Risk evolution in the Richebach torrent, Switzerland, from 1890 to 2010

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INTRODUCTION

Natural hazards cause high costs worldwide every year. To assess the potential losses, risk analyses are carried out. Risk in this context is a function of the factors natural hazard, elements at risk and their vulnerability (UNDRO 1982). To reduce the resulting damage of natural hazards, technical measures are constructed (Mileti 1999). However, the geomorphological and similarly the socio-economic systems are highly variable over time (Hufschmidt et al. 2005). Thus, the long-term effects of technical measures for risk reduction are contingently considering the dynamics of the hazard processes, elements at risk and vulnerability. Only few studies with multi-temporal risk analysis have been composed to address the challenge of risk evolution (Fuchs et al. 2004; Keiler et al. 2006; Schwendtner 2013). In this study, a multi-temporal risk analysis is conducted over nine time steps between 1890 and 2010 in Richebach torrent, Reichenbach i.K., Switzerland considering the fluvial processes debris flow, hyperconcentrated flow and fluvial sediment transport.

METHODS

To show its influence, each fluvial process scenario is modelled with and without the technical measure of the Richebach torrent. The scenarios with debris flow (an event with a 100-year recurrence interval) and hyperconcentrated flow (based on real event reconstruction) are modelled with RAMMS debris flow (Christen et al. 2012). The fluvial sediment transport scenario is modelled with Flo2D (O'Brien et al. 1993) and inputs of a flood with a 30-year recurrence interval. The analysis of elements at risk considers buildings and their potential structural damage. Two approaches are applied to assess the monetary values of the elements at risk and the vulnerability: Method [G] is based on data from the cantonal building insurance of Bern for the value at risk and the vulnerability according to the vulnerability curve by Papathoma-Köhle et al. (2015). Method [M] is based on building and vulnerability values according to EconoMe (BAFU 2010), a platform for practical cost-effectiveness calculations in Switzerland. The risk is calculated as building value times its vulnerability, which is based on one hazard scenario (occurring process intensity). Thus, different frequencies of the hazardous events are not considered. To show risk evolution, the risk sums of all time steps are displayed chronologically.

RESULTS

All scenarios reveal a clear decrease of risk in the time step 1927-1934 (directly after the implementation of the technical measure).However, the risk in % to 1890 increases until 2010 in all but one scenario. The exceptional scenario (debris flow) shows a risk decrease of almost 50% between 1890 and 2010. The other scenarios show increases in scales of factor 2-5. Although the qualitative comparison of the risk evolution shows a similar trend, the two applied methods illustrate a great dimensional difference. The development of number and values of the elements at risk in the area under investigation is linear and increases approximately by factor 4. The development of the averaged vulnerability values of all buildings indicate increasing and decreasing progressions depending on the considered fluvial process and applied method.

DISCUSSION AND CONCLUSION

This study illustrates the necessity of considering multi-temporal approaches to obtain a better understanding of long term effects of technical measures for risk reduction. The finding about technical measures not necessarily reducing risk in a long term range is consistent with recent literature (Fuchs et al. 2004; Keiler et al. 2006; Schwendtner et al. 2013).

Summary of compiled risk evolution paths showing different dimensions of risk depending on scenario (debris flow, hyperconcentrated flow, fluvial sediment transport) and depending on applied approaches: [G] based on insurance values of the cantonal building insurance and functional vulnerability values by Papathoma-Köhle et al. (2015). [M] based on mean building values and vulnerability values of EconoMe by BAFU (2010).

Scenario	Debris flow		hyperconcentrated flow		fluvial sediment transport	
technical measure (retention basin)	without	with	without	with	without	with
risk sum (Mio. SFr.) 1890/2010 Method [G]	1.03/2.9	0.103/0.512	1.12/2.98	0.858/2.47	6.38/37.7	4.03/28.2
increase of risk in % 1890-2010 Method [G]	280	497	267	288	590	699
increase of risk in % of real development 1890-2010 * Method [G]	-49		220		440	
risk sum (Mio. SFr.) 1890/2010 Method [M]	9.75/30.24	4.94/19.68	4.15/15.57	3.4/12.33	6.74/37.1	6.87/33.52
increase of risk in % 1890-2010 Method [M]	310	400	375	360	550	490
increase of risk in % of real development 1890-2010 * Method [M]	200		300		500	

* =Until 1934: considering the scenarios A (without technical measure), after 1934: considering the scenarios B (with technical measure)

Figure 1. Summary of compiled risk evolution paths

Furthermore the study reveals that the different methods to obtain vulnerabilities cause major uncertainties regarding risk analysis. Additional uncertainties arise due to the choice of the underlying scenario respective to fluvial process type and magnitude. The significant gaps between vulnerability values of the quantitative approach (Papathoma-Köhle et al. 2015) and the semi-quantitative approach of EconoMe (BAFU 2010) deserve great attention in order to reduce the uncertainties in risk analysis - and hence risk evolution.

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KEYWORDS

risk evolution; risk analysis; fluvial processes modelling; vulnerability

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