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Landslide Hazard Assessment and Mapping in the Guil Catchment (Queyras, Southern French Alps): From Landslide Inventory to Susceptibility Modelling

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Landslides are common natural hazards in the Southern French Alps, where they may affect human lives and cause severe damages to infrastructures. As a part of the SAMCO research project dedicated to risk evaluation in mountain areas, this study focuses on the Guil river catchment (317 km^2), Queyras, to assess landslide hazard poorly studied until now. In that area, landslides are mainly occasional, low amplitude phenomena, with limited direct impacts when compared to other hazards such as floods or snow avalanches. However, when interacting with floods during extreme rainfall events, landslides may have indirect consequences of greater importance because of strong hillslope-channel connectivity along the Guil River and its tributaries (i.e. positive feedbacks). This specific morphodynamic functioning reinforces the need to have a better understanding of landslide hazards and their spatial distribution at the catchment scale to prevent local population from disasters with multi-hazard origin.

The aim of this study is to produce a landslide susceptibility mapping at 1:50 000 scale as a first step towards global estimation of landslide hazard and risk. The three main methodologies used for assessing landslide susceptibility are qualitative (i.e. expert opinion), deterministic (i.e. physics-based models) and statistical methods (i.e. probabilistic models). Due to the rapid development of geographical information systems (GIS) during the last two decades, statistical methods are today widely used because they offer a greater objectivity and reproducibility at large scales. Among them, multivariate analyses are considered as the most robust techniques, especially the logistic regression method commonly used in landslide susceptibility mapping. However, this method like others is strongly dependent on the accuracy of the input data to avoid significant errors in the final results. In particular, a complete and accurate landslide inventory is required before the modelling.

The methodology used in our study includes five main steps: (i) a landslide inventory was compiled through extraction of landslide occurrences in existing national databases (BDMvt, RTM), photointerpretation of aerial photographs and extensive field surveys; (ii) the main predisposing factors were identified and implemented as digital layers into a GIS together with the landslide inventory map, thus constituting the predictive variables to introduce into the model; (iii) a logistic regression model was applied to analyze the spatial and mathematical relationships between the response variable (i.e. absence/presence of landslides) and the set of predictive variables (i.e. predisposing factors), after a selection procedure based on statistical tests (χ^2-test and Cramer's V coefficient); (iv) an evaluation of the model performance and quality results was conducted using a validation strategy based on ROC curve and AUC analyses; (v) a final susceptibility map in four classes was proposed using a discretization method based on success/prediction rate curves. The results of the susceptibility modelling were finally interpreted and discussed in the light of what was previously known about landslide occurrence and triggering in the study area. The major influence of the distance-to-streams variable on the model confirms the strong hillslope-channel coupling observed empirically during rainfall-induced landslide events.