Geophysical Research Abstracts
Vol. 13, EGU2011-8945, 2011
EGU General Assembly 2011

Shallow landslides susceptibility mapping: comparison of different deterministic methods

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Shallow landslides are usually triggered by short-period but very intense rainfall events; they can cause widespread direct and indirect damage to the terrain, infrastructure, as well as urban and rural developments.
This research compares the predictive capability of three different models for producing shallow earth slide susceptibility maps, namely the SINMAP, SHALSTAB, which are terrain stability models that combine steady state hydrology assumptions with the infinite slope stability model and the Transient Rainfall Infiltration and Grid-based Regional Slope-Stability (TRIGRS) that couples an infinite-slope stability analysis with a one-dimensional analytical solution for rainfall infiltration.
The test site is an area of about 250 km2 corresponding to the north-eastern sector of Oltrepo Pavese (italian northern Apennines) where, in April 2009, rainfall combined with snowmelt triggered more than 1600 of landslides. Most of the slides were shallow (thickness usually from 0.5 to 2 m) with the failure surface located along the contact between colluvial cover and the weathered bedrock; sometimes they involved portions of bedrock. According to the Cruden & Varnes (1996) classification and that proposed by Campus et al. (1998) for rainfall-triggered landslides, four types of landslides were recognized: a) incipient translational slide; b) translational soil slide; c) rotational slide, d) complex landslide. Most of the shallow landslides occurred in marls and of gravel, sand and poorly cemented conglomerates, generally in correspondence of slope angle changes which also correspond to changes in land use (from gentle slope with vineyards to steep slopes with wood-land).
Although the volume of the failures rarely exceeded several hundreds of cubic meters, the landslides damaged roads and agricultural lands, caused one fatality and several injured people with high direct and indirect costs for the community.
An inventory of the landslides triggered by the event was obtained from interpretation of aerial photos dating back to May 2009, with a spatial resolution of 15 cm. Field investigations involved detailed study of failure site geomorphology and landslides characteristics. A dataset of causal factors including soil type, soil thickness, land cover, slope angle, aspect and curvature was created.
The geotechnical characterization of colluvial deposits was based on standard soils analysis conducted according to the ASTM standard. The performed tests include (i) assessment of the physical parameters of materials (grain size distribution, bulk and dry densities and Atterberg Limits), (ii) standard geotechnical tests (direct shear tests).
The study discusses the practical advantages and limitations of the three predictive models in connection with the geological characteristics of the studied area, which could be representative of similar geological contexts in the Apennines.
In particular the results obtained using TRIGRS model demonstrated a good agreement between predicted shallow landslide hazard and the inventory map derived from surveys. Most of the source areas are in fact correctly triggered even if the model shows little over-estimates. More accurate results can be obtained using detailed calibration region which also include land use and consequently variation of parameters such as soil cohesion and permeability in order to take also account of the role played by the roots.