IWMI
International
Water Management
Institute

ICARDA

# Turning Environmental Burdens into Economic Opportunities

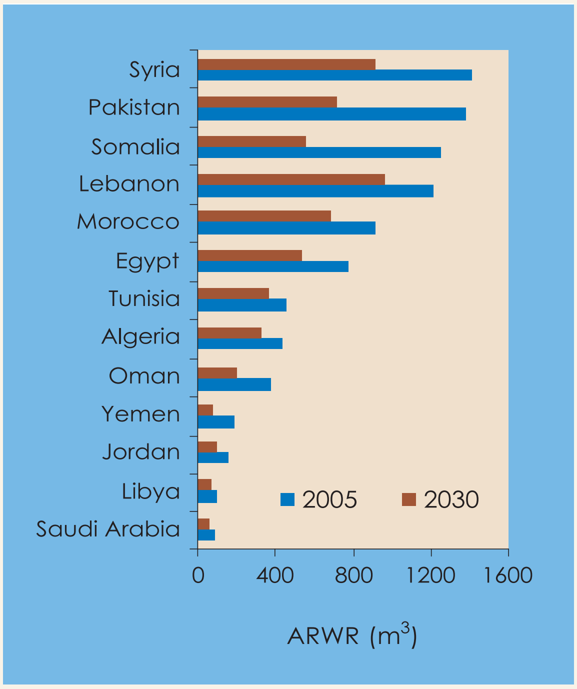



## ICARDA-IWMI Joint Program

### Marginal-quality Water Resources and Salt-affected Soils

## Background

Analysis of the global water cycle yields some encouraging numbers, with annual per capita renewable water supply about 7000 m³ (7 million liters). However, some countries have as little as 500 m³ per capita, with periodic extreme shortages. Clearly, the world's freshwater resources and population densities are unevenly distributed. Considering current demographic trends and future growth projections, as much as 60% of the global population may suffer water scarcity by the year 2025.



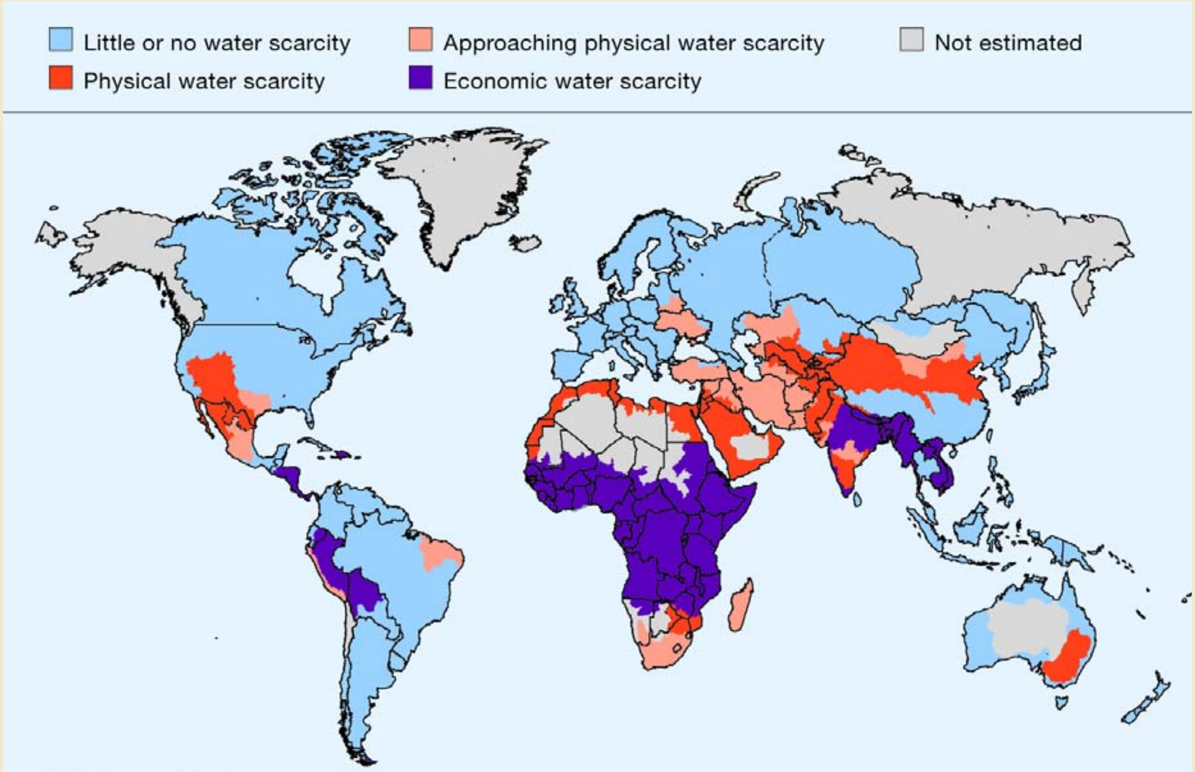

Annual renewable water resources (ARWR) per capita in some countries of West Asia and North Africa, in years 2005 and 2030 (projected)

In addition to water scarcity, water quality deterioration is expected to intensify in resource-poor countries in the dry areas, due to human activity and the increasing possibility of extreme events as a result of climate change. Saline water intrusion is projected to intensify due to sea level rise in coastal zones as well as salt-induced soil degradation and water quality deterioration in arid and semi-arid regions as a result of mismanaged irrigation. Households and industries will generate increasing volumes of wastewater as more people move to urban areas. In addition, increased frequency of severe rainstorms will increase the amount of chemicals that run off from farms and urban areas. These predictions suggest the availability of greater volumes of marginal-quality water in the future. In order to narrow the gap between freshwater demand and supply, water-scarce countries will have to increasingly rely on marginal-quality water resources for crop production, agroforestry, and aquaculture.

There are two broad categories of marginal-quality water: wastewater generated by the domestic, commercial, and industrial sectors; and saline water from agricultural drainage systems, surface runoff, or pumped from overexploited aquifers. Millions of small-scale farmers around the world already irrigate with marginal-quality water, often because they have no alternative.

Wastewater generated by municipal and industrial activities contains a variety of constituents at levels higher than those usually found in freshwater, including salts, metals, metalloids, residual drugs, organic compounds, endocrine disrupter compounds, active residues of personal care products, and/or pathogens. Irrigation with untreated, partly treated, and/or diluted wastewater creates multidimensional impacts, including environmental and health risks. The impacts are particularly complex when untreated domestic and industrial wastewaters are found in the same irrigation system. Most farmers and some government agencies in many developing countries are not fully aware of these impacts - but the consequences could be severe, unless wastewater irrigation is carefully managed.

With increasing use of saline water for agriculture, salinity and sodicity in irrigated soils will also increase. Soil, irrigation, and crop management practices will need to be modified to cope with these increases. About 30% of the world's irrigated land is already salt-affected; with a significant




**Definitions and indicators**

- *Little or no water scarcity.* Abundant water resources relative to use, with less than 25% of water from rivers withdrawn for human purposes.
- *Physical water scarcity* (water resources development is approaching or has exceeded sustainable limits). More than 75% of river flows are withdrawn for agriculture, industry, and domestic purposes (accounting for recycling of return flows). This definition—relating water availability to water demand—implies that dry areas are not necessarily water scarce.
- *Approaching physical water scarcity.* More than 60% of river flows are withdrawn. These basins will experience physical water scarcity in the near future.
- *Economic water scarcity* (human, institutional, and financial capital limit access to water even though water in nature is available locally to meet human demands). Water resources are abundant relative to water use, with less than 25% of water from rivers withdrawn for human purposes, but malnutrition exists.

Source: International Water Management Institute analysis done for the Comprehensive Assessment of Water Management in Agriculture using the Watersim model.

Areas of physical and economic water scarcity

part belonging to poor smallholder farmers who rely on that land to satisfy their food and feed needs. With population growth and increased demand for food, feed, fiber, and energy, larger areas of salt-affected soils will need to be cropped in the future. Saline water and salt-affected soils are valuable resources that cannot be neglected, especially in areas where significant investments have already been made in irrigation infrastructure.

The recently completed Comprehensive Assessment of Water Management in Agriculture concludes that we will have enough food in the future only if we are much smarter about how we manage our water and land resources, and use them more productively. The use of marginal-quality waters and salt-affected soils presents both challenges and opportunities. Addressing the following questions will help guide investment and management decisions on land and water use in agriculture.

- What is the extent of marginal-quality water resources and salt-affected soils?
- What are the environmental, health, and socio-economic implications of their use in agriculture?

Wastewater is used in treated, untreated, partly-treated, and diluted forms to grow a variety of crops and vegetables

Wastewater irrigation in peri-urban Cairo, Egypt; a common feature in many developing countries

Salt-induced land degradation in Uzbekistan; a major impediment to sustainable crop production

Mismanagement of irrigation water is a major cause of salinization in arid and semi-arid regions

- How best can we use marginal-quality water resources and salt-affected soils to improve crop productivity, food security, environmental quality, and livelihoods of communities?

ICARDA and IWMI have joined hands to address the assessment as well as economically and environmentally sustainable management of marginal-quality water resources and salt-affected soils. The Strategic Plans of ICARDA (2007-2016) and IWMI (2009-2013) emphasize the need to improve the use of different types of water resources in agriculture as vital for not only for agricultural productivity but also for ecosystem health. With activities ranging from global to region-specific projects, the joint initiative has built partnerships with advanced research institutes and developing-country institutions in the dry areas.

## Salinity Bright Spot Project in Central Asia (2005-2008)

Expansion in irrigated agriculture in Central Asia in the second half of the twentieth century led to the conversion of virgin lands into productive agricultural lands, resulting in significant increases in employment and income. Central Asia is one of the world's most heavily irrigated regions. Irrigated land in the region has increased from 5.2 million hectares in 1960 to 9.6 million hectares today.

Irrigated agriculture brought not only positive socio-economic development, but also serious environmental impacts. Excessive use of irrigation water coupled with inadequate drainage systems has caused large-scale land degradation and water quality deterioration in downstream parts of the two main rivers, Amu-Darya and Syr-Darya, which fall within the Aral Sea Basin. Nearly half of the irrigated land in Central Asia has salt-affected and/or waterlogged soils.

Considering these challenges, IWMI, ICARDA, and the International Center for Biosaline Agriculture (ICBA) worked together to develop community-based interventions to reverse resource degradation, while maintaining or enhancing food security and farm incomes. Funded by the Asian Development Bank, the 3-year project (March 2005 to June 2008) was implemented in partnership with farming communities and researchers from three Central Asian countries: Uzbekistan, Turkmenistan, and Kazakhstan.

The collaborating national institutions included: Kazakh Research Institute of Water Management, Taraz, Kazakhstan; Turkmen Research Institute of Agriculture, Ashgabat; Ministry of Agriculture, Turkmenistan; Gulistan State University, Uzbekistan; Ministry of Agriculture and Water Management, Uzbekistan; Uzbek Research Institute of Cotton Growing, Uzbekistan; and Tashkent Irrigation and Melioration Institute, Uzbekistan.

Salient project-led interventions are:

- ***Phosphogypsum technology for magnesium-affected soils (Kazakhstan):*** Phosphogypsum is a major source of calcium and phosphorus, and to a lesser extent potassium. Application of phosphogypsum to magnesium-affected soils increased cotton yield by up to 100%. Improvements in crop yield and soil properties were greater when it was applied before the winter snowfall, rather than in spring after the snowmelt. Soil quality was enhanced through improved ionic balance

Patchy germination and growth of cotton on a high-magnesium soil

Improved germination and growth of cotton on a high-magnesium soil through phosphogypsum application between calcium and magnesium; higher nutrient availability through increased levels of phosphorus and potassium; increased moisture storage and availability in the root zone; and improved soil structure facilitating water and nutrient availability to plant roots. This intervention has already been out-scaled over 100 hectares in Kazakhstan. Project partners are working with policy makers to facilitate phosphogypsum supply to farmers for out-scaling this technology to a much larger area.

Mulching of alternate furrows saves wheat straw for other purposes such as animal feed

Conjunctive use of saline and freshwater, and mulching of alternate furrows, improve crop yield and soil quality by reducing soil salinity and sodicity

- ***Furrow mulching for efficient water use (Uzbekistan):*** Application of wheat straw to alternate furrows at the rate of 1.25 t $ha^{-1}$ (compared to the conventional 8-10 t $ha^{-1}$) increased cotton yields by up to 12%, decreased evapotranspiration by 12%, and reduced soil salinity by 13% and soil sodicity by 18% compared to the no-mulch control. The lower application rate of mulching material 'frees up' wheat straw for other competing uses.

- ***Optimal fertilizer use to mitigate salinity effects (Kazakhstan):*** Nitrogen application 20% higher than the recommended rate resulted in better crop establishment in the early growth stages; and increased cotton yield by up to 16%, demonstrating that appropriate combinations of nitrogen application and irrigation water quality can partly offset the effects of saline water irrigation.

Conjunctive use of saline and freshwater, and rational use of nitrogen fertilizer can save freshwater for other uses, and improve crop establishment and yield

- ***Conservation agriculture for wheat-rice systems (Uzbekistan):*** Different combinations of zero tillage and land levelling increased crop yield and water productivity by up to 50%. Zero tillage reduced soil salinity up to 36% compared to traditional tillage practices.

- ***Fodder-based systems for saline water irrigation (Turkmenistan):*** Sorghum and maize gave promising results in terms of biomass production under saline water irrigation. This will help address fodder shortages in salt-affected areas and improve the resilience of crop-livestock systems under saline conditions.

## SWUP-MED Project: Sustainable Water Use in the Mediterranean Region (2008-2012)

Water quality deterioration and multiple abiotic stresses on field crops have major impacts on agricultural productivity in dry areas of the Mediterranean region. The extent of marginal-quality waters, and drought and salinity stresses are becoming even more pronounced with climate change (drier conditions, higher temperatures), and desertification. To meet these challenges, a two-pronged approach is needed: (i) select, test and introduce cereals, grain legumes and new crops and varieties with improved abiotic stress tolerance, (ii) assess the environmental implications of using marginal-quality water in agriculture, and develop environmentally feasible interventions aiming at the efficient use of these resources.

Participants of the project kick-off workshop (1-4 July 2008), ICARDA headquarters, Aleppo, Syria

Environmental impact assessment of wastewater irrigation in Aleppo region; core map of the 60 km study area developed using GIS tools to create reference points for sampling sites

The national partner from Syria for undertaking this work will be General Commission for Scientific Agricultural Research (GCSAR).

A multi-partner project, funded by the European Commission Seventh Framework Programme on research and technological development, will address sustainable water use for securing food production in the Mediterranean region. The joint work of ICARDA and IWMI in the project will focus on environmental impact assessment, evaluating the effects of using marginal-quality water (saline water and wastewater) on salt balance, nutrient availability status, and metal ion concentration in irrigated soils, and the impacts on crop yield and quality. In addition, selected genotypes of grain legumes (chickpea, lentil, and faba bean) will be characterized in terms of their tolerances to salinity and drought stresses.

The 4-year project was initiated in July 2008 with a workshop organized at ICARDA headquarters. It is led by the University of Copenhagen, Denmark. In addition to ICARDA and IWMI, other partners include: Universidade Nova de Lisboa, Portugal; Institute for Agricultural and Forest Mediterranean Systems, Napoli, Italy; Centre for Ecology and Hydrology, Wallingford, UK; Centre for Environment and Development for the Arab Region and Europe, Cairo, Egypt; Institut Agronomique et Veterinaire Hassan II, Rabat, Morocco; Cukurova University, Adana, Turkey; and Institute of Agriculture, University of Western Australia, Crawley, Australia.

The expected outcomes of the project include: improved productivity and sustainable use of freshwater and marginal-quality water for agriculture, more diverse farming systems, stronger economic development in target Mediterranean countries, and accelerated adoption of improved agricultural technologies to meet future constraints imposed by climate change and desertification.

## Production, Use, and Implications of Urban Wastewater in Syria (2004-2005)

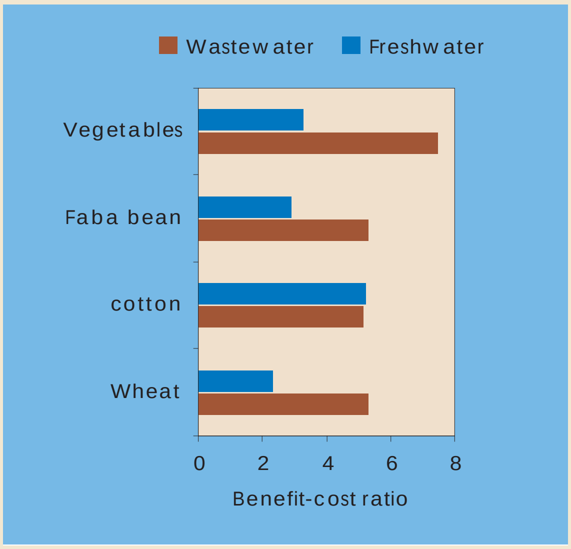
The domestic, municipal, and industrial sectors in Syria generate 1360 million $m^3$ of wastewater per year. About 40% of this wastewater is treated. Most of the wastewater is used to grow a range of crops on about 70,000 hectares. The area under wastewater irrigation is small (less than 5% of the irrigated area in Syria), but economically important. In partnership with Syrian national institutions, ICARDA and IWMI aim to maximize the safe use of wastewater and minimize threats to the environment and human health.

ICARDA and IWMI carried out a pilot study to assess the production, treatment, and use of wastewater in the Aleppo region. Aleppo (population 2.5 million) is Syria's second largest city, located within the Euphrates-Aleppo Basin in the northeastern part of the country. For centuries, the city's water requirements were met from the small Qweik River, which originates in Turkey. Continuous extraction of water within the Turkish part of the river has rendered the Syrian part almost dry. The flow rate of the river before entering Aleppo is less than 1 cubic meter per second. Formerly a source of freshwater, Qweik River is now a carrier of wastewater generated from Aleppo city.

Farmers with lands near the Qweik River practice wastewater irrigation as and when needed. The pilot study found three main reasons why farmers prefer wastewater irrigation. The most important reason (given by 57% of farmers) was the year-round availability of wastewater. The second most important reason (26% of farmers) was the high nutrient content of wastewater, which reduces or even eliminates the need for expensive chemical fertilizers. The third reason (17%) was that pumping wastewater costs less than pumping groundwater.

The Syrian Standardization Commission Code of Practice (2003) prohibits wastewater irrigation of vegetables that are eaten raw. Wheat is the major crop,

Wastewater from Aleppo flows through the Qweik River, from where it is pumped for irrigation by peri-urban farmers occupying more than half of the wastewater irrigated area. The comparative benefit-cost analysis of wastewater and freshwater irrigation showed that the return on wheat irrigated with wastewater was




Benefit-cost ratio for wastewater versus groundwater irrigation in different crops grown in peri-urban area of Aleppo

double the return on wheat irrigated with groundwater. For each US dollar invested in wheat irrigated with wastewater the return is US$ 5.31. Wheat irrigated with groundwater returns US$ 2.34 per dollar invested. Wastewater irrigation gave higher yields because of the high nutrient content. Farmers also saved on the costs of fertilizer (US$ 95 per ha) and pumping.

The study found a critical shortage of Syrian staff trained to monitor and analyze solid and liquid wastes. There is a limited number of staff with technical skills to operate, maintain, and monitor industrial wastewater treatment plants. Building skills is particularly important because responsibilities for treatment, disposal, and reuse of wastewater are shared by multiple institutions. Along with capacity building, research on new technologies for using wastewater could help maximize the benefits to communities and minimize adverse environmental impacts.

## Crop-Livestock Systems under Salt-affected Environments (2007-2009)

Salt-induced soil degradation is common in arid and semi-arid regions. The extent of the problem has increased steadily over the last few decades in several river basins in South and Central Asia, with substantial economic losses and environmental implications. The annual economic losses due to salinization are estimated to be US$ 230 million in the Indus Basin in Pakistan; US$ 210 million in the Syrian part of the Euphrates Basin; and US$ 2 billion in the Aral Sea Basin in Central Asia. Crop-livestock systems are the basis of livelihoods for poor rural communities in salt-affected areas of these basins; but high-quality livestock feed is in short supply due to lack of high-quality grazing lands, and lack of efforts to exploit marginal-quality soil and water resources to narrow the gap between feed supply and demand.

There is a need to develop biophysical interventions and promote institutional and policy options for sustainable and integrated use of salt-affected soils and saline water for feed and forage crops in order to improve food security, alleviate poverty and enhance ecosystem health in smallholder crop-livestock systems in South and Central Asia. This can be achieved by improving the productivity of crop-livestock systems per unit of saline water and/or salt-affected soil resources, fortifying feed, enhancing the adoption of innovative strategies, and generating income for resource-poor farmers while reversing salt-induced soil degradation and water quality deterioration and enhancing environmental goods and services.

In partnership with national research institutions in three countries of West and Central Asia (Pakistan, Uzbekistan, and Syria), ICARDA and IWMI worked together to synthesize and analyze the existing information on crop-livestock interactions in salt-affected areas of the Indus, Euphrates, and Aral Sea Basins. Other major partners were the International Centre for

Underutilised Crops; University of California, Riverside, USA; and Justus Liebig University, Giessen, Germany. A project proposal has been developed through extensive discussions involving all partner institutions, made possible through a seed grant from the CGIAR Systemwide Livestock Program (SLP). Potential donors are being identified to fund the new project.

## Water Productivity Project in Karkheh River Basin, Iran (2004-2009)

The Karkheh River Basin is important for both dryland and irrigated agriculture in Iran. Water availability in the basin is limited and becoming scarcer as population and demand increase. Irrigation management is inadequate, cropping systems are sub-optimal, and policies and institutions are weak. The basin reflects in many aspects the problems of water management in other basins in the region, such as the Euphrates and Amu-Darya River Basins, which are characterized by widespread salinization of land and water resources.

An important component of the project addressed community-based management of salt-affected land and saline water resources to improve crop productivity and farm income in the Karkheh River Basin. Project-led interventions focused primarily on irrigation management in salt-affected soils. In addition, salt-tolerant wheat, barley and sorghum varieties were introduced in saline areas. Financial support for this project was provided by the CGIAR Challenge Program on Water and Food.

Over-irrigation is a major cause of soil salinization in the Lower Karkheh River Basin

## Middle East Water and Livelihoods Initiative Project (2008-2013)

With continuing overuse of scarce water resources and consequent degradation of agro-ecosystems in the Middle East, there are serious implications for the livelihoods of rural communities. Increased non-agricultural demand for water and land, rising food prices, and climate change have complicated the situation further. Attempts to improve rural livelihoods have made little progress. It is imperative that efforts now focus on increasing income-generating opportunities while reversing the degradation of watersheds through sustainable water and land management strategies. Agricultural and natural resource management research is fragmented; and adoption of the research findings by farmers has been very limited. Current water and land-use policies are often inappropriate. Human capacity too is in decline, with a growing shortage of trained personnel.

As a result, most Middle Eastern countries may face a worsening crisis within their rural ecosystems, with serious long-term social, political and economic implications. However, the problem can be viewed as an opportunity for change. There is recognition of the need to manage water and land resources through greater engagement of stakeholders while renewing human capital for future generations. With initial funding from the USAID, the Middle East Water and Livelihood Initiative (WLI) Project is intended to make the most of this opportunity. The goal of the WLI is to improve the livelihoods of rural households and communities in areas where water scarcity, land degradation, and water quality deterioration are prevalent in the seven participating Middle East countries.

Led by ICARDA, this multi-partner project is strengthened by two other CGIAR centers (IWMI and IFPRI), five US universities (Texas A&M University; University of California at Davis and Riverside; University of Florida; University of Illinois at Urbana-Champaign; and Utah State University), and national agricultural research and extension institutions and regional universities from seven Middle East countries (Egypt, Iraq, Jordan, Lebanon, Palestine, Syria and Yemen). The 5-year project was initiated in July 2008 with an inception workshop at ICARDA headquarters.

Participants of the Water and Livelihood Initiative Project inception workshop (7-9 July 2008), ICARDA headquarters, Aleppo, Syria

## Other Projects and Activities

Other IWMI and ICARDA activities, receiving technical input under this joint program, include:

- Use of Wastewater as a Source of Supplemental Irrigation to Improve the Productivity of Rainfed Wheat in Algeria: Algeria-ICARDA project (2006-2009), funded by the International Development Research Centre, Canada

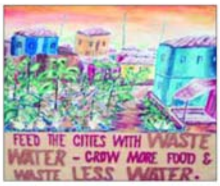
- Soil and Water Management Project in Central Asia: ICARDA project (2004-2007), funded by the Asian Development Bank

- Water Benchmark Project in West Asia and North Africa: ICARDA project (2004-2009), co-financed by the International Fund for Agricultural Development, Arab Fund for Economic and Social Development, and OPEC Fund for International Development

- Extent, Characterization, and Implications of Salt-affected Land Resources in Iran: IWMI initiative (2004-2006) supported by IWMI-Iran

## Comprehensive Assessment of Water Management in Agriculture

The Comprehensive Assessment of Water Management in Agriculture evaluated the benefits, costs, and impacts of the past 50 years of water development, the water management challenges communities are facing today, and solutions people have developed. The results will help improve investment and management decisions in water and agriculture in the near future and over the next 50 years. The assessment was conducted by a broad partnership of practitioners, researchers and policy makers.




**Feed the cities**

Artist: Titilope Shittu, Nigeria

**11 Agricultural use of marginal-quality water—opportunities and challenges**

Coordinating lead author: Manzoor Qadir

Lead authors: Dennis Wichelns, Liqa Raschid-Sally, Paramjit Singh Minhas, Pay Drechsel, Akiça Bahri, and Peter McCornick

Contributing authors: Blanca Jimenez, Juan Antonio Sagardoy, Samia El-Guindy, Safwat Abdel-Dayem, Jeroen H. J. Ensink, Jacob W. Kijne, J. D. Oster, Wim van der Hoek, Sasha Koo-Oshima, Fatma Attia, Lekan Oyebande, and Robert Abaidoo

**Overview**

*Millions of small-scale farmers around the world irrigate with marginal-quality water, often because they have no alternative.* There are two major types of marginal-quality water: wastewater from urban and peri-urban areas, and saline and sodic agricultural drainage water and groundwater. Around cities in developing countries, farmers use wastewater from residential, commercial, and industrial sources, sometimes diluted but often without treatment. Sometimes farmers in deltaic areas and tailend sections of large-scale irrigation schemes irrigate with a blend of canal water, saline drainage water, and wastewater. Still others irrigate with saline or sodic groundwater, either exclusively or in conjunction with higher quality surface water. Many of those farmers cannot control the volume or quality of water they receive.

*Wastewater often contains a variety of pollutants:* salts, metals, metalloids, pathogens, residual drugs, organic compounds, endocrine disruptor compounds, and active residues of personal care products. Any of these components can harm human health and the environment. Farmers can suffer harmful health effects from contact with wastewater, while consumers are at risk from eating fruits and vegetables irrigated with wastewater. Application of wastewater has to be carefully managed for effective use.

*In contrast to wastewater, saline and sodic water contains salts that can impair plant growth but rarely contains metals or pathogens.* However, it can lead to soil salinization and waterlogging, which impair productivity on millions of hectares of agricultural land. Irrigating successfully with saline or sodic water requires careful management to prevent near-term reductions in crop yield and long-term reductions in productivity.

The Comprehensive Assessment synthesis book Water for Food, Water for Life was published in 2007. A key chapter in the book, Agricultural Use of Marginal-quality Water ? Opportunities and Challenges, discusses issues relating to categorization, implications, response options, and policy and institutional aspects of marginal-quality water resources. Considering the inevitable use of marginal-quality water resources, particularly in water-scarce settings, the chapter highlights the role of stakeholders in making safe and productive use of these water resources. The chapter was written by a team of 19 authors (Coordinating Lead Author: Manzoor Qadir).

## International Assessment of Agricultural Science and Technology for Development (IAASTD)

Within the framework of a global assessment and five sub-global assessments, the IAASTD addressed the fundamental questions of reducing hunger and poverty; improving rural livelihoods; and facilitating equitable, environmentally, socially and economically sustainable development through the generation of, access to, and use of agricultural knowledge, science and technology. One of the sub-global assessments covered the Central and West Asia and North Africa (CWANA) region. Chapter 2 of the IAASTD-CWANA assessment Historical and Current Perspectives of Agricultural Knowledge, Science and Technology was developed by a team of 15 authors (Lead Author: Manzoor Qadir).

# Capacity Building

## Bridging Workshop Series

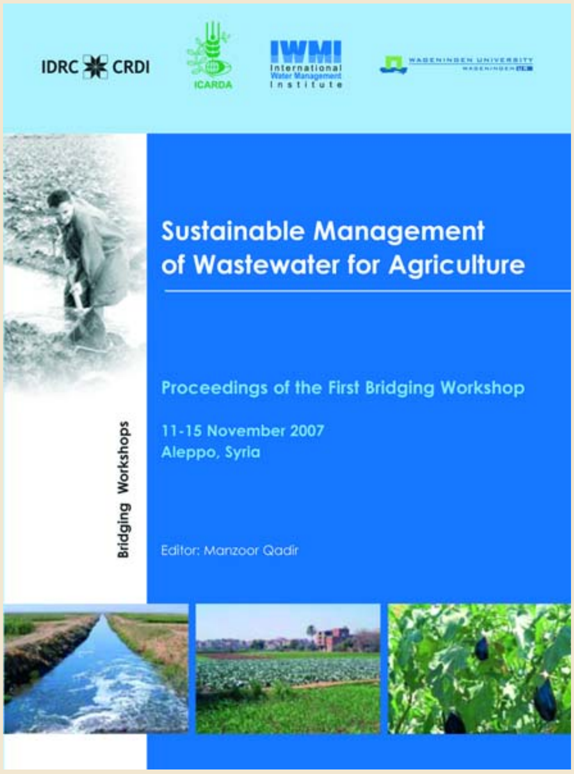
**First Workshop: Sustainable Management of Wastewater for Agriculture**

Within the framework of the joint initiative, IWMI and ICARDA have planned a series of "Bridging Workshops" to bridge the knowledge gap between advanced research institutions and young professionals from national agricultural research institutions in developing countries. These workshops will guide the young researchers towards the state-of-the-art in multi-disciplinary and cutting-edge research, applying an open-space and open-mind environment where participants are mentored by experienced scientists, and encouraged to interact and ask all those questions they could never ask in a conventional workshop. This initiative will involve lead international scientists and young scientists in the exchange of information and experience relating to different aspects of marginal-quality water resources. Each workshop is expected to culminate in the development of workshop proceedings and joint initiatives for future collaboration in research and capacity development.

Participants of the first Bridging Workshop on sustainable management of wastewater for agriculture (11-15 November 2007, Aleppo, Syria)

With a focus on the safe use of wastewater in agriculture, the first Bridging Workshop was organized during 11-15 November 2007 at ICARDA's headquarters in Aleppo, Syria. The opening session outlined the particular character of the Bridging Workshops. This was followed by three further sessions:

- *Stimulating presentations* by lead scientists/resource persons on predefined topics, highlighting the challenges and opportunities, followed by one-hour discussions
- *Country presentations* by young researchers actively involved in research relating to the stimulating presentations
- *Final session* to summarize research challenges and gaps identified in the previous sessions

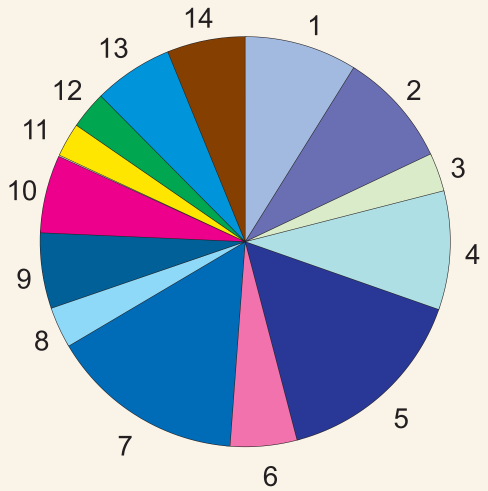



The stimulating presentations covered the following topics:

- The reversed water chain approach: optimizing agricultural use of urban wastewater
- Low-cost decentralized water treatment and the way forward

- Moving towards a more holistic approach to research on wastewater and greywater use: Where are we at?
- What can be done in cases where wastewater treatment does not work?
- Linking sanitation and agricultural sectors for more effective resource recovery through multi-stakeholder platforms and learning alliances
- Social, economic and livelihood impacts of wastewater use in agriculture
- WHO guidelines, the basis for their revision, and future perspectives

Based on extensive discussions, the participants prioritized important research and development issues related to wastewater use in agriculture. The two most important topics were bridging the gap between research and farmer practice in low-income countries; and developing holistic approaches for sustainable management of wastewater in agriculture. These two topics were followed by another priority set of three topics, including: Upstream-downstream challenges for wastewater management; impacts of wastewater on livelihoods and health; and stakeholder involvement throughout the planning and operational processes of wastewater management.




Response of workshop participants in terms of prioritizing the research and practice addressing different aspects of wastewater.
1 = upstream-downstream challenges, 2 = livelihood and health implications, 3 = national level impacts, 4 = stakeholder involvement at all levels, 5 = bridging research-farmers' practices gap, 6 = networks and workshops for knowledge sharing, 7 = developing holistic approaches, 8 = capacity development for water quality monitoring, 9 = separation of industrial wastewater from domestic wastewater, 10 = decentralized wastewater treatment in developing countries, 11 = organic farming with treated wastewater, 12 = phytoremediation, 13 = addressing inorganic and organic pollutants, 14 = evaluation of recent WHO guidelines

The workshop was funded by the International Development Research Centre, Canada, and Wageningen University, the Netherlands. Over 25 scientists and technologists from 13 countries participated. Four young researchers won awards for best papers presented at the workshop.

Based on the promising outcome of this workshop, further Bridging Workshops on water resources management will be held. The second Bridging Workshop is scheduled for November 2009, and will focus on productive and sustainable use of saline water for agriculture.

## Borlaug International Fellows

Based on the academic accomplishments and leadership qualities, Borlaug Fellows in different disciplines are selected by the USDA's Foreign Agricultural Service. US universities and international institutions interested in hosting Borlaug Fellow(s) are selected on the basis of proposals highlighting the research facilities and research expertise and international experience of mentors. The ICARDA-IWMI joint initiative was selected by the USDA-FAS to host two Fellows from Iraq. They will work on soil salinity management for improved crop production, and water quality improvement for agricultural productivity enhancement.

## Post-doctoral Fellow

**Dr Ahmed El-Hawary:** Drainage Research Institute (DRI), Delta Barrage, Cairo, Egypt; funded by the Agbar Foundation through the Mediterranean Network on Wastewater Reclamation and Reuse (1 October 2004 to 30 November 2004)

*Research topic*: Simulating the effects of different practices of irrigation using marginal-quality water

## Ph.D. Students

**Tulkun Yuldashev:** Central Asian Research Institute for Irrigation (SANIIRI), Tashkent, Uzbekistan; funded by SANIIRI and Salinity Bright Spot Project in Central Asia (2005-2009)

*Research topic*: Tree plantations as a biological ameliorant for the degraded lands in Hungry steppe in Uzbekistan

**Amir Hussain:** Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad (UAF), Pakistan; funded by UAF and ICARDA (2006 - 2009)

*Research topic*: Accumulation and partitioning of cadmium, zinc and copper by cereal and legume crops under city effluent irrigation

## M.S. Student

**Tichatonga Gonah:** Wageningen University, the Netherlands; funded by Wageningen University (2006-2007)

*Research topic*: Opportunities for improving marginal-quality water use in the Jabbul area in Syria

**Toshio Sato:** Tottori University (TU), Japan; funded by Tottori University and ICARDA (2008-2010)

*Research topic*: Environmental impact assessment of wastewater irrigation in Syria

## Internship

**Gregory Sixt:** Department of International Development, Community Planning, and Environment, Clark University, Worcester, USA; funded by Clark University and ICARDA (August-November, 2008)

*Research Topic*: Water quality as affected by wastewater irrigation in Aleppo region, Syria

## Individual Non-degree Training

**Saifullah:** Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan; funded by ICARDA (November 2007)

*Research Topic*: Management of marginal-quality water resources

## Training Courses Organized

Training Workshop and Expert Consultation on the Evaluation of Technologies Addressing Salt-prone Land and Water Resources in Central Asia (9-12 April 2006); ICARDA-IWMI Joint Course funded by the Salinity Bright Spot Project in Central Asia

Training Course on the Procedures and Tools for Salinity Related Data Processing and Statistical Analysis (26-30 March 2007); ICARDA-IWMI-ICBA Joint Course funded by the Salinity Bright Spot Project

Participation in other training courses:

- Water Management for Improved Water Use Efficiency in the Dry Areas (co-sponsored by the Japanese International Cooperation Agency and ICARDA), organized annually in May-June for researchers from developing countries
- Biosaline Agriculture: Principles and Applications (sponsored by the International Center for Biosaline Agriculture), organized for researchers from Central Asia (September 2004)

## Journal Articles

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