Developing a resilience framework for water resources systems

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INTRODUCTION

A framework for understanding the dynamics of complex systems is offered by the resilience theory (Bennett et al., 2005) which is now used in a variety of scientific disciplines.

In Namibia, water resources are generally scarce and their annual replenishment is highly variable. Water supply systems, e.g. surface water dams in urban areas or groundwater abstraction in rural areas, are of diverse size, but have complex interactions between people and water resources in common.

Management strategies for such systems require novel approaches of system analysis and modeling. The resilience concept is, although still in its infancy, an important tool for achieving sustainability (Folke, 2006).

Rural water supply in Otjimbingwe, Namibia: Wells and boreholes are connected to reservoirs supplying water to livestock and people

OBJECTIVES

The overall objective is the development of a quantification method for the resilience of water resources systems.

Preliminary objectives are to:

- analyse existing resilience definitions and frameworks
- elaborate a novel resilience framework for water resources systems
- apply the new framework to the focal area in Namibia

Resilience definitions

	ECOLOGICAL RESILIENCE	SOCIAL-ECOLOGICAL RESILIENCE	ENGINEERING RESILIENCE	RESILIENCE OF WATER RESOURCES SYSTEMS
DEFINITION	system capacity to absorb disturbance while retaining essentially the same function, structure, feedbacks, and therefore identity (Walker et al., 2004).	includes additionally the dynamic adaptive interplay of disturbance and reorganization, sustaining and developing (Folke, 2006)	the speed at which the system returns to the stable point or trajectory following a perturbation (Pimm, 1984).	system persistance to slow regime change and response and recovery after a shock, all depending upon the system's adaptive capacity (Wang et al., 2009)
FOCUS	persistence, robustness, change, unpredictability	adaptive capacity, transformability, learning, innovation	efficiency, recovery, constancy, predictability	robustness, recovery, adaptive capacity

RESILIENCE FRAMEWORK

In the manifold literature on the resilience concept a lack of clarity and practical applicability prevails (Brand & Jax, 2007). In order to progress in assessing the resilience of water resource systems, a framework was developed drawing on the guidelines of the Resilience Alliance (2007) and Cumming et al. (2005). It includes complex interactions, causes and rates of change, thresholds and consequences.

The conceptual framework provides an operational tool for developing an overall picture of the system and for assessing the resilience of complex adaptive systems. The application is not a static procedure, it rather might be necessary to move back and forward again.

1 UNDERSTANDING THE SYSTEM

DEFINING THE SYSTEM
- Significant issues and characteristic variables
- Boundaries: spatial and temporal
- Ecosystem services
- Key groups (policy, management and resource use)

➡ **Resilience of what?**

AFFECTING FACTORS
- Drivers
- Perturbations
- Changes: social and ecological
- Cross-scale interactions
- Controlling variables

➡ **Resilience to what?**

2 ASSESSING RESILIENCE

SYSTEM MODELS
- Mental models
- State-and-transition models
- Conceptual models

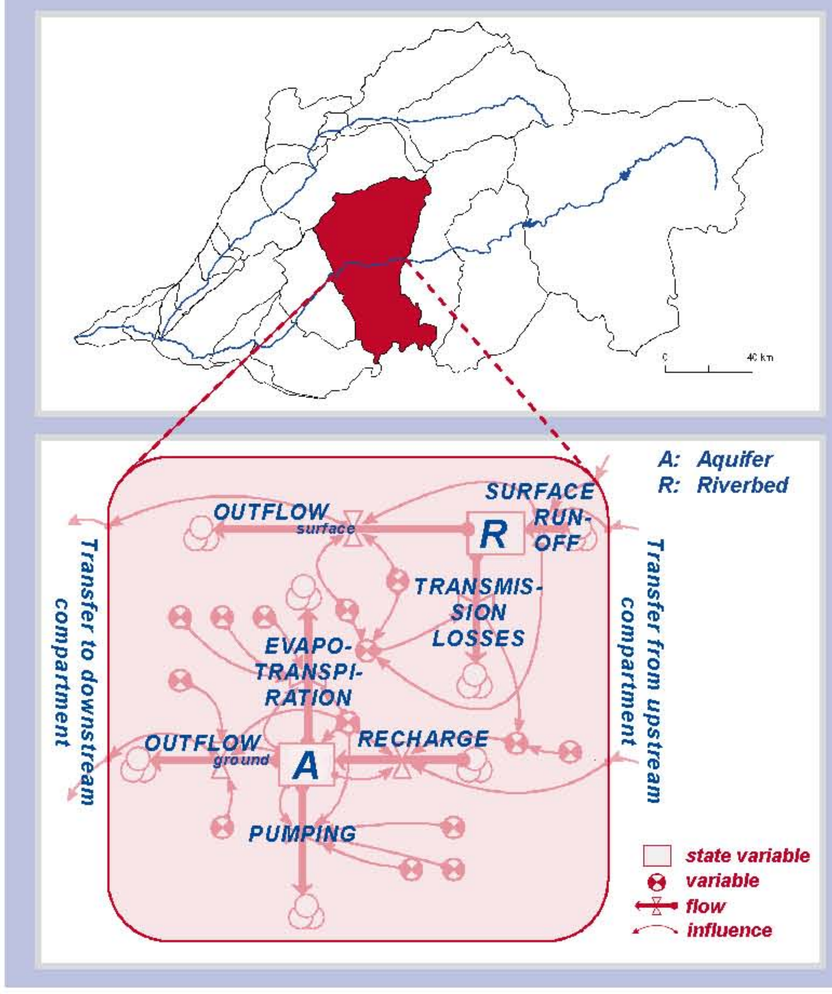
ALTERNATIVE SYSTEMS
- Scenario building
- Thresholds and consequences
- Feedback changes

QUANTIFICATION
- Probability of threshold exceedance
- Likelihoods of each scenario
- Uncertainty

MANAGEMENT
- Implications for management

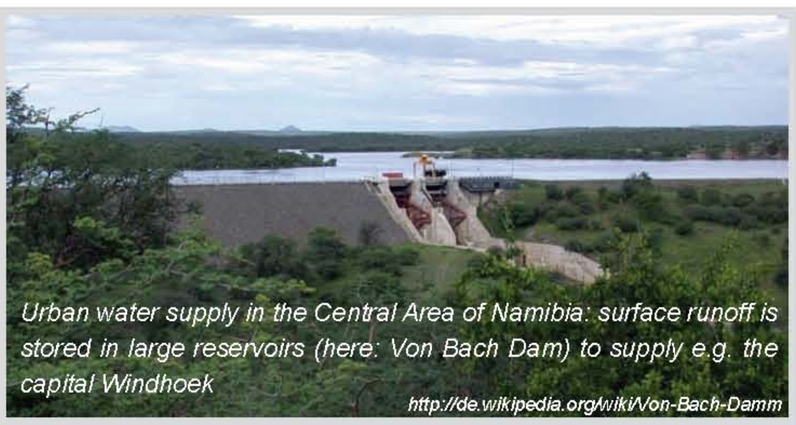
FOCAL AREA: SWAKOP RIVER, NAMIBIA

The basin is currently undergoing major changes due to the expanding mining sector leading to strong competition over water related ecosystem services. For a better understanding of the alluvial system, the model IGHMS (Integrated Geo-Hydrological Model of the Swakop River) will be applied and developed to be integrated into the resilience assessment.



The alluvial aquifer in the Swakop River basin is divided into compartments by natural barriers leading to a characteristic water balance with recharge and evapotranspiration being the dominant flows. One of these compartments and the contributing sub-catchments are highlighted in red.

IGHMS consists of a series of compartment sub-models developed in SIMILE which is a visual modelling environment for ecological, biological and environmental research. The application of IGHMS will help to explore the system trajectories under several boundary conditions. A first scenario analysis will include vegetation, dam and adaptive water management.



Urban water supply in the Central Area of Namibia: surface runoff is stored in large reservoirs (here: Von Bach Dam) to supply e.g. the capital Windhoek

http://de.wikipedia.org/wiki/Von-Bach-Damm

CONCLUSION

The resilience framework being developed is based on existing concepts. Yet, it lacks clarity in practical application. The focus of further research will thus be set on developing a quantification method for the resilience of water resources systems including system inherent properties such as mean residence time. Further, the resilience framework will be applied to the focal area, the Swakop River Basin in Namibia, in detail.

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