

Developing a methodology for the national-scale assessment of rainfall-induced landslide hazard in a changing climate

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Landslides together with earthquakes and floods represent the main natural hazards in Romania, causing major impacts to human activities. The RO-RISK (Disaster Risk Evaluation at a National Level) project is a flagship project aimed to strengthen risk prevention and management in Romania, by evaluating – among the specific risks in the country – landslide hazard and risk at a national level. Landslide hazard is defined as “the probability of occurrence within a specified period of time and within a given area of a landslide of a given magnitude” (Varnes 1984; Guzzetti et al. 1999). Nevertheless, most landslide ‘hazard’ maps only consist in susceptibility (i.e. spatial probability) zonations without considering temporal or magnitude information on the hazard. This study proposes a methodology for the assessment of landslide hazard at the national scale on a scenario basis, while also considering changes in hazard patterns and levels under climate change conditions.

A national landslide database consisting of more than 3,000 records has been analyzed against a meteorological observation dataset in order to assess the relationship between precipitation and landslides. Various extreme climate indices were computed in order to account for the different rainfall patterns able to prepare/trigger landslides (e.g. extreme levels of seasonal rainfall, 3-days rainfall or number of consecutive rainy days with different return periods). In order to derive national rainfall thresholds, i.e. valid for diverse climatic environments across the country, values in the parameter maps were rendered comparable by means of normalization with the mean annual precipitation and the rainy-day-normal. A hazard assessment builds on a frequency–magnitude relationship. In the current hazard scenario approach, frequency was kept constant for each single map, while the magnitude of the expected geomorphic event was modeled in relation to the distributed magnitude of the triggering factor. Given the small-scale context, landslides were interpreted as multiple-occurrence regional landslide events (MORLE) (Crozier 2005) and consequently their magnitude was expressed by means of the number of triggered processes. In order to achieve acceptable relations between the intensity of the trigger and the magnitude of the MORLE for different morphological and lithological conditions, a prior distinction of homogenous territories in terms of landslide predisposing characteristics was considered. Since landslide data was statistically insufficient, empiric knowledge gained on rainfall thresholds was used to modulate expert judgment and build semi-quantitative hazard matrices. Climate projections (2021-2050) from EURO-CORDEX regional models (downscaled to a 1 km resolution) under RCP 4.5 and RCP 8.5 scenarios were considered to estimate future patterns and levels of landslide hazard across Romania and investigate expected changes.

The established hazard scenarios allow the identification of the high-hazard ‘hotspot’ regions across the country as well as of those assigned to the medium-to-high hazard magnitudes under both current and future climates. Trends in the expected impact of climate change on landslide hazard are discussed with reference to related uncertainties. This study is part of the RO-RISK project coordinated by the Romanian General Inspectorate for Emergency Situations (IGSU) and supported by the European Social Fund through the Operational Programme for Administrative Capacity (POCA).