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► To cite this version:

Corinne Curt, Jean-Marc Tacnet. Introducing new uncertainty theories into decision-aid methods: application to expert assessment of natural risks in mountains and hydraulic dams. 12e congrès annuel de la Société française de Recherche Opérationnelle et d'Aide à la Décision, Mar 2011, Saint-Etienne, France. 2 p. hal-00726716

HAL Id: hal-00726716

<https://hal.science/hal-00726716>

Submitted on 31 Aug 2012

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Introducing new uncertainty theories into decision-aid methods: application to expert assessment of natural risks in mountains and hydraulic dams

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Keyword: *natural hazard, hydraulic dam, information imperfection, reliability, expert assessment, multicriteria decision analysis, fuzzy logics, belief function theory, DST, DSMT*

1 Introduction

Management and control of natural and technological risks is an important societal issue. This paper deals more specifically with natural hazards in mountains (snow avalanches, torrential floods) and technological risks induced by hydraulic dams. In those two contexts, it is essential to provide methods and tools to make risk management the most safe and efficient as possible. These tools are used either by stakeholders or infrastructures managers. Decision are often based on imperfect information (uncertain, imprecise, incomplete, conflicting) provided by multiple and heterogeneous sources (numerical models, expert assessments, G.I.S). Information imperfection is classically represented by probabilistic approaches. In our application cases, knowledge is often lacking (epistemic uncertainty) and expert assessment can remain vague and qualitative. In those cases, probabilities remain quite subjective and other frameworks can be more efficient to represent imperfections. Two application cases using possibility, belief function theories and multicriteria decision making are described in the following sections.

2 Possibility-based approach for the assessment of dam safety

The reliability or safety loss of a civil engineering works can lead to deteriorations or failures such as dam failure. The development of tools and methods able to manage the reliability and the safety of dams represents a main industrial issue and an interesting way of research. The various data used in the assessment of these characteristics (visual inspections, monitoring data, design and construction information and data, calculated data obtained with mechanical models) are frequently imprecise, uncertain or incomplete. We use the theory of possibility ([1]) to develop a method that allows the representation of these imperfections, their propagation in a model developed for the assessment of the reliability and safety of dam and, if necessary, the proposition of a precise assessment of safety and reliability ([2]). The application of the method on real cases showed its relevancy and ease to use.

3 A new methodology to take decisions based on imperfect information

Rapid mass movement hazards such as snow avalanches or torrential floods put humans and property at risk with dramatic consequences. In a context of insufficient knowledge on natural phenomena, expert assessment is required for decision. Risk zoning maps are a typical application example: the choice of the zones limits is a decision that depends on several expert assessments and imperfect data [3]. These decisions are closely related to the availability, quality, and uncertainty of the available information resulting from measurements, historical analysis, eye witness accounts as well as subjective, possibly conflicting, assessments made by the experts themselves. Evidential reasoning and multicriteria decision analysis (ER-MCDA) [3] is a new methodology mixing the analytic hierarchy process (AHP) [4], a decision analysis (MCDA) methods [5], fuzzy sets [6], possibility theory [1] and information fusion using the belief function theories [7, 8]. Experts are considered as more or less reliable and provide imprecise and uncertain evaluations of quantitative and qualitative criteria that are combined through information fusion. At the end, this new methodology allows a decision to be taken and also provides an evaluation of the quality of information that was used to take this decision. It can deal with technical but also environmental and social aspects of decisions [5]. Such methodological results were used in specific information systems dedicated to risk management in mountains such as the avalanche information system [9].

4 Conclusion

Probability theory is often considered as the unique classical theoretical framework for risk assessment. This paper shows that alternative theories such as possibility or belief function theories can be used and combined to other decision-aid methods such as multicriteria decision analysis to take decisions for risk management.

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