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Stakeholder Group Consensus based on Multi-aspect Hydrology Decision Making

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Floods are a natural phenomenon. Their catastrophic impact is the result of an interaction between extreme hydrological events and environmental, social and economic processes. Yet, despite their undeniably negative impact, floods may also have a positive influence on the environment. Therefore, an integrated approach to flood management plays an important role in sustainable development. Such an approach requires bringing together experts from various fields, landowners etc. and forming a team of all involved stakeholders.

Exposure to flood risks can be mitigated by structural measures, e.g. by increasing river discharge capacity and by construction retention dams, as has been the practice in the past. However, recent experience has shown that absolute flood protection is neither economically feasible nor environmentally desirable. Hence, as demonstrated in the case study of the Zarosice catchment, it is the task of experts from various fields of competency, to conduct necessary evaluations and assessments. Also, landowners and people living in the region are invited to take part in a common discussion on how to solve problems related to flood risk most effectively.

In the case study of the Zraosice catchment a group of experts first of all analysed the catchment data, focusing particularly on designed rainfall data. The KINFIL model was subsequently applied, being the most adequate hydrologic tool for the purposes of this case study. The KINFIL model is one of the best suited models for converting design input rainfall and producing the corresponding output runoff. Previous experience has shown that a part of the urbanised territory of the Zarosice village suffered badly from periodical flooding. Therefore land use changes, which influence runoff conditions, had to be taken into consideration. There were many alternatives. Selecting the most feasible option, i.e. a combination of proper land use and management interventions, adequate flood protection measures and other improvements, reflecting the fact that, after all, we must live with floods, was not only the responsibility of expert, who base their decisions on scientific assessments from the biotechnical point of view, but also the responsibility of directly concerned stakeholders, who had to take into consideration also the economic and social aspects of the problem. This kind of shared responsibility led to a common consensus, underlining the importance of participatory planning in effective flood risk management.

Environmental and hydrological decision making includes assessment of risks and impacts, as well as action planning. Most of these tasks are ill-structured, multi-dimensional, complex, possibly multi-discipline, vague and uncertain. Sometimes it also may be appropriate to refer to knowledge, intuition and judgments of several experts, who have their own personal experience and intuitive understanding of the problem. The team of experts should represent a spectrum of standpoints and typically should comprise experts from the fields of hydrology and water resources management, nature protection, risk management, land use, civil security services, municipalities, economists, rescue team coordinators, land owners and other stakeholders.

Therefore, the team of experts must consider all the aspects of the problem. Some aspects of the problem may be of a conflicting nature. Therefore, in order to reach a feasible solution of the problem, it is not enough to simply aggregate the opinions of experts. Evaluating the level of mutual agreement is necessary.

In principle, the estimations of experts can serve two specific purposes:

(a) to find a solution to specific YES/NO problems,

(b) to estimate the value of specific attributes or parameters.

The estimations made by experts might be analytical or even intuitive. In both above cases, experts should have a possibility to formulate their opinions either in the crisp form, or as a fuzzy number or a fuzzy interval.

In order to tackle inherent conflicts of opinions amongst experts the overall reliability of conclusions should be

improved through consensus evaluation. Various averaging operators can be used to obtain a collective meaning. In order to measure and evaluate the level of agreement between experts, the authors developed a method for assessing the level of agreement and the value of τ-agreement, based on the Shannon theory of entropy. The authors also developed a special averaging operator *MaxAgM,* which maximizes the level of agreement. This averaging operator represents this value τ for which the best collective agreement of standpoints of all experts and stakeholders is achieved.

Our recently developed open access AGREEMENT software computes the value of τ-agreement and computes the value *MaxAgM* maximizing agreement.

The averaging operator *MaxAgM* can be used for both above mentioned purposes: averaging YES/NO estimates and estimating a value of a certain parameter, specified in a given interval of in possible real numbers.

The use of such fuzzy-group-agreement decision making procedure, involving a broad range of stakeholders, will be illustrated by the flood control case study in the village of Zarosice, Czech Republic.