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The SLID project: tools and methods to estimate agricultural soil loss in clayey Mediterranean hillslopes

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In the Mediterranean hillslope catchments, intensive agricultural exploitation is becoming more and more widespread, often inducing soil loss due to unsound practices.

The goals of the "SLID" (Shallow Landslide Investigation Device) LIFE EU project has been to develop and make available to public and private institution state-of-the-art software tools and field investigation techniques helpful for decision making.

We chose to build the model and the related software on top of the SHALSTAB theory (Montgomery and Dietrich, 1994) for the mapping of shallow landslide potential. In fact, the largest part of agricultural soil loss in these hillslope occurs due to small failures and mud flows rather than rainsplash and overland flow erosion. The model couples the infinite slope equation with a simple steady-state throughflow scheme, assuming that a clear slip surface and a hydraulic conductivity threshold exist between a shallow soil mantle layer: while these assumptions are debatable for clayey natural hillslopes, agricultural practice (such as plowing) generates a well-defined topsoil layer, as expected by the model.

The application, calibration and testing of the model was performed at two different spatial scales: a) a regional scale (about 1000 sq km), over the Italian Northern Apennines' clayey hillslopes located between the Lamone and Savio rivers, after the collection and integration of a G.I.S. database including topography, bedrock lithology and bedding orientation, land use and a landslide inventory; and b) a field scale, measuring at selected sites the detailed topography, soil depth and its geomechanical and hydrological parameters, as well as detailed mapping of large landslides and smaller soil slips.

In particular, a significant number of real soil slips mapped at two field sites (located respectively near Predappio and Cusercoli - Italy) were not related to the topographic parameters (slope angle and drainage area), but seemed clearly controlled by the artificial surface drainage modifications.

For this reason we proceeded to modify the SLID software, accounting for the change of the surface drainage pattern, improving significantly the performance of the model.

The final version, provided with a clear graphic user interface, was made available to the public and private operators, after a brief workshop on the theory and application of SLID.

As the SLID model does not attempt to estimate the timing of the failure, we explored on a parallel research line the possibility to estimate the critical rainstorm patterns (intensity-duration) most likely to trigger a soil slip.

An experimental station was installed on an hillslope parcel of the Centonara catchment (Bologna, Italy), equipped to record in real time the hourly variations of the meteorological parameters (temperature, solar radiation, wind speed, humidity, evaporation, rainfall intensity) as well as the water content and water potential of the soil mantle, using three TDR probes located at different depths (20, 40 and 80 cm). Furthermore, we installed a mass deformation cable to record the profile of the soil displacement with depth, and performed a GPR survey followed by a campaign of sampling and laboratory testing of the geotechnical and hydrological properties.

The failure occurred in May 2006 at a depth of about 1.30 m, following a precipitation pattern quite ordinary. Indeed, close examination of the TDR record for two full hydrological years revealed that similar rainstorm patterns produced quite different responses in terms of soil moisture and soil water potential. This suggests that hydrological modeling alone might not lead to satisfactory results in terms of estimating the timing of failure, but more hydrological years are needed to claim reliable conclusions.

References

Montgomery, D. R., and Dietrich, W. E., A Physically-Based Model for the Topographic Control on Shallow Landsliding, Water Resources Research, v. 30, p. 1153-1171, 1994.