BED LOAD DELIVERY OF ALPINE MOUNTAIN TORRENT SYSTEMS DURING EXTREME EVENTS

DEVELOPMENT OF A GIS-BASED ASSESSMENT METHOD

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In alpine regions, many villages situated on alluvial fans are threatened by torrential events. In many cases, not only floods, but also and for the most part the transported bed load is responsible for severe damages. That's why experts, while making hazard evaluations, always have to estimate as precise as possible the expected bed load volumes during extreme events (return period 100 to 300 years). This task includes a lot of uncertainties, because processes in mountain torrents are complex, haven't yet been comprehended in all details and sometimes contain chaotic components.

PROJECT

The project presented here started 2004 and is financed by the Swiss Federal Office for the Environment. Its aim is:

- to contribute to a better understanding of bed load processes in mountain torrents based on the analysis of 60 extreme events which took place in the Swiss Alps.
- to develop from these results a GIS-based method to assess bed load processes and the total bed load which can be transported to the fan apex during extreme events.

DATASET

In addition to the existing digital spatial dataset, describing the watersheds topography, geology and land cover, a new data base was built. It contains information on 60 extreme events (all of which took place within the last twenty years) in Swiss mountain torrents with a watershed smaller than 10 km^2. The information used for this dataset was gathered either from event documentations or gained through field analysis after recent events, e. g. in August 2005. The following parameters in relating to bed load were considered:

Hillslope: sediment relevant area, delivery process, amount of delivered sediment

Channel: bed load relevant reaches of the channel and their function during the event, mobilization processes and erosion rates, transport process, accumulation processes and accumulated bed load volumes, total bed load at the fan apex

SYSTEM ANALYSIS

The raster-based spatial dataset of the above described 60 watersheds build the base for further investigations. In a first step, different system elements in the hillslope and channel area of the whole torrent system are defined subject to their function during the event. Then these system elements are spatially connected. Afterwards, every systems elements

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importance to the entire system and its influence on the total bed load at the fan apex is determined. The importance is weighted after the following criteria:

- Local disposition for bed load delivery given by the natural factors topography, geology and land cover in the system element area
- Influence of upstream situated system elements on the examined system element
- Influence of the examined system element on downstream situated system elements

Fig. 1 shows in a simplified example the longitudinal profile of a mountain torrent system: The channel system element X has a high local disposition for active bed load delivery, because the slope is steep and the channel bottom lies in an unlimited bed load source area. The release of a debris flow is possible. The influence of the system element X depends from its spatial position in the whole torrent system: in Situation 1 the system element X influences the system less, than in Situation 2, because it is followed by a flat system element (Y), where debris flows can be blocked up, and transported bed load can be accumulated. In Situation 2, the system element X influences the whole system more because there is no retention possibility downstream and the runoff entering the system element X from upstream has free transport capacity (e.g. because of a long rocky channel part (R) or an accumulation part (A) in the upper system elements) and therefore high erosion rates in system element X are expected.

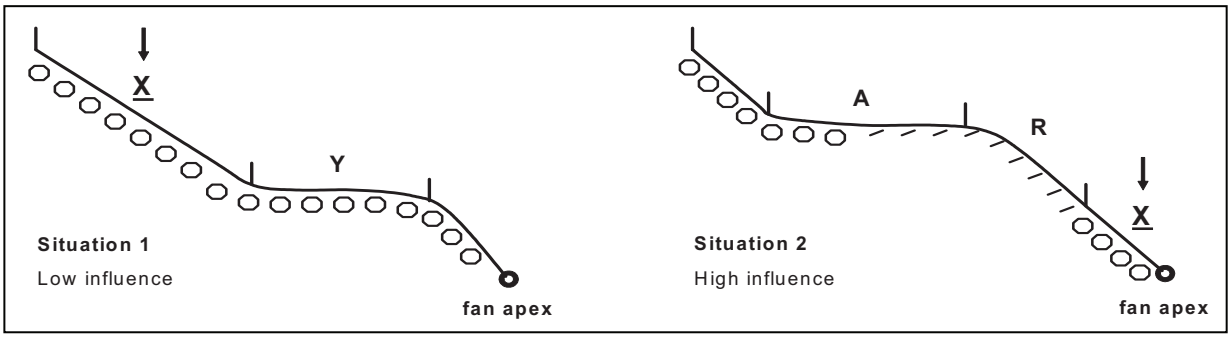

Fig. 1: Effects of the spatial position of a system element on its influence on the whole system

After this system analysis, the bed load balances observed during the 60 extreme events are statistically analyzed for every single system element. The aim is, to define and quantify threshold values subject to the local disposition of the system element and the accumulative disposition from upstream. These findings can be initiated as decision criteria and input-values for a rough calculation of the expected total bed load at the fan apex in the planned GIS-based assessment method.

GIS-BASED ASSESSMENT METHOD

Thus, results and products of this project and its GIS-based assessment method for mountain torrent systems will be:

- Detailed analysis of the torrent system and thereby predications of the disposition for bed load delivery during extreme events
- Conclusions about the sensibility of the torrent system, particularly in regard to key elements, that have an important influence on the whole system
- Rough estimation of total bed load of the torrent system transported to the fan apex during an extreme event, developed by the 60 analyzed watersheds and extreme events

Keywords: mountain torrent, bed load, extreme events, GIS, assessment method, case studies