Research Paper

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Landslide Hazard Zoning in the Yellow River Basin Using Fuzzy Logic

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1-Introduction

It is believed that selecting the route for the construction of highways, freeways and subways, choosing the location of earth dams, concrete as well as gutters and canals, the construction of traffic tunnels and plans such as development of natural forests and rangelands and any mineral development are among the most sensitive and most important issues in major construction projects that depend on the study of the stability of the region's natural slopes. Failure to pay attention to this issue can cause irreparable damage. Urban areas design is highly risky due to population densities and the construction of industrial workshops and factories and development projects and paying attention to this issue is of particular importance. Landslides in fast clays and saturated soft sand and silt can also have very serious consequences; therefore, ruptures in these soils occur very quickly without warning. Therefore, due to this large volume of casualties, financial and economic damages, the study of this important geological phenomenon to consider the necessary measures to reduce the risks and damages caused by it is essential.

2-Methodology

The Yellow River Basin in southwestern Iran is located in the Zagros Mountains between 49 degrees and 25 minutes to 50 degrees and 5 minutes' east longitude and 31 degrees and 23 minutes to 31 degrees and 42 minutes' north latitude.

2-1- Data sources and tools

A) Physical tools: Geological map 1: 100000, Topographic map 1: 50000, Digital elevation model 30 m, Meteorological Organization precipitation data.

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B) Conceptual tools: Shapes and geomorphological parameters were measured based on field studies and G.I.S software. Google Earth software has also been used to study the landslide geomorphology hazard in the study area.

2-2- Fuzzy logic

A) The fuzzy collections

The fuzzy method evaluates the probability of a pixel joining fuzzy sets with respect to the fuzzy membership function. Fuzzy sets have no definite boundaries and membership of a place in a particular set is gradual Equation (1), (Gay, 1991).

B) Evaluation of statistical methods

Equation (1) QS = $QS = \sum_{i=1}^{n}(Dr-1)^2 * S$

3- Results and Discussion

In order to investigate the relationship between factors affecting landslide occurrence in the study area after mapping landslide dispersion, the distribution of these points to nine factors affecting landslide occurrence has been studied. Each of the information layers (elevation, slope, slope direction, fault distance, river distance, road distance, precipitation, lithology, and land use) was classified into 5 classes. Moreover, based on the degree of susceptibility to the earthquake, each of the classes was assigned a rating of 1 to 5, with a rating of 5 being assigned to the class that was most sensitive to the earthquake. In order to determine the relationship between landslides and the factors affecting its occurrence, the map of landslide hazard zoning map was integrated with the landslide distribution map.

3-1- Fuzzy layers

After classifying the layers, they were fuzzed in the next step. To fuzz these maps from the fuzzy membership menu, we selected the Spatial Analyst and because we used distance variations to find landslide-prone zones, the membership function type was selected as linear. The resulting layers are layers that convert input values to values between zero and one. Therefore, those areas with a membership degree of 1 or nearer are more valuable than values with a membership of zero or near zero. For all available layers, the afore-mentioned procedure was performed.

3-2- Zoning map

To modify the very high sensitivity of the fuzzy multiplier operator and the very low sensitivity of the fuzzy multiplier operator, another operator is introduced called fuzzy gamma, which is the fuzzy multiplication interval between the multiplication and the algebraic sum. The fuzzy gamma operator is a general case of multipliers and addition,

and by choosing the right gamma value, it can integrate both the decreasing and incremental parameters simultaneously, resulting in output values that result from the flexible adaptation between the incremental and descending tendencies of the multiplicative and multiplicative operators that can be a fuzzy addition.

3-3- Assessment of zoning method

In this study, landslide hazard maps with fuzzy gamma operator have been calculated with values of 0.7, 0.8, 0.9. Finally, the best gamma among different gamma must be selected to evaluate the mass movement-zoning map. According to the results of evaluation of these maps using qualitative index method, hazard map with 0.9 gamma, which has higher index of qualitative index (0.552), has the highest accuracy in the study area.

4- Conclusions

The zoning was performed using fuzzy 0.7, 0.8, 0.9 gamma operators. In order to select the most suitable zoning, the qualitative summation method (Qs) was used, which finally identified a 0.9 phase fuzzy gamma with the highest Qs (0.529) for desirable basin with more accuracy and desirability than the 0.7 and 0.8 fuzzy operator for landslide hazard zonation. Its zoning map was selected as a landslide hazard-zoning map in the study area in five very high, high, medium, low and very low risk classes. The results showed that 21.56% of the area was in high-risk zone and 43.24% of the area was in low-risk zone.

Keywords: Landslide zoning, Fuzzy logic, Qualitative summation, Yellow River, Khuzestan.