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Uncertainty analysis in vulnerability estimations for elements at risk– a review of concepts and some examples on landslides

R. L. Ciurean and T. Glade
Dep. of Geography and Regional Research, University of Vienna, Austria

Decision under uncertainty is a constant of everyday life and an important component of risk management and governance. Recently, experts have emphasized the importance of quantifying uncertainty in all phases of landslide risk analysis. Due to its multi-dimensional and dynamic nature, (physical) vulnerability is inherently complex and the "degree of loss" estimates imprecise and to some extent even subjective. Uncertainty analysis introduces quantitative modeling approaches that allow for a more explicitly objective output, improving the risk management process as well as enhancing communication between various stakeholders for better risk governance.
This study presents a review of concepts for uncertainty analysis in vulnerability of elements at risk to landslides. Different semi-quantitative and quantitative methods are compared based on their feasibility in real-world situations, hazard dependency, process stage in vulnerability assessment (i.e. input data, model, output), and applicability within an integrated landslide hazard and risk framework. The resulted observations will help to identify current gaps and future needs in vulnerability assessment, including estimation of uncertainty propagation, transferability of the methods, development of visualization tools, but also address basic questions like what is uncertainty and how uncertainty can be quantified or treated in a reliable and reproducible way.