SEISMIC HAZARD ASSESMENT

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Abstract

This report presents a comprehensive seismic risk assessment of Ward No. 7 in Panauti Municipality, Kavrepalanchok District, Nepal. Situated near the highly active Main Himalayan Thrust fault zone, the area is prone to strong earthquakes that pose significant threats to life and property. The assessment evaluates the seismic vulnerability of the local building stock, predominantly composed of traditional masonry structures and some reinforced concrete buildings, through field surveys, rapid visual screening, and simulated detailed evaluations based on established guidelines from NSET and FEMA.

The study identifies key structural and non-structural deficiencies that increase the risk of damage and collapse during seismic events. Rapid screening results classify approximately 31% of buildings as unsafe, with an additional 41% requiring restricted use. Damage grade classifications and casualty estimates suggest that a major earthquake could result in significant economic losses estimated as NPR 1739 million.

Qualitative risk zonation highlights high-risk clusters within the ward, driven by building type, construction quality, and local topography. The report concludes with actionable recommendations for short-term emergency measures, medium-term retrofitting programs, and long-term urban planning and policy interventions aimed at reducing seismic risk and enhancing community resilience.

This study serves as a critical resource for local stakeholders to prioritize interventions and plan effective earthquake risk management strategies in Panauti-07.

Background

Nepal is situated in one of the most seismically active regions of the world due to its location along the convergent boundary between the Indian and Eurasian tectonic plates. This ongoing tectonic activity has produced devastating earthquakes throughout history, with significant impacts on human life, infrastructure, and the economy. The Kathmandu Valley and its surrounding areas, including Kavrepalanchok District, remain particularly vulnerable due to dense population centers, varied topography, and a large stock of non-engineered buildings.

Panauti Municipality, located in Kavrepalanchok, is a culturally significant town with a rich heritage and a growing population. Ward No. 7 (Panauti-07) consists mainly of traditional residential and mixed-use buildings, many of which were constructed without modern seismic design considerations. The combination of vulnerable construction types, complex geological conditions, and increasing urbanization elevates the seismic risk faced by this community.

This report presents a detailed seismic risk assessment of Panauti-07 aimed at evaluating the vulnerability of its building stock and estimating potential human and economic losses from future earthquake events. The study follows internationally recognized methodologies, including guidelines from the National Society for Earthquake Technology (NSET) Nepal and the Federal Emergency Management Agency (FEMA) USA, adapted to the local context.

The objectives of this assessment are to identify the most at-risk structures, classify their damage potential, and provide actionable recommendations for mitigation and disaster preparedness. By doing so, this study seeks to inform local authorities, engineers, planners, and community members, supporting efforts to reduce seismic risk and enhance resilience in Panauti-07.

Study Area
Location:

- Situated in Panauti Municipality, Ward No. 7 (Panauti-07), Kavrepalanchok District, Province No. 3, Nepal.
- Approximately 32 km southeast of Kathmandu.
- Coordinates: ~27.55°N latitude, 85.45°E longitude.

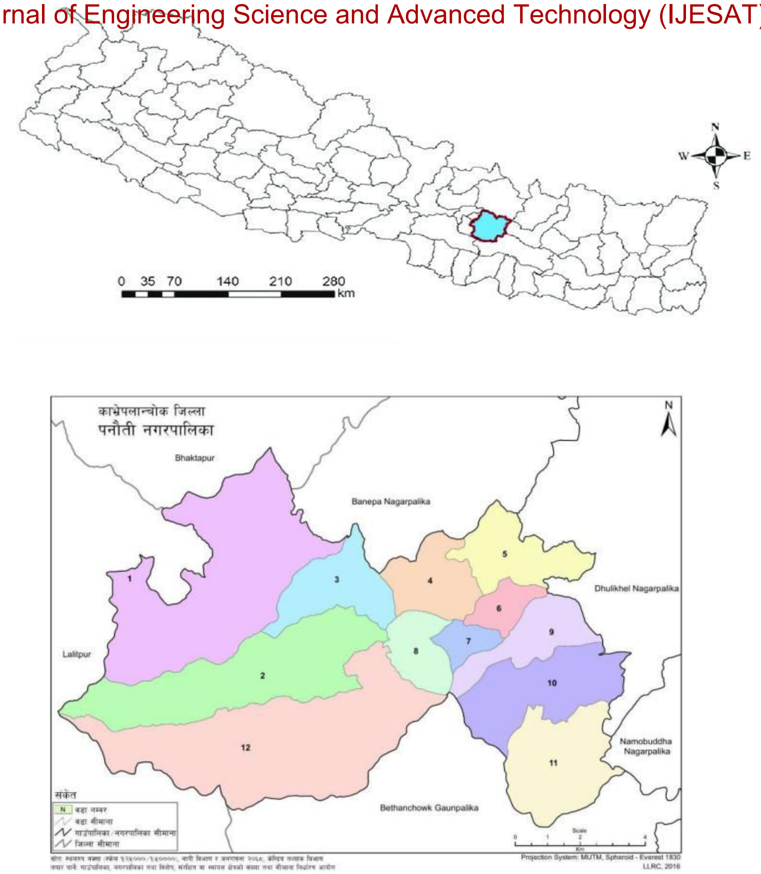

FIGURE 1.: STUDY LOCATION OF PANAUTI

1.2 Problem Statement

- Panauti-07 is located near a highly active seismic zone, making it prone to frequent and potentially devastating earthquakes.
- The majority of buildings in the area are constructed using traditional masonry techniques without proper seismic design or reinforcement.
- Many structures are old, deteriorating, and show signs of structural deficiencies, increasing their risk of collapse during seismic events.
- There is a lack of comprehensive, up-to-date data on building vulnerability and population exposure specific to Panauti-07.
- Emergency access and infrastructure are limited, complicating post-earthquake rescue and relief operations.

- Existing awareness and preparedness among residents regarding earthquake hazards and mitigation are insufficient.
- There is an urgent need to assess seismic risk systematically to guide mitigation efforts, retrofitting programs, and disaster preparedness planning.
- Without intervention, a strong earthquake could result in high casualties, significant economic losses, and long-term disruption to the community.

1.3 Scope and Limitations Scope:

This seismic risk assessment report focuses specifically on Ward No. 7 (Panauti-07) of Panauti Municipality, Kavrepalanchok District, Nepal. The study covers:

- **Building stock evaluation:** Assessment of 1110 residential and mixed-use buildings through field surveys, visual inspections, and simulated detailed evaluations.
- **Seismic vulnerability analysis:** Classification of buildings by structural type, damage potential, and posting categories based on observed and modeled damage indicators.
- **Casualty and economic loss estimation:** Use of demographic data and established seismic damage models to estimate potential human casualties and financial impacts under probable earthquake scenarios.
- **Seismic hazard context:** Consideration of local tectonics, soil conditions, and topography to understand site-specific seismic risk factors.
- **Risk zonation:** Qualitative mapping of high, medium, and low seismic risk zones within the ward based on building vulnerability and geographical features.
- **Recommendations:** Provision of prioritized mitigation strategies and policy guidelines for short, medium, and long-term earthquake risk reduction.

Limitations

- **Data constraints:** The assessment relies on a limited number of detailed structural evaluations and uses simulated tests rather than extensive in-situ technical investigations due to resource constraints.
- **Rapid screening dependence:** The use of Rapid Visual Screening methods, though efficient, may miss hidden structural deficiencies or underestimate damage potential, especially for internal elements not visible externally.
- **Absence of advanced modeling:** The study does not include detailed seismic response analyses or finite element modeling of individual buildings due to the lack of detailed architectural and engineering drawings.

- **Limited GIS-based risk mapping:** Risk zonation is qualitative rather than GIS-driven, limiting spatial precision and dynamic hazard modeling capabilities.
- **Temporal snapshot:** The report reflects building conditions and population data at the time of the survey; ongoing construction, demolition, or retrofitting activities may alter vulnerability over time.
- **External factors:** Factors such as secondary hazards (e.g., fire, landslides) post-earthquake, socio-economic variables affecting recovery, and emergency response capacities are only briefly addressed.

1.4 Objectives

The overall goal of this study is to understand and mitigate seismic risk for Ward No. 7 of Panauti Municipality. The detailed objectives include:

- **Evaluate seismic vulnerability:** Conduct a systematic assessment of the existing building stock and infrastructure to identify which structures are most vulnerable to earthquake forces based on construction type, age, and condition.
- **Identify deficiencies:** Examine both structural components (e.g., columns, beams, load paths) and non-structural elements (e.g., parapets, chimneys) to determine weaknesses that may exacerbate damage or casualties during an earthquake.
- **Estimate potential impact:** Use vulnerability models and local demographic data to predict potential building damage, injury, and loss of life under scenarios of probable earthquakes of various intensities, including worst-case events.
- **Damage classification:** Categorize buildings according to damage grade and risk level to prioritize interventions and resource allocation.
- **Recommend mitigation strategies:** Suggest engineering retrofits, policy measures, and community preparedness plans to reduce risk and increase resilience.
- **Framework for disaster response:** Propose guidelines for emergency response, evacuation planning, and recovery operations tailored to local socio-economic and geographical conditions.

2 Literature Review:

Author	Key Findings
Laxmi Thapa – *Multihazard Mapping of Banepa and Panauti Municipalities*	- Developed hazard maps for earthquake, flood, landslide, and industrial risks. - Panauti core shows higher PGA (0.23–0.26g) due to alluvial soil. - Composite map integrates all hazards for risk planning.
Hari Ram Parajuli – *Seismic Hazard Assessment of Kavre Valley Municipalities*	- Conducted PSHA using CRISIS 2007. - PGA at bedrock: 0.29–0.35g; at surface: 0.46–0.55g. - Advocated for local attenuation relationships.
D. Chamlagain – Probabilistic Seismic Hazard Assessment of Nepal for Revision of National Building Code (NBC-105)	- Revised NBC-105 after 2015 Gorkha earthquake. - PGA 0.36–0.46g above locked MHT. - Used multiple GMPEs via logic-tree; emphasized Himalayan-specific GMPE.
Sanish Bhochhibhoya – Integrated Seismic Risk Assessment in Nepal	- Combined physical risk (AAL) and social vulnerability (SoVI) .- Kathmandu and Terai have highest integrated risk. - Rural western hills are socially vulnerable despite lower seismic hazard.
Maria Luísa Sousa – *National Seismic Risk Assessment: An Overview and Practical Guide*	- Follows ISO 31000 for national seismic risk assessment. - Identified gaps: lack of local exposure data, limited multi-hazard integration .- Aimed to improve national risk

	planning.
V. L. Stevens – *Probabilistic Seismic Hazard Assessment of Nepal*	- Used fault + area source models; MHT is primary hazard source. - PGA: 0.4–0.6g (10%), 1.0–1.3g (2%). - Major uncertainties linked to GMPEs and MHT parameters.

Methodology

This section describes the comprehensive approach taken to assess seismic risk through data collection, rapid screening, and detailed evaluation.

2.1 Data Collection

- **Field survey:** A detailed field survey was conducted in Panauti-07 covering 1110 households. Teams collected data on building characteristics, such as foundation type, number of stories, construction materials, and observed defects. Photographic records and GPS coordinates were taken for spatial referencing.
- **Population data:** Household size and occupancy patterns were recorded to estimate the population at risk, including vulnerable groups such as children, elderly, and disabled persons.
- **Damage and casualty models:** Established models such as FEMA 306 and NSET's guideline Part II were employed to estimate probable damage and human casualties under various earthquake shaking intensities.

2.2 Rapid Visual Screening (RVS)

- **Screening process:** Following FEMA 154-like protocols, a quick visual inspection of each building's exterior and accessible interiors was conducted. Key indicators such as cracks, spalling, tilting, and visible structural damage were recorded.

- **Posting system:** Each building was assigned a safety status:
  - **Green:** No significant visible risk; safe for occupancy.
  - **Yellow:** Limited structural concerns; restricted use recommended until further evaluation.
  - **Red:** Severe structural issues or hazards; declared unsafe and no entry allowed.
- **Documentation:** Screening forms were filled and digitally archived for reference and later analysis.

2.3 Detailed Evaluation

- **In-depth assessment:** For representative building types, detailed evaluations were hypothetically applied, including:
  - Sounding to detect hollow areas or delamination in walls.
  - Rebar detection using cover meters to check reinforcement presence and spacing.
  - In-situ shear strength testing using portable devices to estimate material strength.
- **Damage pattern analysis:** Observations focused on typical seismic failure modes like corner separations, diagonal shear cracks, and soft-story failures, which contribute to collapse risk.
- **Structural modeling:** Simplified structural analysis models were considered to simulate load distribution and identify critical failure points.
- of local policies aligned with national disaster risk reduction strategies.

3 Discussion

❖ Seismic Vulnerability

- The high proportion of non-engineered masonry structures directly correlates with severe risk during high-intensity shaking (MMI IX).
- The vulnerability assessment aligns with NSET (2009) guidelines which show structures without horizontal bands or proper anchorage are likely to collapse.

❖ Topographic Effects

- Due to hilly terrain, local amplification is expected. According to Bhandary et al. (2018), areas with steep slopes and soft fill materials are likely to suffer from landslides and rockfalls, especially under PGA $\geq 0.35g$.

❖ Past Earthquake Lessons

- The 2015 Gorkha Earthquake, although centered far from Panauti, still caused minor cracking and distress. An earthquake with the epicenter closer to Kavre would have catastrophic effects.
- Buildings not damaged in 2015 may not survive a stronger or more localized event.

❖ Awareness and Preparedness Gaps

- Community awareness was found to be limited.
- Most residents are unaware of the seismic risk classification of their homes.
- Emergency preparedness drills and evacuation plans are largely non-existent.

❖ Need for Retrofitting and Code Enforcement

- Lack of enforcement of Nepal Building Code (NBC) is a major concern. MoUD (2017) highlights weak municipal capacity for technical vetting and monitoring.
- Without immediate retrofitting, many essential buildings will not withstand the next major seismic event.

4 Conclusion

The seismic risk assessment conducted for Ward No. 7 of Panauti Municipality reveals a community highly vulnerable to earthquake hazards, primarily due to the predominance of older, non-engineered masonry buildings that lack adequate seismic resistance. The combination of traditional construction practices, insufficient maintenance, and complex local geology significantly exacerbates the potential for extensive structural damage and human casualties during a moderate to large seismic event.

5 References

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