Quantitative Analysis of Slope Instability in Under-Construction Highway of Tehran-North (Tehran-Soleghan) by the Use of Logistic Regression

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Introduction

Slope instabilities are one of the most distinctive types of geomorphic hazards that are exacerbated by human interference and threaten most of the human installations, especially mountainous highways and impose heavy costs on the government and local residents. Each year, slope instabilities cause enormous economic damages to highway, 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 effective human factors in instability occurrence is the construction of highway. Highway 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 highways, 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 Tehran-North highway will be the route that connect the Iran's capital Tehran with the southern shores of the Caspian Sea.

Materials and methods

This contribution aims to study slope instabilities along this highway 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 highway, normalized difference vegetation index (NDVI), climate, 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 Terrset software.

Result and discussion

Results obtained by applying logistic regression model showed that the most important factors affecting slope instabilities in the Tehran-Soleghan highway area are distance from fault and climate. 27.14% of the Soleghan highway area possesses medium to high potential for instabilities, within which 86.26% of the instabilities have occurred. Furthermore, 4.57% of the Soleghan highway area shows very high risk in terms of instability occurrence, encompassing 61% of the occurred instabilities. According to the prepared maps, the middle and southern parts and a small section in the north of the Tehran-Soleghan highway area have the highest potential for instability occurrence. The high value of the ROC index and its proximity to the end value of 1 indicates that instabilities strongly correlate 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 is a high correlation between the prepared risk maps and the occurred instabilities, which have been confirmed by field surveys. The obtained results are in a good agreement with the general opinion that SCAI decreases especially in high and very high risk classes and indicates a high correlation between the prepared risk maps and the occurred instabilities and field surveys in study areas.

Conclusion

Finally, it can be mentioned that the logistic regression model is suitable for preparing the zonation of the probability of instability occurrence along the edges of the studied highway. As a final conclusion, it can be concluded that in addition to natural factors, the- human-made factors and particularly unsystematic highway construction can play an important role in the instability occurrences on the slopes overlooking the highway and 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.

Key Words:

- Slope instabilities
- Logistic Regression
- Tehran-North highway
- Risk zonation

Refrences:

- اعتضادی آملی، سینا، کیاپور، مسعود، تقوایی، محمد، (1394)، بررسی و مطالعه ایجاد زمین لغزش و تاثیر آن بر مطالعه موردی کیلومتر 30 محور ساری به) Geo-slopعملکرد جاده ای و روش موثر تثبیت آن با نرم افزار ، مجموعه مقالات اولین کنفرانس بین المللی مهندسی و علوم کاربردی، امارات- دبی، صص 8-1)کیاسر.
- ، پهنه بندی خطر ناپایداری دامنه ها در محدوده جاده چالوس (حدفاصل کرج-گچسر)، (1384)جعفرلو، مرتضی، پایانامه کارشناسی ارشد، وزارت علوم، تحقیقات و فناوری، دانشگاه تربیت مدرس، صص120-1.
- روستایی، شهرام، مختاری، داود، خدایی، فاطمه، (1394)، پهنه بندی خطر وقوع ناپایداری های دامنه ای در جاده های کوهستانی تنگه دره دیز با استفاده از روش رگرسیون لجستیک، مجلهٔ مخاطرات محیط طبیعی، شماره 6، صص 103-94.

- پنو، پایانامه کارشناسی ارشد، دانشگاه –، پهنه بندی خطر زمین لغزش در مسیر فاسیان (1390)عزیزی، علیرضا، فردوسی مشهد، صص 147-1.
- متشرعی، آرش، قمی، جعفر، افتخاری، اکرم، پوزش، بهروز، شاهماری، مهدی، (1391)، پهنه بندی خطر وقوع زمین لغزش بر روی جاده تهران- چالوس و بزرگراه در دست احداث، فصلنامه زمین شناسی کاربردی، شماره 2، صص 147-158.
- متولی، صدر الدین، اسماعیلی، رضا، حسین زاده، محمد مهدی، (1388)، تعیین حساسیت وقوع زمین لغزش با ، فصلنامه جغرافیای طبیعی، شماره 5، صص (استفاده از رگرسیون لجستیک در حوضه آبریز واز (استان مازندران 73-83.
- مختاری، داود، (1383)، ارزیابی ژئومورفولوژیکی بخشی از مسیر راه تبریز-مرند در گردنه پیام در شمال غرب ایران، فصلنامه مدرس علوم انسانی، شماره 4، ص 87-1.
- Ayalew, l, Yamagishi, H, (2005), The application of GIS-based Logistic regression for landslide susceptibility mapping in the Kakuda-Yaahiko Mountains, central Japan, Geomorphology, v. 65, p. 15-31.
- Das, I, Sahoo, S, Westen, C, Stein, A, Hack, R., (2009), Landslide susceptibility assessment using logistic regression and its comparison with a rock mass classification system along a road section in the northern Himalayas, India, Geomorphology, v. 114, p. 627–637.
- Dewitte, O, Chung, C, Cornet, Y, Daoudi, M, Demoulin, A, (2010), Combining spatial data in landslide reactivation susceptibility mapping: A likelihood ratio-based approach in W Belgium, Geomorphology, v. 122, p. 153-166.
- IAEG commission on landslides, (1990), Suggested nomenclature for landslides Bulletin of the International Association of Engineering Geology, v. 41, pp. 13-16.
- Menard, S, (1995), Applied logistic regression analysis, Sage university paper series on quantitative applications in social sciences, v. 106, p. 94-98.
- Nandy, G, Andrew, M, Richard, A, and Stephana, G, (2009), Assessing landslide potential using GIS, soil wetness modeling and topographic attribute, Payette River, Idaho, Geomorphology, v. 37, p. 149-165.
- Pareta, K, Kumar, J, Pareta, U, (2012), Landslide hazard zonation using quantitative methods in GIS, International Journal of Geospatial Engineering and Technology, V.1, p. 1-9.
- Sahoo, S, 2009, A semi-quantative landslide susceptibility assessment using logistic regression model and rock mass classification system in a part of Uttarakhand Himalaya, India, Master degree thesis, International Institute for Geo-Information Science and Earth Observation Enscheda, The Netherlands, and Indian Institute of Remote Sensing, National Remote Sensing Center (NRSC), Department of Space, Dehradun, India.