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GIS-based 3D spatial-temporal assessment of landslide hazard

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A desirable landslide hazard assessment should give answers to three key questions: the magnitude, the location, and the occurrence time of failure(s). It is thus necessary to evaluate the effects of both the static variables (such as geological and geotechnical properties that contribute to landslide susceptibility) and the dynamic variables (such as rainfall and earthquake that tend to trigger landslides in an area of given susceptibility) on slope stability at the same time. With the fast development in earth observation science and geotechnology, there are more and more techniques available for acquiring data of both static and dynamic variables, and for carrying out a more reliable analysis to explain the triggering mechanism of landslide. Taking advantage of these techniques can result in an efficient and advanced spatial-temporal assessment of landslide hazard. It means that all the necessary data, including geological and geomorphological data and real-time monitoring data on rainfall or earthquake, should be acquired and integrated into a database, and being quickly analyzed at any time by an advanced method which developed by, for example, coupling geotechnical and hydrological models, to evaluate what will happen in certain situations. To achieve this task, a uniform platform is also needed to integrate various types of data and models into a standardized form for efficient treatment and easy implementation.

Based on the above consideration, a GIS-based three-dimensional spatial-temporal assessment methodology is proposed. In this methodology, a GIS raster-based framework is delivered to achieve 3D slope stability analysis; a Monte Carlo technique is used to locate the potential slip surfaces by means of minimizing the 3D safety factor through an iterative procedure, based on a simulation of ellipsoid for the 3D shape of slip surfaces; a GIS-based model is developed by coupling a dynamic rainfall-infiltration model with a GIS-based 3D model to quantify the varying safety factors during rainfall infiltration. All proposed methods are applied by developing a GIS-based comprehensive system. Using this system, the location and the magnitude of potential failures can be identified through the random searching procedure; the time of occurrence of failures can be forecasted by mapping the changing distribution of safety factors during rainfall event. The effectiveness of the method and the practicality of the developed system have been verified by several case studies and practical applications.

This paper will firstly review the newly advanced researches and techniques relating to rainfall-induced landslide hazard assessment, then detail the proposed method, to [U+3000] show how the GIS technique can be applied in a complex landslide hazard assessment to enhance data treatment and models coupling.