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رودخانه زاینده رود

IWRM
ZAYANDEH RUD

Integrated Water Resources Management Zayandeh Rud

German-Iranian Research and Development Cooperation for a Better Future

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Preamble by Mohammad Ali Torfeh

Sustainable and fair distribution of water in the Zayandeh Rud catchment have always been the main challenges with respect to the social and economic development of the region. For this reason allocation rules for the precious water resources of the Zayandeh Rud were established around 500 years ago, probably the first rules of this kind in Iran. These allocation rules were named after the famous theologian and lawyer Sheikh Bahai. Their aim was the controlled distribution of river water among the different agricultural areas throughout the catchment.

Today, climatic and anthropogenic changes pose novel challenges to the decision-makers and inhabitants, requiring new thinking and action. Steady population growth, industrial development of the Isfahan province but also the allotment of new agricultural areas have been increasing the pressure on water resources. Moreover, the region has been suffering from more frequent and intense drought periods over the last two decades. All this has exacerbated the delicate water situation in the region in quantitative and qualitative terms. Every year, the national and particularly the regional decision-makers can feel the consequences: Rising tensions between the riparian provinces and the water users cannot be ignored.

Current decision formats, mainly based on comprehensive experiences of institutions and experts, no longer meet the requirements of an increasingly complex water management situation. Economic development, the environment and the health of the people are at stake. The situation threatens social peace in the catchment and beyond.

Based on the conviction that these circumstances require new thinking, innovative technologies but most of all joint action, back in 2010 – when I was still the managing director of the Isfahan Regional Water Board Company – I accepted the offer by the Ministry of Energy to create new approaches for integrated water resources management together with German experts. We agreed upon the joint development of ideas, products and models that could serve officials as a basis for improved decision-making and that could provide citizens and companies with options for more efficient water use. By emphasizing the cooperation of the stakeholders in every project stage, we want to make sure that the results are widely acceptable, reconise the range of water management decisions needed and legitimize them.

With the IT-based decision support system as the connecting element of the project, we are aiming for a practice and implementation oriented system that can be adjusted and extended as per requirements. This is supposed to be a major contribution for the long-term development and consolidation of the IWRM process, but also for identifying and visualizing new issues and challenges.

Over the last five years important steps have been made on this path which has surely created benefits for the Iranian but also for the German experts. These steps have to be accelerated and accomplished in the coming years, and practical tools and approaches have to be further developed and implemented.

I am confident that the contacts and friendships that have been established over the past years between German and Iranian experts and decision-makers as well as the energy and commitment that have been invested will guarantee the success of this endeavor. I would like to wish the project partners success beyond the Zayandeh Rud catchment borders and I'm looking forward to future project results.

Mohammad Ali Torfeh
Coordinating deputy of urban development,
Governor General of Isfahan

Preamble by Dr. Masoud Mirmohammad Sadeghi and Kourosh Naderi

The Zayandeh Rud river basin is now experiencing a serious water crisis reflected by drying rivers and wetlands, declining groundwater resources, land subsidence, deteriorating water quality, agricultural losses and ecosystem damages. The Zayandeh Rud River, the backbone of human development in central Iran, dries up seasonally (the Gav Khuni wetland dries completely), imposing extensive pressure on agriculture, industries and urban population.

The Zayandeh Rud basin has experienced a significant population growth in recent decades. Its population has increased almost three times over the last fifty years which has promoted different socio-economic changes. While annual renewable water resources per capita in Iran is 1,700 cubic meters, due to population growth and water shortage, less than 1,000 cubic meters of water per capita (slightly above the water scarcity threshold) is available in the Zayandeh Rud basin. In addition to population growth, inappropriate population distribution, inefficient agriculture and mismanagement of socio-economic development, many analysts and professionals argue that the water crisis in the basin is the result of sectorial thinking and a fragmented water management approach. Increased awareness of the water resources limitations in the Zayandeh Rud basin and its role for sustainable development has augmented the necessity for a shift towards a holistic, sustainable, and integrated management approach.

The concept of Integrated Water Resource Management (IWRM) was established as early as 1992 as an international guiding principle within the framework of the Dublin Principles and Agenda 21. This concept is based on sustainable, quantitative and qualitative, demand-oriented management of the interacting components – surface waters, aquifers, coastal waters and land – in order to support not only social and economic development but also to preserve ecosystem functions. Research and development activities of IWRM include varieties of topics such as capacity development, instruments for decision support and governance, and participation of all stakeholders.

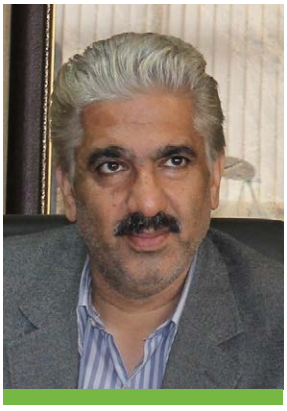
The first stage of the Integrated Water Resources Management Zayandeh Rud Project had the aim of identifying the current state of water resources and water uses, preparing a framework for IWRM implementation, and developing a water resources management tool for decision support in the Zayandeh Rud basin. These activities were coordinated by the Isfahan Regional Water Company and the inter 3 Institute for Resource Management and have been funded by the German Federal

Ministry of Education and Research since 2010. Achieving the project aims required that the local experts as well as users and decision-makers discussed what information was needed, indicated how necessary data might be accessed and developed a common understanding of the problem. Experts from relevant sectors had the opportunity to describe what they perceived as the most important challenges connected with managing the catchment area and what they expected of the management tool. The next step of the project consisted of gathering all the decision-relevant information in a database. On this basis, a conceptual model of the basin was set up and water management and decision tools were selected and improved. At the present stage of the project, a framework for the water management tool has been developed for the catchment area of the Zayandeh Rud. The decision-making tools, models and databases are being further developed.

The second project phase focuses on implementing the IWRM concept in the entire catchment. This requires the application not only of new technologies but also of new intellectual approaches. The German-Iranian cooperation in this project has provided the opportunity to take on such new perspectives on water resources and their management. Up until today, a number of valuable and trustful contacts, professional as well as personal, have been established which will hopefully outlast the project duration.

Dr Masoud Mirmohammad Sadeghi
Managing Director of the Isfahan Regional Water Company

Kourosh Naderi
Managing Director of the Chaharmahal-va-Bakhtiari Regional Water Company



Part I: Developing the IWRM Concept 2010 – 2015

Puddle in the dry river bed.

IWRM – International Water Research Funded by the German Government

The Federal Ministry of Education and Research (BMBF) supports research for sustainable development and the solution of global challenges, like water scarcity or climate change. For this purpose the concept of Integrated Water Resource Management (IWRM) is one of the ministry's funding priorities.

At the World Summit on Sustainable Development in Rio de Janeiro 1992 the concept of IWRM was established as the international guiding principle for managing increasingly scarce water resources. Agenda 21 and the Dublin Principles form its implementation framework. In response to failed sectoral approaches, IWRM emblematizes a paradigm shift to integrated and basin wide thinking: Water bodies and their related ecosystems, water using sectors and different governance levels have to be considered in management decisions. Ecological, economic and social objectives must be linked together in order to achieve sustainable outcomes. IWRM requires a meaningful mixture of management approaches for the respective water basin, ranging from participation of public and private stakeholders to the implementation of new technologies.

Sustainable solutions through management approaches

The Global Water Partnership network's definition of IWRM is widely accepted:

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

A key objective of the BMBF is to promote the innovative and technological potential of German science and business to develop solutions for water availability and solving water quality problems.

The main aims are:

- better access to clean water and safe sanitation,
- higher water productivity and more efficient water use,
- improved water quality.

The BMBF funding priority "Integrated Water Resources Management (IWRM)" provides the framework for a project structure that enables a duration of up to three project phases:

1st project phase: Research and development,

2nd project phase: Implementation,

3rd project phase: Evaluation and generalization.

Usually, the project partners from both partner countries present their project results after one funding period and apply for funding of the next project phase after successful evaluation by the BMBF.

The Gavkhuni Salt Lake: up until a few years ago an ideal habitat for Flamingos.

IWRM Projects funded by the BMBF since 2006, 2015.

IWRM – One of Germany's contributions to the UN Sustainable Development Goals

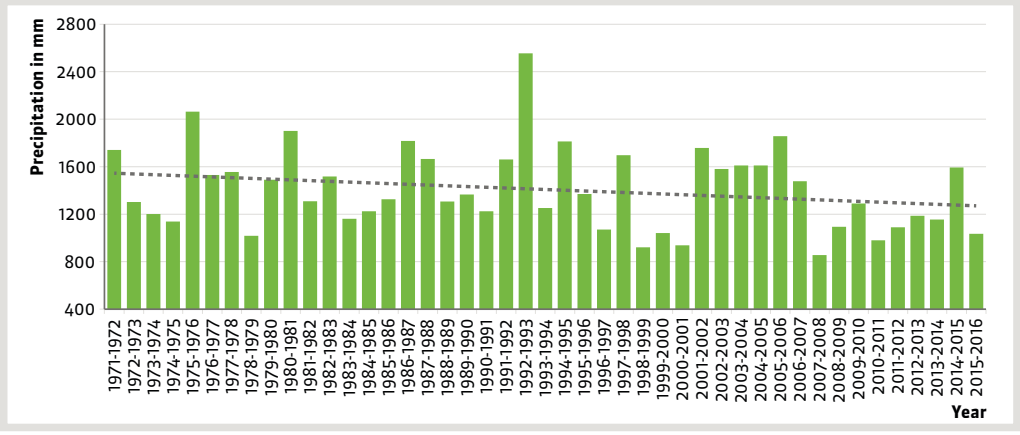
In 18 research projects in Europe, the Middle East, Asia, Africa and Latin America various approaches, methods and technologies have been looked at to discern what is necessary and feasible for IWRM and how management concepts can be adjusted to local conditions. By developing integrated planning tools, adjusting water technologies to different climatic, economic and social conditions and through multifarious training activities, the BMBF contributes to the United Nation's Sustainable Development Goals (SDG). Target 6.5 states: „By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate". As a Middle Eastern country with severe water challenges, Iran is one of the focal areas of BMBF research activities where the implementation of IWRM can produce valuable results for the entire region.

The Zayandeh Rud in autumn.

The Zayandeh Rud: The Lifeblood of an Entire Region

The catchment of the Zayandeh Rud (Farsi for 'life-giving river'), is one of the most diverse regions in Iran: From the snow-covered Zagros Mountains, through wide floodplains and desert regions to the Gavkhuni Salt Lake, the catchment is a special habitat. For centuries the river has attracted people and the entire region is host to a uniquely diverse ecology.

During the last 60 years, the population in the catchment has grown from less than a million to almost four million (for more figures see table on page 12). Today, more than 1 million people live from the land producing wheat, barley and other staple food. Important steel, oil and cement industries have settled along the river which along with numerous smaller enterprises employ more than 300,000 people.



Annual Total Precipitation in Chelgerd Station for 45 Water Years.

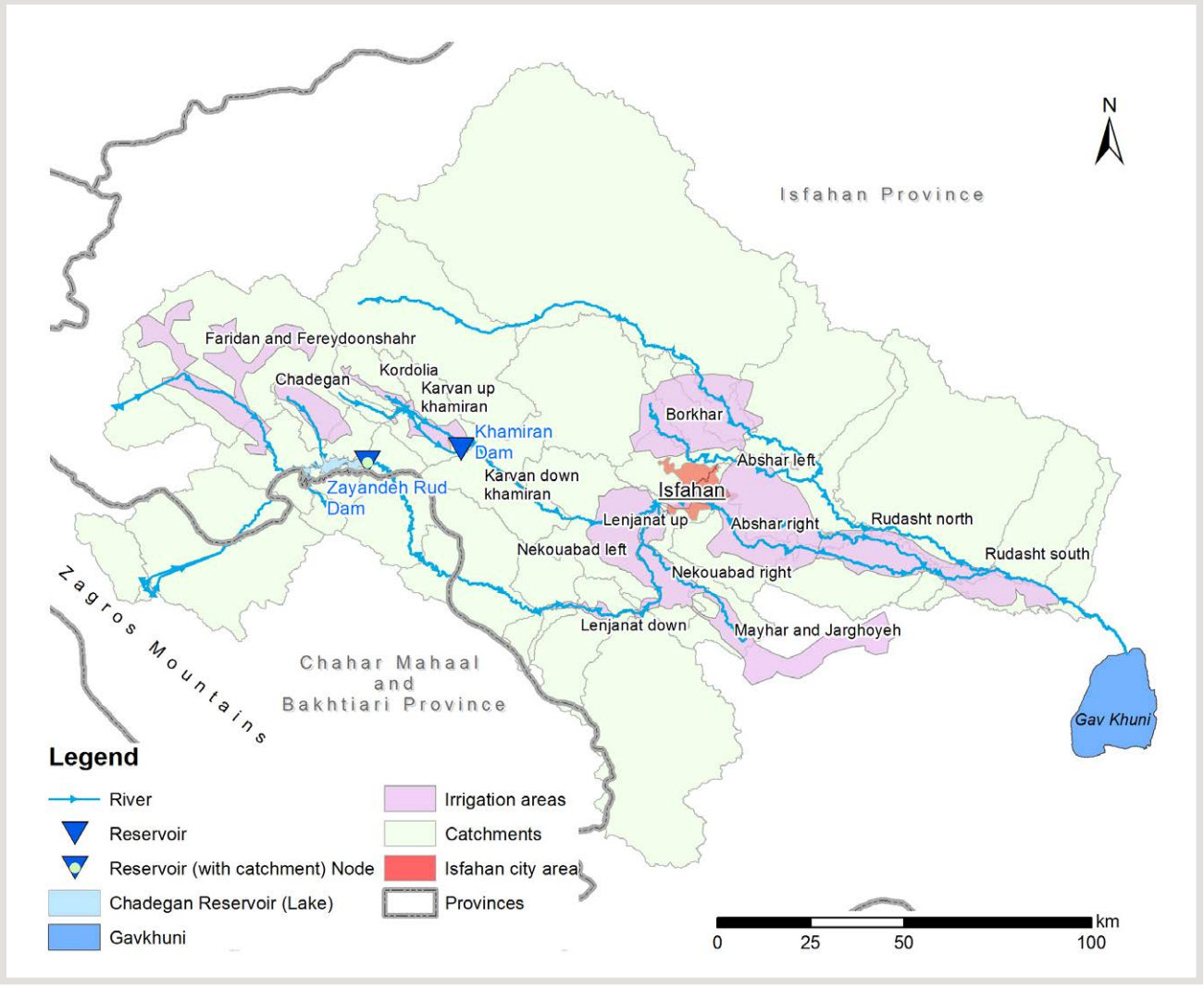
Opportunities and problems of regional growth

The steady growth of the region, coupled with the onset of climate change, have taken their respective tolls, leading to increasing water management challenges. While water demand rises, the Zayandeh Rud's water resources decrease and with them the livelihood of people and important ecosystems dwindle. Temperatures have been rising constantly, while annual rainfall has been declining.

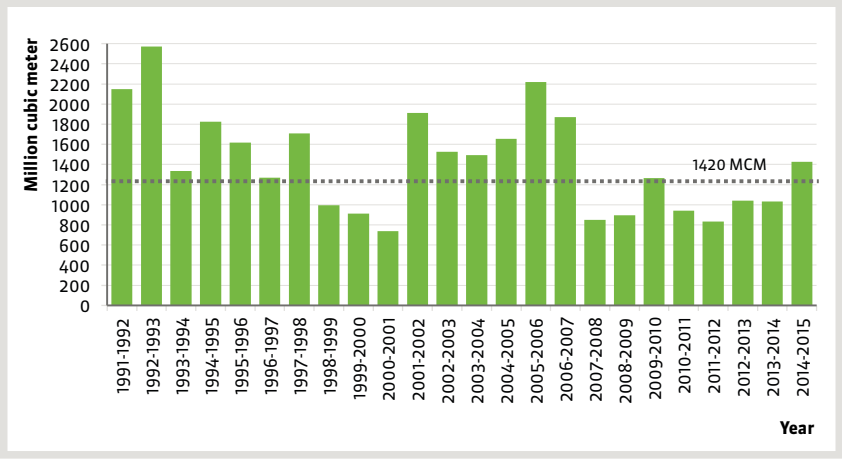
Up until a few years ago the river dominated the cityscape of Isfahan. Its historical bridges and little canals were famous tourist attractions and places of recreation for young and old alike. Numerous species of birds migrate there for the winter in the region around the Gavkhuni Salt Lake and even ventured into the city centre. For flamingos the salty lake was an ideal habitat.

The gap between water demand and water availability

As the gap between water availability and water demand grows the different water users increasingly compete for the scarce resource. Farmers, subject to uncertainty, ask themselves, "When will the next drought come? Will I have enough water for my fields? Will I be able to feed my family?" Industrial and drinking water supply is also under threat. Up until today, industrial enterprises in the catchment are still depending on fresh water resources for various purposes, and their demand is rising



The Zayandeh Rud catchment.



Average annual inlet into the Zayandeh Rud dam between 1991 and 2015.

with steady industrial growth. Last but not least, the Zayandeh Rud is the main supplier for drinking water in the region.

The diminishment of 'the life-giving river' is a tragedy for the entire region and not only for economic reasons but also from social, health and ecological perspectives. This situation that has evolved over years, however, will not be solved overnight. But it is worthwhile being tenacious in alluring all stakeholders for sustainable water management. There are many good examples for successful cooperation of different stakeholders even across borders, like the International Commission for the Protection of the Rhine (see page 13).

A sustainable and integrated water management concept for the Zayandeh Rud catchment is therefore fundamental. The natural beauty of the region, its biodiversity and not to mention more than 4.3 million people will benefit collectively from efficacious solutions. In this regard the Zayandeh Rud is representative of the plight of humans and their environment in many parts of Iran and in the Middle East in that it is dominated by a dry climate and water scarcity.


وزارت داخله

حکومت اصفهان

(اعلان)

Public announcement on water shortages, 1932

The Zayandeh Rud Catchment in Figures

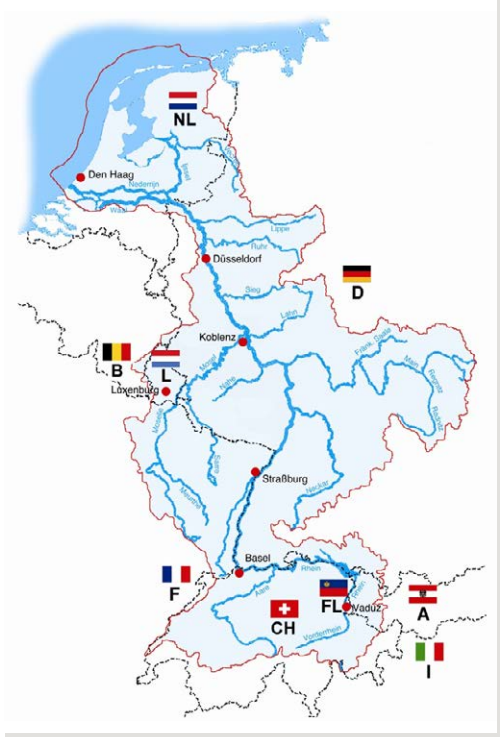
The following table presents some main figures in relation to the Zayandeh Rud catchment. The lion's share of the catchment is located in Isfahan Province, with a majority of inhabitants living in urban areas. Over the last years, the water available in the Zayandeh Rud dam was not able to meet the actual water demands or water withdrawal rights. Particularly the agricultural sector and the environment suffered from water scarcity. Farmers have not been able to exercise their water withdrawal rights – as approved by the High Water Council at its 13th session and by the RBO Zayandeh Rud at its 4th session on August 24, 2014 (see last 3 lines) – since water supply has been strictly curtailed. The Gavkhuni wetland has received too little water and also the floodplains along the river have been adversely affected.

Area and population	
Total area	26,917 km^2
Share of total area located in Isfahan Province	92.9%
Share of total area located in Chaharmahal-va-Bakhtiari Province	7.1%
Population in Isfahan Province's share	3,890,188 (urban 87%, rural 13%)
Population in Chaharmahal-va-Bakhtiari Province's share	88,172 (urban 47%, rural 53%)

Water availability and withdrawal	
Average precipitation*	265 mm/a
Average inflow into Zayandeh Rud dam (incl. transfers)*	1402 million m^3/a
Water withdrawal for drinking water Isfahan	334 million m^3/a
Water withdrawal for industry	152 million m^3/a
Water withdrawal Chaharmahal-va-Bakhtiari (total)	237 million m^3/a
Water withdrawal for drinking water supply of Yazd	65 million m^3/a
Agricultural water withdrawal rights (Haghabe)	419 million m^3/a (unconfirmed)
Agricultural water withdrawal rights (Sahmabe)	655 million m^3/a (unconfirmed)
Environmental water share (Gavkhuni wetland)	176 million m^3/a

** Statistical period: 1971-2013*

The River Rhine is joined by the Moselle in Koblenz.



The 9 riparian countries of the river Rhine.

The River Rhine

The River Rhine is used more intensely than any other river in Europe. On its 1,200 km from the Alps to the North Sea it flows through nine European countries. Water uses are manifold, they often compete and almost always they modify the water body and have negative effects on water quality.

The International Commission

1950, five years after World War II, Germany, France, Luxembourg, Holland and Switzerland founded the International Commission for the Protection of the Rhine. Today, the Commission is made up of 9 countries. In the 1990s, the commission's activities served as examples for many other river basins.

Challenges and Achievements

The initial aims were to monitor the pollution of the Rhine and its groundwater bodies to jointly recommend protection measures, to harmonize measurement and analysis methods, to exchange validated data and to monitor the impact of measures. After long negotiations, agreements for the protection of the river were concluded; today cross-border cooperation is a matter of course.

For the integration of the different interests regarding use and protection, the member states analysed the most important uses in an inventory in 2004 and made a prognosis of future developments. Most recently the Rhine Commission decided upon a basin-wide strategy for adapting to climate change, with a priority on flood protection.

It is mainly due to the work of Europe's oldest river basin commission that the river recovered from year-long pollution and environmental disasters like the chemical accident of Sandoz in November 1986.

"For 66 years now the International Commission for the Protection of the Rhine has maintained its unity despite significant challenges owing to the multi-faceted fields of endeavour of our stakeholders. Our joint efforts bring together green NGOs, water supply, industry, agriculture, inland navigation, hydropower, energy and municipalities. Our determination has paid off: over the years the water quality has improved and salmon, sea trout and more than 65 fish species are once again populating the Rhine."

Dr. Fritz Holzwarth, IKSR president (2004-2007)

Dry Zayandeh Rud river bed in Isfahan.

The Research and Development Project "IWRM Zayandeh Rud" – Setting the Goals

Within the "IWRM Zayandeh Rud" project Iranian and German partners have been developing and implementing a generally accepted water management concept for the entire catchment. Both partner countries combine their skills to achieve the project objectives: to make water use along the river sustainable and to balance the competing interests of the different water users.

The German consortium involves 7 scientific institutes and companies specialised in water economics. The Iranian consortium involves 15 governmental bodies, research and consulting institutions. inter 3 is the German project leader and coordinator.

After consulting the Iranian Ministry of Energy it was decided that the Iranian project coordinator would be the Isfahan Regional Water Company, and that all important regional stakeholders have to be involved in the project.

Memorandum of Understanding, 29 November 2010.

Three stages of project work

The Memorandum of Understanding which was signed in 2010 adopted all three BMBF funding periods in an adjusted form. Consequently, the overall project is implemented in three stages:

1. Stage: getting to know the catchment, collecting data and information and creating WMT,

2. Stage: development of strategies and instruments and implementation, and

3. Stage: dissemination of results.

Both partner countries combine their skills to achieve the project objectives: to make water use along the river sustainable and to balance the competing interests of the different water users.

The overarching aim of the project is to present options for integrated water management in Iran and the entire region using the example of the Zayandeh Rud catchment. The project team has been working towards this goal since 2010 in two stages. The focus of the first stage was to get to know the catchment and its main water management actors and institutions, to collect data and to define the necessary tools for IWRM. After these tasks were successfully fulfilled in early 2015, the second stage has now turned its attention towards implementing the IWRM concept.

Actors' cooperation as the first objective

A necessary precondition for IWRM is that the relevant actors of the affected provinces, sectors and national institutions become aware that they do not only sit in one boat but also have to row in the same direction. IWRM requires discussion and agreement on the measures to be taken and to cooperate in order to reach a common goal.

To this end the project team has developed an IWRM concept in close cooperation with all stakeholders and has designed a complementary bundle of adjusted technologies and management tools. Now all main water using sectors like urban and rural water industries, agriculture, industry and environment have been taken into account. The approaches include technological as well as non-technological measures like the optimisation of wastewater treatment plants, the modelling of water resources or innovative methods for the participation of affected people.

"Interdependencies in water management, degree of salinization and historically developed water supply principles increase the complexity of planning. To develop tools based on models poses new challenges for us which we can only solve with the support of our Iranian colleagues. This allows for a comprehensive approach in which the necessary management processes are integrated."

Dr. Michael Kaltofen, Head of DHI-WASY branch Dresden

Project meeting with regional and national decision-makers in Berlin.

Presentation of project results in Isfahan.

Presentation of project results in Isfahan.

Zayandeh Rud dam.

Goal 1: Creating Preconditions for IWRM

IWRM seeks social equality, economic effiency and ecological sustainability. It is therefore obvious that interests run contrary to one another. Negotiation skills and the willingness to give-and-take are therefore essential to the IWRM process.

The increasing pressure on water resources inevitably leads to more competition between the different water users but also between regions or governmental institutions like the sector ministries. It is clear that not everyone will accomplish their goals completely. Therefore all people involved need to keep negotiating to reach collective water management decisions. This is the only route to joint planning and implementation of specific measures.

Structures and database for negotiation and decision-making

In order to establish such negotiating processes consistently an umbrella organisation is required that involves all stakeholders and that maintains a view of the bigger picture. Every reasonable decision requires reliable information. Hence we need a solid and mutually accepted database on the use, quantity, quality and ecological conditions of the catchment. A catchment organisation does not only have to collect and agree upon these data but also take management decisions at the catchment level and see to their implementation. To do so it requires management tools like IT-assisted decision support systems (DSS).

Specific measures can then be implemented using adjusted technologies and methods. This again requires appropriate knowhow which can be achieved by capacity development in the form of knowledge transfer and exchange of experiences regarding individual technologies but also the institutional design of IWRM.

Workshop participants.

From theory to practice

Numerous studies from all over the world have shown that these preconditions for IWRM are universally valid. There is however, no blueprint for IWRM implementation, and the challenge is to find adequate, adjusted forms for every region and catchment. All stakeholders have to be involved in the IWRM process to turn these preconditions into precise, action-guiding credos.

IWRM Requirements at a Glance

- An umbrella organisation that maintains an overall view of the bigger picture and that coordinates water management at catchment level.
- A valid and universally accepted database.
- Supporting tools for decisions concerning necessary and appropriate water management measures.
- Fine-tuned training of experts from all relevant fields.

Site visit at a small Zayandeh Rud waterfall.

Goal 2: Mutual Definition of Challenges in the Catchment

At the beginning of the project it quickly became obvious that there was not only a large number of stakeholders that had to be taken into account in an IWRM concept, there were also many conflicting opinions about the actual situation and the most pressing challenges in the Zayandeh Rud catchment. But a mutual definition of challenges in the catchment was necessary – and could be achieved in a participatory process.

In order to create a common understanding, the German project team decided to conduct an interactive workshop, a locally adjusted version of the World Café which is a method often successfully applied in Europe.

As limited experience exists with participatory methods in Iran, it was clear that the adaptation of such approaches would be time-consuming. Due to their expertise, however, the project managers knew that it was worth the effort to achieve mutually accepted results.

Participation is time-consuming but worthwhile

In this workshop in Isfahan, around 30 experts and decision-makers from all water-relevant fields participated: representatives of the provincial and urban administrations, the regional water company, the environmental and agricultural organizations, water suppliers and waste water companies, industry, NGOs and academia. German participation experts led the event. The fact that the issue of hierarchical thinking was addressed in an open way, and that small discussion groups were formed with participants from different hierarchical levels, sectors and professional fields, led to very good results.

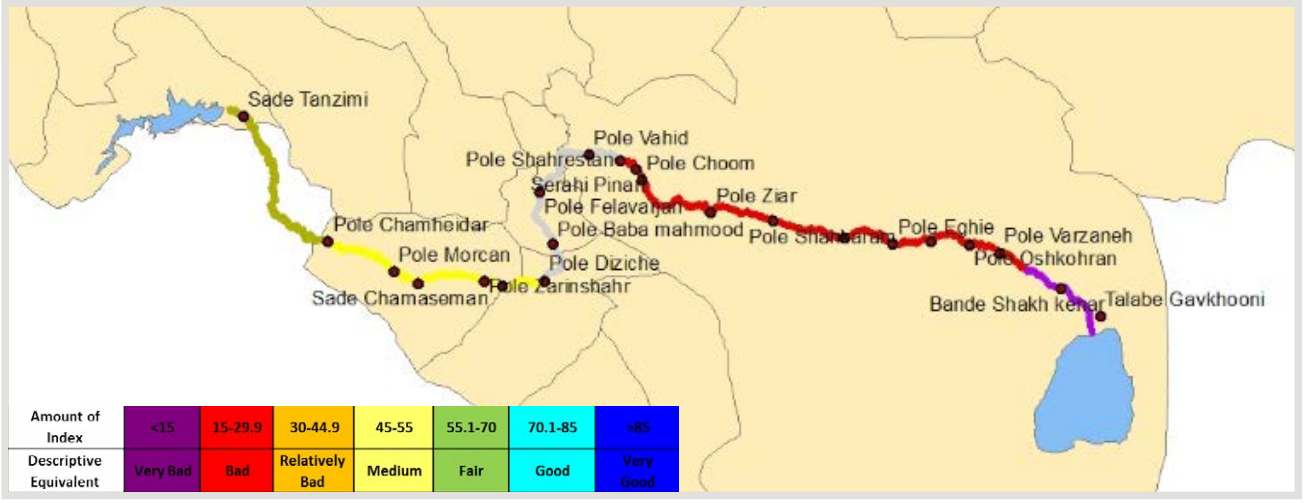
Joint definition of challenges and possible solutions: IWRM Workshop in Isfahan.

The main challenges: Water shortage, overuse and quality

The participants identified the main challenges as being:

- Human needs and climate change are mainly responsible for the increasing water shortage and overuse. This would require sustainable management approaches. The measures taken to date, like water transfers, would not be able to alleviate the problem by themselves and might even exacerbate resource conflicts.
- The participants stated that the increased use of ground and surface water would lead to further reduced water quality. Apart from rising water-borne diseases this would also lead to irreparable negative effects on the environment.

The participants also discussed which necessary preconditions for IWRM were hitherto prevalent in the Zayandeh Rud catchment. They agreed that the required bases for an IWRM process were basically non-existent:



Declining Water Quality. Iranian Water Quality Index.

- The workshop participants concluded that there was no integrated management plan for the catchment. This resulted from mutual mistrust of the stakeholders and their purely sectoral approaches. Subsequently an umbrella organisation that could coordinate and harmonise the various interests was lacking.

- According to the participants there was also a lack of valid and accepted data for the entire catchment. Water management decisions would therefore be taken on the basis of inconsistent and inappropriate data, and were therefore often inefficient or even counter-productive. Even decisions of the national government were not founded upon scientific and transparent bases.

Date	Consequences	Historian
1031	Cholera outbreak - great famine	Nasir Khosrow
1717	Famine – people had to eat cadavers	Charles Melville
1751	Loss of gardens	Jean Gore
1871	Death of thousands of people	Abdollah Mostowfi
1916	Great famine - social uprising	Hassan Hosseini Abari
1946	Death of thousands of people	Mohammad Hassan Khan Jaberi

Historically documented droughts and their consequences.

IWRM as a widely accepted solution path

The workshop participants expressed the view that an independent IT-based decision support tool was necessary. This tool should be able to depict the impacts of decisions on water resources in the catchment and thus improve decision making. It should also be able to grasp inherently complex and continuously changing local conditions.

Based on the results of the interactive workshop the specific direction of the first project stage was defined which had two main pillars: The IWRM concept, an adjusted and approved idea for IWRM planning and decision-making in the catchment; and second the decision support system (DSS).

Apart from the analysis of the status quo and the main water management challenges, the workshop had the desired side-effect which was to strengthen the collective will of the stakeholders to implement an IWRM process.

Date	Climatic condition
1956-1967	11 years of drought
1967-1982	15 wet years
1982-1985	3 years of drought
1985-1996	11 wet years
1996-1999	3 normal years
1999-2002	3 years of drought
2002-2007	5 normal years
2007-2015	8 years of drought

Climatic conditions during the last 60 years illustrate the decrease in wet years.

The Zayandeh Rud river in Spring.

Goal 3: IWRM Concept and DSS as Foundations of Cooperation

So how can the complexity of the situation be adequately understood? What guarantee is there that the solution to one problem will not just lead to another problem? And how can we make sure that decisions that seem adequate from a water management perspective become acceptable from political and social perspectives as well?

As the basis for the IWRM process the project team developed an IWRM concept for the Zayandeh Rud catchment together with, and accepted by, the main stakeholders. The German and Iranian project partners also agreed upon developing an IT based decision support system. This system is able to process large amounts of data and provide information about the possible results of management decisions through models. It is neutral in its analysis, clear in the presentation of its results and therefore the ideal tool for steering an IWRM process.

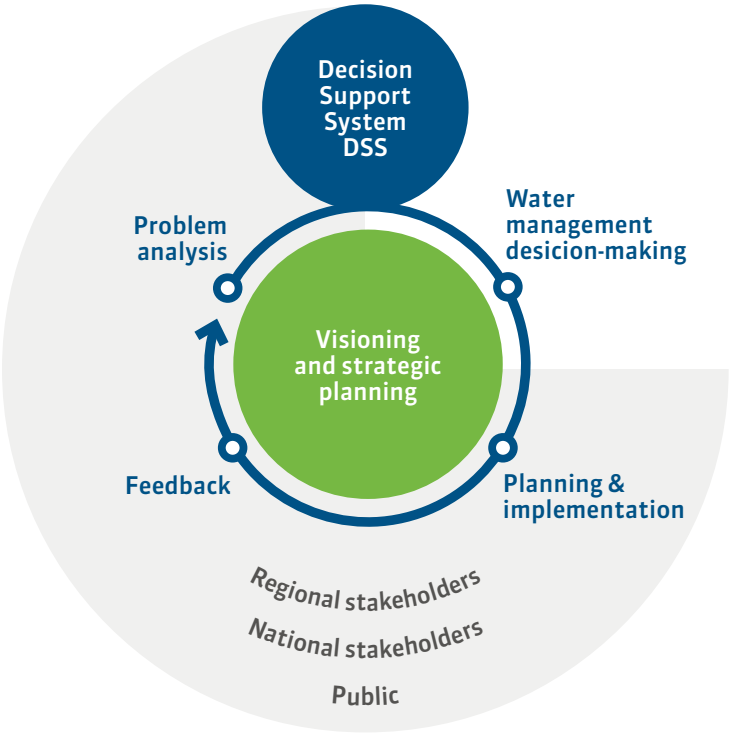
Step by step towards the IWRM process

The IWRM concept provides a step-by-step process where the main national, regional and local stakeholders identify the problems in the catchment and collect ideas for their solutions (see IWRM concept on page 21).

This is how it works:

- An idea, for example the withdrawal of water access rights, is fed into the DSS. Now the DSS can show how this proposed measure will impact upon water resources in the catchment.
- Based on this, specific recommendations can be developed which should be

BMBF representatives visiting the Isfahan North Wastewater treatment plant.



Adapted IWRM concept for the Zayandeh Rud catchment.

adjusted to a vision or overall strategy for the catchment. Eventually a water management decision should be taken which is acceptable for ministers and farmers alike.

- Built on a good and acceptable decision, the planning and implementation of specific measures can be carried out and their status and impact need to be monitored continuously.

- Depending on how well a measure has taken effect, it can be adjusted and ideas on problem solving can be redefined.

"One of the achievements of this project has been defining and furthering the objectives of integrated water management with continuous cooperation and collaboration of the governmental organizations, relevant institutions, and water users in the basin. This led, in particular, to the compilation of comprehensive data and information especially on the agricultural sector and also the creation of a database at basin scale which has been endorsed by all stakeholders for the first time. This is an important step for achieving sustainable water resources management in the Zayandeh Rud river basin."

Abbas Asady, former IWRM-Zayandeh Rud Project Manager at the Isfahan Water Board Co.

Boat trip on the Zayandeh Rud.

Goal 4: The Water Management Tool as the Basis for DSS

As the basis for DSS the water management tool (WMT) had to be established in the first project stage. After long negotiations with the main stakeholders the central functions of WMT were defined.

In order to clarify the main influences on water resources and their interactions it was decided to develop four independent models and integrate them: a climate change model, a hydrological model (SWAT), a groundwater model (FEFLOW) and the MIKE Basin model which can depict changes in water availability in the catchment subsequent to specific management decisions.

Consistent and acceptable data for the catchment

Every model is only as good as the data it feeds upon. A working WMT or DSS therefore requires good quality data. At the beginning of the project however there were no consistent and acceptable data for the catchment. Therefore regulation measures of individual institutions which were based on their data were always disputed and led to conflicts rather than solutions. It was always a question of the interpretation of "fair water distribution" and all stakeholders always had good reasons for their opinions.

Feeding the models with universally accepted data and making them operate were at the forefront of the first project

Presentation of MIKE Basin model.

Presentation of project aims at the Zayandeh Rud Conference in Isfahan, 2013.

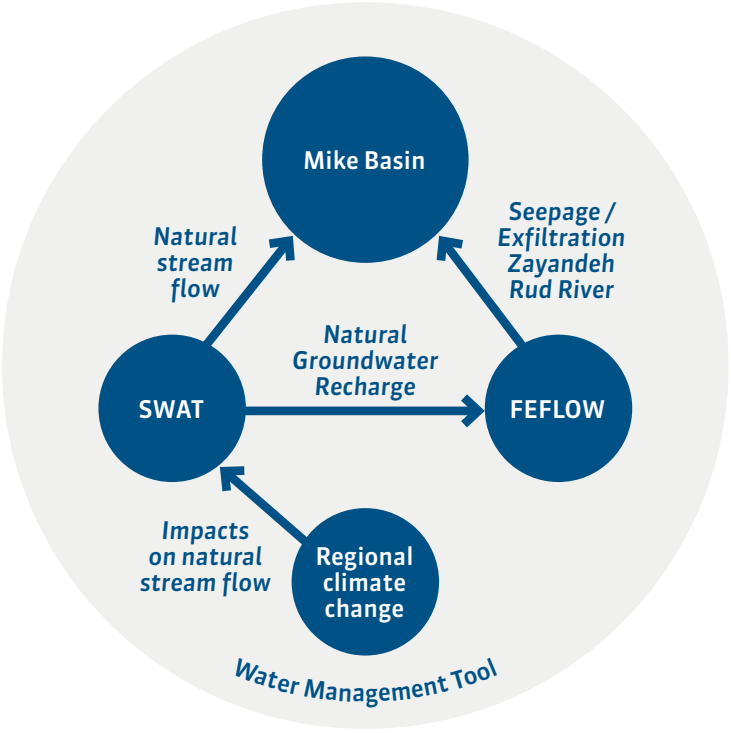
stage. With success: For the main water using sectors –agriculture, industry, and urban water consumption – existing and new data were collected in cooperation with the Iranian partners.

WMT as the basis for future water management decisions

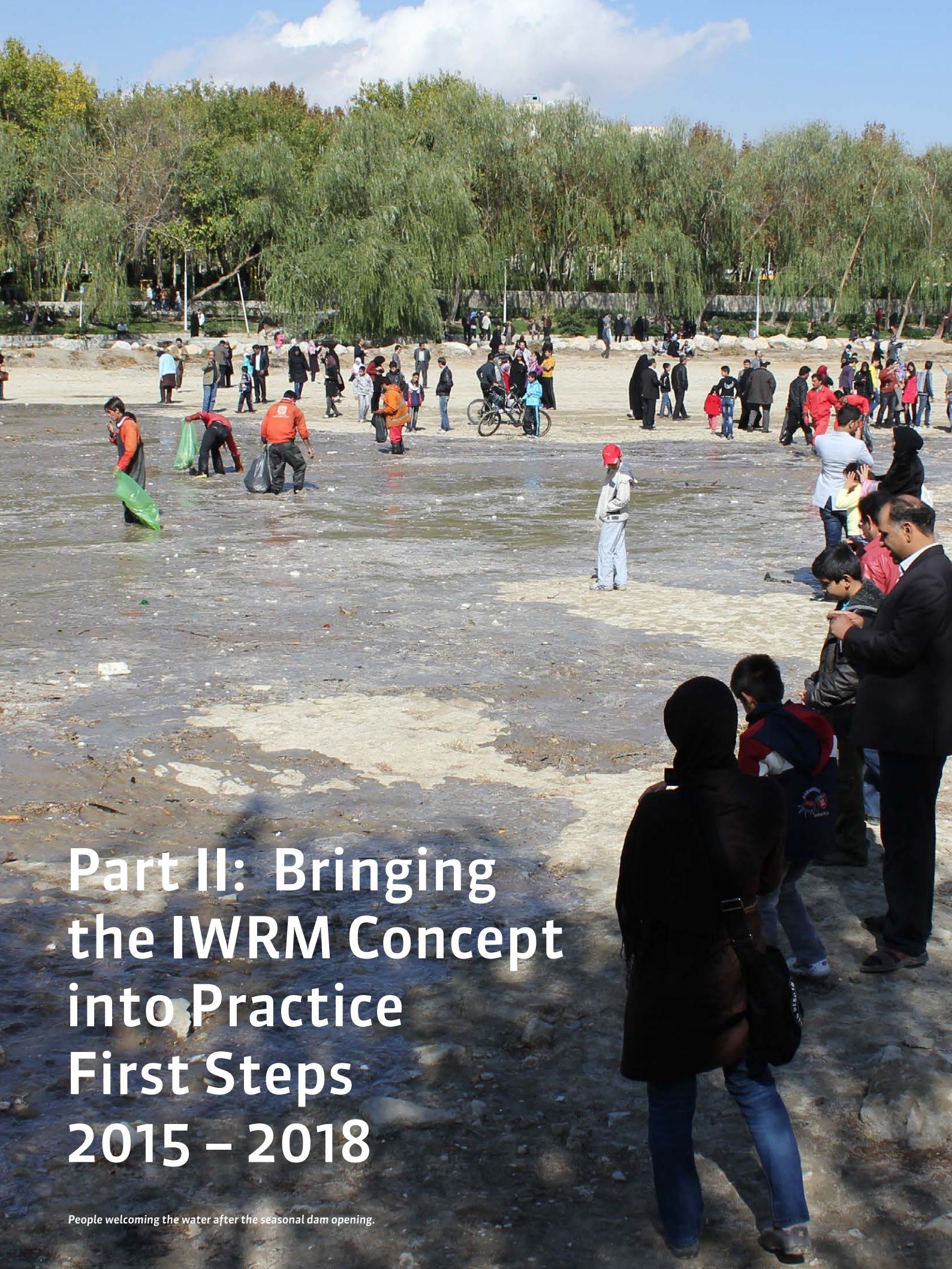
With the WMT there is now a basis for future decisions about which water management challenges should be addressed and how. Using DSS results, in the future it will also be possible to develop and implement different measures that at best serve the common goal to revive the Zayandeh Rud from its source to its mouth.

"In those days there were many old fruit trees, pomegranates, grapes and mulberry trees, and we would take a nap under the trees after work. I say those days, because everything changed when the river ran dry. When the old friends sit together, we tell each other what a great time it was, when there were lots of fishes, widgeons, and wild animals. We couldn't sleep because of the frogs croaking on the river bank. But now, what has happened to them?! The trees and wild nature died. The drying-up of the river has turned our farmlands into deserts. We grew up with the river, but now we are losing everything we have lived with."

Mohammad Hashemi, a farmer from the Roodasht region



Scheme of the Water Management Tool.



Part II: Bringing the IWRM Concept into Practice First Steps 2015 – 2018

People welcoming the water after the seasonal dam opening.

Our Approach to Implementing IWRM in the Zayandeh Rud Catchment

The IWRM concept for the Zayandeh Rud catchment and the basic modules for the Decision Support System have been at the ready since spring 2015. They have been developed with the intense participation of the Iranian partners and, as such, provide the best possible foundation for the implementation the IWRM process.

It is obvious that the implementation of IWRM requires appointing a management team and creating an enabling institutional environment. In doing so, the challenge is to use as many existing structures as possible, to improve them where it seems reasonable, and to create new structures only where necessary. IWRM also means to develop a thread for water management, and to tie up loose ends and create integrated approaches.

Shaping the IWRM process: Building on solid groundwork

How does the German-Iranian project team intend to achieve its objectives in the second funding period? The project team has prepared a package of measures that involves the main actors and sectors in the IWRM process and that seeks for the integral nexus between them:

- The project team gives advisory support for the Zayandeh Rud river basin organisation based on international experiences, particularly from the European Union (see page 26).
- The further development of the Water Management Tool data base to a Decision Support System (DSS) is one of the central elements of the project (see page 29).
- For the agricultural and industrial sectors, strategies for sustainable development are assessed (see pages 32 and 37).
- The tentative application of innovative technologies is a cross-sectoral approach, involving technologies for irrigation (page 35), wastewater treatment (pages 41 and 45) and water consumption management (page 44).
- Also, capacity development is carried out in the course of all pilot projects. Moreover, a German-Iranian Competence Center for Water and Wastewater Management will, next to training of trainers, implement the recommendations for training system improvement developed by the project team (see page 47).

In a situation where people, economic sectors and the environment are already threatened by acute water problems, the time is now to tackle the major water management issues. Within the project duration, it is possible to set the course.

Abandoned caravanserai.

Taking a rest in the park.

A Necessary Organization for River Basin Management

A basic characteristic of the IWRM idea is to acknowledge the whole catchment as a management unit. This makes IWRM implementation very challenging because it requires the concurrent coordination between administrative units that stretch across the catchment, like provinces, administrative levels, for example provincial and central government, and the water using sectors. The prevalent solution for this is the establishment of a river basin organisation.

A river basin organisation (RBO) is usually established as an umbrella organisation that maintains the bigger picture of water management issues in a catchment. A statement by the United Nations Environmental Program (UNEP 2014) reveals the global popularity of this policy "If Integrated River Basin Management is 'the most appropriate tool' to deliver IWRM at a basin scale, then river basin organisations are increasingly being promoted as the vehicle by which this tool should be implemented."

River basin organisations: Balancing the interests of all actors

At the interactive stakeholder workshop the lack of a catchment related organisation was discussed. Such an organisation would require a clear mandate and the trust of the different actors so that interests are balanced out and that the measures implemented retain the support of those actors.

Based on a Supreme Water Council resolution the first Iranian river basin organisation was established in 2014 for the Zayandeh Rud catchment. It is chaired by the Minister of Energy as the highest authority for water issues in the government, its other members are representatives of the national and provincial governments, sectoral departments and affected people. The RBO can also invite other relevant authorities, experts, associations, and entities to attend its sessions which are held every 3 months. According to the resolution the RBO Zayandeh Rud has the power to make decisions covering all water management issues in the catchment.

Successful negotiations: Including the external view

The RBO's main aim is to improve and provide fair water distribution which is to be achieved through the involvement of the main stakeholders. It is supposed to be effectively established as the main decision-making body in the Zayandeh Rud catchment in the near future. Especially in its infancy it makes sense to look at other RBOs and adapt successful strategies for conflict resolution or their organisational structure.

"All eyes are now on the RBO Zayandeh Rud as a 'pilot' organization. German experiences can support us in implementing an effective organisation and use it as an example for other Iranian river basins."

Mehrzad Ehsani, director general on IWRM for the Central Plateau Basin, Iran Water Resources Management Co.

Kids playing in the empty river bed.

Towards an Effective River Basin Organisation

Challenge: The RBO Zayandeh Rud still lacks the necessary experience to run things smoothly. Different opinions on what fair water distribution means leads to recurring conflicts and hampers mutually acceptable decisions. During the regular meetings acute issues of water distribution have been discussed but a long term vision and a management plan remain elusive. Questions regarding organisational framework, agenda setting, conflict resolution mechanisms, duties and assignment of responsibilities are as yet unresolved.

Project Activities: The project team wants to support the Iranian partners in the further development of the RB Zayandeh Rud so that acceptable water management decisions, in the sense of IWRM, can be taken. Expertise, especially from Germany and other countries where river basin organisations have been successfully implemented, will be incorporated. Examples will come from Australia (as an arid country) or EU countries that have implemented the European Water Framework Directive. An important step will be the handover of the DSS which will serve the RBO decision making process in the long term.

Expected Outcome: The envisaged results of this pilot project are adequate answers to the open organizational and governance questions. An effective river basin organization shall be put into operation that can serve as an example for future RBOs in Iran and the entire region.

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RBO Workshop poster.

Workshop on River Basin Organizations in Tehran, 2016.

Working groups at the RBO workshop.

The Cham-aseman Watergate.

Making the Decision Support System Work

The Decision Support System (DSS) is supposed to serve decision makers on issues concerning water management strategies by summarising, merging and visualising relevant information. Therefore the DSS is the key component in the IWRM process.

The DSS is designed as a practice and implementation oriented system that can visualize the current water resources situation and the medium and long-term impact of water management decisions and measures on the basis of generally accepted data.

The running system, which can be extended as per requirements, will merge complex model results and make it possible to,

- identify water management alternatives,
- estimate the scope of water management decisions and,
- legitimise decisions.

DSS – key component of the IWRM process

Fed with data about the water resources in the catchment and water demands of the different water users, the DSS is able to depict the interlinkage of important elements like water using sectors, groundwater and surface water, present and future. This way it creates the centre of reference for water management decisions and their implementation across the various sectors.

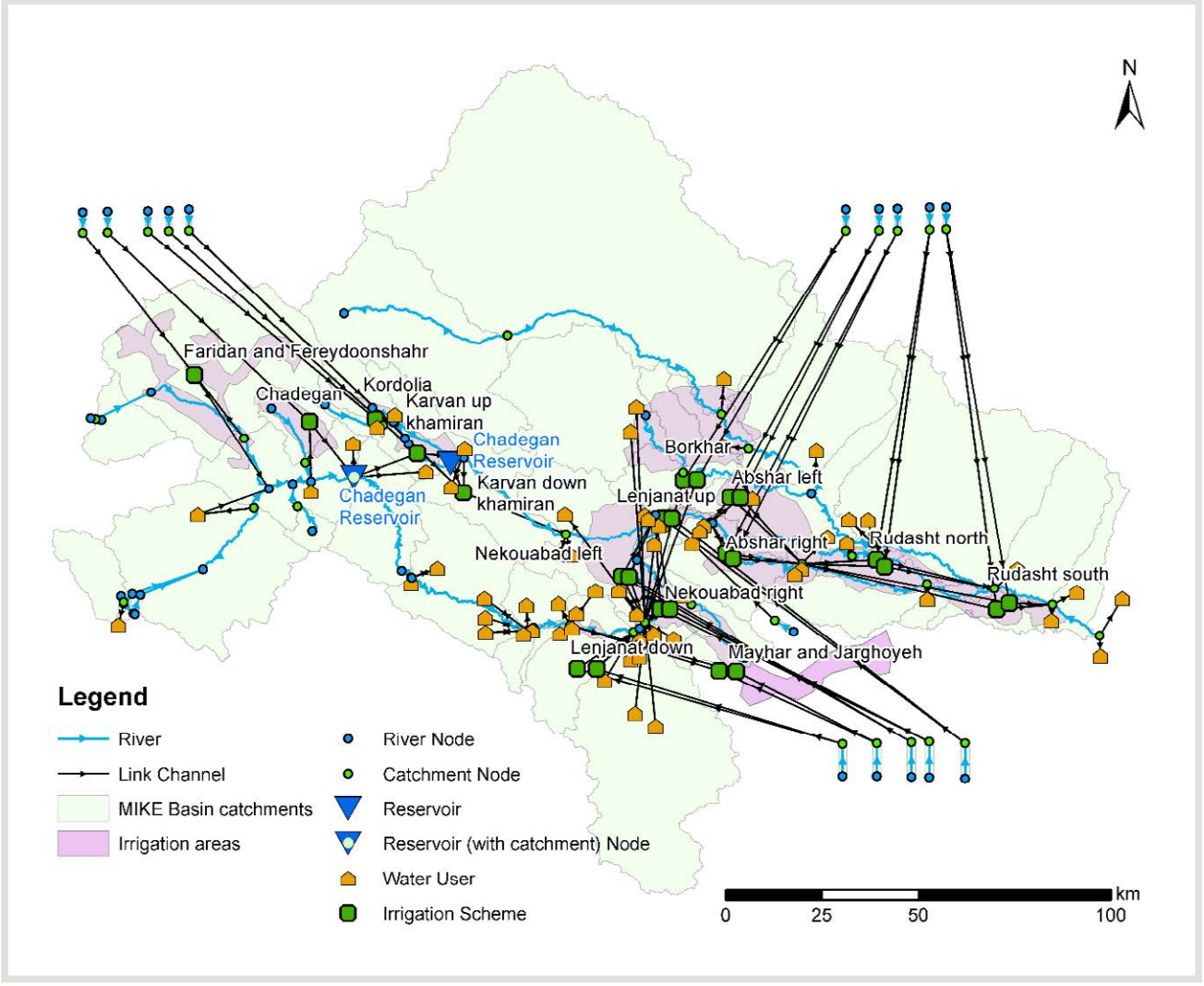
The DSS is therefore the best known tool for handling the multifaceted challenges and issues in the catchment and for the

"An important result of the German-Iranian cooperation is the creation of the DSS foundation. DSS will make it possible to predict e.g. the effects of upstream water management decisions on downstream water availability. This way, water management decisions will become more comprehensible for all water users."

Gholamhosein Heydarpour, Director of Studies Water Resources at the Isfahan Regional Water Board Co., Iranian IWRM-Zayandeh Rud Project Manager

increasing pressures that have been brought on as a consequence of climate change.

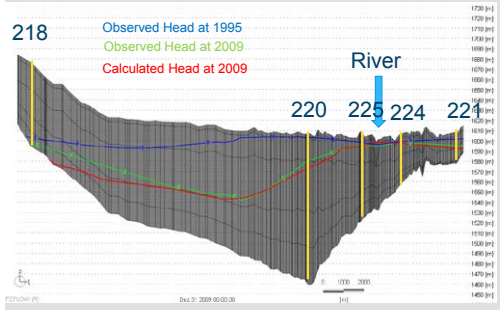
By the end of the project's second stage, the water management tool (WMT) is to be turned into the DSS and put into operation. Within the pilot project "Turning WMT into a DSS", missing data will be complemented by the German-Iranian project team and integrated into the system.



MIKE Basin model setup.

Working group FEFLOW.

Working group MIKE Basin.



FEFLOW groundwater model: Cross section views through sub catchment Najafabad.

Turning WMT into a DSS

Challenge: The basic module of the WMT is ready but still requires information that is important for taking reasonable water management decisions. Missing information includes data on the Chaharmahal-va-Bakhtiari province and the significance of ground and surface water salinization for the water demand of crops.

Project Activities: In addition to the missing data on the Chaharmahal-va-Bakhtiari province and salinization, model variations and alternative strategies will be included into WMT in the form of agricultural transformation, industrial development and sustainable groundwater management scenarios.

In order to guarantee the completeness and acceptance of WMT by the Iranian partners the following joint activities for the second project stage have been defined:

- Further development of WMT by applying stochastic methods in water management.
- Catchment areas located in Chaharmahal province shall also be included.
- Extension of WMT by a model for ground and surface water salinization prognosis.
- Development, modelling and assessment of adaptation strategies and development scenarios.

Throughout the project implementation, Iranian experts from different institutions receive training by using the final models in order to ensure their independent handling of the management tools after the project completion. A training module for the IWRM related application of WMT will be developed and carried out.

Expected Outcome: The DSS is expected to be in operation and able to provide the basis for future decisions about which water management challenges should be addressed and how. Its integrative character makes it possible to use its outputs for developing and implementing different, harmonized measures at the same time.

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Harvesting potatoes in Isfahan Province.

Assessing Possibilities for Agricultural Transformation

Agriculture is the main water user in the Zayandeh Rud catchment with more than 80 percent of water consumption. Farmers in particular are suffering more and more from periods of extreme drought which leaves them with little or no water. This in turn threatens their very existence. The subsequent decrease in agricultural areas would result in increased desertification.

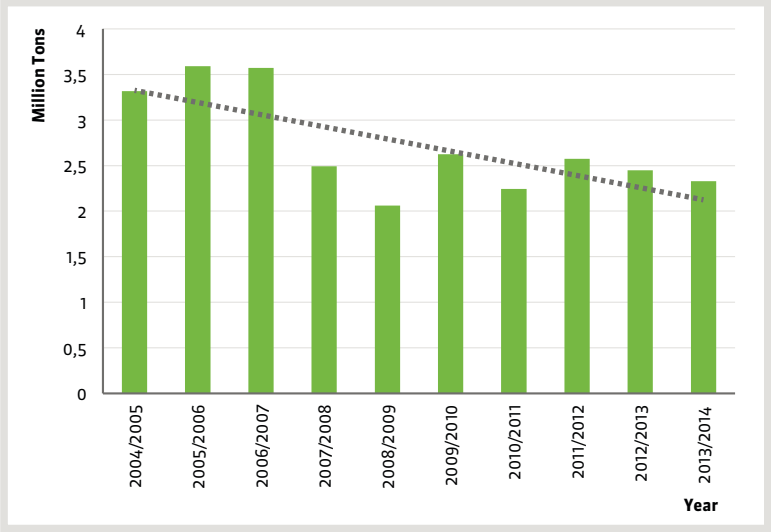
In recent years haphazard measures to reduce social and water management problems have had modest success. Compensation for crop losses due to climate change is not a feasible policy. On different occasions farmers have clamoured for acceptable solutions. Many farmers have pleaded for their traditional water rights. However in light of diminishing water resources and increasing competition with other water users it is obvious that new ways must be found.

Strategies for farming with limited water resources

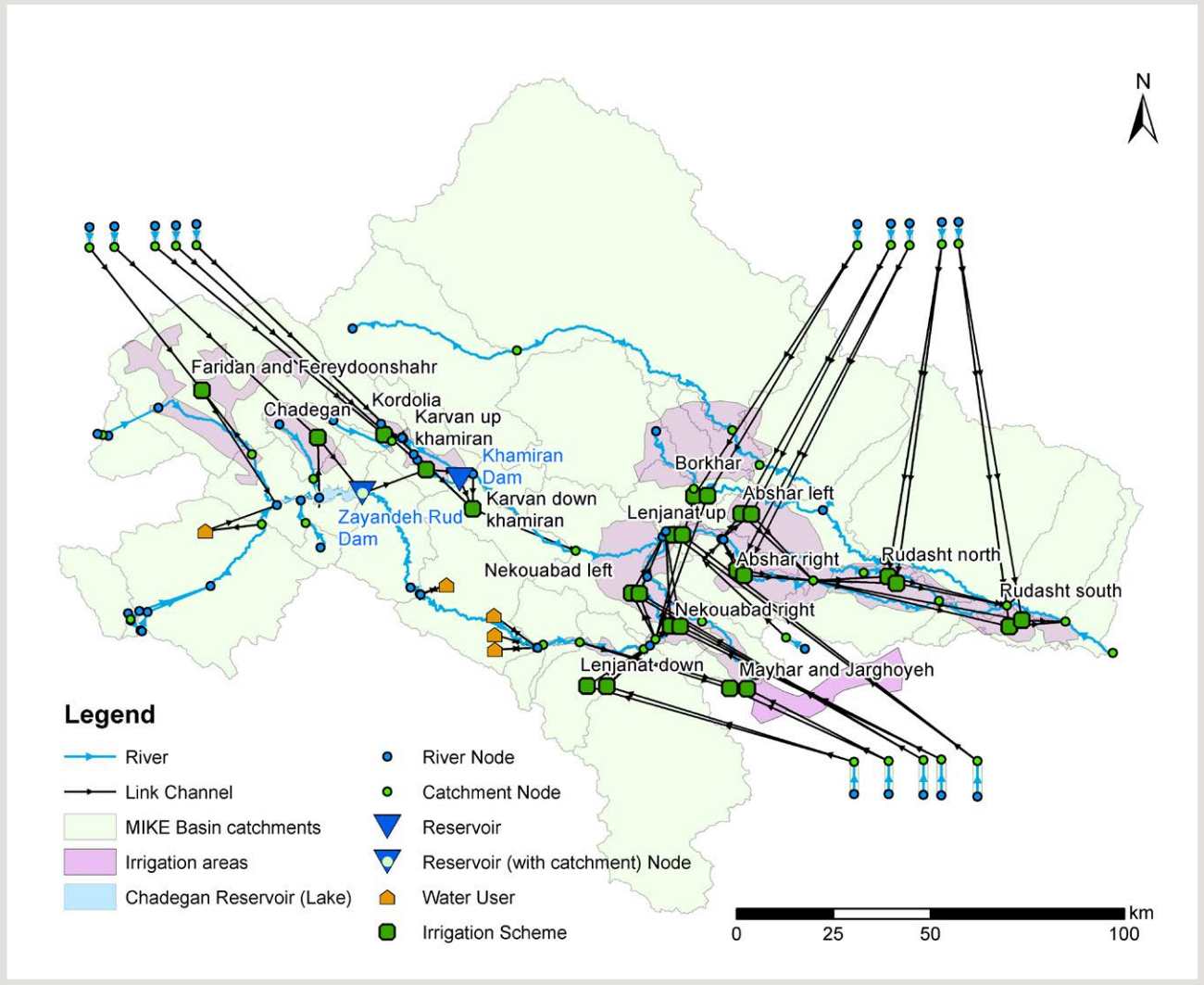
The agricultural sector is the critical variable for a successful IWRM process and at the same time the biggest challenge. New sustainable strategies for farming are essential to coping with limited water resources. Here the international experience of the project team comes into its own: in a mix of participatory methods, the tentative application of innovative technologies and use of a computer model, options for a forward-looking strategy are developed. The target is

to provide local land users with a settled future perspective and to prevent further desertification.

By 2018 the pilot projects "Citizens' Juries for Participatory Agricultural Transformation" and "Decreasing Water Consumption by Applying Innovative Irrigation Technology and Soil Conditioner" are expected to deliver results for the development of adapted land use strategies. These will be incorporated into the "The AgroHyd Farm Model for Assessing Agricultural Strategies" pilot project and eventually become part of the DSS.



Crop Production Decline in Isfahan Province, 2004 – 2014.



WMT model of agricultural water use.

"Citizens' Juries" for Participatory Agricultural Transformation

Challenge: The agricultural sector provides the livelihood for more than a million people. Without their commitment the efforts to use water more efficiently will not lead to satisfactory results. Local farmers and their representatives should therefore actively be involved in the development of strategies for optimised land use.

Project Activities: Several workshops will be run using a locally adapted form of Citizens' Juries methodology. This approach was developed in Germany and has been successfully applied in various countries. A citizens' jury is a group of about 25 randomly chosen people affected by a specific issue. Stakeholders give input concerning this issue from opposing perspectives. The participants discuss the issue in small groups, agree upon their main statements and present their results. Every participant is invited to weigh up the arguments. The members of the small groups change during the day in order to avoid individuals dominating talks, and the stakeholders are not present at this time. The results of the discussions are summarised in a citizens' report. Usually several citizens' juries work simultaneously in order to increase representation.

In a first workshop held in December 2016 in Isfahan, around 60 farmers from the entire catchment produced recommendations for feasible farming alternatives. The topics had been defined together with our Iranian partners. They included measures for increasing economic water productivity (more Rial revenue per litre of water) and for increasing crop productivity (more kg yield per litre of water). Input presentations were held by lecturers from different Iranian institutions. The main comments and recommendations will be presented to the decision makers in the form of a report.

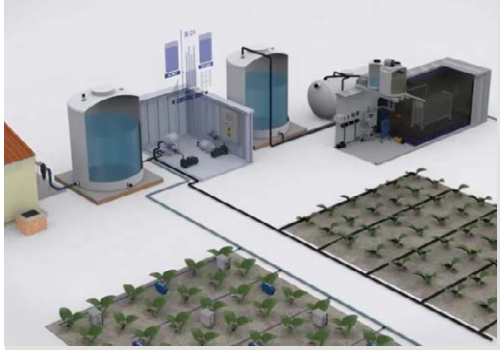
Expected Outcome: The recommendations developed during the stakeholder workshops will provide a well-grounded basis for future land use strategies and measures. At the same time, participants and stakeholders will have gained proficient knowledge in participatory methods.

Contact: Lena Horlemann, inter 3, horlemann@inter3.de

Workshop poster.

Participants of the first Citizen's Juries Workshop in 2016.

Sense of togetherness: Farmers from Chaharmahal and Isfahan provinces.



Exemplary design of the DOFISYS technology.

Field work in the countryside.

Decreasing Water Consumption by Applying Innovative Irrigation and Fertilization Technology and Soil Conditioner

Challenge: During the last few years, many traditional irrigation systems in Iran have been replaced by sprinkler irrigation systems. To do so, funding programs were set up by the Iranian government. After the change, however, various problems became apparent: due to hygienic issues (release of aerosols), some crops could no longer be cultivated, and farmers just took the reduced water demand as an excuse to increase their cultivated area which in turn had some negative consequences for the regional water balance.

Project Activities: The pilot project pursues two strategies: First, the introduction and dissemination of specific irrigation technologies (DOFISYS system) for demand-responsive irrigation and fertilization using purified wastewater. DOFISYS was developed to maximize agricultural water and fertilizer effiency and avoid nutrient leaching into the groundwater. The technique consists of three interlinked units that communicate with each other: an irrigation module, a control module and a monitoring module. And second, the application of soil conditioner. By using soil conditioners, abiotic and biotic site factors shall be improved to increase water efficiency and yields. The test field will be located at the Isfahan Agricultural and Natural Resources Research and Education Center.

Expected Outcome: The agricultural water demand is expected to drop without decreasing the production output. Additional outcomes are an improved water supply, less water stress for crops, improved soil quality through the application of micro-nutrients, and improved nutrition of the plants through increased activity of micro-organisms.

Contact: Ulf Tscherner, abc advanced biomass concepts, ut@abc-loesung.de

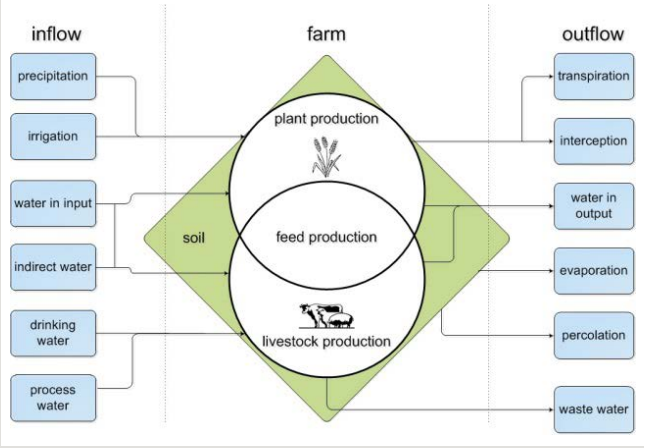
The AgroHyd Farm Model for Assessing Agricultural Strategies

Challenge: What can farmers in the Zayandeh Rud catchment do to meet the water demand for food production in face of water scarcity? To answer this question, it is necessary to evaluate the interactions between agricultural management strategies to increase farm water productivity and the hydrological processes in the catchment. Potential impacts from implementing new farm strategies must be assessed before action can be taken.

Project Activities: In order to simulate the water resources in the catchment basin, the WMT requires estimates of the water demand of all water users. The AgroHyd Farm Model is being used to estimate the irrigation demand for crops in the basin and the effects of changing agricultural practices on agricultural water use. The synthesis of models started in the first project stage by coupling the surface and groundwater models (MIKE Basin and FEFLOW) to develop the WMT. This synthesis is continued and extended by a bottom-up approach of the AgroHyd Farm Model that quantifies water use on farms. A database of indicators is being built throughout the project. The AgroHyd Farm Model is a GIS based model which is able to depict the water productivity of individual farms or irrigation districts. It will be used to evaluate scenarios for improving farm water productivity.

Expected Outcome: The change in irrigation demand caused by implementing various agricultural strategies, e.g. innovative irrigation systems, conservation tillage or alternative crops, will be calculated by the model. That way, promising combinations of strategies for more sustainable water and land management can be identified at the local level.

Contact: Dr. Judy Libra, Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), jlibra@atb-potsdam.de



Water flows and boundaries of farm system.

Herdsman in Isfahan Province.

Research test site.

Farmers in Isfahan Province.

Industrial site.

Industry

Planning for Sustainable Industrial Growth

Besides agriculture, industry is an important economic sector in the Zayandeh Rud catchment. More than 350,000 people work in large steel and cement factories, oil refineries and around 13,000 businesses. In the medium and long term, the region needs industrial development in order to keep or rather raise the citizens' standard of living.

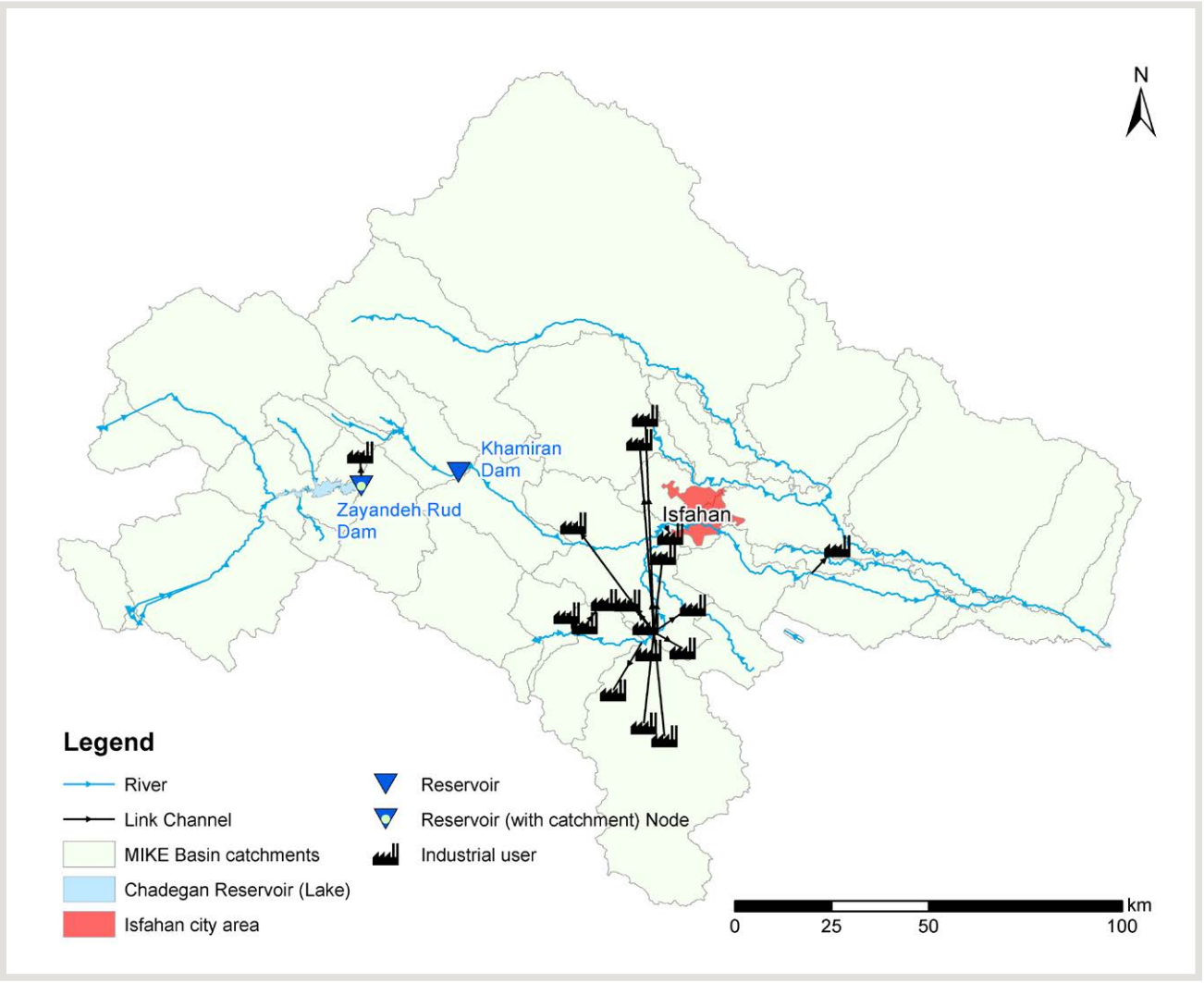
With the international sanctions coming to an end Iran will most probably undergo an economic boom. In the coming years a further expansion of the industrial sector in the Zayandeh Rud catchment is therefore very likely, and an increasing water demand between around 70% and around 130% by 2025 is expected.

Less is more: Water use reduction and alternative water sources

For the industrial sector approaches are needed to lower water consumption, to reuse water within the company, and to develop new water sources. Therefore, the demands of the Iranian partners and the international experience of the German project team were brought together to develop sustainable and custom-fit measures to be implemented in the second project stage.

These include tests for the use of alternative water sources, the optimization of an industrial wastewater treatment plant and the exemplary design of an industrial settlement using the 'eco-industrial park' model.

By 2018, the two pilot projects "Alternative Water Resources for Industrial Processes"



WMT model of industrial water use.

"A forward-looking industrial sector needs to be open-minded. Therefore we address the water management challenges and develop – like in Moorche Khort – concepts for a consequent wastewater reuse."

Seyed Alireza Momeni, Director of Environment, Safety and Health, Industrial Settlements Organization of Isfahan

and "Industrial Settlements Designed after the 'Eco-Industrial Park' Concept" are expected to generate locally adjusted strategies and measures for sustainable industrial growth.

Site visit at the Isfahan Power Plant.

Alternative Water Resources for Industrial Processes

Challenge: There is no substitute for water in industrial processes where it is used for multiple purposes: for cleaning, heating or cooling, transport, as a raw material or dissolver. In times of water scarcity, thus, alternatives to fresh water resources need to be explored and assessed.

Project Activities: Measures developed in the project will be quality tested in two steel companies (Mobarakeh Steel Company and Esfahan Steel Company) and one gas-fired power plant in Isfahan as these industries have the highest industrial water demand in the catchment. The transferability shall be guaranteed by the fact that these measures can be implemented without or with little additional costs.

Key elements are:

- the development of a technological-economic concept for the reuse of municipal wastewater as process water with various qualities,
- to reduce water consumption and apply recycling technologies for dropping the specific water demand, and
- the development of criteria and a process for treating concentrates from membrane systems.

For the reuse of municipal wastewater, in-house water recycling and the reduction of water consumption, an integrated water-energy-material flow-model is developed. It will be able to calculate and compare different alternatives. Depending on limiting conditions, ideal measures will be defined and implemented.

Expected Outcome: The pilot project prepares transferable strategies and measures for sustainable industrial growth by reducing industrial water consumption, reusing water internally and developing alternative water resources.

Contact: Prof. Dr. Sven Geißen, Technical University Berlin, sven.geissen@tu-berlin.de

Industrial Settlements Designed after the 'Eco-Industrial Park' Concept

Challenge: The "Industrial Settlement Organizations" of the provinces have little experience in designing the growing industrial settlements in a coordinated, resource efficient and environmentally friendly way.

Project Activities: The project team supports the organization in Isfahan to assess different options for water consumption reduction and wastewater reuse using the example of the "Morcheh Khort" industrial settlement.

This industry complex is located north of Isfahan city and comprises around 300 active companies with 17,000 employees. Water demand is around 4 million cubic metres per year. Around 160 companies are connected to the local wastewater treatment plant.

The results of these assessments are the basis for a development plan focussing on water and wastewater according to the "Eco-Industrial Park" (EIP) concept. This concept was created more than 20 years ago in a Canadian-American cooperation and has since been successfully implemented around the world. The basic idea is the creation of networks within an industrial settlement in order to mutually use and reuse resources.

Project activities include:

- Development and analysis of selected business profiles with a focus on water demand and wastewater production;
- Material flow (water and wastewater streams) analysis using STAN software;
- Design of network models and technical modules for wastewater treatment and reuse;
- Economic and ecological model analysis;
- Preparation of recommendations for the future Industrial Settlement development.

Expected Outcome: The expected result of the pilot project is the identification and implementation of planning approaches for resource-optimized, environmental-friendly and cross-linked development of industrial settlements.

Contact: Wolf Raber, inter 3, raber@inter3.de

Moorche Khort Industrial Settlement.

Wastewater treatment plant Moorche Khort.

Blower station at Moorche Khort.

Working on the Moorche Khort Industrial Settlement project.

Ultrafiltration Plant in the Morcheh Khort WWTP.

Chemical Sedimentation - Morcheh Khort Wastewater Reuse Plant.

Morcheh Khort Industrial Settlement Wastewater Treatment Plant

Challenge: The Morcheh Khort water reuse plant has not been able to reach its ambitious goals with regard to total daily clean water production, posing challenges to all parties involved in planning, administration and operation.

Project Activities: The project team supports the improvement of the overall proficiency of the Wastewater Treatment Plant (WWTP). In Morcheh Khort Industrial Settlement, wastewater of the single industrial units is collected in a main sewer collection network and treated in a central WWTP. Certain industries, however, run decentralized pre-treatment units on their realms, prior to discharge into the sewer network. The WWTP has a total treatment capacity of 2,000 m^3/d and currently treats mixed wastewater streams with a proportion of around 60% sanitary and 40% industrial wastewater.

In 2014 a water reuse plant has been set up at the WWTP site in order to produce treated wastewater for industrial use in qualities suitable to substitute fresh water resources. The plant was designed to supply 500 to 1,000 m^3/d and consists of Chemical Sedimentation, Multi Media Filtration, Ultrafiltration, Activated Carbon Filtration and a Reverse Osmosis as final treatment step. Due to various difficulties regarding wastewater streams and relatively new technologies, the plant's output underachieves considerably. Project activities therefore include:

- Installation of online measurement devices for continuous monitoring of WWTP inlet water qualities;
- Evaluation of WWTP and reuse plant operational data;
- Provision of technical reports, including results of profound design- and process evaluation and proposals for optimization and adaption;
- Practical training for personnel in operation and maintenance of Ultrafiltration plants;
- Discussion of project challenges and results with all participating Iranian partners (consultants, administration, operation).

Expected Outcome: The expected results of the pilot project are 1) the optimization of WWTP operation, 2) an increase of reuse plant water output and the substitution of fresh water, and 3) best practice example for other wastewater reuse plants in Iran.

Contact: Steffen Vogler, p2mberlin GmbH, steffen.vogler@p2mberlin.de

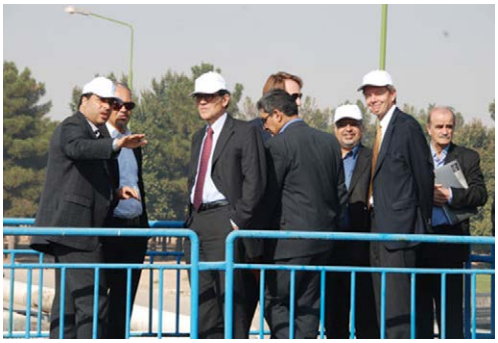
Isfahan North Sewage Plant.

Water and Wastewater

Efficient Development of Urban Water Services

Rapid population growth, decreasing water availability and high per-capita consumption put safe drinking water provision in the catchment at risk in the long run. There is great demand for management methods that focus on individual water consumption, as has been successfully applied in Europe.

Not only the drinking water supply, but also wastewater treatment, will play a major role in future water management. Purified wastewater as a reusable resource increasingly attracts the attention of decision-makers in Iran. At the same time, sub-standard and inefficient plants or overloaded wastewater treatment plants lead to the pollution of natural resources in the catchment more frequently.



German Ambassador Michael von Ungern-Sternberg at the Isfahan North wastewater treatment plant.

Improving both ends of the pipe

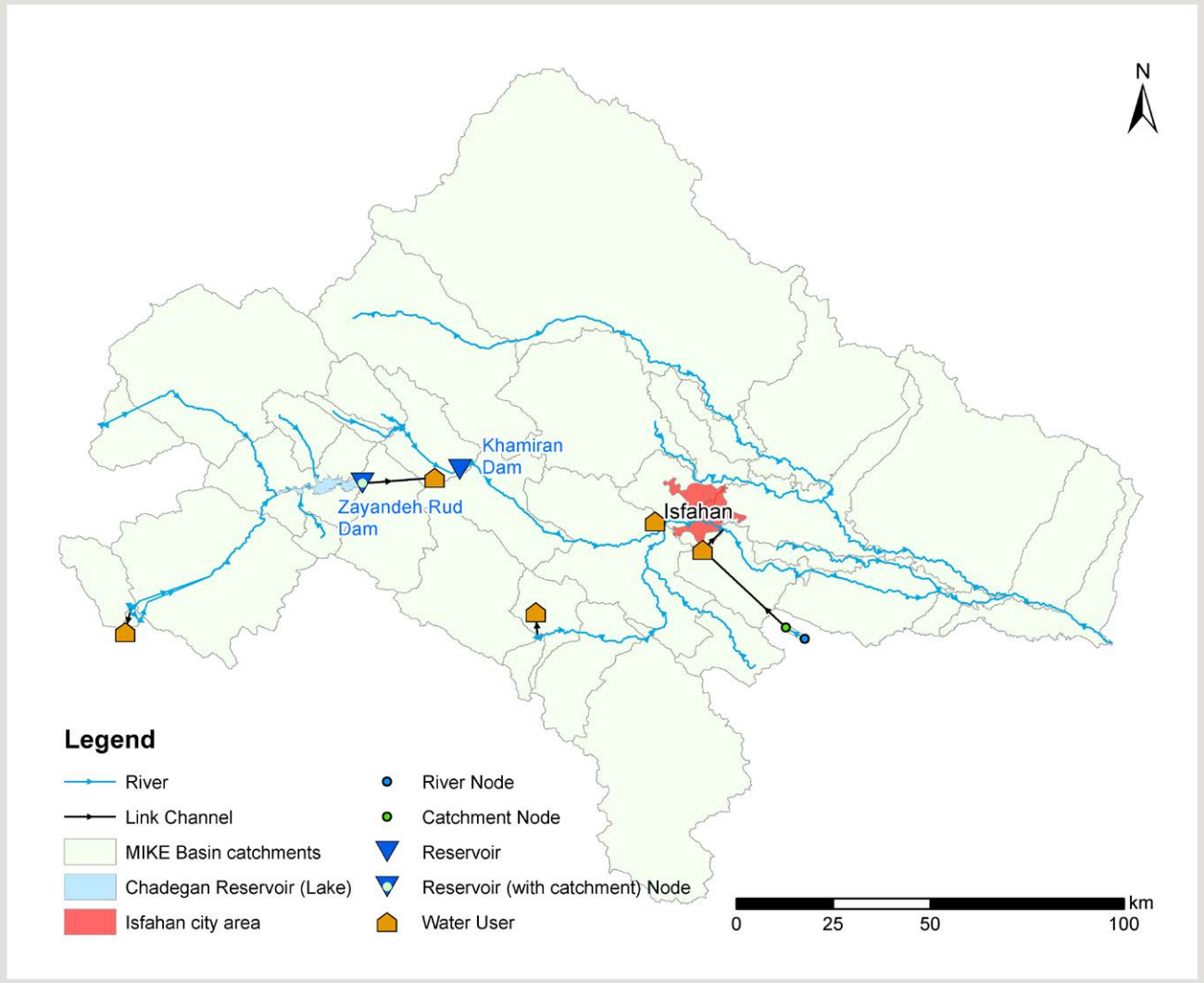
The project team concentrates on household consumption, wastewater treatment plants as well as the sewer system itself. Three pilot projects will concentrate on developing and testing methods for household water

consumption management as well as for optimizing wastewater treatment plants and their operability by 2018. Innovative techniques of sewer rehabilitation are also being tested with the Iranian partners.

The pilot project Drinking Water Consumption Management takes a look at individual households and their water consumption patterns. Special water meters will help to find recommendations for more water efficiency that each individual can realize. The pilot project Operational Optimization of the Wastewater Treatment Plant Isfahan North focuses on the application of upgrades and of innovative technology. And in the pilot project Rehabilitation of a Sewer Unit in Isfahan a cost efficient cured-in-place pipe technology is being tested.

"In the course of the project module I of the Isfahan North wastewater treatment plant has successfully been modernized. Optimized discharge values serve the environment and improve the people's quality of life. Iran and Germany both benefit from this kind of technology and know-how transfer."

Hashem Amini, Chairman of the Board, Managing Director of the Water and Wastewater Co. Isfahan



WMT model of urban water use.

Drinking Water Consumption Management

Challenge: The daily overall water consumption of citizens supplied by the Isfahan Water and Wastewater Co. is around 250 litres per person on average (including commerce and industry as well as losses caused by leakages). In order to design adequate measures for reducing household water use, the customers' consumption patterns need to be identified. The definition of countermeasures requires information on the exact time water is used, the amount and for what purpose.

Project Activities: Within this pilot project the consumption patterns of selected households are tentatively measured and water saving potential is identified. Using the DEMAPLAN software, gathered data are analysed and strategies for adequate consumption management are designed. DEMAPLAN prognosis models also allow for deriving starting points for a demand-orientated drink water supply.

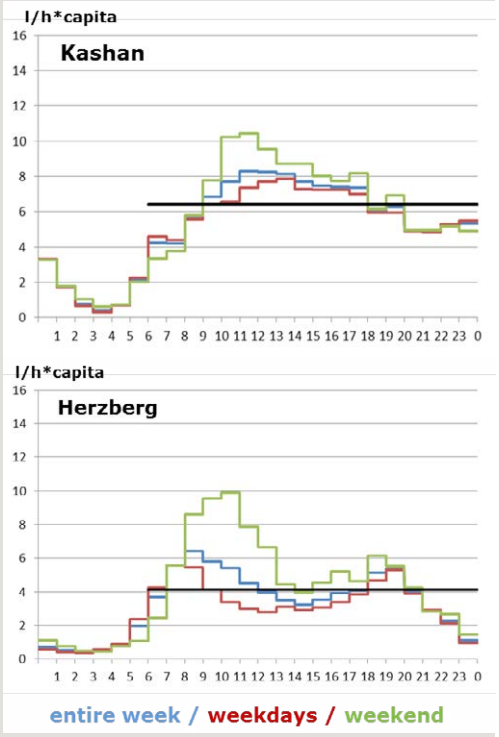
Initial measurements were successfully taken in more than 50 households in Kashan, and analysed. The activities are now extended to further towns in the catchment which differ considerably with regards to their climatic conditions and therefore presumably also their water consumption patterns.

The pilot project involves the development of a training module for water consumption management.

Expected Outcome: After dependencies and water consumption patterns are understood, locally adjusted water consumption strategies are developed using prioritized measures. The training module is offered by the German-Iranian Competence Center for Water and Wastewater Management (GICC, see page 49).

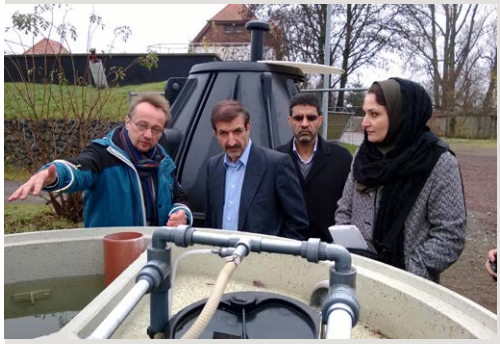
Contact: Tamara Nuñez von Voigt, inter 3, nunez@inter3.de

Installation of DEMAPLAN measuring devices.



Comparison of hourly per capita water consumption of households in Herzberg (Germany) and Kashan (Iran).

Isfahan North Wastewater Treatment Plant.



Visit of a decentralized wastewater treatment system in Leipzig.

The pilot plant for innovative wastewater technology was put into operation in 2014.

Wastewater Treatment Plant Isfahan North, digester Phase 1.

Operational Optimization of the Wastewater Treatment Plant Isfahan North

Challenge: Isfahan's wastewater treatment plants are, in general, big enough to handle the accumulating wastewater. Like other wastewater treatment plants in Iran, however, they show various operational problems and due to that, poor water quality values.

Project Activities: This pilot project aims at improving the discharge quality of the Isfahan North wastewater treatment plant. To achieve this goal, three different approaches are possible: An upgrading of the current technology, the introduction of additional innovative technologies for wastewater treatment, or a mix of upgraded and new technologies. The most economic and ecologically reasonable strategy is assessed, taking into account manageability and availability of the technologies in Iran.

In order to estimate the impacts of **technology upgrading** on discharge quality, various measures are implemented and evaluated. Initial research revealed great need for action in the field of sludge treatment: to discharge the surplus sludge in a controlled way and to treat it properly afterwards. To do so, the sludge treatment section is equipped with measuring devices and put into operation. Operational staff will be trained with regards to correlation and interaction of the main parameters.

Another upgrade will be the installation and **initial start-up of an automated aeration control**. This will lead not only to optimized operation but also to a significant reduction in electric power consumption, which represents one of the goals identified by the German project team.

As **innovative technology** for wastewater treatment, the application of ultra-filtration facilities and wastewater screens is assessed. The aim is to purify the currently poorly treated wastewater in the test plant so that further disinfection with chlorine becomes unnecessary. The tests will reveal to what extent these technologies can be implemented and actually put into operation.

Expected Outcome: At the end of the pilot project, the operation of the treatment plant is expected to be optimized. By a comparison of the approaches and the economic analysis it will be observable which strategies prove to be most feasible from an ecological and economic perspective, and which can be transferred to other locations.

Contact: Christoph Sahlmann, p2m berlin, christoph.sahlmann@p2mberlin.de

Rehabilitation of a Sewer Unit in Isfahan

Challenge: Isfahan was the first city in Iran with a modern sewer system. On the other hand it is more than 40 years old and parts of it are in a bad condition due to poor maintenance. To this day Iran has amassed little experience with successful sewer system rehabilitation.

Project Activities: In the course of this pilot project the Cured In Place Pipe (CIPP) method, a cost-efficient alternative to open construction work, is tested. The new pipe is installed tight-fitting to the old pipe.

The Saghir Street has already been defined as an appropriate canal section where the method is now being tested. After necessary preliminary works and planning the section will now be rehabilitated by the German company Frisch & Faust Tiefbau. The Iranian Water and Wastewater Engineering Company (NWWEC) staffs are involved in the rehabilitation works and are being supervised in order for them to gain practical experience in applying this method. The rehabilitation works will be recorded in order to use the film as training material in the future.

Expected Outcome: The prospected outcome of this pilot project is the successful training of multipliers (training of trainers) for the future use of the CIPP technology.

Contact: Ute Eismann, p2m berlin, ute.eismann@p2mberlin.de

Hamid Reza Janbaz, Managing Director of NWWEC.

Assessment of possible sewer rehabilitation test site.

Visit at the IFAT fair 2010.

Capacity Development

Supporting Capacity Development

The implementation of the IWRM concept does not only require the willingness, but also comprehensive knowledge of all people involved to introduce new approaches and measures of sustainable water management. Capacity development can not only create awareness and acceptance of integrated system solutions but it also offers the opportunity to implement approaches in a sustainable way.

In this regard Germany is an ideal partner for Iran in many ways: it has great technology and innovation potential in the water sector and many years of experience in international training. Germany is one of the market leaders in the water sector, for example in the fields of measurement and control technology, and is even world market leader in wastewater technologies, plant and component engineering. Water is a core area for German development cooperation in 27 countries, the German government supports water related projects with around 400 million Euros per year, and they all include educational elements.

"Even our best ideas for integrated water resources management can only work with adequately skilled personnel. By establishing the GICC we take another important step in the right direction."

Dr. Mohammadreza Fadaei Tehrani, Head of the Isfahan Higher Education and Research Institute (IHEARI)

Various BMBF or DWA scholarship programmes support young international scientists and engineers.

Project meeting at the Ministry of Energy.

Expanding skills for IWRM implementation

From the perspective of the educational field, Iran faces two main challenges which are closely related: on the one hand many training courses do not adequately prepare the participants for solving practical problems, for example at wastewater treatment plants. On the other hand inflexible bureaucratic processes of training demand assessment and evaluation hamper efficient water management.

The aim of the project is therefore to address these challenges in two interrelated pilot projects: by establishing a German-Iranian Competence Center for Water and Wastewater Management (GICC) and by improving the overall vocational training system. By 2018 the GICC is supposed to be in its set-up stage, and the recommendations for the training system improvement will be successfully incorporated into its day-to-day business.

Visit of a sewer shaft for vacuum drainage in Brandenburg.

The project team visiting IHEARI.

IHEARI laboratory.

Training workshop at IHEARI.

Facilitating Knowledge and Technology Transfer - The GICC

Challenge: Iran's water sector has a wide variety and high number of training offers ranging from university courses to short-term training. There are, however, shortcomings in the established Iranian training and educational institutes with regards to training in the field of innovative, practice oriented concepts and newer technologies.

Project Activities: At the German-Iranian Competence Center for Water and Wastewater Management (GICC) a marketplace of opportunity for German and Iranian water sector stakeholders will be established. Here technologies can be presented and tested, experiences exchanged and cooperation enhanced.

The GICC will presumably be located at the Isfahan Higher Education and Research Institute (IHEARI). It involves three main pillars:

- Training modules: The GICC will offer training in the field of water and wastewater management. Training-of-Trainer (ToT) measures bearing "Vocational training made in Germany" as a seal of quality will be implemented.
- Pilot projects: The GICC will create a strong practical link through the pilot projects. These projects will serve as demonstration sites and within which training modules will be developed.
- Showroom: GICC will provide German companies with the opportunity to present their technology and offer corresponding training. This way a platform for further cooperation will materialise.

Within the IWRM project different training modules will be developed and trainers will be trained as multipliers. The training of trainers also includes didactic and methodical knowledge. Pilot training will be evaluated and results incorporated into future training modules and curricula.

Expected Outcome: An independent training centre is established where German experience and Iranian demands are connected in order to enable an efficient and demand-orientated exchange of technology and know-how, and to upgrade existing training offers. This way, IWRM knowledge is bundled in the centre and presented to the public, managers and employees of water management institutions and companies.

Contact: Dr. Shahrooz Mohajeri, inter 3, mohajeri@inter3.de

Recommendations for Training System Improvement

Challenges: Practical and advanced training misses to communicate how to identify and address actual water management problems in day-to-day business. This seems to be the case particularly for governmental training facilities that are the main providers for advanced training in Iran's water sector. There is, though, a political will to adjust the educational system to the changing conditions in the water sector.

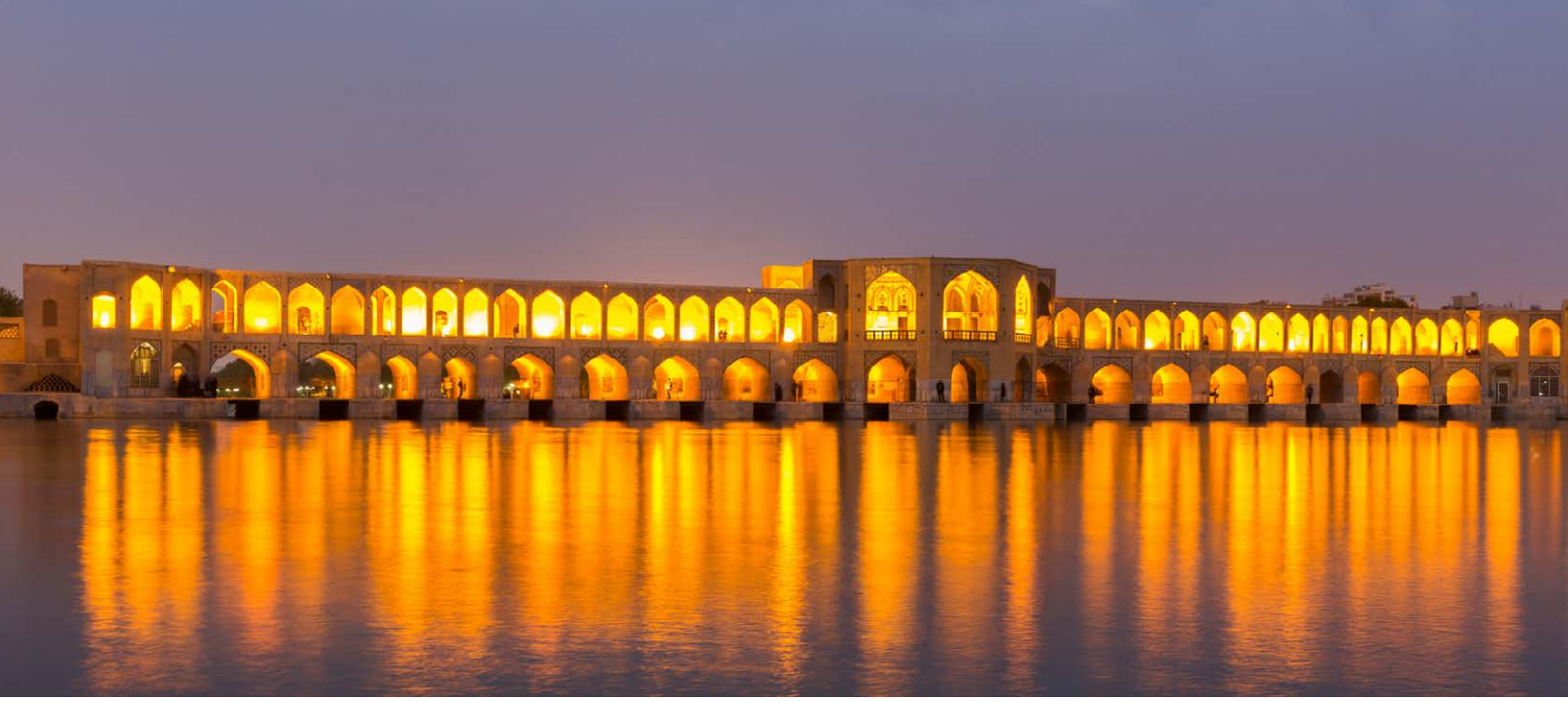
Project Activities: The project addresses the fields of training demand assessment and evaluation in particular because here bureaucratic guidelines and actual procedures do not appear to be productive. Workshops and expert interviews are used to collocate the main challenges using a Constellation Analysis, a tool which allows analysing and visualizing the interaction of different actors and factors. The fact that the constellation analysis takes into account not only actors and institutions but also technologies, resources, and legal and economic factors ensures that the obstacles analysis is conducted in the required complexity. Visualizing the results permits locating the actors involved within the overall advanced training system constellation. The German-Iranian project team will develop recommendations for optimising the current system.

Expected Outcomes: The developed recommendations are incorporated into the GICC concept. It is expected that the recommendations and their experimental adaptation provides useful impulses for further improvement of the training sector as a whole.

Contact: Lena Horlemann, inter 3, horlemann@inter3.de

Capacity development at Passavant & Watec.

Workshop participant.



The Khaju Bridge at dusk.

What's Next?

"Can 'the Germans'- despite immense climatic and cultural differences between Iran and Germany – really identify suitable solutions and measures for sustainable water management in Iran?"

This question, which has been posed time and again, shows why it took some time and energy to establish the necessary trust between German and Iranian partners during the first stage of the project. Sceptics, however, owe us an explanation about their alternatives to an international exchange of experiences and knowledge or the use of innovative technologies. Idleness, certainly, is not an alternative.

And still, these sceptics are right in some way. Necessary decisions regarding sustainable water resources management have to be taken by the Iranian decision-makers. German partners can only show possible ways to a locally adjusted IWRM based on their long standing experiences in Germany or other international projects. They can do this by developing and providing necessary concepts, tools and know-how. The Iranian partners, however, have to take care of the implementation and further development of the IWRM process.

Leisure time at the Zayandeh Rud.

What does this mean in practice? We can give an example: The German team resolved to outline a joint picture of the main water management challenges in the Zayandeh Rud catchment together with the Iranian stakeholders. These defined challenges had to be acknowledged by all stakeholders and regarded as being manageable at the same time. The Iranian decision-makers now have to recognize these challenges as a collective and put them on their political agenda, as a whole or at least in parts. After that the German team can support the Iranian partners in identifying, prioritizing and implementing measures accordingly.

Another example: One of the main prerequisites for an IWRM process is a widely accepted database as the foundation of a common understanding and course of

action. Transparency and participation of all stakeholders in the determination of the main parameters and data collection are of major importance. Only then will all partners trust the data and use the database. The German team set up this database; after a comprehensive process of participation, assessment and coordination involving all stakeholders, a draft version is now available. Its actual application, use and further development for future water management decisions are now in the hands of the Iranian decision-makers.

It is obvious that the concepts and tools developed within the project are necessary for sustainable planning and use of water resources, but never enough. They can only come into effect if the decision-makers lead the way on a joint journey towards IWRM instead of achieving the maximum outcome for their own region or sector. It sounds trivial: Success is only possible if people stop pointing at others or just 'wait and see', but delineate their own contribution to saving the Zayandeh Rud River. Such rethinking of the decision-makers is necessary, because neither the Zayandeh Rud nor the Gavkhuni or the people that live in the catchment have time for power games. The German partners will do their utmost to support this process. Precisely because all decisions in the region have to be taken by the Iranian partners, the unbiased and internationally experienced German team can moderate and mediate between the parties.

The establishment of the RBO Zayandeh Rud is without doubt an important step towards common thinking and acting. Now it is time for developing a joint vision, defining the necessary measures for achieving the goals, implementing the measures step by step and evaluating their impact. The products and results developed so far within the German-Iranian project can play a major role in this process. They include the set-up of a database for water management in the catchment, the further development of the Water Management Tool into a DSS, the elaboration of agricultural transformation strategies in the catchment, the foundation of a German-Iranian training centre, but also rather simple measures like optimizing the wastewater treatment plant operation or the reuse of treated wastewater.

Certainly, the IWRM concept, tools and measures are simply individual pieces of a great puzzle that will only be completed with the decision-makers' strong will to give-and-take. Today, the reality looks different, but as the late German chancellor Helmut Schmidt put it: "You need a naïve approach to fundamental questions. I think the problems of the world and of mankind cannot be solved without idealism."

Dr. Shahrooz Mohajeri
inter 3 Managing Director and leader of the IWRM project

IWRM process for the Zayandeh Rud River Basin

Inside the Khaju Bridge.

Acknowledgements

We would like to express our gratitude to the German Federal Ministry of Education and Research (BMBF) for funding this project and thereby enabling this fruitful German-Iranian cooperation. We also like to thank the Iranian Ministry of Energy, the Iranian Water Resources Management Company as well as the National Water and Wastewater Engineering Company. It is to their credit that the IWRM Zayandeh Rud project has attracted more and more attention over the years.

Moreover, we like to thank the Governor's Office Isfahan, the Water and Wastewater Companies in Isfahan and Kashan, the Jihad Agricultural Organization Isfahan, the Environmental Protection Organization Isfahan, the Regional Water Company Chaharmahal-va-Bakhtiari, the Mirab Zayandeh Rud Company, the Isfahan Higher Education and Research Institute, Zayandab Consulting Engineers, the Zayandeh Rud Urban Development Organization, the Industrial Settlement Organization, the Isfahan University of Technology as well as the large industries in Isfahan Province who have all made this project possible.

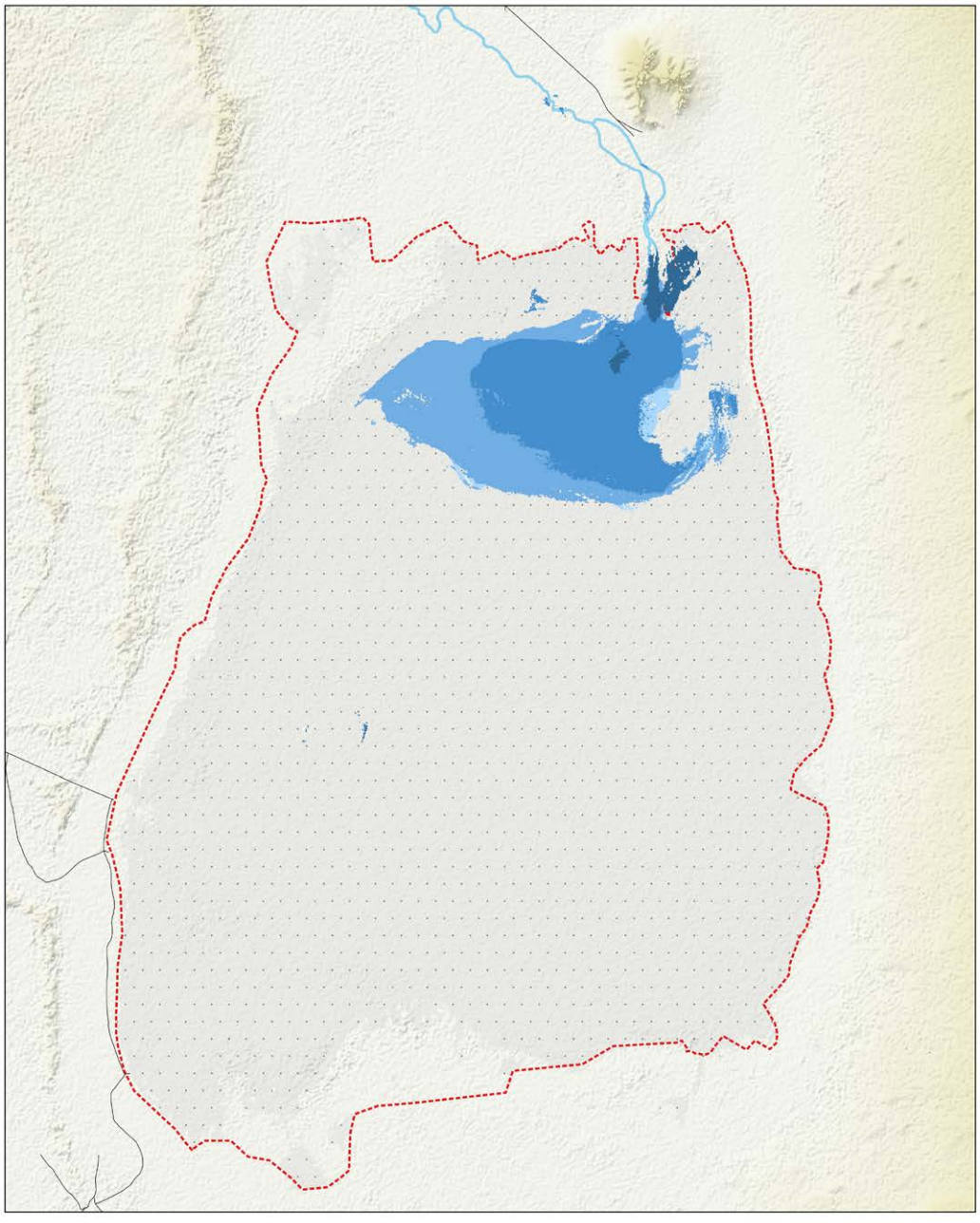
Special thanks go to the Regional Water Company Isfahan, particularly Mr. Torfeh who – in his time as Managing Director and Chairman of the Board of Directors – welcomed us with open arms, put his trust in the project and provided us with everything we needed, be it tangible and intangible. Dr. Mirmohammad Sadeghi who has taken over the reins is also worthy of praise, not least because he provided the necessary resources for the IWRM project office in Isfahan.

We would like to thank the IWRM project management at the Regional Water Company Isfahan in Isfahan, our current project manager Mr. Heydarpour and Mr. Asady, who was project manager from 2010 to 2015, and their entire team.

We are also grateful to the IWRM commission and all its former and current members who have accompanied the project with their valuable and indispensable expertise.

Last but not least we would like to thank Mr. Aghili who assisted the project team by translating and interpreting, and Dr. Ali Asghar Besalatpour for his valuable scientific support.

"All work is a seed sown; it grows and spreads, and sows itself anew", says an Iranian proverb. And so the joint efforts of the stakeholders bear small but promising fruit: Between December 2015 and March 2016 the water levels of the Gavkhuni wetlands have risen, hopefully heralding a new era for Zayandeh Rud's water resources.



Service: Partner Profiles and Publications

View on the Chadegan Reservoir.

Project Partners

The German Project Partners

Cooperating within the "IWRM Zayandeh Rud" project were various renowned research institutes and companies, seven in the first and eight in the second project stage. These partners bring years of international project experience with them in the field of sustainable water management.

The **inter 3 Institute for Resource Management** is a research and consultancy expert, combining technological, environmental and socio-economic approaches for sustainable resource management. For more than 15 years inter 3 has been successfully cooperating with Iranian partners in the field of water management.

abc advanced biomass concepts is an expert in the practical implementation of international projects in the field of recycling and renewable energies, with a focus on the use of wastes and residues, biomass and solar energy.

DHI WASY has for over 50 years been a leader in research and development of innovative solutions in the field of water and the environment. Its core competency is digitalising, modelling and visualising water systems.

With around 14,000 members, the **German Association for Water, Wastewater and Waste (DWA)** is committed to the development of sustainable water and waste management in Germany. DWA has set technical standards, supported research and training and has advised politicians, scientists and industry in Germany and abroad.

The **German Water Partnership (GWP)** is a joint initiative of the German private and public sectors, combining commercial enterprises, government and non-government organisations, scientific institutions and water-related associations.

The **Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB)** is a European research centre at the nexus between biological and technical systems. It develops highly innovative and efficient technologies for the use of natural resources in agricultural production systems.

p2mberlin, the consulting and engineering company within the Berlinwasser Group, is a leading provider of planning, design and implementation services in water related investment projects.

PASSAVANT & WATEC is a specialist in remote monitoring and automation facilities as system solutions for drinking water suppliers, wastewater disposal companies and industry. For more than 20 years they have offered planning, building, installation, maintenance and optimisation.

The internationally renowned **Technische Universität Berlin** is one of the largest universities of technology in Germany. Its Environmental Process Engineering Chair focuses on the design and operation of industrial processes with minimum effects on the environment.

The **IEEM gGmbH – Institute of Environmental Engineering and Management** at the Witten/Herdecke University integrates the academic fields of "technology" (engineering) and "economics" (management, finance) to form a trans-disciplinary field of science for practical application. (Only 1st project stage)

The **Institute for Social-Ecological Research (ISOE)** is an independent institute that develops social-ecological concepts for sustainable development. As an innovative scientific think tank they undertake trans-disciplinary research for society, policy makers and industry – providing support for sound decision-making processes. (Only 1st project stage)

The Iranian Project Partners

Cooperating within the "IWRM Zayandeh Rud" project were various governmental bodies, renowned research institutes and companies. These partners bring years of experience in Iran's water sector with them.

The **Ministry of Energy**, as one of the most important ministries of the government, is responsible for the management of water, energy and wastewater services and also for promoting training, research and technological development. It plays a major role in the preservation of natural resources, public health and welfare.

The **Iran Water Resources Management Company** is an agency of the Ministry of Energy responsible for enforcing its policies and laws related to water resources, for collecting, analyzing and providing basic information on water resources, promoting research, technology transfer and training in the water sector.

The **National Water and Wastewater Engineering Company** is responsible for organizing the official activities of the Ministry of Energy in water supply and wastewater affairs including the efficient management of water supply and wastewater treatment companies and services, their supervision and evaluation.

As the supreme representative of the government the **Governor General of Isfahan Province** is responsible for the implementation of general national policies in conjunction with ministries, companies, governmental institutions and non-governmental public organizations.

The **Isfahan Regional Water Company**, as the provincial authority of the Ministry of Energy, is responsible for the fair distribution of water, the implementation and supervision of water infrastructure projects and for collecting, providing and analysing information regarding water resources' quality and quantity.

The **Regional Water Company Chaharmahal-va-Bakhtiari**, as the provincial authority of the Ministry of Energy, is responsible for the fair distribution of water, the implementation and supervision of water infrastructure projects and for collecting, providing and analyzing information regarding water resources' quality and quantity.

The **Isfahan Water and Wastewater Company** is one of the oldest WWCs in Iran. It specializes in the construction and operation of infrastructures related to the sustainable supply of potable and hygienic water and the collection, transmission, treatment, reuse and hygienic sewage disposal.

The **Isfahan Agricultural Organization** is an important government body for achieving the targets set in Iran's 20 year outlook plan and many clauses of the 4th and 5th development plans, especially in terms of food security and self-sufficiency in producing staple foods, export development and protection of natural resources.

The **Kashan Water and Wastewater Company** is subordinated to the national water and waste water company. It specializes in the construction and operation of infrastructures related to the sustainable supply of potable and hygienic water and the collection, transmission, treatment, reuse and hygienic sewage disposal.

The **Mirab Zayandeh Rud Company** is responsible for signing water transfer and supply agreements, setting up water user associations, for inspection, monitoring, operation of diversion structures and water flow rate registration, protection of river beds and maintenance of water networks.

The **Environmental Protection Organization of Isfahan** is the main local authority in the realms of human and natural environments, for the supervision of law enforcement, for public relations and training in the environmental sector.

The **Isfahan University of Technology** is one of the largest universities in Iran and top grade in the disciplines of engineering, agriculture and natural science. With high ranking professors and talented students, it was appointed 'Center of Excellence' by Iran's Ministry of Science and Technology.

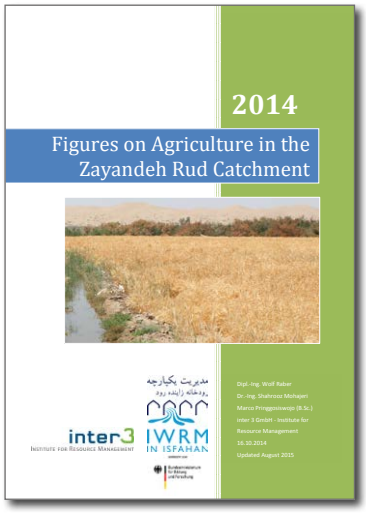
Zayandab Consulting Engineers have a thirty year successful history as water technical specialists with a number of eligibility certificates in water & sewage installations, irrigation and drainage networks, dam construction, protection and engineering of rivers etc.

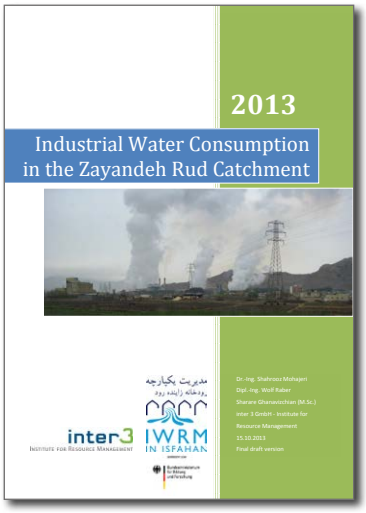
The main responsibility of the **Zayandeh Rud Urban Development Organization** is to organize disciplined and supervised tourism in the Zayandeh Rud basin according to the laws and regulations of the Islamic Republic of Iran.

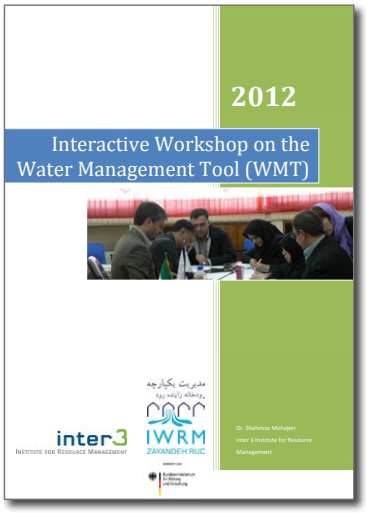
The **Industrial Settlements Organization of Isfahan** is responsible for policymaking and strategic planning for the development of industrial settlements, plot lay-out, promotion of goods and services export and enabling the launching, promotion and extension of private (foreign) investment for large and small industries.

The **Isfahan Higher Education and Research Institute in Water & Power** is the main provider of scientific-practical research and training for the Ministry of Energy and its subordinated organizations, for generating and transferring up-to-date technology and know-how and thereby enhancing required skills in the water and power sectors.

Project Reports







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- Water Management Tool / MIKE Basin, Dr. Michael Kaltofen, DHI-WASY
- Towards a Sustainable Advanced Training Sector in Iran – Analysis of Main Obstacles, Lena Horlemann, inter 3

2014

- Climate Change Impacts on Hydrological Variables in Zayandeh-Rud River Basin, Prof. Saeid Eslamian et al., Isfahan University of Technology
- Concept for Sludge Reuse in Isfahan, Dr. Naylson Maciel, p2m berlin
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- Interactive Workshop on the Water Management Tool (WMT), Dr. Shahrooz Mohajeri, inter 3

For more information visit **www.iwrm-zayandehrud.com**, or contact **iwrm@inter3.de** (Berlin) / **iwrm@esrw.ir** (Isfahan)

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Endangered nature.