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Computation of direct costs for the probabilistic landslide risk assessment at a regional scale

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A probabilistic landslide risk evaluation is developed for both roads and buildings existing in a small test site (20 square kilometres) in the North of Lisbon Region (Portugal). This evaluation is performed integrating into a GIS environment the landslide hazard data with the vulnerability of exposed elements and associated estimated values. Landslide hazard is assessed at a probabilistic basis for three different types of slope movements (shallow translational slides, translational slides and rotational slides), based on the following assumptions: (i) the likelihood of future landslide occurrence can be measured through statistical relationships between past landslide distribution and specified spatial data sets considered as landslide predisposing factors; (ii) future landslides of a specific type will have a 'geometric severity' [landslide magnitude] similar to those verified in the past in the test site for the same type of slope movement; (iii) the rainfall combination (amount - duration) that produced slope instability in the past within the test site will produce the same effects (i.e. same type of landslides and similar total affected area) each time they occur in the future. As the return period of rainfall triggering events is known, different scenarios can be modelled, each one ascribed to a specific return period. Therefore, landslide hazard is quantitatively assessed at a raster basis, and is expressed as the probability for each pixel (25 square meters) to be affected by a future landslide of type Z, considering a rainfall triggering scenario with return period of N years. Vulnerability is considered as the degree of loss to a given element or set of elements resulting from the occurrence of a natural phenomenon [landslide] of a given magnitude. Vulnerability depends not only from structural properties of exposed elements, but also from type of process, namely its magnitude; i.e., vulnerability cannot be defined in absolute terms, but only with respect to a specific landslide type. Therefore, vulnerability of different building types and roads inventoried in the test site is classified considering the exposition to the

previous mentioned three landslide type, and taking into account: (i) damage levels produced by past landslide events of type Z in the study area; (ii) geometrical severity of landslide type Z (typical depth, volume and velocity); and (iii) vulnerability classifications reported in literature. Value of vulnerable elements (roads and buildings) is defined through the evaluation of reconstruction costs, following the guidelines of the Portuguese Insurance Institute. Previous landslide occurrence in the study area and the next recovering works are considered to assess future landslide costs. Finally, the landslide risk assessment considering direct costs is made in an automatic way within the GIS, crossing the following three layers: (i) a probabilistic hazard map for a landslide type Z, considering a particular rainfall triggering scenario whose return period is known; (ii) a vulnerability map (values from 0 to 1) of the buildings and roads exposed to landslide type Z; and (iii) the value map of the vulnerable elements, considering reconstruction costs.