Seismic Vulnerability and Earthquake Forecasting in the Bengal Basin: Insights from Indo-Burmese Subduction Dynamics

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Abstract: Bangladesh, situated within an active deltaic system primarily composed of unconsolidated alluvial sediments, is acutely vulnerable to seismic hazards due to its tectonic position near the convergent boundaries of the Indian and Burmese plates. Although the country has not experienced any major earthquakes in recent decades, it frequently encounters low-magnitude tremors that cause structural deformations such as cracks and tilting in buildings. This study integrates historical earthquake records with recent geophysical and geodetic models to assess seismic potential and tectonic stress accumulation. Findings highlight the possibility of a megathrust event (Mw 8.2–9.0) along the Indo-Burmese subduction zone, threatening the eastern region of Bangladesh. Historical events, such as the 1762 Cheduba Island earthquake (Mw > 8), which triggered a tsunami that reached the Bangladeshi coast, exemplify the seismic vulnerability of this tectonic domain. Between 1822 and 1918, four major earthquakes (Mw > 7) occurred, followed by an unusually quiet period exceeding a century, suggesting an accumulation of strain energy. Despite the growing awareness of seismic risks, earthquake research in Bangladesh remains constrained by limited institutional collaboration and technical capacity. Enhancing fault characterization, crustal stress modelling, and regional geodynamic studies are essential for mitigating the impact of potential future earthquakes.

Keywords: ***Subduction, Seismic vulnerability, Earthquake***

Introduction

Bangladesh lies at the junction of the Indian and Burmese plates, forming a part of the tectonically active Bengal Basin. The region's alluvial deposits and deltaic sequences amplify seismic waves, increasing the potential for ground deformation. Although recent tremors have been of low magnitude, the absence of large events since the early 20th century is a cause for concern (Steckler et al., 2016). Rapid urbanization and inadequate building standards further amplify the vulnerability of major cities such as Dhaka, Chattogram, and Sylhet. The Indo-Burmese subduction system, which marks the eastern margin of Bangladesh, remains a critical source of seismic threat. The strain accumulation rate measured through GPS observations indicates ongoing tectonic compression, implying a high potential for large-magnitude events.

Methodology

This research synthesizes geological, geophysical, and geodetic datasets to evaluate seismic vulnerability in the Bengal Basin. Historical earthquake catalogs were analyzed alongside fault mapping data from regional studies (CDMP, 2014). GPS-based strain rate analyses and fault geometry models were integrated to identify potential rupture zones. Additionally, past earthquake recurrence intervals were estimated using probabilistic seismic hazard assessment (PSHA) techniques to quantify the likelihood of large-magnitude events.

Results

The Indo-Burmese subduction front exhibits complex interactions among the Indian, Burmese, and Eurasian plates. Geodetic investigations indicate that the subduction zone is locked, storing significant strain energy (Steckler et al., 2016). The recurrence interval for high-magnitude earthquakes is estimated between 900 and 1100 years, implying that the region may currently be in a stress accumulation phase. Historical data reveal that the 1762 Cheduba earthquake caused extensive ground deformation and coastal subsidence. Subsequent major events in the 19th century indicate an active seismic regime that has since entered an anomalously quiet phase. This prolonged quiescence raises concerns about a possible 'seismic gap' along the fault system, increasing the risk of future megathrust rupture. Bangladesh's vulnerability is compounded by poor enforcement of seismic design codes, limited seismic monitoring infrastructure, and a lack of multidisciplinary collaboration. Urban areas built on soft sediments could experience amplified shaking during a major event. Strengthening institutional and research capacity in geosciences, coupled with effective early-warning systems, is crucial to enhance resilience.

Conclusions

The Bengal Basin faces a significant but underappreciated seismic threat. Integration of geological, geophysical, and geodetic evidence underscores the high potential for a major earthquake along the Indo-Burmese subduction zone. Enhancing

seismic research infrastructure, improving cross-border data sharing, and promoting community-level preparedness are essential steps toward mitigating the risk. Strengthening predictive models and establishing a national seismic observatory network could play a decisive role in safeguarding lives and infrastructure in Bangladesh.

Recommendations

The findings of this research can assist policymakers in formulating effective mitigation strategies to address seismic vulnerability in Bangladesh. The following recommendations are proposed:

- Enhance Seismic Monitoring: Establish a dense GPS and seismograph network across eastern Bangladesh to monitor crustal deformation and stress accumulation in real time.
- Fault Characterization: Conduct detailed geological and geophysical mapping to delineate active faults, subsurface structures, and potential rupture zones along the Indo-Burmese subduction front.
- Data Integration: Promote regional collaboration for sharing geodetic, seismic, and satellite datasets to improve accuracy in seismic hazard models.

Acknowledgement

Author is grateful to Director General and other colleagues of the Geological Survey of Bangladesh (GSB) for their kind assistance and cooperation for this study.

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