Landslide susceptibility: predictive power of the MSUE conditional analysis method in the Milia Valley (Tuscany, Italy)

Marco Capitani (1) and Paolo Roberto Federici (1)

(1) Università di Pisa, Dipartimento di Scienze Delle Terre, Pisa, Italia (capitani@das.unipi.it);

Over the last few decades, many researchers have produced landslide susceptibility maps using different methods of statistical analysis applied to Unique Condition Units (UCUs). However, no one has emphasized how the choice of representing the dependent variable (which is defined into the landslides inventory) can lead to the construction of models with un-definable predictive power. Theoretically, the dependent variable should be represented in the landslides inventory as the area where landslides have been originated, i.e., the depletion zones (or detachment zones, or rupture zones), since susceptibility assessment claims to identify under what conditions landslides are generated. Due to the fact that the depletion zones are only partially visible, their definition into an inventory map is highly subjective. Moreover, without a geophysical prospecting, there is not the possibility to define how our representation differs from reality. This fact introduces unquantifiable errors in the dependent variable and makes uncertain the results of the power prediction validation for the models so built. In fact, the dependent variable is used both in the construction of models and in their validation. So, only a certain dependent variable should be used into landslide susceptibility analysis. Among the systems of representation of the landslides inventory that do not introduce large margins of subjectivity and therefore unquantifiable errors, the Main Scarp Upper Edge method is the only that could be better adapted to the purposes of the landslide susceptibility analysis. On the other hand, among the methods of statistical analysis used to create landslide susceptibility maps, the conditional method appears to be one of the easiest to understand and to read for non-specialists. Therefore, an attempt to assess the predictive capability of the MSUE-conditional method and its advantages and limitations has been made. This method was used to evaluate landslide susceptibility in the Milia Valley, an area of 101 km² in Tuscany (Italy). A detailed geomorphological mapping, assisted by aerial photographs analysis, enabled us to build two landslide inventories using a time scale. The 1834 landslides related to a period before 1975 were used to create the models, while the 205 landslides related to a period after 1975 were used to validate the models predictive power. All landslides have been classified on the basis of the prevailing type of movement into slides, flow and rotational. For each type and temporal group only the MSUEs were acquired in a GIS vector form. Five time invariant factors maps (liothology, slope angle, aspect, distance to stream and to tectonic lineaments) were also developed in a GIS environment and reclassified. A preliminary statistical analysis, performed by cross tabulation (contingency tables) between MSUEs and determinant factors, was carried out in order to evaluate the most influencing factors. Finally, the inventory landslides maps and the five landslide-related factor maps were processed using a model (scripts) in a GIS environment. The procedure was applied separately to the most frequent landslide typologies and for each different combinations of the five factors. The comparison between the distribution of landslides after 1975 and the predicted distribution derived from susceptibility models (originated from the landslides before 1975) established the power prediction of each model. The results of this analysis show how for the Milia valley (the MSUE-conditional method has a good predictive capability for the landslides belonging to slides typology, while for the others it denotes limits presumably associated to the choice of MSUE as dependent variable in a context where old and ancient landslides are present.

A framework for flow-like mass movements susceptibility analysis and zoning at medium scale

Leonardo Cascini (1), Silvio Di Nocera (2), Michela Calvello (1), Sabatino Cusanno (1), Settimio Ferresi (1), and Fabio Matano (2)

(1) University Of Salerno, Dept. Civil Engineering, Fisciano - Sa - Italy; (2) University Of Naples Federico II, Dept. Geology, Naples, Italy;

In the last few decades, several methods for landslide susceptibility analysis have been proposed in the scientific literature. Generally, these methods differ among them depending on the scale (and related purpose) of the analysis and, consequently, on the quality/quantity of input data and the adopted procedures (heuristic, statistical and deterministic). However, owing to the complexity of the problem and the variability of the factors involved in the analyses (passing from a case study to another), standardised methodological criteria are lacking. In that respect, this paper shows the results of an ongoing research programme aimed at developing a standardised criterion for landslide susceptibility analysis and zoning at medium scale (1:25,000). Scale. To this aim, a general framework embracing the contribution that both geological and geotechnical approaches can provide to this kind of problems is presently finalized. The different steps described in the framework to fulfil a proper use of the available input data within heuristic and statistical procedures are, then, applied to a well-documented case study in the Campania region (southern Italy). The selected test site is located in the municipality of Nocera Inferiore whose territory was affected, on March 2005, by some landslides among which a debris avalanche caused 3 fatalities. This landslide was triggered on a steep open slope within the Monte Albino massif which is characterised by calcareous-dolomitic stratified and fractured rocks covered by up to 5-6 m thick in-situ and worked pyroclastic recent deposits. This context it is prone to further rainfall-induced flow-like mass movements (hyperconcentrated flows and flowslides) involving the soil covers. On the basis of the proposed framework, new thematic maps and a new landslide inventory map are firstly created (phase I) starting from the controversial evidence reported in four different landslide inventory maps (at scales varying from 1:2500 to 1:5000) available for the area. This task follows a multidisciplinary approach involving expertise in geology, geotechnics, historical data treatment, geomorphics, and geostatistics. The reliable landslide inventory map, produced in this first step of the analysis, is subsequently used (phase II) to analyse the susceptibility of the area (extending for about 200 ha) with reference to both hyperconcentrated flows and debris avalanches. The susceptibility analyses are carried out with the purpose of zoning (phase III) the slope areas prone to i) erosion, which may originate hyperconcentrated flows (along channels) and ii) landsliding (over open slopes). Referring specifically to phase II, all the analyses are preliminary carried out using heuristic procedures followed by, in the case of hyperconcentrated flows, statistical models. In both analyses, the main factors and features predisposing to erosion are the slope angle and the thickness of the soil cover. As for the hyperconcentrated flows, the results of the different methods highlight the potential of an approach which moves from preliminary to intermediate level of susceptibility zoning. In particular, the multivariate analyses offer a significant contribution for reducing the uncertainties related to the final zoning map taking into account appropriate statistical indicators. As for the debris avalanches, the lack of an adequate dataset of historical events did not allow the application of statistically-based methods and, therefore, the susceptibility was only zoned at a preliminary level. The obtained results highlight the potentialities offered by the combined use of different procedures in conceiving a standardised criterion to be adopted in problems dealing with the analysis of susceptibility to rainfall-induced flow-like mass movements. Moreover, they underline the role played by a statistically-based quantitative approach on the reliability of the landslide susceptibility zoning.