

Regional scale risk assessment for landslides and debris flows (mass-wasting) in Hindukush mountain Ranges, Northern Pakistan

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Landslides and debris flows are recurring and damaging natural hazards in mountainous terrains, leading to severe environmental and economic losses and casualties. Vulnerability and risk assessments are essential for hazard mitigation, land use and developmental planning. However, they are often rarely available in developing countries. Given the topographic, climatic and environmental settings, landslides and debris flows have severely impacted communities, infrastructure and socio-economic conditions in northern Pakistan. In this study, a methodology is developed and applied using freely available geospatial tools and field-based data for one of the most prone areas for mass wasting in the Hindukush mountain ranges of northern Pakistan. These techniques are applied individually for landslides and debris flows. Very high-resolution satellite images are used to develop the inventory for landslides and debris flows and their spectral characteristics are utilized to compute the causative factors for landslides and debris flows. A bivariate model is used to generate the landslide susceptibility map. The hazard index map for landslides is computed by integrating the susceptibility map with the triggering indicator, additionally, the analytical hierarchy process is applied for hazard assessment of debris flows. The freely available remote sensing and detailed field data are used to create a set of indicators for the element at risk. Element at-risk data includes the typological data of the building footprints, roads, population, and land cover. Finally, a spatial multi-criteria evaluation technique is applied to assess the element's vulnerability at-risk data. Furthermore, semi-quantitative techniques are applied for the risk assessment, separately, for landslides and debris flows. These risk maps are classified into five categories: very low, low, moderate, high, and very high. The generated risk index maps shall be helpful in highlighting the risk hotspots and risk reduction strategies.

Keywords: Mass-wasting; Remote-sensing; Hazard; Vulnerability; Risk