Prediction of snow avalanche -susceptibility in Meigun-Shemshak road using rare events logistic regression

Kazem Nosrati [a1], Sara Kiashemshaki [b], Mohammad Mehdi Hoseinzadeh [c]

[a]*Department of Physical Geography, Shahid Beheshti University, Tehran, IRAN.*
[b]*M.Sc. Graduate Student, Department of Physical Geography, Shahid Beheshti University, Tehran, IRAN.*
[c]*Department of Physical Geography Shahid Beheshti University, Tehran, IRAN.*

Received 22 August 2015
Accepted 4 April 2016

1. Introduction

Mountain regions are increasingly endangered by a variety of disaster, including avalanche, debris flows, and rock slide. Some characteristics such as elevation, angle of slope, vegetation and climatic elements could affect the avalanche event. Indeed, avalanche is the second factor in soil erosion that causes demolition; therefore, it threatens the food safety. Iran has two main large mountain ranges of Alborz and Zagros with risk of avalanches. In mountains and snow routes, avalanche is an inevitable event and due to special geomorphological condition, Meigoun- Shemshak road is significantly highlighted. Meigoun- Shemshak road has been situated in Shemshak drainage basin. The objectives of this study are to identify the role of effective factors in avalanche events and its zoning in Meigoun- Shemshak road and to find high risk regions.

2. Material and Methods

Meigoun- Shemshak road has been located in Shemshak drainage basin (51º26'49″ to 51º31'39″ E; and 35º57'28″ to 36º3'15″ N) with the area of 37.75 Km^2 in Roodbar Ghasran District, Shemiranat County, Northeastern Tehran. The minimum and maximum elevations of the study area are 2200 and 4200 m, respectively.

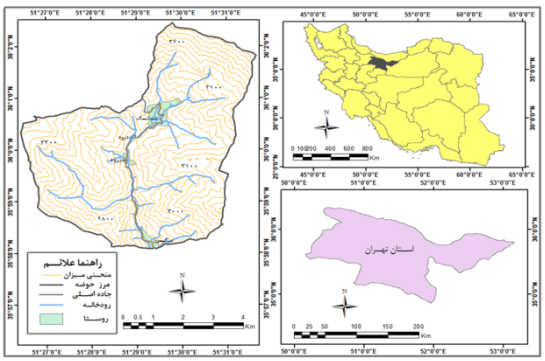
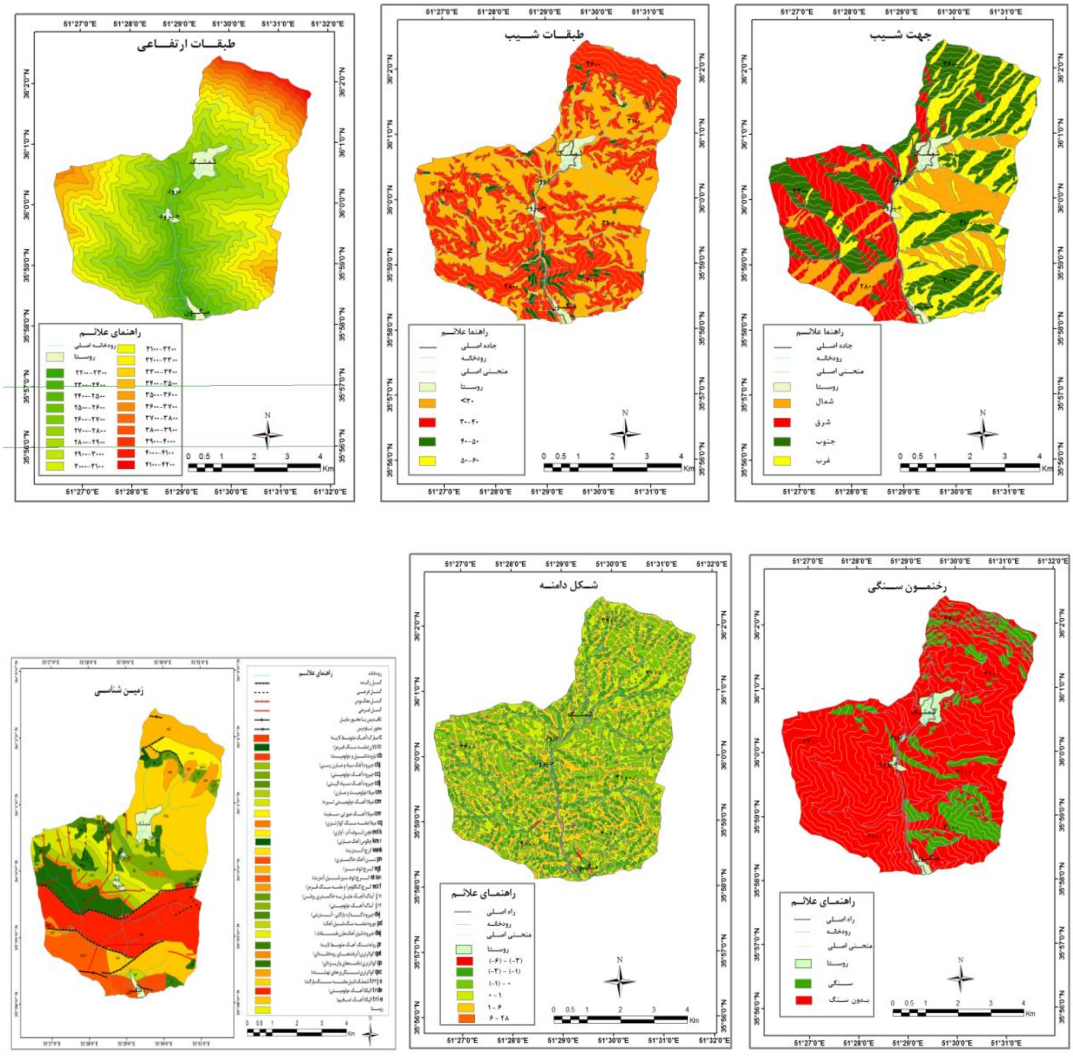


Figure 1. Geographical location of Shemshak Basin

1 Corresponding author : Kazem Nosrati. Tel: 021-29902604 E-mail: k_nosrati@sbu.ac.ir

In order to prepare the effective factors in controlling the avalanche events, the primary data and maps including topographic maps in 1:25000 scale and geological maps with 1:100000 scale as well as Google Earth images were used. Independent variables including elevation, aspect, slope, curvature, outcrop rock and geological were prepared based on the basic maps. The snow accumulation area were found using Google Earth along with the researcher's knowledge of the region, and then converted to polygon layer by GIS software. Since the area of avalanche zones is so smaller than the total area, the Rare Event Logistic Regression was used to find the effective factor in controlling the avalanche events. ROC index was used in order to evaluate the validity of the model, accordingly. Finally, the susceptibility map of avalanche events was prepared using the factors resulted from RELR.



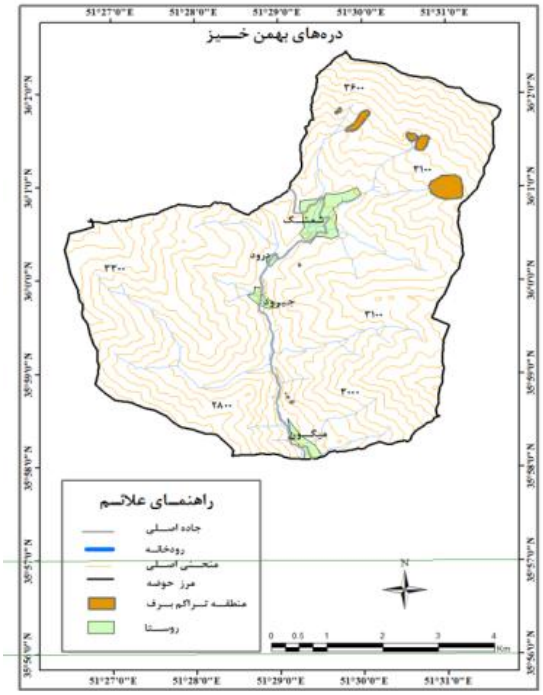


Figure 2. Variables used in logistic modeling

3. Results and Discussion

The RELR was applied to find the relationship between the snow accumulation areas as dependent variable and independent variables, including slope, aspect, geology, elevation and other similar elements. The results showed that depth stratum, curvature, elevation, outcrop rock, slope, and aspect were selected as final factro in controlling the avalanch event. The susceptibility map of avalanche events resulted from controlling factors were classified into three classes, including low risk (67.35% of total area), medium risk (24.9% of total area), and high risk (8.06% of total area). Since the area of avalanche regions is less than total area; therefore, we considered 10 % of one and zero regions for the validity model and executed it in half of the basin. The area under the curve is 0.75, and it is reliable for being close to one.

Table 1. *Rare event logistic regression results*

Parameter	Coefficient β
Fixed coefficient	-6.247
Curvature	-6.936
Elevation	4.436
Outcrop Rock	1.521
Slope	1.254
Aspect	1.079

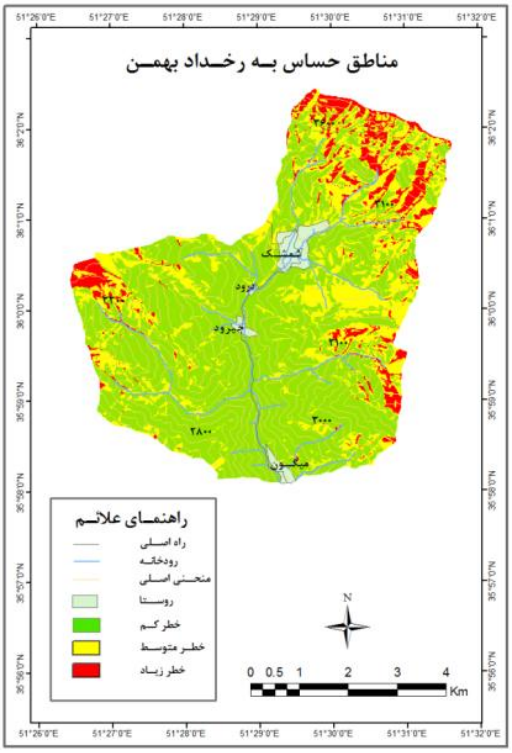


Figure 3. Regional distribution map affected by avalanche

5. Conclusion

According to the results of the rare events logistic model, curvature, elevation, outcrop rock, slope and aspect layers were known as effective factors in the snow accumulation area, respectively. 61.49 % of the snow accumulation area is related to convex footslope and 38.51 of density in the concave area. The highest snow accumulation area ranges from 3200 to 3400 elevations and 13% of the basin total area is appropriate for snow accumulation. The slope map indicates that 58.22% of density is in the slope 30 -40º, which is the best slope for the occurance of avalanche. The most snow accumulation area is located in the southern part of the region (49.85% of the total area) and the western part with 29.14 %. 99.97 % of the region, which have no outcrop rocks prone to the snow accumulation area.

Key Words: Snow Avalanche, Snow hazard mapping, Rare Events Logistic Regression, Meigoun- Shemshak road.

References (in Persian)

Armstrong, B. R., & Knox, W. (1977). *The avalanche book* (M. Dadkhah, Trans.). Tehran: University of Teheran Press.

Ahmadi, H., & Nasri, M. (2007). An investigation on avalanche zoning in Se Pestan valley watershed (Fereidunshahr, Isfahan Province) using GIS techniques. *Journal of the Iranian Natural Res, 1*, 13-32.

Raeesi, M. (2011). *Step by step training of social channel analysis: The practical exploratory report of learning machine course.* Tehran: Amirkabir University of Technology- Tehran Polytechnic Publications.

Zare Bidaki, R., Ahmadi. H., Mahdavi. M., & Sedaghatkerdar. A. (2011). Avalanche hazard mapping in Nesa -Gachsar road using geomorphologic and climatic data. *Journal of Range and Watershed Management, 3*, 295-306.

Sajadian, M., Barfi, Z., & Ghahramani. M.M. (2013). Towns January fertile and Mazandaran roads review by the GIS and AHP. *Quarterly Geographical Journal of Chashmandaz-e-Zagros, 18,* 73-85.

Saffarian, A., & Sardashti, M. (2007, February). *Assessment of the risk of avalanches and ways to prevent it using remote sensing and geographic information system (RS & GIS) Case Study: Col Zhalanh in the city of Marivan.* Third International Conference on Crisis Management in Natural Disaster, Tehran.

References (in English)

Falahtabar, N. (2000). The effect of some geographical factors on the ways network of country. *Geographical research quarterly, 38,* 47-55.

FAO. (1985). *Snow and avalanche control* (H. Ahmadi & S. Taheri, Trans.). Tehran: University of Teheran Press.

Gassner, M., & Brabes, B. (2002). Nearest neighbor models for local and regional avalanche forecasting. *Natural Hazards and Earth System Sciences, 2*, 247- 253.

Ghanavati, E. (2008). Avalanche risk zonation based on geomorphological characteristics in Haraz road. *Journal of Geographical Sciences*, 9(12), 83-100.

Gruber, U., & Haefner, H. (1995). Avalanche hazard mapping with satellite data and a digital elevation model. *Applied Geography, 15*, 99-113.

Mohammadi, E. (1995). *The avalanche analysis and its path identification in Sirvan watershed* (Unpublished Master thesis). Tarbiat Modares University, Tehran, Iran.

Rice Jr, R., Decker, R., Jensen, N., Patterson, R., Singer, S., Sullivan, C., & Wells, L. (2002). Avalanche hazard reduction for transportation corridors using real-time detection and alarms. *Cold Regions Science and Technology, 34*(1), 31–42.

Straub, D., & Grêt-Regamey, A. (2006). A bayesian probabilistic framework for avalanche modelling based on observations. *Cold Regions Science and Technology, 46*(3), 192-20.

Van Den Eeckhaut, M., Vanwalleghem, T., Poesen, J., Govers, G., Verstraeten, G., & Vandekerckhove, L. (2006). Prediction of landslide susceptibility using rare events logistic regression: A case-study in the Flemish Ardennes (Belgium). *Geomorphology, 76,* 392-410.