Geophysical Research Abstracts
Vol. 12, EGU2010-12274, 2010
EGU General Assembly 2010

GIS-analysis of gully erosion susceptibility: a key study in north-central Sicily, Italy

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Erosion by water is responsible for severe geo-environmental problems in semi-humid to arid Mediterranean areas. Large sectors of Sicily are affected by intense soil erosion phenomena leading to severe damages in agriculture lands that, in some cases, experience high soil loss rates. An important contribution to sediment yield from these areas is given by gully erosion phenomena; the latter, in the last decades, attracted attention of many researches that developed and applied methods to quantify soil loss volumes and to evaluate proneness of territory to this process.

The present research aims to assess gully erosion susceptibility in the basin of the San Giorgio torrent, a mountain stream flowing in north-central Sicily and draining an area of about 9.5 km2; the watershed, which is mainly covered by arable lands, has highly erodible slopes characterized by the outcropping of clays and marls. In order to predict gully erosion susceptibility, a multivariate geostatistical approach is adopted here. In particular, the method is based on the definition of spatial relationships between the geographical variability of a set of controlling factors and the occurrence of gullies on slopes; the linear density of gullies computed on homogeneous domains is selected as the probabilistic function expressing how proneness to gully erosion spatially changes in the studied area.

Available thematic maps, which were integrated by field and remote surveys, and a high quality DEM, were used to derive eight layers of terrain variables, selected according to geomorphological criteria and expressing both soil erodibility (bedrock lithology, land use) and erosivity of flowing waters (slope angle, Stream Power Index, SL-factor, Topographic Wetness Index, plan and profile curvature). All the parameters were computed for homogeneous spatial domains, created by intersecting a grid of 50m square polygons and a layer of slope units automatically derived from DEM; therefore, the eight layers were combined to produce the Unique Condition Units (UCUs) layer used as the basis for evaluating gully density values and erosion susceptibility.

Two time-archives of gully landforms, both permanent and ephemeral, were created by means of remote-analysis of 1:10.000 orthophotos dated at 2000 and 2007, respectively; moreover, those gullies recognized in both time series were field-checked in 2009, in order to attest the reliability of the mapping criteria. The two gully archives were turned into separate GIS-layers; therefore, according to a time-partition validation strategy, the 2000 gully layer was used to train the model and to produce a susceptibility map that was intersected with landforms of 2007, in order to evaluate the predictive power of the method. The validation results attested for a good predictive performance of the susceptibility model since about 50% of the 2007 gullies falls within 20% of the area predicted as most susceptible; moreover, the shapes of the validation curves reflect those characteristics that a good spatial correlation between a model and its unknown target pattern would produce.

In conclusion, the goodness of the acquired results encourages further application of the method, that is simple and easy exportable to other similar areas for the evaluation of gully erosion susceptibility.