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

The main aim of the project is to understand and quantify the feedbacks between recent (last 50 years) landscape dynamics (focusing on debris-flow and landslide hazards) and ecosystem services provision in tropical mountains of South America over various temporal (decadal, annual, intra-annual) and spatial scales (landform-, catchment-, and regional-scale), based on remote sensing and field-based data. The research will be conducted in two key study locations in the Andes (i.e. Eje Cafetero, Colombia and Quispicanchi Province, Peru), representing different climatic conditions and various degrees of direct human impact. Geomorphic dynamics in many mountain areas is controlled by recent climate changes and direct human activities (especially land-use/land-cover changes). For example, observations and simulations have suggested a substantial role of land use changes in the intensification of hazardous debris flows and landslides. Potentially, other factors like changes in precipitation regime and tectonic activity may also significantly influence the rate and volume of debris transport, even though so far this has yet to be fully recognized. Existing theoretical models of geomorphic sensitivity to climate changes are simplified, and the key issue is that they have not been tested and compared in a wider range of mountain settings. Moreover, the quantitative aspect of recent geohazards related to land-use and climate changes remains largely unknown despite being critically important due to their potentially substantial impact on numerous human communities. To understand how rapidly debris can be re-distributed by mass movement processes and how they can impact ecosystem services provision, the theoretical models need to be constrained, while more specific representations for different settings also need to be developed. Herein lies the key motivation for this study. The proposed research will employ field-based and remote sensing observations to quantify and compare the geomorphic sensitivity of mountain landscapes to climate change and direct anthropogenic influence within a range of mountain settings characterised by different socio-economic and environmental conditions. The project will: (1) map modern traces of mass movement activities (such as debris flow and landslides) based on recent high-resolution satellite images; (2) investigate historical changes in the magnitude and frequency of geomorphic processes on a decadal time-scale based on a time-series of archival aerial photographs; (3) quantify the annual and intra-annual rates and volume of relief changes based on repetitive UAV surveys and multi-stereo time-lapse cameras; (4) quantify the impact of future land surface dynamics on the ecosystem services provision using agent-based modelling and simulations. A statistical model that predicts the probability of geohazards will then be developed based on the collected data. The impact of this work will be seen in its capacity to quantify the rates and magnitudes of geohazards such as landslide and debris flowing, and to propose new theoretical and statistical models of mountain response to recent climate changes and their direct human impact. As such, the realisation of this project should lead to a quantified understanding of geomorphic risk through time and its impact on the provision of ecosystem services, which is important especially in the context of a world where human activity in mountain areas is increasing on a scale that has not been seen before.