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IWRM

Integrated Water Resources Management: From Research to Implementation

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Integrated Water Resources Management: From Research to Implementation

FOREWORD

The sustainable treatment of resources in light of the global challenges posed by climate and demographic change is currently of the highest priority for mankind. The protection and sustainable management of water resources are of the greatest significance here: nearly a billion people have no access to clean drinking water, and circa 2.5 billion people have no waste water treatment. Five million people die every year as a result of deficient hygienic conditions, most of them children. The Federal Ministry of Education and Research (BMBF) has thus, in the framework program "Research for Sustainable Development – FONA", with the new funding priority "Sustainable Water Management - NaWaM", created the conditions for improving the use and application of the innovative potential of German research in addressing the global water challenges.

The BMBF supports Integrated Water Resources Management (IWRM) projects in cooperation with emerging and developing nations. IWRM concepts have been developed in selected model regions, ensuring the long term availability of water in sufficient quantity and quality through sustainable resources management, and the transferability of these concepts to other regions. In addition to developing technological innovations, the education of scientists, engineers and technicians in the partner countries is of paramount importance in achieving the long term realisation of IWRM.

This brochure introduces the range and high-profile results of the BMBF research funding initiative "Integrated Water Resources Management – from Research to Implementation". I wish the project partners and the people in the affected regions ongoing success in this important and vital work. The joint research projects have already lead to tangible implementations of IWRM and have improved access to clean drinking water for many people.

Prof. Dr. Annette Schavan, MdB
Federal Minister of Education and Research

TABLE OF CONTENTS

Background

Water is life. Societies need a sufficient amount of it for their economical and social development. People need water for drinking, agriculture and industry. Societies also need sustainable sanitation in order to protect human health and prevent damage to the environment.

Enormous deficits in water supply and sanitation as well as in the ecological status of waters face many societies. Currently, circa 900 million people suffer from drinking water shortages and circa 2.6 billion people live without safe sanitation. About 1.5 million children die each year due to water-borne diseases (United Nations 2010). These issues particularly affect emerging and developing countries. Poor water quality in many water bodies is the main problem in industrial countries and in the expanding industrial regions of emerging countries, which affects social prosperity and the ecological situation. Climate and land use change and population growth in many parts of the world will exacerbate these problems.

Consequently, the international community supports a sustainable water resources management. In 2000, state representatives emphasized the enormous relevance of this topic and established challenging millennium goals for improving access to water and safe sanitation: the number of people living without access to clean drinking water and without basic sanitary services should be halved by the year 2015 (United Nations 2000). Enormous investments in water infrastructures will be necessary in order to achieve these goals. A study by Deutsche Bank Research estimates that about 400 to 500 billion Euros must be invested annually in the global water economy (Heymann et al. 2010). The most urgent tasks are the development of integrated strategies and concepts and the adaptation of technologies to local conditions. The aim is to achieve an optimal distribution and usage of water without causing a quantitative or qualitative depletion of resources. The high academic and technological skills available in Europe, and especially Germany, can help to solve these water problems with a systemic approach.

Figure 1:
A boy at a water kiosk in Darkhan, Mongolia (Photo: L. Horlemann).

Approach

The Integrated Water Resources Management (IWRM) concept was established as an international guiding principle in 1992 with the Dublin principles and Agenda 21. This concept is based on the sustainable quantitative and qualitative management of the interacting components – surface waters, aquifers and coastal waters – in order to support not only social and economic development but also the preservation of ecosystem functions. Ecological, economic and social objectives must thus be linked, making the active participation and cooperation of different social and private actors in the planning and decision-making processes a necessity.

Definition of IWRM

IWRM is a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (Global Water Partnership 2000).

The Integrated Water Resources Management concept has recently become a top priority in the water sector, supporting numerous technical and conceptual innovations. With the concept, the water community moved from sectoral approaches to integrative and transdisciplinary practices. The key elements are summarized below:

- Water resources planning must be understood as a consecutive circular process. The management cycle includes the definition of long-term development targets and an action planning, which focuses on spatial, temporal and thematic priorities. The status of water resources and water infrastructures is continuously monitored in order to evaluate the success of implemented measures and to identify new challenges, which must also be considered in the setting of future goals.

- The basic units for planning and management are the catchment areas of rivers, lakes, ground waters and coastal zones. This approach requires institutional integration and coordination, as water catchment areas usually do not correspond to administrative and national borders.
However, a catchment area is not a closed unit but part of a nested system with interfaces to adjacent catchment areas. It can be considered as a part of a larger and ultimately international catchment area, which should be taken into consideration when setting objectives and in planning.

- There are complex interactions between the surface and underground compartments of a water body just as there are between water and land resources. All compartments should be considered integratively and should be managed with an ecosystem management approach.

- An Integrated Water Resources Management generally includes the perspectives of residents from both the upper and lower reaches of a catchment area, whereby the vulnerability of the lower reaches to up-stream activities, e.g. the discharge of waste waters, is to be given special consideration.

- The IWRM concept pursues a cross-sectoral framework plan, which equally considers qualitative and quantitative aspects and is ultimately directed to the protection and sustainable use of water resources. Knowledge from different disciplines (economics, ecology, political science, hydrology, engineering etc.) is to be incorporated in the alternative management plans.

Figure 2:
Sediment deposited by flash floods in Wadi Wala, Jordan (Photo: S. Geyer).

- An important element of IWRM is the participation of stakeholders in decision making processes. These include for example drinking water suppliers, waste water disposal companies, energy producers, waste management, shipping, agriculture and forestry, fishery or tourism, all of which are potential competitors for limited water resources. Appropriate structures must therefore be developed that integrate and balance the various demands for water resources. Political, institutional and economic reforms are thus crucial in many places in order to coordinate water policy with economic policy and other political sectors.

BMBF Funding Initiative IWRM

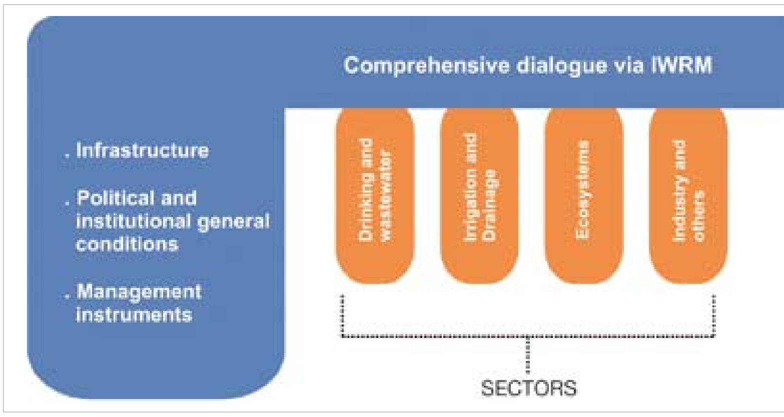
The Federal Ministry of Education and Research (BMBF) has consequently launched a funding programm on Integrated Water Resources Management. Under this funding priority, new approaches and concepts for Integrated Water Resources Management will be developed in suitable model regions of manageable size outside the European Union. The goal is to help improve the local population's access to clean drinking water and sanitary wastewater disposal. Industrial partners are to be involved at an early stage in the application of technical solutions in order to facilitate the exploitation of new markets for the German export economy.

Another focal point of the funding initiative is to support bi- and multilateral collaboration in the water sector and to facilitate transdisciplinary and international cooperation between science, industry, administration and supply and disposal practices. This will ultimately benefit Germany as a location for education and research.

Projects of the Funding Initiative IWRM

The Federal Ministry of Education and Research currently supports more than a dozen research projects on Integrated Water Resources Management and research and development projects with a comparable objective. The priority regions of the research initiative are shown in figure 4. The research

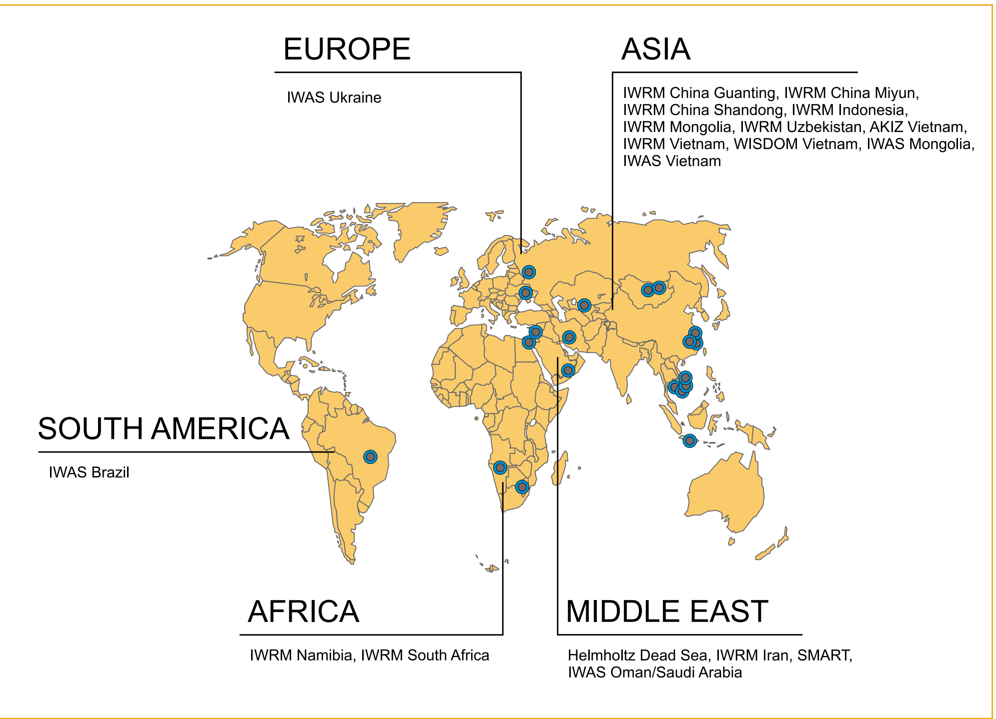
Figure 3: IWRM and its references to different sub-sectors (Global Water Partnership 2000, modified).



projects, which started between 2006 and 2010 are joint projects with partners from universities, research facilities and industrial companies. The project selection was based on an ideas competition and a transdisciplinary peer-reviewing process. The close cooperation of the joint research projects with partners in the target regions was a fundamental prerequisite for the development of adapted management concepts and the implementation of action plans. The basis for all projects is the integrated approach, which takes all relevant actors into consideration. However, concepts and methods should always be developed in the context of the geographical, ecological and socio-economic conditions. Thus, different problems will be addressed for each model region and adapted solutions will be developed.

The R&D-projects of the IWRM funding initiative are supported by two accompanying projects. Synergy effects on research activities will be generated within the context of a networking project, located at the Helmholtz Centre for Environmental Research – UFZ. The research initiative and its results will be presented to the expert community and in the political sphere (see page 49, Networking activities for the BMBF Funding Priority IWRM). A second accompanying project, supervised by the International Bureau (IB) of the BMBF, supports the projects in the implementation of the developed solutions and reviews the funding options from international donor organisations (see page 48,

Figure 4: Regions of the globe in which BMBF-funded research projects on Integrated Water Resources Management are in progress.



Potential synergy effects are thus to be used in the derivation of recommendations for further research projects, project administrators and the Federal Ministry of Education and Research. The following cross-cutting topics are particularly significant: Capacity Development, Instruments for Decision Support, Governance, Participation and Economics. The cross-cutting topics were discussed within the IWRM-networking activities during thematic workshops, international conferences and fairs as well as in topic-oriented workgroups. Some results of these discussions are presented below.

Support of the BMBF Funding Priorities „IWRM“ and „CLIENT“ by the International Bureau of the BMBF: „Assistance for Implementation“). The project administrator Karlsruhe, division Water Technology and Waste Management, and the project administrator Jülich, department Environment and Sustainability, supervise the individual projects.

IWRM Cross-Cutting Topics

The development of integrated management approaches and of conceptual and technical solutions within the framework of the IWRM funding initiative encompasses a variety of topics. However, the BMBF has made it a declared objective to support the exchange between project parties and other actors from policy, administration and economy with regard to specific cross-cutting topics and to gather the results of the individual projects together.

Figure 5: Participation workshop with local users in Northern Namibia (Photo: CuveWaters Project).

Capacity Development

The implementation of Integrated Water Resources Management is often unsatisfactory, although it is largely recognized as a basis for the necessary change from sectoral to sustainable water management. Besides an inadequate institutional basis for governance and participation, it is often the absence of necessary competencies which lead to the unsatisfactory outcomes. A far-reaching Capacity Development program is needed in the target regions in order to address this problem. Based on the definitions of UNDP (2008) and ALAERTS (2009), Capacity Development (CD) is to be understood as the process of improving existing skills, of strengthening problem solving abilities, of learning from experience and of generating knowledge.

Capacity = skills, abilities, qualifications

For a functional IWRM, individuals, institutions and society must be competent in order to be able to critically reflect and implement possible options. This multi-level approach addresses different target groups on all three levels: science, administration, economy, the public (water consumers) or schools. On the individual level, capacity development measures usually encompass education and training courses (for university students, engineers and other technical staff etc.). In addition to human resources development, a CD-concept encompasses organizational development, reform processes and the support of future development strategies. Knowledge transfer, awareness raising and exchange of experiences are the basis for a sustainable IWRM.

Capacity development is thus crucial for the activities of the BMBF funding initiative in order to achieve long-term solutions. However, CD is not limited to the project regions – the researcher's skills simultaneously increase.

The prospects of success increase greatly with the combination of an IWRM process with a suitable and adapted CD process. Care should be taken that successful concepts and measures are adapted to the specific local conditions, and adapted as closely as possible to existing knowledge gaps and the set objectives in the individual study regions, as well as efficiently using existing skills. A sustainable CD thus requires accurate knowledge of the specific structures in the target region.

Moments of inter- and transdisciplinarity in Capacity Development are of great significance and are increasingly being considered in the IWRM processes. There is a need for sufficient temporal and financial resources, particularly when people with very different experiences come together, in order to build trust and to accomplish participatory measures that increase competences. Finally, it is also important to encourage and strengthen the ownership of actors in order to achieve lasting results.

Figure 6:
Capacity Development in Mongolia
(Photo: D. Krätz).

Decision Support Systems

Usually, public decisions in favor of sustainable development are reached after a carefully executed decision-making process. The long running time of the decision-making process offers the opportunity to collect and collate information. Several choices of action can be simulated, further opinions can be obtained, concerned parties can be involved and all facts, assessments and positions can be balanced in order to make a good decision. Complex strategies and decisions are usually backed up by scientists and professional political advisers, who base their advice on scientific findings.

In the context of IWRM, complex decisions have to be made, so decision support systems can be helpful. Decision makers have to cope with a number of different, often even conflicting, interests. These can be the supply of drinking water, waste water treatment, irrigation, flood control, tourism and shipping and last but not least, the aim of achieving good chemical and ecological water quality. Additionally, economic principles such as cost efficiency, usage based attribution of costs and finally cost recovery also have to be considered.

Several general decision support system concepts may be implemented:

- Fully automated systems, that calculate multiple solutions based on the entered data
- Interactive systems that include expert knowledge and decisions
- Modelling Systems, that generate a general structure for decision processes e.g. in UML or as a flow chart.

Three types of systems can be used in the context of IWRM:

- Systems that structure and stage data. These are information systems for data storage, data management and data structuring. Decisions are neither made nor proposed.
- Technical systems that propose decisions. Those systems calculate benchmarked decisions optionally by simulating different scenarios and calculating uncertainties. This may lead to inconclusive results.
- Methods for structuring decision making processes. Technical and logical systems exist which help to structure processes. Decision makers have a more or less strict tolerance to reach a decision. The systems offer guidelines such as heuristics instead of recommended procedures.

Systems in the field usually use a hybrid model and cannot be assigned to one strict theoretical concept.

Figure 7:
A typical paddy in the Mecong delta
(Photo: WISDOM Project).

Economics

"The world is not short of water, the world is short of water management." This idea illustrates the point that there would be sufficent natural water resources in most of the regions of the world to cover local water demand if adequate water management were in place. The reality is that such good water management does not exist, especially in emerging and developing nations. In addition to the lack of knowledge and water wastages due to subsidized prices, a lack of funding for the sustainable operation, maintenance and reinvestment in existing networks and systems leads to their failure and inability to function in the long term. Investors (including the international donor banks) are thus increasingly recognizing that not only technical but also economic planning aspects should be considered in the planning phase. This also includes management tasks such as human resources development, monitoring and quality assurance.

Economic aspects refer to more than the technical compilation of expected construction costs; it is the "smart use of available resources, the perceptive planning and the far-seeing preservation of the capital". What Aristotle paraphrased in this context is known today as "sustainability". In the context of IWRM, the investment costs, operating costs and the refinancing perspectives must be tangibly described for the preferred projects. Through the integration of the three revenue types "TTT - Tariffs, Taxes, Transfers", social and ecological aspects are also inherently integrated (for the tariffs information on the affordability and willingness to pay of the water consumers is integrated, and with the taxes and transfers or grants information on the developmental political and ecological preferences is integrated).

The configuration of water prices has a central function as water prices have guiding functions. In the context of IWRM, political-social aspects (tax relief for people living in poverty) and economic-ecologial aspects (low water prices support the water wastage and make water cycles unprofitable) have to be balanced. The main economic understanding also applies for the concept of the Integrated Water Resources Management: At micro level, projects and investments are to be designed so that they function in the long term. High losses in the drinking water network lead to an increased use of ground and surface water, negative environmental impacts and the contamination of the natural water resources. At the macro level, the reasonable allocation of water resources is to be achieved. That means that the distribution of water resources should lead to the maximum economic benefit, without excessively exploiting the resources. In the context of IWRM and sustainability research, it is clear that the term "economically optimal" must cover more than just those values which can be expressed monetarily.

Figure 8:
There is a global need of investment funding for water infrastructures: Supply pipe for the hydropower plant Lam Dong, Vietnam (Photo: IWRM Vietnam Project).

Figure 9: Dilapidated infrastructure systems can often be ascribed to insufficient governance conditions (Photo: L. Horlemann).

Governance

The definition of the term Governance can vary greatly depending on the subject area and the field of application. Ultimately, however, the question is who decides what, how and according to which rules. All water governance definitions focus mainly on legal and organisational aspects.

A governance system consists of specific actors, institutions, interaction forms and governance structures, which build the framework for the development and the management of water resources. Central actors come from government, the private sector and from civil society. They act within a specific institutional framework of formal and informal rules and interact in either a hierarchical or negotiating manner. Certain governance structures such as markets, hierarchies and networks also determine a governance system. Taking this into account, a governance system can be configurated in many different ways.

The governance dimension is strongly associated with the IWRM concept. It can be assumed that the specific design of a governance system affects the decision making and implementation of IWRM. The global water crisis has thus, in recent years, been depicted as less of a physical problem, but increasingly as a governance problem: sustainable management normally does not fail due to a lack of knowledge on specific management measures but because of the inadequate political, social, economic and administrative conditions.

Water Governance refers to the range of political, social, economic and administrative systems that are in place to regulate development and management of water resources and provision of water services at different levels of society (Rogers and Hall 2003).

Research on governance issues is as diverse as the term governance. It ranges from simple analyses of the status quo to in-depth social science studies from different disciplines such as political science, economics and law. In the simple analyses, central actors (stakeholders) and the institutional structures (organisations, rules, processes) which are relevant for achieving an IWRM are identified and described. With in-depth socio-scientific studies, the support or hindrance of IWRM implementation by existing governance structures can be analysed, and those fields identified in which e.g. institutional changes would be required. In order to tackle tangible water issues, questions arise on the role of particular governance structures for effective and efficient problem-solving with respect to a sustainable water resource management and the functionality of specific political instruments such as taxes and prices.

Participation

What does participation mean in the context of IWRM? The question is legitimate: While the term IWRM is usually uniformly defined, there are many interpretations of the term participation. One common denominator of the different definitions is the understanding of participation as the involvement of persons concerned by political decision-making, who are not regularly involved in political decision making processes. Using a broad interpretation of participation, concerned persons can include a wide spectrum of persons from vital stakeholders to the individual water consumer. In the context of IWRM, these persons can be actors from civil society, business companies as well as political and administrative actors on different levels.

Which role does participation play in achieving an IWRM? After numerous discussions in relevant workshops and working groups, it can be assumed that participation is highly significant to the implementation of IWRM. Participation is particularly, but not exclusively, considered as a means to an end. The relevance of participation for IWRM is mainly explained with three central functions, which increase the effectiveness of decisions:

- Participation increases the knowledge level of the actors with regard to the sustainable handling of water resources. This applies to the general public, for example in the management of water-specific technologies, but it also concerns individual stakeholders who are introduced to other ideas through an intensive exchange of knowledge and thus leading them to perceive the complex reality in a more differentiated way.

- Participation supports the integration of interests: An intensive exchange of information requires the involvement of concerned actors and lays the foundations for the necessary cooperation.

Figure 10: German-Ukrainian stakeholder workshop in Ternopil, Ukraine (Photo: V. Kuzma).

- Participation is one condition for ownership: Often, it is only through participation that decisions are made understandable and acceptable and can thus be implemented.

Together, the three mentioned functions support a sustainable, comprehensive and cross-sectoral solution of water related issues.

Although the high potential of participation in achieving IWRM is well known, it becomes clear that the way in which participation processes are designed determines their added value. The central findings of the IWRM projects encompass the participating parties, the time frame and the way participation processes should be implemented. But in spite of the existence of relevant experiences, many questions concerning the design of participation processes remain unanswered. This includes, among others, the role of cultural and gender aspects in participation processes.

The Guanting project: Sustainable water and agricultural land use in the Guanting watershed under limited water resources

Project duration: 06/2009–05/2012
Geographic location: Watershed of the Guanting reservoir, Provinces Beijing, Hebei and Shanxi, North China

Project summary

Context and objectives

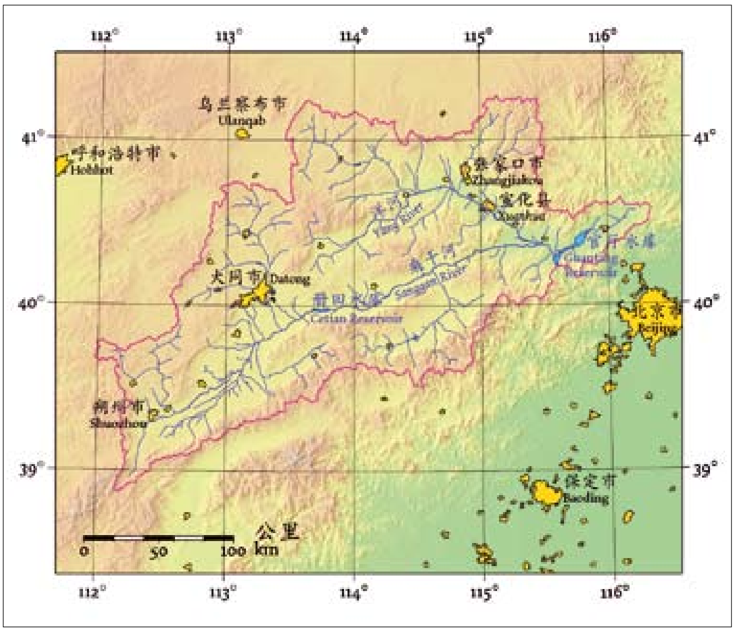
The region around Peking is distinguished by high economic growth and a distinctive urbanization and population growth. Longer persistent periods of drought, severe water pollution, water use conflicts and decreasing ground water levels present the provinces of Shanxi, Hebei and Peking with serious problems. As a result of climate change, the current situation could drastically intensify, if the total available water resources decrease, the growing season lengthens and precipitation is distributed more unequally.

The main foci of the Guanting-Project are the protection of sustainable water and land use within the Guanting catchment area, taking into consideration climatic, ecological and economic conditions.

The purpose is to provide a long-term water management plan to support the sustainable use of surfaces water resources. This „master plan" consists of four components:

1. important processes of global change including climate change, its regional characteristics and their effects on water quality, water demand and water pollution,
2. availability and demand in water quantity management,
3. requirements and quality class goals for managing nutrient discharge and improving water quality,
4. general recommendations for sustainable water management in the catchment area.

Figure 11: Guanting catchment area (Source: T. Conradt, PIK).



Study area

Catchment area: 43.000 km²

Average temperature (year): 10–13° C

Precipitation: yearly ca. 400 mm

Inhabitants: ca. 8,5 million

Agricultural used area:
10.900 km², ca. 4.000 km² of this is irrigated area

Figure 12: Guanting-Reservoir (Photo: Guanting Project).

www.guanting.de

Figure 13: Typical channel in the Guanting catchment area (Photo: Guanting Project).

Approach

The concept which was developed during the "GLOWA-Elbe Project" will be modified for the investigation area, in order to develop a regionally adapted and transferable water- and land use management concept. Four scenario-related target areas will be differentiated:

1. regionalization of global change scenarios: estimating the external driving forces, and particularly the expected regional specification of future climate and socioeconomic conditions,
2. balancing and evaluation of surface water quantity: long term balancing of surface water quantity supply and demand and integrated evaluation of management alternatives for the achievement of management goals,
3. balancing and evaluation of surface water quality: long term balancing of nutrient entry and normative targets for water body quality and the integrated evaluation of management alternatives for the achievement of 'good ecological status',
4. integrative measures planning: Recommendations for alternative water and land use management measures and strategies that may contribute to improving water availability and water quality in the region.

Results

The master plan offers opportunities for German equipment manufacturers and project developers, who aim to optimize water efficiency and water quality as well as minimize water conflicts. The efficiency and reliability of the models used in the project, STAR, CLM, SWIM, WBalMo and MONERIS, will be optimized for future use in this region as well as in Germany and Europe. The subsequent usage of STAR, CLM, SWIM and MONERIS is generally permitted.

Project partners in Germany:

- Potsdam Institute for Climate Impact Research, Potsdam (PIK)
- DHI-WASY GmbH, Berlin
- Leibniz-Institute for Freshwater Ecology and Inland Fisheries, Berlin (IGB)
- Institute for Applied Freshwater Ecology, Seddiner See (IaG)

Project partners in China:

- Hebei Provincial Academy of Water Resources, Shijiazhuang, Hebei province
- Shanxi Water Research Institute, Taiyuan, Shanxi province
- Haihe River Water Conservation Commission, Tianjin
- Beijing Hydraulic Research Institute, Beijing
- National Climate Centre (NCC), Beijing

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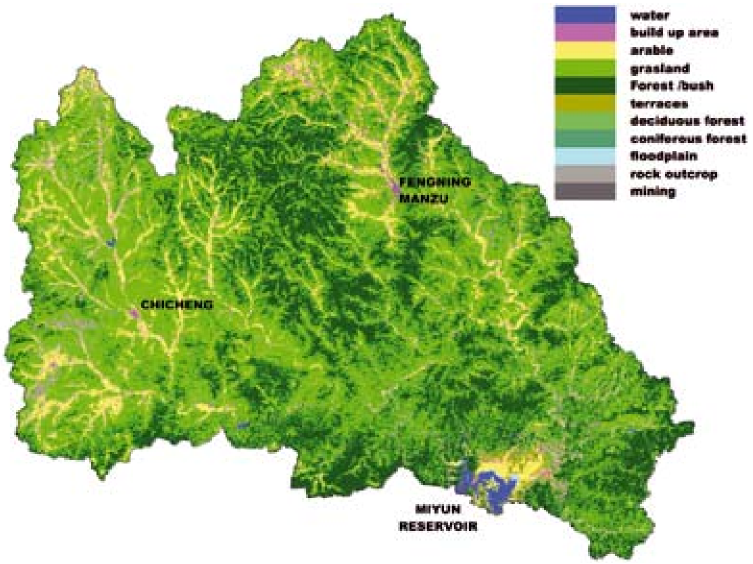
Development and implementation of a scientific based management system for non-point source pollution control in the Miyun basin near Beijing

Project duration: 10/2009–09/2012
Geographic location: Beijing Municipality , Province Hebei, China

Project summary

Context and objectives
The Miyun reservoir is one of the main surface water supply sources for the Beijing agglomeration. It suffers from increasing water quality problems caused by a relatively high population density that increases economic pressure on soil and water resources. Inadequate land use, over-fertilization, rapid crop rotations, excessive livestock breeding in scattered areas and uncontrolled disposal of waste are the main causes of pollution in the Miyun basin. Additional "stressors" include long term droughts, sediment delivery through debris flows as well as fishpond aquaculture, economy and tourism. The aforementioned causes lead to a continuing deterioration of the raw water quality from the Miyun reservoir, which is endangering the sustainable access to drinking water for the capital city. Improving the management of the Miyun watershed environment is therefore vital to securing the sustainable drinking water supply of the Beijing agglomeration.

Figure 14: Land use in the catchment from Landsat TM (data from 2009/2010; tasseled cap-procedure).



Study area

Area: ~ 16.000 km²

Altitude range: 330 to 2.000 m.a.s.l.

Average annual temperature: 11,8° C

Average annual rainfall: 619 mm

Land use: Cropland in the lowlands and floodplain forest / tree plantation in the mountains

Approach
Mass fluxes balancing model: collection and review of relevant data on climatology, geography, hydrology, land use, population etc. for the entire Miyun catchment in order to document a meso-scale water and nutrient mass balance model; these results are input into a model evaluating the main sources of water and solute fluxes in the catchment that serves as an underlying tool for scenario building and policy recommendations.

Monitoring and modelling: hydrological and pedological measurements and assessment in representative sub-catchments of the Miyun reservoir in order to identify main water and nutrient transport pathways; these results are input into a model documenting flows and leaching processes that then serves as an underlying tool for scenario-building and decision support.

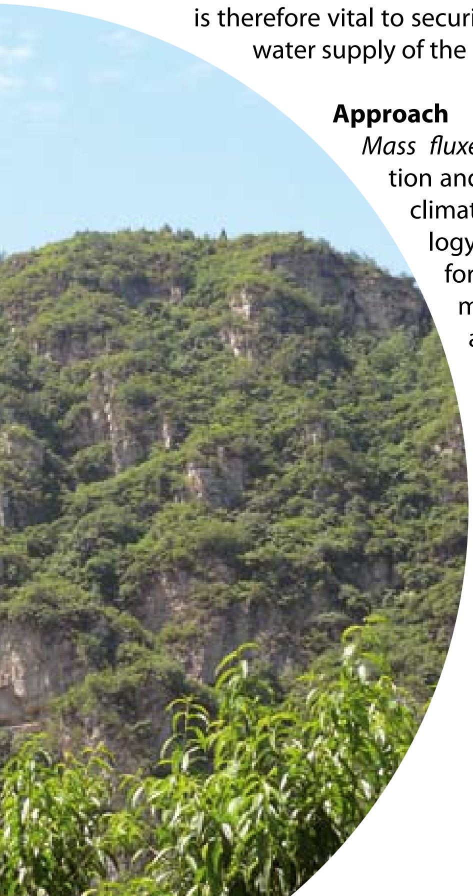


Figure 15: Almost pristine mountain forest in the western part of the Miyun reservoir catchment (Photo: G. Ollesch).

www.ufz.de

Figure 16: Installation of a sophisticated graviation lysimeter station (company UGT Muencheberg) at the Shixia research station (Photo: G. Ollesch).

Project partners in Germany:

- Helmholtz Centre for Environmental Research – UFZ, Department Soil Physics
- Rostock University, Institute of Environmental Engineering
- Society for Applied Landscape Research (GALF)

Project partners in China:

- Beijing Water Authority
- Beijing Soil and Water Conservation Center
- Beijing Capital Normal University

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Application and knowledge transfer: evaluation of waste water treatment systems adapted to the needs of the region and development of technical solutions and management systems for the reduction of nutrient inputs into the reservoir; these results are utilized to design a water resources management strategy and systems for securing the long term water supply of the Beijing capital city.

Results

The combination of advanced measuring technology, modelling techniques, scenario-building and decision support tools, which will be tested and proved in the project, could be used to encourage policy upgrades by the relevant water resources authorities with regard to the need for the establishment of systematic and continuous monitoring, documentation and enhanced water resources management planning in many areas in China where heavy and problematic diffuse and non-point pollution sources discharge into water bodies (lakes, reservoirs, rivers) that are considered of prime importance for the public water supply.

Integrated Water Resources Management (IWRM) Joint Project: "Sustainable Water Resources Management in the Coastal Area of Shandong Province, PR China"

Project duration: 06/2008–12/2011
Geographic location: Shandong Province, PR China

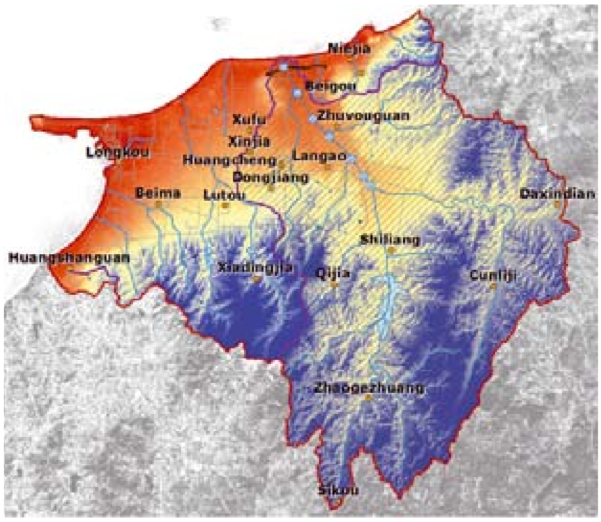
Project summary

Context and objectives
The Huangshuihe river basin is an outstanding example of water conflicts arising from piecemeal development, rapid population growth, industry, and agriculture that can only be resolved by an Integrated Water Resources Management approach. Over-exploitation causes problems for water resources management and agriculture resulting from saltwater intrusion into the groundwater system. Industrial and agricultural development is adversely affected by water shortages; water pollution has serious impacts on the health and livelihoods of the population and the natural ecology. The aim of the project is to improve water resources management in the Huangshuihe river basin. This German-Chinese joint project brings together traditional German water management expertise and recent developments, particularly relating to the EU Water Framework Directive, with current research undertaken in the coastal region of Shandong Province. It is intended that the project will later be regionalized to the scale of Shandong Province (156,700 km²).

Approach
An integrated water resources approach should be developed and implemented according to given regional social, economic and natural conditions. The project is split into the following four sub projects:

1. Socio-economic decision criteria for a decision support system (DSS), Institute for Ecological Economy Research (IÖW), Berlin
2. Development of a method to plan sustainable measures in the framework of an IWRM, DHI-WASY GmbH, Berlin (overall project coordination: Prof. Dr. Stefan Kaden) and Ruhr-University Bochum, Institute for Hydrology, Water Management and Environmental Engineering
3. Integrative concept for water saving, grey water recycling and wastewater reuse in households, industry and agriculture, Schlegel Consulting Engineers GmbH & Co. KG, Munich (including Prof. Geiger group, UNESCO Chair in Sustainable Water Management, Beijing/ Munich)

Figure 17: Project region in the Huangshui river basin, Shandong Province (Source: B. Monninkhoff, DHI-WASY).



Study area

Region: ca. 1.560 km² in the northern part of the Shandong peninsula

Coastline: ca. 64 km

Length of the Huangshuihe: 55.43 km

Climate: warm-temperate and semi-humid monsoon climate, featuring four distinct seasons and a marked rain period in months July through September.

Flow direction: from the hilly regions in the south and east to the coastal region in the north west

Figure 18: Exchange with a local farmer (Photo: K. Bossel, DHI-WASY).

http://dhi-wasy.eu/shandong.html

Figure 19:
Distinctive gate in the vicinity of a monitoring well (Photo: K. Bossel, DHI-WASY).

4. Development of a water monitoring and management concept for the Huangshuihe river basin, DHI-WASY GmbH, Berlin with UGT (Environmental Equipment Technology), Muencheberg.

Results

In the planning phase a methodology and a two-stage DSS was created for the planning of sustainable measures in an IWRM. A mathematical algorithm was developed for the DSS, which is intended to be used not only as a planning instrument to select cost-effective measures, but also for supporting political decisions. A catalog of all existing and potential measures for sustainable water management was compiled as a foundation for the DSS. After completing a survey of the present water use situation, socio-economic decision criteria were included in the second phase of the DSS, and concepts and pilot facilities were designed for water saving and reuse in households, industry and agriculture and for controlling salt water intrusion. Both the effective Chinese water quality standards and the existing monitoring system were analyzed, and suggestions for improvements were elaborated. In the implementation phase, concepts and pilot facilities were realized, and monitoring systems to follow groundwater levels and quality, as well as the discharge situation, were implemented. All sub projects were carried out in close collaboration with the respective Chinese partner institutions.

Project partners in Germany:

- Institute for Ecological Economy Research (IÖW), Berlin
- DHI-WASY GmbH, Berlin
- Ruhr-University Bochum (RUB), Chair of Hydrology, Water Management and Environmental Engineering, Bochum
- Schlegel Consulting Engineers GmbH & Co. KG, Munich
- Prof Geiger, UNESCO Chair in Sustainable Water Management, Beijing/ Munich
- UGT (Environmental Equipment Technology), Muencheberg

Project partners in China:

- Shandong University (SDU), Institute for Hydrology and Water Resources, Jinan
- Shandong Agricultural University (SDAU), School of Water and Civil Engineering, Taian
- Shandong Water Conservancy Research Institute (WCRI), Section of Water Resources Research, Jinan
- Longkou Water Affairs Authority (LKWAA), Longkou
- Shandong Construction University (SDJU), Jinan
- Shandong Normal University (SDNU), Department of Population, Resources and Environment, Jinan

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Integrated Water Resources Management (IWRM) in Gunung Kidul, Java, Indonesia

Project duration: 06/2008–05/2013
Geographic location: District of Gunung Kidul, Yogyakarta Special Province, Indonesia

Project summary

Context and objectives

Karst landscapes are formed by the dissolution of soluble rocks, limestone and dolomite. More than 25 % of the world's population either lives or depends on karst aquifers as a source of water. Due to the absence of surface water storage possibilities, people living in karst regions often suffer from acute water shortages, particularly during dry seasons. However, in many karst regions large networks of underground rivers exist with continuous water flow. However there is often limited accessibility to these rivers due to their deep underground location. High infiltration rates further aggravate the situation because of the vulnerability to contamination e.g. from agriculture and urban waste water.

The karst region Gunung Sewu, located in the district of Gunung Kidul, Yogyakarta Special Province, on the southern coast of Java island, is a region facing the aforementioned problems. In the past, the Indonesian government has expended much effort in exploring the karst aquifers with conventional technologies. Sustainable solutions have not been in place until now, however.

Figure 20: Location of the karst area of Gunung Sewu on the island of Java, Indonesia (Source: IWRM Indonesia Project).

Study area

Karst region Gunung Sewu ("1000 hills", 1400 km²)

Severe water scarcity during dry seasons

Total exchange of the surface run-off to an underground river system due to karst infiltration

Hundreds of interconnected underground river systems and caves

Unsuccessful attempts at sustainably using underground water resources

Approach

In order to implement a sustainable solution, the IWRM concept is developed through interdisciplinary approaches from natural to engineering sciences and covers all aspects of research and development of water resources including infrastructure (civil works), water distribution systems, water quality regulation, wastewater treatment and disposal. Operational and economical aspects must be taken into consideration regarding hydrological, hygienic, ecological, social and cultural boundary conditions.

Results

Water availability in the target area has been assessed based on the evaluation of the hydrological, hydraulic and hydro-geological conditions. Relevant facts were obtained through field studies such as continuous monitoring, speleological surveys, geophysical and

Figure 21: The karst area of Gunung Sewu during the dry season (Photo: IWRM Indonesia Project).

www.iwrm-indonesien.de

tracer methods, as well as geodetic surveying of the surrounding topography.

The cooperation between scientists and industrial partners resulted in the development of innovative concepts and technologies such as pumping technologies based on regenerative hydro power, real-time optimization of water distribution networks and pilot facilities for water and wastewater treatment, which are currently being implemented. In addition, ecological analysis and technology impact assessments of these developments through Life Cycle Assessment (LCA) and Life Cycle Cost Analysis (LCCA) are accomplished. Furthermore, diverse results of new methodologies and techniques for potential world-wide implementation have been generated and tested, for example underground river network investigations with VLF-EM, karst injections, automated discontinuity rock structure analysis, etc.

During the water management concept design and implementation process, accompanying 'capacity development' measures have been carried out, such as workshops, awareness-raising campaigns and intensive knowledge transfer through trainings, handbooks, posters, etc. This knowledge transfer specifically includes the local communities (end-users) as well as the concerned administrative authorities, scientific institutions and the chambers of industry and commerce.

Project partners in Germany:

- Karlsruhe Institute of Technology (KIT)
- Justus Liebig University of Gießen (JLU)
- Water Technology Center (TZW)
- KSB AG, Frankenthal
- IDS GmbH, Ettlingen
- COS Systemhaus OHG, Ettlingen
- Geotechnisches Ingenieurbüro Prof. Fecker & Partner GmbH (GIF), Ettlingen
- CIP Chemisches Institut Pforzheim GmbH
- Hans Huber AG, Berching

Project partners in Indonesia:

- Ministries
  - Ministry of Public Works (DPU)
  - Ministry of Research and Technology (RISTEK)
  - Ministry of National Education (DIKNAS)
- State government of the Yogyakarta Special Province (DIY)
- National Nuclear Energy Agency (BATAN)
- Universities
  - Universitas Gadjah Mada, Yogyakarta (UGM)
  - Universitas Sebelas Maret, Solo (UNS)
  - Universitas Islam Indonesia, Yogyakarta (UII)
  - Institut Teknologi Surabaya, Surabaya (ITS)
  - Universitas Pendidikan Nasional, Yogyakarta (UPN)
- ASC, Speleological Club Yogyakarta

Figure 22: Existing underground dam in Bribin Cave with newly installed discharge monitoring equipment (Photo: IWRM Indonesia Project).

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Integrated Water Resources Management in Central Asia – Model Region Mongolia

Project duration: 08/2006–10/2009 (phase I) and 05/2010–04/2013 (phase II)
Geographic location: Kharaa catchment, Darkhan-Uul Province, Mongolia

Project summary

Context and objectives

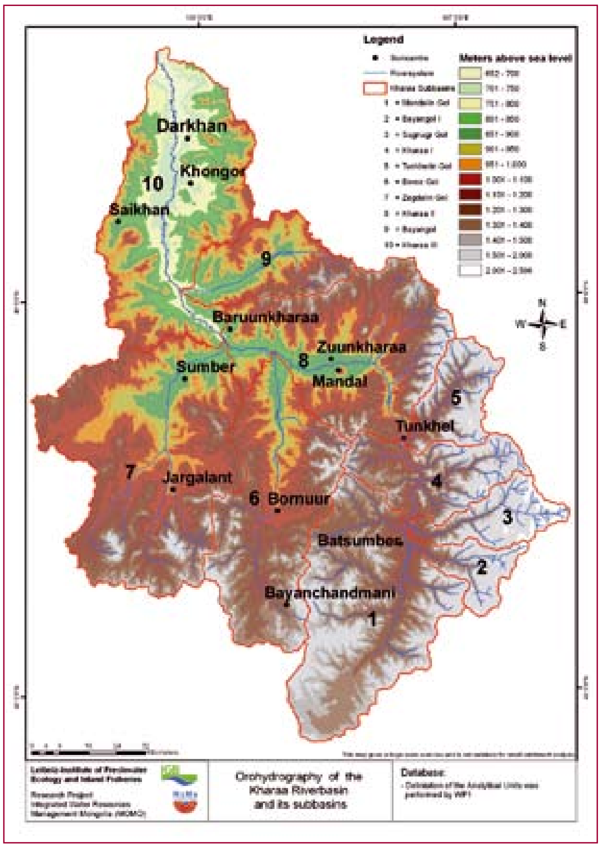
The project aims to develop a sustainability-oriented IWRM in Mogolia's Kharaa catchment, which is considered as a model region for central Asia. Land-use change, increasing exploitation of natural resources and an extremely continental climate are particular challenges in the region. Building on experiences made during the first project phase, the second phase aims to expand the scientific basis for an IWRM plan. Specific elements of IWRM are simultaneously implemented in selected problem fields. Key issues related to hydrology and land use, aquatic ecology, water quality and integral urban water management are addressed by the project's thematic modules.

Approach

A monitoring system will be established and operated during the course of the project. This system will include hydrological parameters, other environmental factors (e.g. climate, soils) and interdependences with socio-economic processes and anthropogenic influences such as land use change. This integrative view leads to an improved understanding of hydrological questions, but also allows the control and evaluation of specific measures to be implemented.

Technical solutions are developed for the urban and rural water management sectors. Participation of local stakeholders is encouraged at the same time. The project's capacity development incorporates key results from the scientific studies and its activities target both the general public and local experts and decision-makers in order to promote the concept of a sustainable water resources management.

Figure 23:
Subcatchments of the Kharaa River
(Source: IGB Berlin).



Study area:

- Highly continental climate with harsh winters
- Nomadic / seminomadic lifestyle
- Transnational importance (drainage towards Lake Baikal, Russia)
- Conflicting water demands (e.g. mining, agriculture, water supply)
- Heterogeneous population distribution

Figure 24:
Winter in the central Kharaa catchment
(Photo: D. Karthe).

www.iwrm-momo.de

Figure 25:
Old waste water treatment plant, Darkhan
(Photo: D. Karthe).

Results
The scientific basis for an IWRM in the catchment of the Kharaa was elaborated during the first project phase. Climate scenarios indicate that the current warming trend is likely to continue while the trend in precipitation may be spatially very heterogeneous. It is expected that water resources will decline at least in some regions. The intensification of agriculture, the expansion of mining and industrial activities and a relatively high rate of population growth will simutaneously increase the demand for water. Key problems were identified with regard to ground water quality and the ecological status of surface waters, (e.g. introduction of insufficiently treated waste water and agrochemicals, overfishing). Deficits in water infrastructure (both supply and waste water) exist in both rural and urban regions. Improved water management structures are necessary in order to solve these problems.

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Project partners in Germany:

- Center for Environmental Systems Research (CESR), Kassel University
- Fraunhofer Center for Applied Systems Technology (FhAST), Ilmenau
- Geographic Institute, Heidelberg University
- Helmholtz Centre for Environmental Research – UFZ
- Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB)
- Department Urban Water Management, Weimar University
- Bergmann Clean Waste Water Technology (BCAT)
- Training and Demonstration Centre for Decentralized Sewage Treatment (BDZ) e.V.
- Passavant-Roediger GmbH , Hanau
- p2m berlin GmbH, Berlin
- terrestris GmbH & Co. KG
- Seecon Germany GmbH

Project partners in Mongolia:

- National University of Mongolia (NUM), Ulan Bator
- Mongolian University of Science and Technology (MUST), Ulan Bator & Darkhan
- University of Agriculture Darkhan (UoAD)
- Mongolian Ministry of Education, Culture and Science
- Mongolian Ministry of Nature, Environment and Tourism
- Mongolian Ministry of Transportation, Construction and Urban Development
- National Water Authority of Mongolia
- Water Supply and Sewerage Company of Darkhan (USAG)

Economic and ecological restructuring of land and water use in Khorezm, Uzbekistan. A pilot project in development research

Project duration: 11/2001–12/2011
Geographic location: Khorezm region, Uzbekistan (Phases I–III)

Project summary

Context and objectives
Increasing water scarcity and inefficient, non-sustainable irrigation methods have been creating challenging problems for agricultural production and endangering the livelihood of the peoples in Central Asia. In particular in the lowlands of the Aral Sea basin in Uzbekistan, decades of intensive irrigated cotton cultivation have caused enormous ecological damage to the soil and water resources.
A project started by the Center for Development Research (ZEF) in Germany with the support of BMBF and UNESCO in 2001, has been developing ecologically sustainable and economically efficient concepts for an improved management of land and water resources in this region. Around 70 international scientists have been working with the project in an interdisciplinary way and in close cooperation with Uzbek partners. The regional project office is located in Khorezm, in northwest Uzbekistan.
The project's overall goal is to develop technological, institutional and agro-political concepts and innovations for local implementation. The latter is realized by developing local academic and human capacities, and by involving local farmers and their associations, irrigation institutions and policy makers. In the end, the project outcome, tools and infrastructure will be passed over to local partners and Uzbek authorities, so they can be put into practice beyond Khorezm on a larger scale.

Figure 26:
Geographic location of Khorezm/ Uzbekistan in the catchment area of the Aral Sea
(Source: University of Würzburg, NASA, ESRI Germany).

Study area

Location: In the northwest of Uzbekistan at the lower reaches of Amu Darya

Arid climate conditions

Total area: 0,7 million hectare

Irrigable surface area: 0,275 million hectare

Population: 1,3 million

Approach
Scientists from different disciplines, such as water and soil specialists, agronomists, social scientists and economists, work together on innovative and sustainable solutions for an improved natural resources management in the region. In order to achieve synergies and integrated solutions, the project has developed interdisciplinary models and tools that can analyze and combine ecological, social and economic aspects of land and water use. In this way, the long-term impact of single interventions can be projected. In addition, cost-benefit analyses indicate the financial implications of the different technological options, enabling local policy makers to make sound, science-based decisions.

Figure 27:
Capacity building in Uzbekistan
(I. Abdullayev).

www.zef.de/khorezm.0.html

Results

In recent years, the national and international institutions in Uzbekistan have become increasingly aware and interested in the project's set-up, concepts and output. The project databank, for example, containing data collected by remote sensing technology and processed with Geographic Information System (GIS) tools, is not only used by scientists, but also by local administration units and ministries.

The project's scientists have tested and calibrated innovative concepts and technologies for land and water use: from the field level up to the regional scale of Khorezm. By means of GIS, remote sensing, and model-based planning tools, they can be transferred to and applied in similar irrigation areas in Central Asia, particularly in the realms of agriculture, afforestation, irrigation and drainage management as well as environmental monitoring.

Guided by its interdisciplinary philosophy, the project aims at actually implementing research results. Local stakeholders must thus be involved, so that research outcomes can be adapted to local conditions. Local expectations, demands, and needs have to be taken into account and integrated into the technical and institutional solutions provided by the scientists. The experience gathered by scientists in the ZEF/UNESCO project in terms of a participatory research approach has shown that close collaboration with local partners in the actual phase of innovation development increases the local acceptance of science-based solutions considerably. This participatory approach has been complemented by organizing training for farmers and technicians in the field of water resources management, and by establishing adequate organization and communication tools with the support of German, Uzbek and international partner organizations.

Project partners in Germany:

- German Aerospace Center (DLR)
- University of Wuerzburg

Project partners in Uzbekistan:

- Ministry of Agriculture and Water Resources (MAWR) of the Republic of Uzbekistan
- Urgench State University
- Tashkent Institute for Irrigation and Mechanization (TIIM)
- Interstate Commission for Water Coordination (ICWC)
- Central Asia Scientific Research Institute of Irrigation (SANIIRI)
- United Nations Educational, Scientific and Cultural Organization (UNESCO)
- International Center for Agricultural Research in Dry Areas (ICARDA), Syria
- International Maize and Wheat Improvement Center (CIMMYT), Mexico

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Figure 28:
Cotton cultivation in Uzbekistan (A. M. Manschadi).

AKIZ joint research project – Integrated Wastewater Concept for Industrial Zones exemplified by the Tra Noc Industrial Zone, Vietnam

Project duration: 11/2009–04/2014
Geographic location: Tra Noc Industrial Zone, Can Tho City, Vietnam

Project Summary

Context and objectives
Vietnam has more than 200 registered industrial zones, most of them without sustainable wastewater treatment, which has lead to serious consequences for the population and the environment.

Solutions to the precarious situation are to be demonstrated within the framework of the BMBF-funded joint research project. A transferable integrated waste water concept for industrial zones is to be developed during the construction of a central waste water treatment plant in an industrial zone in Can Tho City on the Mekong delta.

Figure 29: Tra Noc Industrial Zone in Can Tho in South Vietnam (Source: AKIZ Project).

Study area

Industrial zone with about 130 companies

Area approx. 300 hectare

Location in Mekong delta in South Vietnam

Tropical climate

Approach
The basic concept of the integrated approach is to combine centralized and decentralized, near-to-source solutions for industrial wastewater treatment and the integration of technological, economic and financial aspects, including tariffing models. Within the framework of the project, German and Vietnamese universities, and their industrial partners, will work together on several relevant aspects of the concept development.

Technological near-to-source treatment solutions are to be demonstrated at representative factories, with the following objectives:
(a) de-toxification,
(b) energy generation,
(c) recuperation of valuables.
Proven and efficient high-tech solutions for industrial wastewater treatment as used in Germany and other industrialised countries, are to be adapted to the specific working conditions and tropical climate in Vietnam. Containerized pilot systems from German industrial partners will thus be utilized in selected industries such as pesticides and pharmacy processing, seafood production and brewing.

A monitoring and control system will be set up, including a containerized laboratory unit, especially configured for the local conditions in the industrial zone. These are to provide the base data for technological adaptations and the administrative and financial realization of wastewater treatment.

In Vietnam, there is currently no sustainable solution for sludge or waste management. A sludge and waste management plan will be developed for the disposal or processing of sewage sludges and other waste from the planned centralised sewage treatment plant, and decentralized treatment systems.

The research programm is to be completed by parallel studies on sociological and ecological aspects, which will consider the potential for enforcing internationally accepted environmental standards as a precondition for the application of high-tech solutions from Germany, and highlight any obstacles, which would prevent or hinder this outcome.

Figure 30: Life on the water – floating markets in Can Tho (Photo: T. Fuhrmann).

www.akiz.de

Results
All of the mentioned aspects will flow into the overall AKIZ management concept and will constitute the technical and economical conditions for the sustainable operation of wastewater infrastructure in industrial zones. It will take into consideration decentralised wastewater pre-treatment as well as the centralised sewage treatment plant, and will be based on a comprehensive monitoring and control system.

Additionally, it will provide reliable quality control of the day-to-day operations and should create the basis for cost calculations and re-financing of all wastewater facilities and organisations within the industrial zone.

The project results will be used to develop best practice guides on integrated wastewater concepts for industrial zones. The sustainable implementation will be supported by capacity building measures with Vietnamese local partners and stakeholders.

Project partners in Germany:

- Institute of Environmental Engineering and Management at the University of Witten / Herdecke gGmbH (IEEM), Witten
- HST Hydro-Systemtechnik GmbH
- University of Stuttgart
- Passavant Roediger GmbH, Hanau
- Leibniz University of Hannover
- EnviroChemie GmbH
- Technical University of Darmstadt
- LAR Process Analysers AG
- Technical University of Braunschweig

Project partners in Vietnam:

- Hanoi University of Science (HUS)
- National Economics University (NEU)
- Southern Institute of Water Resources Research (SIWRR)
- Hanoi University of Civil Engineering (HUCE)
- Vietnamese-German University (VGU)
- Vietnam Institute of Industrial Chemistry (VIIC)
- Can Tho University (CTU)

Figure 31:
Open Drainage in Tra Noc (Photo: T. Fuhrmann).

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Integrated Water Resources Management in Vietnam

Project duration: 07/2006–08/2011
Geographic location: Provinces Lam Dong, Can Tho and Nam Dinh, Vietnam

Project summary

Context and objectives
The joint research project IWRM Vietnam is structured on two planning levels, with the following objectives:

- At the regional level (river basin), the development of Planning and Decision Support Tools for IWRM
- At the local level, the adaption of water technology (drinking water, municipal and industrial wastewater) to Vietnamese conditions based on exemplary individual measures.

Approach
At the regional level, Planning and Decision Support Tools for IWRM in Vietnam have been developed and applied in three project regions. The tools are used to give an overview of the intensity of water management problems over a whole river basin. The aim is to identify and prioritize Water Management Units (WMU, river sub-basin) with significant problems in terms of quantitative and qualitative risks to the water resources (water deficit, risk of contamination).

In WMUs with higher problem intensities, detailed research is necessary in order to choose locations where local measures are useful.

Local level individual pilot measures for waste water treatment, water supply and monitoring are being implemented in three project regions.

Figure 32: Overview of the three project regions (Source: eE+E, 2010).

Study area

	Can Tho	Lam Dong	Nam Dinh
Area	5.000 km²	15.000 km²	1.800 km²
Main river	Cuu Long	Dong Nai	Song Hong
Topography	Delta	Lowland, High plateau, Highlands	Delta
Provincial capital	Can Tho	Da Lat	Nam Dinh

Figure 33: Irrigated vegetable fields in Can Tho (Photo: S. Jaschinski).

www.rub.de/ecology
www.iwrm-vietnam.vn

Figure 34: Irrigated rice fields in Hoa Bac (Lam Dong) (Photo: F. Klingel).

Results
The following three Planning and Decision Support Tools have been developed at the regional level:

The ***Water Balance Tool*** connects hydrological and socio-economic data in order to calculate the water quantities of the Water Management Units. The tool contrasts the water resources and water demands of water users in a WMU, and thus identifies surpluses and deficits. The calculation is made on a monthly basis, for the dry season, the rainy season and for the whole year.
The ***Contamination Risk Tool*** is used to estimate the contamination risk of water resources (groundwater and surface water) by pollutants from diffuse and point sources.
The ***Ranking Tool*** determines those WMUs with higher problem intensities (with regard to water balance and contamination risk) and a prioritized need for action.

The results on the regional level are summarized in a (analogue and digital) planning atlas for the IWRM in the three project regions, in a related handbook of methods and in publications on the implementation of the method.

Individual pilot measures were developed and applied on the local level in the three project areas, for example a web-based GIS, in order to display the quality of surface water (Can Tho).

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Project partners in Germany:

- Ruhr-University of Bochum, Environmental Engineering and Ecology (eE+E)
- University of Bonn, Institute of Crop Science & Resource Conservation (INRES)
- University of Greifswald, Institute of Geography and Geology (IGG)
- Fraunhofer Institute of Environmental, Safety and Energy Technology (Fraunhofer UMSICHT), Oberhausen
- Engineering consulting company for urban water management (IAKS GMBH), Sonthofen
- Moskito GIS GmbH, Dortmund

Project partners in Vietnam:

- Vietnamese Ministry of Natural Resources and Environment, Department Water Resources Management (MONRE/ DWRM)
- Vietnamese Ministry of Science and Technology (MOST)
- Vietnamese research institutes (VIWRR, VAST, SIWRR)
- Departments of Natural Resources and Environment of the three project provinces (DONREs)
- Departments of Science and Technology in the three project provinces (DOSTs)
- Vietnamese-German University (VGU)
- Vietnam Institute of Industrial Chemistry (VIIC)

Joint Research Project WISDOM – Water related Information System for the sustainable development of the Mekong Delta

Project duration: 04/2007–09/2013 (Phase I–II)
Geographic location: Mekong-Delta, Vietnam

Figure 35: Mekong Delta and project areas (green) Can-Tho province and Tam-Nong district (Source: WISDOM Project, 2010).

Figure 36: Laboratory water quality analysis (Photo: WISDOM Project).

Project summary

Context and objectives

On the basis of interdisciplinary research, the aim of the WISDOM Project is to implement supporting tools for the development of an Integrated Water Resources Management and to design adaption methods in the context of Climate Change for the Mekong Delta. The second phase (2010–2013) project consortium consists of seven German and eight Vietnamese research institutions, six German small enterprises (SMEs) and eleven associated partners.

During the first project phase (2007-2010), a prototype water and land information system had been developed based on the project research. This "Information System" stands for both a physical web-based information system and an expertise network for the Mekong Delta. The WISDOM Information System combines data from different disciplines such as hydrology, geochemistry, sociology, geography, modelling and information technology and earth observation.

Study area

Mekong river: total length 4350 km

Neighbouring countries: China, Myanmar, Thailand, Laos, Cambodia and Vietnam

3-scale spatial project focus:

1. Mekong Basin,
2. Mekong Delta,
3. Investigation areas: Can- Tho province, Tam-Nong district

Total Area of the Mekong Delta: 40 000 km^2

Tropical Climate with rainy season from June - November and dry season from December - May

The information system provides visualizations of multiple information and analysis of specific Mekong-Delta related spatial problems to potential clients. The aim is to enhance the regional cooperation of Vietnamese institutions in the exchange of information, expertise and data for the sustainable development of water and land resources.

The second project phase focuses on the implementation of the information system in Vietnam. The provision of comprehensive trainings will www.wisdom.caf.dlr.de

Figure 37: Technical training for the utilization of the Information System (Photo: WISDOM Project).

strengthen the system and its usage, and support the possibility of sustainable and long-term information generation in Vietnam. IWRM-related planning actions can thus be supported in the Mekong Delta as a result.

Approach

Sustainable solutions for water resources management and the implementation of a water and land information system for the support of regional planning activities.

Results

- A water-related information system for the visualization and further analysis of project results from the research fields of hydrology, geochemistry, sociology, geography, modelling, information technology and earth observation.
- In every project phase 15 PhD candidates graduate within water-related topics.

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Project partners in Germany:

- German Aerospace Center (DLR)
- United Nation University – Institute for Environment and Human Security (UNU-EHS)
- University of Wurzburg – Institute of Geography – Department for Remote Sensing
- Helmholtz Centre Potsdam – German Research Centre for Geosciences (GFZ)
- Center for Development Research (ZEF), Rheinisch Friedrich-Wilhems-University of Bonn
- Earth Observation and Mapping GmbH & Co. KG (EOMAP)
- Vienna University of Technology – Institute for Photogrammetry and Remote Sensing (IPF)
- HYDROMOD Service GmbH (HYDROMOD)
- lat/lon enterprise for Spatial Information Systems GmbH (lat/lon)
- IAMARIS Institute for Advanced Marine and Limnic Studies e.V. (IAMARIS)
- Aquaplaner – consulting engineers for sustainable Water Management (Aquaplaner)

Project partners in Vietnam:

- Southern Institute for Water Resources Research (SIWRR)
- Can Tho University (CTU)
- Ho-Chi-Minh-City Institute for Remote Sensing and GIS under Vietnamese Academy of Science and Technology (VAST-HCMIRG)
- Geomatics Centre of Vietnamese National University
- Southern Region Hydro-Meteorological Centre (SRHMC)
- Southern Institute of Sustainable Development (SISD)
- Sub-National Institute for Agricultural Planning and Projection (Sub-NIAPP)
- Institute for Tropical Biology (ITB)

Helmholtz Dead Sea Sumar: Sustainable management of water resources (quantity and quality) in the region of the Dead Sea

Project duration: 02/2007–03/2012
Geographic location: Immediate catchment area of the Dead Sea, Israel / Jordan / Palestine, Middle East

Project summary

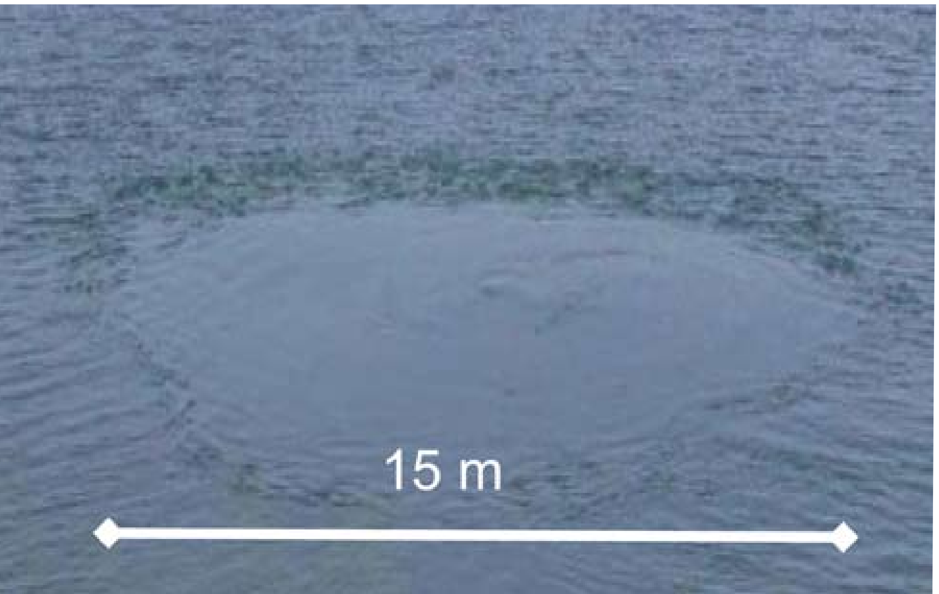
Context and objectives
The Dead Sea is shrinking. The water level has dropped in the last two decades by an average of 1.10 m / year. More water is lost through evaporation than fresh water flows in to replenish it. The fresh water shortage, coupled with seasonal fluctuations in precipitation, years of drought, high population growth and rising living standards requires an innovative water resources management plan.

Approach
Real-time modelling and understanding of the natural water balance in the catchment area of the Dead Sea provide the basis for this plan. A mass balance of the Dead Sea will thus be generated in the Sumar project together with a diversity of approaches for capturing data, both quantitatively and qualitatively, on all surface and subsurface flows into the Dead Sea.
Methods will be developed in order to precisely define short term and sudden flows in wadis (flash floods) and to quantify previously undetected underground groundwater inflows into the Dead Sea.

Results
The continuously flowing rivers of the region (primarily the Lower Jordan and Zarqa River) still make the largest contribution to the water balance of the Dead Sea (ca. 70%), but with rising water use in the region this is in decline.
A gauging station in the Lower Jordan River has been installed for the first time with the aid of the Sumar project, in order to obtain accurate flow and water quality values. Several robust monitoring stations were installed in ephemeral wadis. Radar methods were calibrated to measure the direct runoff during flood events. The subsurface water flows into the Dead Sea are particularly difficult to quantify.

Figure 38: Project area Dead Sea with the location of the main superficial ephemeral tributaries (Source: NASA altered).

In addition to isotope geochemistry and trace element studies with rare-earths as natural groundwater tracers, an aerial survey with a thermal infrared camera was carried out on the west side of the Dead Sea, both to detect and to quantify if possible colder and warmer ground water inflows.
Additionally, groundwater recharge, surface runoff and groundwater inflow



Study area

Dead Sea

Lowest point: -730 m bsl

Sea level 2011: -427m bsl

Area: 805 km^2

Catchment area: 44,000 km^2

Figure 39: Submarine groundwater spring (up-welling) in Ein Feshka, western Dead Sea (Photo: S. Geyer).

www.ufz.de/index.php?de=17692

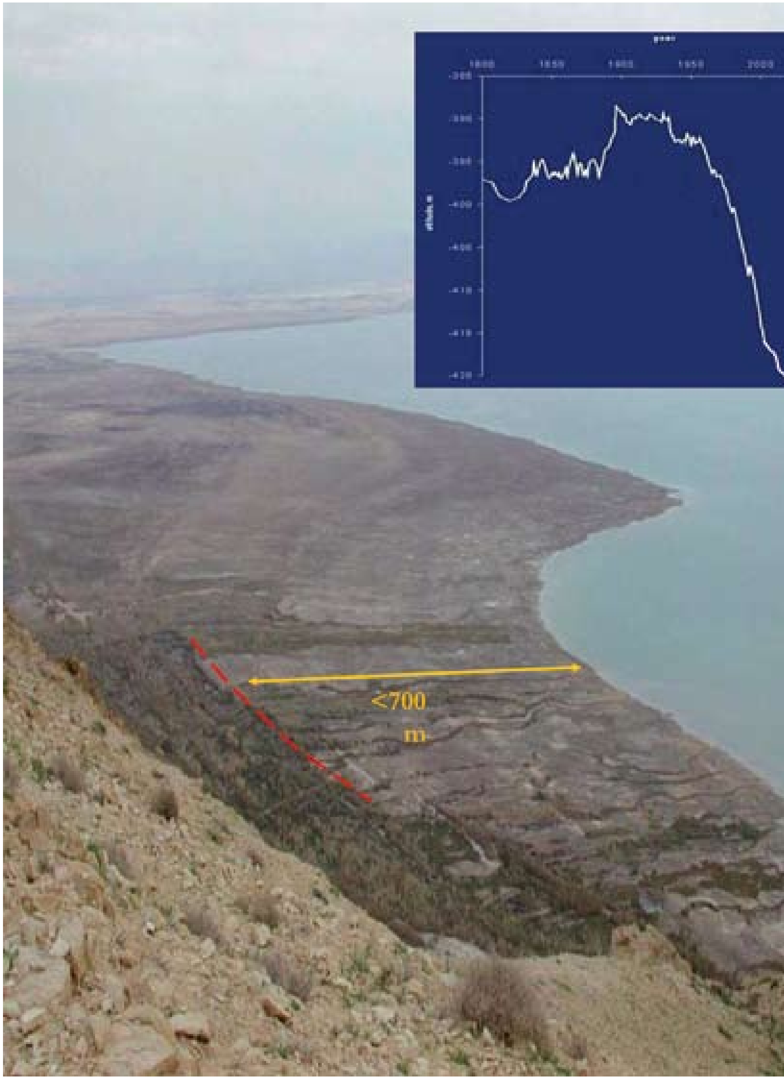


Figure 40:
Decline in water levels in the Dead Sea between 2000 and 2010 (Photo: S. Geyer).

to the Dead Sea is forecasted using a combined approach consisting of a water-soil balance modeling (JAMS 2000) and a groundwater flow modeling (open GeoSys). First results show the climate sensitivity of this arid region: A decrease of annual precipitation by 20% causes a decrease in groundwater recharge of about 53%. Increasing the annual average temperature by 2° C reduces groundwater recharge by approximately 23%. Assuming a constant water flow to the Dead Sea of current levels (2010), the water level continues to decrease. A new balance between evaporation and inflow will be reached only at a water level 100 m lower than today (2011: -427 m bsl). This means that the Dead Sea surface will reach a level of > -500 m bsl.
The SUMAR project studies the effects, such as e.g. the sinking of groundwater aquifers in the immediate catchment area, the formation of sinkholes, and especially the effects on the quantity and quality of the available groundwater resources.

Project partners in Germany:

- Helmholtz Centre for Environmental Research – UFZ, Department Catchment Hydrology
- University of Göttingen
- Federal Institute for Geosciences and Natural Resources, BGR (remote sensing)

Project partners in Israel:

- Ben-Gurion University, Be'er Sheva
- MEKOROT Co., Tel Aviv

Project partners in Jordan:

- Jordan University, Amman
- Al-Balqa Applied University, Al-Salt

Partners in Palestine:

- Al-Quds University, Jerusalem
- Ah-Najah University, Nablus
- Birzeit University, Birzeit

Other contacts:

- Palestinian National Water Authority
- Ministry of Water and Irrigation of Jordan

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Integrated Water Resources Management in the Lower Jordan Valley: SMART – Sustainable management of the available water resources with innovative technologies

Project duration: 07/2006–12/2009 (Phase I), 03/2010–02/2013 (Phase II)
Geographic location: Lower Jordan valley – Dead Sea, Israel/Jordan/Palestine, Middle East

Project summary

Context and objectives

The arid to semi-arid catchment of the lower Jordan river, an area of 5000 km², extends from the lake of Genezareth to the Dead Sea. The waters flowing to the Genezareth Lake, which is the most important fresh water reservoir in the region, are almost completely diverted to the coastal plains of the Mediterranean. Insufficient water remains in the lower reaches to cover the needs of the growing population, or to compensate for evaporation losses. This leads to a steady lowering of the water levels in the Dead Sea, as well as the drying up of wells and the lowering of ground water levels.

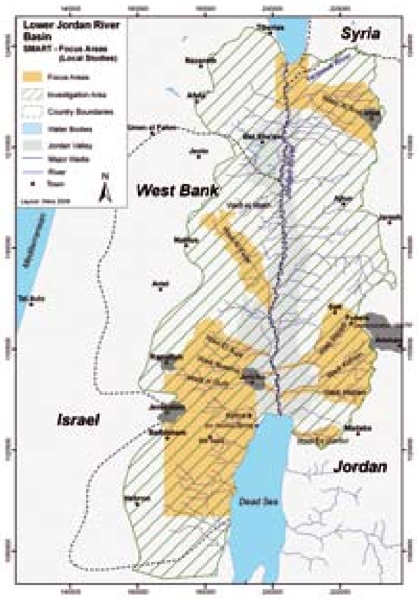

Figure 41: Location of the study area, the sub-catchments are marked yellow (Source: H. Werz).

Study area

Extreme natural water scarcity due to the arid to semi-arid climate conditions

Completely closed hydrological system with terminal lake "Dead Sea"

Large scale location below sea level

Overuse of natural water resources due to high population, which continues to grow

Transnational catchment in politically sensitive region

The aim of research is to develop a transferable approach for the integrated management of existing water resources, in order to increase the available resources and water quality. New technologies will be used, which will make it possible to adequately utilize and later implement unconventional water sources.
The IWRM model is to be based on engineering, technological and socio-economic studies and is ultimately to initiate a self-sustaining IWRM process in the study region, which would be of long-term duration and would be transferable to neighbouring regions. Science, industry, specialist authorities, local non-governmental organisations, external experts and consultants are all involved in the multilateral, interdisciplinary research group.

Approach

The core principle of SMART is the integration of all water resources in the study region as usable resources. This requires a comprehensive and integrated management and exploitation approach in Phase I of the project. Water resources, which have not been exploited as yet for quality reasons or due to a lack of adequate water storage options, will also be explored and evaluated. Suitable treatment technologies will thus be identified and temporary water storage options will be developed. In Phase II the innovative technologies and IWRM tools are to be developed further, demonstrated and implemented as models. The focal points here are a) options for the subsurface storage of flood waters, evaporation losses thus being avoided, b) the desalination of brackish water with modern membrane technologies as well as c) the provision of decentralised smaller waste water treatment plants for rural and suburban areas. The individual approaches are ultimately to be integrated in a comprehensive IWRM concept, in order to make decision support available for stakeholders, with the aid of collaborative knowledge management.

Figure 42: Dam in Wadi Wala south of Amman, Jordan, after one of the very rare rain events in January 2010 (Photo: A. Sawarieh).

www.iwrm-smart.org

Figure 43: "Ein Feshkha" - spring on the North West shore of the Dead Sea, ca. 20 km south of Jericho, Westbank (Photo: H. Hötzl).

Results

A transnational and interdisciplinary project database has been established and currently has over 1.5 million entries; infrastructure measures have been implemented and environmental monitoring networks have been set up or expanded. The pilot and research plant Fuheis was constructed for decentralised waste water treatment, in addition to regional or technical experimental sites for further research activities. There is interest in waste water treatment, membrane technologies, artificial ground water recharge and software-supported decision making from the German Water Partnership. The KfW Development bank of the Federal Republic also identified a large potential for realisation. The central findings of the joint research project were integrated in the "National Strategic Water Plan 2008-2022" in Jordan; significant preparations for the systemic solution of decentralised water management were thus also politically realised.

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- Karlsruhe Institute for Technology (KIT), Institute for Applied Geosciences
- University of Göttingen, Centre for Applied Geology
- University of Heidelberg, Institute for Geosciences
- Helmholtz Centre for Environmental Research – UFZ
- DVGW Technology Centre Water (TZW), Karlsruhe
- ATB Environmental Technology GmbH, Porta Westfalica
- Hans Huber AG, Berching

Project partners in Israel:

- Tel Aviv University, Tel Aviv
- Mekorot Water Company Ltd., Tel Aviv
- Environmental & Water Resources Engineering Ltd. (EWRE), Haifa
- Ben-Gurion University of the Negev

Project partners in Jordan:

- Ministry of Water and Irrigation, Amman
- Al-Balqa University, Salt
- University of Jordan, Amman
- German-Jordan University, Amman
- EcoConsult, Amman
- NAW-Nabil Ayoub Wakileh & Co., Amman

Project partners in Palestine:

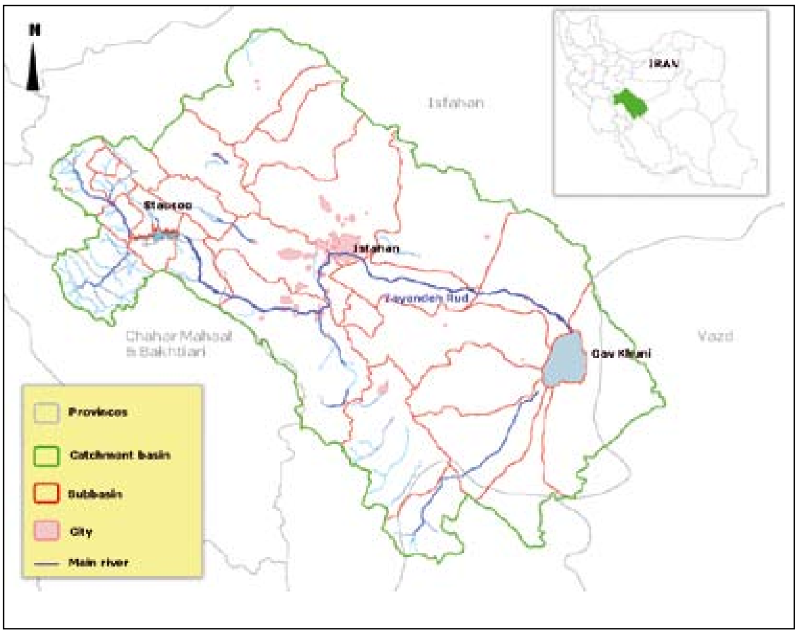
- Al-Quds University, East Jerusalem
- Palestinian Hydrology Group, Ramallah
- Palestinian Water Authority, Ramallah

Integrated Water Resources Management in Isfahan (Iran)

Project duration: 09/2010–08/2013
Geographic location: Isfahan, Iran

Project summary

Figure 44:
Catchment area of the Zayandeh Rud
(Source: inter 3).



Context and objectives

The main objective of the project is to develop an implementable concept for an integrated form of water resources management in the catchment area of the Zayandeh Rud in Iran. This region is characterized by water scarcity, climate change, population growth, frequent dry periods and increasingly the deterioration of surface and ground water quality due to overuse and the pollution of water resources. Furthermore, increasing competition among different user groups poses enormous challenges for water management and underlines the necessity for the IWRM process.

In addition to the transfer of modern technology and management instruments, the process aims to involve different user groups from agriculture, industry, expanding cities and relevant government agencies.

Approach

The close cooperation of interdisciplinary research teams and leading water management companies in a research association will allow for the adaptation of proven German technology and management strategies to the specific climatic and socio-economic conditions of the region.

Figure 45:
Dried-out river bed at the Si-o-se Bridge in Isfahan
(Photo: inter 3).

In the first phase, the current situation is being determined and analysed in terms of technical, organizational, socio-economic and ecological aspects. Based on the results, a decision-support system is to be developed for the sustainable management of water resources. It consists of two related water management tools: one tool based on a long term water balance model for the quantitative

Study area

Zayandeh Rud: 355 km-long river from the Zagros Mountains to the wetland Gav Khuni

Surface area: 42,000 km^2

Population: 4.5 million

Climate: Semi-arid and arid

Use: 240,000 hectare irrigated agriculture, second largest industrial area in Iran www.iwrm-isfahan.com

Figure 46:
River bank at the Si-o-se Bridge in Isfahan
(Photo: inter 3).

simulation of water resources; and a second that considers influencing socio-economic factors. The tools are designed to enable Iranian decision makers and project partners in the Ministry of Energy and water authorities in Isfahan to work with relevant user groups in carrying out a successful IWRM process for the catchment area of the Zayandeh Rud.

The project comprises the five sector modules of agriculture, urban water management, industry, tourism and environment, representing the main water users in the catchment area of the Zayandeh Rud. Using the IWRM process, the different requirements and possible conflict of interests are to be identified and sustainable solutions to be created. The scientific results of the sector modules are to be grouped as follows: (1) Knowledge Map (2) Organizational Development, (3) Capacity Development, (4) Participation Management and Public Relations.

Results
The overall results of the water resource tools and the sector modules are to be integrated into a standardized IWRM decision-making system that is flexible and can be amended and made more comprehensive as required. Based on this, a second project phase beginning in 2013 is to investigate the long-term interactive effects occurring between ground water use, water quality and climate change.

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- inter 3 Institute for Resource Management, Berlin
- Institute for Social-Ecological Research (ISOE), Frankfurt / Main
- DHI–WASY GmbH, Berlin
- p2m berlin GmbH, Berlin
- Passavant Roediger GmbH, Hanau
- German Water Partnership (GWP), Berlin
- Institute of Environmental Engineering and Management at the University of Witten / Herdecke gGmbH (IEEM), Witten

Project partners in Iran:

- Ministry of Energy
- Isfahan Regional Water Company

CuveWaters – Integrated Water Resources Management in Central Northern Namibia (Cuvelai-Etosha Basin)

Project duration: 11/2006–06/2013 (Phases I–II)
Geographic location: North-Central, Cuvelai-Etosha Basin, Namibia

Project summary

Context and objectives
The CuveWater project aims to develop and implement an Integrated Water Resource Management (IWRM) concept in central north Namibia. The driest country in southern Africa is particularly affected by water shortages and climate change. A region specific IWRM should secure the livelihoods of the people in the long term.
Intra- and interbasinal connections, conflicts of use and bi-national dependencies are characteristic for the project area. In CuveWaters, these challenges are investigated as an integrated problem – the management and use of water is considered a cross-sectional task. The central components of the project are thus knowledge-management, technology transfer, participation and capacity development.

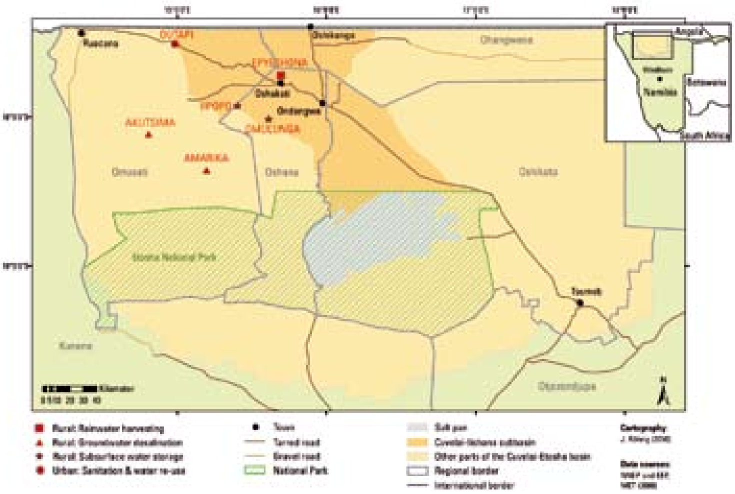

Figure 47:
CuveWaters project area and implementation sites
(Photo: ISOE, Dr. J. Röhrig).

Study area

Very high climate variability

Few perennial rivers

50 % of the Namibian population live in this area, which covers only 15 % of the area of Namibia

Approach
In CuveWaters endogenous resource potentials are to be enhanced and supported through a multi-resource mix. Water is thus to be collected from various local sources utilizing diverse technologies and then used for different purposes. Rainwater harvesting, small scale groundwater desalination, subsurface water storage and a sanitation concept with water re-use allow inhabitants to use resources efficiently. International teams, working with local inhabitants, have thus constructed various pilot water storage and treatment plants:
In accordance with the sanitation concept, nutrient rich sewage water is used for irrigating agricultural land in an urban area. In rural areas, different decentralised plants are used for groundwater desalination. Until now, these villages only had very salty groundwater and hand-dug wells for supplying drinking water, and these were microbiologically contaminated. They were not connected to the Namibian water supply infrastructure. In another village, rainwater is collected in tanks to be used for gardening. Local floodwater is collected for the subsurface water storage and stored for use in the dry season.
In the context of Capacity Development, technical training is provided and scientific work is generated.

Figure 48:
Open canal for water supply in Northern Namibia
(Photo: CuveWaters Project).

www.cuvewaters.net

Project partners in Germany:

- Institute for Social-Ecological Research (ISOE), Frankfurt / Main
- University of Applied Sciences Darmstadt (TUD), Institute IWAR:
- Chair of Water Supply and Groundwater Protection
- Department for Wastewater Technology
- Terrawater, Kiel
- Proaqua, Mainz
- Solarinstitute Jülich – IBEU
- Fraunhofer Institute for Solar Energy Systems ISE, Stuttgart
- Roediger Vacuum, Hanau

Other partners:

- Ministry for Agriculture, Water and Forestry (MAWF)
- Desert Research Foundation of Namibia (DRFN)
- Deutsche Gesellschaft für internationale Zusammenarbeit (giz), offices Windhoek and Oshakati
- Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Section Afrika
- Other local and regional institutions

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Figure 49:
Construction team for rainwater harvesting plant (Photo: CuveWaters Project).

Results

In CuveWaters, systems are developed that are specifically adapted to semi-arid regions with high climate variability. With its multi-resource-mix, CuveWaters aims for a 3 “R” strategy: “Reuse”, “Recharge” and “Retention”. “Reuse” implies an increase in water-use efficiency for irrigating urban agriculture. Additional essential nutrients are thus gained for plant production. “Recharge” technologies are explored that make flood-water available during the dry season. “Retention” implies the collection of rainwater for horticulture. A distinctive feature here is the alleviation of poverty through associated gardening projects. Water availability will be further increased in the project area through groundwater desalination.

The developed methods are also important results of the project: the social-ecological impact assessment, the analysis of system-related interdependencies, the development of scenarios as well as the process of participation. An important outcome for the project is the transferability of its results to other regions with comparable problems.

IWRM – Pilot project "Middle Olifants" in South Africa with technology transfer through a franchise concept

Project duration: 08/2006–12/2010
Geographic location: Middle Olifants, South Africa

Project summary

Context and objectives

The project area is the "Middle Olifants", a river basin east of Pretoria with highly intensive water use through large scale agriculture, mining (with one of the largest platinum mines in the world, amongst others) and tourism. In the dry periods, users in the lower reaches must periodically reduce their water consumption in order to avoid damage to the population and ecology (e.g. in Krüger National Park). Many water treatment works are non-functional, so that mine waste waters additionally negatively affect the water quality in the rivers. Climate change and the problems associated with refugees (in particular in the provinces close to the Zimbabwe borders) intensify this situation on a regional level.
An IWRM concept suitable for Africa is to be developed that could improve the water supply situation in the project area through the interdisciplinary combination of economics, engineering and ecology.

Approach

The project is structured in four connected modules:

(1) **WRM (Water Resources Module)**: Water quantity and quality will be simulated in the modelling of the river basin (based on hydrological data and under consideration of climate change perspectives)

(2) **WAM (Water Allocation Module)**: An economic analysis of water use (private households, agriculture, mining and tourism) and the provision of water services

(3) **WIM (Water Intervention Module)**: A water management intervention strategy with a catalogue of regulative and executive measures for the realisation of the IWRM

(4) **a franchise concept**, which initiates a transfer of technology from experienced water providers to local companies (Water Franchise). With additional funding from the World Bank, this franchise model could be prepared for a refugee village, going as far as the implementation of a pilot plant.

Figure 50:
Location of the project area in South Africa (Source: M. Bombeck).

Study area

Catchment area: 22.552 km²

Length of the river: 300 km in the study area

Source: Highveld

Estuary: Indian Ocean (Mozambique)

Climate: semiarid

Figure 51:
The Olifants north of Groblersdal
(Photo: T. Walter).

www.iwrm-southafrica.de

Results

Improved protection and a more efficient distribution of the limited water resources can be achieved in the project area as the simulation of the iterative coupling of the WARM and WAM modules shows. The root cause of the problems is not water scarcity, but insufficient water resources management. The sustainable operation of the existing water technology plants is crucial for success, as well as upgrading the waste water treatment infrastructure (this was the tone of the recently published report of the South African Water Ministry). In particular in the running and maintenance of the infrastructure it is less a lack of available technology which is the problem, as this can be imported, but rather the deficits in management and a lack of technical abilities.

With the franchise model, the research project was able to increase ownership of the individual interest groups, which has considerably improved the quality of installation and ongoing maintenance – and thus the sustainability (the administrative water losses sank from 85% to 35%). Exogenic "implanted" measures are generally not well received in South Africa, in contrast to solutions which involve local groups. The franchise model was awarded a World Bank prize in 2006.

Figure 52:
Domestic water supply in rural settlements (Photo: T. Walter).

Project partners in Germany:

- Institute of Environmental Engineering and Management at the University Witten / Herdecke gGmbH (IEEM), Witten
- Center for Development Research (ZEF), Rheinisch Friedrich-Wilhems-University of Bonn
- REMONDIS Aqua International GmbH, Lünen
- HUBER SE (previously Hans Huber AG), Berching

Project partners in South Africa:

- Department for Water Affairs (DWA)
- Water Research Commission (WRC)
- School of Agricultural Engineering at the University of Limpopo
- Biwater South Africa (Pty) Ltd., Bothjeng Water (Pty) Ltd.

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Integrated Water Resources Management in the Catchment Areas of the Rivers Volga and Rhine using the Example of Problem Regions

Project duration: 05/2007–12/2010
Geographic location: The catchment area of the river Volga, the conurbation of Moscow - Nizhny Novgorod, Russia

Project summary

Context and objectives

The catchment area of the river Volga is the economical and cultural heart of Russia with circa 35% of the Russian population living within it. The river represents an enormous economic potential due to its water and energy resources which have been used for decades. In the mid 1930s, for example, 11 consecutive major hydroelectric power plants were built along the river Volga. Today, its biggest affluent Kama is producing a total power of more than 11 gigawatt. Such significant interferences in the river system, however, bring about ecological risks and potential conflicts over broad areas, with the impacts extending to the mouth of the river Volga.
The situation as described above and the insights gained in a previous joint project on IWRM in the problem regions of the Volga and Rhine rivers highlight the urgent necessity for an IWRM on the river-basin scale with a particular emphasis on urban agglomerations. A comprehensive German-Russian joint project thus aims to discover sustainable solutions for the economical and environmentally compatible management of the river Volga and its tributaries. The focus lies on the investigation of water and sediment quality in the Volga and Oka, on the quantitative and qualitative analysis of water and substance fluxes within the catchment area, on the discharge of nutrients and heavy metals relevant for eutrophication, on water management and on the security of construction works.

Figure 53:
Catchment area of River Volga
(Source: www.welt-atlas.de - modified IWG).

Study area

Catchment area of River Volga: F = 1360000 km^2

Length: 1540 km

200 tributaries

Height difference between source and mouth: 256 m

Highest high water discharge: HHQ = 39.400 m^3/s

Approach

Comprehensive and concerted planning instruments are thus being developed on an interdisciplinary scientific basis for exploring solutions to complex water resources management problems. In this context, the definitive objectives are the quantitative and qualitative safeguarding and distribution of the available water resources and wastewater disposal. Depending on local circumstances, the water supply networks of urban areas are to be optimized, diffuse contaminations are to be reduced by using sustainable

Figure 54:
Mouth of River Oka in River Volga at Nizhny Novgorod
(Photo: IWG).

www.iwg.uni-karlsruhe.de/
http://wasserchemie.ebi.kit.edu/english/index.php

Project partners in Germany:

- Karlsruhe Institute of Technology (KIT), Institute for Water and River Basin Management (IWG)
- Karlsruhe Institute of Technology (KIT), Engler-Bunte-Institute, DVGW-Research Center for Water Technology
- University of Heidelberg, Institute for Environmental Geochemistry
- Helmholtz Centre for Environmental Research – UFZ, Department Soil Physics
- MC – Innovation in Building Chemicals Bottrop
- SMP Ingenieure im Bauwesen GmbH Karlsruhe

Project partners in Russia:

- State University for Environmental Sciences Moscow (MSUEE)
- All-Russian Research Institute for Hydrotechnology and Melioration (Moscow)
- Nizhny Novgorod State University of Architecture and Civil Engineering
- Power Generating Company RusHydro
- Russian Academy of Sciences Pushchino

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Figure 55:
The vast expanse of the River Volga
(Photo: IWG).

management concepts, and the raw and drinking water quality is to be recorded. The water bodies are to be left in as near natural a state as possible in order to conserve their ecological function as an integral part of the natural environment as well as their socio-economic value, e. g. as a recreational area.

Results

The project has an excellent opportunity for making a considerable contribution to the implementation of an IWRM in the greater Moscow-Nizhny Novgorod area and the river basins of the Oka and Volga, especially with regard to the already existing models and experience held by the German partner, and the coordination between German and Russian partners. Established interdisciplinary coordinated and regionally specific optimised instruments of IWRM can offer valuable solutions and create a reliable basis for planning the sustainable development of this area. New perspectives for future German-Russian cooperations in the fields of environmental protection, energy economy and technology development are thus created. Furthermore, the cooperation offers manifold possibilities for German enterprises to invest in the very dynamic Russian market.

International Water Research Alliance Saxony – IWAS

Project duration: 08/2008–12/2010 (Phase I), 01/2011–06/2013 (Phase II)
Geographic location: Eastern Europe (Ukraine), Central Asia (Mongolia), South East Asia (Vietnam), Middle East (Saudi Arabia/Oman), Latin America (Brazil)

Project summary

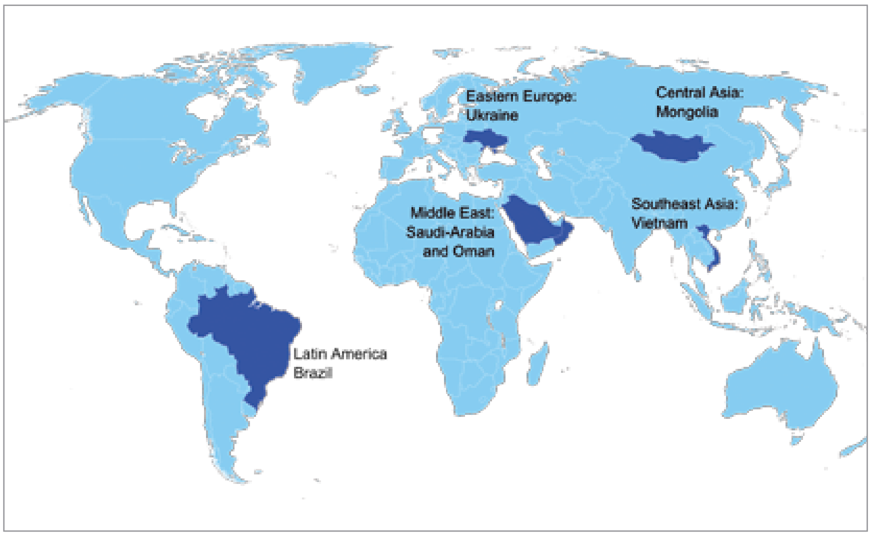

Figure 56: The International Water Research Alliance Saxony study regions (Source: IWAS Project).

The most urgent global water problems are in the areas of drinking water supply, waste water disposal, agricultural irrigation, ecosystem services and extreme events. IWAS seeks to address these issues with the development of tangible contributions to Integrated Water Resources Management in five hydrologically sensitive global regions. Every region has its own unique profile, just as the causes of the occurring water problems differ:

In **Eastern Europe,** solutions are to be developed for the adaptation to international environmental quality standards, for improving surface water quality. An example river has been selected for this purpose; the Western Bug, situated on a national boundary. Significant matter sources and pathways are to be identified at catchment level, processes are to be studied and models are to be developed, which are to consider urban water management and hydrobiological aspects, technology developments, ecosystem services and socio-economic and institutional framework conditions, in this pilot project which is to serve as an example for the transformation states of the former Soviet Union.

In **Central Asia**, processes of ecosystem functions and services are studied in the example Selenge River Basin in Mongolia. Near-natural but extreme climate conditions prevail in this region, as well as rapid population growth associated with the industrial, agricultural and demographic change processes that are characteristic for emerging and developing nations. As environmental processes, socio-economic framework conditions, technology developments and predictive models are to be coupled in these studies, strategic and tangible system solutions are to be derived that form the basis for decision-making for IWRM and which are to be transferable to comparable transformation states in the region.

In **South-East Asia**, the development of sustainable waste water management systems is being researched in the example mega-city of Hanoi, Vietnam. Innovative solutions for waste water treatment and subsequent artificial water enriching are to combat sinking groundwater levels and enable the utilisation of sewage sludge. Cooperation with local infrastructure operators, decision makers and universities ensure the sustainable implementation of the concepts. A national water competency centre is to be established at the same time in order to strengthen the knowledge base of local companies and management in the long-term.

New solution pathways for the sustainable management of limited water resources in (semi)arid regions will be developed in the **Middle-East** with the Arabian Peninsula serving as an example. Ground water recharge is being studied on the large scale and with high precision; the storage and use of ephemeral rivers are also being studied as well as the optimisation of agricultural water use. Modern hydrogeological, tracer and isotope methods will be used here, which will enable the development of integrated river basin www.iwas-initiative.de

Figure 57: Sugenugr River in the Khentil mountains, Mongolia; a reference river which has remained largely untouched by anthropogenic influences (Photo: R. Ibisch).

models and process-orientated management systems, in order to utilise the limited resources for efficient and sustainable irrigation in particular. The new management practises will be conveyed in agreement with decision makers and tested with local farmers.
The developments in the Brazilian capital city, Brasilia, under the influence of regional, demographic and land-use change will serve as the example for rapidly growing metropolitan regions in **Latin America**. The aim here is to find a sustainable solution for an IWRM plan with the emphasis on the long-term stable supply of drinking water. A system analysis of existing water resources, infrastructures, demand patterns and potential risks and the socio-economic framework conditions which make up the foundation for alternative management strategies and concepts, will be conducted in cooperation with regional decision makers and operators.
The studies in the five model regions, which are focussed to just 3 in phase 2 (Eastern Europe, Middle-East, Latin America), will be supplemented by four cross-cutting topics: System and scenario analysis, technological development and implementation, governance research and capacity development. Data, methods and models and their components from the regions will be gathered together in a cooperatively developed modelling platform (IWAS-toolbox) and linked. Decisions on implementation options can be supported through integrated system analysis. IWAS offers both in accordance with the requirements and applications of an IWRM plan: Problem-orientated system solutions, adaptation strategies, options for action and tangible measures, which can be tested in the field, as well as transregional transferable methods and model developments.

Project partners in Germany:

- Helmholtz Centre for Environmental Research – UFZ, Leipzig
- Technische Universität Dresden
- Stadtentwässerung Dresden GmbH
- DREBERIS – International Strategy Consultants
- itwh – Institute for Technical and Scientific Hydrology, Hannover

Project partners in the study regions:

- Various cooperation partners, see www.iwas-initiative.de

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Support of the BMBF Funding Priorities "IWRM" and "CLIENT" by the International Bureau of the BMBF: "Assistance for Implementation" (AIM)

Project duration: 04/2007–12/2011

Project summary

The International Bureau of the BMBF (IB) has been commissioned by the BMBF to strengthen the international ties of German universities, research institutes and enterprises with the ultimate goal of building competencies and fostering competitive advantages for industry and the research community in Germany in the areas of research and innovation. In doing so, the IB is making an important contribution to promoting an international dimension in the BMBF's research programmes.

In the accompanying assignment "Assistance for Implementation" (AIM) within the IWRM funding priority, the IB supports research projects in improving the prospects for the implementation of their technical solutions and IWRM concepts. For this objective, it is important to emphasise the necessity of developing these solutions according to the requirements of the relevant authorities and stakeholders in the partner countries as well as to prove the application-oriented, ecological and economical advantages of the solutions developed by the project partners.

Substantial infrastructural investments e.g. for wastewater treatment are often required in the implementation of IWRM concepts. These investments – with the possible exception of some pilot installations – are not part of R&D projects. The public and private sectors in the partner countries are often not able to raise the necessary investment funds on their own, however. In order to address this problem, AIM analyses the extent and conditions under which R&D projects can form the basis for infrastructure projects financed by bilateral or multilateral development banks. This process is then initiated in appropriate cases. This includes providing advice to the projects and a dialogue with bi- and multilateral development banks as well as establishing contacts to and communicating with ministries, planning authorities and other relevant government bodies in the partner countries. The possibility of taking advantage of synergies with multilateral funding programmes, for example those of the EU or the UN, is also investigated.

Figure 58:
Implementation of infrastructure solutions (A. Künzelmann / UFZ).

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Networking activities for the BMBF Funding Priority IWRM by the Helmholtz Centre for Environmental Research – UFZ

Project duration: 01/2009–12/2011

Project summary

IWRM activities are focussed on the transfer of information and technology within the context of the sustainability goals formulated at the Johannesburg World Summit in 2002. The IWRM projects presented in this brochure develop situationally-adapted concepts and integrated system solutions in model regions in developing and emerging countries. An important question here is to which extent fundamental guidelines and standards can be derived from the country-specific activities in order to develop and implement integrated management approaches. Furthermore, it is necessary that the involved scientists and decision makers from politics, administration and economy exchange their project experiences, draw conclusions from research results and communicate these conclusions outwards.

Against this background, the BMBF established a networking and coordinating project in early 2009 at the Helmholtz Centre for Environmental Research – UFZ with the following objectives:

- Intensification of the professional exchange between the project participants from the IWRM-funding initiative and other actors from science, politics, administration and economy in order to achieve synergy effects from the different activities,
- Presentation of the IWRM funding activities and their results in the national and international sphere in order to contribute to a direct utilization of the research and development results.

So far, the following networking activities have been realized:

- Organization of thematic workshops on central cross-cutting topics such as instruments for decision support, information management, Capacity Development, participation processes, analysis of actors and institutions, concepts and implementation of IWRM
- Organization of thematic working groups, events for Ph.D. students as well as seminars at international conferences and fairs,
- Public relations measures such as a comprehensive internet web site, IWRM-newsletters and other information materials.

Figure 59:
Networking (Photo: A. Künzelmann / UFZ).

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Industry meets research
Win-win-situations in the field of Integrated Water Resources Management

In order to sustainably manage water resources, close cooperation is often needed between research and industry – between scientific partners that develop innovative options and partners from industry who then implement these options. Examples for innovative solutions in the water sector are decentralized wastewater treatment methods or plants for groundwater desalination. Actors from the industry support the implementation of elaborated measures through their knowledge and investment activities. Combined with suitable socio-economical and institutional conditions, the cooperation between science and industry benefits the local population.

However, the intensive cooperation does not only benefit the local population. The cooperation processes creates numerous mutual benefits:

The partners from industry particularly emphasise the significance of the cooperation with research parties in politically unstable and poorly developed regions, which is essential in order to enable a market entry in the first place. Cooperation also makes intensive work possible on questions that cannot be adequately examined within a company. An additional benefit to cooperation is the chance for recruiting potential staff and for advertising and promotion within prestigious projects.

Scientists emphasize current and progressing research possibilities and the increasing implementation prospects of their products as a result of the cooperation with the economy. An exemplary implementation is particularly important in this context in order to test new technologies under real life conditions. Finally, the cooperation with industrial partners enables the often valuable access to their production and testing facilities.

In order to achieve an improvement for the inhabitants of a project region in the long term, Capacity Development measures (compare p. 11 of this brochure) have to be considered in addition to the important cooperation between science and industry. The socio-economical and institutional conditions must also be taken into consideration. Together, these activities support a real win-win-situation in terms of a public-private-people-partnership-approach.

Figure 60:
KIT-scientists and Herrenknecht-engineers achieve the "breakthrough": a successful shaft sinking up to 100 m deep. Cooperation between research and industry as a real win-win-situation (Photo: IWRM Indonesia Project).

Figure 61:
Water conveying module at the KSG test facility: direct exchange between research and industry for the development of adapted technologies (Photo: IWRM Indonesia Project).

An example for a successful cooperation between partners from science and industry is the IWRM project in Gunung Kidul, Java, Indonesia (compare p. 22/23 of this brochure). To achieve the objective of a sustainable water resources management, scientists from different research institutions work together with Indonesian and German industry partners. Project parties emphasize the strong benefits for research and industry resulting from this cooperation:

Scientific actors note that the research institution and the industrial partners can develop joint, adapted technologies such as the adapted "Pump as Turbine"(PaT)-Technology, which is operated within the IWRM project. The scientific actors often emphasize the importance of having the possibility of gaining access to the production and inspection facilities of the industry partners, such as for instance the test facilities at the KSB AG.

Economic actors also emphasize numerous cooperation benefits within the Indonesian project. One important point is the exploitation of international market chances. An example is the development of a prototype vertical drilling machine by Herrenknecht AG; this was one of the first steps to a shaft drilling machine, which can quickly sink shafts in mixed geology, rock and especially under groundwater conditions with low vibration and emissions. Another example for the successful initialization of new market segments through the BMBF-project is the new department for pumps in the operation of turbines at the KSB AG that was founded in 2008 due to the worldwide commercial potential of PATs. Since then, the company has extended this branch and the product is used in numerous countries around the world.

This cooperation between science and technology does not generate specific problems in the project. Crucial is the awareness of both parties that open-ended research can include modifiable general conditions, which can lead to an adaption of temporal conditions and project objectives to new results.

In summary, the following can be stated from the perspective of the Indonesian project: Cooperation is definitely profitable – for research and for the economy and ultimately also for the local population.

Review and Outlook

Review
Many emerging and developing countries as well as the industrial nations face huge challenges in the water sector. The concept of Integrated Water Resources Management presented in this brochure is a vital approach to solving the problems associated with the topic of Water. It is the aim of the Federal Ministry of Education and Research to transfer this approach in adapted measures within the funding initiative IWRM. The ongoing research and development projects have different approaches and regional foci for achieving a sustainable water resources management. The main focus is the integrative concept approach and the multilateral cooperation of project parties from Germany, the partner countries and from different sectors such as research, industry and administration. On this basis, it was possible to make the first important steps in the research and implementation of adjusted management concepts in recent years.

An accompanying project at the international office of the BMBF makes a significant contribution to the implementation of the academic concepts by giving advice to the project partners, in addition to a networking project, which creates the framework for a mutual exchange of information. The experiences of the presented projects show that cooperation not only benefits the local population and the scientific actors but also the economy.

Outlook
Productive Cooperation across borders, actor groups and specific problem situations – all of these are core areas of the BMBF funding initiative IWRM. How will it continue? Which role will the concept of IWRM play in the future? Which further results can be expected from the IWRM projects?

IWRM as an approach for a sustainable water resources management will endure, but it is still often not implemented to a satisfactory degree.
Further results to vital research questions and implementation of the results and solutions according to target region and main focus can be expected in the future from the ongoing research and development projects. The implementation of pilot plants, the adjustment of measures and the transfer to comparable regions are all highly important. Due to the increasing relevance of the implementation of research results, a more intense cooperation between research and economic actors is necessary. The extent to which these efforts will ultimately contribute to a sustainable water resources management in the model regions is determined by the social and political conditions. The transfer of knowledge through capacity development activities and the local, national and international governance requirements in the model regions are central for the implementation of sustainable system solutions. These essential challenges are part of a long-term reform process for achieving sustainable water resources management.

Figure 62: Water is life
(Photo: A. Künzelmann / UFZ).

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Integrated Water Resources Management (IWRM) is a globally recognized concept for the modern and sustainable management of water, a limited resource. The framework for this management concept was set in place as an international model in 1992 with the Dublin Principles and Agenda 21. The German Federal Ministry of Education and Research (BMBF) consequently created the funded research programm IWRM for the development of evidence-based integrated planning tools and methods for use in current and future applications of IWRM concepts. This brochure provides information on all IWRM research projects of the respective funding initiative and several related projects and programmes.