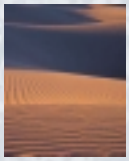
GLOWA

sponsored by
Federal Ministry
of Education
and Research

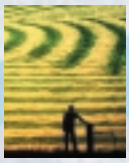
GLOWA

Global Change in the Hydrological Cycle







Research is providing tools for sustainable, far-sighted water management of large river catchments

Introduction to GLOWA

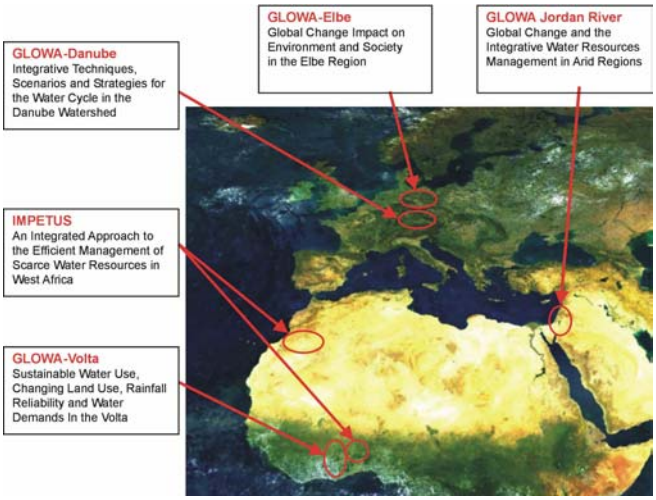
Actions in business and society no longer have a purely local focus and impact but involve increasingly the Earth as a whole. This process of globalization represents a challenge requiring new research strategies. Global Change Research is done with the objective of revealing to politics, industry and society the causes of the global pattern changes observed and the interactions involved, the extent to which the natural variability of global environmental phenomena is influenced by humankind, the extent to which changes can be forecasted, and the implications of these changes for social systems, in particular with regard to the aim of sustainable development. Because global environmental changes alter the current and future living conditions of people, there is an increasing need to shift this research towards more direct practical applications in order to help to provide answers to the questions raised by stakeholders and decision-makers. As a major contribution to this effort the German Federal Ministry of Education and Research (BMBF) has launched the program GLOWA.

Scientific goals

GLOWA focuses on the problem of water availability. The medium and long-term availability of water is not only called into question by the continuous growth of the world population and in some areas by the excessive use of water resources, but is also increasingly influenced by global environmental changes. The aim of GLOWA is to develop simulation-tools and instruments which will allow to develop and to realize strategies for sustainable and future-oriented water management at regional level (river basins of approx. 100.000 km^2), while taking into account global environmental changes and the socioeconomic framework conditions.

Within GLOWA five large cluster projects have been started. Two of them are located in Germany (Danube, Elbe), the other are investigating river catchment areas in North and West Africa (Draa, Queme, Volta) as well as in the Near East (Jordan). Each of these projects is tackling the following scientific core themes in an interdisciplinary and integrative research approach:

- Natural variability of precipitation, variations caused by human activities and their effect on the hydrological cycle
- Interactions between the hydrological cycle, the biosphere and land use
- Water availability and conflicting water uses



The GLOWA Chain of Cluster Projects

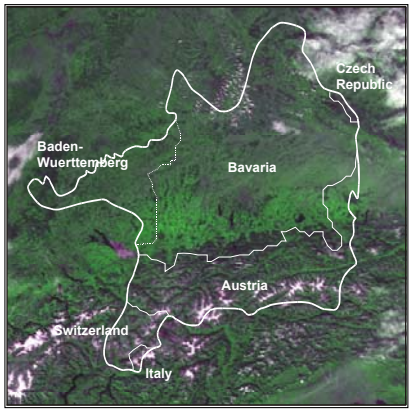
Research policy objectives

GLOWA aims to create a basis for the development of innovative technologies and cost-effective services for the sustainable, far-sighted management of water resources. In particular the GLOWA projects will:

- combine competence and capacities of various natural and social science disciplines thereby providing user oriented services on a sound integrated scientific and technical analysis
- develop scientific collaboration across different national and international programs, initiatives and sectors
- promote increased staff competence, in Germany as well as in the GLOWA partner countries, through special support for young scientists, exchanges of scientists and supporting vocational education and training in developing countries
- improve the transfer of knowledge between science and industry through co-operation, networking and staff exchanges

GLOWA-Danube
Integrative Techniques, Scenarios and Strategies for the Future of Water in the Upper Danube Basin

The aim of GLOWA-Danube is to build and use the integrative Global Change Decision Support System DANUBIA to investigate ways of sustainable future water use. It integrates the large expertise of involved partners to build a platform to *commonly* solve practical future water problems in the Upper Danube Basin.



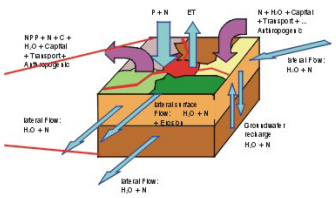
The Upper Danube River Basin

No single scientific discipline, with its inevitably unilateral view of the world, is capable to understand the complex interactions between nature, water and humans. Therefore hydrologists, water resources engineers, meteorologists, glaciologists, geographers, ecologists, environmental economists, environmental psychologists and computer scientists meet within GLOWA-Danube. Techniques to integrate knowledge and models across disciplines are developed and complex scenarios of future water resource management are simulated within GLOWA-Danube. The scenarios will be used to support decision making regarding water use in the Upper Danube Basin.

DANUBIA – an Integrated Global Change Decision Support System

In order to develop DANUBIA as a mutual transdisciplinary communication platform and to bridge the gap between the participating disciplines, new information technologies are intensively utilized. DANUBIA is both proxel- and network-based. Proxels (Process Pixels) are used in natural and social sciences to describe the spatial distribution of processes. The net

makes DANUBIA flexible and capable to directly apply the best models from each partaking partner.



The DANUBIA Proxel-Concept

Based on the de facto industry standard UML (Unified Modelling Language), DANUBIA for the first time in environmental modelling utilizes a corporate, transdisciplinary language to model, visualize and document. This opens up new ways for dialogue and creates new forms of cooperation between natural and social sciences. DANUBIA makes intensive use of remote sensing data as integrative spatial data source. Remote sensing is used to monitor Global Change and its influence on natural and social systems. DANUBIA will simulate water-related environmental management alternatives considering ecological, economical and cultural aspects, such as flood risk and protection, agriculture and water quality and quantity, tourism and water as well as water and climate. Decision makers will choose the most appropriate development solution based on simulated scenarios of future development.

Integration Area: The Upper Danube Basin

The 77.000 km² Upper Danube Basin, where many water-related problems (e.g. up- and downstream conflict, water and agriculture, water quality and environmental protection, tourism, Alps vs. forelands, flood risks, vulnerability due to climatic change) are exemplarily concentrated, serves as the experimental test bed for DANUBIA.

The Upper Danube Gauge at Passau

The Alps and their forelands enforce large gradients in climate, vegetation and water supply within a comparably small area. Along with good data coverage both in natural and social sciences, this makes the Upper Danube an excellent prototype for integrative research.

Global Change Impact on the Environment and Society in the Elbe Region (GLOWA-Elbe)

Overall objective

Development of integrated strategies towards the sustainable solution of

- problems in water availability and quality
- resulting conflicts in water use and allocation
- associated socio-economic and environmental problems.

Investigation area: Elbe River Basin

The Elbe River Basin (124,268 km^2) covers large parts of two central European countries, namely the Czech Republic (about 1/3) and Germany (about 2/3), and different geographical regions from middle mountain ranges in the west and south to large flatlands and lowlands in the central, northern and eastern part of the basin. A nested approach will be applied, which considers on the one hand the whole basin area (SP1, SP4) and on the other hand tributary river basins and subbasins with special conflicts and problems, namely the Spree/Havel River Basin (SP 2) and the Unstrut Basin (SP 3) (Fig. 1).

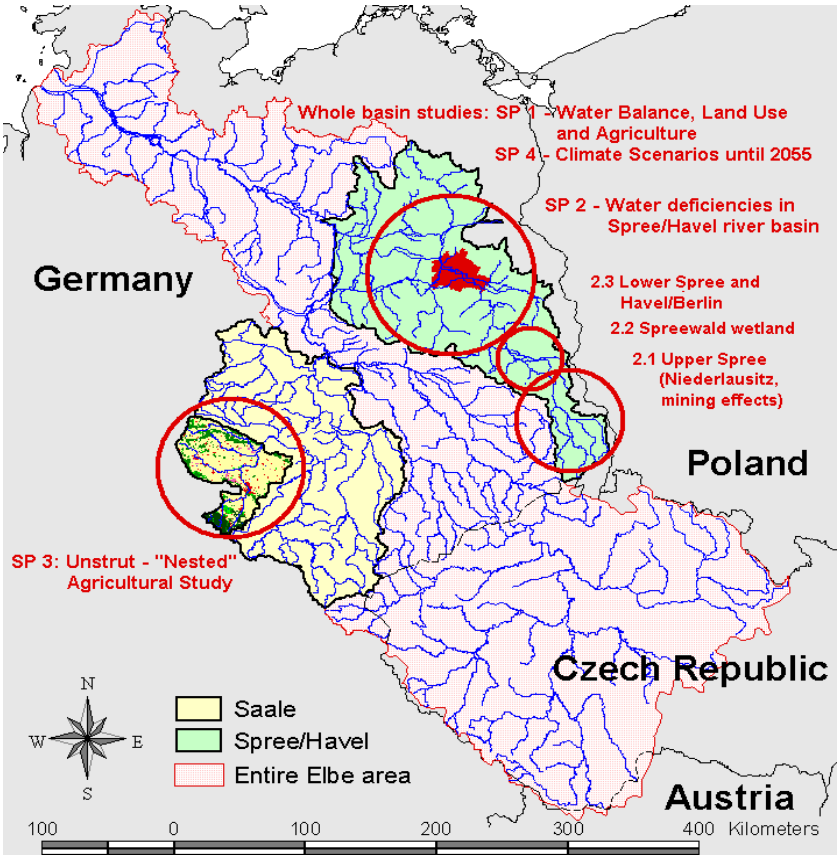


Fig. 1 *Multiscale "nested studies" and subprojects (SP) of GLOWA-Elbe*

Concept of an integrated analysis

A new integration approach was developed integrating environmental with socio-economic, i.e. social, economic and political aspects under changing conditions. It consists of four main steps (see Fig. 2):

1. Development of a catalogue to scenarios of change in climate, demographic and social development, trade etc. and possible actions at the regional scale (land use, policy etc.) taking into account the interests of stakeholders, decision makers and various interest groups (communities, environmentalists, etc.);
2. Identification of indicators of sustainability and corresponding criteria for the evaluation of different scenarios of development;
3. Analysis of the impacts resulting from the alternative scenarios of change with respect to the selected criteria, using all available data, models, expert knowledge, literature, etc.;
4. Multicriteria analysis and equity analysis to determine optimum or generally acceptable measures and programs for action to ensure sustainable development.

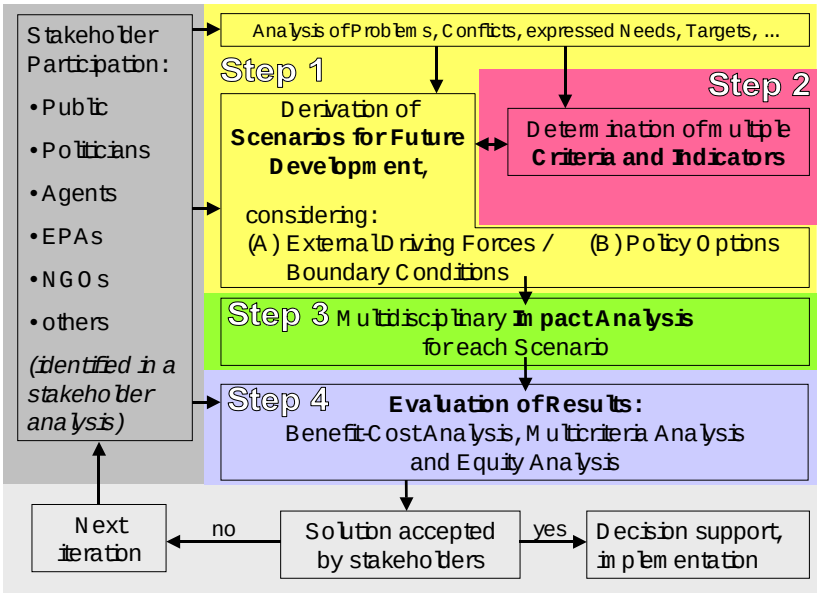


Fig. 2 *The GLOWA-Elbe Integration Approach*

This concept will be applied on different scales, firstly in the selected subregions and tributary river basins of interest (SP 2 and 3), and then in the entire Elbe Basin.

Research groups from four universities, nine research institutions and two private research companies are co-operating in the project to achieve the project objectives.

IMPETUS: An Integrated Approach to the Efficient Management of Scarce Water Resources in West Africa

In the IMPETUS project thorough investigations of all aspects of the hydrological cycle are carried out within two river catchments in North West and West Africa: the wadi Drâa in the south east of Morocco and the river Ouémé in Benin. This choice is motivated by the possibility that the climates of Africa and Europe interact through atmospheric teleconnections, and evidence that since the 1970s the droughts north and south of the Sahara have probably been related.

The two catchments of consideration. The DRÂA catchment in Morocco and the OUÉMÉ catchment in Benin are boldly bordered. A sub-catchment of 10.000 km^2 west of Parakou (HVO) has been chosen as an area of focused investigations in Benin.

Project A: The hydrological cycle of the Ouémé catchment and socio-economic implications

Since the early 1970s Tropical West Africa has suffered from a prolonged drought that reached its first climax in the first half of the 80s. All climatic zones, from the semi-arid Sahel and the sub-humid Sudanese zone down to the humid Gulf of Guinea, have been affected. These rainfall deficits have brought about a profound deterioration in the economic and social development of the West African countries, among which is also Benin.

A hierarchy of nested meteorological and hydrological models have been developed to assess the effects of environmental and anthropogenic change on the hydrological cycle and to analyse likely 'future scenarios'. Dramatic land use and land cover changes were already detected at a number of 'hot spots' for the last 20 years by remote sensing. Migration into the study area takes place in an institutional vacuum and without governmental support. The consequences are transformations of socio-economic structures on the local scale and changes in land use patterns. A close co-operation of the anthropological and medical sciences provides a basis for the detection of communal 'hazards' influencing the water system with respect to quantity and quality, the local perceptions of these dangers and the role of local risk minimising strategies.

Project B: Water-balance of the Drâa catchment area and socio-economic implications

Since the late 1970s, Morocco has experienced a number of extremely dry winter seasons, the causes of which are not fully understood. They are assumed to be related to changes of the large scale circulation on interannual and interdecadal time scales as manifested in the North Atlantic Oscillation or the El Niño-Southern Oscillation. Against this background, the development of sustainable water resource management is a strong necessity.

In order to address a number of imminent problems limiting the availability and allocation of water along the wadi Drâa 11 measurement sites were installed along a gradient of elevation and aridity. Monitoring of the thickness and the extent of the snow cover in the High Atlas mountains is essential to enable the competing water users (power generation, irrigation, domestic consumption) to have adequate supplies. In addition to seeking a better understanding and prediction of the geospheric, atmospheric, and biospheric components of the hydrological cycle, the IMPETUS activities centre around the questions of the influence, risks and resulting conflicts of human activities in the context of the specific social and economical structures encountered in the area.

Sustainable Water Use under Changing Land Use, Rainfall Reliability and Water Demands in the Volta Basin (GLOWA Volta)

The Volta Basin covers 400,000 km² of the sub-humid to semi-arid West African savanna zone. About 40% lies in Ghana, 40% in Burkina Faso, and 20% in Mali, Côte d'Ivoire, Togo, and Benin. Rainfall averages 1000 mm/yr of which only 9% (35 km³) becomes river discharge. Hydropower generation for the industrial South competes directly with irrigation development in the rural North over water resources.

Population doubles every twenty-three years, implying dramatic land use and land cover changes. Land use change affects the hydrological cycle in two ways. Firstly, the land surface determines how much of the rainfall evaporates and how much becomes available as runoff in the river. Secondly, changing the land cover changes the energy exchange between land and atmosphere thereby altering local weather patterns. Both impacts are simulated with a detailed atmospheric-hydrologic model for present and future climate.

Objective

Development of a *scientifically sound decision support system for the assessment, sustainable use and development of water resources in the Volta Basin* is the principal objective of the GLOWA Volta project.

Scientific approach

To reach the objective, predictions of both water demand and water supply throughout the basin are modeled. Water demand and supply are dependent on the socio-economic development of the region. It is, therefore, necessary to analyze and model not only the physical

environment but society as well. In effect, the GLOWA Volta project addresses many aspects of water resource development; from meteorology and hydrology, through pedology and agronomy, to economy and law. The foremost scientific challenge of the GLOWA Volta Project is to quantitatively link models from all these disciplines involved.

Important progress has been made in measurement and parameterization of surface-atmosphere interactions, development of a common sampling frame for collection of social and physical data, and on integration of hydrology, economy, and institutional analysis in a water use optimization algorithm. The latter is the nucleus of the decision support system that will guide regional managers of water resources in the Volta Basin.

Research network:

- *Center for Development Research (ZEF), University of Bonn, Germany*
- *Institute for Meteorology and Climate Research, Research Center Karlsruhe, Germany*
- *Institute for Tropical Medicine and Hygiene, University of Heidelberg, Germany*
- *Meteorology and Air Quality Group, Wageningen University, The Netherlands*
- *Savanna Agricultural Research Institute (SARI), Tamale, Ghana*
- *Water Research Institute (WRI), Accra, Ghana*
- *Institute of Statistical, Social and Economic Research (ISSER), Accra, Ghana*
- *Institut de l'Environnement et de Recherches Agricoles (INERA), Ouagadougou, Burkina Faso*

www.glowa-volta.de

Vulnerability of Water Resources in Eastern Mediterranean Environments - An Integrated Approach to Sustainable Management

GLOWA Jordan River focuses on one of the most critical regions of current and future water scarcity. Having one of the lowest per capita water availabilities worldwide does not allow enough food production for self sufficiency. Due to high population growth rates and economic development, water demand is rapidly increasing. Furthermore, climate predictions for the eastern Mediterranean, derived from large-scale climate models, indicate future aridification and increasing variability of precipitation. Prolonged drought periods in recent years, which have reduced surface and groundwater resources to record lows, may be first indications of this trend.

Ecosystems in the Jordan region are quite diverse, mostly due to a strong climatic gradient from sub-humid Mediterranean environments in the north to arid climate in the south and east. Four different biogeographic regions meet in the Jordan River basin. This leaves the regional ecosystems very vulnerable to changes in climate, in particular with respect to ecosystem functioning, species composition, and distribution of vegetation types.

Agriculture and irrigation consume more than two thirds of the regional water resources. Most water sources are located in the upper catchment of the Jordan River, from where large amounts of water are exported to the south and beyond the basin. A number of water use conflicts arise from this situation and from the fact that the Jordan River and regional aquifers are transboundary resources. Strategies for sustainable management of the regional water resources have to be based on collaboration between the various regional stakeholders and on a sound scientific knowledge.

Objective

GLOWA Jordan River is an interdisciplinary project that addresses the vulnerability of water resources in the Jordan River catchment under global change, as a case study of eastern Mediterranean environments. An integrated research approach provides scientific underpinning for sustainable and cooperative management practices. Results from GLOWA Jordan River should be transferable to other arid and semi-arid regions with transboundary water resources.

The project will also address non-conventional methods of water management, such as desalination, wastewater reuse, and water imports as well as their ecological and socio-economic implications.

Scientific approach

The multitude of stakeholders in the basin calls for a multilateral research consortium. Research institutions from Israel, Palestinian Autonomy, Jordan, and Germany contribute scientific knowledge from a range of sources, such as in-situ and remote sensing measurements, environmental monitoring and manipulative experiments, census and other socio-economic data, and modelling. A modelling framework is developed to integrate data, information and methods from various disciplines. A dialogue with regional stakeholders is held both, simultaneously with the design of research strategies and methods, as well as at a later stage when synthesising results, for producing information which is relevant for water management.

The main work packages of GLOWA Jordan River are: (1) global change, (2) water resources, (3) ecosystems, (4) agriculture, and (5) integration and stakeholder participation. Extreme events, such as severe drought spells will receive special attention within these work packages.

Jordan River

GLOWA