

USING GIS TO DEVELOP A PREDICTION METHOD

Landslide Hazard Mapping in Austria

In Austria many manmade objects such as roads and buildings are vulnerable to landslides caused by heavy rainstorms. These result from climate change and changes in geological structure. Using GIS, the authors analysed the characteristics of landslides and developed a prediction method. Recent events have demonstrated how the method can support decision-makers in urban and regional planning.

Population growth and changes in land-use policy result in increased hazard risks. For example, lack of risk awareness causes governments to allow the building of houses in potential hazard zones. As yet, little is known about the distribution of landslides. Figure 1 shows some of the characteristics of landslides in the province Burgenland, Austria; one severe consequence is the demolishing of houses.

Prediction Method

In our study, funded by the Federal Government of Burgenland Department of Geology, we used the method of Weights of Evidence (WoE) to predict the possible occurrence of landslides. Originally developed for mineral and ore exploration, this probabilistic method is now also often used for the statistical assessment of landslides. WoE uses a Bayesian approach to combine geo-data for predicting the occurrence of events, in our case landslides. The factors or evidence themes determining the possible occurrence of landslides include (1) geology, (2) land use, (3) slope, (4) aspect and (5) terrain roughness expressed as Surface to Area Ratio, and these were the five factors we selected for our study. Not all factors will contribute equally to the occurrence of landslides and therefore weights have to be assigned to each and every factor. The method is available as part of Arc-SDM 3.1, which is a free extension for ESRI ArcGIS available from Natural Resources Canada at <http://ntsर्व.gis.nrcan.gc.ca/sdm>.

Sediments

The study covers an area of 738km² with elevations between 150m and 540m above sea level and is dominated by the rivers Strem, Lafnitz, Pinka and Raab (see Figure 2); the average slope of the valleys is 15%. Since terrain roughness increases from north to south, whereas towards the east and the Pannonian Basin the landscape flattens out, landslides are most likely to occur in the southern and central parts whilst none are to be expected in the flat valleys and in the flatter hills northeast of Güssing. The region is dominated geologically by sediments such as clay, silt, sand and fine gravel. Such geological formations become unstable under heavy rainfall, resulting in landslides. In the south, fine-grained sediments are overlaid by layers of middle to coarse gravel that may have a stabilising effect on slopes. In the larger valleys alluvial sediments are found, accompanied by gravel terraces along the banks.

Datasets

Most geo-data used in the study was provided by the GIS Department of the Burgenland government and originally produced by the Austrian Federal Office for Calibration and Survey (BEV). A Digital Elevation Model (DEM) with 10m ground-resolution was automatically generated from 1:15,000 airborne imagery captured in 2001 using stereo matching techniques. From the same imagery Digital Colour Orthophotos with a ground resolution of 0.25m were created. The mapping process was supported by national topographic base-map scale 1:50,000 and topographical vector data containing, amongst other things, rivers and roads. Geological maps from the Geological Survey Austria cover the area at scale 1:200,000. For northern areas a more detailed map at scale 1:50,000 provided complementary information. The Austrian Environmental Agency provided data on land use from the European Corine Landcover dataset. Thorough understanding of the region's geology and landslide occurrence was obtained through interviews with local authorities, land-use managers and geologists, and from the literature.

Fieldwork

After collection of the above data, extensive field campaigns began in summer 2005. The aim of the fieldwork was to arrive at a comprehensive overview on landslides, their characteristics and spatial extent and the damage they caused to manmade objects. Landslide extent was recorded with a Trimble GeoXM handheld GPS receiver with ESRI ArcPad 6 software (Figure 3); accuracy of 10m enabled generation of a hazard map at scale 1:50,000. Data on morphological features such as the presence of abnormally steep slopes, subsidence, neck-valleys and increase in soil moisture were systematically collected. Trees were also inspected for the presence of bending, another landslide indicator. Damage to manmade objects that could possibly be attributed to landslides was also recorded. The fieldwork showed that, in general, substantial damage rarely occurred. Most landslide areas have been stabilised and, where necessary, houses and roads permanently renovated.

GIS Processing

All collected data was transferred as layers into an ArcGIS database. Using the colour orthophotos as backdrop, field recordings were validated and, if necessary, corrected on-screen, especially in forested areas where the GPS signals were weak. The layers were converted to 10m raster, and terrain parameters derived from the DEM using Spatial Analyst. In Arc-SDM each of the five factors enumerated above was duly given a weight and the probability of the occurrence of landslides over the whole area then computed for each raster cell on a scale of 0 to 1. To enhance the results for presentation to decision-makers, these values were transformed into three classes (see Figure 4): not endangered (beige), landslides possible (light blue) and endangered (orange). About 50% of the region is predicted to be not endangered, in about 33% of the region landslides may occur and about 17% is definitely endangered

Validation

Comparison of the hazard map with experience and fieldwork observations proved the predictive capacity of the map: presence of landslides as observed onsite correlated well with the hotspots in the hazard map and about 98% of randomly selected points were correctly predicted. In spring 2006 heavy rainfall near Loipersdorf triggered landslides. Comparing the location with the hazard map, the Burgenland government's chief geologist expert was able to confirm that the landslide had taken place within the orange hazard zone. The hazard map has been well received by local government: such area-wide mapping of landslide susceptibility, new to the province, is establishing itself as a very useful tool for regional planning. Although municipalities are sometimes aware of danger zones, a comprehensive overview enables them to bring hazard zones to the attention of federal government, resulting in possible adjustments to urban and rural plans.

Concluding Remarks

The WoE method turned out to be useful for landslide predication. In 2006 a follow-up project started in Oberwart district, north of the study area. Our method will now be used here, where the geology and morphology is largely identical to that of the trial area. The hazard map will form the basis for further investigations and an extension of the model area is planned. We are currently working on a follow-up project on landslide hazard mapping in the district of Oberwart, Austria.

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Further Reading

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