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A comparison of different vulnerability functions for mountain hazard risk management

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Until now, various works have been undertaken to determine vulnerability values for elements at risk exposed to mountain hazards, in particular with respect to torrent processes and snow avalanches. Yet, many studies only provide rough estimates for vulnerability values based on proxies for process intensities. However, the vulnerability values proposed in the literature show a high range, in particular with respect to medium and high process intensities. In our study, we compare vulnerability functions for torrent processes derived from studies in test sites located in the European Alps and in Taiwan. Based on this comparison we deduce needs for future research in order to enhance mountain hazard risk management with a particular focus on the question of vulnerability on a catchment scale.

The method applied is based on an ex-post approach examining recent incidences were information on both, the height of loss and the documentation of the hazardous event, were available. Vulnerability was quantified using an economic approach by establishing a quotient between the loss and the reinstatement value of every individual element at risk exposed. In a second set of calculations, this ratio obtained for every individual element at risk was attributed to the respective proxy for process intensity. The data were analysed in a spatially explicit way by using GIS. As a result, scatterplots were developed linking process intensities to vulnerability values. These data were analysed using regression approaches in order to develop vulnerability functions which served as a proxy for the structural resistance of buildings with respect to the torrent processes studied. Additionally, uncertainties were quantified by calculating confidence bands with different confidence levels (90, 95 and 99 %).

The results of this study have shown that fluvial sediment transport processes due to torrent events cause similar economic damage than damage related to debris flow processes. Hence, the general assumption that fluvial sediment transport processes are less destructive than debris flow processes cannot be confirmed by the present study. In general, the test sites resulted in a similar functional relationship of process intensities and damage ratio, which was shown in a respective vulnerability function. Even if the range in the results was considerable, the comparative assessment provided insight in an enhanced understanding of vulnerability to torrent events. If compared to previous studies published from the European Alps, the quantitative approach clearly resulted in comparable and reproducible results, which are important for any ex-ante approach as well as for a conversion of results to other test sites. Nevertheless, further research is needed with respect to a spatial and temporal resolution of vulnerability, since in the European Alps, a major trigger can be attributed to intense but local and therefore spatially limited thunderstorms, leading to either debris flows or fluvial sediment transport of moderate magnitudes, while the trigger in Taiwan is of typhoon type with a regional and therefore less-spatially limited extent leading to large-scale events.