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Seismotectonic Dynamics and Disaster Preparedness: A Multidimensional Review of Earthquake Risk in India

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Abstract - *India occupies one of the world's most complex seismotectonic environments due to the persistent convergence of the Indian and Eurasian plates. This report provides an integrated assessment of the nation's seismic hazard profile by examining geological processes, historical earthquake patterns, and emerging anthropogenic influences. The analysis demonstrates that compressional stresses generated along the Himalayan collision zone propagate deep into the Indian craton, challenging perceptions of the peninsular shield as a stable tectonic block. It further highlights the growing significance of human-induced seismicity, showing how reservoir impoundment, groundwater extraction, and related activities can destabilize critically stressed fault systems.*

A detailed review of India's seismic zonation framework, major past earthquakes, and the evolution of national preparedness measures reveals a clear transition from reactive disaster response to proactive, mitigation-oriented risk management. Despite substantial progress in monitoring networks, institutional capacity, and seismic-resistant construction practices, persistent challenges—including funding limitations, enforcement gaps, and the intrinsic unpredictability of seismic events—underscore the need for sustained research, technological investment, and policy advancement. The study concludes by emphasizing the importance of long-term commitment to building a resilient seismic-risk governance system for India.

Key Words: **Disaster preparedness, Hazard mitigation, Geodynamic processes, Paleo seismicity, Structural vulnerability, Risk management**

1. INTRODUCTION

1.1 Background

The Indian subcontinent has long been recognized as one of the most seismically active regions of the world, shaped fundamentally by the interaction of major lithospheric plates. Its tectonic setting is dominated by the persistent northward drift of the Indian Plate and its ongoing collision with the Eurasian Plate—an orogenic process responsible for the uplift and continuous evolution of the Himalayan mountain system. This convergent plate boundary generates substantial tectonic stress, which is distributed not only along the Himalayan arc but also across the broader continental interior. According to the Ministry of Earth Sciences, approximately 59% of India's land area falls under zones classified as moderate to very high seismic risk, underscoring the extensive geographic extent of seismic vulnerability.

Compounding this geological predisposition is India's vast population density and rapid urban expansion, which significantly heighten the potential impact of seismic events. Urban centers with inadequate structural resilience, aging infrastructure, and high concentrations of people and assets face disproportionately greater risk. Consequently, understanding the nation's seismic hazard profile requires a multifaceted examination of both geophysical processes and socio-environmental conditions.

1.2 Scope and Objectives

This research seeks to develop a comprehensive, integrative analysis of earthquake hazards in India. Moving beyond conventional descriptions of seismically active regions, the report investigates the geological drivers, historical seismicity, and emerging factors—such as intraplate earthquakes and anthropogenically induced seismicity—that influence the seismic risk landscape. A central objective is to interrogate the prevailing misconception that certain regions of India remain "seismically safe," demonstrating instead that vulnerabilities extend far beyond the Himalayan frontal arc.

The study aims to:

Elucidate the tectonic mechanisms underpinning seismic activity in both inter-plate and intraplate settings.

Examine major historical earthquakes to identify spatial patterns and recurrence characteristics.

Assess the evolution of national mitigation frameworks, including preparedness, policy reforms, and engineering interventions.

Highlight human-induced seismicity as an increasingly relevant component of India's hazard profile.

Through this approach, the research seeks to deliver a nuanced, evidence-based understanding of the country's seismic vulnerabilities and to contribute meaningfully to discussions on national resilience.

1.3 Structural and Methodological Framework

The organization of this research builds upon the foundational structure of the academic work "A Study and Analysis of Earthquake in India." To achieve a higher degree of analytical depth and disciplinary rigor, each section has been substantially expanded and supplemented with insights drawn from a diverse range of scholarly and institutional sources. These include peer-reviewed scientific literature; technical documents from national agencies such as the National Disaster Management Authority (NDMA), GSI, and IMD; and data from governmental press releases and seismic monitoring reports.

The methodological approach integrates:

- **Geophysical and tectonic analysis** based on current scientific models.
- **Historical earthquake assessment** using documented event catalogues.
- **Policy and institutional review** through official government frameworks.
- **Comparative synthesis** of contemporary research to evaluate trends and vulnerabilities.

By triangulating findings across multiple reputable sources, this study provides a robust, evidence-driven introduction to India's seismic risk profile, ensuring both academic reliability and practical relevance for hazard mitigation planning.

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2. GEOLOGICAL AND TECTONIC FRAMEWORK OF THE INDIAN SUBCONTINENT

2.1 The Indian Plate and the Himalaya–Eurasia Collision

The primary driver of seismicity across the Indian subcontinent is the ongoing convergence between the Indian and Eurasian lithospheric plates. The Indian Plate continues to migrate northward at an estimated ~47 mm/year, resulting in its under thrusting beneath the comparatively stable Eurasian Plate. This sustained convergence has produced the Himalayan orogenic belt—one of the most rapidly deforming and seismically active mountain systems on the planet. The deformation is principally accommodated along several major tectonic discontinuities, most prominently the Main Frontal Thrust (MFT), Main Boundary Thrust (MBT), and Main Central Thrust (MCT), which together define the Himalayan megathrust system.

The seismic hazard in this region, however, is not confined to the primary orogenic front. Strain accumulation and release occur across a broader network of active fault systems, including the Indo-Burmese Arc to the east and the Sulaiman–Kirthar fold-and-thrust belt to the west. These peripheral tectonic domains absorb significant portions of the compressional stress resulting from India–Eurasia convergence, rendering the entire northern and northeastern margin of the Indian Plate susceptible to large, potentially catastrophic earthquakes. This distributed deformation underscores the complex, regionally interconnected tectonic architecture governing seismicity in South Asia.

2.2 Intraplate Seismicity and Stress Transmission Mechanisms

Although the Himalayan collision zone dominates India's seismic hazard narrative, the recurrent occurrence of damaging earthquakes within the interior of the Indian Plate highlights the importance of intraplate seismicity in national risk assessments. The Indian craton, traditionally regarded as a tectonically stable continental block, continues to experience significant stress perturbations transmitted southward from the Himalayan collision system. These stresses are not fully absorbed at the plate boundary and instead propagate through the lithosphere, inducing strain accumulation along ancient, structurally inherited weaknesses.

Many intraplate faults within peninsular India originated during the breakup of the Gondwanaland supercontinent and have remained dormant for millions of years. Under contemporary compressional stress regimes, these paleo-structures can be reactivated, producing seismic events far removed from active plate boundaries. Notable examples include the 1993 Latur earthquake (Mw 6.2) and the 1967 Koyna earthquake (Mw 6.6), both occurring in regions historically considered seismically quiescent. These events illustrate that tectonic stability is relative rather than absolute; the Indian shield remains sensitive to stress transfer processes and lithospheric-scale deformation. Consequently, intraplate seismicity challenges any notion of seismically "safe" zones within the subcontinent and highlights the need for comprehensive hazard assessments that incorporate internal plate dynamics.

2.3 Anthropogenic Modulation of Seismicity

In addition to natural tectonic stresses, increasing evidence supports the role of human activities in modulating seismicity, particularly in geologically sensitive environments. Such events, classified as human-induced or anthropogenically triggered earthquakes, occur when anthropogenic processes perturb the existing stress equilibrium along pre-stressed or critically loaded faults.

Reservoir-Induced Seismicity (RIS) represents one of the most thoroughly documented mechanisms of induced

seismicity in India. The impoundment of large water bodies behind dams results in significant loading and pore-pressure diffusion within the crust, conditions capable of destabilizing nearby fault systems. The 1967 Koyna earthquake, one of the most destructive intraplate events in India, is widely recognized as a classic example of RIS, wherein fluctuations in reservoir levels correlated strongly with seismic activity in the region.

Groundwater over-extraction constitutes another important anthropogenic driver. In regions such as Delhi–NCR and the Gangetic plains, accelerated depletion of groundwater between 2003 and 2012 reduced lithostatic support and altered pore-pressure regimes, conditions that were associated with an increase in shallow seismicity. Subsequent stabilization of groundwater levels after 2014 corresponded with a notable decline in seismic event frequency, reinforcing the causal link between hydrological variations and seismic behavior.

Additional activities—including mining operations, deep-well fluid injection, hydraulic fracturing, and the construction of mega-infrastructure projects—further demonstrate the susceptibility of critically stressed crustal faults to anthropogenic influences. These findings reveal a complex interplay between developmental pressures and the intrinsic tectonic fabric of the Indian lithosphere, emphasizing the need for rigorous geotechnical evaluation and monitoring in regions undergoing substantial human-driven subsurface modification.

3.0 SEISMIC ZONING AND REGIONAL VULNERABILITY

3.1 The Indian Seismic Zoning Framework

India's seismic zoning framework, formalized by the Bureau of Indian Standards (BIS) under IS 1893: Criteria for Earthquake-Resistant Design of Structures, provides the foundational classification used to quantify earthquake hazard across the subcontinent. The BIS has delineated the nation into four seismic zones—II, III, IV, and V, reflecting progressively increasing levels of expected ground shaking intensity and earthquake damage potential. This zonation is based on historical seismicity, active tectonic structures, geophysical observations, and macro seismic intensity distributions.

- Zone II: Low Damage Risk Zone (corresponding to MSK VI or lower)
- Zone III: Moderate Damage Risk Zone
- Zone IV: High Damage Risk Zone
- Zone V: Very High Damage Risk Zone (corresponding to MSK IX and above)

Each zone is associated with a defined zone factor—a numerical coefficient (e.g., 0.10 for Zone II, 0.36 for Zone V)—used by structural engineers to estimate design base shear and seismic lateral forces. These zone factors serve as input parameters for seismic load calculations pursuant to structural design standards. Although the zoning map offers a broad, national-scale depiction of seismic hazard, it is inherently generalized and does not currently incorporate probabilistic seismic hazard analysis (PSHA), micro zonation data, or local site effects, which are critical for urban-scale risk assessment.

3.2 ANALYSIS OF MAJOR EARTHQUAKE-PRONE REGIONS

3.2.1 Himalayan and Northeastern Region (Zone V)

The Himalayan and northeastern belt constitutes the most seismically active and tectonically complex region of India. This region is situated directly along the convergent boundary where the Indian Plate underthrusts the Eurasian Plate, forming the Himalayan orogeny. The Main Himalayan Thrust (MHT)—the principal megathrust fault underlying the region—accommodates the majority of the ongoing convergence, leading to substantial strain accumulation. This accumulated strain is episodically released through large to great earthquakes (Mw > 7.5), rendering the entire arc exceptionally prone to destructive seismic events.

The northeastern states, lying at the intersection of the Indian, Eurasian, and Burmese plates, are additionally influenced by complex oblique subduction and strike-slip deformation along the Indo-Burmese Arc. This has produced several of the most powerful recorded earthquakes globally, underscoring the region's classification as Zone V.

3.2.2 Indo-Gangetic Plains (Primarily Zone IV)

Despite being located away from an active plate boundary, the Indo-Gangetic Plain (IGP) exhibits high seismic vulnerability attributable to pronounced sedimentary basin effects. The IGP is a foreland basin filled with thick sequences of unconsolidated to semi-consolidated alluvial deposits. When seismic waves originating from Himalayan earthquakes propagate into this basin, they undergo significant amplification due to the low shear-wave velocities of the sedimentary layers.

Empirical and modeling studies indicate that peak ground acceleration (PGA) in the IGP can be amplified by a factor of 2 to 7, with amplification reaching 6–7 times in the Delhi region. This results in severe ground shaking even from earthquakes occurring hundreds of kilometers away. Additionally, concealed basement faults beneath the alluvium contribute to the seismic hazard, posing risks that are not immediately evident from surface geological mapping.

The combination of basin amplification, dense urban populations, and concealed tectonic structures makes the IGP one of the most vulnerable regions to widespread seismic impact.

3.2.3 Kachchh and Western India (Zone V)

The Kachchh region of Gujarat represents one of the most active intraplate seismic zones globally. Geologically, Kachchh is a pericratonic rift basin, originally formed under an extensional regime during the breakup of Gondwanaland. However, the far-field compressional stresses generated by the India–Eurasia collision have reactivated the region's ancient rift faults in a new compressional tectonic environment.
Major active faults in this region—such as the Kachchh Mainland Fault (KMF), Island Belt Fault (IBF), and Katrol Hill Fault (KHF)—have produced several large earthquakes, including:

- 1819 Kachchh Earthquake (Mw 7.8): Produced the notable Allah Bund uplift.
- 2001 Bhuj Earthquake (Ms 7.6): One of the most devastating intraplate earthquakes recorded, causing extensive structural damage and loss of life.

The combination of fault reactivation, basement-involved deformation, and high crustal stress transfer justifies the region's classification under Zone V, highlighting the need for enhanced regional seismic preparedness**.**

3.2.4 Peninsular and Southern India (Zones II & III)

Peninsular and southern India, historically regarded as a tectonically stable continental block, is now understood to possess non-negligible seismic potential due to the reactivation of ancient Precambrian faults under the influence of stress transmitted from the Himalayan collision zone. Significant intraplate earthquakes in the region include: 1967 Koyna Earthquake (Mw 6.6): Widely studied as a case of reservoir-induced seismicity.

1993 Latur Earthquake (Mw 6.2): Resulted from reactivation of deeply buried faults within the stable carton. These events reveal that even regions classified under Zones II and III can experience damaging seismicity, often with little to no precursory activity. The presence of critically stressed crustal faults, combined with anthropogenic factors such as reservoir loading and groundwater extraction, further increases seismic susceptibility.

Thus, the peninsular shield cannot be considered seismically inert; rather, it remains vulnerable through complex internal deformation mechanisms driven by the broader geodynamic evolution of the Indian Plate.

4. HISTORICAL SEISMICITY AND STATISTICAL ANALYSIS

4.1 Historical Overview of Major Earthquakes

The seismic history of the Indian subcontinent is punctuated by several high-magnitude earthquakes that have profoundly influenced scientific understanding, urban planning, and national disaster-management frameworks. Early instrumental and macro seismic records document a sequence of great Himalayan earthquakes beginning with the 1897 Shillong earthquake (Mw 8.0), characterized by a massive rupture along the Shillong Plateau's blind thrust system, and the 1905 Kangra earthquake (Ms 7.8), which produced extensive damage across the western Himalayan arc.

Subsequent events, including the 1934 Nepal–Bihar earthquake (Mw 8.0) and the 1950 Assam–Tibet earthquake (Mw 8.6), are among the most powerful continental earthquakes globally. The 1950 earthquake, in particular, is notable as the largest recorded intraplate continental megathrust event in modern seismological history.

More recently, intraplate seismic events have challenged long-held assumptions regarding the tectonic stability of the peninsular shield. The 1993 Latur earthquake (Mw 6.2) and the 2001 Bhuj earthquake (Ms 7.7) demonstrated that deeply buried Precambrian fault systems can be reactivated under contemporary stress regimes, producing catastrophic outcomes. Additionally, the 2015 Gorkha (Nepal) earthquake (Mw 7.8), though centered outside Indian Territory, inflicted significant losses in northern India and highlighted the transboundary nature of seismic hazard within the Himalayan region.

Collectively, these events underscore the complex interplay between interpolate megathrust processes along the Himalayan arc and intraplate fault reactivation within the Indian shield.

4.2 Frequency and Magnitude Distribution of Earthquakes

India experiences a broad spectrum of seismic activity, with 200–250 earthquakes recorded annually, the majority of which fall below Mw 5.0 and remain imperceptible to the population. The frequency–magnitude distribution of Indian earthquakes generally conforms to the Gutenberg–Richter relationship, with a pronounced clustering of moderate-to-large events along the Himalayan collision zone.

The central and eastern Himalaya, owing to the locked nature of the Main Himalayan Thrust (MHT), exhibit recurrent moderate-to-strong earthquakes, reflecting ongoing strain accumulation. Intraplate domains such as Kachchh and the Deccan region follow a distinctly different seismicity pattern,

characterized by episodic, high-magnitude events separated by long recurrence intervals.

India's national geophysical monitoring capability has improved significantly in the past decade. The number of seismic observatories operated by the India Meteorological Department (IMD) increased from 80 in 2014 to 168 by February 2025, resulting in denser instrumental coverage, enhanced hypocentral accuracy, and better detection of low-magnitude events. This upgraded network allows for more precise characterization of seismic hazard and supports advanced methodologies such as Probabilistic Seismic Hazard Analysis (PSHA) and real-time early-warning algorithms.

4.3 Casualty and Damage Assessment Trends

Earthquake-induced human and economic losses in India have historically been substantial. Data compiled by the National Disaster Management Authority (NDMA) indicate that over 22,000 fatalities occurred between 1950 and 2019 due to major earthquakes. Among these, the 2001 Bhuj earthquake remains one of the deadliest intraplate events globally, causing between 13,805 and 20,023 deaths, widespread structural collapse, and economic losses estimated at USD 10 billion.

The 1993 Latur earthquake resulted in 9,748 fatalities, despite its moderate magnitude—an outcome attributed to vulnerable masonry structures and high population density in the affected areas. Similarly, the 2005 Kashmir earthquake, though centered in Pakistan, generated substantial damage in the Indian-administered regions of Jammu and Kashmir, causing over 1,300 deaths and displacing several million people.

The persistent pattern of high casualty rates, disproportionate damage to non-engineered buildings, and severe socioeconomic disruption underscores India's systemic vulnerability to seismic hazards. These historical losses highlight the critical need for sustained investment in seismic risk mitigation, urban micro zonation, resilient infrastructure design, and community-level preparedness.

Table -1: Major Historical Earthquakes in India

Date	Location	Magnitude (Mw)	Deaths (Estimated)	Technical Notes
1905-04-04	Kangra, Himachal Pradesh	7.8	>20,000	Major Himalayan rupture causing widespread devastation.
1934-01-15	Nepal–Bihar	8.0	6,000–10,700	Severe basin amplification effects across the IGP; high liquefaction.
1950-08-15	Assam–Tibet	8.6	1,500–3,300	Strongest instrumentally recorded earthquake in India; large landslides.
1967-12-11	Koyna, Maharashtra	6.6	177–180	Classical case of reservoir-induced seismicity (RIS).
1993-09-30	Latur, Maharashtra	6.2	9,748	Intraplate reactivation of stable shield faults; unexpected severe damage.
2001-01-26	Bhuj, Gujarat	7.7	13,805–20,023	Massive intraplate rupture; triggered major reforms in Indian seismic codes.
2005-10-08	Kashmir (India–Pakistan)	7.6	86,000–87,351*	Extremely destructive; caused heavy loss in India and Pakistan.
2015-04-25	Nepal (impact in India)	7.8	8,964	Devastating Himalayan event; significant shaking in northern India.
2021-04-28	Assam	6.0	2	Moderate intraplate event; structural damage reported.
2023-11-03	North India & Nepal	5.7	153*	Fatalities primarily in Nepal; structural damage across northern India.

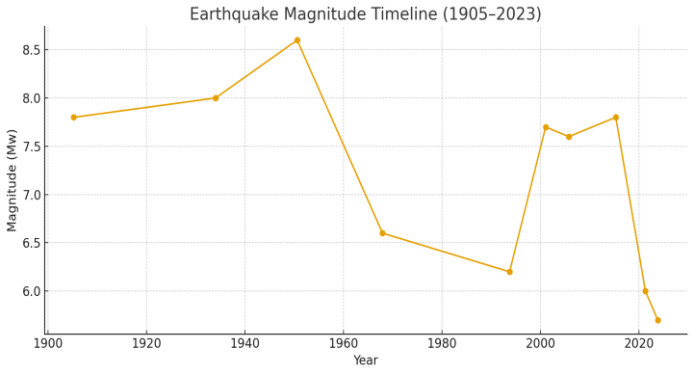

Chart -1: Major Historical Earthquakes in India & Deaths

5.0 NATIONAL PREPAREDNESS AND MITIGATION STRATEGIES

5.1 Institutional and Legislative Framework

India's disaster governance shifted from a relief-driven model to a proactive risk-reduction system with the Disaster Management Act (2005). This Act established the National Disaster Management Authority (NDMA), State Disaster Management Authorities (SDMAs), and District Disaster Management Authorities (DDMAs) to oversee hazard assessment, policy formulation, and operational response. NDMA's Earthquake Disaster Risk Index (EDRI) is a key national initiative that quantifies seismic hazard, exposure, and vulnerability across major Indian cities to support risk-informed planning.

5.2 Seismic-Resistant Building Codes

India's seismic engineering framework is anchored in the BIS codes, primarily:
IS 1893 – defines seismic zones and design forces.
IS 13920 – mandates ductile detailing for reinforced concrete structures.
The 2001 Bhuj earthquake triggered major policy reforms, making ductile detailing mandatory in high-risk Zones III–V. These codes aim to prevent structural collapse under strong shaking and minimize damage during moderate earthquakes.

5.3 Retrofitting and Structural Strengthening

Recognizing the vulnerability of older, non-engineered buildings, India has prioritized seismic retrofitting of schools, hospitals, and lifeline structures. Techniques include column jacketing, steel bracing, shear wall addition, and base isolation. Government programs under NDMA and state agencies support vulnerability assessment and rehabilitation, though large-scale implementation remains constrained by financial and logistical challenges.

5.4 Seismic Monitoring and Early Warning Systems

India's seismic observatory network has expanded significantly, improving national monitoring capabilities. IMD now operates more than 160 modern stations, enabling faster detection and improved hazard modeling. Pilot Earthquake Early Warning (EEW) systems have been deployed in Uttarakhand and Himachal Pradesh. Emerging tools—such as GNSS deformation networks, InSAR, and machine-learning models—enhance real-time situational awareness and risk forecasting.

5.5 Community Preparedness and Capacity Building

Public awareness, community training, and school safety programs form the backbone of India's earthquake resilience strategy. Regular mock drills, first-responder training, and capacity-building initiatives for engineers and planners strengthen local preparedness. However, varying institutional capacity and low public risk perception remain persistent challenges.

Table – 2 Key Indian Seismic Codes and their Purpose

Code Number	Technical Title	Year of Latest Revision	Technical Purpose / Scope
IS 1893 (Part 1)	Criteria for Earthquake-Resistant Design of Structures	2002	Establishes national seismic zoning, defines design basis earthquake (DBE) forces, response spectra, and lateral load calculations for engineered structures.
IS 4326	Code of Practice for Earthquake-Resistant Design and Construction of Buildings	1993	Provides fundamental design principles, material requirements, and construction techniques for enhancing seismic performance of masonry and concrete buildings.
IS 13827	Guidelines for Improving Earthquake Resistance of Earthen Buildings	1993	Offers empirical design rules, reinforcement strategies, and construction practices to improve seismic stability of vernacular earthen structures.
IS 13920	Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces	1993	Specifies ductile detailing provisions (confinement reinforcement, lap splice rules, shear design) for RC frames and shear walls; mandatory in Zones III–V post-Bhuj 2001.
IS 13935	Guidelines for	1993	Details methodologies for

Code Number	Technical Title	Year of Latest Revision	Technical Purpose / Scope
	Repair and Seismic Strengthening of Buildings		post-earthquake damage assessment, retrofitting, and strengthening techniques for masonry, timber, and RC structures.

6. CONCLUSION AND FUTURE OUTLOOK

6.1 Synthesis of Findings

This research demonstrates that India's seismic vulnerability arises from a complex interplay of interpolate megathrust dynamics, intraplate fault reactivation, and anthropogenically modulated stress perturbations. The dominant geodynamic driver—the ongoing convergence between the Indian and Eurasian plates—continues to generate substantial strain accumulation along the Himalayan arc while simultaneously transmitting stresses deep into the Precambrian cratonic interior. This far-field stress propagation facilitates the reactivation of ancient rift-basin faults and shear zones, challenging longstanding assumptions regarding the tectonic stability of the peninsular shield.

Seismic risk in India is further compounded by site-specific geological amplifiers, most prominently within the Indo-Gangetic Plains, where thick alluvial sequences significantly amplify ground-motion intensity through basin resonance and low shear-wave velocities. Consequently, seismic vulnerability in this region is governed not only by regional tectonics but by local geotechnical conditions, underscoring the importance of micro zonation-based hazard evaluation.
India has made notable progress in strengthening its disaster management ecosystem through the establishment of institutional frameworks (NDMA, SDMAs), the development of seismic design codes (IS 1893, IS 13920), expansion of monitoring infrastructure, and pilot deployment of earthquake early warning systems. However, these advances coexist with structural, financial, and operational limitations that continue to constrain national resilience.

6.2 Challenges and Recommendations

Despite improved institutional capacity and scientific understanding, several persistent challenges impede comprehensive seismic risk reduction:
Earthquake unpredictability: The stochastic nature of earthquake nucleation limits the capacity for precise forecasting, necessitating reliance on probabilistic hazard models and real-time monitoring rather than deterministic prediction.

Retrofitting and infrastructure modernization: The cost of upgrading India's vast inventory of non-engineered and seismically deficient buildings is substantial, posing financial and logistical challenges—particularly in densely populated urban corridors.
Code enforcement limitations: Inconsistent compliance with BIS seismic provisions, especially in peri-urban and informal construction sectors, undermines the effectiveness of existing engineering standards.
Anthropogenic seismicity risks: Large infrastructure projects, groundwater extraction, and reservoir impoundment require rigorous seismic risk assessment to mitigate induced seismicity.

Based on these constraints, the following evidence-driven recommendations are proposed:
Expansion and integration of seismic monitoring networks: Increase density of broadband seismometers, strong-motion accelerographs, and GNSS deformation stations, particularly in high-risk urban clusters, to support real-time source characterization and enhanced early warning capabilities.
Strengthening of building code enforcement and compliance: Implement mandatory third-party structural audits, digitized approval systems, and rigorous field inspections to ensure adherence to IS 1893 and IS 13920 for both new construction and retrofit projects.
Systematic retrofitting of vulnerable structures: Prioritize seismic strengthening of lifeline infrastructure—hospitals, schools, bridges, dams—and adopt cost-effective retrofit technologies tailored for low-income urban settlements.

Mandatory seismic hazard assessments for major infrastructure projects: Require probabilistic hazard analysis (PSHA), site-response studies, and risk modeling for dams, energy facilities, metro systems, and high-rise developments to reduce the potential for human-induced or triggered seismicity.

Nationwide community preparedness and risk communication programs: Institutionalize public education campaigns, school safety programs, and community emergency response training to cultivate a culture of seismic resilience, ensuring that risk awareness and preparedness extend beyond technical institutions to society at large.
Collectively, these measures align with the strategic national goal of establishing a robust, multi-layered, and science-driven earthquake resilience framework capable of safeguarding India's rapidly urbanizing landscape and critical infrastructure systems in the decades ahead.

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