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INTERNATIONAL WATER MANAGEMENT INSTITUTE
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RESEARCH Update

News of the Progress and Impact of IWMI's Research • November 2000

PUTTING IRRIGATION MANAGEMENT INTO FARMERS' HANDS

Pakistan's Punjab province brings authorities and local farmers into shared irrigation management.

"Our country has a vast farming and rural culture, and all our agriculture is irrigated…"

Mian Abdul Wahid, Munir Ahmad and Naeem Akhtar—farmers in Pakistan's Punjab Province—are the first participants in an ambitious experiment, which aims to transfer the management of much of the province's sub-regional irrigation system to the responsibility of farmers.

In this semiarid climate, near the town of Haroonabad on the edge of the Punjab's Cholistan Desert, virtually all the water needed to grow crops must come from irrigation. This water is supplied by the Punjab canal system, flowing from the main and branch canals (primary level) to the Hakra 4-R Distributary, one of the larger secondary canals in Punjab that irrigates their fields—and the crops of some 4,700 farms—through 124 tertiary canals.

These farmers are members of the first newly created Farmer Organization (FO) in the Punjab Province, which is served by the Hakra 4-R Distributary canal. Through the FO, farmers in this area are taking over responsibility from the irrigation department for delivering water from the distributary level to the fields through tertiary canals. The organization has the power to assess and collect water fees, schedule the delivery of water to all fields in the area, enforce local water allocation rules and settle disputes between farmers. Most significantly, it can impose fines and take legal action against 'water thieves' who use more than their agreed share of irrigation water, and those who default on payment.

General membership of the Hakra 4-R Farmer Organization.

The Hakra 4-R Farmer Organization is the first new group of this kind to be created as part of the vast reform of the Punjab Province's irrigation management system that was initiated by the Punjab's Irrigation Department in 1997. The target of these reforms is twofold: to reduce the number of management irrigation institutions to one—the newly formed Punjab Irrigation and Drainage Authority (PIDA)—and to transfer the responsibility for local water distribution, including the management, maintenance and revenue, to some 2,700 FOs at the distributary systems across the province. When this ambitious plan is in full swing, it will require the creation of some 400 new farmer organizations like Hakra 4-R every year.

Suleman Ghani, Punjab Secretary for Irrigation at the time these reforms were initiated, is one of the architects of this change process. He explains the difference between this type of effort and other attempts by many countries to transfer the management responsibility of irrigation systems to farmers. "Many of the Irrigation Management Transfer projects of the past 15 years simply handed

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Wastewater Irrigation Creates Millions of Micro-Economies

Are the economic value, environmental factors and health risks of this practice understood?

In rural and peri-urban areas of most developing countries, the use of sewage and wastewater for irrigation is a fact of life, not a matter of choice. In some cases, irrigation, canals or rivers carry domestic waste from upstream villages and towns. In semiarid areas, the use of local sewage is the only water source that supports the livelihoods of millions of poor people who irrigate high-value crops.

The obvious solutions for affluent countries—building wastewater treatment facilities—are prohibitively expensive, so not an option for poor villages of Africa, Asia and South America. Neither is legislation to ban the use of wastewater and sewage for crop irrigation. The mainstay of many poor rural economies is the cultivation of crops that cannot exist without the use of this alternate water resource.

An important first step for policymakers in these countries is to understand the implications of wastewater irrigation on the agricultural economies and the environment, says Wim van der Hoek, Leader of IWMI's Health and Environment research program. The Institute's research in Mexico and Pakistan is examining this question.

Two recently completed IWMI research projects, in Mexico and Pakistan have studied the socioeconomic, institutional and health aspects of irrigating with wastewater. Both confirm that there are equal positive and negative aspects, with no clear-cut choices for policy or health practices. This work is the starting point for a broader IWMI wastewater irrigation research program which is now being developed. Likely future research locations include Pakistan, Vietnam, South Africa and Morocco.

A new project to begin in Pakistan in January 2001, funded by the German Ministry for Economic and Development Cooperation, will look at practices and impacts of the reuse of wastewater in peri-urban areas.

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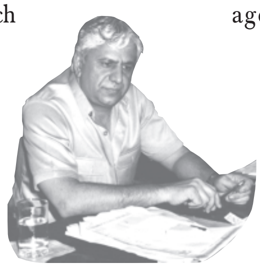
over responsibility for running an irrigation system to farmers without giving them adequate training, or leaving them married to an infrastructure that was in poor repair," he says. "Rather than transferring all responsibility, our approach builds a partnership between the authority and farmers. The management of water distributed to the secondary and field levels of the system has been devolved to farmers. But the PIDA is responsible for the other parts of the system above this. Revenue is shared between the partners—with 60 percent for the authority and 40 percent for the Farmer Organization."



Legal Specialist
Dil Mohamad Malik

The International Water Management Institute (IWMI) has participated in this initiative since its beginning. From its Lahore office, IWMI has worked closely with PIDA, providing research thinking and recommendations on the new legal framework. The Institute has also facilitated negotiations for the revenue sharing agreement between farmers and irrigation authorities.

At the IWMI field office in Haroonabad, researchers concentrated on social mobilization. They organized meetings and encouraged local farmers to agree to nominate the best candidate as president of the Farmer Organization and its management board. The 'best' candidate is the person most respected by all, not necessarily the most politically connected farmer in the village.

The most precarious period in this pilot phase came during the two-year period, after the Farmer Organization was formed, but before it could function legally. "With no provision in the national irrigation law for revenue sharing and local responsibility for irrigation management, farmers' hands were tied. They had the mandate to manage their system, and they wanted to. But the law would not allow farmers to take responsibility for the operation and management of part of the irrigation system," explains S.A. Prathapar, former Director of IWMI's Pakistan office.

During this waiting period, IWMI helped farmers retain their enthusiasm for the project. The Farmers' Organization held regular meetings, and farmers launched a number of self-financed canal maintenance efforts.

During this period—back in Lahore—IWMI was helping irrigation authorities design the new law and have it adopted. Here, Dil Mohamad Malik, a consultant to IWMI and PIDA, and the Dean of the Law Faculty of the University of Punjab, helped the government design its new law. This work included evaluations of the latest developments in Participatory Irrigation Management in other areas, such as India's Andhra Pradesh Province, in Nepal, Sri Lanka, Turkey, Egypt, Mexico and Indonesia. "We learned that you can create Farmer Organizations through an excellent process, but without a clear set of rules and the proper support, reforms will not work in the long run. The approach we have chosen for the Punjab invests all powers in the Farmer Organization," says Malik.

Suleman Ghani
Former Punjab
Irrigation Secretary

At the field level in Hakra 4R, the coordination of water allocation between farmers has always gone well. Each farmer knows how many minutes of irrigation he has per week, takes the water and passes it onto his colleagues. The perpetual problem in the past, and big change proposed by the reforms, is accountability at the distributary level, says Chaudry Mohammad Ashraff, Director of *On-Farm Management*, a division of the Department of Agriculture that is helping PIDA roll out the Punjab reforms. "Our reforms bring a sense of ownership to the distributary level. It now has a face—the Farmer Organization Executive Committee. This new structure makes it impossible for the new irrigation managers to hide behind bureaucracy."

The Irrigators: Hakra 4-R Farmers Explain the Reforms to Others

At a recent meeting the Hakra 4-R Executive Committee collected views from farmers from a nearby distributary that heard that *'farmers were managing their own distributary in Hakra 4-R…'* The meeting was arranged by National Rural Support Program (NRSP), a local NGO. The Executive Committee is composed of: President, Mian Abdul Wahid, Muhammad Amin, General Secretary, Executive Member (Muhammad Amin Sukhera); Tour Committee Secretary (Mian Munir Ahmad). All are smallholder farmers in the Hakra 4-R distributary. Some points from the discussion:

Farmer: We hear rumors of an increase in rates…

(*Editor's note:* this is a rumor spread by those who oppose reforms).

Executive Secretary: What you pay now as water tax will be collected in future locally, through the Tertiary Canal Members of the Harka 4-R FO. There will be no special increase for the FO alone.

Farmer: Who monitors the system's performance?

Farmers of the Hakra 4-R Executive Committee.

Executive secretary: The Irrigation Department will monitor our performance and trains to manage the system until someone can be found to take over this task.

Farmer: How do you really organize yourselves?

General Secretary: Initially there was a lot of negative propaganda against organizing farmers…*(he explains the structure and organization of direct representation in the organization)*. But then IWMI's people held discussions with us and explained that the FO will be chosen by the farmers, governed by the farmers and will work for the farmers. It is easy to organize... Elect one FO member from each tertiary canal (*delivers water to the individual fields*). These members then choose the Executive Committee.

During elections, some opportunists tried to grab positions on the committee, but they were not elected. People voted on the past work and reputation of the candidates in their community.

Farmer: What if some farmers or tertiary areas don't want to join, how can we create a Farmer Organization?

Executive Secretary: Don't worry if everyone doesn't join you at first, just get started.

Farmer from Hakra 4R: The two tertiaries that did not join the Hakra 4R body from the start, stayed away because they received ten times more water that they were allowed! But when they saw that everyone joined the FO, they felt left alone. Today, they are with us and are part of our FO.

Water Court Secretary: Our local Water Court has started to work for us. One person was using more than their share, the amount was calculated and the person was fined.

The past system was 70 years old and we can't fix everything in a day. But now that everyone is involved, the system is self-regulating.

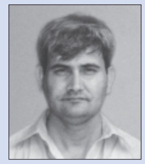
Ashraff does not hide the fact that the depth and scope of these reforms is daunting. "In our culture there is no precedent on which we can base our work. Most of the human activity in the province is centered around agriculture, and all agriculture is irrigated. This is why we have proceeded with the Hakra pilot phase very cautiously," he says. "But I see a lot of enthusiasm for the process; and this factor will make a big difference." For reforms to take on a momentum of their own, a critical mass is required. This will happen when some 100 farmer organizations have been created—in 2–5 years' time.

Mohammad Ashraff
Director, On-farm Management

Word of the reforms has spread to farmers in other areas and provinces of Pakistan. Mian Abdul Wahid and his colleagues at the Hakra FO receive regular visits from farmers in other villages or provinces asking if they should form an FO, how it works in practice, and how they can organize themselves.

With the pilot project firmly in place IWMI's real research work is beginning, for team leader, Mehmood Ul Hassan and his colleagues at the IWMI field station in Haroonabad. "We are monitoring the process and working closely with farmers to identify problems and suggest improvements. These findings will be fed back into the system here in the Punjab and communicated to irrigation authorities in other provinces," he concludes. In the broader context of IWMI's work, the lessons learned are being prepared for publication so that irrigation reformers in all developing countries can benefit from this experience.

Tracking the Impact of Participatory Irrigation Management



Mehmood Ul Hassan, team leader of the IWMI Haroonabad research station, explains the context of IWMI's research.

Much of the work on this project seems to be social mobilization and technical assistance activities. How does this fit with IWMI's research mandate?

The core of our work on this project is research. Our primary activity has been to set up and study the pilot project—through this 'laboratory' we are studying the social, institutional and hydrological situation surrounding the creation of this new approach.

In addition to our role as an international research institute we have grown into the position of an independent adviser to the government and as a trusted partner of farmers. This link has helped build the trust necessary for the reform to move forward.

With the Hakra 4-R pilot site running, our work is to monitor the situation. The new irrigation authority together with NGOs will implement the reform across the province. Our research provides the standard model through which this can be implemented here and in other provinces.

What are the expected impacts of this work?

Our efforts together with the Punjab government over the past four years have created permanent and lasting impacts. IWMI's work has helped create a legal basis that supports this type of participatory irrigation management. As a part of this law we have reviewed all water related Acts in the current Water Law and looked at what other countries were doing.

IWMI experts sat on several committees that drafted rules and bylaws governing the running of Farmer Organizations. We also facilitated the cost apportionment negotiations between farmers and the irrigation authority.

As the reforms progress the results of this work will contribute to change the way agriculture is managed, and the transfer of these practices to other provinces.

The longer term objectives for the government are to recoup its investment in the coming 7–10 years, and for irrigation in the Punjab Province to be self-supporting, and no longer dependent on subsidies.

(Continued from front page)

Wastewater Irrigation Creates Millions of Micro-Economies

Mexico: Balancing ecological and economic concerns

IWMI's research in Mexico examines the advantages and disadvantages of using urban wastewater for crop production in Mexico's water-scarce Guanajuato river basin. Here, wastewater irrigation is a critical component of intensive water recycling practices. This study shows that the 140-hectare site downstream of Guanajuato—that is irrigated with raw sewage—serves as a defacto water treatment facility with significant retention of contaminants. "We found that the economic value of wastewater used for irrigation represents a significant monetary benefit to both society and these water users," says Dr. Chris Scott, the IWMI researcher leading this project.

Scott says that the findings of this study suggest that the continued application of wastewater to the land in this area would be a more economical form of wastewater treatment than building a wastewater treatment plant. The building of a treatment facility is currently being studied by local authorities. "If the treatment plant planned for the Guanajuato basin were built, local farmers' net incomes would be reduced, as they would have to buy crop nutrients to replace those previously provided by wastewater," he explains. "Our research has reached this conclusion with the caveat that the potential for serious negative impacts on health and the environment must be researched. Both the positive and negative costs must be carefully evaluated, he cautions.

It is true, this research concludes, that the short-term benefits of wastewater irrigation could be offset by the considerably high health and environmental costs of this activity. But then again, many regions will simply not be able to afford the high cost of proper waste treatment facilities. "This is why IWMI's research initiative on wastewater irrigation has been expanded," says Wim van der Hoek. "We are interested in identifying the precise conditions under which the benefits of wastewater irrigation can be realized, while minimizing the risk and associated costs for public health and environmental quality."

Pakistan: Expanding use in peri-urban uses

In Pakistan, a study near the town of Haroonabad in the Southern Punjab region is documenting current wastewater practices and the related irrigation, health and environmental issues. Based on this reconnaissance work a comprehensive study on wastewater irrigation will be designed and implemented.

The primary benefits are financial gains for local farmers who cultivate high value crops, and increased crop productivity without the need to purchase additional fertilizer. This is also good business for local landowners, who can rent plots to wastewater irrigators for five-to-six times more than the rate for land irrigated by canal water. The Haroonabad study reveals an accumulation of heavy metals in the wastewater-irrigated soils, indicating that land will become unprofitable unless it is properly managed, using reclamation and other measures.

This study confirms that wastewater irrigation offers benefits that can help many rural water-short areas in Pakistan increase their agricultural productivity and profitability. But in each location the negative impacts and sustainability issues must be carefully evaluated.

To learn more about IWMI's wastewater irrigation research, point your browser to: **www.iwmi.org**

Understanding wastewater use in agriculture

Key Research Questions

- What are the dangers of uncontrolled wastewater irrigation in terms of public health and pollution?
- How can the nutrient value of wastewater be assessed?
- What sustainable practices are being used that can be transferred to benefit poor rural areas in other countries?
- Which crops are the best candidates for wastewater irrigation and which should not be cultivated?

Piecing Together the Water/Malaria Picture

Understanding interactions between malaria and water used in agriculture, in three target areas: tank cascade irrigation, semiarid areas and rice ecosystems.

The worlds of water and malaria are inextricably linked. The sharp end of the malaria problem in many developing countries is their irrigated and agricultural areas. Here malaria is a part of daily life for many poor people who are directly affected by the way water in agriculture is managed (or mismanaged).

To address this problem, IWMI's Health and Environment research program has been studying irrigation-related malaria in the three main climatic and geographic areas where it affects the highest number of the world's poor. These are: the environments around tank cascade irrigation systems used across South Asia and in parts of Africa and South America; canal irrigation systems serving semiarid climates such as the Punjab—in India and Pakistan; and in rice ecosystems in China and Africa where the way water is used in this type of cultivation can create the conditions for malaria-breeding mosquitoes to thrive.

"One of IWMI's research goals is to produce scientifically validated conclusions that describe the health, institutional and hydrological factors that must fit together, for countries to create an effective malaria prevention strategy using water management. Health specialists must understand the needs and concerns of irrigation engineers and vice versa. But in most countries, there is little dialogue between these two groups on the topic of malaria prevention," says Dr. Felix Amerasinghe, the lead scientist for IWMI's water and malaria research.

Malaria in Tank Cascade systems

South Asia has thousands of tank cascade irrigation systems. Most are in need of rehabilitation. The stagnant pools formed by water leaking from the system create an ideal mosquito breeding ground along the entire irrigation network, near thousands of rural villages.

IWMI hydrologist, Yatuka Matsuno recalls the early discussions with Sri Lankan partners. "When presented with the flushing approach, irrigation engineers' reaction was that that it could not be done, because there was no additional water in the system for this operation. We showed that the canals could be flushed effectively using the same amount of water. Because we have precise data about the development cycle of the mosquito and its breeding places, we now know exactly at what periods in the insect's development to flush the system," he comments.

The data generated by the IWMI team over the past three years sets out the priorities and imperatives needed to reduce malaria in the study area in Sri Lanka. The rehabilitation of the tanks to reduce water seepage is in progress and all the options available to regulate water flows through canals are being evaluated—in association with the Mahaweli Irrigation Authority and local farmer organizations. Once the strategy is operational in 2001, IWMI and its partners will measure the malaria incidence against a data set for the same area started in 1994.

Conclusive results are expected by 2003. By then, the fine-tuning of the new practice will be complete. A new malaria prevention system will be in place that is expected integrate irrigation authorities, farmer organizations and the Ministry of Health.

Some have questioned the usefulness of doing malaria research in an area such as the Punjab—the vast semiarid area that spans southeastern Pakistan and northwestern India—whose malaria figures have declined steadily for the past 20 years. The last major epidemic was in the 1970s.

Semiarid areas: Will reduced salinity trigger new epidemics?

IWMI Health and Environment program research leader, Dr. Wim van der Hoek explains why doing water/malaria research here today is vital for the region. "The Punjab has a clay layer just below the surface that prevents adequate drainage and creates waterlogging. This leaves behind a large quantities of saline water, making the soil infertile for most crops. Both the Indian and Pakistani governments are planning to restore this agricultural land by building large-scale drainage schemes. Better drainage will reduce salinity. It also will leave behind fresh water that attracts malaria breeding mosquitoes."

Here, IWMI's primary research hypothesis is: *'Is the steady reduction in malaria over the past 20 years related to progressive water and soil salinization? Has salinity made standing water in this region unfit for breeding habits of malaria vector mosquitoes?'*

Rice ecosystems: Do new water saving practices discourage disease?

If this is the case, a program that reduces surface water salinity in the Punjab could trigger a serious malaria epidemic, says van der Hoek. Having a clear understanding of the situation today will help these governments have an anti-malaria strategy in place when these new agricultural lands are restored.

Some Asian and African countries use a wet/dry irrigation technique for rice cultivation. It involves draining fields, then releasing new water at critical moments in the rice growth cycle. It is said that this saves water and can strengthen roots.

The health risk of the wet/dry technique is caused by pools of standing water left in fields that are not properly leveled and drained—creating a breeding ground for mosquitoes that carry malaria and Japanese encephalitis. Looking at China alone, with its millions of square kilometers of rice cultivation, the potential for increased disease transmission could become a serious health concern if the wet/dry practice is expanded.

Reducing malaria with water management requires close cooperation between a countries' health and irrigation authorities.

IWMI's research in malaria in rice ecosystems is being done in several field trials in India and Kenya. There are plans for a similar project in China, where IWMI has been working with the International Rice Research Institute (IRRI), Wuhan University of Hydraulic and Electrical Engineering and the Zhang He Irrigation System on the question of water saving in wet/dry irrigation.

"For water management to be effective in preventing these diseases in a rice ecosystem, every farmer must appreciate the importance of leveling the field and emptying water from fields at the prescribed time," says Felix Amerasinghe, on the importance of the involvement of farmers. IWMI researchers are looking into the best ways to implement farmer participation on a large scale.

The Cost of Malaria Control in Sri Lanka

• Spray home	...	$ 2.87
• Provide bed net	...	$ 0.87
• Larvicide in water	...	$ 0.50
• Water management flushing		$ 0.25

Source:
Kondradsen etal. 1999.
(Cost of malaria control in Sri Lanka, WHO).

World Water and Climate Atlas Gives a New View of Land and Water Resources

For food security planners, here's an instant view of the rain-fed agricultural potential of any location.

Gathering the data to plan irrigation systems or set up large-scale rain-fed agricultural schemes typically takes project teams weeks or months. The IWMI World Water and Climate Atlas helps reduce this preparation time to days, or even hours, by bringing together water, climate and agricultural data from sources around the world and presenting it in an easy-to-use software tool. Using the Atlas, planners have instant access to a host of useful water and climate data. The Atlas data is presented on an open platform—data from other sources can be added or the Atlas data can be exported to other software tools.

The Atlas is a policy and planning tool that has direct relevance for the poorest areas of the world. Policy makers in developing countries can use it to analyze when and how much water reaches their country's agricultural areas and ecosystems, and to improve food security planning in water-stressed areas or places with low crop yields.

Specifically, this data set can be used to reveal the type of crops that can—or cannot—be cultivated in a given area, or other practical information that agricultural planners and crop researchers need. Key questions include: *Where can rain-fed agriculture be expanded; where is supplemental irrigation necessary to increase crop yields; where is irrigation essential for optimal agricultural production?*

Dr. David Seckler, former Director General of IWMI and the driving force of this project, explains the thinking behind the creation of this global dataset. "The agricultural potential for rain-fed areas can only be determined using detailed climate maps, but it has been difficult to access accurate data in many countries. This lack of rapid access to the right information is a handicap to agricultural planners and food security policy people; and our motivation to create the Atlas."

The new edition of the Atlas, which has just been released by IWMI, incorporates climate data covering the entire world—from over 30,000 weather stations between 1961 and 1990. "Planners can zoom-in to examine the rain-fed agriculture situation in any location on the globe." says Ian Makin, the IWMI researcher leading this project. "The largest dimension of the grid squares is only 16 km^2 at the equator, the highest resolution currently available for a global data set of this kind."

The Atlas contains data on precipitation, temperature, humidity, hours of sunshine, evaporation estimates, wind speed, total number of days with and without rainfall, and days without frost. These key indicators can be combined with information on terrain, elevation, land cover and land use, to develop a clear picture of the agricultural potential in their area. "This view can be further refined by incorporating data on population density, stream flow, vegetative indices and developed water resources at any scale from a country to a region or a smaller geographic area," says Makin.

With its global data set now operational, the next step for the Atlas is to develop a series of applications that help poor countries improve their food security planning. IWMI is cooperating with developing country partners and researchers in the CGIAR/Future Harvest Centers to help these specialists use the Atlas to answer crop and water availability questions.

IWMI is planning new on-line services using the Atlas data. These include rapid response services which display water and climate data for any given terrestrial coordinates; or a calculation of water requirements, where the user types in the coordinates, type of crop and the season. Depending on the complexity of the computation required, the information is returned to the user directly or by e-mail.

PRACTICAL USES OF THE WORLD WATER AND CLIMATE ATLAS

Some examples taken from IWMI's research program:

Answering the question: "How much irrigation do we need?"

To better understand the world's future irrigation requirements, IWMI researchers are using the Atlas to calculate the global potential for rainfed agriculture. Previous global studies relied on coarse-resolution climate data. The Atlas's high resolution data is 39 times more accurate than the standard 30 minute arc resolution). It combines with a soil water storage capacity map and a dynamic water and crop model to estimate rainfed agriculture potential.

Malaria risk mapping

IWMI researchers are using the Atlas to more accurately identify high-risk malaria areas. Previous risk mapping studies use rainfall as the primary indicator of malaria risk. IWMI's work is creating a picture of seasonal soil moisture content—a more reliable indicator—to map the disease. The Atlas climate data is combined with the FAO's Digital Soil Map of the World. This new view shows where and when conditions are favorable for the breeding of malaria-carrying mosquitoes. These maps will be refined using satellite remote sensing tools.

A simpler calculation of evapotranspiration

IWMI scientists are developing a simple, single equation method for calculating potential evapotranspiration anywhere in the world—a breakthrough made possible with the Atlas' comprehensive data set. This new method, extending the original Hargreaves approach, only requires data on maximum and minimum temperatures, and provides a practical alternative to the Penman-Montieth method in situations where there is minimal or inaccurate climate data.

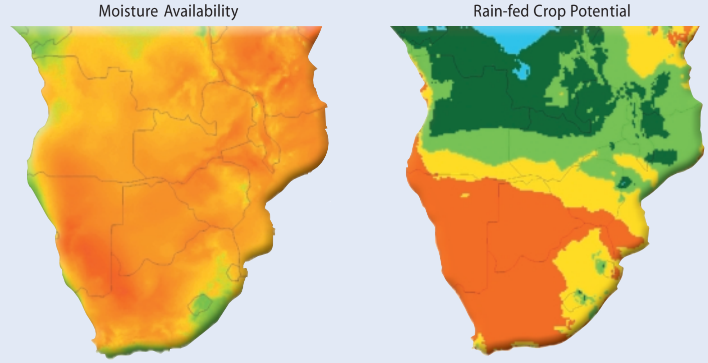
Using the Hargreaves Moisture Availability Index (MAI = ET/P75), the Atlas clearly shows which regions can support rain-fed agriculture (green & blue), which require supplemental irrigation (yellow), and which need full irrigation to be productive (orange).

Potential for rain-fed agriculture on a global scale

Some 46 percent of the earth's surface is unsuitable for rain-fed agriculture due to climatic constraints. This leaves approximately 7 billion ha with a potential for rainfed crop production, of which, 4.7 billion ha is classified as moderate to highly suitable. Researchers are currently refining this preliminary estimate taking into consideration the non-climate related factors (e.g., areas not available for conversion to agriculture).

Sub-Saharan Africa

Moisture Availability | Rain-fed Crop Potential



Download the IWMI World Water and Climate Atlas from the IWMI Internet site www.iwmi.org or request a CD-Rom copy from *d.vaneyck@cgiar.org*

The Atlas was created by researchers from the International Water Management Institute with the support of the Japanese Overseas Development Agency and USAID.

Matching Available Water with Optimal Storage Strategies

As water scarcity and the uncertainty of supply increase in many regions of the world, water storage is a practical, and in some cases the only, solution to the water scarcity crisis. IWMI's research looks at options for combined surface storage and aquifer recharge.

The International Water Management Institute's (IWMI) recently published research on water storage compares three options of keeping freshwater water–for months (small reservoirs), years (large reservoirs), and through the recharging of underground aquifers. These options are compared from the hydrological, economic and operational perspectives, together with some environmental observations.

In this study, the authors, IWMI scientists Andrew Keller, R. Sakthivadivel and David Seckler, reach two conclusions: first, that each of these storage technologies is indispensable and has a strong comparative advantage in specific situations. Secondly, this research suggests that–where these three storage approaches can be combined in an integrated system–substantial gains in water productivity can be achieved.

Combined storage approaches

A number of combined storage approaches already exist and are effective in meeting fluctuating demand. 'The melons on a vine' irrigation schemes in China and Sri Lanka demonstrate how small and large reservoirs can be linked. Using this approach, a few large storage facilities supply water to numerous small tanks within a river basin. Using this combination, small reservoirs provide a buffer to lessen the potential shock caused by mismatches in supply and demand from large reservoirs. Complementarities also occur where many storage reservoirs, which were previously used as irrigation tanks in the arid and semi-arid parts of India, have now been converted to ponds used for recharging groundwater aquifers.

Faced with increasing water scarcity in many regions and the emerging trend of less predictable rainfall, countries need to devise innovative water storage strategies to guarantee supply and food security. The first step says, R. Sakthivadivel, is to have a clear view of the situation. He calls for water accounting inventories to be done on all the major river basins of the world. This water balance sheet will help planners clearly see where water is available for potential storage. "The amount of potentially usable water that is flowing out of these river basins must be determined. Then where it is possible to combine these three approaches in an integrated system, plans can be made to efficiently capture and use it. This is the beginning of developing a sound storage strategy," he says.

The multiple storage paradigm

Within this multiple storage paradigm, IWMI's research suggests that the best options are a combination of surface storage and groundwater recharge, where this is feasible. If storage projects are to serve their purpose with maximum efficiency, then a variety of options should be considered, the study states.

Reflecting on the history of large water storage projects, Sakthivadivel says that, economies of scale have been the main consideration in selecting the type of water storage, often at unacceptable social and environmental costs. "Many large dams have been built because of their low-cost per cubic meter of water stored, not because they were particularly appropriate in the given situation. Our research indicates that the combined storage approach matches with effective aquifer management, optimizes the advantages and minimizes the disadvantages of each type of storage."

Striking a balance: Social, ecological and agricultural aspects

The challenge for countries today is to strike the balance between finding ways to capture and keep the necessary amounts of water to ensure food security and agricultural productivity, while respecting the ecological and social balance. This 'integrated planning' approach for water storage features in much of IWMI's research on the water storage that has been completed over the past five years.

Taking the climate change as a result of global warming and the vagaries of rainfall into consideration, the need for freshwater storage will become even more acute. Although it has been practiced in many areas of the world, it has not been put into practice from the planning stage. Effective institutional, policy and infrastructure framework is essential for a successful and smooth operation of these techniques.

To get the full details of the research, read Reseach Report 39 at **www.iwmi.org**

	Groundwater storage	Small surface water reservoirs	Large dam reservoirs
Advantages	Little evaporation loss Ubiquitous distribution Operational efficiency Available on demand Water quality	Ease of operation Responsive to rainfall Multiple use Groundwater recharge	Large, reliable yield Carryover capacity Low cost per m^3 water stored Multipurpose Flood control and hydropower Groundwater recharge
Limitations	Slow recharge rate Groundwater contamination Cost of extraction Recoverable fraction	High evaporation loss fraction Relatively high unit cost Absence of over-year storage	Complexity of operations Siting High initial investment cost Time needed to plan and construct
Key issues	Declining water levels Rising water levels Management of access and use Groundwater salinization Groundwater pollution	Sedimentation Adequate design Dam safety Environmental impacts	Social and environmental impacts Sedimentation Dam safety

Comparative advantages, limitations, and key issues associated with groundwater, small reservoir, and large dam water storage.

Storage type	Conservation potential	Operational flexibility	Adequacy	Reliability
Large reservoir	H	L	H	L
Small reservoir	L	H	L	L
Groundwater storage	H	H	L	H
Large and small reservoirs combined	H	H	H	L
Large and small reservoirs combined with groundwater storage	H	H	H	H

Notes: H = High; L = Low; Adequacy = Sufficiency of yield to meet needs of command area; Reliability = Assuredness of water deliveries.

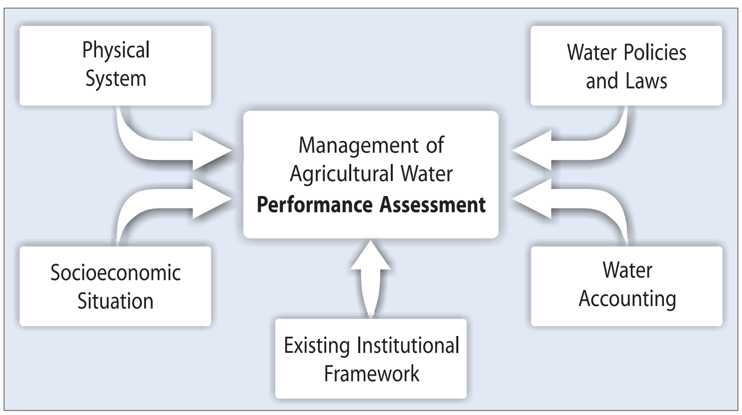
Characteristics of storage structures.

A Better Understanding of Problems in Water-Scarce River Basins

Helping water policy makers and planners to see agricultural water use from a river basin perspective—in China, Nepal, Indonesia, the Philippines and Sri Lanka.

In five river basins in Asia, an IWMI research team is studying how water sector institutions can effectively deal with the growing problems of water scarcity and the intersectoral competition for water. The basins chosen for the comparative study are Fuyang (North China), East Rapti (Nepal), Lembang/Sumpur/Ombilin (Indonesia), Pampanga (the Philippines), and Deduru Oya (Sri Lanka).

Each basin represents a different dimension of the scarcity problem: from a water surplus or 'open' basin as in the Philippines to a water-scarce or 'closed' basin in China, and different levels of spatial and temporal water scarcity that characterize the selected basins in Indonesia, Nepal and Sri Lanka.



Institutional analysis for improved agricultural water productivity in a river basin context.

The goal of this work is to better understand the problems in water-short basins, document how these countries are addressing the situation, and examine solutions that could help improve the management of agriculture in water-scarce basins.

Identifying Change

The primary impact of this research will be to identify changes in the water sector institutions in these countries, by helping planners see the advantages–and importance–of viewing their water resources from the river basin perspective. The findings and recommendations of this three-year study will also provide practical information for water planners in the developing world that face similar situations. This collaborative research is being done by a team composed of IWMI scientists and researchers from national research centers in the selected countries.

"We want to encourage water policy makers and planners in these basins to see their irrigation needs in a broader context of the river basin. Our research looks at the hydrological, social, and economic interactions that affect the use and availability of water," explains IWMI senior researcher, Tissa Bandaragoda.

To do this, IWMI researchers and their local research partners are asking questions such as:

How much water is in the basin and how much is actually available?; who are the current users and what are the water use patterns and the nature of the conflicts between users?; what are the policy deficiencies that hinder the productivity of water used in agriculture?; and what are possible future trends in each basin–particularly in irrigated agriculture?

Researchers are gathering data in these areas: physical characteristics; water accounting; socioeconomic conditions; stakeholder perceptions, and performance assessment.

Another important component of this project investigates the policies these countries have adopted to ensure that the water needs of the poor and the other advantaged people are met. "In water-scarce river basins such as these, the increased competition for a finite water supply inevitably hits the poorest members of society the hardest, especially women and children," says Bandaragoda. "One of the goals of this research is to better understand what policies are in place to protect the interest of such people. We are analyzing which approaches work and why," he explains.

In Sri Lanka and Indonesia the research is expected to initiate institutional changes that establish an integrated approach to water resources management. The primary output of the Chinese work will be the creation of approaches for the better management of water scarcity.

Institutional Options

Madar Samad, an IWMI researcher working on this project states there is now widespread recognition that the river basin is the most appropriate unit of analysis for planning and managing water resources. "Although there is a fairly good knowledge base on the hydrology of river basins, there is much uncertainty about the institutional options of the effective management of river basins. The investigations of the five basins and the lessons from three case studies of the more advanced river basin management entities of the Brantas River (Indonesia) Omungawa basin (Japan), Murray-Darling river (Australia) are attempts made to fill this gap in knowledge," he says.

This project is funded by the Asian Development Bank. The research partners are Chinese Academy of Agricultural Sciences (China), Center for Irrigation, Land and Water Resources and Development, Andalas University, Padang (Indonesia), Department of Irrigation and the Institute of Agriculture and Animal Science, University of Thribuvan (Nepal), Ministry of Irrigation and power, Divisional Secretariats of the river basin, Irrigation Department, Provincial Agriculture Department, and Water Resources Secretariat (Sri Lanka).

BASIN PROFILES

- **China**

  Fuxi basin in Hebei Province is an important agricultural production region of wheat, maize cotton, oil-bearing crops and horticultural crops, and an industrial region.

  Research focus Institutional arrangements for groundwater management, to effectively deal with intersectoral competition and pollution control.

- **Indonesia**

  A combination of three interconnected basins in Padang, West Sumatra: the Lembang, Sumpur, Ombilin (Rivers) and Lake Singkarak. The complexity of the basin requires selective fieldwork to address the situation.

  Research focus Managing agricultural water supply under variable river flow conditions, intersectoral competition and pollution control.

- **Philippines**

  The upper Pampanga River is characterized by two pronounced seasons—dry (November to April) and wet (May to October).

  Research focus Study variability of water supply and how it can best be managed.

- **Sri Lanka**

  Deduru Oya in the North Western Province. This is a relatively water-short basin for irrigation purposes.

  Research focus Find effective institutional mechanisms to better manage water in a basin where there is spatial and temporal scarcity of water.

- **Nepal**

  The East Rapti basin, is characterized by small-scale irrigation systems, groundwater extraction, and where there is a substantial demand of water for environmental purposes.

  Research focus Managing water in a transnational river where some parts of the basin experience seasonal water scarcity and also for environmental purposes without adversely affecting agriculture.

2001–2005 Strategic Plan Takes Shape

The IWMI strategic plan that will set the Institute's research priorities for the coming five years is nearing completion. The Plan was shaped by IWMI staff, and the contents were completed in consultation with a broad group of IMWI stakeholders around the world, including partners, other research centers working in the fields of water, environmental and agricultural topics. The current third revision of the draft will be presented to the IWMI Board of Governors for adoption in December.

The Plan covers all key aspects of the Institute's work, including a description of five research themes (integrated water resources management for agriculture, sustainable smallholder land and water management systems, sustainable groundwater management, water resources institutions and policies, water health and environment), a concept for research partnerships and for maintaining a long term research presence in 'benchmark' river basins in several developing countries. Management issues are also covered, these include: an analysis of strengths and weaknesses, human resources policy, impact assessment and several proposed organizational change projects.

When adopted, the Plan will be put in place beginning January 2001.

Sri Lanka among the First to Use New Satellite Tools to Track Water Resources

Sri Lanka's Departments of Meteorology and Irrigation, with the International Water Management Institute (IWMI) are testing new satellite remote sensing tools that can help the country better understand and manage its water resources. This is one of the first uses of this kind of technology by a developing country. The lessons learned here provide examples that can help other countries implement remote sensing programs to support water allocation and food security strategies.

Using the tools applied in this study, agricultural specialists and government policymakers can interpret low-cost public domain satellite images to reveal data such as the amount of water use by crop, the rate of vegetation growth, or how much water is flowing out of a river basin into the sea. These techniques were developed by Wageningen Agricultural University, the International Institute for Aerospace Survey and Earth Sciences (ITC) in the Netherlands, and IWMI.

Welcome to Five New Scientists

Five new post-doctoral scientists will join IWMI's research team in early 2001

- **Dr. Jinxia Wang (China)** is currently a Program Leader in Water Resources Policy at the Chinese Academy of Agricultural Sciences, and has a PhD in Agricultural Economics from the academy.
- **Abdul B. Kamara (Sierra Leone)** is a Doctoral Research Fellow and Teaching Assistant at the University of Geottingen, Germany and completing his PhD in Agricultural Economics there. He has been a Research Assistant at the Institute of Development Studies, University of Nairobi and served as a joint Research Associate for the International food Policy Research Institute and the International Livestock Research Institute.
- **Dr. Mohammed Mainuddin (Bangladesh)** is currently a Research Specialist in the Water Engineering & Management Program at the Asian Institute of Technology in Bangkok. He served as Research Engineer in the Water Engineering and Management Program at AIT during the period September 1994 to March 2000. He will be located in the IWMI Pakistan Office.
- **Madhusudan Bhattarai (Nepal)** is a graduate Research Assistant in the Department of Agricultural and Applied Economics at the Clemson University, USA and is completing his Doctorate in Applied Economics there. He has worked as an affiliate Research Scholar and as a consultant at the Social Science Division at the International Rice Research Institute in the Philippines. He has also served as an Agricultural Economist at the Ministry of Agriculture in Nepal.
- **Shrinivas Badiger (India)** is a graduate Research Assistant at the Department of Agricultural Engineering at the University of Illinois, and is completing his PhD there in Soil and Water Resources Engineering. He has served as a Water Resources Engineer from 1995 to 1996 at Green Engineering in Thailand and has also been a Program Associate and a Graduate Research Fellow at the Asian Institute of Technology in Bangkok.

IWMI Opens Regional Research Office in South Africa

Signing the memorandum: IWMI DG Frank Rijsberman and Njabulo Nduli of the South Africa National Development of Agriculture.

A Memorandum of Understanding signed between the National Department of Agriculture (NDA) of South Africa and (IWMI) paves the way for the opening of an IWMI research office in Pretoria.

This regional office will coordinate IWMI's research activities on water resources management in southern and sub-Saharan Africa, with a team of local and international scientists. To do this research, IWMI will tap the expertise of researchers and technical experts from South African universities. The IWMI scientific team includes specialists in areas such as hydrology, agriculture, sociology, economics and gender.

The new office will strengthen IWMI's existing research in South Africa, which has been progressing for the past three years. Much of this is concentrated around the Olifants River basin and looks at smallholder irrigation and how it relates to water management at the river basin level. IWMI's partners include the National Department of Agriculture, the Department of Agriculture Land and Environment, Department of Water Affairs and Forestry, Agricultural Research Council, University of the North, University of Pretoria, Water Research Commission, the Olifants River Forum, Nkuzi Development Association, Naledi Development Consultants and local Water Users Associations.

Recent Publications

Research Reports

Charles L. Abernethy; Hilmy Sally; Kurt Lonsway; and Chégou Maman. 2000. *Farmer-based financing of operations in the Niger Valley irrigation schemes.* Research Report 37.

Douglas L. Vermillion; Madar Samad; Suprodjo Pusposutardjo; Sigit S. Arif; and Saiful Rochdyanto. 2000. *An assessment of the small-scale irrigation management turnover program in Indonesia.* Research Report 38.

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Martin Lacroix; Geoff Kite; and Peter Droogers. 2000. *Using datasets from the internet for hydrological modeling: An example from the Küçük Menderes Basin, Turkey.* Research Report 40.

Christopher A. Scott; J. Antonio Zarazúa; and Gilbert Levine. 2000. Urban wastewater reuse for crop production in the water-short Guanajuato River Basin, Mexico. Research Report 41.

Read all IWMI Research Reports online at www.iwmi.org

IWMI Papers in Internationally Refereed Journals

Bastiaanssen, W. G. M.; Bos, M. G. 1999. Irrigation performance indicators based on remotely sensed data: A review of literature. *Irrigation and Drainage Systems* 13(4):291-311.

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