Review of different models used to assess the susceptibility of exogenous mass movements in the mountainous regions

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ГОСУДАРСТВЕННЫЙ КОМИТЕТ РЕСПУБЛИКИ УЗБЕКИСТАН
ПО ГЕОЛОГИИ И МИНЕРАЛЬНЫМ РЕСУРСАМ

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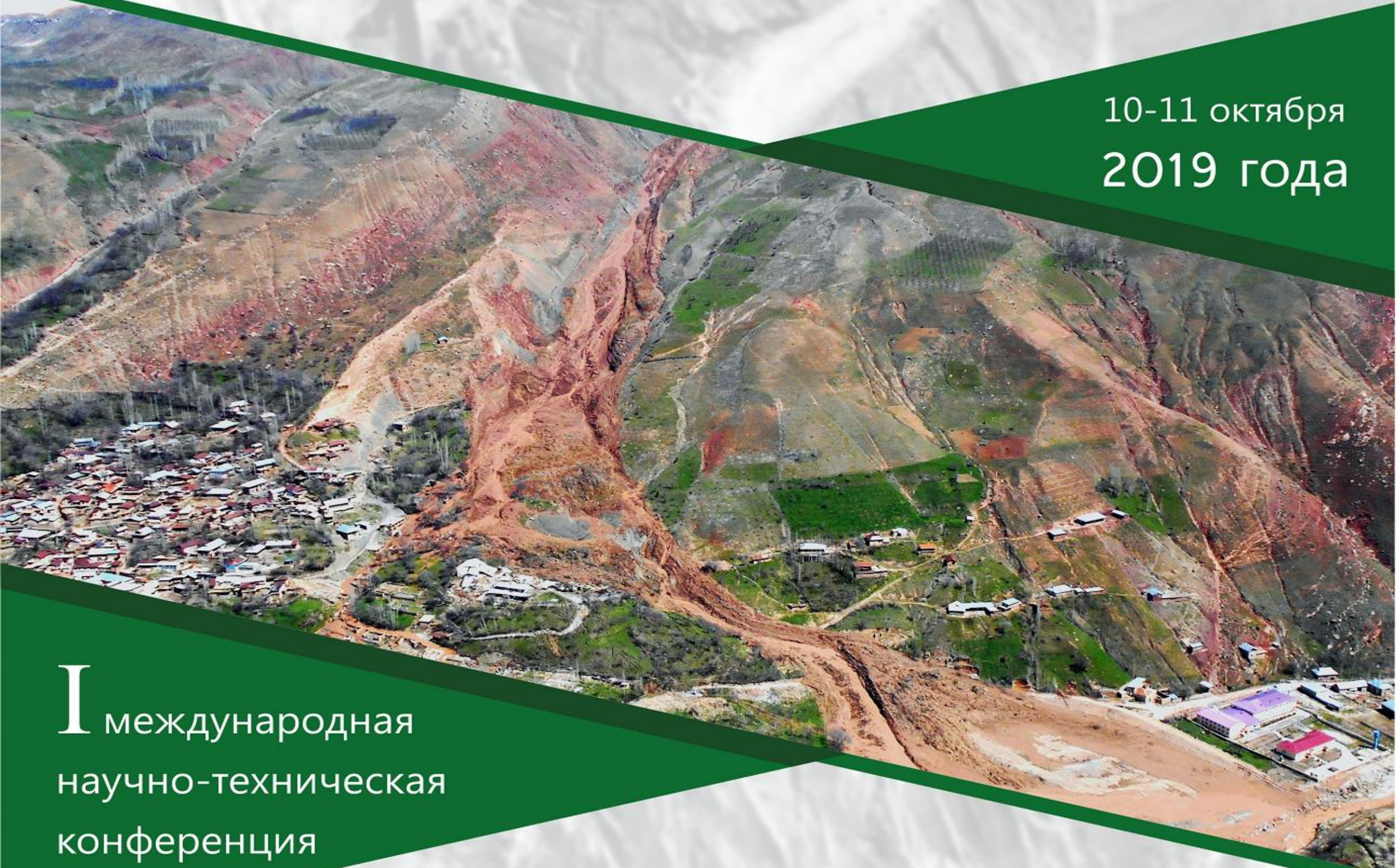
ПО СЛЕЖЕНИЮ ЗА ОПАСНЫМИ ГЕОЛОГИЧЕСКИМИ ПРОЦЕССАМИ



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REVIEW OF DIFFERENT MODELS USED TO ASSESS THE SUSCEPTIBILITY OF EXOGENOUS MASS MOVEMENTS IN THE MOUNTAINOUS REGIONS

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Introduction

Central Asian countries have a long history of disasters that have brought out economic and human losses. In this territory, we can observe all types of natural and technological hazards, including earthquakes, floods, landslides, mudslides, debris flows, avalanches, droughts [3].

Earthquakes are the prevailing hazard in Uzbekistan. It lies in a region with low to very high seismic hazard zone [3]. Since 1955, Uzbekistan has experienced 81 earthquakes above five in magnitude, of which 11 were above six. An earthquake struck Tashkent on 26 April 1966 that killed 10 people, affected 100,000 others and caused economic losses of $300 million [13, 19].

Landslides are the second natural hazard in terms of number of victims and damages. However, most of the earlier publications were in Russian and, thus, remained practically unknown in the Western World [7].

In Central Asia, landslides often occur in the loess zone of contact with other rocks, on clay interlayers of the Mesozoic and Cenozoic age, reaching a volume from tens of thousands up to 15-40 million m^3, characterized by duration of preparedness and relatively rapid and catastrophic displacement of the masses [14].

During the last years, a large number of projects and studies have been conducted in the mountainous regions of Uzbekistan to prevent landslide processes. In Uzbekistan, 90000 km^2 area covered by mountains, where about 3,0 million people are living, 17% mountainous area vulnerable to landslides, 10-12% of the total damage caused by natural disasters falls on landslides. Formation of landslide processes is a natural relief forming processes which, due to changes in climatic conditions and the development of mountain slopes increasing year by year. Mountain region of Uzbekistan are most prone to geohazards in Central Asia region. Landslide processes are often associated with influence of three factors: climatic, seismic and man-made or technogenic.

Landslides triggered by snow melting, precipitation and underground waters consist 65-70%, by old and recent earthquakes – 25-20% and by technogenic factors – 15-20%. Last years the great attention paid to building new and reconstruction of old transport communication and transport movement on mountain highways has increased in ten times that can trigger the formation of new landslide sites. In mountain zones still operating existing economic constructions and mines where throughout 30-40 years large landslides developed. Their main feature is that, despite the long period of development, they continue to move year after year and become less predictable (Niyazov, 2009).

Remote sensing technologies became a powerful tool in natural sciences. During the last decades that this technology has also extended to landslides [1, 8, 12, 20, 21].

Nowadays, new techniques of Remote sensing finding their application more effective for landslide detection, mapping, monitoring and hazard analysis. Landslide detection and mapping can be done by optical and radar imagery. New generation of high-resolution satellites, such as World-View, GeoEye can be very useful for creating inventory maps of landslides in regional and local scales [2, 12].

Models used for the landslide susceptibility

Landslide hazard and risk assessments start from landslide susceptibility mapping of the territory under investigation [5, 21]. Generally, landslide susceptibility is the spatial probability of landsliding in a given area, depending on a combination of various factors such as geology, land use and land cover (LULC), tectonics, slope, aspect, and others [6, 22]. During the last decades, a variety of approaches for landslide susceptibility analysis have been developed. They are categorized into heuristic, physically-based and statistical methods [4, 8].

During the last decade, investigations on landslide susceptibility assessment have increased because of remote sensing and GIS tools development [15].

Few studies on landslide susceptibility mapping in the territory of Central Asia have yet been documented. Saporano et al. [18] conducted research on earthquake-triggered landslide susceptibility, whereas Saporano et al. [17] performed a statistical landslide susceptibility analysis for the entire territory of Kyrgyzstan. Golovko et al. [5] compared an inventory of landslides automatically detected from satellite data with an inventory derived from mapping by experts. Juliev et al. [10] compared three models to assess the landslide susceptibility for the Bostanlik region, Uzbekistan.

According to the review paper of Pourghasemi et al. [16] landslide susceptibility indexed papers mostly published in journals Environmental Earth Sciences (EES), Natural Hazards, Geomorphology, Landslides, Arabian Journal of Geosciences, Landslide Science and Practice, Computers and Geosciences, Catena, Engineering Geology, and Bulletin of Engineering Geology and the Environment. During the period 2005-2016, a total of 469 articles have been published by 270 authors from 54 different countries for a given topic. Almost 73% of the articles originated from 12 countries: China (14%), Turkey (9,6%), Iran (9%), Italy (8,1%), India (7,5%), Malaysia (5,8%), Korea (4,7%), Japan (3,4%), Nepal (3,2%), the USA (3%), Greece (2,6%), and Austria (2,3%). For this period, just one paper was published for the territory of Kyrgyzstan.

Kyrgyzstan, Tajikistan and Uzbekistan from Central Asian countries have close contact with landsliding consequences. Therefore, it is necessary for the researchers of current countries to increase a number of research projects and publications on the landslide susceptibility mapping.

Conclusion

Remote sensing technologies can be a good tool for the data-scarce territories like Uzbekistan and could be utilized for landslide detection, mapping, monitoring and hazard analysis. We can see that landslide susceptibility assessment have increased because of remote sensing and GIS tools development. Central Asian researchers have a good potential in this topic, because we have not been yet applied landslide susceptibility models for our study areas.

REFERENCES

1. *Canuti P., Casagli N., Ermini L., Fanti R., Farina P.* 2004, Landslide activity as a geoindicator in Italy: significance and new perspectives from remote sensing, Environ. Geol., 45, 907-919.

2. *Casagli N., Fanti R., Nocentini M., Righini G.* 2005, Assessing the capabilities of VHR satellite data for debris flow mapping in the Machu Picchu area, in: Landslides, risk analysis and sustainable disaster management, edited by: Sassa K., Fukuoka H., Wang F., Wang G., Proceeding of the First General Assembly of the International Consortium on Landslides.

3. Central Asia and Caucasus Disaster Risk Management Initiative (CAC DRMI), 2009, Risk Assessment for Central Asia and Caucasus Desk Study Review.

4. *Fan W., Wei X., Cao Y., Zheng B.* Landslide susceptibility assessment using the certainty factor and analytic hierarchy process. J. Mt. Sci. 2017, 14, 906-925, doi:10.1007/s11629-016-4068-2.

5. *Golovko D., Roessner S., Behling R., Wetzel H.-U., Kleinschmit B.* Evaluation of Remote-Sensing-Based Landslide Inventories for Hazard Assessment in Southern Kyrgyzstan. Remote Sens. 2017, 9, 943, doi: 10.3390/rs9090943.

6. *Guzzetti F., Reichenbach P., Ardizzone F., Cardinali M., Galli M.* Estimating the quality of landslide susceptibility models. Geomorphology 2006, 81, 166-184, doi:10.1016/j.geomorph.2006.04.007.

7. *Havenith H.B., Strom A., Torgoev I., Torgoev A., Lamair L., Ischuk A., Abdrakhmatov K.,* 2015, Tien Shan Geohazards Database: Earthquakes and landslides. Geomorphology 249, 16-31

8. *Hong Y., Adler R., Huffman G.* 2007, Use of satellite remote sensing data in the mapping of global landslide susceptibility. Nat. Hazards, 43, 23-44.

9. *Hong H., Liu J., Zhu A.-X., Shahabi H., Pham B.T., Chen W., Pradhan B., Bui D.T.* A novel hybrid integration model using support vector machines and random subspace for weather-triggered landslide susceptibility assessment in the Wuning area (China). Environ. Earth Sci. 2017, 76, doi:10.1007/s12665-017-6981-2.

10. *Juliev M., Mergili M., Mondal I., Nurtaev B., Pulatov A., Hubl J.* (2018). Comparative analysis of statistical methods for landslide susceptibility mapping in the Bostanlik District, Uzbekistan. Science of the Total Environment, 653, 801-814.

11. *Lu P., Stumpf A., Kerle N., Casagli N.* 2011, Object-oriented change detection for landslide rapid mapping. Geosci. Remote Sens. Lett., 8, 701-705.

12. *Martha T., Kerle N., van Westen C.J., Kumar K.* 2010, Characterising spectral, spatial and morphometric properties of landslides for semi-automatic detection using object-oriented methods, Geomorphology, 116, 24-36.

13. *Mavlyanova N., Inagamov R., Rakhmatullaev H., Tolipova N.,* 2004 Seismic Code of Uzbekistan. 13th World Conference on Earthquake Engineering, 1611.

14. *Niyazov R.* 1982, Formation of large landslides in Central Asia., Tashkent

15. Pourghasemi HR, Kerle N (2016) Random forests and evidential belief function-based landslide susceptibility assessment in Western Mazandaran Province, Iran. Environ Earth Sci 75(3):1-17.

16. *Pourghasemi H.R., Teimoori Yansari Z., Panagos P., Pradhan B.* Analysis and evaluation of landslide susceptibility: a review on articles published during 2005–2016 (periods of 2005-2012 and 2013-2016). Arab. J. Geosci. 2018, 11, doi:10.1007/s12517-018-3531-5.

17. *Saponaro A., Pilz M., Wieland M., Bindi D., Moldobekov B., Parolai S.* Landslide susceptibility analysis in data-scarce regions: the case of Kyrgyzstan. Bull. Eng. Geol. Environ. 2015b, 74, 1117-1136, doi: 10.1007/s10064-014-0709-2.

18. *Saponaro A., Pilz M., Bindi D., Parolai S.* The contribution of EMCA to landslide susceptibility mapping in Central Asia. Ann. Geophys. 2015a, 58.

19. *Thurman M.* Natural Disaster Risks in Central Asia, 11 April 2011 Disaster Risk Reduction Advisor, Europe and CIS.

20. *Tofani V., Segoni S., Agostini A., Catani F., Casagli N.,* 2013, Technical Note: Use of remote sensing for landslide studies in Europe. Nat. Hazards Earth Syst. Sci., 13, 299-309.

21. *Westen C.J., Castellanos E., Kuriakose S.L.* 2008,. Spatial data for landslide susceptibility, hazard, and vulnerability assessment: An overview, Eng. Geol., 102, 112-131.

22. *Wu Y., Li W., Wang Q., Liu Q., Yang D., Xing M., Pei Y., Yan S.* Landslide susceptibility assessment using frequency ratio, statistical index and certainty factor models for the Gangu County, China. Arab. J. Geosci. 2016, 9, doi:10.1007/s12517-015-2112-0.