INDIA'S EARTHQUAKE VULNERABILITY: GEOGRAPHY

NEWS: A tectonic shift in thinking to build seismic resilience

WHAT'S IN THE NEWS?

Despite minor tremors near Delhi exposing urban vulnerabilities, India is significantly advancing its disaster management strategy through institutional reforms, technological upgrades, and public awareness, aiming for an earthquake-resilient nation by 2047. This includes doubling seismic observatories, retrofitting critical infrastructure, and comprehensive early warning systems, particularly in high-risk Himalayan and Northeastern regions.

India's Earthquake Vulnerability & Disaster Management Strategy

A recent 4.4 magnitude earthquake near Delhi in July 2025 highlighted India's infrastructural vulnerabilities, emphasizing the urgent need for enhanced earthquake preparedness given its seismic geography. India's evolving disaster management strategy focuses on technology, institutional reforms, and public awareness.

Key Highlights of India's Evolving Disaster Management Strategy:

- **Institutional Reforms & Initiatives:**
    - **Gujarat's Pioneering Role:** Gujarat was the first state to establish a Disaster Management Committee post-2001 earthquake, which inspired the formation of the **National Disaster Management Authority (NDMA)** in 2005.
    - **Scientific Research Institutes:** Establishment of the **Institute of Seismological Research** in Gujarat, followed by the **National Centre of Seismology (NCS)** at the national level, dedicated to earthquake monitoring and research.
- **Scientific & Monitoring Advancements:**
    - **Increased Seismic Observatories:** The number of seismic observatories in India significantly increased from 80 in 2014 to 168 in 2024, doubling in a decade.
    - **Enhanced Northeast Monitoring:** Continuous expansion of earthquake monitoring in the Northeast, enabling detection of quakes above magnitude 3.0.
- **Infrastructure Retrofitting & Code Compliance:**
    - **Critical Infrastructure Focus:** Emphasis on retrofitting important buildings like AIIMS Delhi and Bhuj Hospital, Gujarat, to make them earthquake-resistant.
    - **Strict Building Code Enforcement:** Efforts to strictly enforce Indian Standards (IS) seismic building codes and retrofit existing schools and public buildings.
    - **Vision 2047:** A nationwide retrofitting plan is aligned with Vision 2047, aiming for an earthquake-resilient India.
- **Public Awareness & Community Preparedness:**

    - **Regular Drills & Campaigns:** Conduct of regular mock drills, public awareness campaigns (e.g., 'Aapda Ka Samna' on Doordarshan), and distribution of simplified safety guides for homeowners.
    - **Simplified Guidelines:** Simplified guidelines under the Building Code of India were issued in 2021 for structural safety.
- **Himalayan Belt & Early Warning Systems:**
    - **Deployment of Early Warning Systems:** Installation of early warning systems and clear response protocols in Uttarakhand and other Himalayan states.
    - **Focus Areas:** Specific emphasis on disaster education, preparedness, and real-time alerts in these high-risk regions.
- **Northeast Focus & Developmental Push:**
    - **Top Priority:** Earthquake resilience in Northeast India remains a top priority due to its high seismic activity.
    - **Related Missions:** Launch of initiatives like 'Mission Mausam', space-tech programs, and allocation of ₹1,000 crore for space startups to aid disaster management.
- **Risk Transfer & Insurance Mechanisms:**
    - **Infrastructure Insurance:** Introduction of a 'Risk Transfer Mechanism' for providing insurance against seismic damage to infrastructure.
    - **Comprehensive Protocols:** Establishment of comprehensive protocols for damage assessment and insurance provision post-earthquake.

Understanding Earthquake Resilience:

- **Definition:** Earthquake resilience refers to the ability of people, infrastructure, and systems to **withstand, adapt to, and quickly recover** from earthquakes with minimal disruption. It ensures sustained functionality after an event.
- **Key Components & Actions:**
    - **Withstanding (Robustness):** Focuses on preventing collapse through earthquake-resistant design, use of ductile materials (steel, reinforced concrete), and advanced technologies like base isolation, dampers, and bracing.
    - **Adapting (Adaptive Capacity):** Involves evolving and preparing through updating building codes, retrofitting old buildings, conducting risk zonation and hazard mapping, and smart urban planning.
    - **Recovering (Rapidity & Resourcefulness):** Aims for quick recovery via emergency plans and drills, ensuring resilient power, water, and transport systems, public awareness, economic rehabilitation, and the "Build Back Better" approach.

Basics of Earthquakes:

- **Definition:** An earthquake is a sudden release of energy in the Earth's crust that generates seismic waves.
- **Key Terminology:**
    - **Focus (Hypocentre):** The exact point *within* the Earth where an earthquake originates.
    - **Epicenter:** The point on the Earth's surface **directly above** the focus.
    - **Fault:** A fracture in the Earth's crust where two tectonic plates meet and move past each other.
    - **Foreshocks:** Smaller earthquakes that precede the main earthquake in the same area.
    - **Aftershocks:** Smaller earthquakes that follow a larger earthquake as the Earth's crust adjusts.
    - **Seismograph:** An instrument used to measure and record ground motion caused by earthquakes.
    - **Seismology:** The scientific study of earthquakes.
    - **Seismic waves:** Waves of energy that travel through the Earth's crust, causing ground shaking during an earthquake.
- **Diverse Causes of Earthquakes:**
    - **Plate Tectonics:** Movement and interaction of Earth's tectonic plates along boundaries (e.g., 2023 Turkey-Syria earthquake due to East Anatolian Fault).
    - **Volcanic Activity:** Movement of magma beneath a volcano causing ground shaking (e.g., seismic swarms at Mount Rainier in 2024-2025).
    - **Human Activity (Induced Seismicity):** Activities like fluid injection for waste disposal or oil/gas extraction (e.g., persistent seismic activity in West Texas, 2023-2025).
    - **Reservoir-induced Earthquakes:** Changes in water weight from filling/emptying large reservoirs/dams (e.g., seismic events near Three Gorges Dam, China).
    - **Glacial Rebound:** Changes in Earth's crust due to advancing or retreating glaciers (e.g., South Lhonak GLOF in Sikkim, 2023).

Measuring Earthquakes: Magnitude and Intensity:

- **Magnitude:** Measures the **energy released** by an earthquake.
    - **Richter Scale:** Most commonly used, ranges from 0 to 9, with each increase representing a tenfold increase in energy.
- **Intensity:** Measures the **impact at a specific location** based on effects on the ground, buildings, and people.

- **Modified Mercalli Intensity (MMI) Scale:** Ranges from I to XII, considering factors like building construction, height, and distance from the epicenter.

Seismic Vulnerability in India:

- **Global Ranking:** India is ranked as the **seventh most earthquake-prone country** globally.
- **Geological Instability:** Situated at the convergence of major lithospheric plates, India is in one of the world's most seismically volatile zones.
- **Himalayan Threat:** The Indian Plate's continuous northward push against the Eurasian Plate forms the Himalayas, an **active zone long overdue for a catastrophic quake** exceeding magnitude 8, potentially affecting over 300 million people.
- **Pan-Indian Vulnerability:** Approximately **59% of India is vulnerable** to earthquakes.
- **Seismic Zones (BIS Classification):** The Bureau of Indian Standards (BIS) classifies India into **four seismic zones (Zone II to Zone V)** based on risk:
    - **Zone V (Most Active):** Includes regions like the Himalayas, Northeast India (Manipur, Nagaland, Mizoram), and the Andaman and Nicobar Islands.
    - **Zone II (Least Affected):** Represents areas with the lowest risk.
- **Examples of Recent Activity:**
    - May 2025: 5.7 magnitude Tibetan quake caused tremors in Sikkim, highlighting Himalayan restlessness.
    - March 2025: 7.7 magnitude Mandalay quake in Myanmar caused frequent shocks in Northeast India.
    - Andaman and Nicobar Islands: Highly susceptible to tsunamis from subduction zone activity (e.g., 2004 tsunami).

About Bureau of Indian Standards (BIS):

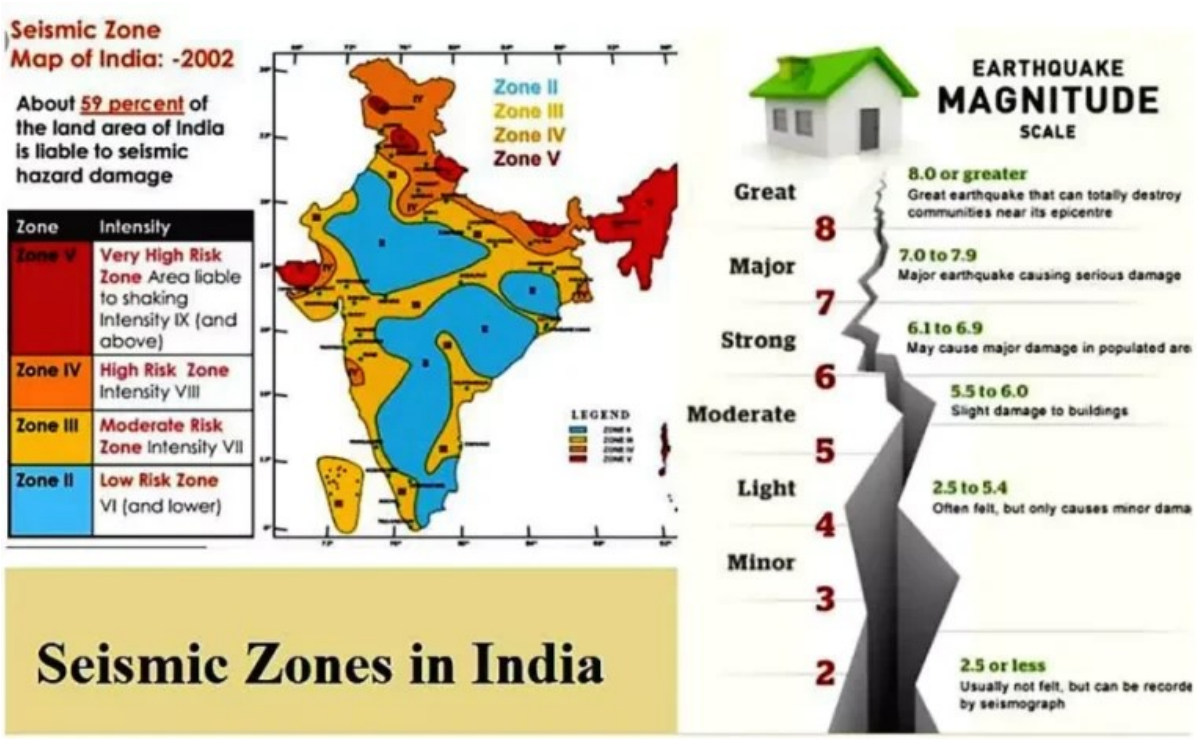
- **National Standard Body:** Established under the BIS Act 2016 for standardisation, marking, and quality certification of goods in India.
- **Mandatory Certification:** Enables the government to enforce compulsory certification for goods or services in public interest, for health, safety, environment, fair trade, or national security.
- **Hallmarking:** Provisions for mandatory hallmarking of precious metal articles.

Historical Failures in Earthquake Resilience:

- The 2001 Bhuj (7.7 magnitude, ~20,000 deaths) and 2015 Nepal (7.8 magnitude, ~9,000 deaths) earthquakes underscore the devastating impact of inadequate preparedness, leading to mass casualties, infrastructure collapse, and prolonged socio-economic disruption.

Global Tectonic Interconnectedness:

- A recent surge in global seismic activity (Greece, Indonesia, Chile-Argentina, Ecuador since March 2025) serves as a global reminder for heightened vigilance and preparedness in India, especially with the looming "Himalayan seismic gap."



India's Earthquake Preparedness:

- **Key Government Agencies:**
    - **National Disaster Management Authority (NDMA):** Issues hazard-specific guidelines for Earthquake Risk Mitigation, including the Homeowner's Guide (2019) and Simplified Earthquake Safety Guidelines (2021).
    - **National Centre for Seismology (NCS):** Nodal agency for monitoring earthquake activity in India.
    - **Indian National Centre for Ocean Information Services (INCOIS) & India Meteorological Department (IMD):** Operate advanced seismic monitoring networks.
    - **National Disaster Response Force (NDRF):** Conducts regular mock exercises and response drills.
- **Policy Measures:**
    - **National Disaster Management Plan (NDMP):** Includes a dedicated section on earthquake preparedness, retrofitting, and response, revised in 2019.
    - **BhooKamp app:** Launched for real-time earthquake updates.

- **National Earthquake Risk Mitigation Project (NERMP):** Aims to enhance earthquake-resistant construction, capacity building, and public awareness.
- **Common Alerting Protocol (CAP):** Ensures geo-targeted and multilingual earthquake alerts via SMS, apps, TV, sirens, etc.
- **Earthquake Disaster Risk Index (EDRI):** Aims to assess and map urban earthquake risk.

- **Other Initiatives:**
  - **State Disaster Management Authorities (SDMAs):** Many have school safety programs, mock drills, and retrofitting of lifeline buildings.
  - **National Institute of Disaster Management (NIDM):** Conducts training programs on earthquake resilience.
  - **INSAT and Doppler Weather Radar (DWR):** Help monitor earthquake-linked landslide or flood risks.
  - **International Collaboration:** India promotes research and forecasting collaboration through BIMSTEC, SCO, and Japan.

Smritivan Memorial, Bhuj: Honouring Resilience:

- **Purpose:** Commemorates victims of the 2001 Gujarat earthquake (magnitude 7.9).
- **Location & Features:** Inaugurated in August 2022, spans 470 acres on Bhujiyo Dungar, featuring a 1.1 MW solar plant, 50 check-dams with victims' names, and the world's largest Miyawaki forest (3 lakh+ plants).
- **Museum:** Has 7 thematic blocks including a 5D simulator.
- **Recognition:** Shortlisted for the Prix Versailles 2024 by UNESCO, India's first museum to receive this.

Challenges Posed by Rising Seismic Activities in India:

- **Immediate Impacts and Hazards:**
  - **Structural Collapse:** Non-seismic construction leads to widespread collapse and casualties.
  - **Ground Deformation:** Fault ruptures, intense shaking, and liquefaction cause severe damage.
  - **Landslides & Rockfalls:** Common in hilly areas, burying settlements and blocking roads.
  - **Tsunamis:** Underwater quakes can cause devastating coastal flooding.
  - **Secondary Hazards:** Fires, explosions (from ruptured gas/electrical lines), dam failures, and hazardous industrial leaks.

    - **Service Disruption:** Power, water, communication, and transport failures cripple emergency response.

- **Weak Implementation of Safety Rules:** A significant gap exists between knowing about earthquake risks and actually implementing safety measures. Building rules are often not followed, and public awareness remains low compared to countries like Taiwan and Japan.

- **Social and Economic Impact:** Strong earthquakes lead to widespread disruption, loss of homes and livelihoods, overloaded healthcare systems, mental stress, and prolonged rebuilding costs, hindering economic growth.

- **Link to Climate Change:** Climate change exacerbates earthquake risks; heavy rain, floods, and landslides can weaken infrastructure and delay rescue efforts, creating a compounding chain of problems.

Way Forward (Solutions):

1. **Learning from Global Best Practices:**

    - **Taiwan:** Overhauled disaster governance, enforced strict building codes (e.g., base isolation, tuned mass dampers), and built a real-time seismic monitoring network post-1999 Chi-Chi quake.

    - **Japan:** Strict seismic codes, use of base isolation/damping, reinforced materials, early warning systems, and high community preparedness through drills.

    - **Chile:** Adaptive building codes, use of reinforced concrete shear walls, performance-based designs, and effective tsunami warning systems.

    - **New Zealand:** Life-safety-oriented codes, low-damage technologies (base isolators, rocking walls), and an all-hazards approach post-Canterbury quakes.

2. **Stronger Laws and Better Coordination:**

    - **Strict Building Rules:** Mandatory enforcement of IS 1893:2016 seismic code for all new buildings with independent inspections.

    - **Regular Law Updates:** Frequent revision of disaster management laws and building rules based on new scientific knowledge.

    - **Better Coordination:** Enhanced collaboration among key ministries (Earth Sciences, Housing, Urban Affairs, Transport) and state disaster bodies.

    - **Safer City Planning:** Implementing seismic microzonation in cities to avoid construction on vulnerable land.

3. **Retrofitting and Safer Infrastructure:**

    - **Focus on Older Buildings:** Large-scale retrofitting drives in vulnerable cities (e.g., Delhi) using methods like steel jacketing, FRP wrapping, and base isolation.

    - **Essential Services Resilience:** Strengthening telecom infrastructure, power grids, water/sewage systems, and transport networks to withstand earthquakes.

- **Funding:** Estimated annual retrofitting cost of around ₹50,000 crore requires dedicated funding and smart finance models.

4. **Technology and Data Use:**

    - **Increased Sensors & Early Warning:** Expanding and upgrading earthquake sensor networks for quicker alerts and early warning systems (e.g., ShakeMap).
    - **AI & Machine Learning:** Utilizing AI for improved prediction, damage forecasting, and response planning.
    - **GIS Mapping:** Using digital maps with building, land, and population data for vulnerability assessment and response planning.

5. **Public Participation and Awareness:**

    - **Education Campaigns:** Multi-language awareness programs on safety, emergency kits, and evacuation.
    - **Regular Practice Drills:** Conducting mock drills in schools, offices, and public places.
    - **Citizen Involvement:** Encouraging reporting of unsafe buildings and participation in local surveys.
    - **Training Local Teams:** Building community disaster teams for first aid, rescue, and damage reporting, acknowledging the critical role of local responders (as seen in Bhuj).
    - **Traditional Wisdom:** Documenting and promoting local, time-tested earthquake-safe building styles.

Conclusion:

The July 2025 Delhi tremors underscore the critical need for **seismic resilience** rooted in constitutional values of safety and dignity. Effective enforcement of building codes, sustained investment in resilient infrastructure, and robust public awareness initiatives are crucial, aligning with **SDG 11 (Sustainable Cities)** and **SDG 13 (Climate Action)**.

Source: https://www.thehindu.com/opinion/op-ed/a-tectonic-shift-in-thinking-to-build-seismic-resilience/article69820061.ece