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Landslide susceptibility assessment using multiple linear regression and artificial neural networks, in the region Jvanrood – Ravansar

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ABSTRACT

Ravansar-Javanroud region located in northwest ZagrosMountain, because of its particular topographical, geological and weather conditions, can be prone to the occurrence of landslides in Iran. Since, landslide in this region can be a serious danger to destroy natural resources including soil, pasture, forests and a potential threat for urban and rural resident places, roads and their related installations, the study and zoning of this threat is necessary in order to manage it. This study was done to compare the performance and efficiency of two models of multiple regression and artificial neural network in zoning the occurrence of landslide in this region and also recognition of importance and the effect of each of these factors to apply correct management on them. For this purpose, first of all, the map of distribution of landslides as the dependent variable using aerial and satellite photographs and field visits was prepared. Next, the most effective factors in landslide occurrence in this region were identified based on previous studies and experts opinions and its database was prepared in GIS environment. Finally, the zoning was done using SPSS and two ways of multiple regression and artificial neural network. Based on the results from the two models, the variables of slope degree, litology and slope direction had the most effects in the occurrence of the landslides in this region. Climatic factors such as annual rainfall, number of frost days and human factors such as distance from major and minor roads and the distance from the residential areas and the use of land are other factors influencing landslides in this region, respectively. Studying the maps obtained from proposed models also shows that mast of the landslides are in the zones of high and most high sensitivities.

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INTRODUCTION

Landslide is a part of a range of movements that notes to move materials forward and down according to the effect of gravity on the slopes. The factors affecting landslide occurrence can be divided into two main groups. (a) Predisposing factors (intrinsic), such as slope, slope orientation, geology, and (b) stimulating factors (environmental), such as earthquakes, frost days, sudden heavy rainfall and human factors such as road construction, etc. [6]. Rapid population growth in recent decades and settlements spread to the regions with high gradients caused much human intervention in natural processes. These two factors has resulted in an alarming increase in the likelihood of landslides and rising damages and losses caused by this phenomenon in recent years. According to preliminary estimates, about 500 milliard rials in annual compensation are imposed by landslide [5]. According to the survey also conducted in early 1378, this phenomenon caused the death of 162 people, destroyed 176 homes, causing damage to the amount of 1,866 billion rials, destroyed 6763 hectares of forest, destroyed 170 kilometers of road and make annual deposits 963,707 m^3 [3]. One of the most important measures in this area is landslide zonation map. Landslide zonation is the division of land into homogeneous regions based on the actual or potential risks arising from the occurrence of landslides [4]. The main objective of this work is to determine the critical points of this phenomenon and to identify important factors that influence its occurrence. The studies and research experiences in modeling and hazard zonation of landslide occurrence and mass movements is on 50 years ago in developed countries [3]. Iran began the serious studies on landslide on early seventies. Among the new researches in this area can cited Inanloo et al. Hassanpour et al. Azimpour et al., Alaei et al. Hosseinzadeh et al., Karami [7] and others. The use of artificial neural networks and multiple

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variables regression statistical methodin landslide zonation studies were also done that the work of Jaewon Choi et al. [13] can be noted. Isak Yilmaz [10] examined, using the three methods of frequency ratio, the logistic regression and artificial neural networks of the risk of landslide occurrence in Tekat of Turkey. Massimo Conforti et al. and Leonardo Ermini et al. [12] evaluated the landslide in area of their study using the artificial neural networks. Mashallah Khamechian ei al. domestically assessed the performance of artificial neural networks in region of Sefidar galeh in Semnan province. Salman Suri et al. assessed the risk of landslide in a national basin (Nojian) using the artificial neural networks.

Location of the study area:

A North West District Javanroud- Ravansar, Kermanshah, is located in North West of Zagros mountain range. Itis located incoordinate's ″ 49'59 ° 34 - ″ 49'59 ° 34 north latitude and ″ 52'46 ° 46 - ″ 36'16 ° 46 'east longitude (Figure 1).The range area is 1369 km^2. The maximum height is 3345 meters in the area, according to the North West highlands of Shahoo in the area and the minimum height is 327 m in the output of Layla River in the west of the region.

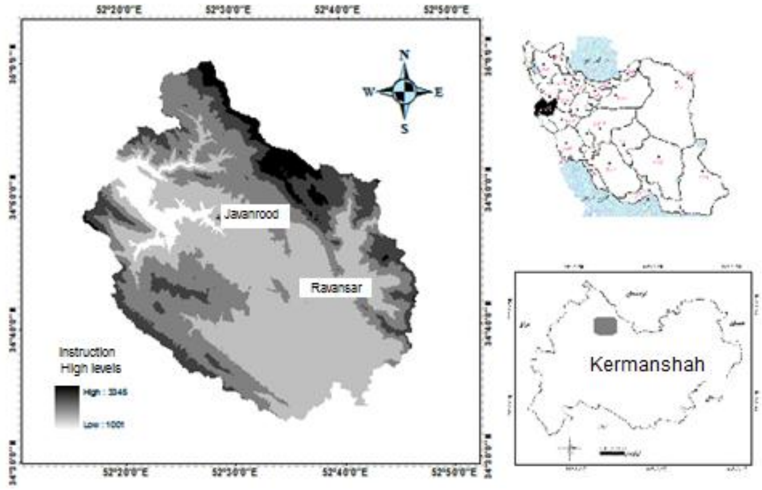

Fig. 1: Location of Javanroud - Ravansar, Source: The authors

Data and Methods:

In order to zoning and modeling for landslide occurrence of this phenomenon, the old landslide map (the place), is produced first as the dependent variable.Therefore, in this study, in the first step, the landslides distribution map of the study area using aerial photographs, satellite images ETM^+ in 2002 and 2009, 1:25000 scale topographic maps, land surveys (accessible viewing areas) has been prepared (Figure 2).

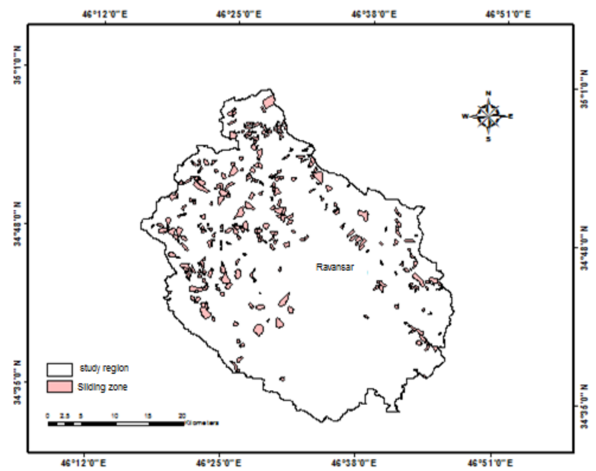

Fig. 2: Distribution of landslides occurred in the area Ravansar - Javanroud, source: authors

The next step is the most important variable affecting the occurrence of landslides in the study area as independent variables, the sum of the variables that can theoretically be effective on the occurrence of this phenomenon was detected.The map of the level and slope categories and classes needed in using maps DEM (Digital elevation model) and topographic maps with a scale of 1:25000 was prepared.Lithologyand distance from the fault zone maps using 1:10000 scales, and the geological sheet map of Kermanshah with 1:250000 scales were obtained, respectively.Map of precipitation, temperature and frost days as well as climatic factors using data from stations within and near the study area was prepared in Arc GIS software.Land use map was prepared using satellite images ETM^+in 2009 and utilization of natural resources and watershed experts Kermanshah Province, respectively.The base map of major roads, villages and rural settlements was prepared by means of the base map of the province roads of the Department of Roads and Urban Development.

In zonation of landslide maps, there are both qualitative and quantitative methods.In quantitative methods, it is trying to control the type and the extent of the relationships between variables controlling landslide numeric expression. Statistical methods such as quantitative methods for landslide zoning are in an area.In this research, trying to achieve predetermined objectives of multiple regression and artificial neural networks, two methods are used.

The zoning landslide in the study area was carried out with the following steps:

1. Creating intelligence layer: This layer consists of landslide maps and drawings as the dependent variable and slope, slope orientation, land use, lithology, distance to faults, climatic variables (including rainfall, temperature fluctuations and frost days), distance from roads, and the distance from the settlements, are the independent variables.
2. Landslide densities calculated for each category or class of independent variables through the overlay these maps with maps of landslide as the dependent variable.
3. Calculate the weighted values of the independent variables (e.g., lithology) and the dependent variable (landslide) to enter the desired model.

The relationship between a dependent variable in the multiple regression model and a set of independent variables are analyzed simultaneously. Modeling using multiple regression requires the correlation between the dependent variable and independent variables. After determining the correlation between landslide and effective variables, the data for these variables were entered into multiple regression model.The method of stepwise among multiple regression methods was used. In this method, independent variablesmost important to least important of them, one by one entered the model.

In this research for the zoning landslide in the study area, in addition to modeling using the multiple regression, Regression analysis, artificial neural network models were used as a non-linear model to compare results and detect more accurate model.The data used in the modeling through artificial neural networks is that the data used in the multiple regression.In order to simulate the occurrence of landslides in the study area Multi-layer perceptron with pre-propagation algorithm in the SPSS software was used.70 percent of all landslides were used to train the network, 30 percent for testing. Variables of land use, degree and orientation of slope, lithology, annual precipitation, temperature fluctuations, frost days, main roads and minor rural and regional areas as independent variables (input layer) were included in the model.

RESULTS AND DISCUSSION

Calculating the Pearson correlation coefficient between the data landslide factors as the dependent variable and efficient factors in landslide as independent variables have proven the minimal correlation between these two sets of variables necessary to perform multiple regression model.The occurrence of landslides also in the study area is observed with the highest correlation value variable of slope degree, lithology and slope orientation had the lowest correlation with variable frost days.

Table 1 shows the coefficients obtained from multiple regression model. Due to varying degrees of slope coefficients listed in Table 1 were entered as the most important variable in the first model and other variables in the models are entered based on the order of 2 to 10.

Table 1: Models and coefficients resulting from the implementation of stepwise multiple regression method

Determination coefficient	Correlation	The entered variables and coefficients are calculated for each	Coefficient	Model No.
0.516	0.718	Slope degree (0.373)	2.250	1
0.668	0.817	Slope degree0.296‹lithology 0.239	1.891	2
0.734	0.857	slope degree0.0214 ‹lithology 0.204‹slope degree 0.197	1.552	3
0.759	0.866	slope degree 0.0206 ‹lithology0.191 ‹slope degree, 0.188, Rural areas 0.076	1.316	4
0.765	0.875	Slope degree 0.178, ‹lithology 0.187 ‹slope orientation 0.178, rural regions0.075 ‹Annual precipitation 0.059	1.267	5
0.785	0.886	Slope degree 0.180 ‹lithology 0.151 ‹slope orientation 0.188 ‹rural areas 0.066‹annual precipitation, 0.88 frost days, -0.055	1.518	6
0.799	0.894	Slope degree, 0.135 lithology 0.149‹slope orientation 0.178, ‹rural areas 0.082 ‹annual precipitation 0.084 ‹frost days 0.092‹temperature fluctuations 0.060	1.517	7
0.809	0.899	Slope degree 0.150 ‹ lithology 0.142 ‹slope orientation 0.162 ‹rural areas	1.414	8

		0.075 ‹annual precipitation 0.079 ‹frost days -0.094 ‹temperature fluctuations 0.052 ‹main road 0.061		
0.814	0.902	Slope degree 0.146 ‹lithology 0.136 ‹slope orientation , 0.167 rural areas, 0.172 annual precipitation ,0.077 frost days -0.093‹temperature fluctuations , 0.045 main road 0.059 ‹distance to the fault , 0.039	1.294	9
0.818	0.905	slope degree 0.147 ‹lithology 0.131 ‹slope orientation 0.160 ‹rural areas 0.0059 ‹ annual precipitation, 0.74 frost days -0.094 ‹temperature fluctuations 0.047 ‹main road 0.058 ‹ distance to the fault 0.04‹ rural road 0.36	1.228	10

Out of ten of the multiple regression models, model number 10 for landslide zonation maps of the area was used. The reason for selection of this model isits high correlation coefficient model (905/0) and the appropriate Determination coefficient (818/0).Meanwhile one of the other models with fewer numbers of variables and the diagnosis of MS, the researcher made use of nature of the region.

Finally, multivariate linear regression equation based on model no.10 to estimate the risk of landslides was obtained as follows (Equation 1):

$$Y = 1.228 + .147\,X_1 + .131\,X_2 + .160\,X_3 + .059\,X_4 + .074\,X_5 - .094\,X_6 + .047\,X_7 + .058\,X_8 + .040\,X_9 + .036\,X_{10} \quad (1)$$

Where Y isthe sensitive factor to the landslide, X_1 is slope variable, $X_2$is variable of lithology, $X_3$is variable slope, $X_4$is variable of distances from rural areas, $X_5$is variable of annual rainfall, $X_6$is variable of frost days, $X_7$is variable of temperature fluctuations, X_8 is variable of distance from the main road, $X_9$is variable of distance from faults and variable X_{10} is variable of the rural road.

After performing multiple regression model and obtain the coefficients of each independent variable landslide zonation map of the study area was prepared in Arc Gis software.The range Ravansar - Javanroud in terms of landslide susceptibility within 5 very low, low, medium, high and very high were divided (Figure 3).

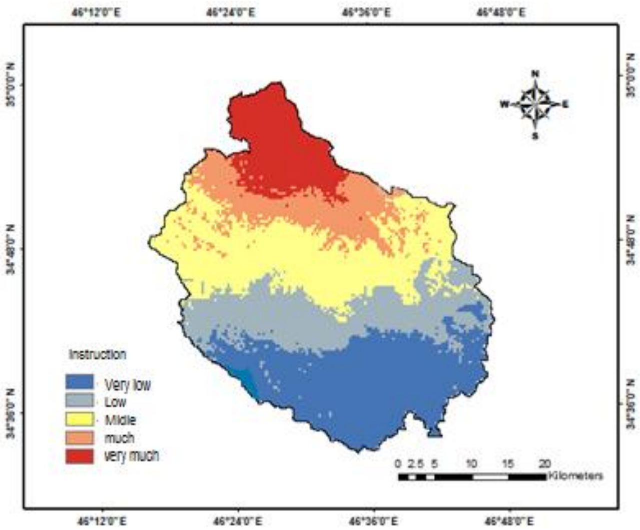

Fig. 3: landslide zonation map using multiple regression model in Ravansar – Javanroud

The results also show that using neural network model given that the output of the model there is a direct and positive relationship between the weights assigned to the sliding weights assigned to the variables affecting landslide (independent variables).According to the results shown in Table 2, the most important variables affecting the landslide area is related to the parameters of slope degree.Lithology and slope parameters, respectively the second and third factors of landslides are participating in the event.Land use also has the lowest impact on the variables entered in the model.

Table 2: Factors influencing variables of Landslide Based on Artificial Neural Network

Importance Normalized	Importance	Independent variables	Importance Normalized	Importance	Independent variables
8.4%	.014	Land use	39.3%	.065	Rural areas
39.6%	.066	Temperature fluctuation	100.0%	.166	Slope degree
56.4%	.094	Annual precipitation	82.5%	.137	Slope orientation
47.6%	.079	Rural road	36.5%	.061	Distance to the faults
40.4%	.067	Main road	79.2%	.131	Lithology
			73.3%	.122	Frost days

Thus, with respect to the coefficients obtained from Table 2, landslide susceptibility mapping using an artificial neural network were obtained in the five regions of very low, low, medium, high and very high in the study area (Figure 4).

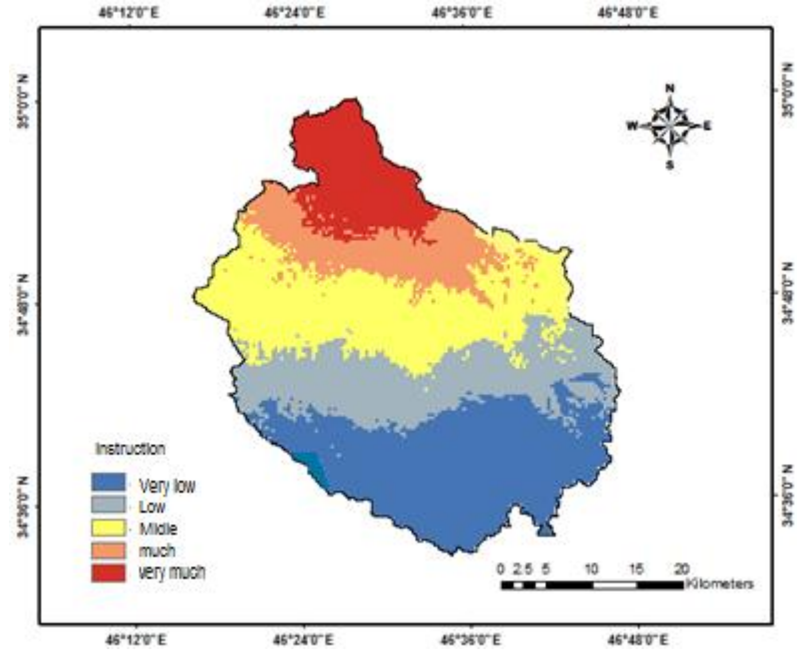

Fig. 4: landslide zonation map using artificial neural networks in regional pJavanroud– Ravansar

Conclusion:

According to the results of multiple regression models outputs and artificial neural networks, the two models provide similar results. Thus, both models, the slope degree, slope and lithologyhave been identified as the most important variables influencing landslides in the region, as well as in multiple regression models of land use due to low levels of factor models significantly were out of the model and the artificial neural network model was allocated to these factors, the lowest coefficient (least important).The area is roughly the same for both models for different presented classes of risk, thus, in both models; about 24.5 percent of the study area was in the range of high and very high risk (Table 3).

Table 3: Percentage of landslide hazard area by using multiple linear regression and neural networks

Percentage of landslide hazard area					
Very high	high	medium	low	Very low	Model Name
11.78	12.73	27.25	20.53	27.7	Multiple regression
11.58	12.82	26.87	20.51	28.19	Artificial neural network

There is significant highcorrelation coefficient (99.7%) of the landslide hazard zonation map using multiple regression and zoning map produced by the model of artificial neural networks, we can say that both methods have the required performance to obtain the goals of this paper.However, multiple regression methods for reasons such as ease and speed of work, flexibility in arrival and departure of several variables in the model as well as the ability to analyze linear relationships between variables, was identified as a better method.

REFERENCES

[1] Khamechian, M., 2007. Application of artificial neural network system for landslide hazard zonation: A CASE STUDY Sefidargaleh area in Semnan, Tehran: University Journal of Science, 33(1): 57-64

[2] Sury, Salman., 2012. Landslide hazard zonation using artificial neural network case study: a national basin (Nojian), Journal of Engineering Geology, Issue 2.

[3] Karam, Abdul Amir, Mahmoudi, Farajollah, modeling and landslide hazard zonation in the folded Zagros Basin case study Sarkhoon - Chahar Mahal Bakhtiari, Geographical Research, 1-14, 51.

[4] Ghayoumian, J.F., T. Breed, 2005. landslide zonation in Nojian Sorkhab using GIS, Second Conference of Environmental and Geological Engineering.

[5] Komakpanah and Hafezi moghadas., 1996. Proceedings of the Second Conference on Landslides and reduce its losses, International Institute for Environment and Engineering, earthquakes, 148, p 7.

Advances in Environmental Biology, 8(11) Special 2014, Pages: 393-398

[6] Mahdifar, M.R., Armiyei, Ali and Fatemi Aghda, Seyed Mahmoud., 1997. Landslide zoning in the city of Rustam Khorsh in Khalkhal province.
[7] Karam, Abdul-Amir., 2001.quantitative modeling of landslide hazard zonation folded Zagros Basin case study Sarkhoon - Chahar Mahal Bakhtiari, Ph.D. dissertation, University.
[8] Andrew, S., Goudie., 2004. Encyclopedia of Geomorphology, 1: 605-608.
[9] Ayalew, l. and H. Yamagishi, 2005. The application of GIS-based Logistic regression for landslide susceptibility mapping in the Kakuda-Yaahiko Mountains, central Japan,Geomorphology, 65: 15-31.
[10] Işık Yilmaz., 2008. Landslide susceptibility mapping using frequency ratio, logistic regression, artificial neural networks and their comparison: A case study from Kat landslides (Tokat—Turkey)
[11] Lee, S., J.H. Ryu, M.J. Lee, J.S. Won, 2006. The Application of artificial neural networks to landslide susceptibility mapping at Janghong, Korea,Mathematical Geology, 38(2): 199-220.
[12] Leonardo Ermini., 2005. Artificial Neural Networks applied to landslide susceptibility assessment, 66: 327-343.
[13] Jaewon Choi., 2011. Combining landslide susceptibility maps obtained from frequency ratio, logistic regression, and artificial neural network models using ASTER images and.
[14] GIS Massimo Conforti., 2013. Evaluation of prediction capability of the artificial neural networks for mapping landslide usceptibility in the Turbolo River catchment (northern Calabria, Italy) CATENA, 113: 236-250.
[15] Thiery, Y., J.P. Malet, S. Sterlacchn, A. Puissant, O. Maquaire, 2007. Landslide Susceptibility ssessment by bivariate methods at large scale. Geomorphology, 92: 38-9.