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**TRANSFORMING TSUNAMI SCIENCE  
AFTER 2004 EARTHQUAKE**

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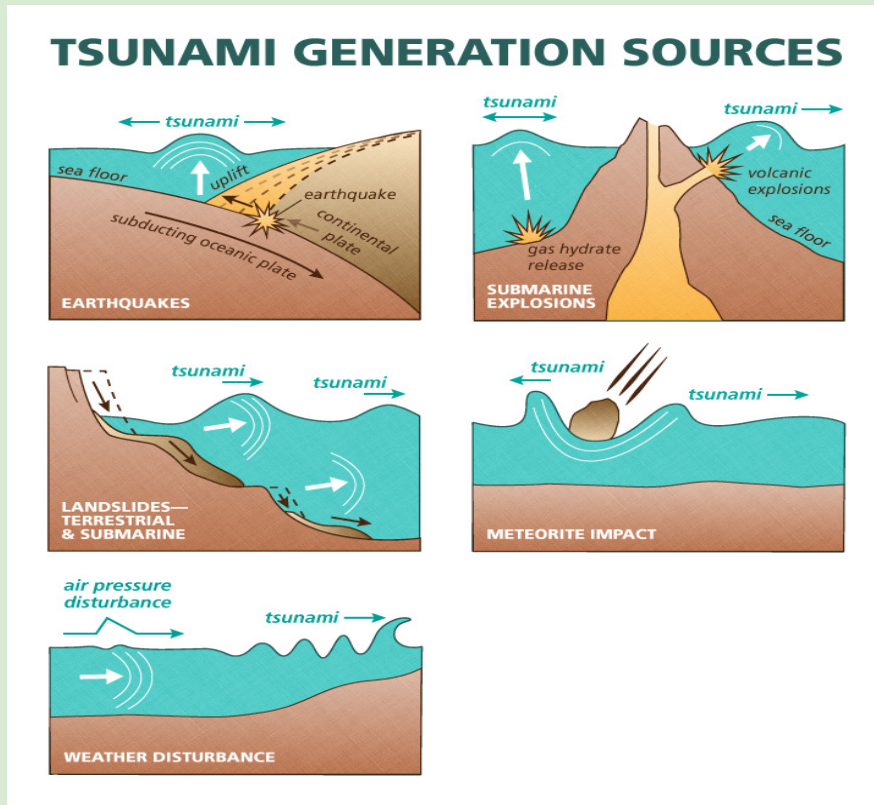
## TRANSFORMING TSUNAMI SCIENCE AFTER 2004 EARTHQUAKE

### Context

- December 26, 2024, marks the 20th anniversary of the devastating 2004 Indian Ocean earthquake and tsunami, which was triggered by a magnitude 9.1 earthquake **off the coast of Sumatra**, profoundly changed the field of tsunami science and disaster preparedness.

### Do you know ?

- A tsunami is a series of waves caused by a sudden and large displacement of the ocean.



- The most common triggers are large earthquakes beneath or near the ocean floor, but other causes include landslides, volcanic activity, certain weather conditions, and meteorite impacts.
- Tsunamis typically occur along large fault lines, particularly around the Pacific Ring of Fire, but can also be triggered by landslides or volcanic eruptions far from coastlines.

### Tsunami Science in India

- Tsunamis, often triggered by undersea earthquakes, pose significant threats to coastal regions.
- The Indian Ocean earthquake in 2004, which was the third largest since 1900, originated 30 km below the **ocean floor in the Sunda Trench**, where the **Indo-Australian plate** subducts beneath the **Burma microplate**.
- The resulting tsunami **affected 17 countries** around the Indian Ocean, causing unprecedented destruction and a death toll of approximately 227,000 people.
- The sheer scale of the disaster highlighted the world's vulnerability to such natural hazards.
  - ♦ **69% of tsunamis occur** in the **Pacific Ocean**.

### Early Challenges and Developments

- Prior to 2004, India's awareness and preparedness for tsunamis were minimal. The country had experienced tsunamis before, such as the **1881 Car Nicobar earthquake** and the **1883 Krakatoa eruption**, but these events were relatively minor.

- The 2004 tsunami, however, was a wake-up call. It highlighted the gaps in India's disaster management infrastructure and the necessity for scientific advancements in tsunami detection and response.

### Advances in Tsunami Science

- **Indian Tsunami Early Warning Centre (ITEWC):** In response to the 2004 earthquake disaster, India established the **ITEWC** at the Indian National Centre for Ocean Information Services (INCOIS) in Hyderabad to detect tsunamigenic earthquakes and issue timely warnings.
- **Enhanced Early Warning Systems:** INCOIS developed a **state-of-the-art Tsunami Early Warning System (TEWS)**, which became operational in 2007.
  - ♦ It integrates data from seismic stations, tide gauges, and deep-ocean tsunami detection buoys to provide timely warnings.
  - ♦ Today, there are around 150 stations globally, including **Deep-ocean Assessment and Reporting of Tsunamis (DART)** buoys that monitor pressure changes on the seafloor to detect tsunamis.
- **Improved Technology:** Advances in technology have significantly reduced the time required to detect and model tsunamis.
  - ♦ Modern algorithms and faster supercomputers now allow for rapid transmission of information, reducing the time to issue warnings from up to 50 minutes to just five to seven minutes.
- **Increased Monitoring Stations:** The number of sea level monitoring stations has increased dramatically, from just one in 2004 to over 14,000 today.
  - ♦ This extensive network provides critical data for early detection and response.

### Community Preparedness and Education

- Beyond technological advancements, community preparedness is crucial for mitigating tsunami impacts.
- INCOIS conducts regular workshops, training sessions, and mock drills to educate coastal communities about tsunami risks and response strategies.
- The **'Tsunami Ready' program**, initiated by **UNESCO-IOC**, aims to enhance community preparedness through a structured approach.

### Global Preparedness and Resilience

- Initiatives led by the United Nations and other international bodies have improved preparedness across vulnerable regions.
- The ITEWC provides advisories to Indian Ocean rim countries under the framework of the **Intergovernmental Oceanographic Commission (IOC) of UNESCO**.
  - ♦ It ensures a coordinated response to tsunami threats across the region.

### Research and Future Directions

- **Detection and Early Warning Systems:** While significant progress has been made in developing early warning systems, there are **still gaps in coverage, especially in remote and underdeveloped regions**.
  - ♦ Improving the density and accuracy of seismic networks and ocean buoys is crucial for providing timely alerts to vulnerable coastal communities.
- **Infrastructure and Evacuation Plans:** In many regions, inadequate infrastructure and poorly designed evacuation plans can hinder the timely and safe evacuation of residents.
  - ♦ Investing in resilient infrastructure and comprehensive evacuation strategies is essential for minimizing the impact of tsunamis.
- **Research and Technological Advancements:** Continued research and technological advancements are necessary to improve our understanding of tsunamis and enhance prediction models.
  - ♦ Developing more sophisticated models that can accurately simulate tsunami propagation and impact can help authorities make informed decisions during emergencies.
  - ♦ Additionally, integrating new technologies such as satellite-based remote sensing and machine learning can further improve tsunami detection and forecasting.

- **Public Awareness and Education:** Many coastal residents are unaware of the signs of an impending tsunami and the appropriate actions to take during an emergency.
  - ♦ Enhancing public education campaigns and conducting regular drills can help communities better prepare for and respond to tsunami threats.

Source: TH



### Mains Practice Question

Discuss the significant advancements in tsunami science and early warning systems that have occurred in the aftermath of the devastating 2004 Indian Ocean earthquake and tsunami. Analyze the impact of these advancements on coastal communities and the global response to tsunami threats.

