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Landslide Susceptibility Mapping Using a Fuzzy Approach

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Abstract

The present paper proposes a new methodology to characterize the landslide susceptibility of Reggio Calabria territory. The values obtained were classified into five categories and exported into GIS environment to produce a landslide susceptibility map. The principal objective of the proposed study is to identify the sections of the road network exposed to landslide hazards starting from the susceptibility map. To this aim, a fuzzy system was implemented for the assessment of the landslides susceptibility of the considered transport network.

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1. Introduction

Despite tremendous progress in science and technology, natural hazard considerably affects the socio-economic conditions of all regions of the globe. Natural hazards as earthquakes, landslides and floods represent the most common hydrogeological instability realizations.

Landslide susceptibility assessment can be tricky because of the difficult evaluation of both the spatial and temporal distribution of past events for large areas mainly due to limitations and gaps of historical records and geographic information. For these reasons, the Geographic Information Systems (GIS), which allow to analyze and manage a considerable amount of information, have been more often used to evaluate the landslide susceptibility [1].

The main objectives of the present work can be synthesized as follows:

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1. to create a landslide susceptibility map for the province of Reggio Calabria using the GIS software by means of the weighted combination of various factors such as the slope, the lithology, the elevation, the rainfall and the land use;
2. the determinations of the network infrastructures to mainly pay attention to, by applying the fuzzy logic rules “if-then” to the previously obtained landslide susceptibility map.

2. Methodology

2.1. Case study

The considered study area is the territory of the Province of Reggio Calabria (Italy) that with 97 cities and towns and with a total population of 550000 inhabitants is the Province of Calabria with the highest population density.

Almost all the territory of Calabria is subject to phenomena of hydrogeological and seismic risk. The province has a territorial extension of 3183 km², of these 1685 km² (52.95%) are represented by hilly terrain, 1.275 km² (40.07%) are mountainous and the remaining 223 km² (6.97%) are represented by land lowland.

The territory of Calabria is geologically young, and often subject to natural modifications. The hydro-geological disaster (landslides, floods) is one of the risk factors to which Calabria is exposed. This is due, among other conditions, from the physical conformation of the region, and the climatic conditions.

The landslide susceptibility zoning is based on data furnished by the Hydrogeological Layout Plan (Piano di Assetto Idrogeologico, PAI), containing the landslides occurred in the past together with an assessment of the areas with a potential to experience land-sliding in the future, but with no assessment of the landslides occurrence frequency (annual probability).

The objective of the present work is to create a landslide susceptibility map for the province of Reggio Calabria by means of the weighted combination of various indices.

The calculated indices are referred to factors such as the slope, the lithology, and the land use, evaluated by means of GIS devices (Fig.1); the landslide susceptibility values obtained have been divided into five classes: very low, low, moderate, high, very high. The network infrastructures resulting particularly relevant during emergency and which need plans aiming at reducing the landslide risk have been highlighted by means of the superposition of the main network infrastructures on the obtained landslide susceptibility map and the use of the fuzzy-logic rules “if-then”[2].

2.2. Landslide susceptibility zoning map

The landslide susceptibility assessment can be tricky because it is very difficult to evaluate both the spatial and temporal distribution of past events for large areas mainly due to limitations and gaps of both historical records and geographic information. Landslide susceptibility assessment can be considered as the initial step towards a landslide hazard and risk assessment.

In the proposed study, areas with different classes of landslide susceptibility are marked with different colours (from green, which indicates very low susceptibility, to red, standing for very high susceptibility).

2.3. Data description and indices determination

To produce the landslide susceptibility map, a total of 5 inputs were selected for the model, considering the main characteristics of the landslides: the slope, the lithology, the elevation, the rainfall and the land use.

Each factor has been characterized into classes whose weight has been determined based on the relevance resulting from the analysis of the landslide areas map identified by the PAI. The analysis has been carried out by means of GIS devices which allow to analyze easily a considerable amount of data and to convert the map pixels into data sets.

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