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Shallow-landslides hazard assessment by means of fully-coupled models

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According to the Piedmont Region (NW Italy) laws on urban planning and land management, urban-plans approval by regional authorities requires the assessment of natural risk levels. Piedmont Region urban-planning directive provides guide lines for conducting the evaluation of risk and the risk classification criteria. The directive also requires the production of thematic maps related to different environmental aspects: geology, geomorphology, hydrogeology, hydrology and land use. A final hazard map is obtained from the combination of these themes.

The present study introduces a new holistic method for calculating shallow-landslide susceptibility-levels by using data produced during natural risk assessment at local scale. Susceptibility levels are given as a weighted sum of the thematic maps following the Systems Theory and the fully coupled model (FCM) (Jiao and Hudson, 1995). A Binary Interaction Matrix (BIM) is generated to assess the direct influence of each factor controlling of shallow landslides occurrence (i.e. slope angle and water infiltration: the steeper the slope the lower the infiltration rate). Controlling factors are placed in the leading diagonal boxes of the matrix (from the top left corner to the bottom right corner). The relationships are uncoupled, meaning that each factor does not influence itself. Once all these binary relationships are defined, the influence of each factor on itself ("loop") is assessed by means of the Jordan recursion algorithm and the resulting model is therefore converted to fully-coupled one. As an example of loop the feedback of cohesion influence on itself is considered: (1) soil cohesion controls roots growth; (2) vegetation influences the amount of water infiltrating from the surface; (3) infiltration rate controls the water table; (4) - *loop to point 1* - water pore pressure affects the bounds between soil grains. The Binary Interaction Matrix is converted into a Global Interaction Matrix (GIM) which provides the final factors weights.

Input data are in from of thematic maps acquired according to the Piedmont Region urban-planning directive, each map representing a factor involved in the process leading to shallow landslides occurrence. Controlling factors are divided into different classes (land cover, soil thickness etc.). Each class is given values between 0 and 1 (0: low influence on landslides occurrence; 1: high influence on landslides occurrence). Maps are converted into raster format and then shallow landslide susceptibility is obtained as the weighted sum of these raster maps. Susceptibility index values range between 0 and 1 (1: high susceptibility; 0: stable areas)

This methodology was applied in order to assess the shallow-landslide susceptibility for the territories of the municipalities of Vaie, Bruzolo (Susa Valley – W of Turin – Piedmont) and Forno Canavese (NW of Turin – Piedmont). The latter was strongly affected by the 5^{th}-6^{th} of November 1994 and 13^{th}-15^{th} November 2000 floods, when more than 100 shallow landslides were recorded over an area of 16 km^2.

Results are consistent with field observations and shallow-landslide susceptibility calculated by means of different techniques.

Jiao, Y. and Hudson, J.A., 1995. The Fully Coupled Model for rock engineering systems. Rock Mech. & Geomech. Abstr., 32: 491-512.