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A. Zitek

S. Muhar

S. Preis

B. Bredeweg

P. Salles

*See next page for additional authors*

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**Presenter/Author Information**

A. Zitek, S. Muhar, S. Preis, B. Bredeweg, P. Salles, and S. Schmutz

## **Evaluating the potential of qualitative reasoning (QR) models to contribute to a sustainable catchment management**

**A. Zitek<sup>a</sup>, S. Muhar<sup>a</sup>, S. Preis<sup>a</sup>, B. Bredeweg<sup>b</sup>, P. Salles<sup>c</sup> and S. Schmutz<sup>a</sup>**

<sup>a</sup> *Institute of Hydrobiology and Aquatic Ecosystem Management  
Department of Water, Atmosphere and Environment  
University of Natural Resources and Applied Life Sciences,  
Max-Emanuelstraße 17, 1180 Vienna, E-mail: andreas.zitek@boku.ac.at*

<sup>b</sup> *Human Computer Studies, University of Amsterdam  
Kruislaan 419 (matrix 1), 1098 VA Amsterdam, The Netherlands,  
E-mail: bredeweg@science.uva.nl*

<sup>c</sup> *Universidade de Brasilia, Instituto de Ciências Biológicas, Campus Darcy Ribeiro,  
Brasilia - DF, 70.710-900, Brasil, E-mail: paulo.bretas@uol.com.br*

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Within the NaturNet-Redime project (NNR) Qualitative Reasoning (QR) models related to a sustainable catchment management were developed, following a general modelling framework (Bredeweg et al., 2007) and using newly developed Garp3 QR (Garp3, Bredeweg et al., 2008). Two models were developed in the River Kamp (Austria) case study (Zitek, 2006; Zitek et al., 2006): (A) Implementation of sustainable actions in a river catchment (stakeholder integration, quality of sustainability plans, development of ecological integrity and human well being, probability of catastrophic events), and (B) Hydropower production (water storage and release, water abstraction) and its effect on fish.

As a part of training and evaluation activities the potential of the QR models developed within the NNR project were evaluated by experts and students concerning usage in education and decision-making with regard to sustainable management of river catchments.

The models describe basic features related to the sustainable development of the River Kamp Valley in Austria. The catastrophic floods and inundations in August 2002 set new conditions for life and economy in the in the Kamp-valley facing flood control management, landscape architecture and land use planning with essential and future challenges. At the same time the question of an EU-Water Framework Directive (WFD) consistent treatment of the topics flood control/natural retention/prevention was arising. Consequently, the high water event finally represented a chance to develop the riverine landscape together with the local population as well as with the concerned scientific disciplines considering social, economic and ecological claims with regard to the EU-WFD. On this basis an overall integrated concept towards the sustainable development of the River Kamp landscape was developed at the University of Natural Resources and Applied Life Sciences, Vienna. Besides the consideration of the spatial scale (from catchment level up to planning onto municipalities) the interdisciplinary work of the different disciplines biology/nature conservation, landscape planning, water resources management, regional planning, agriculture and forestry and hydropower production is of central relevance for the project. Moreover, planning was conducted in participation with authorities, stakeholders and the local population. The integration of the population into the planning activities exceeded pure information policy with the possibility for the local population to actively participate in developing the future scenarios for their valley. Based on the experiences collected within the Kamp project, two models were developed.

Model A ‘Sustainability Management’ explores the different aspects of a sustainable catchment management. At the beginning of the process, the catastrophic event increased the fear of the population, which forced the politicians to become active for a more

sustainable development. The development of sustainability plans is modelled to be influenced by stakeholder participation (influenced by public information level, social development and accessibility to the decision making process), inclusion of scientific knowledge and preparedness of planners. The implementation of the plans itself (government action for SD) is assumed to be influenced by the quality of development plans, the resistance against measures (which is influenced by stakeholder participation) and personal interests that might cause a significant pressure to the implementation process. Sustainable actions are suggested to be positively related to human well-being and ecological integrity. The model is organized in 4 Sub-models: 'Community fear caused by a catastrophic event influences government action for SD', 'Stakeholder participation', 'Development and implementation of sustainability development plans', and 'Government influences ecological integrity of river basin and human well being'.

Model B explores important problems related to hydropower use in the Kamp valley and its effect on fish. Additionally the aspect of energy production, consumed energy and energy sold is modelled together with stakeholder satisfaction to represent the causal basis for hydropower use by stakeholders and the driving principle behind the tendency of increasing the amount of abstracted water to increase income and stakeholder satisfaction.

There are mainly two ways of influencing a river by hydropower use: (1) water abstraction and the creation of a residual or minimum flow stretch with the related effects to the physical environment like loss of water, loss of flow velocity reduction of depth and an increase of water temperature, and (2) the storage of water in a reservoir and a constant or peaking release of water from hypolimnetic parts of the reservoir which leads to decreased temperatures below the reservoir favouring cold water species and repressing the reproduction of warm-water species; if the water is on the one hand released at a constant rate this destroys the natural flow regime of a river, if released in a peaking mode ('hydropeaking') it affects fish due to the frequent changes of habitat conditions. Therefore model B focuses on the one hand the exploration of the two ways of hydropower use (direct use via a hydropower plant and abstraction to fill a reservoir with subsequent energy production). Additionally representations are developed that describe the effects of a reduced amount of water in the river (reduced flow velocity and increased temperature) and its effects on the fish fauna; both negative and positive effects of the changed physical environment on fish (favouring fish due to temperature increase or suppressing them; favouring fish with low requirements to flow velocity, the so called indifferent species, or suppressing species with high flow velocity needs, the so called rheophilous species) are captured in model fragments. In total eighth scenarios were developed and allow for a comprehensive analysis of the different effects of the different modes of hydropower production on sensitive guilds of the river type specific fish community of the river Kamp.

Both models were evaluated for their potential use in education and decision-making by students and experts. Generally a model evaluation basically covers 'validation and verification' of the model as well as the 'acceptance of the chosen approach and model' by the addressed stakeholder groups. Validation proves if the contents of the model are acceptable for its intended use, verification proves that the model is correctly implemented by a demonstration of its use. Proving the acceptance of stakeholders typically evaluates the potential of the model and the modelling approach for broader use.

Both evaluations, a general evaluation of Model A 'Sustainability Management' and an expert evaluations of Model A & B 'Water abstraction and Fish' yielded a very positive feedback with regard to the QR approach, the GARP3 software used to build models and the models themselves representing important issues related to the sustainable development of the riverine landscape Kamp. For example, using a 5-point scale (fully disagree, largely disagree, somewhat agree/disagree, largely agree, fully agree) most people 'largely or fully agreed' that QR models represent complex knowledge in an understandable manner and that QR and GARP3 can be seen as a valuable learning tool for understanding real world causal relationships related to a sustainable development of riverine landscapes. Also most people 'largely or fully agreed' that the presented QR models might significantly contribute to the understanding of students and stakeholders which entities and processes drive a sustainable development of a riverine landscape and therefore enhances their capability of making decisions. So the general aim, to produce software and models in QR language that

allow people to interact with and learn about sustainable development is clearly supported by the evaluation results.

Important additional statements related to the QR approach, the software and the models were also collected. Most interesting for the attendees was to see the interrelatedness of the system presented and the use of qualitative 'stock-flow' dynamics known from the System Dynamics approach. Only some added that they sometimes got a bit lost when confronted with the total view of the causal model describing a sustainable development of the Kamp valley. It was also stated that when showing these models to other user groups, their general ability to deal with complexity should be accounted for; meaning that for each user group the way of presenting the model should be adopted. Probably sometimes these models might be too complicated for certain stakeholder groups (people need to have some education e.g. to deal with complexity and causal relationships – to understand I's and P's for example, in a modelling approach like this). A high potential of an application of QR models in various fields, mainly in education but also in decision making and research was suggested by many participants. The potential of the GARP3 software and the QR approach to sustain collective, interactive social learning was clearly pointed out. Particularly, the identification of dependencies and causal relationships was seen as a prerequisite for understanding a system and therefore also for learning and decision making. With regard to a broader use of QR models in society especially for decision making it was stated, that it might take some time and engagement to establish approaches like that in society. (University) education using and teaching such approaches can be seen as an important basis for a further application. Summarizing, the QR approach developed within the NNR project was found to be able to capture and communicate mental models in structured way and therefore has a strong potential be used in education as well in the management processes themselves, especially for integrating different viewpoints of people within a 'mediated modelling process' (Van den Belt, 2004). This shared view can be seen as a prerequisite for the development of common actions (Rogers & Biggs, 1999) and therefore represents the basis for a sustainable catchment management, the main target of the WFD.

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