

Semi-quantitative assessment of the physical vulnerability of buildings for the landslide risk analysis. A case study in the Loures municipality, Lisbon district, Portugal

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The physical vulnerability of the buildings of Loures (a Portuguese municipality) to landslides was assessed, and the landslide risk was computed as the product of the landslide hazard by the vulnerability and the market economic value of the buildings.

First, the hazard was assessed by combining the spatio-temporal probability and the frequency-magnitude relationship of the landslides, which was established by plotting the probability of a landslide area. The susceptibility of deep-seated and shallow landslides was assessed by a bi-variate statistical method and was mapped. The annual and multiannual spatio-temporal probabilities were estimated, providing a landslide hazard model.

Then, an assessment of buildings vulnerability to landslides, based on an inquiry of a pool of landslide European experts, was developed and applied to the study area. The inquiry was based on nine magnitude scenarios and four structural building types. A sub-pool of the landslide experts who know the study area was extracted from the pool, and the variability of the answers coming from the pool and the sub-pool was assessed with standard deviation. Moreover, the average vulnerability of the basic geographic entities was compared by changing the map unit and applying the vulnerability to all the buildings of a test site (included in the study area), the inventory of which was listed on the field.

Next, the market economic value of the buildings was calculated using an adaptation of the Portuguese Tax Services approach.

Finally, the annual and multiannual landslide risk was computed for the nine landslide magnitude scenarios and different spatio-temporal probabilities by multiplying the potential loss (Vulnerability \times Economic Value) by the hazard probability.

As a rule, the vulnerability values given by the sub-pool of experts who know the study area are higher than those given by the European experts, namely for the high magnitude landslides. The obtained vulnerabilities vary from 0.2 to 1 as a function of the structural building types and the landslide magnitude, and are maximal for 10 and 20 meters landslide depths. However, the highest annual risk was found for the 3 m deep landslides, with a maximum value of 25.68 € per 5 m pixel, which is explained by the combination of a relatively high frequency in the Loures municipality with a substantial potential damage.