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Use of GIS and Remote Sensing for Landslide Susceptibility Mapping

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INTRODUCTION

In recent years, geographical information systems (GISs) and Remote Sensing (RS) have proven to be common tools adopted for various studies in different scientific disciplines. GIS provides as a set of tools for the input, storage, retrieval, manipulation, management, modeling, analysis and output of spatial data. RS, on the other hand, offers earth observation data for thematic maps related to spatial studies. The use of GIS and RS data for landslide susceptibility mapping are demonstrated by three different landslide susceptibility maps with five different variables (Normalized Difference Vegetation Index (NDVI), Topographic Wetness Index (TWI), slope; lineament density and distance to roads). The comparison of the generated final susceptibility maps with historical landslide locations is given with important factors affecting the accuracy of susceptibility map. The accuracy analysis of the final susceptibility maps for various weighting strategies is performed. The results indicate that assignment of weights to the slope parameter impacts the accuracy in the high susceptible zones.

BACKGROUND

Landslides are among the most common natural hazards and are the most damaging, leading to substantial economic, human, and environmental losses throughout the world. The quantitative assessment of landslide hazards for a large area is critical for mitigation of the associated risks. They are often triggered by natural phenomena and/or human activity, such as earthquakes, precipitation, erosion, deforestation etc. and are difficult to predict. One of the greatest limiting factors in predicting and mapping landslide activity is the lack of understanding of scale-dependent processes, such as erosion, weathering, and fracturing (Glenn et al., 2006). Such maps normally aim at providing a document that depicts the likelihood or possibility of new movements occurring in an area, and therefore helping to reduce future damages. To express the potential for occurrence of landslides in a quantitative manner, maps must incorporate the concept of probability, which is an assessment of the relative frequency of occurrence (Ohlmacher & Davis, 2003). Susceptibility expresses the likelihood that a landslide will occur in an area on the basis of the local terrain conditions (Soeters & Van Westen, 1996); return period or annual probability of occurrence is not considered. The main difference between susceptibility and hazard is therefore that the latter considers the temporal factor, by estimating the probability of occurrence of the phenomenon within a specified period of time (Varnes, 1984) whereas the former considers the likelihood of landslide occurrence. There are many studies in the literature about use

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of GIS to evaluate landslide susceptibility (e.g. Gokceoglu et al. 2005; Akgun et al. 2011; Akgun 2012; Pradhan et al. 2013; Kavzoglu et al. 2013)

MAIN FOCUS

The purpose of this study is to apply the grid based GIS techniques for landslide susceptibility mapping using five different factors including Normalized Difference Vegetation Index (NDVI), Topographic Wetness Index (TWI), slope, lineament density, and distance to roads. The scope includes the preparation of landslide susceptibility map to identify highly susceptible areas and, the accuracy assessment related to the obtained maps.

The susceptibility assessment methodology is demonstrated for More and Romsdal region in Norway (Erener & Duzgun, 2010). The study area occupies approximately 606.755 km^2 in the west part of Norway. The upper left coordinates on 112707,770408 m - 6952112,603469 m and lower right coordinates 6929466,479194 m -144909,272731 m respectively (Figure 1).

Method of Study

An empirical approach is used to map and evaluate landslide susceptibility. In this approach a grid based GIS is adopted to construct a landslide susceptibility map. Five layers of data with 30 × 30 m resolution grid were superimposed to create the landslide susceptibility map. Slope is given the most emphasis, followed by, TWI, NDVI, lineament density and distance to roads. A numerical rating system is applied and each of the five factors is grouped into three categories, and each category is assigned a value between 1 and 3, with 1 being least susceptible and 3 most susceptible to landslides. Based on their relative importance to slope instability in the study area, the five factors are assigned weights between 0.0 and 1.0 (collectively adding to 1.0). A raster-based GIS is used to overlay the five layers with 30 × 30 m resolution and calculate a Landslide Susceptibility Index (LSI) for each individual cell. The final map shows areas of low, medium, and high landslide susceptibility. The method of the study is shown in Figure 2.

Scale and properties of the data used in the study for susceptibility mapping is given in Table 1. Before beginning the processes, the water areas are masked from the layers. Vector based 50 meters contour interval topographic maps, provided from the Geological Survey of Norway (NGU), are the main data used in the study (Figure 3a). DEM data are generated from maps with a cell size of 30 m using triangular irregular network. The

Figure 1. Study region (parts of figure adopted from NGI)