Analysing the resilience of complex resources management systems – a stylised simulation model of human-nature interactions in a river basin

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The uncertainties of global change and the complexity and unpredictability of the dynamics of social-ecological systems demand for new approaches to ecosystem and resources management. Rather than attempting to predict and control natural variability those approaches focus on strengthening the flexibility of a system to cope with unexpected change. The aim is to enhance system resilience and its capacity to adapt. Resilience is the potential of a system to remain in a particular configuration, to maintain its feedbacks and functions and to reorganise following disturbance driven change. Resilience is seen as an important stability property that determines the system's capacity to adapt to and benefit from change. A variety of mechanisms of resilience specific for different systems have been identified, such as genetic and biological diversity, redundancy and modularity, the capacity to learn and store knowledge and experience, to create flexibility in problem solving and balance power among interest groups. In the context of natural resources management a system's capacity to learn from and adaptively respond to stress emerges from interactions between biophysical and social processes. A sound understanding of mechanisms determining the resilience of coupled social-ecological systems is the basis for adaptive management of natural resources.
Simulation models of human-environment interactions are valuable tools to study factors and mechanisms that determine the resilience of a complex resources management system to stresses such as high variability in resources availability, extreme events and long-term changes. We develop a model of a coupled social-ecological system in a river basin to explore the influence of the organisational structure of water management, of cross-scale interactions among actors, information storage and flows, and other factors for the resilience of the coupled system. Special emphasis is put on the role of feedbacks between the human and the environmental system. The aim is to study the interrelationship between system structure and functioning treating the social-ecological system as a complex adaptive system. The model represents a stylized water management system, based on the context of the Amudarya river delta, where water resources are used to sustain agriculture as well as semi-natural fish populations. Besides irrigated agriculture fish is an additional source of income. The model combines a model of a water flows network with an equation-based model of a simplified aquatic ecosystem and an agent-based model of decision making and resources exploitation composed of simple rules. Decision making and information flows are represented at different scales (local, regional, national). The success of individual agents as well as the state of the human-used ecosystem depends on local water availability. Simulation experiments are carried out to test different settings of the agent's ability to obtain information and manage the resource in the face of different levels of variability and uncertainty in water inflow to the region. The resilience (measured as the global and local achievement of production goals, state of the ecosystem, etc.) of the different management regimes is compared. It is expected that the buffer capacities of a water reservoir and the ecosystem are important factors determining the resilience of the system. Access to and transfer of information and learning processes among agents are major factors influencing the capacity of the system to adapt. In the presentation the model concept and first simulation results are presented.