



VI ITALIAN CONFERENCE OF RESEARCHERS IN GEOTECHNICAL ENGINEERING –
Geotechnical Engineering in Multidisciplinary Research: from Microscale to Regional Scale,
CNRIG2016

A map for the choice of landslide risk mitigation countermeasures

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Abstract

The present paper proposes an automatic procedure in GIS providing maps which suggest the more appropriate and feasible intervention type to mitigate landslide risk. These maps are not intended for replacing the designer engineering judgment, nor his work, but to help him in the choice and to help the territorial protection agencies in planning interventions and allocating funds.

In order to make available these results to technical staff of public administrations, designers and insurance companies, operating in landslide risk management, the maps referred to Genoa have been published, as an example, on a webGIS site.

In the paper, the proposed methodology is described and validation cases are reported.

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Peer-review under the responsibility of the organizing and scientific committees of CNRIG2016

Keywords: landslide; risk mitigation; regional scale

1. Introduction

Landslides are extremely widespread throughout Italy, occurring very frequently causing deaths and damage to urban areas, infrastructures, environmental and historical heritages.

This work was inspired by the need to have available instruments for landslide risk management and mitigation.

An automatic procedure has been proposed to provide maps of the interventions to be recommended for slope stabilization and reinforcement. It is believed that a tool capable of analyzing large territorial extensions quickly and with relatively limited resources can be of great help in the increasingly complex management of the territory.

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The procedure correlates factors influencing the occurrence of landslides with different types of intervention and suggests the countermeasures that are best suited to the mitigation of landslide risk.

This work starts from a previous research aimed at zoning landslide susceptibility. In order to develop the landslide susceptibility assessment on wide areas, the authors have proposed a multivariate statistical analysis, paying particular attention to the choice of factors which influence landslide occurrence and triggering [1]. Geomorphologic, geological, climatic and anthropic factors were taken into account. The study also proved that infrastructures as roads and railways influence landslide occurrence; their preservation plays an important role in the economic choices of the territorial authorities.

The implemented automatic GIS procedure integrates spatial variables, provides a map for each influence factor, applies a logistic multiple regression and computes the landslide susceptibility on every pixel of the study area. The produced susceptibility map highlights the zones needing possible countermeasures and their priority. Besides, the knowledge of the influence factors can provide useful design suggestions for the choice of suitable types of interventions.

Consequently, the relation between such factors and the main types of countermeasures was established, producing maps suggesting the more appropriate and feasible intervention type to mitigate landslide risk.

These maps are not intended for replacing the designer engineering judgment, nor his work, but to help him in the choice and the territorial protection agencies in planning interventions and allocating funds.

In the following sections, a brief description of the already mentioned landslide susceptibility procedure is reported in order to better explain the methodology proposed in the present paper.

2. Assessment of landslide susceptibility

Within a National Research Program "Landslide risk mitigation through sustainable countermeasures" (Year 2010-2011 - prot. 2010SWTCKC) the authors have developed an automatic procedure in GIS for the production of susceptibility maps, suited to analyze large territorial areas quickly and with relatively limited resources [1].

The multivariate statistical analysis was considered the most appropriate approach to analyze the landslide occurrence, rarely triggered by a single factor but more often originated from a combination of factors intimately connected.

Geographical, geological, climatic and human factors were considered, focusing on aggression climate and proximity to infrastructures, such as roads and railways, since their realization and presence has a substantial effect on the occurrence of slope instability and because their conservation plays an important role in economic decisions of authorities appointed for territorial planning.

The factors taken into account, whose role in the landslides triggering has been duly investigated are: lithology, slope, aspect, elevation, water accumulation, land use, distance from roads and railways, climatic aggression.

The most important features of the procedure are the total automation, and the fact that it can be immediately applied to any area.

The free and open source software GRASS GIS [2] has been used both for its high processing capacity, both for the possibility to realize automatic procedures *ad hoc* for the specific problem, and for scientific and ethical implications as well.

3. Planning Landslide risk mitigation through sustainable countermeasures

As a natural continuation of the above mentioned procedure, the authors developed an automatic GIS procedure for the creation of maps that, on the basis of predisposing factors and the characteristics of the territory, suggest what may be the most appropriate interventions for the mitigation of landslide risk.

The innovative procedure that has been developed allows one to obtain a medium to small-scale map which suggests appropriate interventions on the slopes.

The six categories of countermeasures identified to create the map are:

- Re-profiling
- Drainage

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