Assessing seismic risk on a local scale in Muzaffarabad city, Northern Pakistan through the integration of satellite data and field observations

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Earthquakes are one of the most devastating and catastrophic natural calamities, often leading to extensive losses in infrastructure and human lives. This research introduces an integrated approach for evaluating seismic risk, encompassing factors such as seismic hazard, vulnerability, coping capacity, and resilience within the earthquake-prone region of Northern Pakistan. Utilizing high- resolution satellite imagery alongside thorough field surveys, the study generated detailed building footprints along with information on building types. Twenty- eight distinct sub factors, covering aspects of seismic hazard, physical, social, and economic vulnerability, and response and recovery capabilities, were employed to construct a comprehensive seismic risk map. Overcoming limitations in available factors by leveraging abundant vulnerability data at the local level, the assessment yielded a detailed high-resolution risk analysis, pinpointing areas highly susceptible to seismic hazards. Employing ArcGIS grid technology and the Analytical Hierarchy Process, the seismic hazard map reveals that the high and very high hazard classes covered an area of 3 km2 (10.7%) and 0.9 km2 (3.2%) respectively. Similarly, vulnerability map identified 1.8 km2 (6.4%) and 0.5 km2 (1.8%) of the total area as exhibiting high to very high vulnerability. The final seismic risk map delineated villages such as Chella Bandi, Dhanni Mysiba, Makri, Dherian Syedian, Ranjata, Baila Noor Shah, Taami, Middle Gojra, Lower Gojra, Rasheed Abad, and Upper Chattar as falling into the high-risk category. Additionally, areas including Pilot, the Madina Market area, Shahnara, and Domail villages were classified as very high risk, covering an area of 1.8 km2 (6.4%). These results inform the formulation of building codes and

land-use plans, ensuring elevated building standards in regions prone to seismic activity. Critical structures within designated hotspots become focal points for infrastructure design and retrofitting initiatives to enhance their seismic resilience. Emergency response plans can be tailored to address potential impacts in high-risk regions, facilitating efficient and focused crisis management strategies. Furthermore, these findings contribute to public awareness campaigns, insurance schemes, and community engagement programs aimed at mitigating overall damage from seismic events.