Prediction of rainfall-generated soil erosion processes with artificial neural networks and GIS

Andreas Knobloch[1], Silke Noack[1], Dr. Andreas Barth[1], Matthias Karl Zeidler[1], Sven Etzold[1], Evelyn Bennewitz[1]

[1] Beak Consultants GmbH, Am St. Niclas Schacht 13, 09599 Freiberg / Germany
andreas.knobloch@beak.de

Abstract

Natural events such as rainfall-generated soil erosion processes are usually caused by complex interaction of factors. Due to the lack of data and knowledge about the details of many geo-processes, mathematical and analytical models cannot be successfully applied with reasonable effort. Methods of artificial intelligence (artificial neural networks: ANN) on the other hand represent a reliable tool to analyse the causal relationships based on the available knowledge. This approach is working with a reasonable effort in terms of data processing, model design and computation time. The software advangeo® was developed by Beak to enable ESRI ArcGIS users to apply methods of ANN on raster geodata.

Advangeo® has been used in three different case studies to predict the probability of extensive soil erosion, soil creeping and the formation of erosion gullies. The first two study areas, Klingenberg and Tharandt / Freital, are located in the Weisseritz catchment in Saxony, Germany. The third study site, Limpopo region, is located in the northeastern region of South Africa. In all three areas, precipitation events characterized by long durations and/or high intensities lead to the dislocation of soil material.

The main controlling factors governing the soil erosion include terrain attributes (slope and flow accumulation; to a lesser extent aspect, profile and plan curvature and flow length); percent composition of top soil (i.e. soil particle size – fine, medium, coarse); dip direction of covering geological units and land use (e.g. arable land, pastures, forests, urban areas).

For modeling, a Multi Layer Perceptron (MLP) approach was used. The artificial neural network was trained with various learning algorithms, activation functions and parameters. Acceptable results were attained with the Resilient Back Propagation (RPROP) algorithm, in combination with a sigmoid activation function.

Finally, the trained ANN model was used to plan erosion prevention measures. Landscape elements such as hedgerows were added into the model as barriers on slopes that were especially susceptible to erosional processes. The subsequent network run confirmed the successful mitigation of the predicted erosion processes. With this approach, prevention measures could be optimized (number and location of barriers), thereby facilitating the conservation of funds.