Visualisation of benefits resulting from flood hazard mitigation: a GIS toolbox

Sven Fuchs, PD Dr.[1]; Micha Heiser, Mag.[1]; Stefan Hellweger, Mag.[2]; Willigis Gallmetzer, Dr.[2]; Bruno Mazzorana, Dr.[2,3]

INTRODUCTION

In order to visualize the benefits resulting from technical mitigation, a toolbox was developed within an open-source GIS application that allows for an assessment of gains and losses for exposed buildings. As a result, beneficiaries of risk reduction may be identified and - more general - also different mitigation options may be strategically evaluated with respect to the height of risk reduction for different objects. As such, multiple management options can be ranked according to their costs and benefits, and in order of priority. The case study for the development of the tool, implemented using the software QGIS (see www.qgis.org), was the community of Innichen-Vierschach in South Tyrol, Italy (Fuchs and Heiser 2014). Starting with different scenarios showing the changes in flood magnitude with respect to the considered management options, the computation was based on the amount and value of buildings exposed as well as their vulnerability, following the general concept of risk assessment (Hübl et al. 2009; Kienholz et al. 2004).

METHODS

A relational database composed from different modules was created in order to mirror the requirements of an open source application and to allow for future dynamics in the data availability as well as the spatiotemporal dynamics of this data (Fuchs et al. 2013). An economic module was used to compute the monetary value of buildings exposed using (a) the building footprint, (b) the information of the building cadaster such as building type, number of storeys and utilisation, and (c) regionally averaged construction costs. An exposition module was applied to connect the spatial GIS information (X and Y coordinates) to the hazard information in order to achieve information on exposure. An impact module linked this information to vulnerability functions (Totschnig and Fuchs 2013; Papathoma-Köhle et al. 2015) in order to achieve the monetary level of risk for every building exposed. These values were finally computed before and after the implementation of mitigation measure in order to show gains and losses, and visualised.

IMPLEMENTATION

The core of the tool is a computation model to calculate the difference between losses before and after the implementation of a mitigation measure (see Fig. 1). The following steps were necessary:

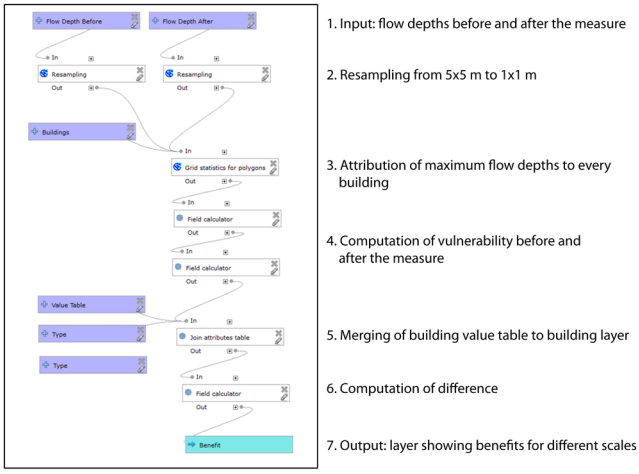

Figure 1. General workflow of the RiskTool Model.

- The input is a raster file with the process magnitude (flow height) for a 1/30, 1/100 and 1/300 probability of occurrence before and after the planned mitigation measure.
- The raster file is resampled in order to better merge the building polygons with the respective hazard magnitudes, and the raster file is merged with the building layer in order to assign maximum flow heights to every building polygon. This is repeated for the scenario before and after the implementation of mitigation measures.
- A vulnerability value is assigned to each building based on the information of flow height using available depth-damage functions (in our case for torrential processes following the vulner ability equation presented in Totschnig and Fuchs (2013)).

- A reconstruction value is assigned to each build ing by joining a table with the respective values based on the building category and the size of the building footprint.
- Finally, the balance before and after the implementation of the mitigation measure is computed and visualized on an object level in GIS. In parallel, the results are exported into a spreadsheet application (such as MS Excel), and based on additional information such as the operation life span of the measure, the associated costs, the interest rate and the rate of inflation the benefits can be computed and visualized in total numbers and in terms of benefit for individual building categories (Fig. 2).

	A	B	C	D
1	Benefits			
2				
3				
4		Return Period 30	Return Period 100	Return Period 300
5	Sum of Benefits	€ 125.458.724	€ 201.746.422	€ 186.710.382
6	Adjusted Benefits	€ 121.230.333	€ 127.900.707	€ 53.001.016
7	Total Benefits		€ 302.132.056	

Figure 2. Calculation of benefit. The amount of prevented loss according to different annuality is presented in the line SUM OF BENEFITS. ADJUSTED BENFITS are computed according to the lifetime of the measure (see Eqn. 1) and added to the TOTAL BENEFITS.

CONCLUSION

A tool has been developed for computation and visualization of possible benefits resulting from the implementation of flood mitigation measures, using the open source GIS QGIS. Costs and benefits can be visualized in spreadsheet applications graphically and in numbers, as well as using the mapping tool of GIS. The tool follows the requirements of open data and allows therefore the adaptation to other cases, the use of more precise data, and the implementation of other process modelling results.

KEYWORDS

cost-benefit analysis; risk assessment; visualisation

REFERENCES

- Fuchs S., Heiser M. (2014). Visualisierungstool des räumlich verteilten Risikos und der Kosten-Nutzenströme von Risikominderungsstrategien. IAN Report 162. Universität für Bodenkultur, Institut für alpine Naturgefahren, Wien
- Fuchs S., Keiler M., Sokratov S.A., Shnyparkov A. (2013). Spatiotemporal dynamics: the need for an innovative approach in mountain hazard risk management. Natural Hazards 68 (3):1217-1241.
- Hübl J., Keiler M., Fuchs S. (2009). Risikomanagement für alpine Naturgefahren. Wildbach- und Lawinenverbau 163:60-74
- Kienholz H., Krummenacher B., Kipfer A., Perret S. (2004). Aspects of integral risk management in practice - considerations with respect to mountain hazards in Switzerland. Österreichische Wasser- und Abfallwirtschaft 56 (3-4):43-50
- Papathoma-Köhle M., Zischg A., Fuchs S., Glade T., Keiler M. (2015). Loss estimation for landslides in mountain areas - An integrated toolbox for vulnerability assessment and damage documentation. Environmental Modelling and Software 63:156-169
- Totschnig R., Fuchs S. (2013). Mountain torrents: quantifying vulnerability and assessing uncertainties. Engineering Geology 155:31-44

1 University of Natural Resources and Life Sciences, Vienna, AUSTRIA, sven.fuchs@boku.ac.at
2 Department of Hydraulic Engineering, Autonomous Province of Bolzano, Bolzano, ITALY
3 Institute of Environmental and Evolutive Sciences, Universidad Austral de Chile, Valdivia, CHILE