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Mapping and geomorphological characterization of small-scale slope-related geohazards in the tropical high-mountain environment: case studies from Cordillera Villcanota, Peru and Eje Cafetero, Colombia

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Slope-related mass movements and erosional processes are common in all regions on Earth and especially dangerous in mountain areas, where they can rapidly transfer material, threatening human lives and infrastructure. However, the characteristics and activity of small scale (< 1000 m^2) events in highly elevated tropical mountains remain poorly understood, even though these areas are often populated. The morphological characterization and investigation of the short-term dynamics of different types of mass movement and erosional processes can help infer about slope processes and take appropriate actions to limit associated hazards. This contribution aims:(1) To recognize the different processes that contribute to overall slope dynamics; (2) To document the morphology and short-term (annual dynamics) of geohazards-related landforms (e.g. small landslides, erosional rills and gullies); (3) To investigate the relationships between the characteristics and dynamics of geohazard sites and the landscape properties; (4) To develop a model of mass wasting mechanisms as agents of slopes development in tropical mountains.

The study areas were located in South America in Cordillera Vilcanota (Willkanuta) in Peruvian Andes and Eje Cafetero region in Colombian Andes. We documented and investigated the morphology and annual spatial pattern of activity of 15 sites representing different types of geohazards. Topographic analyses were based on time series of data captured using an unmanned aerial vehicle (UAV). Where possible, we investigated the observed dynamics of slope processes in combination with data on anthropogenic use to identify the main possible hazards. We identified four main types of processes responsible for transforming the land surface within studied sites: landslides, debris flows, falling, accelerated soil erosion. The morphological expression of these processes included the formation of erosional rills and gullies, landslide head scarps and lobes, debris flow channels, and avalanche deposits. In addition, we identified two main processes that control the activity of small geohazard sites. First, road works often caused activation of mass movements because of undercutting roadsides and associated anthropogenic earth movements. Second, the topographic properties of slopes (mainly slope and aspect) can increase the landscape response to direct anthropogenic pressure. Documented activity often follows a pattern of initiation of movements at the bottom of the site and its further propagation towards the upper escarpment. These results suggest that the dynamics of small geohazard sites

strongly depend on local conditions and direct human impacts. While individual events are hard to predict, the presence of fine-scale rills and furrows might be helpful as indicators of probable increase in activity of slope processes. Over the longer time scales, that can be used to identify the most hazardous elements of the slope systems.

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