Landslide Hazard Mapping Using Dempster-Shafer Theory- A Case Study: Ziarat Watershed, Golestan Province, Iran

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Extended Abstract

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Introduction

Landslides are natural events that one or more factors can effect in its occurrence that each of them plays a special role in this field. The hazard assessments of this phenomenon are a complicated problem due to the interference of the effective factors in its occurrence. The uncertainty that is due to ambiguous conditions of geology characteristics, hydrology, tectonics, land cover, rain, erosion, temperature fluctuations in the slope instability demonstrate the benefit of accurate methods in the study of slope instability. Since the prediction of the landslide occurrence is out of the power of current knowledge, identifying sensitive areas to landslide and ranking it can protect us from landslide dangers. According to preliminary estimates, annually 140 million dollar financial damages inflict by landslides over the country, while the loss of unrecoverable natural resources is not counted. In general, the ultimate goal of studying landslides can be found the ways that to reduce damages caused by them. Therefore, it is necessary to prepare the landslide hazard map.

The main goal of this research is landslide hazard zonation of Ziarat watershed using Dempster-Shafer. For this purpose, 13 modeling approach (using all factors and eliminating of individual factors) to prepare the hazard maps have used. Ultimately, the accuracy of the model has been evaluated

using receiver operating characteristic (ROC) curves. The study area is one of the most prone areas to the landslide in the Golestan region. Sensitive lithology units, high diversity of topography and land-use changes have increased landslide susceptibility in this area. Therefore, investigation of effective factors in landslide occurrence and providing zonation maps to take management action in this area is necessary.

Material and methods

The study area is located in northern Iran, Golestan province. The Ziyarat watershed with an area of about 7800 hectares lies between longitudes 54º 10′ 13″E and 54º 23′ 55″E, and latitudes of 36º 36′ 58″N and 36º 46′ 11″N. At first, extensive field observations of the study area and aerial photos in 1:25000 scales have been used. So, a total of 50 sliding points are recognized and inventory map is produced (dependent variables). Then, 70% of total points (35 points) have considered for hazard zonation maps and 30% (15 points) for model validation.

In this research, twelve factors affecting (independent variables) landslide occurrence to provide hazard maps were applied. These factors include land-use, soil texture, geology, rainfall, slope, aspect, altitude, distance from faults, roads and rivers, stream power index (SPI) and plan curvature (CP). These factors can be divided into three broad categories which are topographical, geological and environmental conditioning parameters. The maps of these 12 factors have been produced using basis maps (DEM and Geology maps) in GIS software. The amount of Landslide density in each factor class have calculated from a combination of independent and dependent variables, and rating of classes have done based on Dempster-Shafer equations. Finally, the Landslide hazard zoning map has drawn from the summation of weighting maps in Arc GIS with 13 approaches. In this map, Value of each pixel is calculated by summing weight of all factors in that pixel. The pixel values are categorized based on natural breaks classifier into very low, low, medium, high and very high hazard zones. Then, an accuracy of zoning map has been evaluated by ROC.

Results and discussion

The result of effecting factors on landslide classification shows that Mobarak formation, forest and agriculture land use, areas with low distance

from road and rivers, low altitudes, rainfall buffer of 550-650 mm, northwest aspect, clay-loam soil texture, areas with high stream power index, high slope amplitude and area with fault density lower than 2 km/km2 contain the most susceptibility to landslide. The result of model validation using ROC demonstrates that with eliminating lithology factor Dempster-Shafer model with 92.9% accuracy is located in the great class. Also, the model accuracy shows that with eliminating rain and altitude factors the model accuracy is decreased to 73.8% and 80.4%, respectively. So, these two factors were identified as the most effective factors in the occurrence of the landslide in the studied area. Based on the landslide zoning hazard map of the Ziarat watershed and landslide points (15 points) that are considered for model validation the 20, 40, 26.67, 13.33 and zero percent of landslides is situated in the very high, high, moderate, low and very low hazard classes.

Conclusion

In this research, susceptible areas to landslide in the Ziarat watershed have been mapped with the Dempster-Shafer model. For this purpose, 13 modeling approach to prepare the hazard maps have been used. The following conclusions are obtained from this study.

- The rain and altitude factors were identified as the most effective factors in the occurrence of landslide in the Ziarat watershed.
- Based on the landslide zoning hazard map of the Ziarat watershed 60 percent of landslides is situated in the very high to high hazard classes.
- The produced landslide hazard map is useful for planners and engineers to reorganize the areas which are susceptible for landslide hazard, and offer appropriate methods for hazard reduction and management.

Keywords: Landslide Hazard, Dempster-Shafer model, Ziarat, Golestan

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