IMPLEMENTATION OF AN INTERACTIVE WEBGIS-BASED OBIA GEOPROCESSING SERVICE

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ABSTRACT:
In this paper we demonstrate the implementation of an object-based image analysis (OBIA) geoprocessing service, coupling OBIA and an interactive WebGIS application. The implementation is exemplarily shown for a 'Vulnerability GIS-Portal' established within the European Union FP7 research project MOVE "Methods for the Improvement of Vulnerability Assessment in Europe". The portal enables users to analyse vulnerability to floods in the Salzach river catchment (Austria). The novelty of the presented approach is the full integration of OBIA components (based on Trimble's eCognition Server) in the WebGIS architecture. Since standardized interfaces are not (yet) available, the connection has been programmed in the Python scripting language and made available via an ArcGIS Server geoprocessing service.

1. INTRODUCTION

Demand is high for heavily customized applications which respect the needs of users for individual and specific map representations. Today, WebGIS applications aim at this user group, resulting in a very high response. A special focus lies in the provision of geoprocessing WebServices, allowing any user the calculation of customized tasks over the web (for a detailed overview see Brauner et al. 2009)

Such online technologies introduce new possibilities in offering research methodologies and the presentation of results to a broader community. Information and computational models can therefore be widely distributed without releasing base data and processing models.

Most geoprocessing WebServices are built on established GIS tasks and GIS workflows, the developments of easy to establish and easy to use services are most advanced in this area (e.g. ESRI's ArcGIS Server technology, but also Open Source projects are implementing the OGC conform Web Processing Service (WPS) interface specification).

Applications focussing on object-based image analysis (OBIA) or rather combining GIS and OBIA are at the moment still limited to desktop solutions. In this paper we demonstrate such a novel implementation based on an interface programmed in the Python scripting language for coupling OBIA (here: eCognition; Trimble Geospatial) and GIS WebServices (here: ArcGIS Server, ESRI) with a WebGIS portal for interactive (expert-based) parameterization of the analysis.

2. CASE STUDY

The catchment of the Salzach river in Austria is largely affected by floods. Currently different protection measures are implemented which mainly target the hazard side. Within risk assessments, two essential domains have to be assessed. On the one hand the hazard has to be identified and modelled (e.g. flood hazard zones), whereas on the other hand the vulnerability of elements at risk has to be assessed. In the context of the European FP7 research project MOVE (Methods for the Improvement of Vulnerability Assessment in Europe, http://www.move-fp7.eu/) a holistic and integrative conceptual framework of risk and vulnerability was developed (Birkmann et al, submitted). Under this frame, vulnerability includes the key factors exposure, susceptibility and lack of resilience. Additionally vulnerability is characterised by different thematic dimensions, such as the social, economic, physical, environmental, cultural and institutional dimensions. Within a (spatial) assessment the challenge is to identify relevant indicators and methodologies to combine them and represent an integrated and holistic view of vulnerability.

Kienberger et al. (2009) have developed a method to represent vulnerability as so-called spatial vulnerability units. The method is based on the conceptual approach of geons, which was published by Lang et al. (2009) and represents generic spatial objects that are homogenous in terms of changing spatial phenomena under the influence of, and partly controlled by, policy actions (ibid.).

The methodology of Kienberger et al. (2009) firstly identifies a set of indicators for the different domains of vulnerability. If required, they are combined in a first instance through weighted linear combination. Weights are derived from expert weighting exercises, who assign points according to the importance of indicators and certain sub-domains. In a final step, the vulnerability units (integrating single indicators, or those combined through weighted linear combination) are delineated through the application of a regionalisation algorithm approach (Baatz & Schäpe, 2000), implemented as multiresolution segmentation in the software eCognition. Here again the expert weights are used to allow a prioritisation of the different input variables. Figure 1 gives a schematic overview of the workflow.

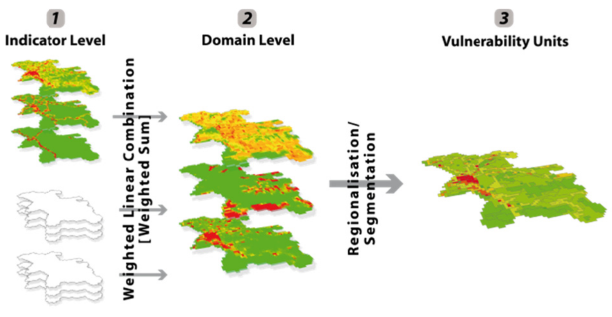

Figure 1. Workflow to generate vulnerability units at the different levels (indicator level [1], domain level [2] and final vulnerability units [3]) (from Kienberger et al., 2009)

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The delineation of such vulnerability units was applied for the Salzach catchment. However, the processing was not automatized and therefore the development of an interactive online portal integrating weighting mechanisms and object-based geoprocessing has been started. This should allow the different stakeholders and experts to automatically delineate certain hot spots of vulnerability. Additionally the portal is intended to serve the needs for decision makers within their assessment and analysis of risk zones.

3. IMPLEMENTATION

The following figure shows the client/server architecture of the geoprocessing WebService, the OBIA geoprocessing service component is encircled in red. At the backend ArcGIS Server is deployed to implement the service logic. Together with ArcGIS API for Flex it is used to provide GIS-processing and GIS-mapping capabilities as a basis for the user oriented web-based application. These technologies provide several ways of interaction, which allow users to participate in the cartographic process. The interface between ArcGIS Server and eCognition is encapsulated as a customized ArcGIS tool, which can be easily integrated into standard ArcGIS Server geoprocessing workflows (here: integration into a geoprocessing model which then can be published as ArcGIS Server geoprocessing service).

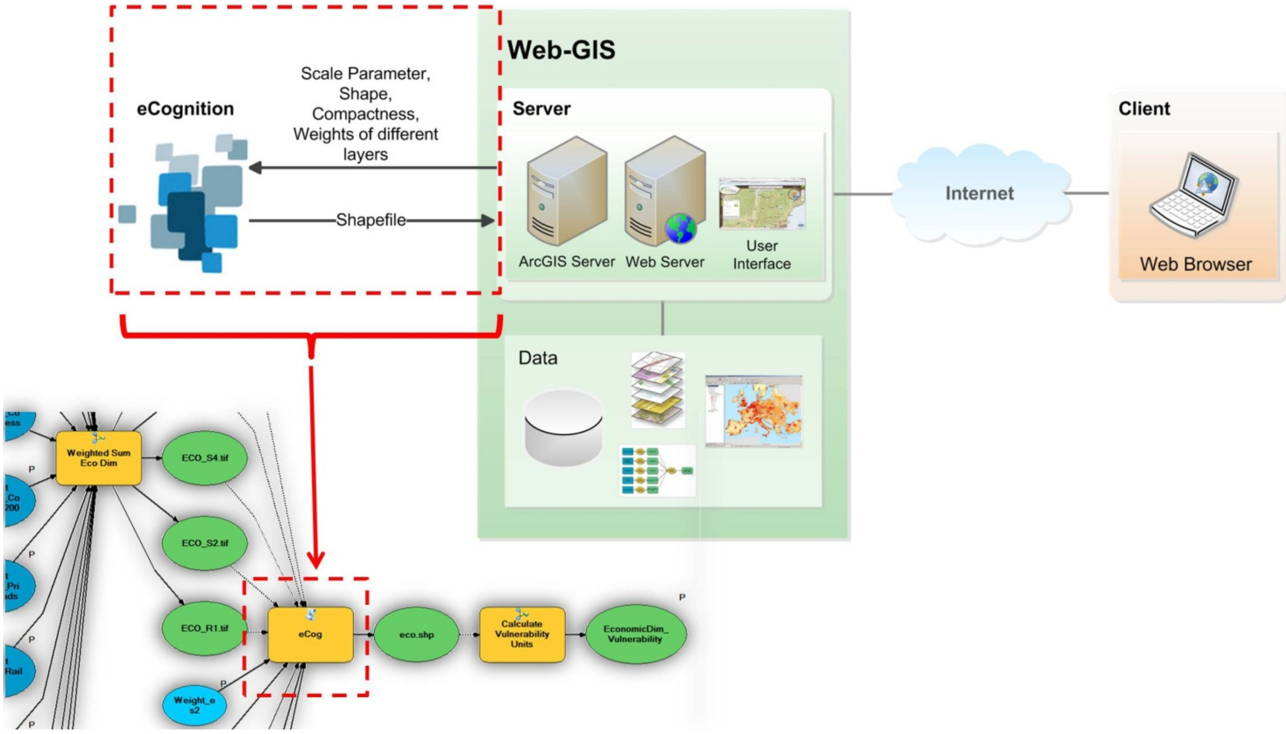

Figure 2. Architecture of the geoprocessing WebService. The OBIA component is encircled in red.

3.1 Web-Interface

SaveX, short for Salzach Vulnerability eXplorer, is a prototype of a web-based application which focuses on visualization and modelling of vulnerability for the Salzach basin. The WebGIS-portal offers an automated and interactive way of generating and visualizing vulnerability units and vulnerability hot spots. The application enables users/experts to influence the vulnerability calculations by weighting single indicators/domains (e.g. population statistics, land use classes, etc.) - relevant for the generation of vulnerability units - according to their priority. The customized outcome is displayed without the requirement of providing own data or installing additional software.

The Web-interface consists of three main components:

a) The map: to view pre-calculated or individual calculated vulnerability units, to explore the base data and the composition of the displayed vulnerability units (see Figure 3a)
b) The framework: context menu which is represented by a clickable diagram of the underlying MOVE framework. Tooltips enable the exploration of the single elements (see Figure 3b)
c) Calculation form: input mask for individual weighting of vulnerability indicators serving as input for the following calculations (Figure 3c)

The entry point to the geoportal represents the basic structure of the MOVE framework. Single elements of the framework, like the dimensions, are equipped with underlying interaction components. Clicking one of those opens a web form for the calculation of the individual vulnerability units per dimension.
Additional cartographic elements like navigation elements (pan, zoom etc.) and tools for displaying and analysing the data (e.g. table of contents, identify tool) are implemented as well.

Figure 3. SaveX web-portal overview and data exploration view, here: potential flood zones of the Salzach river, Salzburg, Austria) (a); the MOVE framework providing background information for the vulnerability analysis (b) and the input mask for individual weighting of vulnerability indicators (c) as basis for the vulnerability analysis (Figure 3b is based on Birkmann et al. (submitted), modified by Huber (2010))

3.2 ArcGIS Server – processing chain

The calculation, examination and visualization of vulnerability units, which are usually derived as a result from a scoring exercise with local stakeholders and experts, form the core elements of the WebGIS portal. To calculate different separate vulnerability scenarios a geoprocessing service is required. This service performs the 'Calculate Vulnerability' functionality, which incorporates the weighting of the different indicators as input parameters (e.g. the weighting of indicators like relevance of infrastructure or importance of different buildings for the physical dimension).

Based on these input weights the related raster layers (situational data per indicator like flood prone area, number and relevance of buildings, socio-economic factors etc.) were processed by the server and combined to sub-domains in a first instance through weighted linear combination.

The following final delineation of vulnerability units is the result of an additional weighted regionalization approach, realized within the eCognition software framework: The combined sub-domain layers and their individual expert weights were send to the eCognition Command Client and segmented accordingly. The result of the segmentation is passed back to the ArcGIS Server in a vector format (Shapefile), where further calculation steps were initiated (symbology and visualization). As a result two vector layers showing vulnerability units and derived risk zones are returned to the client. In Figure 4 the exemplarily calculated results for two different (arbitrary weighted) vulnerability dimensions are shown: Figure 4a represents results for the ecological dimension (risk zones) in the city of Salzburg, whereas in Figure 4b the results for the economic dimension (vulnerability units and risk zones) are displayed for the whole Salzach river catchment.

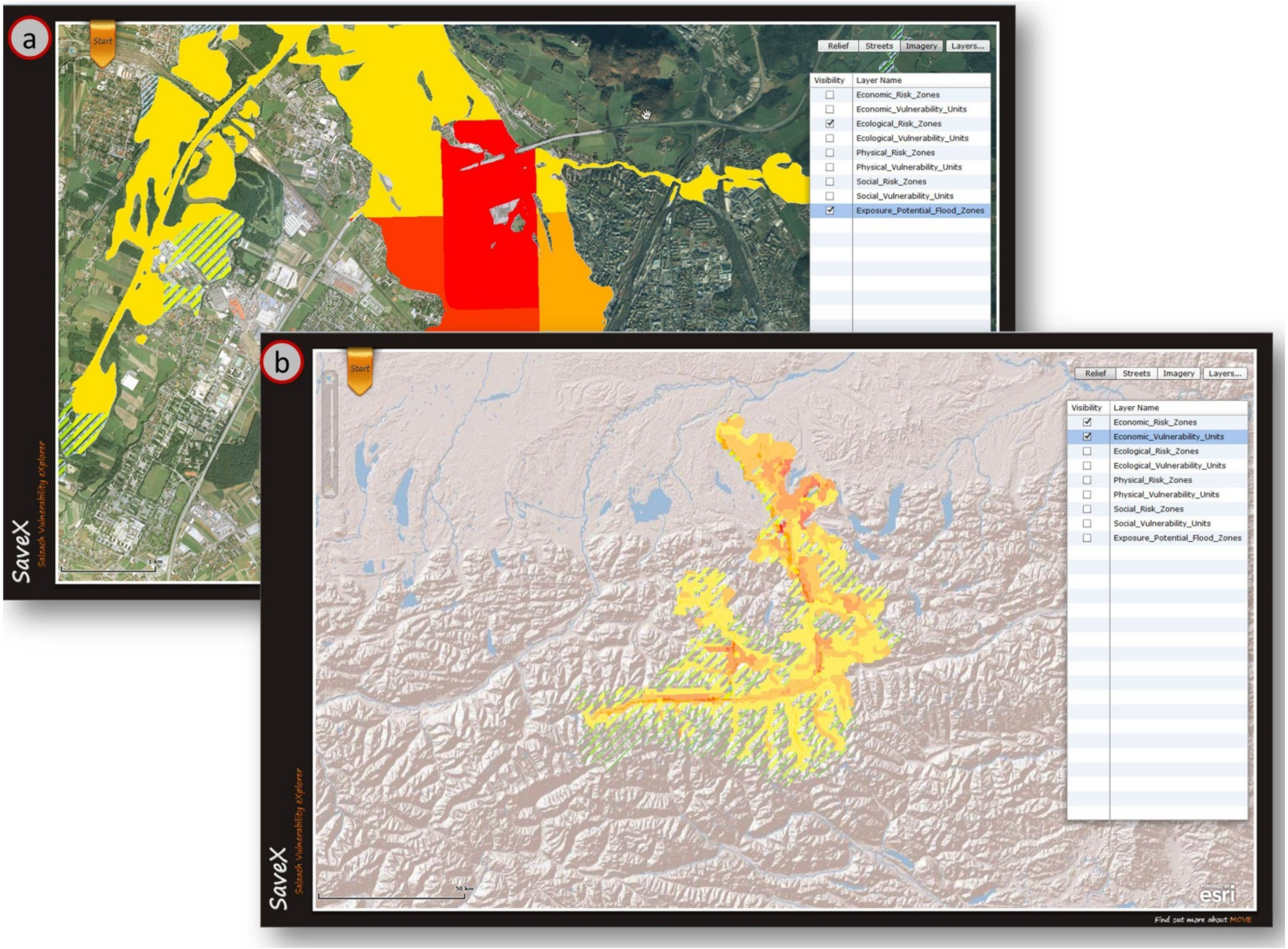

Figure 4. Results of the vulnerability unit calculation based on individual weighting of vulnerability indicators: (a) results for the ecological dimension (risk zones) in the city of Salzburg; (b) results for the economic dimension showing vulnerability units and risk zones for the whole Salzach river catchment.

3.3 eCognition interface

The connection of the eCognition software environment with the web geoprocessing architecture required some novel developments. Since standardized interfaces are not (yet) available, the interface has been programmed in the Python scripting language and made available as ArcGIS geoprocessing tool to be integrated into the ArcGIS geoprocessing service (OBIA-enabled geoprocessing service). The following elements were implemented:

- Fully-automated update of pre-defined OBIA rule-sets: The calculation of vulnerability units using regionalization (segmentation) techniques implemented in eCognition made it necessary to apply pre-defined OBIA rule-sets for the different vulnerability dimensions. Since the expert weighting had to be integrated into the segmentation parameterization (weighting of the different sub-domains), the pre-defined rule-sets needed to be changed before the calculation. Therefore the Python script parses the xml-based rule-set and changes the parameterization according to the individual WebGIS input.
- Fully automated object-based (image) analysis: The modified rule-sets were applied on the pre-combined raster layers (sub-domains) using the command line client version of eCognition (available with eCognition server).
- Export and integration of the resulting vulnerability units layer to the WebGIS application

The programmed Python-scripts were encapsulated as ArcGIS Tools which allows the integration into the vulnerability analysis model (implemented as ArcGIS ModelBuilder model, see Figure 5) and the following publishing as a geoprocessing service via ArcGIS Server.

4. CONCLUSIONS

The presented WebGIS-portal has been successfully tested; it transfers the approach of Kienberger et al. (2009) for the delineation of vulnerability units to a web-service, which was limited to desktop applications only.
It could be shown that OBIA methods can be integrated into such a geoprocessing service and the application is – to our knowledge – the first integration of an eCognition based OBIA application into an interactive WebGIS geoprocessing environment.
Further research is needed to address specific problems, like the performance of the implementation in respect to simultaneous multi-user access and computing performance if applied for larger areas. At the moment the interaction with the OBIA component is limited to the parameterization of a multiresolution-segmentation within eCognition, but in principle this is scalable to complex rule-set as well. Following

the presented scheme, the parameterisation can be directly changed within the xml coded (pre-defined) rule-sets, if the parameters to be changed are well defined. Therefore an implementation for other image analysis applications is feasible. This is also supported by the provision of the OBIA component as an ArcGIS tool and the possibility to integrate it into a larger geoprocessing framework.

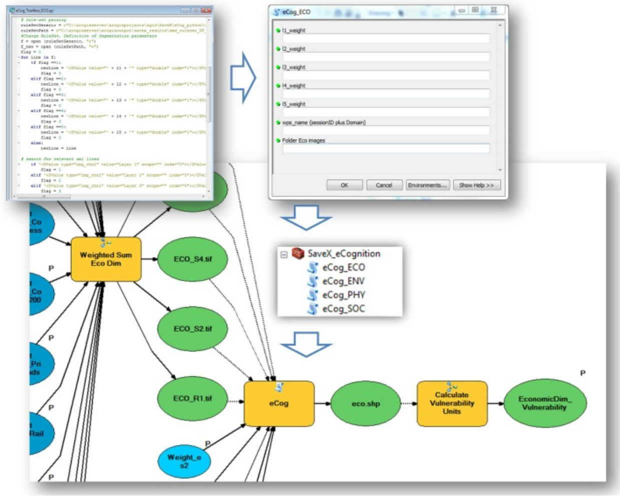

Figure 5. Integration of the eCognition interface programmed in Python as an ArcGIS tool into the geoprocessing model (here illustrated on the example of the economic domain calculation)

5. ACKNOWLEDGEMENTS

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