

Socio-economic vulnerability units – modelling meaningful spatial units

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1. Background

Within the EU-funded research project BrahmaTWinn²⁵ a methodology to derive spatial vulnerability units (VulnUs) independently from administrative boundaries in the Salzach river has been developed. A major aim of the project is the integration of different indicators (social and environmental) within the DPSIR-Framework and the delineation of spatially integrated units, so-called hydrological response units (HRUs; Flügel 1996).

2. The geon concept

An increasing detail of data and complex analysis tasks opens the door for a plurality of solutions (Lang, in press). Complex real world phenomena require means for reducing and modeling the underlying complexity, for extraction the crucial information, for mapping their dynamics and the constant changes. Automated techniques of object-based image analysis (OBIA, Lang & Blaschke, 2006) making effective use of advanced analysis methods try to match the information extraction with our world view. To account for that, a flexible concept of manageable units is required. The term geon was proposed by Lang (in press) to describe generic spatial objects that are homogenous in terms of a varying spatial phenomena under the influence of, and partly controlled by, policy actions. The geon concept acts as a framework for the regionalization of continuous spatial information according to defined parameters of homogeneity. It is flexible in terms of a certain perception of a problem (specific policy realm, specific hazard domain, etc.) and using geons, we are capable of transforming singular domains of information on specific systemic components to policy-relevant, conditioned information (Tiede & Lang, 2007a). Geons are generated by transforming continuous spatial information into discrete objects by algorithms for interpolation, segmentation, regionalization, generalization; they are analyzed in terms of their arrangement, which leads to emergent spatial qualities; they are dynamic and can be monitored in terms of changes. Within the spatial extent in which a certain policy applies or a certain hazard may occur, a group of geons makes up a spatially exhaustive set (geon set). The spatial limit of the geon set, since being derived functionally, may not fully coincide with administrative boundaries. In this study, vulnerability units have been derived as a specific instance of a geon set within an area, exposed to flood risk.

3. Spatial variation of vulnerability based on spatial vulnerability units

The chosen case study covers the central area of the City of Salzburg. The urban

²⁵ <http://www.brahmatwinn.uni-jena.de/>

agglomeration of the city dominates the northern part, whereas additional rural and alpine areas (located in the central-eastern part, and to the South) characterise the chosen study area. The area is highly dynamic through its economic development. Furthermore, it is also prone to floods of various intensity (e.g. HQ-100 flooding in 2002) and therefore serves as an appropriate site to investigate vulnerability within a spatial context.

In an initial step vulnerability was conceptualised and defined. Vulnerability has been confined to the hazard type 'floods'. The overall vulnerability to floods consists of different domains, such as susceptibility, adaptive and social capacity and resilience. For each domain, sub-domains have been identified and relevant indicators and data sources established.

Data applied originates from publicly available GIS data sources and Census data. The data is not only provided on the basis of different administration units, but additionally on a standardised grid (e.g. 250m and 1000m). This is a very unique approach and allows visualising data not only on the arbitrary administration units but shows the characteristics in a spatial distribution. Another advantage is that in subsequent analysis steps the Modifiable Areal Unit Problem (MAUP, Unwin 1996) is minimized.

To integrate the different data sets and different data sources a normalisation has to be applied. For the generation of a composite vulnerability unit each data layer or domain level has to be assigned by a weight. The methodology applied is known as Multi Criteria Analysis (MCA), Multi Criteria Evaluation or Analytical Hierarchy Process (AHP). A profound discussion on that topic and current best practices approaches is available in Carver (1991) and Malczewski (2000). Considering the fact that vulnerability is not directly measurable and due to its complex dimension and human construction an expert based approach is being chosen. The weights have been derived through a scoring exercise with stakeholders and experts in the field of disaster risk reduction and planning in the Salzach catchment. The experts have been asked to assign scores to each of the factors according to their relative importance and contribution to the vulnerability of people in the Salzach basin - with regard to floods.

To integrate the different datasets a regionalisation approach (Batz & Schape 2000) has been chosen. This segmentation algorithm is implemented in the software Definiens Professional. As the algorithm allows weighting of the different layers for each domain delineated units can be derived. The advantage is the application of the algorithm from the beginning, but with the constraint to lose the sub-hierarchical levels. A vulnerability value is finally derived from the vector product of the different layers.

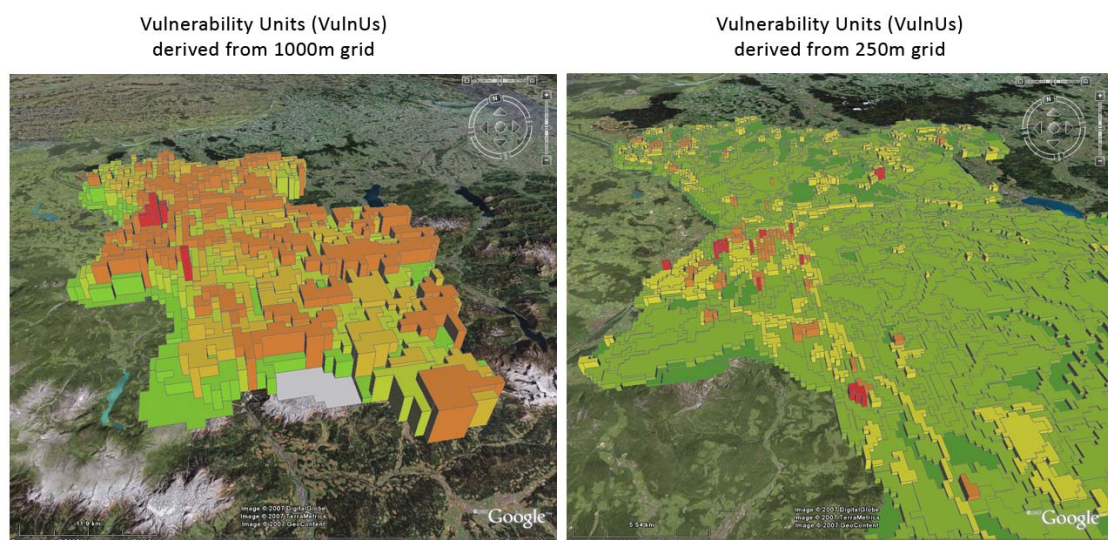


Figure 1. Geon set of vulnerability units (VulnUs) visualised in Google Earth

4. Analytical 3D Views

For visualization and information dissemination of geons (here: vulnerability units) we propose the use of virtual globes as tools for seamlessly combining data on several scales, referenced on a globe and 3D enabled (Figure 1). Freely available virtual globes (e.g. Google Earth, ArcGIS Explorer or NASA World Wind) are providing high spatial resolution contextual data enable to disseminate analytical information to a broad audience. The geons are displayed in virtual globes as Analytical 3D Views (Tiede & Lang, 2007b), which are vector information layers on different spatial aggregation (flexible aggregation units) using extrusion as a means for displaying the crucial spatial information (here: vulnerability measures).

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Biography

Stefan Kienberger is presently working as a researcher and PhD candidate at the Centre for GeoInformatics (Z_GIS), Salzburg University (Austria). His research interests lie in vulnerability science, disaster risk reduction and spatial modelling. Within his PhD research he is assessing the vulnerability to hazards on the district and community level in rural Mozambique.

Stefan Lang, senior researcher and research co-ordinator at Z_GIS, completed his academic qualifications with a PhD (Dr. rer. nat.) in Geography at Salzburg University (Austria). He is a specialist in GIScience and remote sensing for urban applications, nature conservation, landscape analysis and land use/land cover mapping. His research interests include multi-scale spatial modelling and the understanding of complex environmental and societal phenomena in space. Dr Lang is responsible for RTD projects carried out at Z_GIS, and is involved in various educational activities and capacity building projects for GIS and remote sensing in Southern Africa, South Asia and South America.

Dirk Tiede is research associate at the Centre for Geoinformatics (Z_GIS) at Salzburg University, Austria. Involved in a range of EU funded research projects in the field of GMES (GMOSS, LIMES), he is specialised in GIS application development and GIS modelling as well as image analysis using VHSR / LIDAR data and object-based methodologies. His PhD research is focused on the field of bridging remote sensing and GIS – from information extraction to 3D GIS-Visualisation. He is lecturing distance learning modules within the UNIGIS network and university courses in object-based image analysis, 3D Visualization, GIS-Analysis and GIS-Application development.