Quantitative and Comparative Analysis of Slope Instability in Karaj-Chaloos Road (Karaj-Gachsar), and Under Construction Highway of Tehran-North (Tehran-Soleghan) Using Logistic Regression

Shahram Roostai[1*], Davood Mokhtari[2], Christine Jananeh[3]

1- Professor of Geomorphology,Department of Geomorphology, University of Tabriz
2- Professor of Geomorphology, Department of Geomorphology, University of Tabriz
3- Ph.D. student of Geomorphology, Department of Geomorphology, University of Tabriz

1-Introduction

Mass movements of the earth's surficial materials downward the slopes is called slope instability, which is affected by the earth gravity, while the rate of material mobility increases by the presence of water in the sediments. Each year, slope instabilities cause enormous economic damages to roads, railways, power transmission and communication lines, irrigation and watering canals, ore extraction, as well as oil and gas refining installations, infrastructures in cities, factories and industrial centers, dams, artificial and natural lakes, forests, pastures and natural resources, farms, residential areas and villages or threaten them. Nowadays, many instabilities are resulted by human intervention and manipulations. One of the human factors effective in the instability occurrence is the construction of roads. Road construction, especially in mountainous areas, increases the probability of occurrence of various types of instabilities, as it changes the natural balance of the slopes and causes deformations in the land. Each year, lots of casualties and financial losses are imposed by the occurrence of various types of instabilities in the slopes overlooking the roads, which also cause the destruction of many natural resources in the country. However, the construction of roads, highways and freeways is necessary and unavoidable in today's life. The Karaj-Chaloos road and the Tehran-North highway are two routes that connect Tehran as Iran's capital, with the southern shores of the Caspian Sea, although suffering frequent slope instabilities.

2-Methodology

This contribution aimed to study slope instabilities along these roads using logistic regression method. In this regard, layers of 14 effective factors were identified, comprised of elevation classes, slope, aspect, geology, land use, precipitation, distance from fault, river and road, normalized difference vegetation index (NDVI), climate,

* (Corresponding Author), **E-mail:**sh_roostaei@yahoo.com

slope length (LS), stream power index (SPI) and topographic wetness index (TWI). Consequently, maps of the factors responsible for instabilities were prepared as separate layers in the GIS environment and transferred into the Idrisi software. The whole procedure included: (1) preparation of digital elevation model (DEM), river and fault layers based on the 1:25,000 topographic map of the area, as well as distance maps from rivers and faults, (2) creating slope and aspect maps from DEM, (3) preparation of land use and NDVI maps of the region based on unmatched classification of Landsat 8 image of OLI sensor, (4) preparation of geological map, (5) preparation of precipitation and climate layers based on the information obtained from the meteorological organization, (6) creating LS, SPI and TWI layers based on the DEM, (7) conversion of the distribution data of the regional instabilities using Landsat satellite and Google Earth images, (8) correlating the information layers with the regional instability map and calculating their density per unit area, and (9) performing the logistic regression model using Idrisi software.

3-Results and Discussion

Results obtained by applying logistic regression model showed that the most important factors affecting slope instabilities in the Karaj-Gachsar road area were the distance from river, climate and SPI, while those for the Tehran-Soleghan road area were the distance from fault and road and climate. 34.95 percent of the lands in the Karaj road area had medium to high potential for instability occurrence; 54.87 percent of the occurred instabilities corresponded to these areas. Moreover, 4.97% of the Karaj road area had a very high potential for instabilities, which correlated with almost 9% of the occurred instabilities. This was while 27.14% of the Soleghan road area possessed medium to high potential for instabilities, within which 86.26% of the instabilities have occurred. Furthermore, 4.57% of the Soleghan road area showed very high risk in terms of instability occurrence, encompassing 61% of the occurred instabilities. According to the prepared maps, the southern and middle parts of the Karaj-Gachsar road, as well as another part in the northwest of the study area had the highest potential for the occurrence of instabilities, whereas in the Tehran-Soleghan road area, the middle and southern parts and a small section in the north of the area had the highest potential for instability occurrence. By comparing these two areas, it was conceived that areas with medium to high potential of instability in the Soleghan road area were less than those of the Karaj road area (27.24% and 34.95%, respectively). However, the percentage of instabilities occurred in the Soleghan road area was much higher (86.26%) than the Karaj road area (54.87%). The high value of the ROC index and its proximity to the end value of 1 in both areas indicated that instabilities strongly correlated with the probability values derived from the logistic regression model. Additionally, the

assessment of the instability potential map by the SCAI index showed that there was a high correlation between the prepared risk maps and the occurred instabilities, which have been confirmed by field surveys. The obtained results were in a good agreement with the general opinion that SCAI decreases especially in high and very high risk classes indicating a high correlation between the prepared risk maps and the occurred instabilities and field surveys in both areas.

4-Conclusion

The results of this investigation showed that the logistic regression model was suitable for preparing the zonation of the probability of instability occurrence along the edges of the studied roads. Moreover, in addition to natural factors, the human-made factors and particularly unsystematic road construction can play an important role in the instability occurrences on the slopes overlooking the roads. In order to reduce the relative risks and increase the stability of the slopes, it is necessary to avoid manipulating the ecosystem and changing the current land use as much as possible, in addition to policy making for constructions in accordance with geomorphological and geological features of the area.

Keywords: Instability, Logistic Regression, Tehran-North highway, Karaj-Chaloos road, Risk zonation.