



20 Years of Indian Ocean Tsunami 2004

For Prelims: [Sunda Trench](#), [Indo-Australian Plate](#), [Burma Microplate](#), [Eurasian Plate](#), [Coco Islands](#), [Andaman and Nicobar Islands](#), [Tsunami](#), [Volcano](#), [Indian Tsunami Early Warning Centre \(ITEWC\)](#), [Indian National Centre for Ocean Information Services \(INCOIS\)](#), [Indian Ocean](#), [Mangrove](#), [Mahabalipuram](#), [Nuclear Power Plants](#), [Kalpakkam Nuclear Plant](#), [UNESCO](#), [Intergovernmental Oceanographic Commission \(IOC\)](#), [Coastal Regulation Zone \(CRZ\)](#), [NDMA](#), [SDMAs](#).

For Mains: New initiatives in tsunami forecasting, Tsunami disaster management.

[Source: TH](#)

Why in News?

- **26th December 2024**, marked the **20th anniversary** of the **2004 Indian Ocean earthquake and tsunami**.

What was the 2004 Indian Ocean Earthquake and Tsunami?

- **Origin and Cause:** The earthquake had a **magnitude of 9.1**, making it the **third-largest earthquake** [Others two: Chile, 1960 (magnitude 9.5) and Alaska, 1964 (magnitude 9.2)] recorded globally since 1900.
 - The earthquake originated in the [Sunda Trench](#), where the [Indo-Australian plate](#) subducts beneath the [Burma microplate](#) (part of the [Eurasian plate](#)).
- **Geographic Impact:** It affected an astounding **1,300 km** from **Sumatra** in the south to the [Coco Islands](#) in the north.
 - The earthquake's tremors were felt across **Indonesia, Bangladesh, India, Malaysia, Maldives, Myanmar, Singapore, Sri Lanka, and Thailand**.
 - In **Car Nicobar**, the **Indian air force base** was **completely destroyed**, underscoring the scale of destruction.
- **Death and Displacement:** The tsunami resulted in an estimated over **227,000 deaths**, making it the **deadliest tsunami** in recorded history.
 - Over **1.7 million people** were displaced due to the destruction of homes and infrastructure.
- **Lessons for India:** India **didn't anticipate** such a large event along **India's eastern coast**, as the only previous tsunamis occurred in **1881** (from a large earthquake near Car Nicobar island) and **1883** (from the Krakatoa explosion), both producing **only small surges**.
- **Reduction in Mortality:** The **1999 Odisha super cyclone** killed over **10,000 people** while **Cyclone Yaas (2021)** resulted in fewer than **six casualties** that shows India has made significant progress in disaster risk reduction (DRR).
 - However, **infrastructure damage** caused due to cyclones is still a cause of concern. E.g., **Cyclone Dana (2024)** caused widespread damage in Odisha that is estimated at **Rs 616 crore**.

The 2004 Indian Ocean tsunami

A massive earthquake on December 26, 2004 set off a series of tsunamis that tore across the Indian Ocean, killing more than 220,000 people

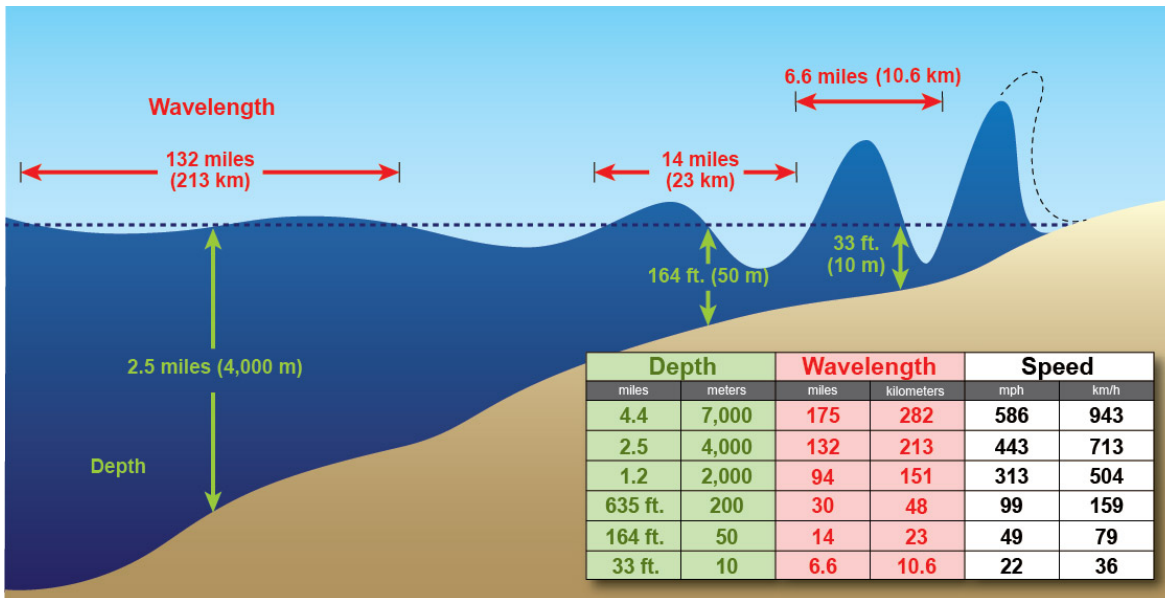


Source : AFP/UN/Nature/USGS

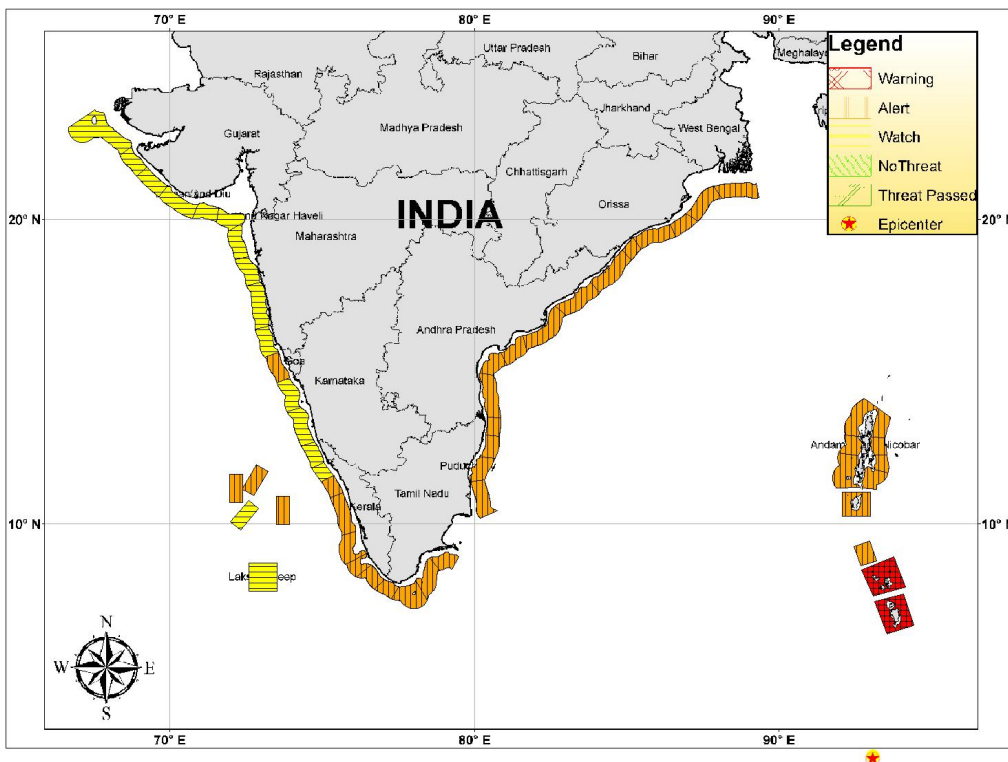


Tsunami

- Tsunamis are **giant waves** caused by **earthquakes** or **volcanic eruptions** under the sea.
 - It is also caused by **landslides**, **nuclear explosion**, **seamount collapse**, and meteorite impact.
- Out in the **depths** of the ocean, tsunami waves do not dramatically increase in height.
 - But as the **tsunami approaches land**, they build up to **higher and higher heights** as the **depth** of the ocean **decreases**.
- The **speed** of tsunami waves depends on **ocean depth rather than the distance** from the source of the wave.
- Tsunami waves may travel **as fast as jet planes over deep waters**, only **slowing down** when reaching **shallow waters**.



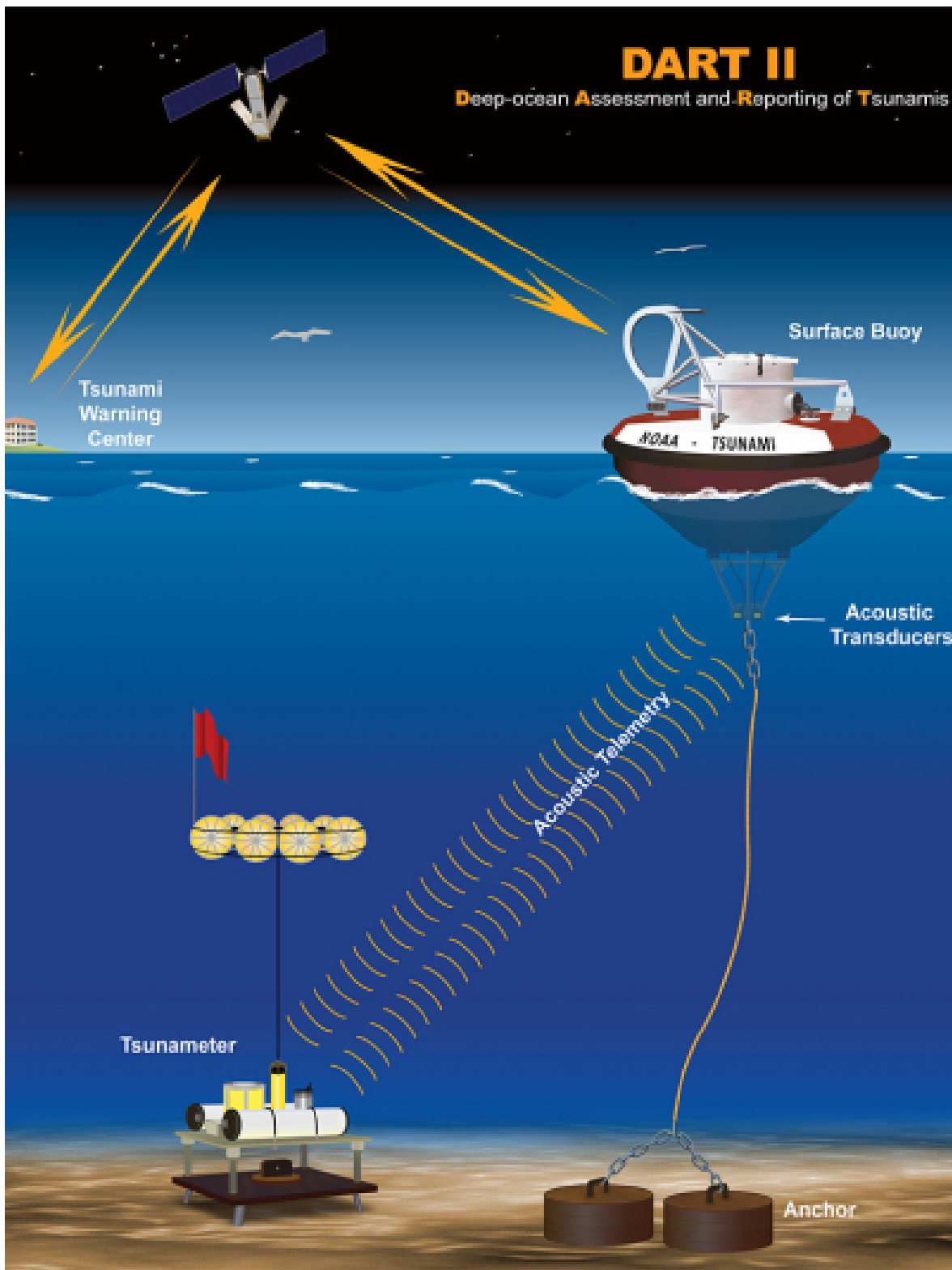
- Tsunami Prone Areas:** India is **vulnerable** to various natural and human-made disasters due to its unique geo-climatic and socio-economic conditions.
 - Of the **7,516 km long coastline**, close to **5,700 km is prone to cyclones and tsunamis**.



What Initiatives Were Taken after the 2004 Indian Ocean Tsunami to Minimise Damages?

- **Early Warning Systems:** The [Indian Tsunami Early Warning Centre \(ITEWC\)](#) was established in **2007** by the **Union Ministry of Earth Sciences**.
 - **ITEWC** operates from the [Indian National Centre for Ocean Information Services \(INCOIS\)](#) in **Hyderabad**, using **seismological stations**, **bottom pressure recorders**, and **tidal stations** across the [Indian Ocean basin](#) to detect and issue early warnings for potential tsunamis.
 - The **ITEWC** functions as an **approved Tsunami Service Provider** of the **Indian Ocean Tsunami Warning & Mitigation System (IOTWMS)** that is an integral part of the **Global Tsunami Warning and Mitigation System**.
 - Global, there are around **150 stations** worldwide monitoring seismic activity, and **Deep-ocean Assessment and Reporting of Tsunamis (DART)** buoys track changes in pressure on the seafloor to detect tsunami generation.





- **Real-time Monitoring: Real-time ocean monitoring systems** were developed to detect tsunami-producing earthquakes and issue alerts in as little as **10 minutes**.
 - India became the **5th country globally** to have an advanced tsunami warning system, joining **the US, Japan, Chile, and Australia**.
 - Globally, **sea-level monitoring stations** have increased from just **one in 2004** to **14,000** today, to detect rising sea levels and potential tsunamis.
- **Technological Advancements:** The early warning systems now use better algorithms and faster supercomputers enabling **rapid modeling**, allowing for faster and more accurate predictions of tsunami behavior.
- **Tsunami Geology Research:** The work of tsunami geology, pioneered by **Brian Atwater** of the

US Geological Survey started to search for evidence of tsunamis in history.

- Investigations of **mangrove swamps** and coastal areas led to the discovery of **past tsunami events (1,000 years ago)** in the Andaman and Nicobar Islands and **Mahabalipuram (a port of the Pallava dynasty)**.
- **Research on Slow Slips:** Researchers started studying **seismic slips** at plate boundaries to understand the processes that occur before and after **major earthquakes**.
 - Investigations indicated a **perceptible downward ground movement** in South Andaman between **2003 and 2004**, before the megathrust earthquake of 2004.
- **Nuclear Plant Vulnerability Studies:** Following the 2004 tsunami, researchers assessed the vulnerability of **nuclear power plants**, such as **Kalpakkam**, to tsunami risks.
 - The **Kalpakkam nuclear plant** shut down automatically due to rising water levels and the reactor **restarted after six days**.
- **Inundation Studies:** **Tsunami modelling** using **mathematical tools** helped identify **inundation limits** and assess risks to coastal infrastructure.
- **Focus on High-Risk Areas:** Experts began to study other high-risk areas like the **Makran Coast** (Iran and Pakistan) and the **Myanmar coast**.
 - The Makran Coast could direct a tsunami towards **India's west coast**, impacting Mumbai and nuclear reactors.
- **Global Cooperation:** The tsunami warning system has become more **globally coordinated**, with countries working together to **monitor earthquakes and tsunamis**.
 - E.g., After the 2004 Indian Ocean tsunami, **UNESCO Intergovernmental Oceanographic Commission (IOC)** was tasked with establishing global tsunami warning services across ocean basins.

What are NDMA Guidelines Tsunami Mitigation?

- **Risk Mapping:** Conducting **comprehensive tsunami risk assessments** for vulnerable coastal areas, identifying the regions at the greatest risk from tsunamis.
- **Early Warning System:** Establishing and maintaining an effective **tsunami early warning system** that includes **seismic sensors, tide gauges, and ocean buoys** to monitor potential tsunami threats.
 - Disseminate tsunami warnings through channels like **SMS, radio, television, and public announcement systems**.
- **Coastal Zoning:** Relevant authorities to implement the **Coastal Regulation Zone (CRZ) Notification** for controlled and sustainable development in coastal areas.
 - Promoting **safe development** in low-risk areas, with a focus on **natural buffers** like **mangroves** and **sand dunes**.
- **Tsunami-Resilient Infrastructure:** Building tsunami-safe infrastructure, including **elevated buildings**, reinforced structures, and emergency shelters above expected tsunami wave heights.
 - Constructing **seawalls, breakwaters, and embankments** in high-risk areas to reduce the impact of tsunami waves.
- **Community Preparedness:** Conducting regular public awareness campaigns on **tsunami risks, warning signs**, and emergency actions.
 - Creating tsunami evacuation plans for coastal areas with **clear signage, maps, and regular drills**.
- **Institutional Framework:** Coordinating national, state, and local agencies, including **NDMA** and **SDMAs**, for effective tsunami mitigation and response.
- **Response and Recovery:** Developing tsunami response and recovery plans with search and rescue, **medical aid, shelters, and food and water** distribution.
 - Establishing strategies for reconstructing affected areas, including financial and logistical support for **rebuilding homes, infrastructure, and livelihoods**.

Conclusion

The 2004 Indian Ocean tsunami highlighted **critical gaps** in early warning systems, prompting **significant advancements** in global and regional tsunami preparedness. Initiatives such as

the establishment of **ITEWC, enhanced monitoring, and international cooperation** have drastically improved disaster response, yet challenges remain, particularly in developing nations.

Drishti Mains Question:

Discuss the initiatives taken post-2004 Indian Ocean tsunami to improve early warning systems.

UPSC Civil Services Examination Previous Year Question (PYQ)

Mains

Q. Discuss about the vulnerability of India to earthquake related hazards. Give examples including the salient features of major disasters caused by earthquakes in different parts of India during the last three decades. **(2021)**

Q. Discuss the recent measures initiated in disaster management by the Government of India departing from the earlier reactive approach. **(2020)**

Q. In December 2004, tsunami brought havoc on fourteen countries including India. Discuss the factors responsible for the occurrence of tsunami and its effects on life and economy. In the light of guidelines of NDMA (2010) describe the mechanisms for preparedness to reduce the risk during such events. **(2017)**

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