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Case study

Frequency ratio and GIS-based evaluation of landslide susceptibility applied to cultural heritage assessment

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ABSTRACT

This study aims to produce landslide susceptibility maps using frequency ratio (FR) model with the help of GIS to be used in cultural heritage (CH) mitigation and assessment for a catchment from northeastern Romania. In total, seven conditioning factors were used to assess the landslide susceptibility index (LSI): elevation, slope angle, curvature, normalised difference vegetation index (NDVI), roughness, distance to rivers and landforms. The landslide susceptibility maps were prepared with the help of GIS software and classified into four susceptibility areas: low, medium, high, and very high. The more conditioning factors were added to the susceptibility, the better validation results were obtained (from an AUC = 0.51 corresponding for five factors, to an AUC = 0.75 for the seven factors). The model validation has shown that the maps made using FR model has a success rate of 75.24%. The landslide susceptibility maps have a high accuracy and will be helpful not only for CH protection and preservation, also for land-use planning, hazard mitigation, and risk reduction. Out of the 47 CH sites, more than a half are located in areas with high and very high susceptibility to landslides.

1. Research aims

The present work aims to report the results obtained with the help of statistical methods applied to landslide susceptibility in a catchment from northeastern Romania. This approach is useful and needed due to the increased intensity of natural hazards (e.g. landslides) throughout the world, in order to assess and mitigate the degradation of CH. There is a lack of studies that apply statistical modelling to assess landslide susceptibility on CH sites; this study comes to fill that gap. The results will be used to evaluate the present state of CH sites, disaster risk reduction, and as a powerful tool for local authorities and stakeholders to plan future mitigation measures.

2. Introduction

Natural hazards represent severe and extreme weather and climate event that occur naturally in all parts of the world; one of the main triggering factors is the global climatic changes that are exponentially increasing every year [1]. Besides the great economic damages, they are also affecting CH sites. At an international level, there are studies referring to certain natural hazards with direct effects on CH, including earthquakes [2], floods [3], gully erosion [4], and coastal erosion [5]. Landslides are one of the most critical environmental hazards of modern times. The last decades have demonstrated that the meteorological and hydrological risk processes have accentuated. The landslide susceptibility can be defined as the likelihood of a landslide to occur in a certain area, taking into account the local environmental factors [6], also known as conditioning factors. Over the last years, there has been an upward trend at the international level to apply statistical modelling to assess landslide susceptibility: bivariate and multivariate statistical approaches [7], binary logistic regression and stochastic gradient tree boost [8], GIS-based exposure analysis [9], CHAID and AHP [10], etc. The same methods were also applied in Romania [11–13], but none is applied in the field of cultural heritage. Tangential mentions are those regarding the monitoring [14], temporal analysis

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[15], and conservation strategies [16–18]. As a consequence of that, this study comes to fill the gap and be a starting point in studies regarding the landslide susceptibility models being applied in the field of CH. The protection and conservation of CH have become one of the most important desiderata of the modern world. CH is an expression of the way in which a community developed and lived, passed on to future generations, including customs, practices, places, objects, artistic expressions, and values [19]. Studies regarding the assessment of hazard and risks are a desideratum of the modern world, in order to provide stakeholders suitable tools to safeguard CH.

Valea Oii river basin (northeastern Romania, Iasi County, Fig. 1a) has been chosen as a study area, due to the availability of spatial data, repetitive field studies and field surveys. From a geological perspective, the Bassarabian deposits of Sarmatian age dominate the basin; Pleistocene terrace deposits are located in the lower half of the basin [20]. The area is highly susceptible to soil erosion processes [21,22] and vulnerable to the natural and anthropogenic pressure [23]. The method chosen to assess the landslide susceptibilities is frequency ratio (FR). The performance of the landslide susceptibility index is assessed using statistical modelling and validation dataset of known landslide locations – landslide

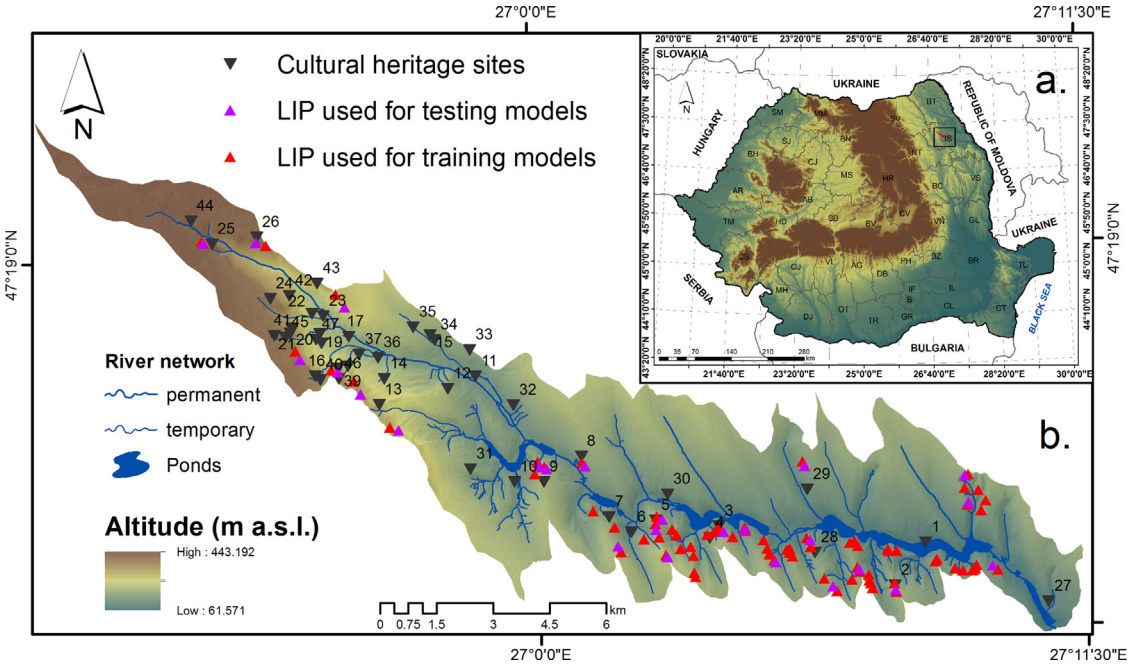

Fig. 1. a: geographical location of the study area in Romania; b: location of the cultural heritage (CH) sites and of the landslide identification point (LIP) used for testing and training.

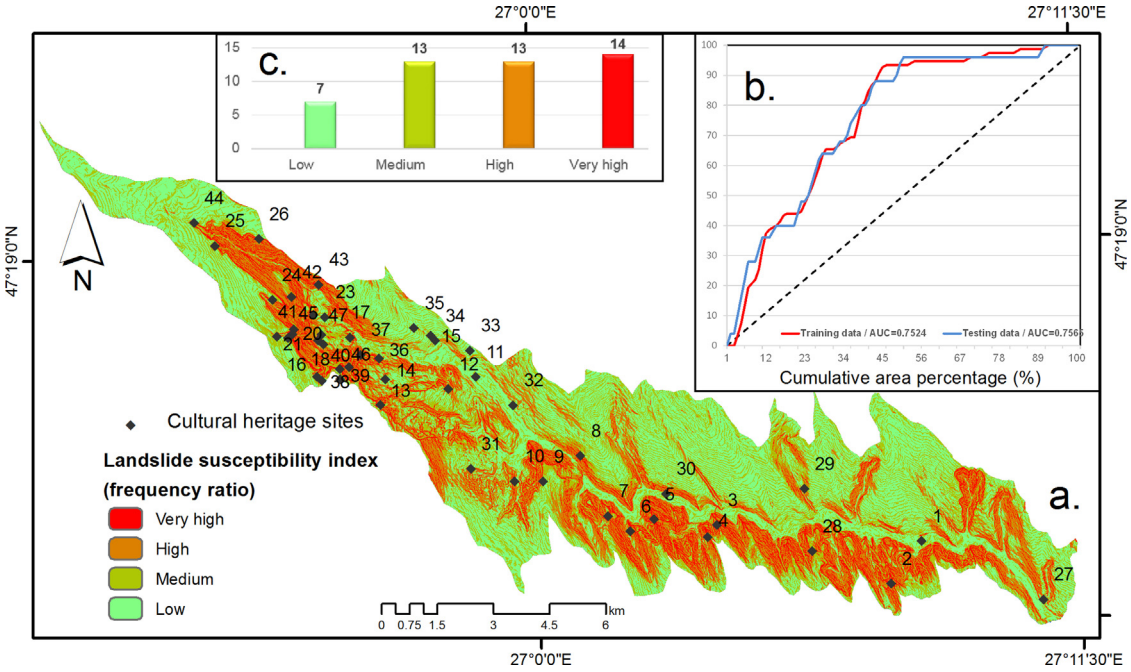

Fig. 2. a: landslide susceptibility map produced using frequency ratio (FR); b: plot of the prediction rate of FR landslide susceptibility map; c: distribution of cultural heritage (CH) sites on landslide susceptibility classes.

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