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Earthquake :
From Risk to Resilince

Safer Seismic Future with AI

Dr Sanjay Kumar Srivastava

On 26 January 2001, the Bhuj earthquake devastated Gujarat, killing more than 13,000 people and causing widespread infrastructure collapse. Beyond the tragic human toll, Bhuj exposed systemic weaknesses in India's seismic preparedness—from unsafe construction to fragmented response systems. Over the past 25 years, India has made important advances in disaster governance, yet earthquake risk remains high due to rapid urbanisation, ageing infrastructure, and persistent enforcement gaps.

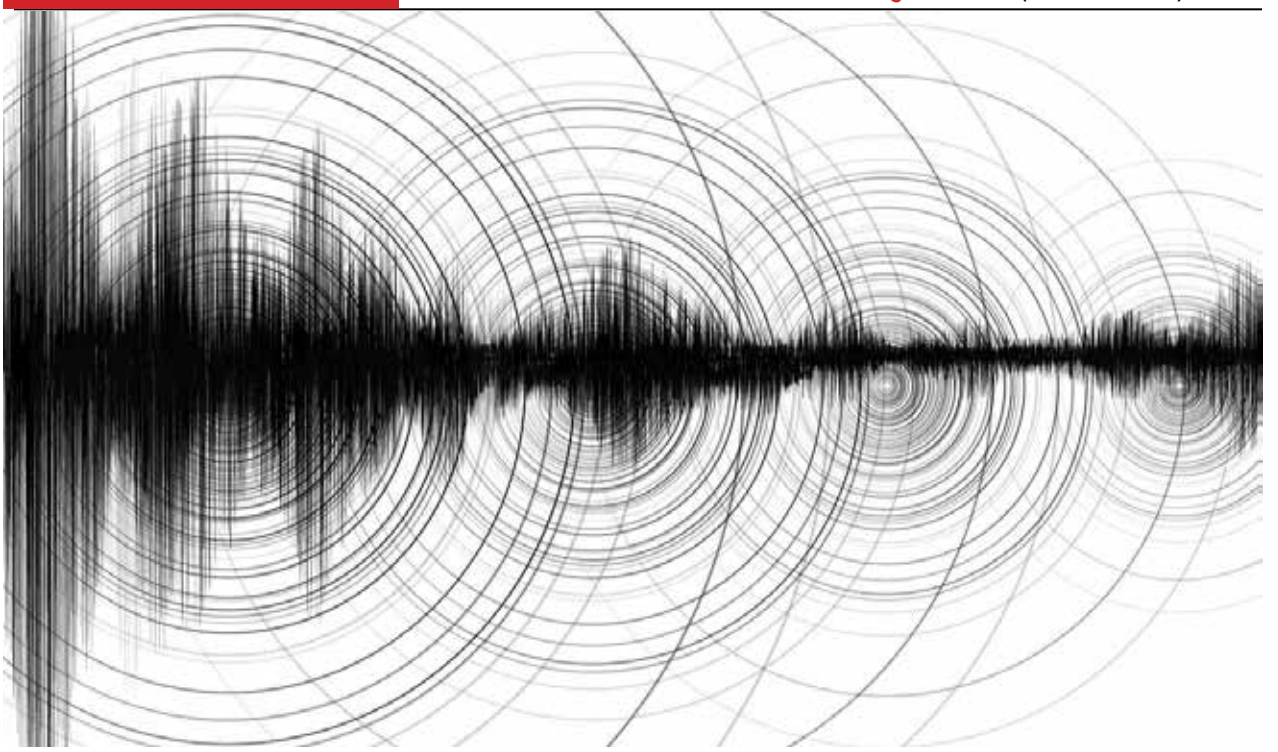
As India marks the 25th anniversary of Bhuj, artificial intelligence (AI) presents a historic opportunity to strengthen earthquake risk reduction fundamentally.

"25 Years After Bhuj: Can AI Redefine India's Earthquake Preparedness?"

Crucially, this opportunity is no longer abstract. The India AI Mission provides a national policy platform capable of translating AI research into operational seismic risk management at scale.

Progress Since Bhuj-and the Limits of Conventional Approaches

In the aftermath of Bhuj, India invested in seismic monitoring networks, updated building codes, and strengthened institutional coordination. Reviews of science- and technology-based earthquake risk reduction in India show that these measures significantly improved post-disaster response capacity (Bansal and Verma 2013). However, they also highlight persistent challenges in anticipatory risk management, particularly in urban areas. Traditional earthquake risk models struggle to integrate the growing volume and diversity of data now available-



from satellite imagery and sensor networks to socio-economic exposure indicators. As a result, decision-making often remains reactive, with limited ability to prioritise prevention investments or optimise emergency response.

AI as a Force Multiplier for Seismic Risk Science

AI fundamentally changes how seismic data can be used. Machine learning models excel at identifying complex, non-linear patterns across large datasets—capabilities increasingly relevant to earthquake science. Recent studies demonstrate that AI-driven systems significantly enhance real-time seismic monitoring and ground-motion estimation (Ahamad & Singh 2025). For India, this enables faster detection of earthquakes, improved localisation of damage hotspots, and more reliable situational awareness in the critical minutes after an event-capabilities essential for densely populated seismic regions such as the Himalayas, Indo-Gangetic plains, and western India.

Predictive Impact Modelling for Risk-Informed Governance

One of the most policy-relevant contributions of AI lies in predictive impact modelling. AI systems can integrate historical seismicity with land use, soil conditions, building typologies, and population data to forecast expected damage and casualties. AI-driven predictive models applied to Indian seismic zones show strong potential for identifying high-impact areas before disasters occur (Bhosale et al.2025). This capability supports a shift from uniform regulation to risk-based prioritisation, enabling policymakers to:

- Target retrofitting programmes to the most vulnerable buildings
- Guide land-use planning away from high-risk zones
- Protect critical lifeline infrastructure

Such precision is essential in a resource-constrained governance environment.

Early Warning, Response Optimisation, and Urban Resilience

Although precise earthquake prediction remains scientifically

unfeasible, early warning systems (EWS) can provide vital seconds of advance notice. AI improves EWS by enhancing signal classification and reducing false alarms, thereby increasing trust and usability (Anbazhagu et al.).

Beyond warnings, AI also strengthens post-earthquake response. AI-based frameworks for demand forecasting and logistics optimisation show how emergency resources can be allocated more effectively following major earthquakes (Biswas et al.). In urban India, AI-enabled disaster management platforms are increasingly linked with smart city control rooms, supporting real-time damage assessment and coordinated response (Naikade and Dharangutti 2025).

The Strategic Role of the India AI Mission

While AI technologies exist, their impact depends on governance, scale, and institutional integration. This is where the India AI Mission becomes strategically critical. The mission's emphasis on shared AI infrastructure, open datasets, capacity building, and public-sector use cases directly aligns with the needs of earthquake risk reduction.

Research on AI adoption in disaster management in India highlights the importance of national-level coordination to avoid fragmented pilots and uneven capacity (Hanspal & Behera 2024). Through the India AI Mission, India can:

- Create national seismic data platforms for AI training and validation
- Support mission-oriented AI models for earthquake impact forecasting
- Embed AI decision-support tools within NDMA and state disaster authorities
- Build a skilled workforce at the intersection of AI, geoscience, and engineering

By institutionalising AI within disaster risk governance, the mission can help translate innovation into resilience.

Policy Imperatives for the Next 25 Years

Global reviews of AI-driven earthquake risk mitigation stress that technology alone is insufficient without standards, accountability, and inclusion (Plevris 2024). For India, priority actions may include:

- Establishing validation and certification frameworks for AI tools used in safety-critical contexts
- Ensuring interoperability between AI systems, sensors, and emergency protocols
- Aligning AI deployment with the Sendai Framework and national disaster plans
- Ensuring ethical, transparent, and inclusive use of AI

From Memory to Mandate

1. The Bhuj earthquake reshaped India's disaster governance in the early 2000s. Twenty-five years later, AI-anchored by the India AI Mission-offers a second transformative moment. By embedding AI into seismic risk science, urban planning, and emergency response, India can move decisively from reactive disaster management to anticipatory risk governance.
2. Honouring Bhuj's legacy requires more than remembrance. It demands sustained investment in science, technology, and institutions capable of protecting lives in a seismically uncertain future.

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(Writer is Associated with S Radhakrishnan Chair Professor, National Institute of Advanced Studies/ Indian Institute of Science Campus, Bengaluru)