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A combined procedure to assess rainfall-induced shallow landslide detachment, transit and runout susceptibility using Machine Learning and GIS techniques

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Rainfall-induced landslides are notoriously dangerous phenomena which can cause a notable death toll as well as major economic losses globally. Usually, shallow landslides are triggered by prolonged or severe rainfalls and frequently may evolve into potentially catastrophic flow-like movements. Shallow failures are typical in hilly and mountainous areas due to the combination of several predisposing factors such as slope morphology, geological and structural setting, mechanical properties of soils, hydrological and hydrogeological conditions, land-use changes and wildfires. Because of the ability of these phenomena to travel long distances, buildings and infrastructures located in areas improperly deemed safe can be affected.

Spatial and temporal hazard posed by flow-like movements is due to both source characteristics (e.g., location and volume) and the successive runout dynamics (e.g., travelled paths and distances). Hence, the assessment of shallow landslide susceptibility has to take into account not only the recognition of the most probable landslide source areas, but also landslide runout (i.e., travel distance). In recent years, a meaningful improvement in landslide detachment susceptibility evaluation has been gained through robust scientific advances, especially by using statistical approaches. Furthermore, various techniques are available for landslide runout susceptibility assessment in quantitative terms. The combination of landslide detachment and runout dynamics has been admitted by many researchers as a suitable and complete procedure for landslide susceptibility evaluation. However, despite its significance, runout assessment is not as widespread in literature as landslide detachment assessment and still remains a challenge for researchers. Currently, only a few studies focus on the assement of both landslide detachment susceptibility (LDS) and landslide runout susceptibility (LRS).

In this study, the adoption of a combined approach allowed to estimate shallow landslide susceptibility to both detachment and potential runout. Such procedure is based on the integration between LDS assessment via Machine Learning techniques (applying the Ensemble approach) and LRS assessment through GIS-based tools (using the “reach angle” method). This methodology has been applied to the Cinque Terre National Park (Liguria, north-west Italy), where risk posed by flow-like movements is very high. Nine predisposing factors were chosen, while a database of about 300 rainfall-induced shallow landslides was used as input. In particular, the obtained map may be useful for urban and regional planning, as well as for decision-makers and stakeholders, to predict areas that may be affected by rainfall-induced shallow landslides in the future and to identify areas where risk mitigation measures are needed.