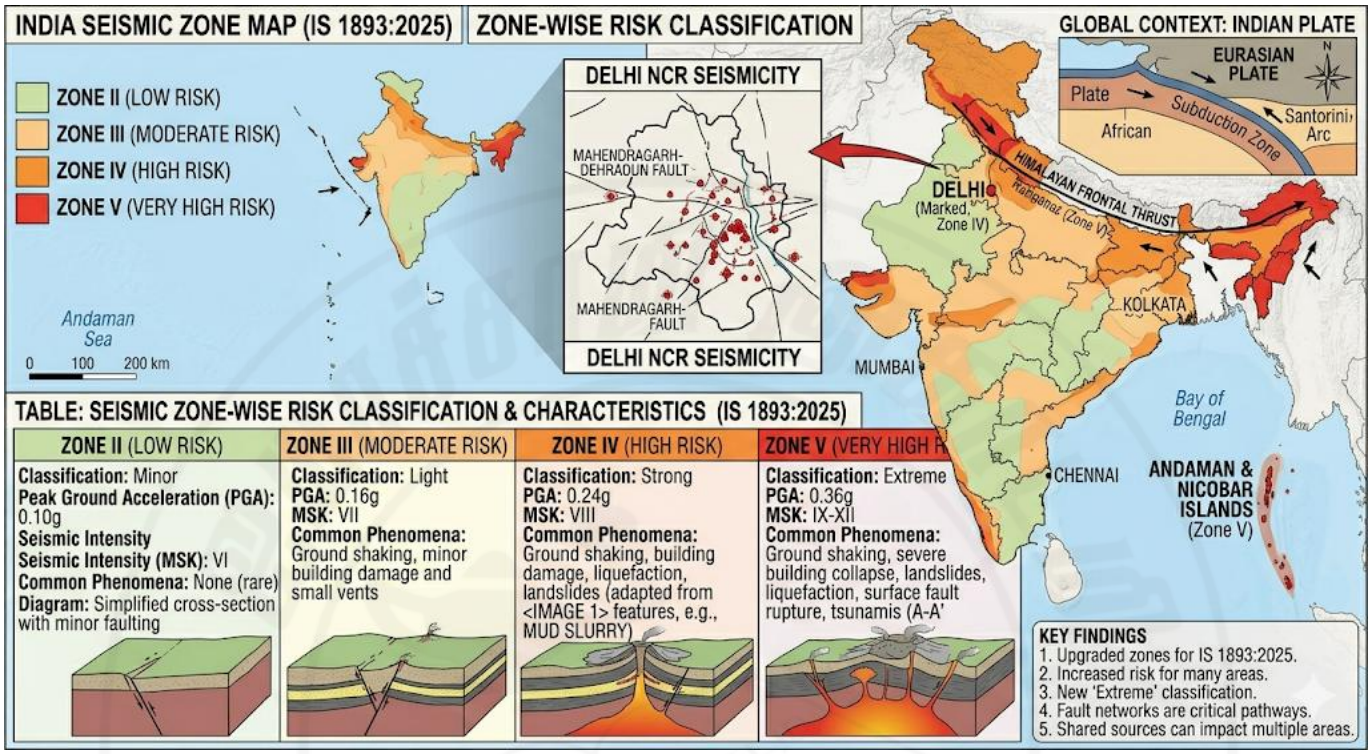
News in Brief

- India lies on a tectonically active plate; the **Himalayan region is overdue for a magnitude 8+ quake** that could impact over **300 million people**. Delhi, in **Seismic Zone IV**, faces high risk.
- The **Himalayan seismic gap** — with built-up strain since the Kangra earthquake (1905) and Nepal earthquake (2015) — increases risk of a massive future quake.
- The **revised Seismic Zone Map (IS 1893:2025)** places **61% of India's landmass** and **75% of the population** under moderate-to-high seismic hazard risk zones (earlier 59% of land area).
- The previous classification had four seismic zones (II–V); the new map adds **Zone VI** as the highest risk zone — placing the **entire Himalayan belt from J&K to Arunachal Pradesh** under it.
- Map is updated using **Probabilistic Seismic Hazard Assessment (PSHA)** method — considers likelihood and intensity of ground shaking, fault data, tectonic movements, and lithology.
- India is the **7th most earthquake-prone country** due to its position at the convergence of tectonic plates. About 59% of India's land was earlier at risk of MSK scale intensity 7 or higher.
- Delhi's urbanisation has created risks due to **liquefaction-prone soils** and **poorly designed high-rises**.

Prelims Connect

Major Himalayan Fault Systems

Fault System	Location / Significance
Main Central Thrust (MCT)	Between Greater Himalayas and Lesser/Middle Himalayas
Main Boundary Thrust (MBT)	Between Lesser Himalayas and Outer Himalayas (Shiwaliks)
Main Frontal Thrust (MFT) / HFF	Between Outer Himalayas and Northern Indian Plains; southernmost fault; densely populated foothills



Prelims Pointers

- **IS 1893:2025** is the revised Earthquake Resistant Design of Structures code under **Bureau of Indian Standards** — mandatory compliance for construction.
- The concept of **'exposure window'** introduced in the revised map considers population density, infrastructure concentration, urban expansion, and socio-economic vulnerability — a multi-hazard assessment approach.
- Retrofitting with **steel jacketing**, **deep pile foundations**, and **base isolation** are essential earthquake-preparedness measures for existing structures.
- **Koyna earthquake (1967, M 6.3, Maharashtra)** killed 180+ people — India's most studied **reservoir-induced earthquake** (attributed to water overloading at Koyna Dam).
- **Human-induced earthquakes**: Mining, groundwater pumping, dam impoundment, fluid injection, and construction can cause stress accumulation and trigger quakes along faultlines.

1950 GREAT ASSAM EARTHQUAKE (M 8.6) — 75TH ANNIVERSARY

August 15, 2025 marked the 75th anniversary of the Great Assam Earthquake (M 8.6) of 1950 — one of the largest earthquakes ever recorded and the most powerful in India's history. Its epicentre was near the Mishmi Hills, on the Arunachal Pradesh–Tibet border.

News in Brief

- **Epicentre**: Near Mishmi Hills, Arunachal Pradesh–Tibet border, at a depth of **15 km**.
- **Tectonics**: Collision of the Indian and Eurasian Plates, involving the **Eastern Himalayan Syntaxis** — a structurally complex bend in the Himalayan arc.
- **Unique mechanism**: Combined **strike-slip and thrusting motion** — unlike most Himalayan quakes which are purely thrust-fault events.
- The **Central Himalayas** remain the most seismically active segment; the region is now far more vulnerable due to urban growth, built infrastructure, and dams.
- With a magnitude of **8.6**, it remains one of the **largest earthquakes globally** recorded with modern instruments.

Prelims Connect

Human-Induced (Triggered) Earthquakes — Causes and India Examples

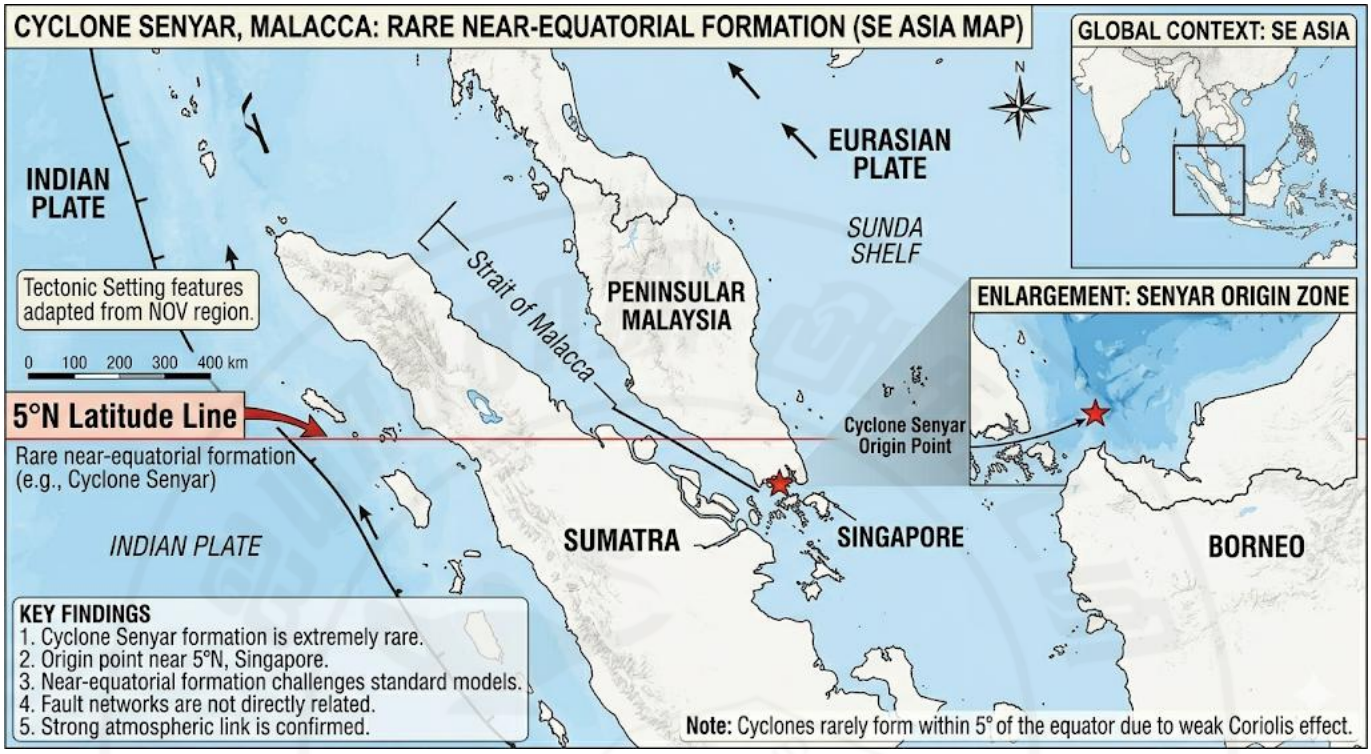
Activity	Mechanism	India Example
Groundwater extraction	Reduces subsurface pressure, causing surface jolts	Delhi-NCR — quakes linked to groundwater depletion (2003–12)
Dam impoundment	Water weight loads fault lines, triggers slip	Koyna (1967) — M6.3, 180+ deaths
Fracking	Fluid injection creates pressure along fault planes	India has 56 fracking sites across 6 states
Mining	Loading/unloading of rock strata causes stress accumulation	Jharkhand coalfields
Glacial melt / heavy rainfall	Altered water load affects tectonic stress on plates	Sahyadri range (Western Ghats) tremors

Prelims Pointers

- **Koyna earthquake (1967)** is India's deadliest known **reservoir-triggered seismic event** — the Koyna dam's impounded water is believed to have loaded a pre-existing fault.
- **Mullaperiyar dam (Idukki, Kerala)** has been experiencing increasing tremors — another seismically active zone of concern for dam safety.
- India has **56 fracking sites across six States** — each a potential induced seismicity risk. **Palghar (Maharashtra)** quakes are linked to fluid migration from rainfall.
- The **1950 Assam quake** triggered massive landslides and blocked the Brahmaputra, causing catastrophic floods when the natural dams burst — a reminder of earthquake–flood cascades in the Himalayas.

CYCLONE SENYAR FORMS OVER STRAIT OF MALACCA — NEAR-EQUATORIAL CYCLONE

A low-pressure area over the Strait of Malacca and the adjoining South Andaman Sea intensified into Cyclone Senyar in November 2025 — an unusual near-equatorial tropical cyclone. Cyclones forming so close to the equator are rare because the Coriolis force needed to spin them is very weak within 5° of the equator. 'Senyar' is a name contributed by Malaysia to the WMO/ESCAP Panel on Tropical Cyclones.



News in Brief

- The Strait of Malacca separates the Malay Peninsula (Malaysia) from Sumatra (Indonesia) and is one of the world's busiest shipping lanes.
- Tropical cyclones generally form between 5°–30° latitude — below 5°, the Coriolis force is too weak to sustain rotation.
- Cyclone names in the North Indian Ocean are maintained by 13 countries through the WMO/ESCAP Panel on Tropical Cyclones.
- IMD New Delhi is the Regional Specialised Meteorological Centre (RSMC) for tropical cyclones in the North Indian Ocean.

Prelims Connect

Tropical Cyclone Naming — WMO/ESCAP Panel (13 Countries)

Country	Example Names Contributed
India	Gati, Tej, Biparjoy, Aag, Vyom, Ghurni
Bangladesh	Nisarga, Biparjoy, Agni, Helen

Iran	Hamoon, Peyarah, Anar
Maldives	Viyaru, Hikaa, Aditya
Myanmar	Mora, Pinku, Kyarr
Oman	Luban, Hikaa, Muzn
Pakistan	Titli, Laila, Bulbul
Qatar	Bahar, Shaheen, Asna
Saudi Arabia	Asir, Sail, Darb
Sri Lanka	Gigum, Gagana
Thailand	Mekkhala, Muifa, Krathon
UAE	Nahhaam, Ghwais, Ma'din
Yemen	Sagar, Daye, Bakhur

Cyclone names are proposed in alphabetical order of contributing countries; the current list (169 names) was released in 2020 with Malaysia added as the 13th country in 2018.

Prelims Pointers

- Different names in different ocean basins: **Hurricanes (N. Atlantic, E. Pacific), Typhoons (NW Pacific), Cyclones (N. Indian Ocean, S. Pacific), Willy-willies (Australia)**.
- Conditions for tropical cyclone formation: **SST ≥ 26.5°C, low vertical wind shear, pre-existing disturbance, latitudes 5°–30°, moist mid-troposphere**.
- Saffir–Simpson Scale classifies hurricanes into **Category 1 (119–153 km/h) to Category 5 (≥ 252 km/h)**; IMD uses its own 7-stage scale.

TYPHOON KALMAEGI (TINO) — ONE OF THE DEADLIEST NATURAL DISASTERS OF 2025

Typhoon Kalmaegi, known locally in the Philippines as Tino, emerged as one of the deadliest natural disasters of 2025 when it battered the Visayas region in November. Central Cebu and adjoining islands reported over 140 deaths and widespread infrastructure damage. Kalmaegi was a Category 3–4 typhoon at landfall — a reminder of the Philippines' exposure to around 20 tropical cyclones every year.

News in Brief

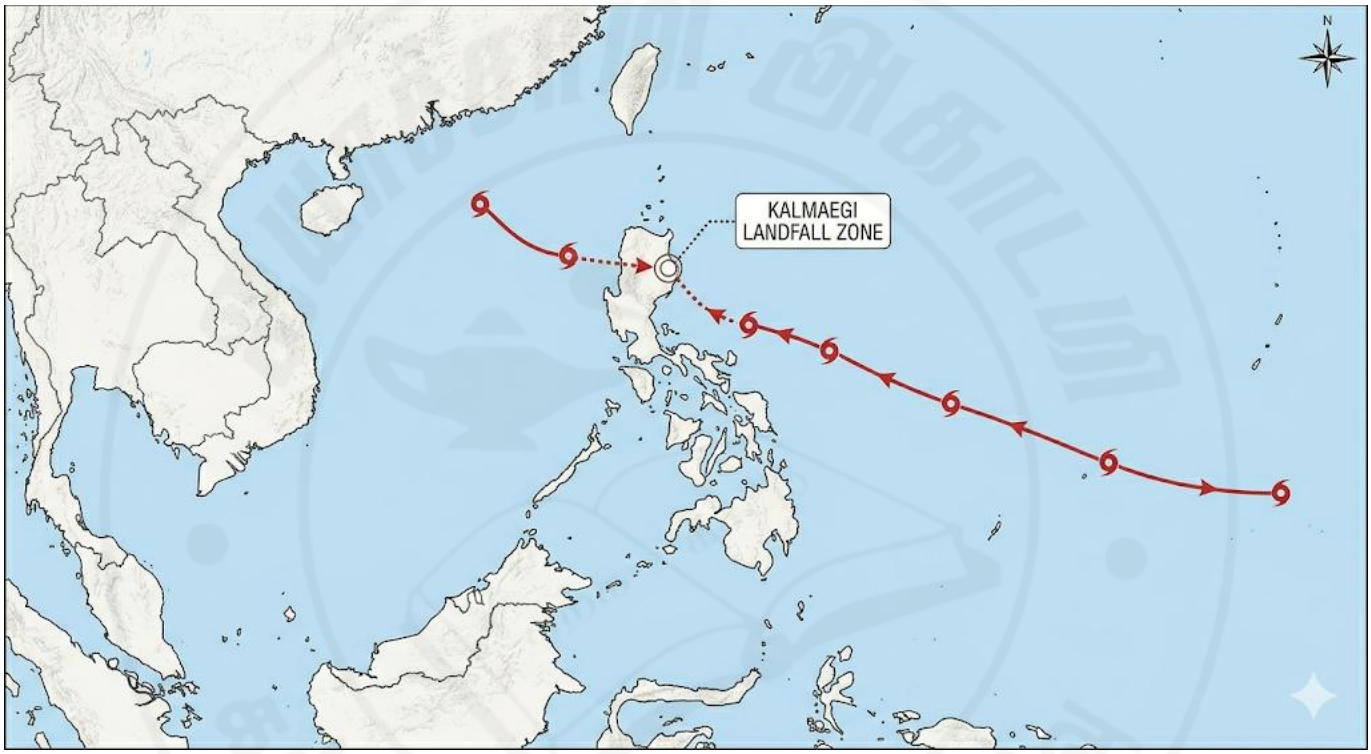
- Typhoon Kalmaegi made landfall over central Philippines in November 2025 with sustained winds of 175 km/h.
- The Philippines sits in the world's most typhoon-prone region — the north-western Pacific Ocean — and is hit by ~20 cyclones per year.
- The Pacific Typhoon season (June–November) is longer and more active than the Atlantic hurricane season.
- Names for Pacific typhoons are assigned by the Tokyo Typhoon Center (RSMC Tokyo) of the Japan Meteorological Agency.

Prelims Connect

Cyclone Terminology by Ocean Basin

Region	Local Name	Peak Season
N. Atlantic & NE Pacific	Hurricane	Jun–Nov
NW Pacific	Typhoon	May–Oct
N. Indian Ocean	Cyclone (Cyclonic Storm)	Apr–Jun & Oct–Dec
SW Indian Ocean	Cyclone	Nov–Apr
SW Pacific & SE Indian	Severe Tropical Cyclone	Nov–Apr
Australia	Willy-willy (informal)	Nov–Apr

The Philippines' state weather agency PAGASA assigns its own local names to typhoons (e.g., 'Tino' for Kalmaegi), independent of the Tokyo Typhoon Center's international names.



Prelims Pointers

- The **Intertropical Convergence Zone (ITCZ)** — where NE and SE trade winds meet — is the breeding ground of tropical cyclones.
- The **'eye' of a cyclone** is a calm central region; it is surrounded by the **eye wall** where winds are strongest.
- Storm surge — abnormal rise in sea level during a cyclone — is the **largest cause of death** in tropical cyclones (e.g., **1970 Bhola cyclone ~5 lakh deaths**).

COPERNICUS SENTINEL-6B — SEA-LEVEL MONITORING MISSION LAUNCHED

Copernicus Sentinel-6B, a joint NASA, ESA and EUMETSAT mission for precise sea-level monitoring, was launched in November 2025. It is the successor to Sentinel-6A 'Michael Freilich' (launched 2020) and together they extend a three-decade-long unbroken satellite record of sea-surface height — one of the most critical datasets in climate science.

News in Brief

- Sentinel-6B is part of the Copernicus Earth Observation Programme of the European Union.
- It carries a high-precision radar altimeter that measures sea-surface height to within a few centimetres — vital for tracking sea-level rise and ocean currents.
- Continuous satellite sea-level measurement began in 1992 with TOPEX/Poseidon, succeeded by Jason-1, Jason-2, Jason-3 and now the Sentinel-6 series.
- Global mean sea level has been rising at 3.7 mm/year (2013–2022 average) and the rate is accelerating.

Prelims Connect

Causes of Sea-Level Rise (IPCC AR6)

Factor	Contribution
Thermal expansion of ocean water	~42% (ocean heats up and expands)
Melting of mountain glaciers	~21%
Melting of Greenland ice sheet	~15%
Melting of Antarctic ice sheet	~8%
Land-water storage (dams, groundwater)	~14%

IPCC AR6 (2021) projects sea-level rise of 0.28–1.01 m by 2100 depending on emission pathway; extreme scenarios involving ice-sheet collapse could push this to 2 m.

Prelims Pointers

- Copernicus is the **EU's Earth Observation Programme** — the Sentinel satellite family covers land, marine, atmosphere, climate, emergency and security domains.
- INCOIS operates **India's satellite-derived sea-level anomaly** products using altimetry data under the Indian Tsunami Early Warning System.
- Thermal expansion is the **dominant cause of 20th-century sea-level rise**; ice-sheet melt is expected to dominate in the 21st century.

INCOIS TO LAY 150 km UNDERWATER CABLE OFF VIZAG FOR OCEAN OBSERVATIONS

The Indian National Centre for Ocean Information Services (INCOIS) is planning to lay a 150 km long fibre-optic cable-based observatory in the Bay of Bengal off Visakhapatnam. The observatory will provide real-time ocean data for tsunami warning, cyclone prediction, marine biology and deep-sea research — making it India's first long-length in-situ ocean monitoring infrastructure.

News in Brief

- INCOIS, based in Hyderabad, is an autonomous body under the Ministry of Earth Sciences.
- It operates the Indian Tsunami Early Warning System (ITEWS), established in October 2007 after the 2004 Indian Ocean tsunami.
- India's existing ocean observing assets include 23 bottom-pressure recorders, 13 tide gauges, over 200 Argo floats, and over 100 data buoys.
- The cable observatory will carry seismometers, pressure sensors and temperature probes along the ocean floor — similar to Japan's S-net and Canada's NEPTUNE systems.

Prelims Connect

India's Ocean Observing Assets

Asset	Purpose	Count
Moored buoys	Met-ocean observations	~13 (NDBP)
Argo floats	Subsurface T & S up to 2000 m	~200
Bottom Pressure Recorders	Tsunami detection	23
Tide gauges	Sea level monitoring	36+ (INCOIS+NIO)
HF Radar	Coastal surface currents	10 stations
Satellite altimetry	Sea surface height	Via OCEANSAT/SARAL

INCOIS issues Potential Fishing Zone (PFZ) advisories, ocean state forecasts, and high-wave alerts in addition to tsunami warnings.

Prelims Pointers

- INCOIS was established in **1999 under the Ministry of Earth Sciences**; it hosts the **Regional Tsunami Service Provider (RTSP)** for the Indian Ocean Rim.
- SARAL (Satellite with Argos and ALtika) is a **joint India–France altimetry mission** for ocean surface topography.
- The **Argo Programme** is a global network of ~4,000 free-drifting profiling floats collecting subsurface ocean data.

CYCLONE BAKUNG OVER INDIAN OCEAN CAUSES UNSEASONAL COLD IN INDIA

Cyclone Bakung intensified over the southeastern Indian Ocean in December 2025 and indirectly caused unseasonal cold weather across parts of northern and central India. Cyclones in the southern hemisphere can influence Indian weather by strengthening moisture-laden winds and altering pressure gradients — a telltale example of teleconnections in regional climate.

News in Brief

- Cyclone Bakung formed in the southern Indian Ocean between Diego Garcia and the West Australian coast.
- It is the first cyclone of the southern hemisphere cyclone season 2025–26; the name is from Indonesia's contribution list.
- The Southern Indian Ocean cyclone season runs November to April — opposite to the North Indian Ocean season.
- Teleconnections like El Niño, La Niña, IOD (Indian Ocean Dipole) and MJO (Madden–Julian Oscillation) can influence Indian weather and monsoon patterns.

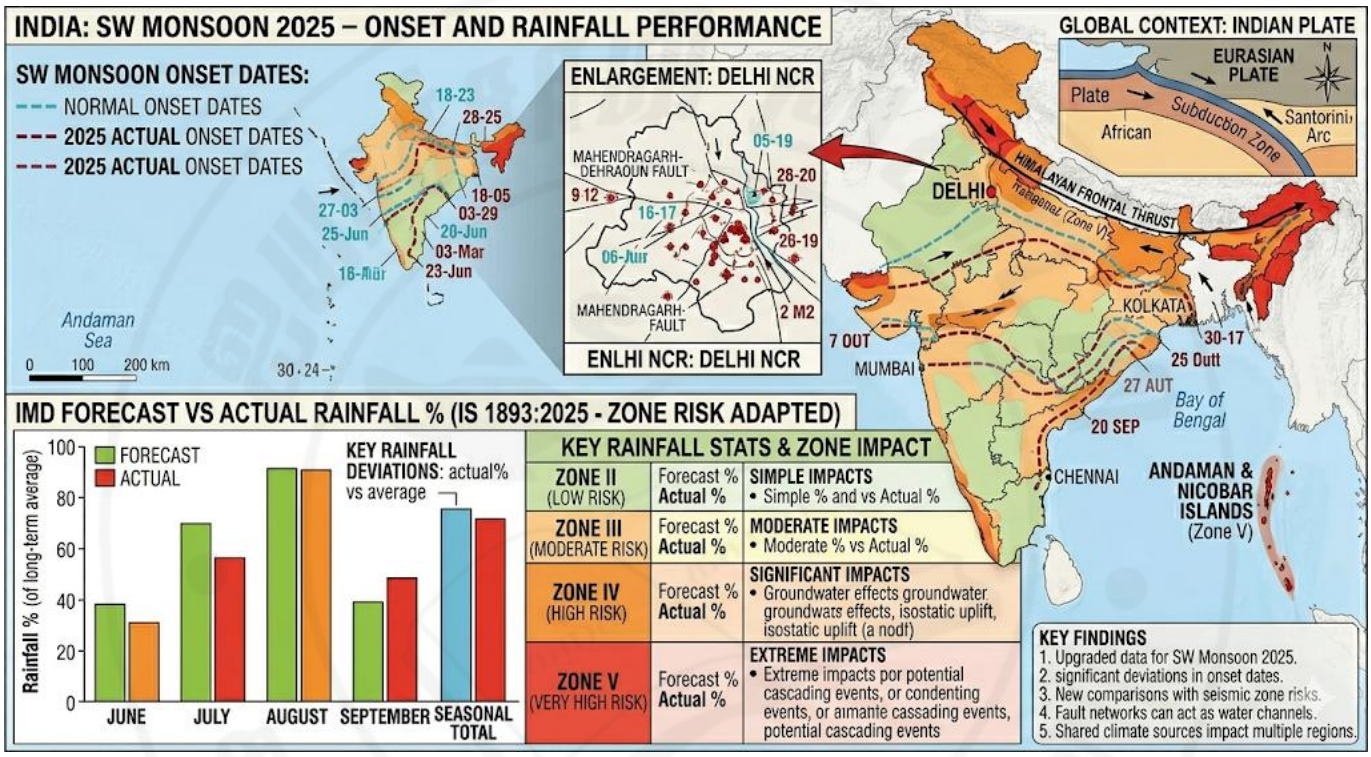
Prelims Connect

Climate Teleconnections Affecting Indian Monsoon

Phenomenon	Nature	Effect on Indian Monsoon

El Niño	Pacific warm phase of ENSO	Weakens SW monsoon — droughts
La Niña	Pacific cool phase of ENSO	Strengthens SW monsoon — floods
IOD+ (Positive)	Warm W. Indian Ocean, cool east	Enhances SW monsoon
IOD− (Negative)	Cool W., warm E. Indian Ocean	Weakens SW monsoon
MJO	Eastward-moving disturbance	Modulates rainfall bursts
Atlantic Niño	Tropical Atlantic warming	Weak influence — indirect

India recorded drought in 2002, 2009, 2014, 2015 — all El Niño years. 2019 had a strong positive IOD that compensated for a weak El Niño, giving above-normal monsoon.



Prelims Pointers

- The **Indian Ocean Dipole (IOD)** was discovered in **1999 by N. H. Saji (alongside B. N. Goswami, P. N. Vinayachandran, and Toshio Yamagata).** and is measured by the **Dipole Mode Index (DMI)**.
- ENSO operates on a **2–7 year cycle**; it is the strongest climate mode after the annual cycle.
- The **Madden–Julian Oscillation (MJO)** is the main intra-seasonal (30–60 day) mode of tropical variability.

TROPICAL CYCLONE INTENSIFIES OFF WESTERN AUSTRALIA — INDIAN OCEAN SYSTEM

A tropical low formed over the Indian Ocean off Western Australia intensified into a tropical cyclone in January 2025, drawing attention to the South-East Indian Ocean cyclone basin. Australia is affected on average by 11 tropical cyclones per year — most of them in the north-west (off the Pilbara coast) and the north-east (Coral Sea).

News in Brief

- The Australian region cyclone season runs from November to April.
- The Bureau of Meteorology (BOM) Australia is the primary forecasting agency and assigns local cyclone names.
- Australia's most intense cyclone was Severe Tropical Cyclone Monica (2006), Category 5, with wind gusts over 300 km/h.
- Since 2017, the Perth Tropical Cyclone Warning Centre uses the Australian Tropical Cyclone Intensity Scale (Category 1–5).

Prelims Connect

Tropical Cyclone Formation — The Six Conditions

Condition	Requirement
Warm sea surface temperature	≥ 26.5°C extending to ~50 m depth
Coriolis force	At least 5° latitude from equator
Low vertical wind shear	<10 m/s through the troposphere
Pre-existing disturbance	Tropical wave, ITCZ trough
Moist mid-troposphere (700 hPa)	Humidity supports deep convection
Oceanic thermal structure	Deep warm layer prevents cold upwelling

These six conditions were proposed by William Gray (1968) and remain the standard climatological checklist for cyclogenesis.

Prelims Pointers

- The **Leeuwin Current** is a warm ocean current that flows southward along the west coast of Australia — unlike most eastern-boundary currents which are cold.
- The **Pilbara coast of Western Australia** has the world's highest cyclone-landfall rate for a single region.

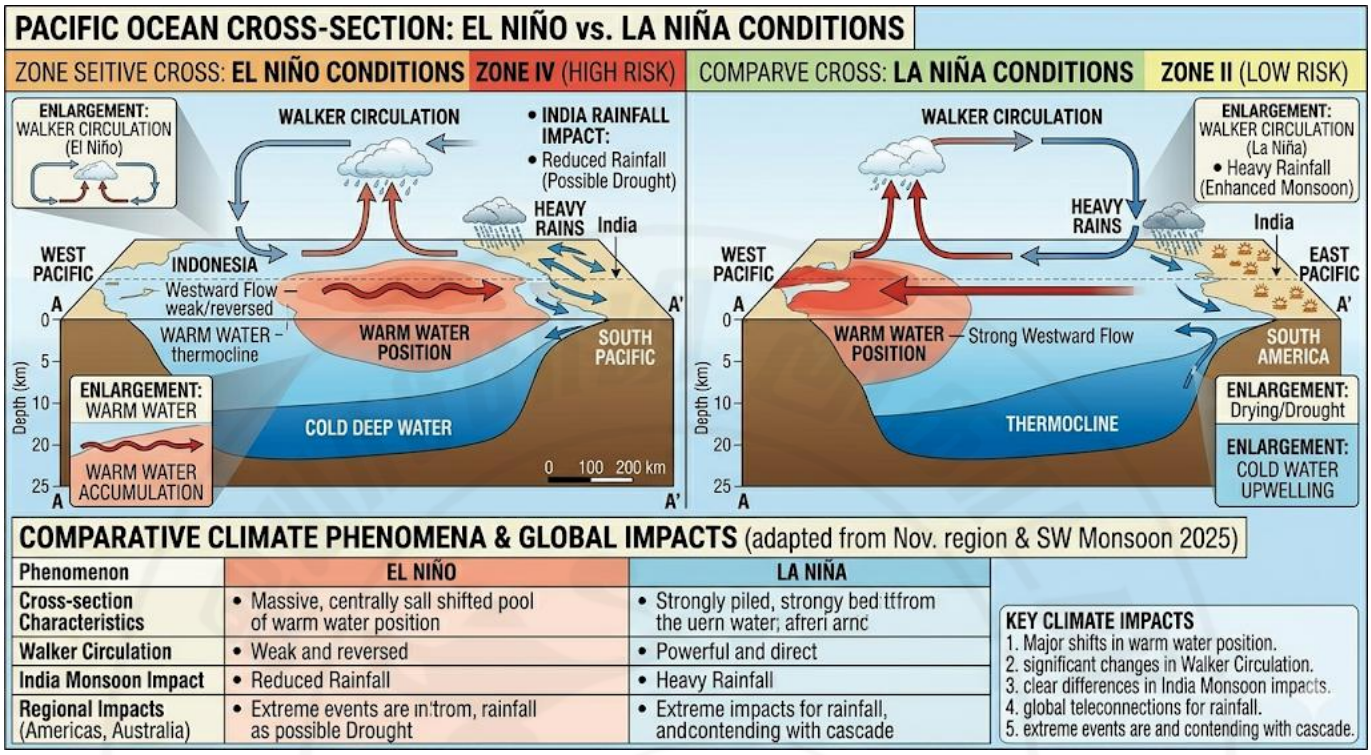
SOUTHWEST MONSOON 2025 — EARLY ONSET AND ABOVE-NORMAL RAINFALL

IMD announced the monsoon onset over Kerala one week earlier than normal (before June 1) in 2025. India received 8% more monsoon rainfall (June–September) than the Long Period Average — the fifth-highest since 2001 and 38th highest since 1901.

News in Brief

- Early arrival in the Andaman Sea does **not guarantee** early onset over Kerala. IMD uses **rainfall amount, wind speed and direction, and outgoing longwave radiation** to declare monsoon onset.
- A **low-pressure system over the Arabian Sea** favoured early monsoon advancement; **La Nina-like conditions** in the Pacific were expected to bring good monsoon rainfall.
- Seasonal rainfall: **27% more in northwest India**, 15% more in central India, 10% more in south peninsula; Eastern and northeastern India received only 80% of usual rainfall.
- There were **7 monsoon depressions** (sub-cyclonic storms); one intensified into a deep depression.

- Heavy rainfall spells were due to **storms from the Mediterranean region** combining with the monsoon trough.
- This marked the **second consecutive year of above-normal rainfall**.
- **Long Period Average (LPA)**: Average rainfall recorded during June to September over a **50-year period** — benchmark for seasonal monsoon forecasts.
- **Southwest Monsoon** is primary rainy season, contributing over **70% of annual rainfall** between June–September.



Prelims Connect

Key Factors Influencing the Indian Monsoon

Factor	Effect on Indian Monsoon
El Nino (warmer E. Pacific)	Weakens SW monsoon — drought tendency
La Nina (cooler E. Pacific)	Strengthens SW monsoon — above-normal rainfall
Positive IOD (warm Arabian Sea)	Enhances SW monsoon — warmer W. Indian Ocean vs E.
MJO (Madden-Julian Oscillation)	Modulates active and break spells (30–60 day cycle)
Somali Jet	Strong Somali jet strengthens monsoon winds over western India
Mascarene High	High-pressure in S. Indian Ocean drives moisture northward towards India
North America warming	Enhances North Pacific High and Hadley circulation — indirect monsoon influence

India recorded drought in 2002, 2009, 2014, 2015 — all El Nino years. 2019 had a strong positive IOD that compensated for weak El Nino, giving above-normal monsoon.

Prelims Pointers

- **Madden–Julian Oscillation (MJO)**: identified in 1971 by Roland Madden and Paul Julian; moves eastward at 4–8 m/s; circles the globe in **30–60 days**. In a favourable phase, enhances rainfall over India.
- **Mascarene High** is a high-pressure area around Mascarene Islands (south Indian Ocean); variation in its intensity is responsible for heavy rains along India's west coast.
- **Somali jet** is a low-level inter-hemispheric cross-equatorial wind band originating near Mauritius and north Madagascar; a strong Somali jet is associated with strengthening of monsoon winds.
- Monsoon winds first reach the Andaman Sea and Bay of Bengal around the **third week of May**; IMD declares onset when it reaches Kerala (normal date: **June 1**); by around **July 15**, monsoon typically covers the entire country.
- **Arabian Sea Mini Warm Pool (MWP)**: Patch of warm sea surface temperatures (>28.5°C) near Kerala coast; forms every year during April–May; acts as a **self-correcting mechanism** helping monsoon recover from El Nino disruption.

EL NINO AND HEAVY RAINS — PARADOX OF DROUGHT AND DELUGE

A new study reveals that El Nino, though known for reducing total rainfall across India, also increases the intensity of heavy downpours in wetter parts of central and southwest India — creating a paradox of drought and deluge in the same season.

News in Brief

- The study analysed **daily rainfall data from 1901 to 2020** and found that during **El Nino years**, extreme rainfall events become **more frequent** even as light and moderate rain events decline.
- This indicates that **El Nino drought years can still bring catastrophic floods** — challenging the simple 'El Nino = drought' narrative.
- **Arabian Sea Mini Warm Pool (MWP)** acts as a **self-correcting mechanism** that helps the monsoon recover from disruptions caused by the previous El Nino.
- **Northeast Monsoon**: Season's share in annual rainfall is **48% for Tamil Nadu** and over **30% for Andhra Pradesh**. The monsoon witnesses at least three cyclonic disturbances over the Bay of Bengal.
- **Tamil Nadu and Kerala** depend on two different monsoon systems: Kerala on SW Monsoon (June–Sept), Tamil Nadu on NE Monsoon (Oct–Dec) — issues arise when these two systems overlap.

Prelims Connect

Northeast Monsoon — Impacts and Urban Flooding

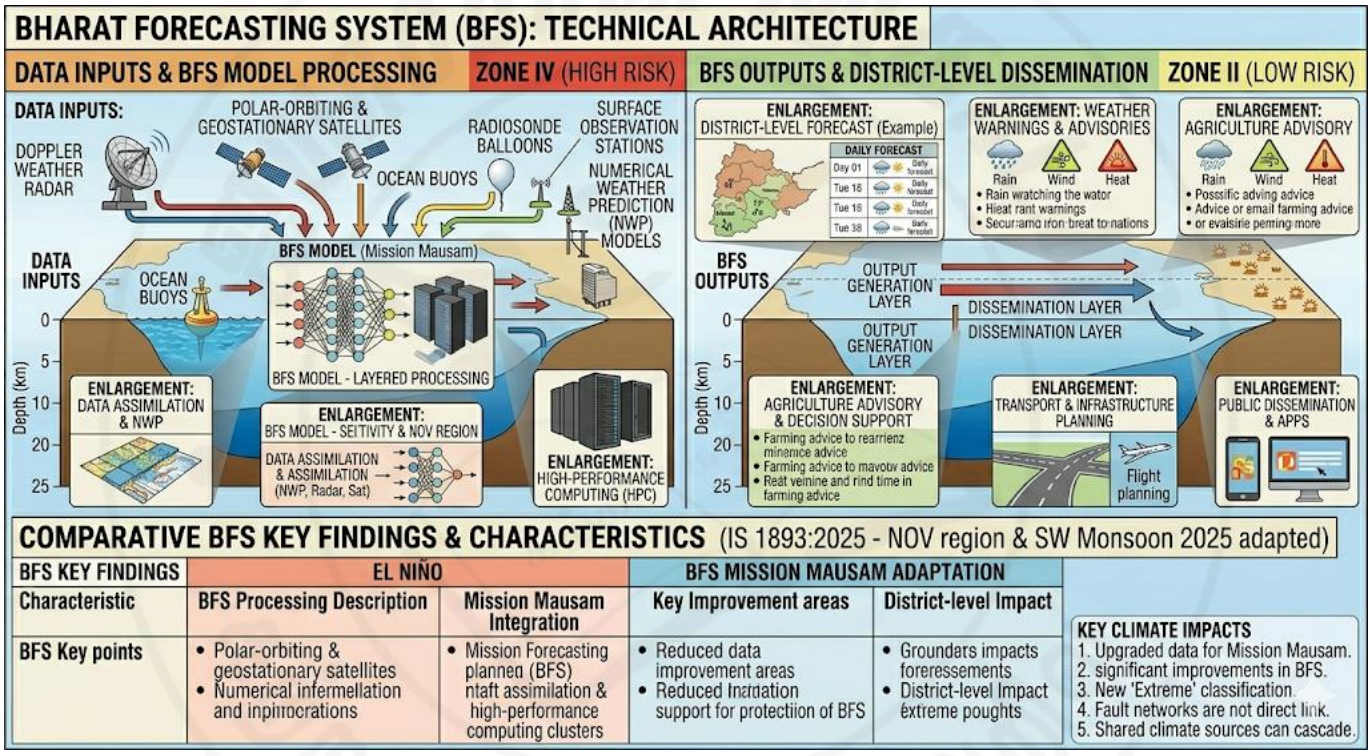
State	Share of Annual Rainfall from NE Monsoon	Key Risk
Tamil Nadu	48%	Urban flooding, cyclones (e.g., Cyclone Michaung 2023)
Andhra Pradesh	30%+	Storm surges, coastal flooding
Kerala	Receives both SW and NE monsoon	Flash floods, landslides, overlapping monsoon systems

Prelims Pointers

- **ENSO** (El Nino Southern Oscillation) operates on a **2–7 year cycle**; it is the strongest climate mode after the annual cycle.
- **Positive IOD** — when the Arabian Sea is warmer than the Bay of Bengal — is favourable for Indian monsoon; **Negative IOD** weakens it.
- Urban areas with concrete and asphalt surfaces cause **rapid runoff, overwhelming drainage systems** — example: Cyclone Michaung (2023) flooding in Chennai.
- Excess water leads to sewage overflows, releasing untreated wastewater into streets and waterbodies. **Persistently high water table** compromises stability of building foundations and roads.
- **Waterlogged soil** suffocates roots, washes away seeds, young crops, and nutrient-rich topsoil; fungal diseases and pests spread easily.

BHARAT FORECASTING SYSTEM (BFS) AND MISSION MAUSAM

The government unveiled the Bharat Forecasting System (BFS) for improved weather prediction, developed by the Pune-based Indian Institute of Tropical Meteorology (IITM). IMD is also rolling out Mission Mausam to upgrade India's weather observation network with a Rs 2,000 crore outlay till 2026.



COMPARATIVE BFS KEY FINDINGS & CHARACTERISTICS (IS 1893:2025 - NOV region & SW Monsoon 2025 adapted)

BFS KEY FINDINGS	EL NIÑO		BFS MISSION MAUSAM ADAPTATION	
Characteristic	BFS Processing Description	Mission Mausam Integration	Key Improvement areas	District-level Impact
BFS Key points	• Polar-orbiting & geostationary satellites • Numerical infermellation and inpiiocrations	• Mission Forecasting planneo (BFS) ntaft assimilation & high-performance computing clusters	• Reduced data improvement areas • Reduced Inaiaation support for protectiion of BFS	• Grounders impacts foreressements • District-level Impact extreme poughts

KEY CLIMATE IMPACTS
1. Upgraded data for Mission Mausam.
2. significant improvements in BFS.
3. New 'Extreme' classification.
4. Fault networks are not direct link.
5. Shared climate sources can cascade.

News in Brief

- **BFS** will provide weather forecasts with a **6 km resolution** — the highest in the world. The older model used **12-km grids**. India is the only country to offer operational weather forecasts at **6 km x 6 km** resolution.
- BFS was made possible by the installation of the new supercomputer **'Arka'**. Improvements are in **short and medium-term forecasts** (3 and 7 days), not in long-range (monthly) forecasts.
- **Mission Mausam**: To improve atmospheric observations; enable better-quality monsoon forecasts; improve air quality alerts; warn of extreme weather events and cyclones. **Nodal agency: Ministry of Earth Sciences**.
- Mission Mausam elements: **Next-generation radars, satellite systems, high-performance supercomputers, earth-system models, GIS-based Decision Support System**.

- Implementing agencies: **IMD, IITM Pune, National Centre for Medium-Range Weather Forecasting (NCMRWF)**.
- By 2026, plans include **60 weather radars, 15 wind profilers, and 15 radiosondes**.
- **IMD** was established in **1875** to centralise meteorological work, following the Calcutta cyclone (1864) and monsoon failures (1866, 1871). **H.F. Blanford** was the 1st Meteorological Reporter.

Prelims Connect

IMD — Key Improvements Since 2014

Metric	Status in 2014	Status in 2024
Cyclone prediction window	1–3 days	7 days
Heavy rainfall forecast accuracy	~50%	~80%
Thunderstorm forecast accuracy	~60%	~86%
Heat/Cold wave accuracy	~65%	~88%
Doppler radar coverage	13 radars	39 radars (target 50+ under Mission Mausam)

National Monsoon Mission (2012, Ministry of Earth Sciences): Improves seasonal and intra-seasonal monsoon forecasts; participating institutions include IMD, INCOIS, IITM. Note: 'Project Mausam' is different — it is under Ministry of Culture (ASI) to reconnect maritime cultural ties among 39 Indian Ocean countries.

Prelims Pointers

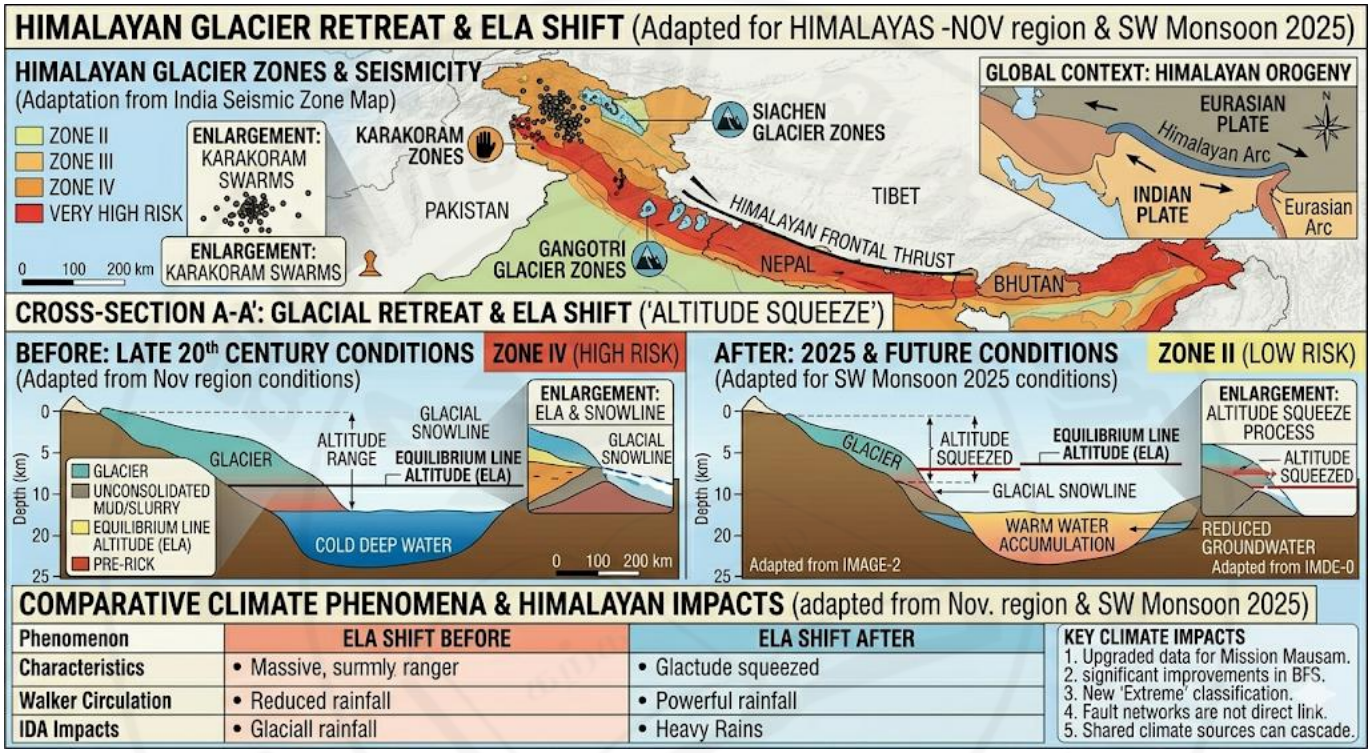
- **Doppler Weather Radars** detect and track precipitation by emitting microwave pulses and measuring the Doppler effect, which reveals velocity and movement of precipitation particles. **34 Doppler Weather Radars** are being installed under Mission Mausam.
- **Wind Profilers** are radars that measure wind speed at various altitudes — aid weather predictions and aviation safety. **Radiosondes** are devices attached to balloons that measure temperature, pressure, and humidity.
- **Cloud-Simulation Chamber** at IITM Pune allows scientists to study artificial clouds and weather modification experiments.
- **CAIPEEX** (Cloud Aerosol Interaction and Precipitation Enhancement Experiment, 2009–19): By IITM Pune; conducted trials over Solapur, Maharashtra. Used **calcium chloride** (not silver iodide) to seed clouds.

CLIMATE CHANGE AND HIMALAYAS — ALTITUDE SQUEEZE AND GLACIAL HAZARDS

The Himalayas are warming faster than the global average — at 0.15°C to 0.60°C per decade. Glacial lake outbursts, landslides, floods, wildfires, and earthquakes are becoming increasingly frequent, endangering millions across 12 Indian Himalayan States and UTs.

News in Brief

- **90% of the Himalayas** could experience year-long droughts if global warming exceeds **3°C**.
- Wildlife faces an **'altitude squeeze'** — warming pushes species such as musk deer and snow trout to higher elevations, threatening biodiversity.
- **State of Climate in Asia 2024 report** (WMO): Asia experienced its **warmest or second warmest year** on record in 2024, with average temperature **1.04°C above** the 30-year average; Asia is warming **nearly twice as fast** as the global average.
- 2024 led to **29 tropical cyclones**, prolonged heat waves, and extreme rainfall events in Asia; India also experienced deadly lightning events, killing about **1,300 people**.
- **23 out of 24 glaciers** in High Mountain Asia (Himalayas, Pamir, Karakoram, Hindu Kush) are showing retreat.
- **ISRO's Landslide Atlas of India (2023)**: 12.6% of India's geographical area is landslide-prone; **66.5% in North-western Himalayas**, 18.8% in North-eastern Himalayas, and 14.7% in the Western Ghats.
- **Yala Glacier (Nepal)** has shrunk by **66% since the 1970s** — likely to become one of Nepal's first 'dead' glaciers. The world's first **glacier funeral** was held for **Okjokull Glacier in Iceland in 2019**.



Prelims Connect

Glacial Lake Outburst Floods (GLOFs) — India and Region

Year	Location	Cause	Impact
2013	Chorabari Lake, Kedarnath (UK)	Cloudburst + moraine breach	Mass casualties; infrastructure loss
2021	Raunthi, Chamoli (UK)	Glacier-rock avalanche	Tapovan dam destroyed; ~200 deaths
2023	South Lhonak Lake, Sikkim	Cloudburst-induced breach	Chungthang dam washed away; 80+ dead

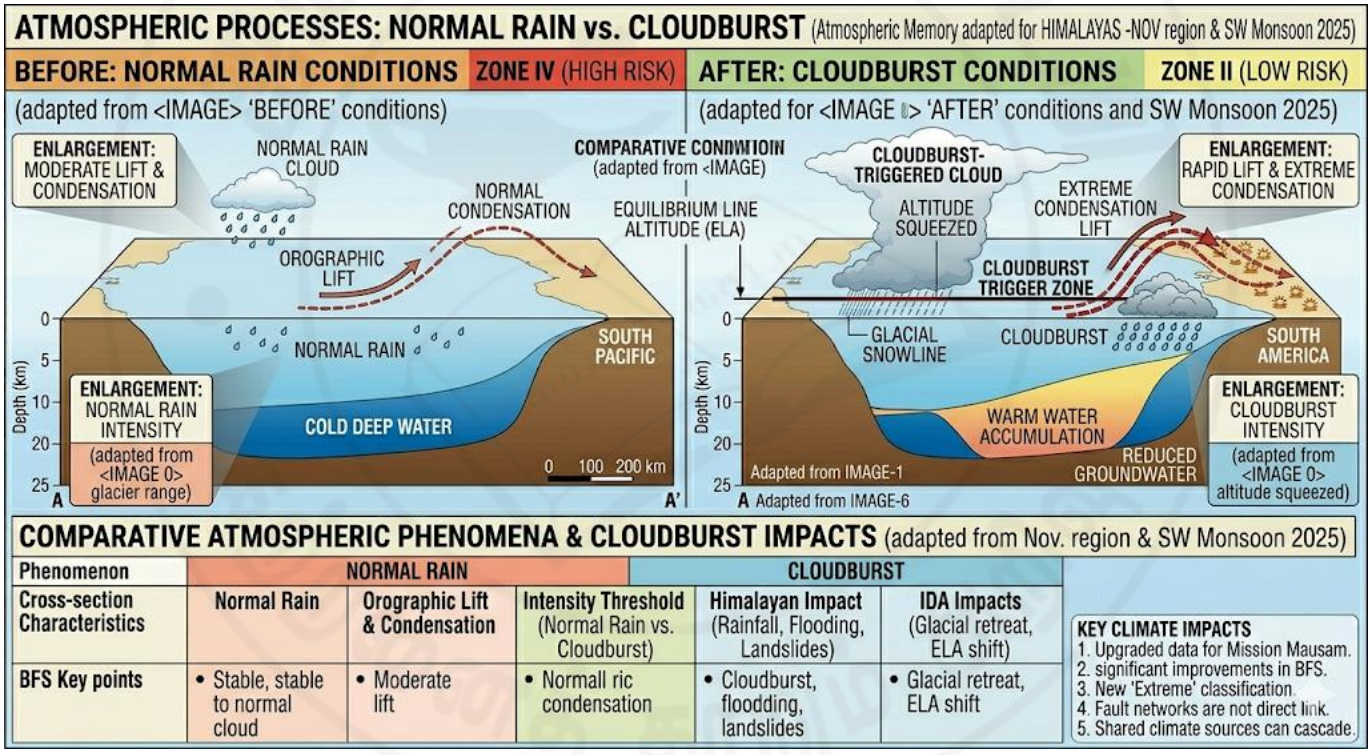
2025	Lende river, Nepal	GLOF	China-built bridge destroyed; 4 hydropower plants disabled — 8% of Nepal's power

Prelims Pointers

- India's Himalayan region hosts **28,000 glacial lakes — 7,500 in India alone**. Types: **Supraglacial lakes** (on glacier surface) and **Moraine-dammed lakes** (dammed by loose debris — vulnerable to failure).
- **United Nations** has declared **2025 as the International Year of Glaciers' Preservation**.
- **NDMA's Committee on Disaster Risk Reduction** targets **195 high-risk glacial lakes**; 40 top-risk lakes surveyed in 2024 using UAVs, bathymetry, and ERT (Electrical Resistivity Tomography) to detect ice cores in moraine dams.
- **Consequences of glacial loss**: Reduced albedo effect (increased heat absorption); melting glaciers caused nearly **2 cm of global sea level rise since 2001**; glaciers store nearly **75% of Earth's freshwater**.
- Unlike rural flooding, **urban flooding** is more severe — developed land can increase flood peaks by **1.8 to 8 times** and flood volumes by up to **6 times**.

CLOUDBURSTS, MINI-CLOUDBURSTS AND ATMOSPHERIC MEMORY

New research shows there is no increasing trend in traditional cloudbursts but a notable increase in 'mini-cloudbursts.' A separate study found that atmospheric memory — not just sunlight — drives the onset and retreat of monsoons.



News in Brief

- **Cloudburst** — technical definition: rainfall of **10 cm or more in one hour** over roughly a **10 km x 10 km area**. More common in hilly areas due to **orographic lift** — warm air rises up a mountainside, expands, cools, and releases moisture; delayed uplift causes sudden massive downpour.

- **Mini-cloudbursts**: sudden, highly localised intense rainfall events with **~5 cm (50 mm) or more in one hour** over 20–30 sq. km; less severe than cloudbursts but can trigger flash floods and landslides. Difficult to predict due to small scale and short duration.
- **Cloud Seeding**: Delhi conducted two cloud seeding trials in collaboration with **IIT Kanpur** — first in nearly 50 years. Technique: spraying salt mixtures (**sodium chloride, calcium chloride, or silver iodide**) into clouds as condensation nuclei.
- **Atmospheric memory study**: Atmosphere stores physical information as **water vapour**, controlling onset and withdrawal of monsoon. The **state of the atmosphere depends on its seasonal history** — this behaviour is called **bistability** (at the same solar radiation, atmosphere can be dry or rainy depending on preceding state).
- **Thirstwave**: Three or more consecutive days of **high evaporative demand**. Unlike heatwaves, thirstwaves are influenced by a combo of temperature, humidity, solar radiation, and wind speed. Global warming is making thirstwaves more intense, frequent, and longer.

Prelims Connect

Cloud Seeding — Historical Timeline in India

Year	Event
1952	First experiment led by S.K. Banerji (DG IMD) in Kolkata using hydrogen balloons with salt and silver iodide
1962	Attempt in Delhi failed due to inadequate conditions
1970s	Aircraft-based seeding experiments began alongside cloud microphysics studies
2009–19	CAIPEEX by IITM Pune — first scientific quantification trials over Solapur, Maharashtra
2025	Delhi cloud seeding trials with IIT Kanpur — after nearly 50-year gap

Prelims Pointers

- In the 1940s, GE scientists **Schaefer and Vonnegut** discovered dry ice could create ice crystals — led to **Project Cirrus**; U.S. later started **Project Skywater** using silver iodide.
- **China** famously deployed cloud seeding for the **2008 Beijing Olympics** to prevent rain. Soviet used it to ensure clear skies during May Day parades.
- **Main limitation of cloud seeding in India**: Absence of suitable moisture-rich monsoon clouds during post-monsoon season. CAIPEEX findings: only clouds with **sufficient water content** can produce meaningful rainfall after seeding.
- **Evaporative demand** determines how much water would evaporate or transpire if water were freely available — measured using standardised short-crop evapotranspiration.
- **Cold Wave**: When minimum temperature of a station is **<=10°C or less in plains** and **0°C or less in hilly regions**, or when temperatures dip **4.5°C to 6.4°C below normal**.
- **Polar Vortex**: Area of low pressure — wide expanse of swirling cold air parked in polar regions. During winter, it expands, sending cold air southward — linked to cold waves.

HURRICANE MELISSA — RECORD-TYING WINDS AT JAMAICA

Hurricane Melissa struck Jamaica with record-tying 296 kmph winds — equalling 2019's Hurricane Dorian and the 1935 Labour Day storm. Melissa made landfall as a Category 3 storm, prompting evacuations in eastern Cuba.

News in Brief

- Hurricane warning was in effect for **Granma, Santiago de Cuba, Guantanamo, Holguin, and Las Tunas** provinces of Cuba.
- Its **central pressure measurement tied the 1935 Labour Day storm**; **296 kmph winds** equalled Hurricane Dorian (2019) and the 1935 storm. **Hurricane Allen (1980) reached 304 kmph**, but not at landfall.
- Melissa showed signs of entering an **eyewall replacement cycle** — inner eyewall is surrounded and replaced by an outer, larger rainband; while storms often weaken during transition, Melissa did **not weaken**.
- A **hurricane** is a tropical cyclone with a low-pressure centre, winds **>=119 km/h**, heavy rain, and a distinct eye; classified on **Saffir–Simpson scale (Category 1–5)**; **Category 3+** are major hurricanes.
- **Super Typhoon Ragasa** made landfall on Calayan Island in the Babuyan Islands of the Philippines; sustained winds of 215 km/h and gusts up to 295 km/h. **Super Typhoon**: tropical cyclone with maximum wind speed exceeding **185 kph** or more than **100 knots**.

Prelims Connect

Cyclone Alert Colour Coding System

Colour Alert	Level	Meaning
Green	All is Well	No severe weather; no action required
Yellow	Be Aware	Potential disruptions due to moderately bad weather; caution advised
Orange	Be Prepared	Likely extremely bad weather causing significant disruptions
Red	Take Action	Hazardous weather posing life risks; immediate action and preparedness required

Prelims Pointers

- **Saffir–Simpson scale**: Category 1 (74–95 mph), Category 2 (96–110 mph), Category 3 (111–129 mph), Category 4 (130–156 mph), Category 5 (157+ mph); **only measures wind speed** — NOT storm surge, flooding, or rainfall.
- Cyclone names in North Indian Ocean are decided by **WMO/ESCAP Panel** — a group of **13 countries** (India, Bangladesh, Myanmar, Oman, Pakistan, Sri Lanka, Thailand, UAE, Yemen, Iran, Maldives, Qatar, Malaysia). Names chosen in rotation.
- **Cyclone Montha** (suggested by Thailand) hit the Andhra Pradesh coast near Kakinada. **Cyclone Senyar** ('lion' in Arabic, submitted by UAE) was the second cyclone in the North Indian Ocean post-monsoon season, developing near the **Strait of Malacca**.
- **Cyclone Ditwah**: Name meaning 'a lagoon', suggested by Yemen — likely derived from **Detwah Lagoon on the northwest coast of Socotra**.

ODISHA'S CYCLONE VULNERABILITY AND COASTAL RESILIENCE

Odisha's 575-kilometre coastline lies in one of the world's six most cyclone-prone regions. Over the past century, nearly 260 cyclones have struck the State, with major improvements in preparedness achieved through zero-casualty cyclone models.

News in Brief

- Major cyclones affecting Odisha: **1999 Super Cyclone**, Phailin (2013), Titli (2018), **Fani (2019)**, and Yaas (2021).
- **Storm surges** and saltwater intrusion degrade fertile soils and wetlands; rising seas prolong saline flooding, reducing agricultural yields.
- **Mangroves, wetlands, and tidal buffers** can cut wave energy by **up to 90%**, offering critical ecological security.
- Odisha's UN-backed **mangrove restoration** and climate-smart aquaculture — from mud-crab farming to rice intensification — demonstrate how adaptation can sustain livelihoods.
- The **North Indian Ocean basin** (Arabian Sea + Bay of Bengal) is prone to cyclones during **pre-monsoon (March–May)** and **post-monsoon (October–December)** periods.

Prelims Connect

North Indian Ocean — Changing Cyclone Patterns

Trend	Details
Overall frequency	Has decreased, but severity has intensified — fewer but stronger storms
Arabian Sea activity	Increasing; historically fewer storms than BoB but tend to be more severe
Bay of Bengal seasonality	Disturbances increasingly originating in October–December instead of July–September
Sea surface warming	Arabian Sea heating faster than average — storms stronger and harder to predict

Prelims Pointers

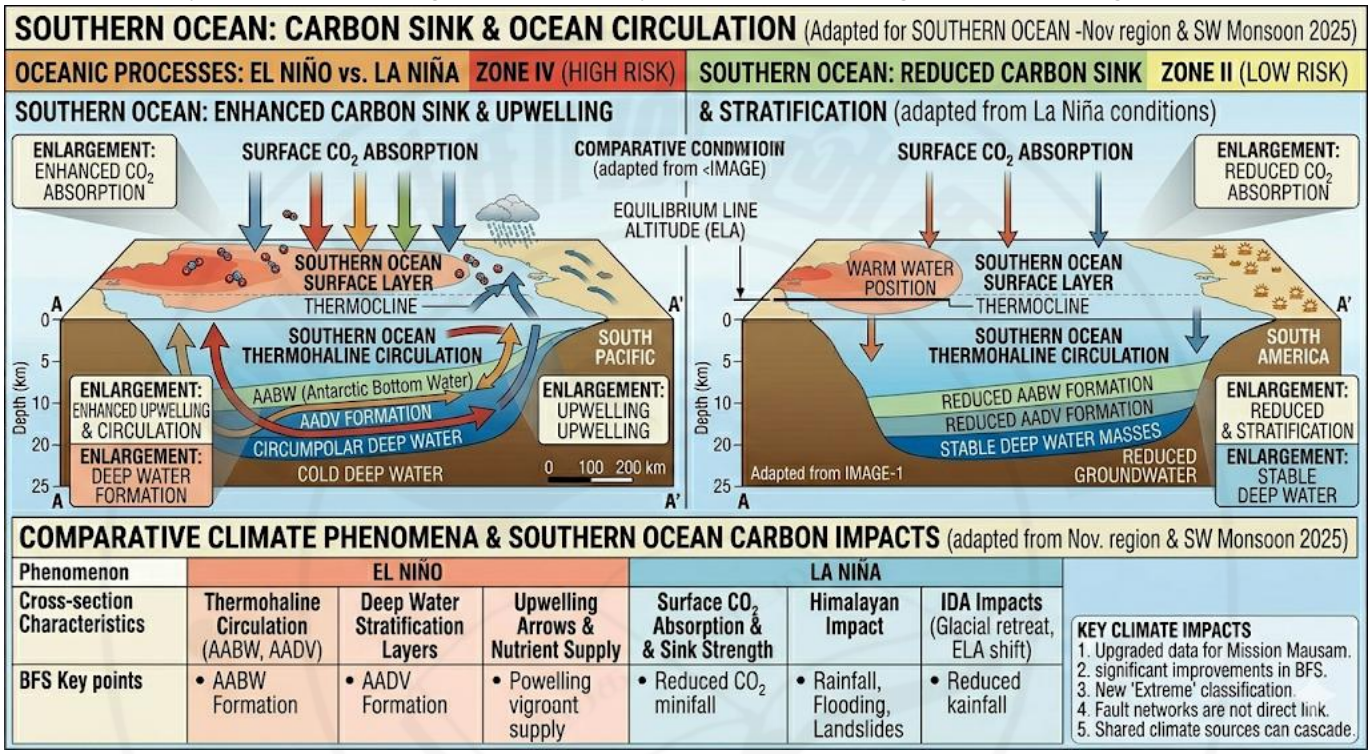
- Cyclone is characterised by **inward spiralling winds** that rotate **anticlockwise in the Northern Hemisphere** and **clockwise in the Southern Hemisphere**.
- Bay of Bengal's **funnel-like shape and warmer waters** make it more prone to cyclones; **complex coastal features** like estuaries and deltas amplify storm surges.
- **IMD New Delhi** is the **Regional Specialised Meteorological Centre (RSMC)** for tropical cyclones in the North Indian Ocean — responsible for issuing cyclone alerts for 13 countries.
- **Meteorological agencies** can predict a cyclone's track **3–5 days in advance** with reasonable accuracy.

SOUTHERN OCEAN — CARBON SINK AND STRATIFICATION DYNAMICS

The Southern Ocean plays an outsized role in regulating Earth's climate — covering roughly 25–30% of the global ocean area and absorbing about 40% of all human-emitted carbon dioxide that the oceans absorb. New research reveals unexpected mechanisms protecting this carbon sink.

News in Brief

- The Southern Ocean's ability to absorb CO2 comes from its **cold and relatively fresh surface layers**, which sit above **warmer, saltier, carbon-rich reservoirs** — allowing it to trap more CO2 than it emits.
- Earlier climate models assumed that intensification of the **meridional overturning circulation** would weaken the carbon sink; new analysis found that even with rising deep waters, the ocean was **not emitting more CO2** — explained by a **thin layer of freshwater at the surface**.
- Over recent decades, the Southern Ocean has become **fresher** due to more rainfall and **meltwater from Antarctica's glaciers**; fresher water is lighter and **strengthens stratification** between surface and deeper waters.
- This stratification has prevented **carbon-rich deep water** from being exposed to the atmosphere — a stabilising mechanism.
- However, if stratification erodes, the **deep carbon dioxide reservoir** is now closer to the surface — carbon expected by models decades ago could suddenly appear, accelerating climate warming.



Prelims Connect

Global Drought Outlook 2025 — Key Data (Released by OECD)

Metric	Data Point
Land area facing frequent severe droughts	40% of world's land area
Annual increase in economic cost of droughts	3%–7.5% per episode
Crop yield decline potential	Up to 22%
Global land with soil moisture decline since 1980	37%

Monitored aquifers experiencing groundwater decline	62%
Disaster-related deaths attributable to droughts (WMO 2021)	34%

Prelims Pointers

- Droughts are responsible for **34% of disaster-related deaths globally** (WMO, 2021). Recent examples: Europe (2022), California (2021), **Horn of Africa and Somalia**.
- **Consequences of glacial loss**: Reduced albedo effect; melting glaciers caused nearly **2 cm of global sea level rise since 2001**; glaciers store nearly **75% of Earth's freshwater**.
- **Cold Wave in India**: Minimum temperature of a station is **<=10°C or less in plains** and **0°C or less in hilly regions**, or when temperatures dip **4.5°C to 6.4°C below normal**.
- **Yala Glacier (Nepal)**: Shrunk by **66% since the 1970s**; other dead glaciers — Pizol (Switzerland, 2019), Clark (US, 2020), Ayoloco (Mexico, 2021). **World's first glacier funeral**: Okjokull Glacier in Iceland (2019).

STRATOSPHERIC AEROSOL INJECTION (SAI) AND SOLAR GEOENGINEERING

Stratospheric Aerosol Injection (SAI) involves injecting aerosols into the stratosphere to reflect sunlight and cool the planet — inspired by volcanic eruptions that naturally cool Earth. A new approach proposes lower-altitude injections (13 km) in polar regions, potentially cheaper and faster.

News in Brief

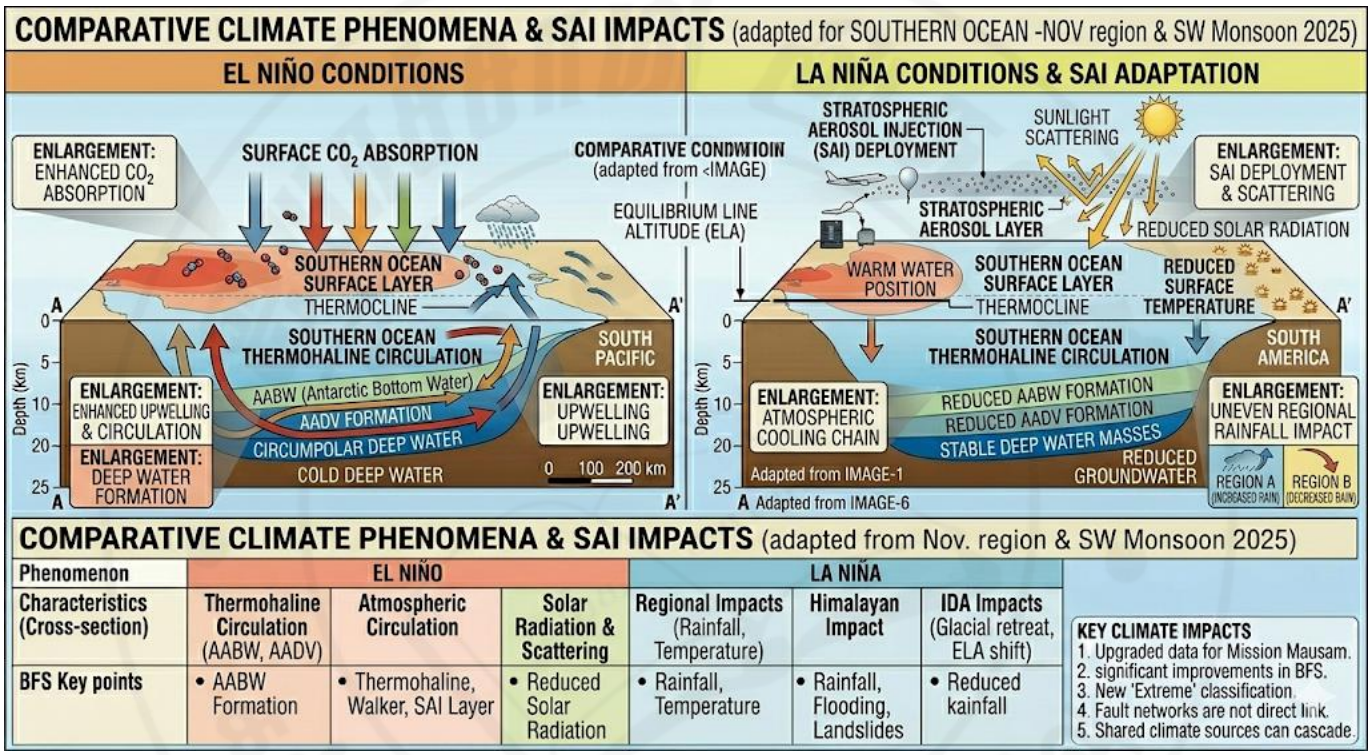
- Traditional SAI focuses on **high-altitude injections (20 km+)**, requiring specially designed aircraft; new approach proposes **13 km injections** at lower cost in polar and extratropical regions.
- **12 million tonnes/year** of sulphur dioxide or calcium carbonate at 13 km could **cool the planet by 0.6°C**.
- Challenges: May cause **ozone depletion, acid rain, delayed ozone hole recovery**; cooling effect stronger at poles but less effective in tropics where warming is most severe.
- **Risk of termination shocks** — sudden temperature spikes if SAI is stopped; could disrupt global weather patterns, affecting food and national security.
- Other Solar Climate Intervention Methods: **Sea Curtains/Walls** (block warm ocean water from reaching ice), **Sea Ice Management** (glass microbeads to increase ice reflectivity), **Basal Water Removal** (remove subglacial water to slow ice movement), **Ocean Fertilisation** (add iron to stimulate phytoplankton, absorb CO2).
- **Ocean Fertilisation** concern: uncontrolled phytoplankton growth disrupts food chains and nutrient cycles.
- **Sea Ice Management** requires **360 million tonnes of glass microbeads annually** — equal to global plastic production; ecotoxicity concerns for zooplankton.

Prelims Connect

Solar Climate Intervention Methods — Summary

Method	Mechanism	Key Concern

Stratospheric Aerosol Injection	Inject SO2 or CaCO3 to reflect sunlight	Ozone depletion; acid rain; termination shock
Sea Curtains / Walls	Block warm ocean water from reaching ice	High logistics cost; affects ocean circulation
Sea Ice Management	Glass microbeads increase ice reflectivity	Ecotoxicity; 360 MT microbeads needed annually
Basal Water Removal	Remove subglacial water to slow ice flow	Emissions-intensive; limited impact
Ocean Fertilisation	Add iron to stimulate phytoplankton CO2 absorption	Uncontrolled algal growth; disrupts nutrient cycles



Prelims Pointers

- **SAI is suggested as a supplement to emissions reductions, not a replacement** — geoengineering cannot substitute deep decarbonisation.
- SAI is **ineffective in polar winters** (no sunlight to reflect) and **redundant in summers** due to existing natural reflectivity.
- The **Tropic of Cancer** passes through **17 countries** across 3 continents. In India, it passes through **8 states**: Gujarat, Rajasthan, Madhya Pradesh, Chhattisgarh, Jharkhand, West Bengal, Tripura, and Mizoram.
- **Thirstwave** (coined by Meetpal Kukal and Mike Hobbins): Three or more consecutive days of high evaporative demand. Unlike heatwaves, influenced by temperature, humidity, solar radiation, and wind speed together.

INDIAN GEOGRAPHY

WORLD'S HIGHEST RAILWAY BRIDGE OVER CHENAB INAUGURATED

Prime Minister Narendra Modi inaugurated the Chenab Rail Bridge in June 2025 — the world's highest single-arch railway bridge, built over the Chenab river in Reasi district, Jammu and Kashmir. Rising 359 m above the river-bed (35 m taller than the Eiffel Tower), it is the crowning achievement of the Udhampur–Srinagar–Baramulla Rail Link (USBRL) project that finally connects the Kashmir Valley to the rest of the Indian railway network.

News in Brief

- The Chenab Bridge is 1,315 m long, 359 m above the river-bed, and uses a 467 m main arch of steel weighing over 10,600 tonnes.
- It is part of the 272 km Udhampur–Srinagar–Baramulla Rail Link (USBRL) project — declared a National Project in 2002.
- The bridge is designed to withstand earthquakes up to Zone V and winds up to 266 km/h.
- Its construction took over 20 years and used blast-resistant steel; it opens direct train services between Delhi and Srinagar.

Prelims Connect

Chenab River — Key Facts

Aspect	Details
Origin	Confluence of Chandra and Bhaga rivers at Tandi, Himachal Pradesh
Length	~960 km (660 km in India)
Basin states	Himachal Pradesh, Jammu & Kashmir, Pakistan (joins Sutlej)
Major dams	Baglihar, Salal, Dul Hasti, Pakal Dul, Sawalkote (proposed)
Indus Treaty (1960)	Western river — allocated to Pakistan; India has restricted use rights

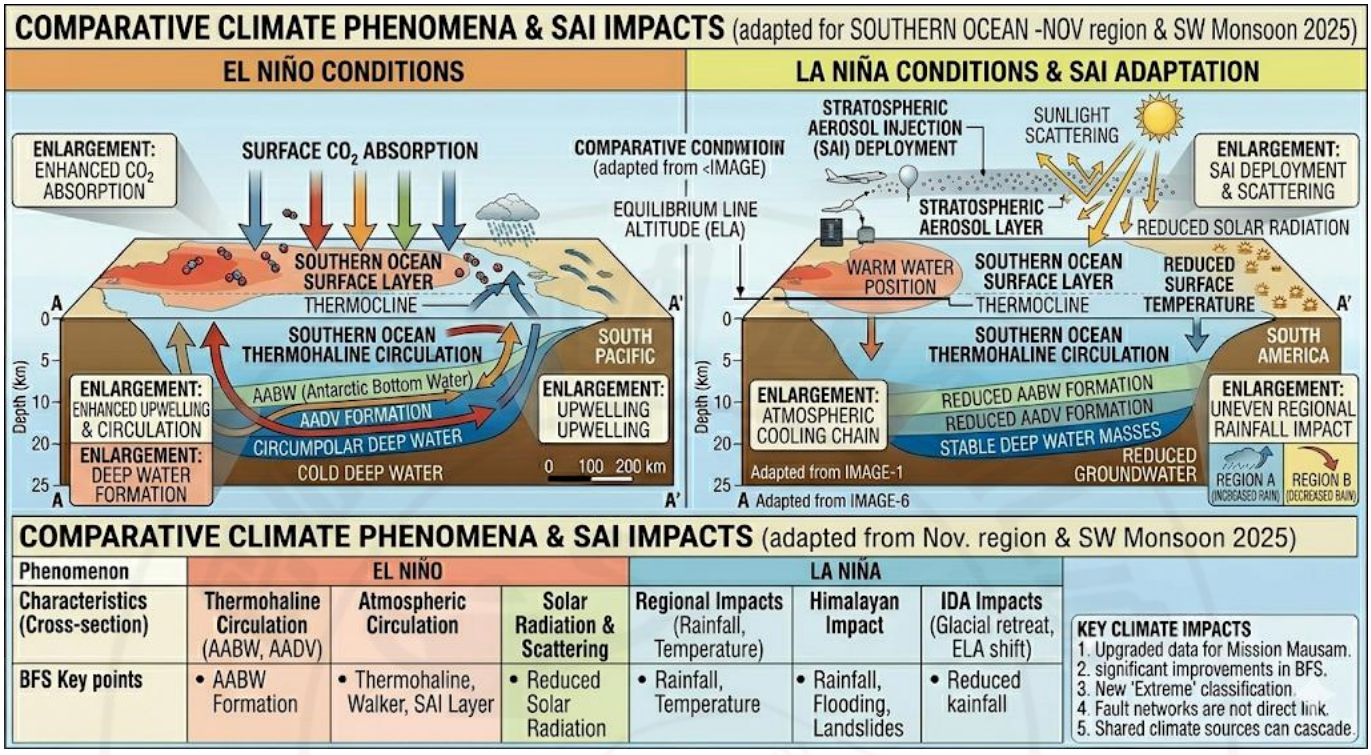
Under the Indus Waters Treaty (1960), the three western rivers — Indus, Jhelum, Chenab — were allocated to Pakistan, with India permitted non-consumptive use like hydropower and limited irrigation.

Prelims Pointers

- The Chenab is known in ancient texts as **Asikni (Rigveda)** and **Chandrabhaga**.
- The USBRL connects Kashmir Valley to the rest of India via the **Pir Panjal Range**; the Pir Panjal Rail Tunnel (11.2 km) is India's longest railway tunnel.
- The Chenab Bridge replaced the **Beipanjiang Bridge (China)** as the world's highest rail bridge; it surpasses the Eiffel Tower (330 m) by 29 m.
- The Indus Waters Treaty (1960) was mediated by the **World Bank** — signed by Nehru and Ayub Khan at Karachi.

CHINA BEGINS WORLD'S LARGEST HYDROPOWER DAM ON BRAHMAPUTRA — MEDOG/MOTUO

China has begun construction on Medog (also called Motuo) Hydropower Station — set to become the world's largest hydropower dam — on the Yarlung Zangbo river (the Brahmaputra in India) in Tibet Autonomous Region in July 2025. The project site is located near the Great Bend where the river drops 2,000 m over just 50 km, offering colossal hydroelectric potential but raising major concerns in India and Bangladesh about water security, sediment flow and earthquake risk.



COMPARATIVE CLIMATE PHENOMENA & SAI IMPACTS (adapted from Nov. region & SW Monsoon 2025)

Phenomenon	EL NIÑO			LA NIÑA			
Characteristics (Cross-section)	Thermohaline Circulation (AABW, AADV)	Atmospheric Circulation	Solar Radiation & Scattering	Regional Impacts (Rainfall, Temperature)	Himalayan Impact	IDA Impacts (Glacial retreat, ELA shift)	KEY CLIMATE IMPACTS
BFS Key points	• AABW Formation	• Thermohaline, Walker, SAI Layer	• Reduced Solar Radiation	• Rainfall, Temperature	• Rainfall, Flooding, Landslides	• Reduced kainfall	1. Upgraded data for Mission Mausam. 2. significant improvements in BFS. 3. New 'Extreme' classification. 4. Fault networks are not direct link. 5. Shared climate sources can cascade.

News in Brief

- The Medog dam will have an installed capacity of about 60,000 MW — three times larger than the Three Gorges Dam.
- It is located on the Yarlung Zangbo river just before it enters India as the Siang (Arunachal Pradesh) and then becomes the Brahmaputra in Assam.
- The site is within a tectonically active zone in the Eastern Himalayan Syntaxis, raising fears of induced seismicity.
- India has objected to the project over transboundary water-sharing and sediment-cycle disruption concerns.

Prelims Connect

Brahmaputra — Transboundary River System

River Name	Country/Region	Length
Yarlung Zangbo	Tibet (China)	~1,625 km
Siang / Dihang	Arunachal Pradesh (India)	~240 km

Brahmaputra	Assam plains (India)	~650 km
Jamuna	Bangladesh	~240 km
Padma (with Ganga)	Bangladesh → Bay of Bengal	~110 km
Total length	Tibet → India → Bangladesh	~2,900 km

There is NO bilateral treaty between India and China on the Brahmaputra. India has proposed a Lower Siang multipurpose dam at Yingkiong (Arunachal) as a counter-measure to buffer against sudden water releases.

Prelims Pointers

- The Brahmaputra's three tributaries in Assam are the **Subansiri, Kameng, Manas, and Dhansiri**; it receives the Lohit and Dibang just after entering India.
- The **Great Bend (Eastern Himalayan Syntaxis)** is where the Yarlung Zangbo makes a U-turn around Namcha Barwa (7,782 m) — one of the world's deepest canyons.
- Majuli, in the Brahmaputra, is the **world's largest river island** — about 352 km² (2011 data).
- The Three Gorges Dam on the Yangtze (China) has **22,500 MW installed capacity**; Medog will exceed it by nearly three times.

ARUNACHAL PRADESH'S ₹26,070 CRORE NHPC JOINT HYDRO PROJECT

The Union Cabinet approved a ₹26,070 crore hydropower project in Arunachal Pradesh in January 2026 — a joint venture between NHPC, Neepco and the Arunachal Pradesh Government. The project on the Dibang/Siang basin is part of India's push to harness the eastern Himalayan hydropower potential and also to establish water-user rights downstream of China's Medog dam.

News in Brief

- The project is a joint venture between NHPC Ltd, NEEPCO and the Government of Arunachal Pradesh.
- Arunachal Pradesh has the highest unexplored hydropower potential in India — estimated at over 50,000 MW.
- The project includes a combination of storage and run-of-river schemes in the Dibang and Siang river basins.
- NHPC is India's largest hydropower PSU, headquartered in Faridabad, Haryana.

Prelims Connect

Hydropower Potential of Indian States (Top 5)

State	Potential (MW)
Arunachal Pradesh	~50,328 MW (Highest in India)
Himachal Pradesh	~18,820 MW
Uttarakhand	~17,998 MW
Jammu & Kashmir + Ladakh	~14,146 MW
Sikkim	~4,286 MW

Only about 23% of India's total hydropower potential (~148 GW) has been developed so far. Arunachal alone has more potential than Himachal and Uttarakhand combined.

Prelims Pointers

- Dibang river originates in **Mishmi Hills, Arunachal Pradesh**, and joins the Lohit to form the Brahmaputra at Sadiya.
- The **Dibang Multipurpose Project (2,880 MW)** in Arunachal, when complete, will be **India's largest hydropower project**.
- NHPC Ltd (1975) manages **Salal, Dulhasti, Tanakpur, Tehri, Dhauliganga, Kishanganga** and other major projects; it is a **Navratna PSU** under MoP.
- India's 2023 Hydropower Policy classifies **all hydro projects (including >25 MW)** as renewable energy — a key policy shift for RPO compliance.

SAWALKOTE DAM ON CHENAB GAINS FRESH MOMENTUM POST-INDUS TREATY SUSPENSION

The Sawalkote hydroelectric project on the Chenab river in Jammu and Kashmir has gained renewed focus in September 2025 following India's suspension of parts of the Indus Waters Treaty after the Pahalgam terror attack. The 1,856 MW project — planned since the 1980s but long delayed due to treaty restrictions — can now be fast-tracked, marking a strategic shift in the use of western-river waters.

News in Brief

- The Sawalkote project (1,856 MW, 193 m concrete dam) is located in Ramban district of J&K on the Chenab river.
- It was first conceptualised in the 1980s but faced repeated delays due to objections by Pakistan under the Indus Waters Treaty.
- In April 2025 (after the Pahalgam terror attack), India announced that it was putting the Indus Waters Treaty 'in abeyance'.
- Other projects accelerated include Kirthai-I & II, Ratle, and Pakal Dul on the Chenab basin.

Prelims Connect

Indus Waters Treaty (1960) — Key Facts

Aspect	Details
Signed on	19 September 1960 at Karachi
Signatories	Jawaharlal Nehru (India), Ayub Khan (Pakistan), W.A.B. Iliff (World Bank)
Western rivers (to Pakistan)	Indus, Jhelum, Chenab — ~135 MAF
Eastern rivers (to India)	Ravi, Beas, Sutlej — ~33 MAF
India's use on western rivers	Domestic, non-consumptive, limited irrigation (~13.42 lakh acres), hydropower
Dispute mechanism	Permanent Indus Commission → Neutral Expert → Court of Arbitration

India had never suspended the Indus Waters Treaty in 65 years despite three wars. The 'abeyance' declared in April 2025 after the Pahalgam attack is an unprecedented move.

Prelims Pointers

- The Chenab basin is **the most densely damed river system in India** — with Baglihar, Salal, Dul Hasti, Pakal Dul and others.
- India's share under IWT is **~20% of total Indus basin waters (33 of 168 MAF)**.
- The **Permanent Indus Commission** has one commissioner from each country and meets at least once a year (alternate countries).

KOSI–MECHI INTRA-STATE LINK PROJECT APPROVED UNDER PMKSY

The Government of India approved the inclusion of the Kosi–Mechi Intra-State Link Project of Bihar in March 2025 under the Pradhan Mantri Krishi Sinchayee Yojana – Accelerated Irrigation Benefit Programme (PMKSY-AIBP). The project will divert water from the Kosi river to the Mechi river via a 117 km link canal, providing irrigation to 2.14 lakh hectares of drought-prone land in the Seemanchal region of north-east Bihar.

News in Brief

- The Kosi–Mechi link is the first inter-basin water transfer project under the National Perspective Plan (1980) to be implemented in Bihar.
- The project involves a 117 km long link canal diverting Kosi waters to the Mechi river — a tributary of Mahananda.
- It will irrigate 2.14 lakh ha in Araria, Purnia, Kishanganj and Katihar districts of Bihar.
- It is part of Ken-Betwa and 30 other link projects envisaged under the National Water Development Agency (NWDA).

Prelims Connect

National Perspective Plan (1980) — Inter-Linking of Rivers (ILR)

Component	Details
Launched by	Ministry of Irrigation (1980)
Implementing agency	National Water Development Agency (NWDA, 1982)
Himalayan Component	14 proposed links; e.g., Ghaghara–Yamuna, Kosi–Mechi, Manas–Sankosh–Tista–Ganga
Peninsular Component	16 proposed links; e.g., Mahanadi–Godavari, Godavari–Krishna–Cauvery–Vaigai–Gundar
First project approved	Ken–Betwa Link Project (Dec 2021)

The Kosi is called the 'Sorrow of Bihar' because of its frequent course changes and floods. It has shifted its course by over 120 km westward in the last 250 years.

Prelims Pointers

- The Kosi river originates in **Tibet**, flows through Nepal (as Sapta Koshi) and enters Bihar near Bhimnagar.
- The **Ken-Betwa Link Project** is the first ILR project to be implemented (MP and UP); it was approved in December 2021.
- PMKSY was launched in **July 2015** with the motto **'Har Khet Ko Paani'** (Water to Every Field).

BANAKACHERLA RESERVOIR PROJECT — FRESH WATER DISPUTE BETWEEN AP & TELANGANA

A fresh political and inter-state water dispute erupted in June 2025 between Andhra Pradesh and Telangana over the Banakacherla Reservoir Project — a proposal by Andhra Pradesh to divert surplus Godavari floodwaters to Banakacherla balancing reservoir in Kurnool district via Polavaram, to aid drought-hit Rayalaseema. Telangana has strongly objected, arguing it infringes on inter-state water rights under the AP Reorganisation Act, 2014.

News in Brief

- The Godavari–Banakacherla Link Project seeks to lift 200 TMC of surplus floodwaters from Godavari to Banakacherla reservoir in Rayalaseema.
- It is intended to address water scarcity in Rayalaseema region of Andhra Pradesh and provide drinking water to 80 lakh people.
- Telangana has raised the issue before the Krishna Water Disputes Tribunal and the Apex Council of the Jal Shakti Ministry.
- The Godavari Water Disputes Tribunal (1980) had earlier allocated waters between Maharashtra, MP, Odisha, Karnataka and undivided AP.

Prelims Connect

Major Inter-State River Water Disputes in India

Dispute	States involved	Tribunal (Year)
Krishna	Maharashtra, Karnataka, AP, Telangana	KWDT-I (1969), KWDT-II (2004)
Cauvery	Karnataka, Tamil Nadu, Kerala, Puducherry	CWDT (1990); CWMA (2018)
Mahadayi	Goa, Karnataka, Maharashtra	MWDT (2010)
Vamsadhara	Odisha, Andhra Pradesh	VWDT (2010)
Ravi–Beas	Punjab, Haryana, Rajasthan, J&K	RWDT (Eradi, 1986)
Godavari	Maharashtra, MP, Chhattisgarh, Odisha, Karnataka, AP, Telangana	GWDT (1980)

Inter-State River Water Disputes Act, 1956 under Article 262 of the Constitution provides the legal framework for adjudicating such disputes through tribunals.

Prelims Pointers

- The Godavari is India's **second longest river** (1,465 km) after the Ganga; it is called **'Dakshin Ganga'**.
- The **Apex Council under AP Reorganisation Act (2014)** is chaired by the Union Jal Shakti Minister with CMs of Telangana and AP as members.
- Polavaram Project (under construction) on the Godavari is declared a **National Project**; its reservoir will link Godavari to Krishna via the Right Main Canal.
- Article 262 bars courts from adjudicating inter-state river disputes; only **tribunals constituted under the 1956 Act** can decide.

NORTHEAST INDIA'S FIRST DEEP GEOTHERMAL DRILL AT TAWANG BY CESHS

The Centre for Earth Sciences and Himalayan Studies (CESHS), Itanagar, successfully drilled Northeast India's first deep geothermal exploratory borehole at Tawang, Arunachal Pradesh in May 2025. The borehole, reaching 200+ metres, is aimed at assessing the geothermal potential of the Eastern Himalayas — a region that hosts several hot springs and lies along active tectonic lineaments.

News in Brief

- CESHS is an autonomous institute under the Department of Science & Technology at Itanagar, Arunachal Pradesh.
- The Tawang borehole is the first deep geothermal drilling effort in NE India; similar initiatives are underway at Puga, Ladakh and Manikaran, Himachal Pradesh.
- The Eastern Himalayas have 12+ known hot springs including Tatopani and Rupa.
- Geothermal energy is classified as renewable but is practically limited in India due to the absence of recent volcanism.

Prelims Connect

India's Geothermal Provinces

Province	Location	Key Sites
Himalayan (Tethys)	J&K, HP, Uttarakhand, Sikkim	Puga (Ladakh), Manikaran (HP), Tapoban (UK)
North-East Himalayas	Arunachal, Sikkim	Tawang, Tatopani, Tsopta
Son–Narmada–Tapti (SONATA)	Central India	Tattapani (Chhattisgarh), Salbardi (MH)
Cambay Basin	Gujarat	Tuwa, Lasundra
West Coast	MH, Goa, Karnataka	Unai, Rajapur, Bendruthirtha
Godavari Valley	AP, Telangana	Manuguru, Nemam

India has ~340 thermal springs with an estimated geothermal potential of 10,600 MWe. The MNRE launched India's first National Geothermal Policy in September 2025.

Prelims Pointers

- Puga Valley in Ladakh is India's **most promising geothermal site** with steam–water mixtures at 130°C — enough for a small power plant.
- Geothermal energy is already used commercially in **Iceland, New Zealand, USA (The Geysers), Philippines, Indonesia, Kenya** — which lie on active volcanic belts.
- The **Main Boundary Thrust (MBT)** and the **Main Central Thrust (MCT)** in the Himalayas are tectonic features that provide thermal gradients.

CHUNGTHANG–LACHEN AXIS RESTORED IN NORTH SIKKIM — 400 ft BAILEY BRIDGE

In February 2026 Raksha Rajya Mantri Shri Sanjay Seth inaugurated the Chungthang–Lachen road axis along with a 400 ft Bailey bridge in North Sikkim — reconnecting the Lachen valley, which had been severed from the rest of India by the October 2023 South Lhonak Lake Glacial Lake Outburst Flood (GLOF). The restoration is a major strategic achievement for connectivity to the Sino-Indian border area and for local civilian life.

News in Brief

- On 4 October 2023, the South Lhonak glacial lake in North Sikkim burst following a cloudburst, causing a massive flood that washed away the Teesta-III hydropower dam at Chungthang and 15 bridges.
- Chungthang is the confluence point of Lachen Chu and Lachung Chu, which together form the Teesta river.
- Lachen and Lachung are border villages in North Sikkim — gateways to Gurudongmar Lake and Yumthang Valley.
- The Bailey bridge is a prefabricated, modular bridge developed during WWII and widely used by the BRO for rapid connectivity restoration.

Prelims Connect

GLOFs (Glacial Lake Outburst Floods) — Major Events in India

Year	Location	Cause	Impact
2013	Chorabari Lake, Uttarakhand	Cloudburst + moraine breach	Kedarnath flash flood — over 6,000 deaths
2021	Raunthi, Chamoli (UK)	Glacier–rock avalanche into Rishiganga	Tapovan dam destroyed; ~200 deaths
2023	South Lhonak Lake, Sikkim	Cloudburst-induced breach	Teesta-III dam washed away; 80+ dead
2024	Multiple small events	Monsoon-triggered	Alert raised for >200 glacial lakes

According to ISRO's Decadal Glacial Lake Atlas (2023), India has 2,431 glacial lakes > 10 ha, of which ~188 are classified as potentially dangerous.

Prelims Pointers

- The Teesta river originates at **Tso Lhamo Lake in North Sikkim** and meets the Brahmaputra in Bangladesh.
- Sikkim became the **22nd state of India in 1975** through the **36th Constitutional Amendment**.
- The **Border Roads Organisation (BRO, 1960)** maintains border roads in frontier regions under the Ministry of Defence.
- Gurudongmar Lake in North Sikkim is one of the **world's highest lakes (5,183 m)**; it is considered sacred in Sikh, Hindu and Buddhist traditions.

SUPREME COURT DIRECTS NEW MULLAPERIYAR DAM SAFETY COMMITTEE

In February 2025 the Supreme Court directed a newly-appointed Mullaperiyar Dam safety supervisory committee to urgently assess and monitor the safety of the 129-year-old Mullaperiyar Dam on the Periyar river — located in Kerala but operated by Tamil Nadu under a 999-year lease from 1886. The SC's move revives the decades-old safety dispute between the two states.

News in Brief

- The Mullaperiyar Dam was built by the British in 1895 across the Periyar river in Idukki district, Kerala.
- It is operated by Tamil Nadu under an 1886 lease agreement from the erstwhile Maharaja of Travancore — for 999 years.
- The dam is 53.6 m high, supplies irrigation to over 2.22 lakh acres in 5 TN districts via the Vaigai basin.
- Kerala wants a new dam (citing safety); TN wants the existing dam to continue operating at full capacity.

Prelims Connect

Mullaperiyar Dispute — Timeline

Year	Event
1886	Lease agreement — Maharaja of Travancore and Madras Presidency
1895	Dam completed by John Pennycuick
1979	First safety concerns raised; water level reduced
2006	SC allowed raising of water level (136 ft → 142 ft)
2014	SC struck down Kerala's 2006 Dam Safety Act as ultra vires
2018	Kerala floods re-ignited safety fears
2025	SC directs new supervisory committee

Under the Dam Safety Act, 2021, the National Committee on Dam Safety (NCDS) and the National Dam Safety Authority (NDSA) have been constituted to handle such inter-state dam issues.

Prelims Pointers

- The Periyar is **Kerala's longest river (244 km)** and the only river flowing year-round in the state.
- The **Dam Safety Act, 2021** applies to all specified dams above 15 m high or reservoirs above 1 MCM capacity.
- John Pennycuick was a **British engineer** who designed and built the Mullaperiyar Dam; he sold his property to fund its completion.

ECONOMIC & RESOURCE GEOGRAPHY

PUDIMADAKA TO HOST INDIA'S FIRST INTEGRATED GREEN HYDROGEN HUB

India's first integrated green hydrogen hub will be set up at Pudimadaka in Anakapalli district of Andhra Pradesh. The hub, announced in January 2025, will have a green hydrogen production capacity of 1,500 tonnes per day (TPD) and will form the anchor project of the National Green Hydrogen Mission (NGHM) launched in January 2023. Pudimadaka was chosen for its port connectivity (Visakhapatnam) and abundant solar-wind renewable resource base.

News in Brief

- The Pudimadaka Green Hydrogen Hub will produce 1,500 TPD of green hydrogen and derivatives (green ammonia, green methanol).
- It is part of the National Green Hydrogen Mission (NGHM) — outlay of ₹19,744 crore, approved January 2023.
- The NGHM targets 5 MMT per annum green hydrogen production by 2030 and reduction of 50 MMT CO_2 emissions.
- Anchor site selection is based on renewable energy availability, water access, port access, industrial off-takers.

Prelims Connect

Colours of Hydrogen — Based on Production Source

Colour	Source	Emissions
Green	Electrolysis using renewable electricity	Zero CO_2
Blue	Natural gas reforming + CCS	Low CO_2
Grey	Natural gas reforming without CCS	High CO_2
Brown/Black	Coal gasification	Highest CO_2
Pink	Electrolysis using nuclear electricity	Zero CO_2
Turquoise	Methane pyrolysis → solid carbon	No CO_2 but solid C
Yellow	Electrolysis using grid electricity	Mixed

India's current hydrogen demand (~6 MTPA) is mostly 'grey' hydrogen used in oil refining and fertiliser (ammonia) production. The NGHM aims to convert this to 'green' hydrogen by 2030.

Prelims Pointers

- The National Green Hydrogen Mission was launched in **January 2023** by the **Ministry of New and Renewable Energy**.
- Under the Mission, **SIGHT (Strategic Interventions for Green Hydrogen Transition)** programme provides incentives for electrolyser manufacturing and green hydrogen production.
- Other green hydrogen projects: **Reliance at Jamnagar, Adani at Mundra, NTPC at Andhra, L&T-IOC partnerships**.
- Visakhapatnam port is located in **Andhra Pradesh**; Anakapalli district was created in 2022.

INDIA'S FIRST NATIONAL POLICY ON GEOTHERMAL ENERGY LAUNCHED

The Ministry of New and Renewable Energy (MNRE) launched India's first-ever National Policy on Geothermal Energy in September 2025. The policy aims to harness India's estimated 10,600 MWe geothermal potential by creating a regulatory framework for exploration, classification of geothermal fields and commercial utilisation of hot springs and deep geothermal reservoirs.

News in Brief

- India has more than 340 thermal springs scattered across seven geothermal provinces.
- The total estimated power potential from these is around 10,600 MWe.
- The new policy covers surface manifestations, deep drilling, direct use (heating, aquaculture), and electricity generation.
- GSI, ONGC Energy Centre and CSIR-NGRI are key research partners.

Prelims Connect

Global Leaders in Geothermal Installed Capacity (2024)

Rank	Country	Installed Capacity (MWe)
1	United States	3,794
2	Indonesia	2,418

3	Philippines	1,952
4	Turkey	1,691
5	New Zealand	1,037
6	Kenya	985
7	Mexico	962
8	Italy	916

India has no commercial geothermal power plant yet. Puga Valley in Ladakh is being developed by ONGC as a pilot project. China leads the world in direct-use geothermal (heating).

Prelims Pointers

- Iceland meets **25% of its electricity and 85% of heating** from geothermal sources — highest share in the world.
- The **enthalpy classification** divides geothermal resources into low (<90°C), medium (90–150°C) and high (>150°C).
- India's first geothermal-based direct-use project is at **Manikaran, Himachal Pradesh** (for cooking and heating).

STATE MINING READINESS INDEX (SMRI) LAUNCHED — FIRST-EVER INDEX

The Ministry of Mines launched the first-ever State Mining Readiness Index (SMRI) in October 2025 to rank states on their preparedness to attract mineral exploration and mining investment. SMRI evaluates states across four pillars — policy & regulation, infrastructure & logistics, environment & social, and outcomes — similar in structure to the Logistics Ease Across Different States (LEADS) index.

News in Brief

- SMRI is the first national ranking index for mining readiness of states, released by the Ministry of Mines.
- It uses 4 pillars and 17 indicators; states are grouped into four performance categories (Achiever, Front Runner, Aspirer, Follower).
- India is the 3rd largest producer of coal, 2nd largest of chromite, and 4th largest of iron ore in the world.
- The Mines and Minerals (Development and Regulation) Act, 1957 (MMDR Act) governs mining in India.

Prelims Connect

India — Top Producer Rankings for Key Minerals

Mineral	India's Rank	Leading States
Coal	2nd (world)	Jharkhand, Odisha, Chhattisgarh
Iron Ore	4th	Odisha, Karnataka, Chhattisgarh, Jharkhand
Manganese	5th	Odisha, MP, Maharashtra
Bauxite	6th	Odisha, Gujarat, Jharkhand
Chromite	2nd	Odisha (~95% of India)

Mica	Largest world reserves	Andhra Pradesh, Jharkhand, Rajasthan
Limestone	Large producer	Rajasthan, MP, AP, Telangana, Karnataka

Critical minerals like Lithium, Cobalt, Nickel, Graphite, REEs are being given special focus through the Critical Minerals Mission launched in 2024; first auction of 20 critical mineral blocks was held in November 2023.

Prelims Pointers

- Lithium reserves have been identified in **Reasi district, Jammu & Kashmir (5.9 million tonnes)** — India's first major lithium find.
- The MMDR Amendment Act, 2023 allows **private sector exploration of atomic minerals and critical minerals**.
- Geological Survey of India (GSI) is the nodal agency for **mineral exploration** — under the Ministry of Mines.
- The **Critical Mineral List (2023)** identifies **30 minerals including Lithium, Cobalt, Nickel, Graphite, Tungsten, REEs**.

ARUNACHAL PRADESH LAUNCHES ITS FIRST COMMERCIAL COAL MINE

Arunachal Pradesh launched its first-ever commercial coal mine at the Namchik–Namphuk coal block in Changlang district in October 2025. The block, with an estimated 29 million tonnes of coal reserves, was auctioned under the Union Government's commercial coal mining regime introduced in 2020 that allows private and public sector participation without end-use restrictions.

News in Brief

- Namchik–Namphuk coal block is located in Changlang district of eastern Arunachal Pradesh.
- The block holds an estimated 29 MT of high-grade, low-ash coking coal reserves.
- Arunachal's coal mining had remained dormant since the 2014 Supreme Court order cancelling coal block allocations.
- The commercial coal mining regime launched in June 2020 allows private entities to mine and sell coal without end-use restrictions.

Prelims Connect

India's Coal Reserves — State-wise (Top 5)

State	Coal Reserves (Billion Tonnes)	% of India
Jharkhand	~83.2	26.1%
Odisha	~80.0	25.1%
Chhattisgarh	~61.1	19.2%
West Bengal	~31.8	9.9%
Madhya Pradesh	~28.4	8.9%
(India Total)	~319 BT	100%

The North-East coalfields of Assam, Meghalaya, Nagaland and Arunachal have high-quality coking coal but small reserves (< 1.5% of India total). Commercial mining was opened to the private sector via the Mineral Laws (Amendment) Act, 2020.

Prelims Pointers

- India is the **2nd largest coal producer in the world** after China (2024 data).
- Coal India Ltd (CIL, 1975) is the **world's largest coal mining company** — headquartered at Kolkata, a Maharatna PSU.
- Gondwana coalfields (250 Myo) produce **98% of India's coal**; Tertiary coalfields are in Assam, Nagaland, Meghalaya and J&K.
- India's **Mission Coking Coal** targets reducing import dependence by doubling domestic coking coal production by 2030.

8TH INTERNATIONAL SOLAR ALLIANCE ASSEMBLY HELD IN NEW DELHI

The 8th International Solar Alliance (ISA) Assembly was held in New Delhi at Bharat Mandapam in October 2025, bringing together 120+ member countries to deliberate on universal solar access and affordable finance. India, the host and co-founder of ISA, used the Assembly to push for a ₹7,500 crore 'Global Solar Facility' to channel private finance to small solar projects in Africa.

News in Brief

- ISA was co-founded by India and France during COP21 (Paris, 2015) and formally launched in 2016.
- ISA Headquarters is in Gurugram, Haryana — the first international inter-governmental treaty-based organisation headquartered in India.
- As of 2025, 120 countries have signed the ISA Framework Agreement, and 106 have ratified it.
- ISA's target is to mobilise US$ 1 trillion of investment in solar energy by 2030.

Prelims Connect

International Solar Alliance — Key Initiatives

Programme	Focus
One Sun One World One Grid (OSOWOG)	Global inter-connected solar grid
Solarising Healthcare	Solar-powered PHCs in Africa
Solar Technology Application Resource Centre (STAR-C)	Training & capacity building
Global Solar Facility	Risk capital for solar projects in Africa
SolarX Startup Challenge	Incubating solar startups

ISA's first Assembly was held in 2018. India's cumulative solar installed capacity crossed 100 GW in 2025; target is 280 GW solar by 2030 under the NDC.

Prelims Pointers

- The ISA Framework Agreement was adopted at **COP21, Paris on 30 November 2015**; it came into force on **6 December 2017**.
- ISA is open only to countries lying fully or partially between the **Tropic of Cancer and Tropic of Capricorn** — the 'sun-belt' of the world.
- India's largest solar parks: **Bhadla (Rajasthan, 2245 MW), Pavagada (Karnataka, 2050 MW), Kurnool (AP, 1000 MW)**.

STATE ENERGY EFFICIENCY INDEX (SEEI) 2024 RELEASED — KARNATAKA TOPS

The State Energy Efficiency Index (SEEI) 2024 was released by the Bureau of Energy Efficiency (BEE) and Alliance for an Energy-Efficient Economy (AEEE) in August 2025. The index ranks states on 50 indicators across 7 sectors — buildings, industry, municipal, transport, agriculture, power distribution, and cross-cutting initiatives. Karnataka was adjudged the best-performing 'Front Runner' state.

News in Brief

- SEEI is published annually by the Bureau of Energy Efficiency (BEE) since 2018.
- The 2024 index covers 36 states and UTs across 7 sectors and 50 indicators.
- States are classified as Front Runner (>60), Achiever (50–60), Contender (30–50), Aspirant (<30).
- Karnataka (best performer), Andhra Pradesh, Rajasthan and Telangana were classified as Front Runners.

Prelims Connect

Bureau of Energy Efficiency (BEE) — Key Programmes

Programme	Focus
Star Rating (S&L)	Star labels for appliances (AC, fans, refrigerators)
ECBC / ENS	Energy Conservation Building Code
PAT Scheme	Perform, Achieve, Trade — energy savings certificates
UJALA	LED bulb distribution (2015)
SLNP	Street Lighting National Programme
Go Electric	Electric vehicle adoption campaign

The Energy Conservation Act, 2001 established BEE and mandates energy efficiency for appliances, vehicles, buildings and industry. Amended in 2022 to include carbon market framework (Section 14AA).

Prelims Pointers

- BEE was set up in **March 2002 under the Energy Conservation Act, 2001**; it is under the Ministry of Power.
- The **Energy Conservation (Amendment) Act, 2022** enables the creation of a **Carbon Credit Trading Scheme (CCTS)** in India.
- UJALA (Jan 2015) is the **world's largest LED distribution programme**; run by EESL (Energy Efficiency Services Ltd).

INDIA & CHINA ACCOUNT FOR 87% OF NEW COAL POWER CAPACITY GLOBALLY (H1 2025)

A September 2025 report by Global Energy Monitor found that India and China together proposed 87% of all new coal power capacity announcements globally in the first half of 2025 — underscoring Asia's continued reliance on coal despite global pressure to decarbonise. China led with 68 GW in the pipeline, India followed with 17 GW.

News in Brief

- The report was published by Global Energy Monitor (GEM), a San Francisco-based research group.
- Globally, 102 GW of new coal capacity was announced in H1 2025; China and India accounted for 87%.
- India's coal-based capacity stood at ~220 GW in mid-2025; the Ministry of Power plans to add 80 GW more thermal capacity by 2031–32.

- This goes alongside India's 500 GW non-fossil target by 2030 under the NDC update.

Prelims Connect

India's Power Mix (2025) — Installed Capacity Shares

Source	Capacity (GW)	Share (%)
Coal	~217	~46%
Solar	~95	~20%
Large hydro	~47	~10%
Wind	~47	~10%
Nuclear	~8.2	~1.7%
Gas	~25	~5%
Biomass & small hydro	~15	~3%
Total (incl. imports)	~470 GW	100%

Under India's updated NDC (2022), the country committed to 50% of installed capacity from non-fossil sources and 45% reduction in emissions intensity of GDP by 2030 (vs 2005 levels).

Prelims Pointers

- India's updated NDC (Aug 2022) commits to **50% non-fossil electricity capacity by 2030** and **net-zero by 2070**.
- COP26 (Glasgow, 2021): PM Modi's **Panchamrit commitments** — 500 GW non-fossil, 50% RE share, 1 BT CO_2 reduction, 45% emission intensity cut, net-zero by 2070.
- The Central Electricity Authority (CEA) is the **apex planning body for the power sector** under the Ministry of Power.

10 BILLION DOLLAR AMMONIA PROJECT AT KAKINADA, ANDHRA PRADESH

A major US$ 10 billion ammonia project was approved for Kakinada in Andhra Pradesh in January 2026. The project will produce 1.5 million tonnes per annum of green and blue ammonia — making it one of the world's largest ammonia export hubs. Kakinada's deep-water port and SEZ status make it a natural home for the ammonia–hydrogen export economy, with Japan and Korea as anchor buyers.

News in Brief

- The Kakinada project will produce 1.5 MTPA of ammonia using both green (electrolyser-based) and blue (natural gas + CCS) pathways.
- Kakinada has a deep-water port and an SEZ — the Kakinada Deep Water Port SEZ — operational since 2009.
- Ammonia is the most efficient hydrogen carrier (NH_3 is 17.6% hydrogen by weight); it can be liquefied at −33°C vs −253°C for pure H_2.
- Japan's Clean Fuel Ammonia Association (CFAA) targets 3 MTPA ammonia imports by 2030, rising to 30 MTPA by 2050.

Prelims Connect

Major Ports of Andhra Pradesh

Port	Type	Key Commodities
Visakhapatnam (Vizag)	Major — Govt of India	Iron ore, coal, containers, POL
Kakinada Deep Water	Non-major (State)	Crude, fertilisers, coal, ammonia
Krishnapatnam	Private (Adani)	Coal, iron ore, containers
Gangavaram	Private (Adani)	Bulk cargo, fertilisers
Machilipatnam (greenfield)	Under construction	Container hub

India has 13 Major Ports (12 operational) and 212 non-major ports. Andhra has 6 operational non-major ports, the highest among all Indian states.

Prelims Pointers

- Ammonia is the **second most-produced chemical globally** (after H_2SO_4); used in fertilisers, explosives, cleaning.
- The Sagarmala Programme (2015) aims at **port-led development** with four pillars: modernisation, connectivity, industrialisation, community development.
- Kakinada is also home to India's offshore hydrocarbon basin — the **Krishna–Godavari (KG) basin** — developed by ONGC and Reliance.

MACHILIPATNAM GREENFIELD PORT — 50% COMPLETE IN ANDHRA PRADESH

Nearly 50% of construction of the Machilipatnam Greenfield Port in Andhra Pradesh is complete as of July 2025. When operational, Machilipatnam will be India's latest entrant in a growing list of greenfield ports being developed under the Sagarmala Programme — India's flagship port-led development initiative.

News in Brief

- Machilipatnam Port is located in Krishna district, Andhra Pradesh, on the Bay of Bengal.
- It is a greenfield project being developed by the Andhra Pradesh Maritime Board.
- The port will handle bulk cargo, containers and multi-purpose cargo with a planned capacity of 35 MT/year.
- Historically, Machilipatnam was a major port city of medieval India — once the chief port of the Golconda Sultanate and later the Qutb Shahis.

Prelims Connect

Greenfield Ports under Development in India

Port	State	Agency
Vadhavan	Maharashtra	JNPA + Maharashtra Maritime Board
Galathea Bay (Great Nicobar)	A&N Islands	Centre (under review)
Machilipatnam	Andhra Pradesh	APMB
Ramayapatnam	Andhra Pradesh	APMB

Mulapeta	Andhra Pradesh	APMB
Enayam	Tamil Nadu	VOCPA
Paradip outer harbour	Odisha	Paradip Port Trust

The Centre approved the Vadhavan Port near Mumbai in June 2024 with an investment of ₹76,220 crore — it will be India's largest container port upon completion.

Prelims Pointers

- The **Sagarmala Programme (March 2015)** has four pillars — **port modernisation, port connectivity, port-led industrialisation, coastal community development**.
- Machilipatnam was referred to as **'Masulipatnam'** by the British and was the **first English East India Company factory on the east coast (1611)**.
- Andhra Pradesh has the **longest coastline among east-coast states (974 km)** and 6 operational non-major ports.

SOUTHERN OCEAN — CARBON SINK AND STRATIFICATION DYNAMICS

The Southern Ocean plays an outsized role in regulating Earth's climate — covering roughly 25–30% of the global ocean area and absorbing about 40% of all human-emitted carbon dioxide that the oceans absorb. New research reveals unexpected mechanisms protecting this carbon sink.

News in Brief

- The Southern Ocean's ability to absorb CO2 comes from its **cold and relatively fresh surface layers**, which sit above **warmer, saltier, carbon-rich reservoirs** — allowing it to trap more CO2 than it emits.
- Earlier climate models assumed that intensification of the **meridional overturning circulation** would weaken the carbon sink; new analysis found that even with rising deep waters, the ocean was **not emitting more CO2** — explained by a **thin layer of freshwater at the surface**.
- Over recent decades, the Southern Ocean has become **fresher** due to more rainfall and **meltwater from Antarctica's glaciers**; fresher water is lighter and **strengthens stratification** between surface and deeper waters.
- This stratification has prevented **carbon-rich deep water** from being exposed to the atmosphere — a stabilising mechanism.
- However, if stratification erodes, the **deep carbon dioxide reservoir** is now closer to the surface — carbon expected by models decades ago could suddenly appear, accelerating climate warming.

Prelims Connect

Global Drought Outlook 2025 — Key Data (Released by OECD)

Metric	Data Point
Land area facing frequent severe droughts	40% of world's land area
Annual increase in economic cost of droughts	3%–7.5% per episode

Crop yield decline potential	Up to 22%
Global land with soil moisture decline since 1980	37%
Monitored aquifers experiencing groundwater decline	62%
Disaster-related deaths attributable to droughts (WMO 2021)	34%

Prelims Pointers

- Droughts are responsible for **34% of disaster-related deaths globally** (WMO, 2021). Recent examples: Europe (2022), California (2021), **Horn of Africa and Somalia**.
- **Consequences of glacial loss**: Reduced albedo effect; melting glaciers caused nearly **2 cm of global sea level rise since 2001**; glaciers store nearly **75% of Earth's freshwater**.
- **Cold Wave in India**: Minimum temperature of a station is **<=10°C or less in plains** and **0°C or less in hilly regions**, or when temperatures dip **4.5°C to 6.4°C below normal**.
- **Yala Glacier (Nepal)**: Shrunk by **66% since the 1970s**; other dead glaciers — Pizol (Switzerland, 2019), Clark (US, 2020), Ayoloco (Mexico, 2021). **World's first glacier funeral**: Okjokull Glacier in Iceland (2019).

STRATOSPHERIC AEROSOL INJECTION (SAI) AND SOLAR GEOENGINEERING

Stratospheric Aerosol Injection (SAI) involves injecting aerosols into the stratosphere to reflect sunlight and cool the planet — inspired by volcanic eruptions that naturally cool Earth. A new approach proposes lower-altitude injections (13 km) in polar regions, potentially cheaper and faster.

News in Brief

- Traditional SAI focuses on **high-altitude injections (20 km+)**, requiring specially designed aircraft; new approach proposes **13 km injections** at lower cost in polar and extratropical regions.
- **12 million tonnes/year** of sulphur dioxide or calcium carbonate at 13 km could **cool the planet by 0.6°C**.
- Challenges: May cause **ozone depletion, acid rain, delayed ozone hole recovery**; cooling effect stronger at poles but less effective in tropics where warming is most severe.
- **Risk of termination shocks** — sudden temperature spikes if SAI is stopped; could disrupt global weather patterns, affecting food and national security.
- Other Solar Climate Intervention Methods: **Sea Curtains/Walls** (block warm ocean water from reaching ice), **Sea Ice Management** (glass microbeads to increase ice reflectivity), **Basal Water Removal** (remove subglacial water to slow ice movement), **Ocean Fertilisation** (add iron to stimulate phytoplankton, absorb CO2).
- **Ocean Fertilisation** concern: uncontrolled phytoplankton growth disrupts food chains and nutrient cycles.
- **Sea Ice Management** requires **360 million tonnes of glass microbeads annually** — equal to global plastic production; ecotoxicity concerns for zooplankton.

Prelims Connect

Solar Climate Intervention Methods — Summary

Method	Mechanism	Key Concern
Stratospheric Aerosol Injection	Inject SO2 or CaCO3 to reflect sunlight	Ozone depletion; acid rain; termination shock
Sea Curtains / Walls	Block warm ocean water from reaching ice	High logistics cost; affects ocean circulation
Sea Ice Management	Glass microbeads increase ice reflectivity	Ecotoxicity; 360 MT microbeads needed annually
Basal Water Removal	Remove subglacial water to slow ice flow	Emissions-intensive; limited impact
Ocean Fertilisation	Add iron to stimulate phytoplankton CO2 absorption	Uncontrolled algal growth; disrupts nutrient cycles

Prelims Pointers

- **SAI is suggested as a supplement to emissions reductions, not a replacement** — geoengineering cannot substitute deep decarbonisation.
- SAI is **ineffective in polar winters** (no sunlight to reflect) and **redundant in summers** due to existing natural reflectivity.
- The **Tropic of Cancer** passes through **17 countries** across 3 continents. In India, it passes through **8 states**: Gujarat, Rajasthan, Madhya Pradesh, Chhattisgarh, Jharkhand, West Bengal, Tripura, and Mizoram.
- **Thirstwave** (coined by Meetpal Kukal and Mike Hobbins): Three or more consecutive days of high evaporative demand. Unlike heatwaves, influenced by temperature, humidity, solar radiation, and wind speed together.

CRITICAL MINERALS — RARE EARTHS, COPPER, GERMANIUM AND RECYCLING

India has taken multiple policy steps to reduce import dependence on critical minerals — approving a Rare Earth Permanent Magnet (REPM) scheme worth Rs 7,280 crore, rationalising royalties for graphite, caesium, rubidium, and zirconium, and launching a Rs 1,500-crore critical minerals recycling scheme.

News in Brief

- **Copper** is classified as a **critical mineral in India** due to limited domestic production and its use in EVs, ACs, and wind turbines. India is the **world's second-biggest importer of refined copper** — may need to source 91–97% of copper concentrate from overseas by 2047.
- Cabinet approved the **Scheme to Promote Manufacturing of Sintered Rare Earth Permanent Magnets (REPM)** with a financial outlay of **Rs 7,280 crore** — to establish **6,000 metric tonnes per annum** of integrated REPM manufacturing. Duration: **7 years**.
- **REPMs — especially neodymium-iron-boron magnets** — are vital in EVs, renewable energy, electronics, aerospace, and defence.
- India has asked State-run miner **IREL to suspend a 13-year-old rare earth export agreement** (especially neodymium for EV motor magnets) **with Japan** to safeguard domestic supplies.
- **Germanium** (NOT a rare earth element): Used in semiconductors, fibre optics, and solar panels. **Over 50% of global supply comes from China**; India is fully reliant on imports. China banned **germanium and gallium exports to the US**.

- **Critical Minerals Royalty**: Cabinet approved rationalisation for graphite, caesium, rubidium, and zirconium. **Graphite shifts from per tonne royalty to ad valorem basis**.
- **Critical Minerals Recycling Scheme**: Cabinet approved **Rs 1,500-crore scheme** to develop recycling capacity. Eligible feedstock: **e-waste, lithium-ion battery scrap, and catalytic converters** from end-of-life vehicles. Operates: **FY2025-26 to FY2030-31** (6 years). Part of **National Critical Mineral Mission (NCMM)**.

Prelims Connect

Rare Earth Elements (REE) — Key Facts

Aspect	Details
Total REE count	17 elements: 15 lanthanides (Lanthanum to Lutetium) + Scandium + Yttrium
Classification	Light REE (Cerium group) and Heavy REE (Yttrium group) based on atomic number
India's REE reserves	Third largest in world (6.9 MT); mainly in monazite sands across AP, Odisha, TN, Kerala
China's dominance	90% of global REE processing, 70% of production, holds only 30% of global reserves
India's production	Less than 1% of world total despite 3rd largest reserves
First commercial REE use	Incandescent lamp mantle (99% thorium oxide + 1% cerium oxide)

India is 100% import-dependent for cobalt, lithium, nickel, REEs, and silicon — crucial for batteries, solar, semiconductors, and advanced electronics. A 2024 IEEFA report said India's demand for critical minerals is expected to more than double by 2030.

Prelims Pointers

- India defines **'critical minerals'** as those essential for economic development and national security, whose limited availability or concentrated production exposes the country to **supply-chain risks**.
- In 2025, India launched the **National Critical Mineral Mission (NCMM)** — to achieve self-reliance; promotes exploration within the country and **offshore locations**; creates fast-track regulatory approval for mining projects.
- India already mines and processes **seven critical minerals**: copper, graphite, silicon, tin, titanium, rare earths, and zirconium. In each case, India's **refining lags either in scale or quality**.
- India generates over **250 million tonnes of coal fly ash annually** — containing light and heavy rare earths. **Red mud** from aluminium plants contains gallium; **zinc residues** contain cobalt; **steel slag** carries vanadium.
- India imported over **53,000 metric tonnes of REE magnets in FY 2024-25**, despite having **8% of world's REE reserves**. India's monazite sands have several **light rare earths including Neodymium** — used in magnets.

COAL POLICY SHIFTS AND FERROUS SCRAP DEFICIT

Cabinet allowed coal acquired through auctioning to be used for any industrial purpose and export under the new CoalSETU policy. Simultaneously, India faces a growing ferrous scrap deficit as international supply tightens.

News in Brief

- **CoalSETU policy**: Allowed coal acquired through auctioning to be used for **any industrial use and export**. The current policy allowed coal to be used only for cement, steel, sponge iron and aluminium via auctions. Policy excludes **resale in India**.
- **Norms for Opening Coal Mines**: Dispensed with the **Coal Controller Organisation (CCO)'s nod** for opening a coal mine; board of concerned coal firm now holds authority. This also applies to permission for **re-starting mines non-operational for 180 days or more**.
- **India's major coal-producing states**: Odisha, Chhattisgarh, Jharkhand, MP, Telangana, Maharashtra, West Bengal. **Odisha now holds 99.2 billion tonnes** of coal — largest reserve in India; its production was **25.74% of total coal output in 2024**.
- **Ferrous Scrap**: Depletion of international ferrous scrap sources due to export curbs by UAE and potential **EU restrictions** linked to circular economy criteria. India's scrap demand to reach **65 million tonnes annually by 2030**, with a potential import gap of 20–30 MT.
- Government is promoting a shift to **Electric Arc Furnace (EAF) steelmaking**, which uses scrap as primary feedstock. **Tata Steel** has begun establishing steel recycling plants to formalise domestic scrap processing.
- India's steel consumption, currently **152 million metric tonnes (MT)**, is projected to grow to **220 MT by FY30**, 260 MT by 2035, and **390 MT by FY50**.

Prelims Connect

Coal Grades in India — Classification

Grade	Properties	Location in India
Anthracite	Highest grade; hard, brittle, black, lustrous; high fixed carbon	Jammu and Kashmir (smaller quantity)
Bituminous	Medium grade; high heating capacity; used for electricity generation	Jharkhand, Odisha, WB, Chhattisgarh, MP
Sub-bituminous	Black, dull (not shiny); higher heating value than lignite	Assam, Meghalaya
Lignite	Lowest grade; least carbon content	Rajasthan, Tamil Nadu, J&K

Prelims Pointers

- India is the **2nd largest coal producer in the world** after China. **Coal India Ltd (CIL, 1975)** is the world's largest coal mining company — headquartered at Kolkata, a **Maharatna PSU**.
- **Gondwana coalfields** (250 million years old) produce **98% of India's coal**; **Tertiary coalfields** are in Assam, Nagaland, Meghalaya, and J&K.
- **Soil Organic Carbon (SOC)**: Defines physical, chemical, and biological properties of soil; governs soil's holding capacity and nutrient use efficiency. As per IISC, **SOC in range of 0.50–0.75% is adequate**.

- **Zinc deficiency in soils** leads to low zinc content in cereals like wheat and rice — linked to **childhood stunting**. India's soils also suffer from deficiency of **sulphur, iron, and boron**.
- In FY25, India exported **20.2 million tonnes of rice** in a global market of 61 MT. **FCI holds about 57 MT of rice** — highest stock in 20 years, nearly four times the buffer norm.

AGRICULTURE IN NEWS — COFFEE, TEA, COTTON, COCONUT, RUBBER AND MORE

Several major crops have been in news due to supply disruptions, climate impacts, and policy changes — from coconut oil hitting all-time high prices to cotton output falling to a 15-year low and rubber plantations facing a new beetle-fungi threat in Kerala.

News in Brief

- **COFFEE**: Karnataka's Chikmagaluru, Coorg, and Hassan districts suffered heavy crop losses due to incessant rainfall and **black rot disease** (fungal). **Coffee exports in 2024–25 crossed $1,000 million for the fourth consecutive year**. Coffee Board established under **Coffee Act VII of 1942**. India grows **Arabica** (mild, aromatic, 15°C–25°C, higher altitude) and **Robusta** (hot and humid, 20°C–30°C). Story began in **1600 AD when Baba Budan planted 7 Mocha seeds** on Baba Budan Giris, Karnataka.
- **TEA**: India is the **second-largest producer and consumer, and third-largest exporter globally**. Kenya remains the **largest exporter**. India's **per capita tea consumption: 840 g/year**; Turkey leads at **3 kg/year** (highest globally). **Conditions**: acidic soil (pH 4.5–5.5), 150–300 cm rainfall, 20–30°C. **FSSAI warning**: the term 'tea' can only be used on labels if the beverage is derived from **Camellia sinensis**.
- **COTTON**: India decided to **withdraw 11% import duty** amid declining domestic production — **294 lakh bales**, lowest in 15 years. **Bt hybrids cover 95% of cotton acreage** but technology has lost potency against **pink bollworm**. India is **2nd largest cotton producer after China**, accounting for **24% of global production**. Brought to India by **British**.
- **COCONUT OIL**: Prices at **all-time high**. **El Nino (2023–24)** affected coconut flower and fruit development. Karnataka, Tamil Nadu, and Kerala are India's leading coconut-producing states, contributing **~90% of output**. **Coconut Development Board (CDB)**, established 1981 — statutory body under Ministry of Agriculture.
- **RUBBER**: Kerala rubber plantations face threat from **ambrosia beetle (Euplatypus parallelus)** and associated **Fusarium fungi** — causing leaf fall, trunk drying, and latex loss. First reported in India in **Goa (2012)**. **Kerala produces 90% of India's rubber**; India is the **6th largest producer globally and 2nd in productivity**.
- **POTATO**: Centre cleared proposal to set up **South Asia regional centre of International Potato Center (CIP)** at Singna in Agra. India is **world's second top producer and consumer** (China leads). Potato is the **third most available food crop** after rice and wheat. Brought to India by **Portuguese**. **ICAR-CPRI (Shimla)** works on potato.
- **ASAFOETIDA (Heeng)**: India was world's largest consumer but fully import-dependent. **CSIR-IHBT Palampur launched indigenous cultivation** in **Himachal Pradesh** (Lahaul and Spiti, cold desert areas) from 2018–2020 seeds sourced from Iran and Afghanistan.

Prelims Connect

Key Crop Conditions and Major Producing States — India

Crop	Major States in India	Key Growing Conditions
Coffee	Karnataka (2/3 of output), Kerala, TN	Western Ghats, 15°C–30°C, well-distributed rainfall, shade

Tea	Assam (largest), WB, TN (Nilgiris), Kerala	Acidic soil (pH 4.5–5.5), 150–300 cm rain, 20–30°C, humid subtropical
Cotton	Gujarat, Maharashtra, Telangana (mainly)	Black soil, 21–30°C, 50–100 cm rain, long frost-free season (200+ days)
Coconut	Karnataka, TN, Kerala (~90%)	Equatorial climate, 1300–2300 mm rain, laterite/sandy/alluvial soil
Rubber	Kerala (90%)	Tropical climate, 200+ cm rain, 25–35°C
Potato	UP and WB (15 MT each), Bihar, Gujarat, MP	Loamy/sandy loam soil, pH 5.2–6.4, temperate climate, brought by Portuguese

Civet Coffee (Kopi Luwak): produced from excreta of Asian palm civet (Paradoxurus hermaphroditus) after consuming ripe coffee cherries; beans undergo natural fermentation in the civet's gut. Pokkali paddy: GI-tagged saltwater-tolerant rice from Pizhala island, Kochi — unique integrated rice-fish farming system (rice monsoon season, fish high-salinity months). Chakhao Rice (Manipur): Black sticky rice; GI tag in 2020.

Prelims Pointers

- **Milk**: India's milk production in 2023-24 was **239.3 million tonnes**. Top 5 states: **UP (15.72%), Rajasthan (14.44%), MP (8.73%), Gujarat (7.49%), Maharashtra (6.70%)**. Per capita availability: **471 grams/day** vs global average of 323 g/day.
- **Operation Flood (1970)** — White Revolution in India; **Home Minister announced White Revolution 2.0** to revolve around **cooperative societies** (same foundation as Operation Flood).
- **Tea Board India** was established under **Section 4 of the Tea Act, 1953** (constituted 1954); origins trace to 1903 Indian Tea Cess Bill.
- **Ambrosia beetles** attack dead, infected, or stressed trees by sensing **ethanol released by stressed trees**. They are invasive — can infest over 80 broadleaf species including cashew, teak, coconut, and coffee.
- **Tapioca (Cassava)**: Tamil Nadu and Kerala contribute more than **90% of total production**. Mealybug (arrived Thrissur 2020) was controlled using **Anagyrus lopezi** wasp — a rare success in **classical biological control** without chemicals.
- **Pathaneer** (palm sap) from palmyra trees in Thoothukudi, TN — processed into **panangkarkandu (palm candy)** and **karupatti (palm jaggery)**. **Palmyra is the State tree of Tamil Nadu**. Sap available only for **5 months** in a year.

HUMAN GEOGRAPHY & PLACES IN NEWS

POPULATION CENSUS 2027 TO BE CONDUCTED IN TWO PHASES

The Government of India has decided to conduct the Population Census – 2027 in two phases, marking the first time India is counting its population after a 16-year gap (previous census was 2011). For the first time in independent India, the 2027 Census will include caste enumeration and will be fully digital, with data collected via mobile apps and self-enumeration options.

News in Brief

- Phase 1 (House Listing & Housing Census): 1 April 2026 – 30 September 2026.

- Phase 2 (Population Enumeration): 1 February 2027 – 1 March 2027 (reference date 1 March 2027).
- For Snow-bound areas (J&K, HP, UK), reference date will be 1 October 2026 instead of 1 March 2027.
- This is India's 16th Census overall and the 8th since independence; it will include caste enumeration (first since 1931).

Prelims Connect

Indian Census — Key Milestones

Year	Significance
1872	First synchronous census under Lord Mayo (incomplete)
1881	First full census under Lord Ripon
1931	Last caste-based census in India
1941	Cost-cutting due to WWII; limited tabulation
1951	First post-independence census
2011	Most recent completed census; population 121.08 crore
2021	Postponed due to COVID-19
2027	To be conducted; first digital & caste census since 1931

The Census is conducted under the Census Act, 1948. The Census Commissioner of India heads the Office of the Registrar General & Census Commissioner (ORGI) under the Ministry of Home Affairs.

Prelims Pointers

- The Census Act, 1948 is a **Central Act**, Census being a **Union List subject (Entry 69)**.
- According to Census 2011: India's population was **1,210,854,977**, sex ratio 940, literacy 74.04%, urban share 31.16%.
- India is projected to remain the **world's most populous country** — it overtook China in April 2023 according to UN estimates.
- Census 2027 will be the **first fully digital census** with GPS-tagged enumeration and self-enumeration options.

KERALA'S TRIBAL HANDICRAFT KANNADIPPAYA GETS GI TAG

Kerala's tribal handicraft Kannadippaya ('mirror mat') has been granted the Geographical Indication (GI) tag in April 2025. This makes Kannadippaya the first tribal craft from Kerala to secure GI status. The craft is traditionally made by the Oorali, Mannan and Muthuvan tribes of Idukki district using split reed bamboo, and is known for its glossy, mirror-like finish.

News in Brief

- Kannadippaya is woven using thin bamboo splints from reed bamboo (Ochlandra travancorica).
- It is called 'mirror mat' because of its lustrous polished finish when held at an angle.
- The craft is practised by the Oorali, Mannan and Muthuvan tribes of Idukki, Kerala.
- The GI registration was facilitated by the Kerala Institute for Research, Training and Development Studies of SC/ST (KIRTADS).

Prelims Connect

Geographical Indication (GI) Tag — Key Facts

Aspect	Details
Governing Act	The Geographical Indications of Goods (Registration & Protection) Act, 1999
In force since	15 September 2003
First GI in India	Darjeeling Tea (2004)
Registering authority	GI Registry, Chennai, under CGPDTM
Duration	10 years (renewable)
WTO/TRIPS source	TRIPS Agreement Articles 22–24

As of 2025, India has over 640 registered GIs. Tamil Nadu has the highest number of GIs (58+), followed by Karnataka and Uttar Pradesh. The recent GI tags include Assam's Bodo Gamsa, Banglar Rasogolla and Kuttanad Pokkali rice.

Prelims Pointers

- A GI tag is a form of **intellectual property (IP) right** that identifies goods originating from a specific geographical region.
- The GI tag provides **legal protection, prevents unauthorised use**, and helps farmers/artisans get premium prices.
- Idukki, Kerala is home to the **Eravikulam National Park and Munnar** — also famous for the Neelakurinji flower that blooms every 12 years.
- Ochlandra travancorica (reed bamboo) grows in the **Western Ghats** — a Biodiversity Hotspot.

LEADS 2024 REPORT RELEASED — LOGISTICS EASE ACROSS DIFFERENT STATES

Union Minister of Commerce & Industry Shri Piyush Goyal unveiled the Logistics Ease Across Different States (LEADS) 2024 Report in January 2025. LEADS is an indigenous index that ranks states and UTs on the ease of doing logistics — covering four key pillars: logistics infrastructure, logistics services, operating and regulatory environment, and sustainable logistics.

News in Brief

- LEADS was launched in 2018 by the Department for Promotion of Industry and Internal Trade (DPIIT) as an India-specific alternative to the World Bank's Logistics Performance Index (LPI).
- The 2024 edition categorises states into four groups — Achievers, Fast Movers, Aspirers, and a new 'Coastal' / 'Landlocked' / 'North-East' / 'UT' sub-classification.
- Andhra Pradesh, Karnataka, Tamil Nadu and Gujarat emerged as 'Achievers' in the 2024 edition.
- India's ranking in the World Bank LPI 2023 improved to 38th out of 139 countries (from 44th in 2018).

Prelims Connect

PM Gati Shakti & National Logistics Policy — Pillars

Pillar	Objective

Integrated Digital System	Single GIS platform — 16 Ministries + 39 data layers
Unified Logistics Interface Platform (ULIP)	API-based integration of all transport modes
Ease of Logistics Services (E-Logs)	Grievance redressal for logistics players
Sector Plan for Efficient Logistics (SPEL)	Sectoral action plans for 7 key sectors
LEADS	State-level performance ranking

The National Logistics Policy was launched on 17 September 2022 with the target of reducing India's logistics cost from 13–14% of GDP to single-digit levels by 2030.

Prelims Pointers

- PM Gati Shakti (launched October 2021) is a **₹100 lakh crore multi-modal connectivity master plan** integrating 16 Ministries under a single GIS platform.
- The World Bank's **Logistics Performance Index (LPI)** is published biennially and ranks countries on 6 criteria: customs, infrastructure, ease of shipments, services, tracking, timeliness.
- India's logistics cost is estimated at **~13–14% of GDP** vs 8–9% in developed economies — a major competitiveness gap.

UK HANDS SOVEREIGNTY OF CHAGOS ISLANDS TO MAURITIUS — DIEGO GARCIA LEASED BACK

The United Kingdom signed an agreement in May 2025 handing sovereignty over the contested and strategically located Chagos Archipelago — including Diego Garcia — to Mauritius. Under the deal, the UK will lease back Diego Garcia from Mauritius for 99 years to continue operating the joint US–UK military base. The move ends a decades-old dispute and fulfils a 2019 International Court of Justice advisory opinion.

News in Brief

- The Chagos Archipelago is a group of 60+ islands in the central Indian Ocean, ~500 km south of Maldives.
- The UK detached the islands from Mauritius in 1965 to form the British Indian Ocean Territory (BIOT) and expelled 1,500–2,000 Chagossians.
- Diego Garcia is the largest island and hosts a joint US–UK naval and air base — one of the most important US overseas military facilities.
- In 2019, the International Court of Justice (ICJ) issued an advisory opinion that UK's continued administration of Chagos was 'unlawful'.

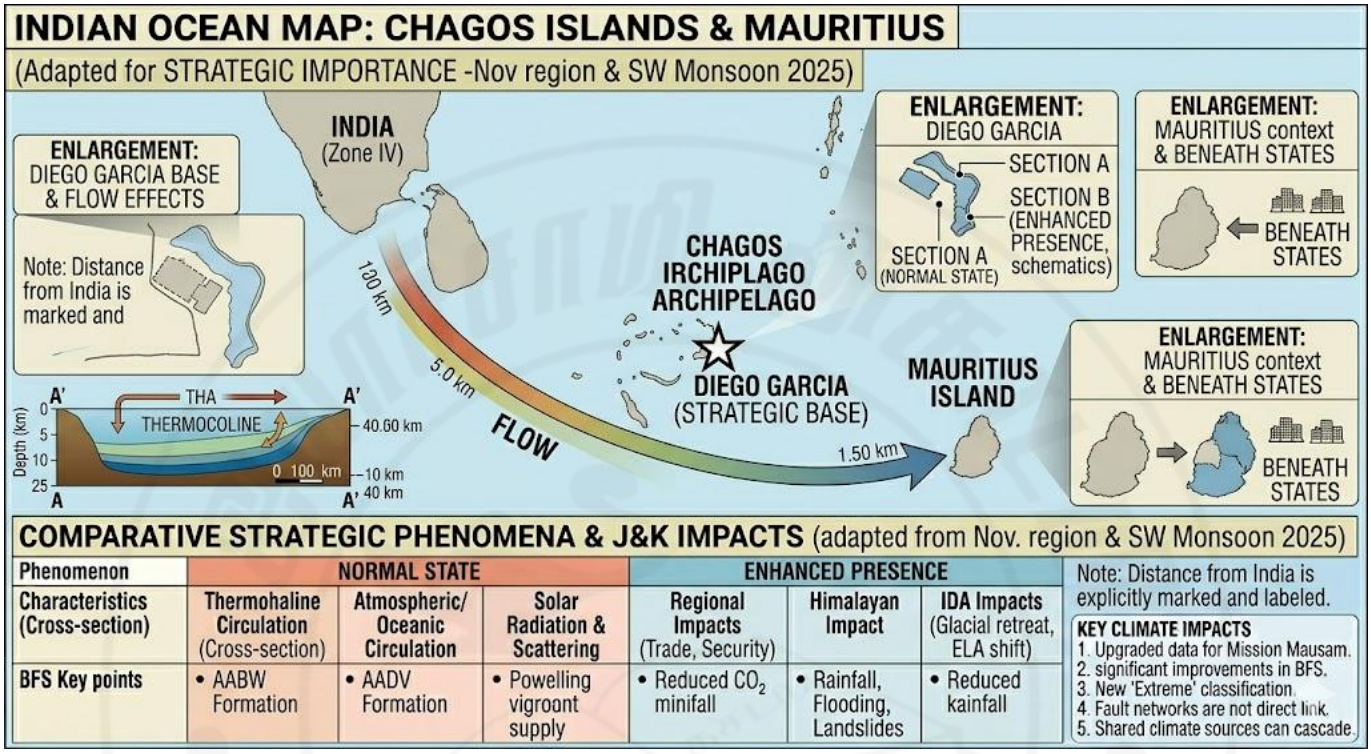
Prelims Connect

Indian Ocean Strategic Chokepoints & Islands

Location	Strategic Significance
Strait of Hormuz	40% of global oil exports transit here (Persian Gulf)
Bab el-Mandeb	Connects Red Sea to Gulf of Aden (Suez Canal route)
Strait of Malacca	30% of global maritime trade (SE Asia to East Asia)
Sunda Strait	Alternative to Malacca (Indonesia)

Lombok Strait	Alternative route between Bali and Lombok
Chagos (Diego Garcia)	US–UK joint military base; central Indian Ocean
Socotra (Yemen)	Near Gulf of Aden, of interest for maritime surveillance
Duqm (Oman)	India accessed for logistics in 2018

India historically supported Mauritius's sovereignty claim and voted in favour at the UN General Assembly Resolution 73/295 (2019) which affirmed Chagos as Mauritian territory.



Prelims Pointers

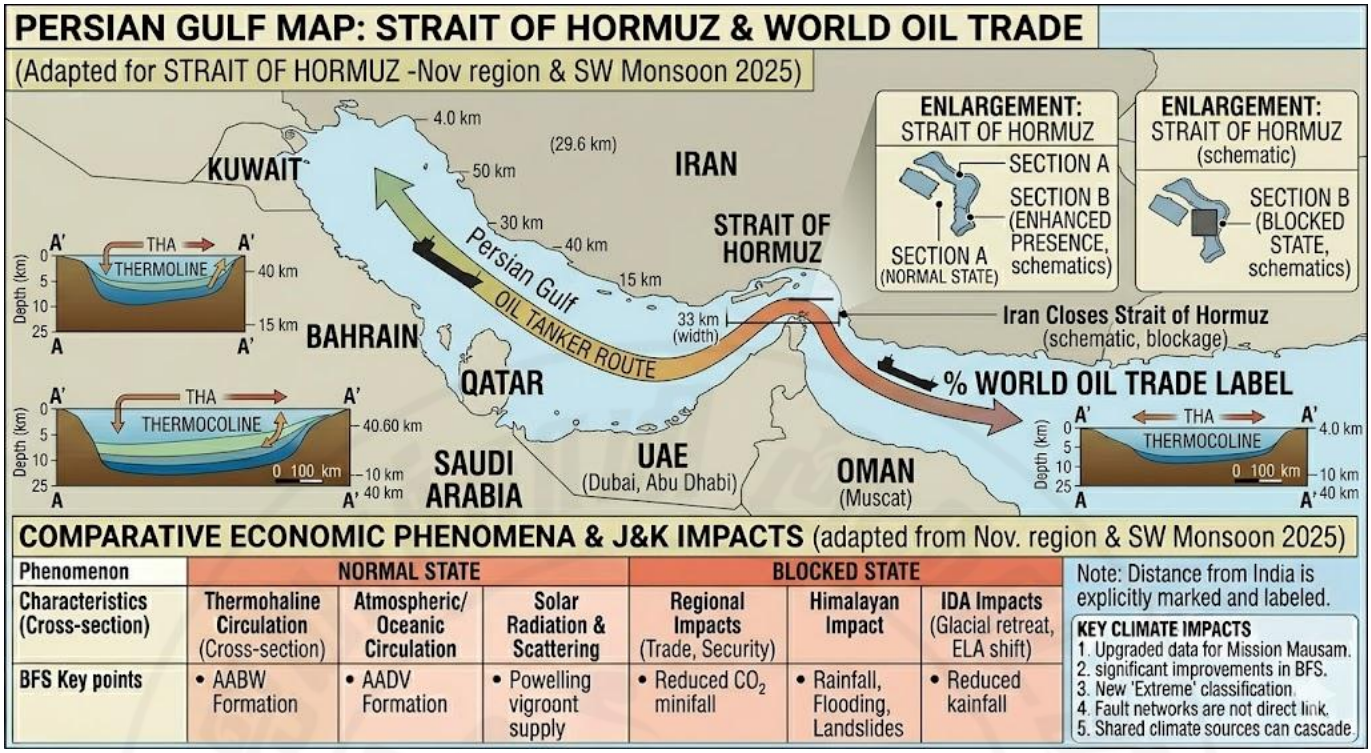
- Mauritius is a **small island nation in the SW Indian Ocean**, about 2,000 km east of Madagascar; it gained independence from UK in 1968.
- India and Mauritius signed a **Comprehensive Economic Cooperation and Partnership Agreement (CECPA) in 2021** — India's first trade pact with an African nation.
- The Chagos Archipelago is part of the **Mascarene Plateau** — a submarine volcanic ridge created by the Réunion hotspot.
- India inaugurated a **naval base and airstrip on Agaléga Island (Mauritius) in February 2024** to monitor sea lanes in the SW Indian Ocean.

IRAN TEMPORARILY CLOSES STRAIT OF HORMUZ FOR LIVE-FIRE DRILLS

Iran temporarily closed the Strait of Hormuz in February 2026 to conduct live-fire military drills, raising global concerns over oil supply. The Strait of Hormuz is the world's most important oil transit chokepoint — about 40% of global oil and over 20% of LNG trade passes through it every day. Any disruption has immediate global price implications, especially for energy-importing nations like India.

News in Brief

- The Strait of Hormuz is a narrow waterway between the Persian Gulf and the Gulf of Oman.
- It is 39 km wide at its narrowest point, with two 3 km-wide shipping lanes (one inbound, one outbound).
- About 20 million barrels of oil per day (bpd) — 25% of global seaborne oil trade — passes through it.
- It lies between Iran (north) and the UAE & Musandam Peninsula of Oman (south).



Prelims Connect

World's Major Oil Transit Chokepoints (IEA Data)

Chokepoint	Oil Flow (mbpd)	% of Global Oil Trade
Strait of Hormuz	~20	~27%
Strait of Malacca	~16	~23%
Suez Canal + SUMED Pipeline	~9	~12%
Bab el-Mandeb	~8.8	~12%
Turkish Straits	~2.9	~4%
Panama Canal	~1.0	~1.5%
Danish Straits	~3.2	~4%

India imports over 85% of its crude oil; about 60% of India's oil imports transit the Strait of Hormuz. Any disruption forces diversion via the Cape of Good Hope — adding weeks and costs to shipping.

Prelims Pointers

- The Persian Gulf is bordered by **Iran, Iraq, Kuwait, Saudi Arabia, Bahrain, Qatar, UAE, and Oman** — the eight Gulf states.

- The Strait of Hormuz is ~**56 km wide at maximum, narrowing to 39 km**; Iran controls the northern shore, Oman's Musandam exclave the southern.
- India's **Strategic Petroleum Reserve (SPR)** stores 5.33 MMT crude oil at Visakhapatnam, Mangaluru, and Padur — sufficient for ~9.5 days of consumption.
- The OPEC+ includes **13 OPEC + 10 non-OPEC members** (including Russia); it controls ~40% of world oil production.

PANGSAU PASS INTERNATIONAL FESTIVAL 2025 — ARUNACHAL PRADESH

The Pangsau Pass International Festival 2025 was celebrated at Nampong in Changlang district of Arunachal Pradesh in January 2025. Held annually, the three-day festival celebrates the cross-border cultural ties between India and Myanmar. Pangsau Pass, on the India–Myanmar border, is the historical entry point of the Stilwell Road — the WWII Allied lifeline from Ledo in Assam to Kunming in China.

News in Brief

- Pangsau Pass (1,136 m) is on the India–Myanmar border in Changlang district, Arunachal Pradesh.
- It was used by Ahom rulers in the 13th century to enter Assam from Upper Burma.
- During WWII, it served as the entry point of the Ledo (Stilwell) Road from Ledo (Assam) to Kunming (Yunnan, China), built by General Joseph Stilwell.
- The festival showcases the culture of the Tangsa, Tutsa, Singpho, Lisu, Naga and other tribes.

Prelims Connect

Important Himalayan and Border Passes in India

Pass	State / Location	Connects
Pangsau Pass	Arunachal Pradesh	India–Myanmar (Stilwell Rd)
Nathu La	Sikkim	India–Tibet (China)
Bum La	Arunachal Pradesh	India–Tibet
Shipki La	Himachal Pradesh	India–Tibet
Rohtang Pass	Himachal Pradesh	Kullu–Lahaul
Zoji La	Ladakh	Srinagar–Leh
Khardung La	Ladakh	Leh–Nubra Valley
Banihal Pass	Jammu & Kashmir	Jammu–Kashmir Valley
Aghil Pass	Ladakh	Ladakh–Xinjiang (Karakoram)
Dokala	Sikkim	India–Bhutan–China tri-junction

The Stilwell Road (1,726 km) was built between 1942–44 to re-open supply lines to China after the Japanese cut off the Burma Road. Its Indian stretch runs from Ledo (Assam) to Pangsau Pass in Arunachal.

Prelims Pointers

- Pangsau Pass is also called the **'Pass of Hell'** because of the hardships faced by Allied troops during WWII road construction.

- India and Myanmar share a **1,643 km border** touching four states: **Arunachal Pradesh, Nagaland, Manipur, Mizoram**.
- The **India–Myanmar Free Movement Regime (FMR)** allowed tribal populations on either side to travel 16 km across without visa — suspended in 2024 for security reasons.

ADT 59 — NEW RICE VARIETY TRANSFORMS CAUVERY DELTA FARMING

The new rice variety ADT 59, developed by Tamil Nadu Agricultural University (TNAU), is significantly boosting rice farming in the Cauvery delta region of Tamil Nadu as of July 2025. Known for its short duration (110–115 days), high yield (6.5 t/ha) and strong resistance to pests, ADT 59 is being hailed as a game-changer for the 'Rice Bowl of Tamil Nadu' — a region long plagued by climate uncertainty and water stress.

News in Brief

- ADT 59 was released by the Aduthurai Research Station of TNAU (the 'ADT' prefix stands for 'Aduthurai').
- It is a medium-short duration variety (110–115 days) suitable for Samba and Thaladi seasons in the Cauvery delta.
- Yield potential: 6.5 tonnes/hectare; resistant to brown planthopper and blast.
- The Cauvery delta (Thanjavur, Thiruvarur, Nagapattinam, Mayiladuthurai districts) is the 'Rice Bowl of Tamil Nadu'.

Prelims Connect

Major Rice-Growing Regions of India & Key Varieties

Region	Key States	Notable Varieties
Cauvery Delta	Tamil Nadu	ADT 59, CO 51, ADT 43, ADT 36
Gangetic Plains	UP, Bihar, WB	Swarna, IR-64, Sarju-52
Godavari Delta	Andhra, Telangana	MTU 1010, Swarna, BPT 5204
Krishna Delta	Andhra	BPT 5204 (Sona Masuri)
Mahanadi Delta	Odisha	Pooja, Lalat, Naveen
Kuttanad	Kerala	Pokkali, Uma, Jyothi
NE states	Assam, Manipur	Joha, Chakhao Amubi (black rice)

India is the world's second-largest rice producer and the largest exporter, exporting ~17 million tonnes in 2024 (40% of global rice trade). Basmati is exported mostly to West Asia; non-Basmati rice goes to Africa.

Prelims Pointers

- The Cauvery delta is called the **'Rice Bowl of Tamil Nadu'**; the Mettur dam on the Cauvery (1934) controls irrigation supply.
- Samba, Thaladi and Kuruvai are the **three rice-growing seasons in Tamil Nadu**; Samba (Aug–Jan) is the principal season.
- IRRI's **IR 8 (the 'miracle rice') launched in 1966** was the foundation of the Green Revolution in Asia.

AMRAVATI TO BECOME WORLD'S FIRST CITY POWERED ENTIRELY BY RENEWABLES

Andhra Pradesh's new capital city Amravati aims to become the world's first city powered entirely by renewable energy, the state government announced in April 2025. The planned capital — a greenfield city on the banks of the Krishna river in Guntur district — will source all its electricity, heating, cooling and mobility needs from solar, wind, and green hydrogen.

News in Brief

- Amravati is the designated capital of Andhra Pradesh, being developed on a 217 km² greenfield site on the south bank of the Krishna river.
- It is part of the Capital Region of Andhra Pradesh Development Authority (APCRDA) covering 8,352 km².
- The city's master plan was prepared by Surbana Jurong (Singapore); it was conceived after the 2014 bifurcation of AP.
- The renewable energy plan includes rooftop solar, solar farms, agro-voltaic panels, green hydrogen for transport.

Prelims Connect

Andhra Pradesh — Key Geographic Facts

Feature	Details
Formation	1 November 1956 (SRC); bifurcated 2 June 2014
Capital	Amravati (de jure); Visakhapatnam proposed as exec capital
Coastline	974 km — longest east-coast state
Area	162,975 km² — 8th largest state
Major rivers	Godavari, Krishna, Penna, Vamsadhara
Major ports	Visakhapatnam (major), Kakinada, Krishnapatnam, Gangavaram

Amravati lies between Vijayawada and Guntur — part of the Krishna delta. It is different from the historical Buddhist site 'Amaravati' (near Guntur) famous for the Amaravati stupa and 2nd century CE Satavahana-era sculptures.

Prelims Pointers

- Andhra Pradesh was the **first state to be created on linguistic basis** — 1 October 1953, from Madras Presidency.
- After the 2014 bifurcation (AP Reorganisation Act, 2014), Telangana became the **29th state of India on 2 June 2014**.
- India's other fully renewable-powered cities/projects: **Diu (100% solar-powered UT, 2018), Kochi International Airport (world's first solar-powered airport, 2015)**.

INDIA'S COASTLINE REVISED TO 11,098.8 KM — THE COASTLINE PARADOX

In 2024, the Ministry of Home Affairs stated that India's coastline increased from 7,516.6 km to 11,098.8 km. This increase is not due to territorial expansion but results from better measurement technology — demonstrating the Coastline Paradox first identified by Lewis Fry Richardson.

News in Brief

- Measurement done by **National Hydrographic Office (NHO) and Survey of India** using **GIS, satellite altimetry, LIDAR-GPS, and drone imaging**.
- The **Coastline Paradox**: coastline length varies with measurement scale — the finer the measuring unit, the longer the calculated coastline. At coarser scales, smaller features like creeks, estuaries, and ridges are missed.
- **Paradox identified by Lewis Fry Richardson**; popularised by **Benoit Mandelbrot in 1967** as fractal-like geometry.
- **BBNJ Treaty** (Biodiversity Beyond National Jurisdictions): India will enact a new law to safeguard its interests in international ocean waters. **MoES formed a 12-member drafting committee** headed by Sanjay Upadhyay.
- The **High Seas Treaty** aims to curb pollution, limit excessive resource extraction, and promote sustainable use of marine biodiversity. A major outcome: **creation of protected areas in high seas**.
- **High seas** refer to areas beyond national territorial waters and EEZs — cover about **64% of the world's ocean area**, currently regarded as global commons.
- India has **signed but not yet ratified** the BBNJ Treaty. **60+ countries have ratified** it, and it came into force 120 days after ratification by the 60th country.

Prelims Connect

UNCLOS and BBNJ — Relationship

Instrument	Key Provisions	Analogy
UNCLOS (1982)	Comprehensive framework governing use and management of oceans; defines rights and duties of nations; territorial sea (12 nm), EEZ (200 nm)	Main treaty
BBNJ Agreement	Implementation agreement under UNCLOS — protected areas in high seas, seabed mining regulation, equitable benefit-sharing	Like Paris Agreement under UNFCCC

Prelims Pointers

- **UNCLOS 1982**: **Territorial sea** extends up to **12 nautical miles** — full sovereignty. Within **EEZ**, a state has **exclusive sovereign economic rights only over resources**, not full sovereignty.
- **Polar Research Vehicle (PRV)**: **Garden Reach Shipbuilders and Engineers (GRSE)** signed MoU with Norwegian firm **Kongsberg** to co-design India's first-ever Polar Research Vehicle.
- **NCOPR** (National Centre for Polar and Ocean Research, est. 1998): Supports India's stations in Antarctica (Maitri and Bharati), Arctic (Himadri), and Himalayas (Himansh). **Finance Ministry approved Maitri II** — India's 4th Antarctic station, ready by **2029**.
- **Sagarmatha Sambaad**: Multi-stakeholder dialogue forum held in Kathmandu, Nepal. Theme: **'Climate Change, Mountains, and the Future of Humanity'**. India outlined a **five-point call** for global action on mountain ecological challenges.

The African Union (AU) endorsed the 'Correct the Map' campaign to replace the Mercator projection with alternatives like the Equal Earth map — challenging the symbolic marginalisation of Africa due to size distortions.

News in Brief

- **Mercator projection**: Designed in **1569 by Gerardus Mercator** to help sailors navigate **rhumb lines** (constant compass directions). Preserves shape and direction but **distorts size** near the poles.
- Distortions: **Africa (30 mn sq. km) appears similar in size to Greenland** (which is 14x smaller); **Europe looks comparable to Africa** though one-third its size. Critics argue distortions shaped perceptions of colonial power.
- **Equal Earth projection (2018)**: Preserves relative area, but shapes appear curved. **Gall-Peters projection**: Preserves area but elongates continents. **Orthographic projection**: Shows Earth as from space, only one hemisphere at a time.
- **Flattening a sphere onto a rectangle always requires distortion** of area, shape, distance, or direction — there is no perfect flat map.

Prelims Connect

Key Places in News — Brief Notes

Place	Why in News	Key Fact
Nyoma, Ladakh	IAF inaugurated new military airbase	4,200 m altitude; 35 km from LAC; handles Rafale and Sukhoi-30MKI; C-130J landed at Mudh-Nyoma air force station
Bekal Fort, Kerala	Cinema tourism promotion	Built ~1650 AD by Shivappa Nayaka of Keladi dynasty; laterite construction; Kasaragod district; largest fort in Kerala
Zehanpora, J&K	Archaeological excavation	Baramulla; ~2,000-year-old Kushan period site; evidence of ancient Buddhist stupas
Rashtra Prerna Sthal	Lotus-shaped memorial on Gomti river	65 acres; statues of Vajpayee, Deen Dayal Upadhyay, Shyama Prasad Mookerjee; close to Gomti river banks, Lucknow
Gomti River	Flows past Rashtra Prerna Sthal	Originates at Gomat Taal (Pilibhit, UP); meets Ganga at Ghazipur; perennial, rain-fed and groundwater-fed (unlike snow-fed Himalayan rivers)
Doodhpathri, Kashmir	Meadows of Kashmir tourism	Upper reaches of Pir Panjal range (Lesser Himalayas); Kehwa is local brew of almonds, saffron, cardamon, cinnamon
Punjab Holy Cities	Holy City status granted	Amritsar, Anandpur Sahib, Talwandi Sabo; host 3 of 5 Sikh Takhts; ban on liquor, tobacco, cigarettes, and meat

Cherrapunji Eastern Craft Gin	First NE India alcohol label exported	Distilled from rainwater sourced from Sohra and Mawsynram — two wettest places on Earth; includes kaji nemu, Khasi mandarin, Sohmarit pepper

Prelims Pointers

- **Five Sikh Takhts**: **Akal Takht** (Amritsar, supreme, 1606 by Guru Hargobind); **Takht Keshgarh Sahib** (Anandpur Sahib — Khalsa raised 1699); **Takht Damdama Sahib** (Talwandi Sabo — Guru Granth Sahib revised here); **Takht Patna Sahib** (Bihar — birthplace of Guru Gobind Singh); **Takht Hazur Sahib** (Nanded, Maharashtra — Guru Gobind Singh's final days).
- **Synchronous All India Elephant Estimation 2021–25**: Reported **22,446 elephants**. **Asian elephant (Elephas maximus)** — Endangered, IUCN Red List since **1986**. India accounts for over **60% of global population**. Counted every **five years** since **Project Elephant (1992)**.
- **Honey Village** — Ramhama, Budgam, Kashmir — for Apiculture (Acacia honey). India's first **mono-floral lavender honey** produced by **CSIR-IIIM in Pulwama**. India is the **7th largest honey producer**.