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Fuzzy logic model in landslide hazard zonation based on expert judgment

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ABSTRACT

In this research landslide, hazard zonation provided based on fuzzy logic method and investigating of this model is efficiency. In the first provided the geology of slope and aspect maps by using aerial photos topography maps and field operations in watershed management of Karaj. Then, these maps classes of priority and coming next determine based on existing landslides area in the geology, slope and aspect of maps in GIS software. In the geology map of Karaj formation (contain shale, tuff, marl, sandstone and conglomerate) and Tizkuh formation (contain limestone) and in the slope map of percent $25 \leq S < 45$ and $0 \leq S < 15$ classes and in the aspect map south and east classes sequential have most and least landslide area. Then, in final drawer to dimension centimeters 2 in region watershed of map and we counted from 0 until 153 based on geology, slope and aspect. Then (y) units settled sequential, numbers 0 to 27 in very low sensitivity class (one class), numbers 28 to 66 in low sensitivity class (two class), numbers 67 to 89 in middle sensitivity class (three class), numbers 90 to 126 in high sensitivity class (four class) and numbers 127 to 153 in very high sensitivity class (class five). Based on these classes, provided the landslide hazard zonation founded on fuzzy logic method. Comparison fuzzy map and surface distribution landslide showed about percent 2.19 (140.53 hectare), percent 5.08 (325.98 hectare), percent 18.79 (1205.75 hectare), percent 43.38 (2783.70 hectare) and percent 30.56 (1961.04 hectare) sequential settled in one, two, three, four and five classes which are acceptable results to recommend it to prevention of the probable risks and damages is suggested, innovation and spreading of road construction in area is on basic of limitations of the landslide risk breadth plan.

Key words: Fuzzy logic method, Landslide, Landslide Hazard Zonation, watershed management, Karaj, Iran

INTRODUCTION

The landslide is a phenomenon that depends on the different factors such as slope, geology, rain, vegetable cover. Earthquake and such as earthquake and perhaps in some countries of the world is considerable more than earthquake phenomenon because of bodily and financial great damage that in cities include of water transfer and electricity a gas and telephone and destroy of buildings and roads and also natural resources. In Iran more than 4200 landslide have registered in different provinces that in Tehran province also happened the most landslide in the north part of cities and kind of the landslide the case of slides, flowing and rock fall, that among these cases flowing. Case in the greatest and perhaps their landslide number in this province on the base of percent reports and desert visit is about one twentieth of the number of Iran landslides. Studied area that is a part of areas of Tehran city, because of variety of effective factors in creation of the landslide include of geology, slope, direction, rain, and has the kinds of the landslide (kind of Slipping, falling and flowing) that has provided and registered possible 110 cases in format form of information bank of landslide. And as well as the plan of dot dispersion and superficial of area landslide that is a base of comparison of the most of breadth ways of the landslide risk, has been provided.

GEOGRAPHY LOCATION OF STUDY AREA

The study area of watershed management of Karaj is in the north of Tehran city and has longitude $50^{\circ}, 57', 46'' -$

$51^{\circ}, 29', 54''$ and altitude $35^{\circ}, 44', 58'' - 36^{\circ}, 08', 22''$ and area about 125,000 hectare.

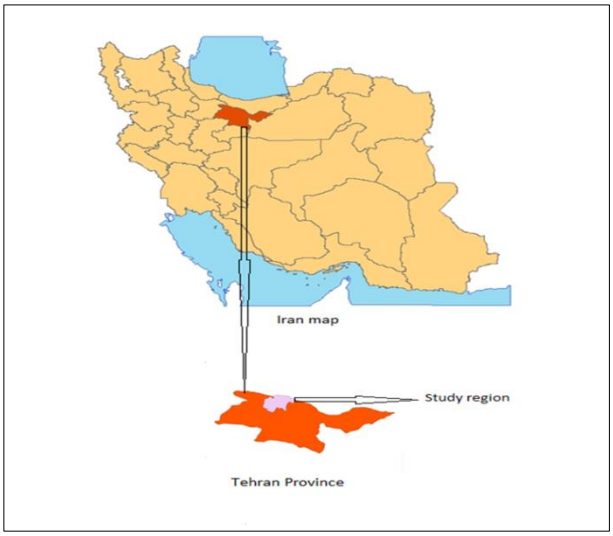


Figure 1: Geography Location map of study area

GEOMORPHOLOGY AND GEOLOGICAL OF REGION

Generally , considerate area is in the north part of Tehran and in part of middle Alborz mountain litho logical area has different groups of sedimentary rocks, igneous rocks metamorphic and structural tectonic zone of Alborz folding and there is different folds and faults with general way of the north west – south east and east – west that area is active Tectonically and as well as in the part of south and north is a place of passing of great faults like as Abiek fault – Firoozkooh - Shahrood and Tehran north fault with general way east-west that is case of unmerciful of the earth crust geological and also there is different stratigraphy from formation Precambrian to quaternary (variate deposit) (Berberian et al – 1995). One of the great (important) factors in landslide is the area lithology that considered area is the plan of twelve units of geology more than lithology and basic of unit that have similar lithology and with due to Fig (2) has been provided in form of formation Karaj formation (contain shale, tuff, marl, sandstone and conglomerate) to Tizkuh formation (contain limestone) and antiantto quaternary (variate deposit and etc), (Fig2).

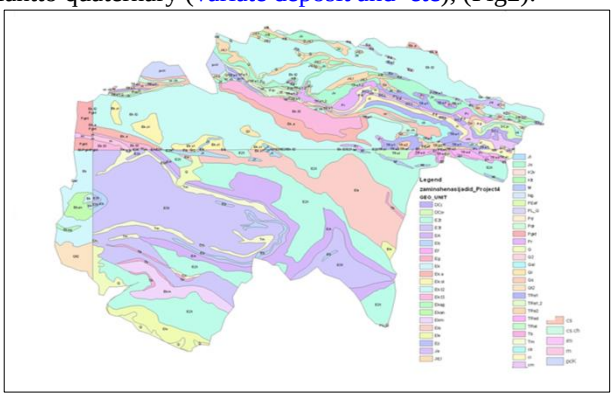


Figure 2: The geological map of considered area
Material and Methods

The first geology is slope and aspect maps provided in G.I.S software by aerial photos, topography maps and field operations in watershed management of Karaj. Then, these maps classes of priority and coming next determine based on existing landslides area in the geology, slope and aspect of maps. The slope as one of the main factors and effective in landslide is considerate and on basic of superficial dispersion and dotted of the area landslide dispersion (Fig 3) and dotted of the area landslide divided to four classes $0 \leq S < 15$, $15 \leq S < 25$, $25 \leq S < 45$ and more than $45 \leq S$ percent on basic of dotted way and networking and with using of formula (1):

$$SS = (A + 4B)/8 \quad (1)$$

Here 'SS' is square slope, 'A' is the total of the slope square and 'B' is presented as slope of middle dote.

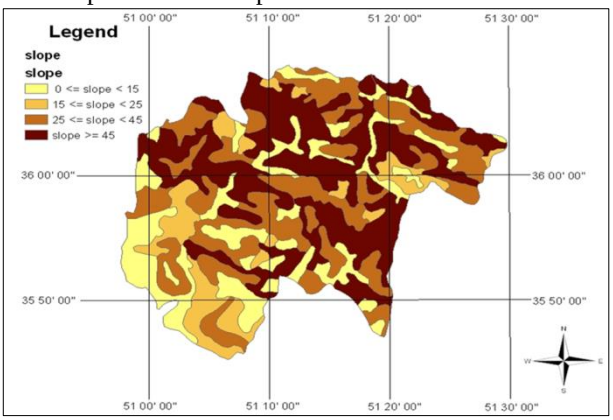


Figure 3: Slope map of area

The direction of the slope also depend on own area is one of the important factors in creating landslide that in area as there is in Fig 2, the direction plan with four main directions North, South, West and East has been provided on basic of exact determination of area frontiers and direction and the valleys of different slopes and with determining north and determination of relation of different directions (Fig 4).

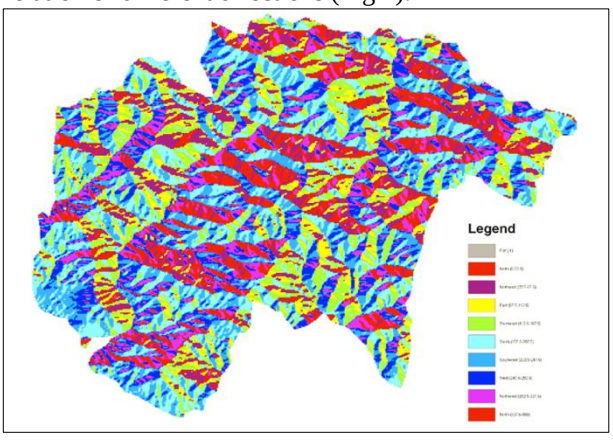


Figure 4: Aspect map considered area

With using of topography plan of the area with deserting operations has been provided the list of area landslides. But for determinate of area percent slipping units in each of slope classes and also for assessment and determinate of the area percent of slipping units in the map landslide hazard zonation,

the map of superficial dispersion of the area landslide has been provided in Fig (5).

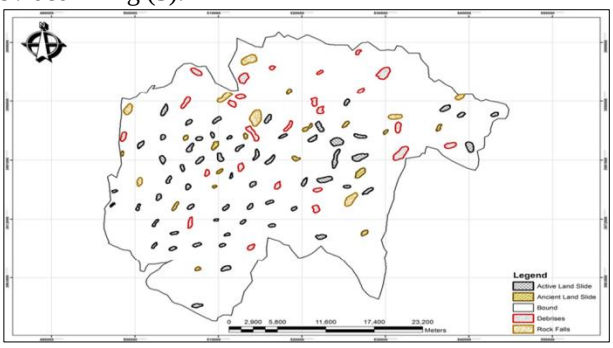


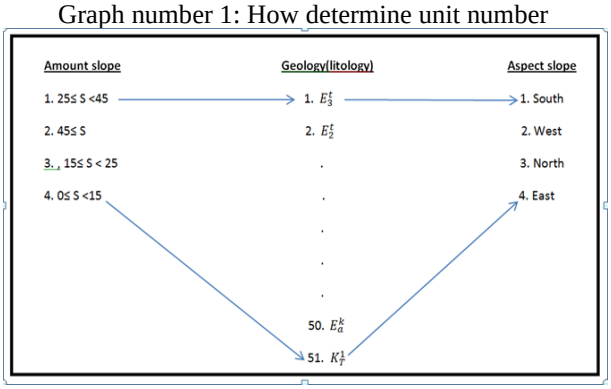
Figure 5 : Distribution surface map of landslides

For providing of the map of landslide hazard zonation in using semi fuzzy logic method, at first, has been determined with using of considered area landslide in slope plans, geology, and direction, priority and coming next of the existing class in plans that have covered in geology, In the geology map of Karaj formation(contain shale, tuff, marl, sandstone and conglomerate) and Tizkuh formation(contain limestone) and in the slope map of percent 25≤ S <45 and 0≤ S <15 classes and in the aspect map south and east classes sequential have the most and least of the area landslide surface. After mentioned at age units respectively classes that has been determined in each of geology factors, slope and slope direction have been numbered based on table 1 and graph 1 from 0 till (to) 815 that among these units there are 153 units in the area. And have been numbered from 0 till 154 and have settled comparison foundation for example based on table 1 and graph 1 a unit that include slope class 25≤ S <45 percent and geology with lithology shale, tuff, marl, sandstone and South direction has unit number 0 and a unit that include slope class 0≤ S <15 percent and geology with lithology limestone and East direction has the most unit number 153.

Table 1 :How determine unit number

Unit No	(0)(0)	(1)(-)	(2)(-)	(3)(1)	…	(813)(152)	(814)(-)	(815)(153)
Slope	1	1	1	1	…	4	4	4
Geology	1	1	1	1	…	51	51	51
Aspect,	1	3	3	4	…	2	3	4

Graph number 1: How determine unit number



At last withdrawing networks in sizing two centimeter in the plan of considered study area and on the basic of slope, geology and direction of slope allocated in each of networks that their numbers has been determined from 0 till 153, then on basic of the plenty of the landslide surfaces in each of the numbers based on table 2 (plenty on basic of amounts) that is the total of landslide area of each unit to the total units area below classes have been separated on basic of units number and their sensitiveness to landslide (Table 3).

Table 2 (summary): Unit numbers and aspect, geology, slope effective factors in landslide

Unit Number	Unit Number in Region	Aspect	Geology	Slope	Landslide Amount (Hectare)
0	0	1	1	1	319
1	-	1	1	2	-
2	-	1	1	3	-
3	1	1	1	4	138
…	….	….	…	…	…
…	….	….	…	…	…
813	152	4	51	2	26
814	-	4	51	3	-
815	153	4	51	4	15

Table 3: The classification of units' number and risk classes

No	Unit Number	Risk Class
I	0-27	Very Low Sensitivity
II	28-66	Low Sensitivity
III	67-89	Middle Sensitivity
IV	90-125	High Sensitivity
V	127-153	Very High Sensitivity

On the basic of above division, the map of landslide hazard zonation has been provided with using of fuzzy way that is its summary in table (4) and Fig (6).

Table 4: The summary results of landslide risk way in phase structure according to landslide area in each risk bread.

Hectare	Percent (%)	Zone and it's Land Percent
2737.5	2.19	Zone With Very Low Sensitivity
6350.5	5.08	Zone With Low Sensitivity
23487.5	18.79	Zone With Middle Sensitivity
54225.0	43.38	Zone With High Sensitivity
38200.0	30.56	Zone With Very High Sensitivity
6417.0	**100.00**	**Total**

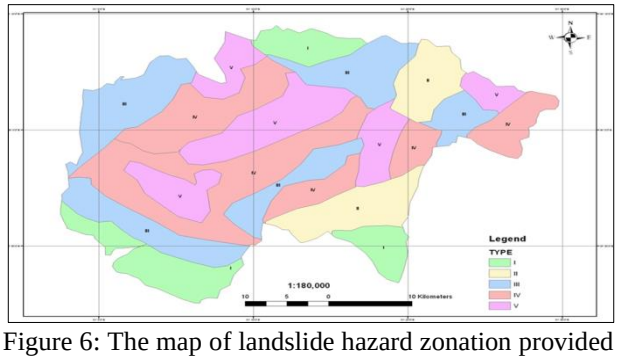


Figure 6: The map of landslide hazard zonation provided in fuzzy way model

CONCOLOSION

In direction of this research on basic of the foreseen way have considerate kinds of the landslide area that there are its generalities with plans and tables. But the summary of the result of assessment in the earth quake risk breadth way on basic of table number (4) and the plan of the landslide risk

bread the number (6) is: There results of the landslide risk breadth in this way is a accepted. But as has been shown in table number (4), but its objection is the low area of the landslide in this way in class or breadth with very high sensitive as compared with breadth with high sensitive and medium sensitive, but in total good results have been assessed and are recommended for executive parts for executive projects and proposals:

1-For prevention of the probable risks and damages is suggested, innovation and spreading of road construction in area is on basic of limitations of the landslide risk breadth plan.

2-When there is certain information and enough of rain fall and the landslide acceleration in the area, is recommended that these two factors also are considered in determining of units.

3-It is better, is prevented of the spreading of the residential areas or public centers in the area especially the areas with high-risk breadths, before their stabilities.

4-It's suggested that control ways and assessment for reducing of damages of the landslide phenomenon in the considerate area, especially in around Amirkabir Dam.

5-In most parts of the considerate areas, its better, is reduced or prevented of risks or damages of the landslide phenomenon because it's risks and damages is more expenses or irreparable.

6-The execute of instruction program for recognition of the landslide phenomenon and increasing of people information.

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