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# The 5 key questions coping with risks due to natural hazards, answered by a case study

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Based on Maslow's hierarchy of needs, human endeavours concern primarily existential needs, consequently, to be safeguarded against both natural as well as man made threads. The subsequent needs are to realize chances in a variety of fields, as economics and many others. Independently, the 5 crucial questions are the same as for coping with risks due to natural hazards specifically.

These 5 key questions are
I) What is the impact in function of space and time ?
II) What protection measures comply with the general opinion and how much do they mitigate the threat?
III) How can the loss be adequately quantified and monetized ?
IV) What budget for prevention and reserves for restoration and compensation are to be planned ?
V) Which mix of measures and allocation of resources is sustainable, thus, optimal ?

The 5 answers, exemplified by a case study, concerning the sustainable management of risk due to the debris flows by the Enterbach / Inzing / Tirol / Austria, are as follows :

I) The impact, created by both the propagation of flooding and sedimentation, has been forecasted by modeling (numerical simulation) the 30, 50, 100, 150, 300 and 1000 year debris flow. The input was specified by detailed studies in meteorology, precipitation and runoff, in geology, hydrogeology, geomorphology and slope stability, in hydraulics, sediment transport and debris flow, in forestry, agriculture and development of communal settlement and infrastructure. All investigations were performed according to the method of ETAlp (Erosion and Transport in Alpine systems). ETAlp has been developed in order to achieve a sustainable development in alpine areas and has been evaluated by the research project "nab", within the context of the EU-Interreg IIIb projects.

II) The risk mitigation measures of concern are in hydraulics at the one hand and in forestry at the other hand. Such risk management is evaluated according to sustainability, which means economic, ecologic and social, in short, "triple" compatibility. 100% protection against the 100 year event shows to be the optimal degree of protection. Consequently, impacts statistically less frequent than once in 100 year are accepted as the remaining risk. Such floods and debris flows respectively cause a fan of propagation which is substantially reduced due to the protection measures against the 100 year event.

III) The "triple loss distribution" shows the monetized triple damage, dependent on its probability. The monetization is performed by the social process of participation of the impacted interests, if not, by official experts in representation. The triple loss distribution rises in time mainly due to the rise in density and value of precious goods. A comparison of the distributions of the triple loss and the triple risk, behaving in opposite direction, is shown and explained within the project.

IV) The recommended yearly reserves to be stocked for restoration and compensation of losses, caused by debris flows, amount to € 70'000.- according to the approach of the "technical risk premium". The discrepancy in

comparison with the much higher amounts according to the common approaches of natural hazards engineering are discussed.

V) The sustainable mix of hydraulic and forestry measures with the highest return on investment at lowest risk is performed according to the portfolio theory (Markowitz), based on the triple value curves, generated by the method of TripelBudgetierung®. Accordingly, the optimum mix of measures to protect the community of Inzing against the natural hazard of debris flow, thus, the most efficient allocation of resources equals to 2/3 for hydraulic, 1/3 for forestry measures.

In detail, the results of the research pilot project "Nachhaltiges Risikomanagement - Enterbach / Inzing / Tirol / Austria" may be consulted under www.ibu.hsr.ch/inzing.