Landslide risk profiles for municipal land use planning in Portugal

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In this work we propose a Landslide Risk Index (LRI) and a Landslide Disaster Index (LDI) for disaster risk management in Portugal at the municipal scale, using an adaptation of the INFORM methodology.

LRI is the product of hazard, exposure and vulnerability. Landslide hazard assessment combines the rainfall triggering conditions and landslide susceptibility. A municipal weather and climate events index was computed using a multicriteria analysis that included the annual frequency of circulation weather types mostly associated to landslides and an index of extreme precipitation susceptibility. Landslide susceptibility was obtained from a national susceptibility model using a geomorphological landslide inventory based on photo-interpretation and fieldwork over 14 sample areas representative of the country geology and geomorphology. The landslide susceptibility model was assessed using the Information Value method and further validated with prediction-rate curves. The percentage of the municipality's territory with positive Information Value was used to assess a landslide susceptibility value per municipality.

Exposure to landslides for each municipality was evaluated using the population density (inhabitants/km2) from the 2011 population census, the average imperviousness obtained from the Corine Land Cover 2012 and the road density (km/km2).

The social vulnerability of the municipalities was assessed using a Principal Component Analysis (PCA) and including the criticality and support capability components. The criticality includes a set of characteristics and behaviors of the individuals who may contribute to the disruption of the individual context and the resources of the communities that allow them to deal with and respond to harmful events. Support capability included the set of territorial infrastructures that allows communities to react in case of disaster and could support the recovery.

Landslide hazard, exposure and vulnerability variables were normalized between 0 (low) and 10 (very high) and weighted using a multicriteria analysis, further validated with the Cronbach Alpha and Lambda 2 reliability tests. Finally, the LRI was computed.

Historical records of damaging landslides were obtained from the Portuguese Disaster database (1865-2015). The annual probability ≥ 1 landslide disaster case, ≥ 1 fatalities and ≥ 1 displaced people was computed using a Gumbel maximum distribution function and the spatial density of landslide disaster cases, fatalities and displaced people (no/km2) was calculated for each municipality.

Landslides impacts variables were equally weighted to obtain the Landslide Impacts Index (LII) for each municipality. Finally, LRI combined with the human damages caused by landslides in the past (LII) provided the LDI.

This work allows identifying the main driving forces of landslide risk at the municipal level and contributes to define public policy measures for spatial planning and land use management to mitigate disaster risk and reduce future losses.