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Using statistical analyses to assess landslide hazard

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The study was realized in the Western Carpathians, in north part of Slovakia. The main objective is to assess landslide hazard in the region, using a quantitative evaluation and compare the results between used methods. Besides the studies to improve investigation techniques and mitigative measures, there has been a constant development of quantitative methods to assess the probability of future landslide occurrence. These methods can be divided into two main distinct categories: the deterministic and the statistical methods.

For assessment three statistical analyses had been applied: bivariate using the weights of input parameters, multivariate conditional analysis and artificial neural networks. The methodology of landslide hazard assessment using statistical methods in a GIS environment is based on an appropriate choice of the factors affecting the stability of slopes. Statistical processing of landslide hazard assessment is based on the geological principle of phenomena and processes that is true, that landslides will occur in places where they occurred in the past respectively in present because of similar activation conditions (Bednarik et al. 2005). In the study four input parameters are evaluated which entered to statistical processing in the form of parametric maps. Statistical evaluation was executed in ArcGIS and Matlab environment. The outputs of this study are three prognostic landslide hazard maps.

Applying bivariate statistical analysis was founded that the most favorable conditions for the development of slope deformation create the combination of slope sediments, south-oriented with slope angle from 11° to 17° in areas where land is used as a transitional woodland-shrub. For bivariate analysis the biggest problem is the determination of weights of individual parameters. In evaluation process is therefore necessary the subjective interference in the automation process and correction of the calculated weight value. This intervention is not required in the case of multivariate method. The advantage of this method is that the researcher can confirm the importance of each factor, but this requires considerable experiences and knowledge of the researcher and not only in the field of engineering geology.

Applying multivariate conditional analysis few possible combinations of input parameters with a 100% probability of slope failures was identified. As an example is provided a combination of 4.5.2.17, which represents the combination of slope sediments in the natural grasslands area with slope angle from 7° to 11° oriented to the North. The advantage of multivariate statistical analysis is that the method primarily works with more data and also indirectly allows to take into account interactions between the input parameters. Another advantage is the lower technical and time complexity of the computer operations.

For artificial neural network, a suitable combination of the conditions for landslides occurrence represents flysch sediments in the area of pastures, northwest oriented with slope from 9° to 15°. The artificial neural network (NN) has many advantages compared with bivariate and multivariate statistical analysis. The artificial neural network method is independent of the statistical distribution of the data and there is no need of specific statistical variables. Compared with the statistical

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methods, neural networks allow the target classes to be defined with much consideration to their distribution in the corresponding domain of each data source (Lee et al. 2004). The disadvantage is the high technical and time complexity of the computer operations.

To verify the degree of success of created prognostic landslide hazard maps receiver operating characteristic (ROC) curves were used. The most important parameter is the area under curve (AUC). The size of the AUC determines the overall quality of predictive models. The maximum area of graph is 1 (ideal model, success rate is 100%), the area of model with a success rate of 50% has AUC = 0.5 (trivial model). The closer the area to the value 1 is, the more accurate the model is (Bednarik et al. 2010). Using bivariate statistical analysis the AUC is 0.852, for multivariate 0.919 and using NN the result is 0.924. The results shows that bigger degree of success has the prognostic landslide hazard map created using NN and it is equal to 92.4%.

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