ADVANCED SCENARIO-BASED HAZARD ANALYSIS IN PRACTICE

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INTRODUCTION

Resolving a substantial part of the uncertainties underlying the hydrological cause-effect chains, like those involving sudden morphological changes or clogging of critical flow sections, is doubtlessly a major challenge in hazard assessment. On the one hand purely numerical modelling approaches fail to accurately and precisely mirror such a wide rage of complex phenomena on the other hand through assessments based only on vaguely expressed expert knowledge the burden of prove still remains. As a consequence it is advisable to mutually corroborate the results stemming from either numerical analysis or expert knowledge through advanced scenario-based hazard analysis techniques. By conducting a case study on the Mareiter torrent in South Tyrol, Italy, we demonstrate the potential of these knowledge integration techniques to enhance hazard analysis in mountain streams and to increase, as a consequence, the reliability of the subsequently delineated hazard maps.

METHODOLOGICAL ASPECTS

As a first step we set up a convenient system representation functional to flood hazard process routing for the defined study (catchment area of about 90 km²) along the Mareiter torrent. Along with the specified objectives of the study to delineate reliable hazard zones for the location of Mareit and its surroundings we introduced a functional distinction between the loading and the response system (LS and RS respectively), i.e. between the confined part of the catchment where water, sediment and wood fluxes are generated and the unconfined areas subject to flooding such as alluvial fans and floodplains, respectively. In the loading system we carried out a process routing along the stream system and integrated the knowledge derived from models with expert judgement by Formative Scenario Analysis (Mazzorana & Fuchs 2010) in order to derive consistent scenarios and inferred their spatially probabilistic structure (Eisenführ et al. 2010). The outcome of the loading system scenarios analysis provided the input variables for the response system analysis. In each response system, two main types of spatial domains were identified based on the predictability of their dynamics, i.e. stochastic and quasi-deterministic domains (compare Fig. 1).

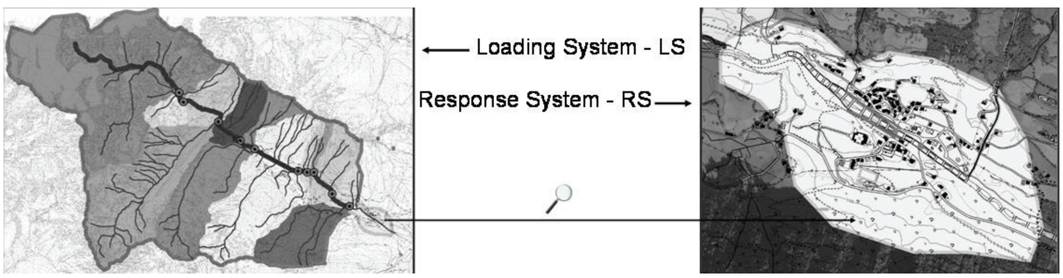

Fig. 1 Definition of the loading system (left) and response system (right). Concerning the loading system (left) the stream is subdivided into abstracted stream elements for process routing. Within the response system (right) the stochastic and quasi-deterministic domains are identified.

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The former represent stream sections or nodes where dynamic evolution cannot be realistically specified by deterministic models (two bridge cross-sections and two levee locations possibly prone to failure), whereas the latter refers to the part of the system where flow propagation can be computed with sufficient precision and accuracy by hydrodynamic models (e.g. stream channel and corridor).

RESULTS

As outlined in the previous section the chosen system representation scheme with an explicit distinction between loading and response system entails specific sets of hazard analysis techniques applied to unfold flood hazard scenarios. The resulting quantitative hazard evaluations are represented as follows: (1) for the loading system by a probabilistic process-tree which contains a spatially explicit representation of all process-chains considered to be possible and the corresponding subjectively assessed probability of occurrence; (2) for the response system by a complete set of process intensity maps. Each one of these corresponds to a specific system state (e.g. first bridge → clogged AND second bridge → free for conveyance AND left levee → stable AND right levee → failed) characterized by a defined probability of occurrence which is conditional upon the considered loading scenario and on the system behaviour within each stochastic domain. The system loading scenarios and the resulting hazard zone map in the response system are shown in Fig. 2.

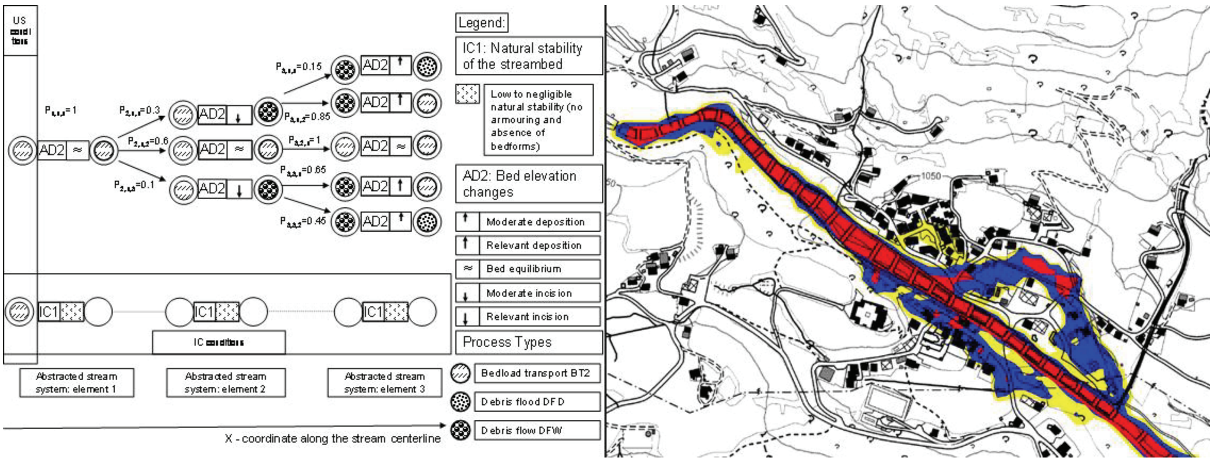

Fig. 2 Process scenarios in the LS (left) and resulting hazard zone map in the RS (right)

Despite its procedural complexity, the advantages of an advanced scenario-based hazard analysis are multi-fold especially for locations where the values of the elements at risk are high. First, the evaluation of how inundated areas change depending on bridge clogging allows for estimates of economical benefit of hazard reduction measures (e.g. structures to trap wood, modification of bridge type and geometry), and thus a cost-benefit analysis of such interventions. Secondly, the identification of the most critical sites can inform the Civil Protection agencies on where and how it is more efficient to concentrate efforts during a flood event, e.g. by placing crane machines close to critical bridges in order to keep them clear from driftwood obstructions. Finally, the need to take into account different flood scenarios in flood risk mapping is set by the EU Floods Directive 2007, and thus the methodology presented could be functional, after further tests and developments, to meet such requirements for the European countries.

REFERENCES

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Keywords: mountain hazards, hazard mapping, formative scenario analysis, risk management