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Shallow translational slides hazard evaluation in Santa Marta de Penaguião (Douro valley – Portugal)

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The present study is developed for the municipality of Santa Marta de Penaguião (70 square kilometers), located in the Douro Valley region (Northern Portugal). In the past, several destructive landslides occurred in this area, and were responsible for deaths and destruction of houses and roads. Despite these losses, mitigation and landslide zonation programs are missing, and the land use planning at the municipal level did not solve yet the problem.
The study area is mainly composed by metamorphic rocks (e.g., schist and quartzite). These rocks are strongly fractured, and weathered materials are abundant in clayed schist, mainly in those areas where agricultural terraces were constructed centuries ago for the vineyard monoculture. From the geomorphologic point of view, the study area is characterized by deep incised valleys, tectonic depressions and slopes controlled by the geological structure. Elevation ranges from 49 m to 1416 m. The main landslide triggering factor is rainfall and the mean annual precipitation ranges from 700 mm (in the bottom of fluvial valleys) to 2500 mm (in the mountains top).
A landslide inventory was performed in 2005-2009 using aerial photo-interpretation (1/5.000 scale) and field work. The inventory includes 848 landslides, most of shallow translational slide type (85% of total slope movements). The landslide density is 10.5 events/square kilometers, and the average landslide area is 535 square meters.
The susceptibility to shallow translational slide occurrence was assessed at the 1: 10 000 scale in a GIS environment. Two different bivariate statistical methods were used to evaluate landslide susceptibility: the Information Value and the Fuzzy Logic Gamma operator. Eight conditioning factors were weighted and integrated to model susceptibility: slope angle, slope aspect, slope curvature, lithology, geomorphologic units, fault density, land use and terrace structures build in slopes.
The susceptibility results were validated using a random partition of the total set of shallow translational slides in two groups (training group and validation group, which were randomly defined, each corresponding to 50% of the complete landslide population.). This strategy allows the independent validation of landslide susceptibility models and the construction of prediction rate curves. The best prediction results were obtained using the information value method (Area Under Curve - AUC = 0.78).
The landslide susceptibility map was classified in 5 susceptibility classes using the slope breaks within the best prediction curve. The empirical probability for each class was also estimated.
Landslide hazard was assessed based on empirical probabilities, using an instability scenario similar to the event occurred in January 2001, which generated 603 shallow translational slides with a total unstable area of 93,029 square meters. This landslide event was triggered by 1064 mm of cumulative rainfall in 90 days, having 18 years of return period. Therefore, we assume that future occurrence of such rainfall amount will generate the same consequences regarding slope instability in the study area (i.e., the same number of landslides and equivalent total unstable area). The landslide hazard was also calculated per year to allow hazard comparison with other areas.
The obtained results have short temporal validity and must be carefully analyzed due to rapid changes in land use in order to get more space for vineyard plantations. In recent years, the slope structures which sustained the soil erosion have been replaced systematically by terraces without soil support structures. In this context, the conditioning factors, susceptibility and hazard maps need to be regularly reassessed.