



Application of analytic hierarchy process, frequency ratio, and statistical index to landslide susceptibility: an approach to endangered cultural heritage

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Abstract

This paper presents the applicability of the analytic hierarchy process, frequency ratio, and statistical index in landslide susceptibility mapping for an area from north-eastern Romania. The dependent factor (in this case the landslides) was determined by combining seven conditioning factors: elevation, slope angle, curvature, normalised difference vegetation index, roughness, distance to rivers, and landforms. A landslide inventory was prepared using topographic plans and orthophotos and by carrying out field surveys with the total station (Leica TCR1201) and geodetic GPS (Leica System 1200) in RTK mode. The final susceptibility maps were made with the help of GIS and validated by carrying out the receiver operating characteristics (ROC) curves. ROC plots for training data have shown that the susceptibility map generated using the analytic hierarchy process with AUC value of 79.46 has a better prediction accuracy compared with frequency ratio method (AUC = 75.24), and statistical index method, which had an AUC value of 61.46. The prediction rate of the three models is over 50% (79.64% for the analytic hierarchy process model, 75.65% for the frequency ratio model, and 66.36% for the statistical index model). More than a half of the cultural heritage sites are located in areas with a very high and high vulnerability to landslides. Taking into consideration that multi-stratified settlements are located in areas with low and medium landslide susceptibility, this fact can indicate a possible awareness of prehistoric people from natural hazards. The final susceptibility maps can be used for land use planning, risk reduction, hazard mitigation, to evaluate the present state of cultural heritage sites in danger and to predict which of the sites will be in more danger in the future.

Keywords Landslide susceptibility · Analytic hierarchy process · Frequency ratio · Statistical index · Cultural heritage · Romania

Introduction

Worldwide, landslides have a devastating effect on the environment causing economic damage and significant changes in the local topography, among other issues; landslides are being acknowledged as one of the most catastrophic natural hazards that are causing human losses and billions of dollars in damage (Guerra et al. 2017). The landslide susceptibility

is defined as the likelihood of a landslide to occur in a certain area, taking into account the local environmental factors (Guzzetti et al. 2016). Over the last years, statistical modelling has become a powerful instrument in order to evaluate and analyse the environmental factors that led to landslide triggering. In this study, credit is given to analytic hierarchy process, frequency ratio, and statistical index.

Analytic hierarchy process represents a qualitative method based on an individual or a group of experts; it is established taking into account the landslide inventory; the expert identifies landslides (based on satellite imagery, old records, field surveys, etc.), the main conditioning factors (extracted from the available spatial data), and evaluates locations that have similar environmental characteristics. It is widely used in the decision-making process and is being applied to a large spectrum of branches belonging to geosciences, such as space planning (Palmisano et al. 2016),

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