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Geomorphological sensitivity to climate change and direct human impact: mapping of debris-flow and landslide hazards in tropical mountain areas (Andes)

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Mountain areas are particularly vulnerable to climate change as the local variations in elevation and aspect amplify general trends in temperature and precipitation alteration. Many of the mountain areas are also under increasing direct human pressure, which is related to food production, settlement, mining, and other direct earth-moving activities. As a response to such external drives, the increase in frequency and magnitude of geomorphic processes has been observed in many places around the world.

Our project focuses on catastrophic geomorphic processes (mainly debris flows, landslides, accelerated soil erosion) as an example of a land-surface response to environmental (including climatic and anthropogenic) change. The research is conducted in two locations in the Andes (Eje Cafetero, Colombia and Quispicanchi Province, Peru), representing different climatic conditions and various degrees of direct human impact. The Eje Cafetero region is located on the slopes of the central and western Cordillera of the Colombian Andes. The average slope is approximately 45 degrees. The seasonal rain passes over the region twice a year. Pressure for urban development, mass-tourism and gold mining constitutes the biggest socio-economic threats that can impact land use in the area. Landslides are the most significant natural hazard, which very often disturbs transportation system, destroying crop areas, and threatening small towns. Quispicanchi Province is located in the southern highlands of Peru. The main focus is on the Willkanuta (Cordillera de Vilcanota) - mountain range which is much less populated than Eje Cafetero, thereby allowing us to study surface dynamics not related to direct human impact. Meanwhile, landslides and debris flows (partly preconditioned by glacier recession) still constitute a serious threat to human infrastructure (roads, villages, etc.), and life.

This study aims to develop an operational framework for geohazard assessment and monitoring in mountain areas. We use a multidisciplinary approach that links remote sensing mapping, geomorphological fieldworks, unmanned aerial vehicle surveys (UAV) and GIS analysis. We mapped geomorphic traces of mass movements (debris-flow channels, erosional rills, rockfall deposits and landslides) that were visible in different years based on a time-series of high-resolution (<1.0 m) satellite imagery. This spatial database was subsequently enriched with information about geology (from geological maps) and topography (slope, aspect, curvatures, slope length, etc.) based on the photogrammetrically-derived Digital Elevation Models (DEMs). The database enabled us to investigate the distribution of mass movement processes and related landforms over the modern landscape and asses their dynamics over the last 15 years. The results will be used to assess the impact of observed geohazards on the provision of ecosystem services across studied mountain landscapes.

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