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ANFIS modeling for the assessment of landslide susceptibility for the Cameron Highland (Malaysia)

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Landslides are one of the recurrent natural hazard problems throughout most of Malaysia. In landslide literature, there are several approaches such as probabilistic, bivariate and multivariate statistical models, fuzzy and artificial neural network models etc. However, a neuro-fuzzy application on the landslide susceptibility assessment has not been encountered in the literature. For this reason, this study presents the results of an adaptive neuro-fuzzy inference system (ANFIS) using remote sensing data and GIS for landslide susceptibility analysis in a part of the Cameron Highland areas in Malaysia. Landslide locations in the study area were identified by interpreting aerial photographs and satellite images, supported by extensive field surveys. Landsat TM satellite imagery was used to map vegetation index. Maps of topography, lineaments, NDVI and land cover were constructed from the spatial datasets. Seven landslide conditioning factors such as altitude, slope angle, curvature, distance from drainage, lithology, distance from faults and NDVI were extracted from the spatial database. These factors were analyzed using an ANFIS to produce the landslide susceptibility maps. During the model development works, total 5 landslide susceptibility models were constructed. For verification, the results of the analyses were then compared with the field-verified landslide locations. Additionally, the ROC curves for all landslide susceptibility models were drawn and the area under curve values were calculated. Landslide locations were used to validate results of the landslide susceptibility map and the verification results showed 97% accuracy for the model 5 employing all parameters produced in the present study as the landslide conditioning factors. The validation results showed sufficient agreement between the obtained susceptibility map and the existing data on landslide areas. Qualitatively, the model yields reasonable results which can be used for preliminary land-use planning purposes. As a final conclusion, the results revealed that the ANFIS modeling is a very useful and powerful tool for the regional landslide susceptibility assessments. However, the results to be obtained from the ANFIS modeling should be assessed carefully because the overlearning may cause misleading results. To prevent overlerning, the numbers of membership functions of inputs and the number of training epochs should be selected optimally and carefully.