SEISMIC HAZARD ANALYSIS OF AZAD JAMMU AND KASHMIR USING GIS AND REMOTE SENSING

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Abstract: Earthquakes are one of the most terrible and catastrophic natural disasters, responsible for widespread infrastructure and population losses. The present study focuses on the use of integrated remote sensing and the Geographical Information System (GIS) approach combined with real field data for the identification of areas highly prone to seismic hazard and risk. The approach adopted for Earthquake Potential Index (EPI) analysis envisaged Sentinel-2 and Shuttle Radar Topography Mission (SRTM) satellite data, earthquake data, and geological data. Important factors related to earthquakes were recognized and relative input data layers (digital elevation model, slope, earthquake magnitude, epicentre location, lineaments, faults, distance to active faults and epicentre) were developed. For data integration in GIS, a numerical ranking scheme has been adopted to establish rank values for each factor for the appraisal of the earthquake potential index (EPI) map. The final earthquake potential index map divides the study region into different corresponding potential classes: high, moderate, low, and very low. The earthquake potential map produced for the region was compared with the previous seismic hazard maps derived from traditional techniques. The use of various parameters and implementation of the suggested method in the study region elucidates its good and detailed estimation of earthquake potential areas compared to traditional techniques.

In addition to the identification of earthquake-prone areas, subsurface material characterization which can considerably affect seismic hazard is of utmost importance. The time-averaged shear wave velocity in the upper 30m of soil, also known as V_{s30} is the basic criteria employed in the seismic site condition and site response analysis. V_{s30} is globally utilized in preparing Seismic Site Characterization Maps (SSCMs) regardless of its considerable limitations. This paper presents the acquisition, and interpretation of 280 real-field V_{s30} measurements using a geophysical instrument named Tromino. Models have been derived based on the three proxies i.e., geological age, lithology and topographic slope. Data analysis and statistical approaches show a good correlation between measured V_{s30} values with the adopted proxies. The models presented in this work consider topographic slope based on a 30m resolution Digital Elevation Model (DEM) in addition to the three geological age and four lithological groups. Cross-correlation of the proxies is performed to correlate the proxies for constructing proxy-based models. Proxy performance evaluation is carried out based on residual analysis and the correlation between real-field V_{s30} measurements and V_{s30} values estimated from proxies is offered to assess the V_{s30} predictive capacity of these proxies. The study establishes a strong correlation between measured Vs_{30} values in densely populated areas and V_{s30} values estimated through proxies, suggesting the viability of geological age, lithology, and slope as effective proxies for local-scale V_{s30} estimation. The models

introduced in the study are assessed for proxy performance, and scatter plots for slope-dependent geological units are provided for further evaluation. The final SSCM (V_{s30} map) categorizes the area into National Earthquake Hazard Reduction Programme (NEHRP) site classes which shows that most of the area is prone to amplified seismic response. Following the comprehensive seismic hazard assessment conducted at the local scale, a rigorous seismic risk evaluation is undertaken for the study area.

A holistic procedure to assess seismic risk in the study area considers the seismic hazard, vulnerability, coping capacity and resilience in the seismically active area in Northern, Pakistan. High-resolution satellite imageries coupled with extensive field investigations have led to the creation of building footprints along with building typological information. Twenty-eight envisaging subfactors related to seismic hazard, physical, social and economic vulnerability accompanied by response and recovery were utilized for the evaluation of detail and comprehensive seismic risk map. Overriding the constraint of limited factors and using the rich vulnerability data on a local scale, a detailed risk assessment at high resolution is performed to identify sites prone to high seismic risk. Prepared with Arc GIS grid technology and Analytical Hierarchy Process, the seismic vulnerability map revealed that 1.8 km^2 (6.4%) and 0.5 km^2 (1.8%) of the total area have high to very high vulnerability. The final seismic risk map shows that villages including Chella Bandi, Dhanni Mysiba, Makri, Dherian Syedian, Ranjata, Baila Noor Shah, Taami, Middle Gojra, Lower Gojra, Rasheed Abad and Upper Chattar lie in high-risk class while Pilot, Madina Market area, Shahnara and Domail villages fall in very high class taking up an area of 1.8 km^2 (6.4%). Seismic risk hotspots identified in this study can help decision-makers in prioritizing the deployment of funds and other resource allocation in these areas. This knowledge informs building codes and land use planning, guaranteeing higher building standards in seismically active areas. Critical structures in designated hotspots are the main focus of infrastructure design and retrofitting efforts can be aimed at improving their seismic resilience framework. Plans for emergency responses can be created taking into account possible effects in high-risk regions to enable effective and focused crisis management. Furthermore, these results impact public awareness campaigns, insurance plans, and community involvement programs to lessen the overall damage.