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GHZ-06 Landslide risks in fluvial systems

Deterministic analysis of slope stability in the Serra do Mar (Paraná, southern Brazil)

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In this work we analyse the influence of geological, geomorphological and land cover factors on slope stability within a watershed of the Serra do Mar area (Paraná, southern Brazil). The Serra do Mar is characterized by dense forest cover (the so called "Mata Atlantica"), high relief energy and intense morphodynamic processes like soil erosion and landslides. Landsliding processes are particularly important, as suggested in the literature by the occurrence of catastrophic landslides which caused loss of lives, despite of the relatively low population density. Landslides develop either in areas covered by forest or in areas with scarce vegetation cover, especially after intense rain events. In order to assess the susceptibility to landsliding of the Serra do Mar slopes, we performed a deterministic analysis based on the evaluation of the factor of safety obtained applying the limit equilibrium approach.
We implemented an analytical model based on the equilibrium of forces acting on a slope of infinite length, where the variables are physical and mechanical properties of soils (specific weight, cohesion, friction angle), pore-water pressure and effects of vegetation cover. We built an inventory of landslides occurring within the study area by integrating photointerpretation and fieldwork. We recognised many earth and debris flows phenomena located in steep forest areas where no or negligible human actions occur. Hence, we also introduced within the algorithm for factor of safety calculation, the effects of wind as a force acting downward, parallel to the slope plunge, the weight of trees and force and cohesion due to root reinforcement and root-soil matrix interactions. Friction angle, cohesion and specific weight of soils were obtained by means of laboratory tests performed on undisturbed soil samples. We implemented the analytical model in GIS environment: physical and mechanical soil properties, pore-water pressure, vegetation parameters, were associated to soil, geomorphology and vegetation geographic databases. Finally, we obtained the slope steepness database by processing a digital elevation model based on the Brazil official topographic maps at the scale of 1:25,000. As a result of the calculation of the analytical model implementing the above parameters, we obtained the spatial distribution of the safety factor both for dry conditions and fully saturated soil (i.e. after extreme rainfall). We also performed a sensitivity analysis to assess ranges of values that friction angle and pore-water pressure can reasonably assume when limit equilibrium conditions (landsliding conditions) occur. The spatial representation of landslide susceptibility within the study area, here represented by values of the factor of safety, could be used as a tool for territorial planning, in order to mitigate landsliding risk through the implementation of directing rules both for land occupation and use.

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