IWMI
International
Water Management
Institute

Annual Report 2004-2005

Mission - improving the management of water and land for food, livelihoods and nature

A remarkable achievement of the past few decades is that food production has increased to keep pace with population growth. But the cost of this achievement has been a water crisis. Water scarcity, competition, pollution, loss of species and persistent malnutrition are the realities we contend with today. Improving water productivity or getting "more crop per drop" is a first step to solving this crisis, But there is still a long way to go. IWMI is working towards improving the management of land and water, for food, livelihoods and nature.

Contents

Joint message from the Board Chair and Director General

Can we help achieve the MDGs?

This year the UN's Committee on Sustainable Development discusses "water" as a priority subject: can we achieve the water-related Millennium Development Goals (MDGs)? It is therefore also a good moment to ask what IWMI can do to help achieve these goals. Water is a contributing factor to many MDGs. The main water-related target – halving the number of people without access to safe and affordable drinking water and sanitation – is one to which IWMI can contribute only marginally. Our work is focused on the goals to reduce poverty and hunger and maintain a healthy environment. But as water is usually only one of many contributing factors, measuring (or claiming) direct impacts on poverty or hunger is not always useful. We do focus sharply, however, on the pathways through which knowledge generated by IWMI and our partners contributes to these goals.

Reviewing the second ten years of research at IWMI

In 1995 IWMI published a volume called "Expanding the Frontiers of Irrigation Management Research: Results of Research and Development at IIMI 1984-1995", authored by Doug Merrey. This reviewed the first ten years of work of IWMI. We now have prepared a second volume that reviews the second ten years, provisionally titled "More Crop Per Drop Revisited". This annual report features brief summaries of the main chapters in this second review.

It shows how IWMI has been very influential in re-shaping the debate on water, food and agriculture. The basin focus and the idea of open, closed and closing basins; "wet" and "dry" water savings, focusing on recycling and re-use; and the emphasis placed on water productivity–more crop per drop–all have helped to change the thinking on the use of water for food and livelihoods. We feel we now have to take the debate forward with a sharper focus on how IWMI's work helps achieve the MDGs.

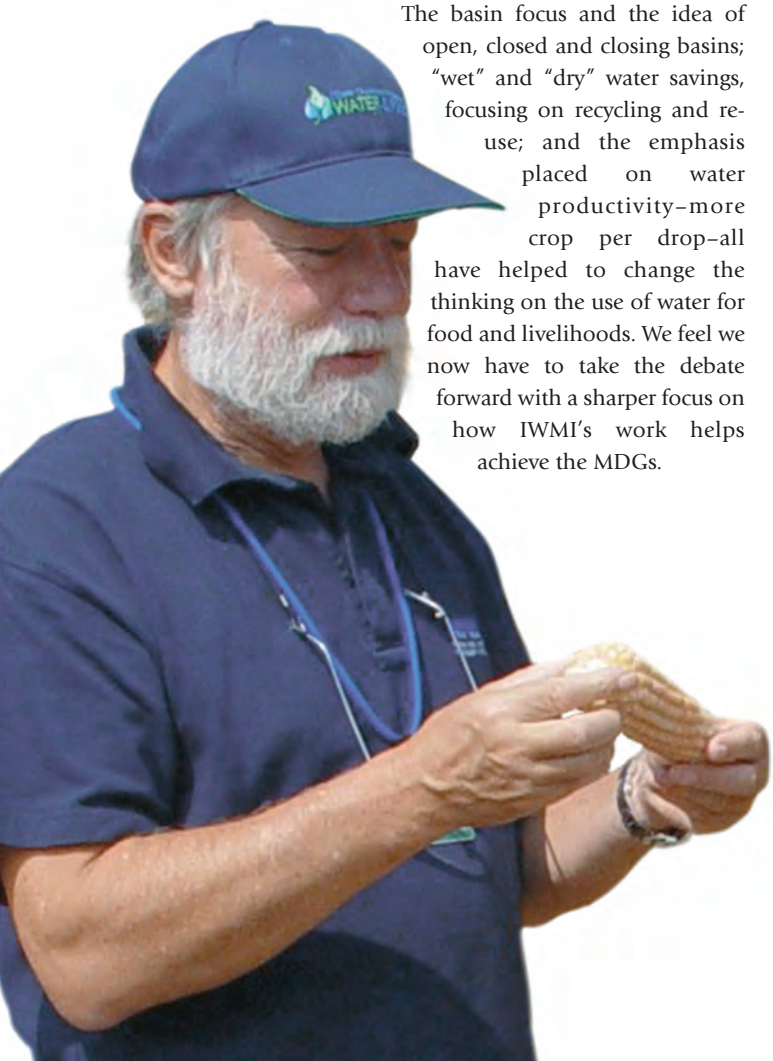


Photo Credit : Sanjini De Silva

Researchers testing soil salinity in the Syr Darya Basin, Central Asia. IWMI identifies and assesses high potential interventions that can improve land and water productivity while maintaining the sustainability of the resource.

A new Framework for IWMI's work

The new framework that is introduced in this report is intended to provide focus to all IWMI work. It does not replace the four new themes but ties them together. It is an attempt to provide a clean, simple structure around which to organise IWMI's work into four blocks of activities.

1. Mapping water productivity: assess water (and land) productivity at basin level for the key crops, complementary livestock/fishery outputs, specific livelihood strategies, and environmental values, spatially disaggregated across the basin.
2. Mapping water poverty: assess spatial patterns of poverty and access of poor people to productive land and water resources throughout the basin.
3. Analysing high potential interventions: identify, assess interventions that can improve water (and land) productivity, the access poor people have to productive water and land resources and the sustainability of natural resource use, i.e. help achieve the MDGs.
4. Assessing impacts: assess the potential impacts of interventions on their contribution towards achieving the MDGs.

We do focus sharply, however, on the pathways through which knowledge generated by IWMI and our partners contributes to these goals.

Ambassador Remo Gautschi
IWMI Board Chair

The four new IWMI themes are:

1. ***Basin Water Management:*** understanding water productivity;
2. ***Land, Water and Livelihoods:*** improving livelihoods for the rural poor;
3. ***Agriculture, Water and Cities:*** making an asset out of wastewater; and
4. ***Water Management and Environment:*** balancing water for food and nature.

Photo Credit : Sanjini De Silva

Buffaloes immersed in wastewater from the Musi River, Hyderabad, India. IWMI is looking at options that minimize the health and environmental risks associated with wastewater which is used by many poor farmers in this region.

Change and continuity at IWMI

The IWMI Board has asked management for a period of consolidation after the very rapid growth of the period 2000-2003. At IWMI that "consolidation" still means a healthy growth rate of some 7% (as achieved in 2004 and expected in 2005). It also means a continuous change process to keep adapting our flexible, lean organization to the rapidly changing outside world. In its November 2004 meeting, the Board approved a new management structure that reduces the management team to six persons and creates a more uniform middle management layer. The Board also approved the new thematic structure which provides a shaper focus and reduces the themes from five to four. In addition, the management is pursuing a policy to reduce the number of projects and strengthen project management.

All in all, IWMI is in great shape and ready to take on the challenges that the coming years will bring us.

Ambassador Remo Gautschi
IWMI Board Chair

Professor Frank Rijsberman
IWMI Director General

All in all, IWMI is in great shape and ready to take on the challenges that the coming years will bring us.

Professor Frank Rijsberman
IWMI Director General

Year in Review

Global Research Division

In The Aftermath of the Indian Ocean Tsunami: IWMI's Response to the Crisis

The impact of the December 2004 tsunami continues to be felt. It struck parts of South Asia and South East Asia with a force that was both unprecedented and unexpected. People were unprepared for what happened—and what followed. They lacked the capacity to mitigate its impact and manage its outcome.

IWMI's immediate response to the devastation of a large area of the Sri Lankan coastline included six emergency supply missions. The 'IWMI-Tsunami Relief Group' was formed to facilitate coordination and ensure fast and meaningful responses. In January 2005 IWMI launched an appeal to raise money to support the tsunami relief and rehabilitation efforts in Sri Lanka. The IWMI Tsunami Relief Appeal Fund received contributions from staff members and other individual donors as well as partner CG centres. The total support provided by the Fund amounted to US$32,000.

In the days following the Tsunami, IWMI's Remote Sensing/Geographic Information Systems (RS/GIS) group collaborated with MapAction UK at the Sri Lanka Government's Center for National Operations (CNO). The team worked around the clock for over two weeks to create a constantly updated GIS database, providing mapping support for the Government of Sri Lanka and organizations involved in the relief effort.

Moving on from the relief phase, IWMI undertook a livelihoods-focused rapid needs assessment in the Hambantota district in southern Sri Lanka—one of the country's worst hit and poorest districts. IWMI has had a long-standing relationship with the district as most of its area falls within IWMI's Ruhuna Benchmark Basin. The study contributed to the post-tsunami rehabilitation efforts, including the preparation of a Master Plan for the Reconstruction and Recovery of the Hambantota District.

In all three districts of Sri Lanka's east coast, groundwater salinity and contamination of wells was recognized as a serious problem, but the technical expertise needed to assess its extent and implications was insufficient and advice urgently needed. IWMI responded to this need by providing guidance on groundwater and well cleaning to organizations and communities in the area. A research study on both the short-term and long-term impacts of salinization on groundwater and water supplies is being carried out in collaboration with the Water Resources Board and the Eastern University of Sri Lanka with financial support from Care International.

Photo Credit : IWMI Global Research Division

In the aftermath of the Indian Ocean tsunami, IWMI carried out groundwater contamination tests and provided guidance on well-cleaning practices to organizations and communities on Sri Lanka's east coast.

Pro–Poor Study

The Dynamics of Poverty

Lessons from a Study on Pro-poor Interventions in Irrigated Agriculture in Asia

Despite the massive investments in irrigation, technologies, institutions and policies that spurred the "Green Revolution" in Asia, poverty still persists in many Asian countries. IWMI scientists and national partners from six countries, namely Bangladesh, China, India, Indonesia, Pakistan and Vietnam, launched a major study in 2001, to uncover the linkages between irrigation and poverty. This study, the first of its kind in terms of geographic scale, coverage of issues and depth of research was sponsored by the Asian Development Bank. Study findings presented at a regional workshop in August 2004 in Colombo, opened up a whole new dimension to the problem of poverty, pointing to the factors that perpetrate it and the options that can alleviate it.

In addition to offering a comprehensive framework for identifying and designing pro-poor interventions, the study provided a menu of pro-poor intervention options and a detailed set of specific actions and guidelines.

Irrigation and system performance has a definite impact on poverty in developing countries but it can be pro-poor, poor - neutral or even anti-poor, depending on certain conditions. Studies showed that Southeast Asian and Chinese systems showed a better performance than South Asian systems because there was land and water equity. The linkages between irrigation, gender, diversity and poverty were also explored in detail.

Factors that determine the poverty–reduction potential of irrigation

- The condition of irrigation infrastructure and its management
- Irrigation water allocation and distribution practices
- Access to resource-conserving technologies, cropping patterns and diversification to high value crops and enterprises.
- Access to support services like information, input and output marketing
- Access to land, land distribution and the quality of land.

Unless irrigation reforms are sharpened with a pro-poor focus, the poor are likely to be bypassed. The study identified the targeting of locations with higher densities of poor people and socio-economic groups for new investments. It recommended the design of investment models according to poverty types, as no single intervention suits all types. Irrigation packages should also be more comprehensive and support services should be provided to increase agricultural productivity.

Poverty Mapping

Examining the Incidence of Poverty

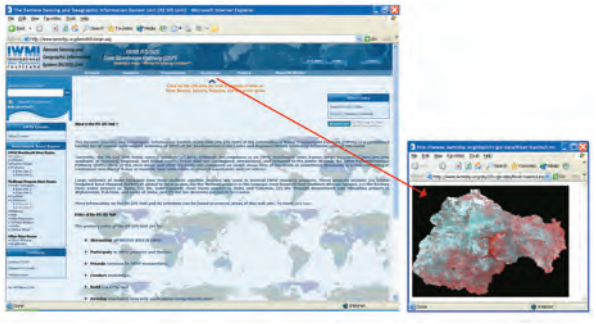
IWMI has developed poverty maps to assess spatial patterns of human poverty across geographic regions. These maps depict different dimensions of human well-being and help researchers to understand how much access poor people have to productive land and water resources within a river basin, while identifying target groups that could benefit from improved access to such resources. Poverty mapping also identifies the factors that contribute to poverty in different economic settings and under different farming systems, for example in irrigated or rainfed agriculture. Since agriculture is the dominant economic activity of rural people, poverty as a unit is associated with indicators such as land, water and soil as well as access to roads and markets. IWMI's research has shown that the provision of irrigation is effective in poverty alleviation. Finding the poor and identifying the spatial patterns are important in order to design interventions for different economic activities.

DSP–IWMI's Data Storehouse Pathway (IWMIDSP):

Opening a gateway to remote sensing and GIS data on river basins, nations, regions, and the world.

The IWMIDSP project offers, for the first time, an opportunity for accessing high quality science data in standard formats for rapid assessment, monitoring, and reporting on the conditions of river basins, nations, regions, and the world.

In order to facilitate high quality research, IWMI saw an urgent need to streamline all the data generated by the institute and create a knowledge bank that would be accessible to researchers across different regions of the world. To accomplish this goal, IWMI streamlined all its remote sensing, GIS, and other spatial data. This involved organizing IWMI data and the IWMI-generated knowledge base according to river basins, countries, regions, and the entire world. It also required synthesizing and making data easily accessible from various satellite sensor systems as a near-continuous time-series. The result was the IWMI Data Storehouse Pathway (IWMIDSP) with state-of-the–art technology. The main emphasis of IWMIDSP was to enhance research and provide a service to both IWMI researchers and external users. The Data Storehouse Pathway also serves programs such as the Challenge Program Water and Food. It is used by researchers from both national and international research centers. IWMIDSP already has 100 GB of baseline data for the Limpopo river basin as well as significant data for the Ruhuna, Krishna, and Ganges river basins. It allows users to access, browse, and download data from any part of the world at: http://www.iwmidsp.org/. Currently it has about 1000 members from over 50 countries.



A screen capture from the DSP. The system allows users from different parts of the world to access, browse through or download data

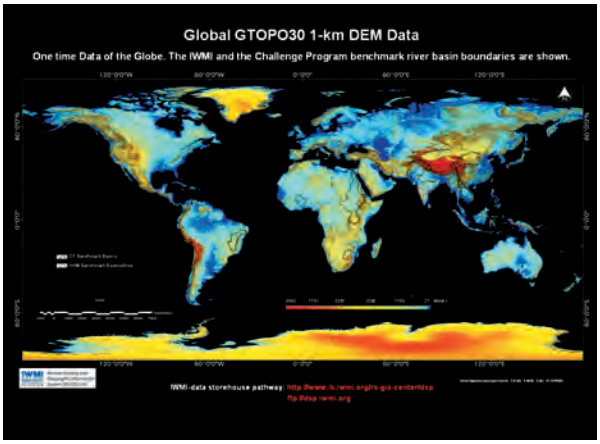


Photo Credit : IWMI Global Research Division

Benchmark river basins and IWMIDSP. The IWMIDSP is conceived as a goldmine for IWMI and CP benchmark river basins (shown above) around the world.

Year in Review

Africa

Improving Agricultural Productivity through Better Irrigation

The APPIA project (Improving Irrigation Performance in Sub-Saharan Africa) is helping farmers and extension services to increase irrigation efficiency. It is training a network of experts across the region to assess small-and medium-scale irrigation systems and devise strategies for their improvement. The framework for this development is a new approach, designed especially for the project, known as "Participatory Rapid Diagnosis and Action Planning for Farmer Managed Irrigation Systems". PRDA consists of an initial diagnosis of the main constraints of irrigation productivity and sustainability, made in consultation with the farmer, which is then used to plan measures to improve performance, through:

- **Enhancing irrigation practices and skills** among farmers through on-farm demonstrations and experiments.
- **Increasing farmers' access to markets** by setting up better channels of information and improving farmers' bargaining powers,
- **Planning cropping calendars,** quality controls and post-harvest processing.
- **Monitoring the results of action-plans** to determine if irrigation performance has actually improved.

In the future, the APPIA project will focus on scaling up and out its approach beyond the current pilot irrigation scheme in Ethiopia (8 schemes), Kenya (10 schemes) and West Africa (29 schemes).

APPIA is financed by a grant from the French government. The Regional Association for Irrigation and Drainage is implementing the project in West Africa, together with the two Regional Inter-State Schools in Water and Rural Engineering based in Burkina Faso. The IWMI sub-regional office coordinates the project in Ethiopia and Kenya, with support from national partners.

The "Paddies Paradox"-Irrigated Agriculture versus Malaria

Africa will face an acute shortage of food and widespread starvation by 2020. While irrigation holds the promise of greater food security, it also carries the threat of malaria. Flooded paddy fields become breeding grounds for malaria mosquitoes. Yet, research by IWMI and partners shows that in most of sub-Saharan Africa, the spread of malaria appears relatively stable. Although the potential for infection is higher in villages near rice fields, there are fewer actual cases of malaria than in the surrounding communities. Studies from Tanzania, Gambia, Burkina Faso and Cameroon also prove that income growth leads directly to better health. Relatively well-off farmers can afford to take simple, but effective protective measures—such as using bed nets and seeking appropriate treatment in time. Therefore, irrigated rice cultivation can even bring about a decline in malaria.

The GLOWA Volta Project-Providing Technological Support for Water Management

Life in the Volta Basin is built around access to water. People in the basin depend on water for cultivation, brick making, watering their herds of cattle and domestic use. Every year, uncertain rainfall condemns them to a struggle for food and livelihood security.

The Volta Basin is a Benchmark Basin of the Comprehensive Assessment Program and Challenge Program.

The GLOWA Volta Project (GVP) is working on a science-based Decision Support System (DSS) to provide countries in the region with the necessary information to manage their water resources. The project is carried out in partnership with the Centre for Development Research (ZEF) of the University of Bonn. The GVP is funded by the Federal Ministry for Education and Research, with additional support from the Ministry of Science and Research of North Rhine-Westphalia.

Photo Credit : Hugh Turral

A small scale irrigation project in Ethiopia. IWMI is coordinating the APPIA project in Ethiopia and Kenya. The project is helping farmers and extension services increase irrigation efficiency.

The Systemwide Initiative on Malaria and Agriculture (SIMA) takes an integrated approach to malaria. It involves experts from different sectors and research disciplines, on the premise that the spread of malaria is influenced by diverse issues including ecological, economic, social and cultural factors. SIMA partners include: IWMI, ILRI, IITA, WARDA, CIAT, ICIPE and IDRC, among others.

See also www.iwmi.org/sima

Key study recommendations

- Locally evaluate the feasibility of alternating wet and dry conditions in rice fields by changing flooding schedules or seasonally alternating rice cultivation with a dry-land crop, such as soya.
- Assess the potential of using cattle as "bait" to divert mosquitoes away from humans in settings where the main malaria mosquitoes prefer to feed more on cattle than people.
- Provide insecticide-treated nets to groups at high risk for malaria, such as pregnant women and young children.

Creating Inclusive Water Management Institutions–the South African Experience

Driven by the goal of redressing historical injustices, the National Water Act (NWA) of 1998 made profound changes to water management in South Africa. The new Catchment Management Agencies and Water Users' Associations (WUAs) were expected to empower the Historically Disadvantaged Individuals (HDIs), both women and men, of African and Asian origin.

The former white, large-scale commercial Irrigation Boards (IBs) were to be transformed into inclusive WUAs. However, only one sixth of the Irrigation Boards have become WUAs so far. Research by IWMI and its partners showed that commercial farmers only took the initiative to open up their organization to small-scale farmers when they were upstream or had to pay. In several cases, small-scale farmers were unaware that they were formally entitled to more water than they received. Yet, small farmers used a mere 10 percent of the water used by the large farmers.

Thus, several key issues must be addressed before the smaller players can have a significant role.

Defining WUAs and what they do

WUAs should be formally defined to include everyone sharing the same water resource—regardless of the fact that the former entitlement was for commercial agriculture only—since small-scale farmers, farm laborers and communities use the 'irrigation' water for multiple purposes.

Large-scale farmer members of WUAs need to be actively involved in developing the capacity of emerging farmers, for instance, by sharing knowledge about efficient irrigation scheduling, technology and overall water resources.

A different water agenda for HDIs

Historically Disadvantaged Individuals (HDIs) are relatively unorganised and unable to voice their specific needs, such as the lack of well-maintained infrastructure. Furthermore, water restrictions on emerging farmers should be less severe during drought periods than on commercial farmers, who can cope better in theses circumstances.

Wetlands – Supporting the Livelihoods of the Rural Poor.

A recent study of wetlands in Tanzania and Zambia, funded by the FAO Netherlands Partnership Program, and conducted jointly by FAO, IUCN and IWMI, recognizes that wetlands are at the heart of the livelihood strategies of many rural poor.

Wetlands are central to the lives of many rural African communities because they support livelihoods and provide food and water. The capacity of wetlands to retain moisture for long periods makes them a valuable resource for agriculture. Farmers take advantage of the year round availability of water in wetlands to diversify crops and cultivate during the dry season. However, the environmental impact of some wetland development (e.g., soil erosion and contamination of water supplies) can have negative repercussions for people dependent on the natural resources provided by wetlands.

To generate more knowledge on wetlands and the role they play, IWMI and partners propose the following actions:

- Mapping wetland boundaries and features using state of the art technology, (including remote sensing and GIS)
- Developing methods to assess the condition of a wetland, its potential to support agriculture and the likely environmental and social consequences of wetland development and change
- Evaluating appropriate land and water management technologies (e.g., treadle pumps, drip irrigation, gully treatment)
- Determining the possible impact of climate change on wetlands.

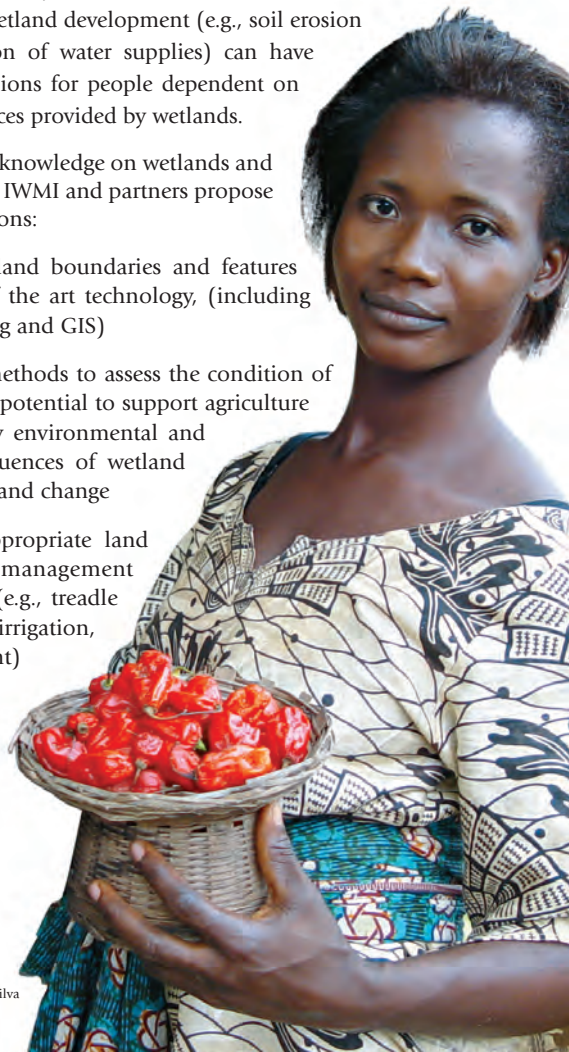


Photo Credit : Sanjini De Silva

Asia

Fighting Drought–Towards a Better Prepared South Asia

Despite the frequent occurrence of droughts in South Asia, coordinated and well-planned drought mitigation strategies are lacking in the region. IWMI's Project on Drought Assessment and Mitigation–carried out as a short-term rapid assessment in India, Pakistan and Afghanistan–is nearing completion and is generating a range of beneficial outputs and identifying areas for future regional collaboration, study and development.

Project Outputs

- Drought Monitoring System. A prototype regional drought monitoring system (DMS) http://dms.iwmi.org based on remote sensing data. The DMS can track drought onset and development by monitoring ground vegetation conditions.
- A software for analysing drought with multiple options
- A regional rainfall database with over 90 monitoring stations and an average of 30-years of observations.
- A regional Drought Workshop held in Colombo in October 2004 brought together scientists and policy makers from Afghanistan, Pakistan and India, as well as donors, international organizations and observers from other countries.
- Project-Website:www.iwmi.cgiar.org/ drought assessment/ index.asp

The project website contains an overview of project activities, links to partner websites, other drought-related websites and databases on drought-related literature. It hosts a drought monitoring system, project publications and general educational information on drought. It is expected to evolve, with time, into a unique drought resource portal for the region.

Future Directions

Although the initial study was limited to Southwest Asia, it is intended to expand drought research to cover the entire South Asia area in the future and develop a regional anti-drought community of practice. A South Asian Conference on Drought Management with high-level political participation is proposed as a regular means for dissemination of drought-related knowledge and exchange of experiences.

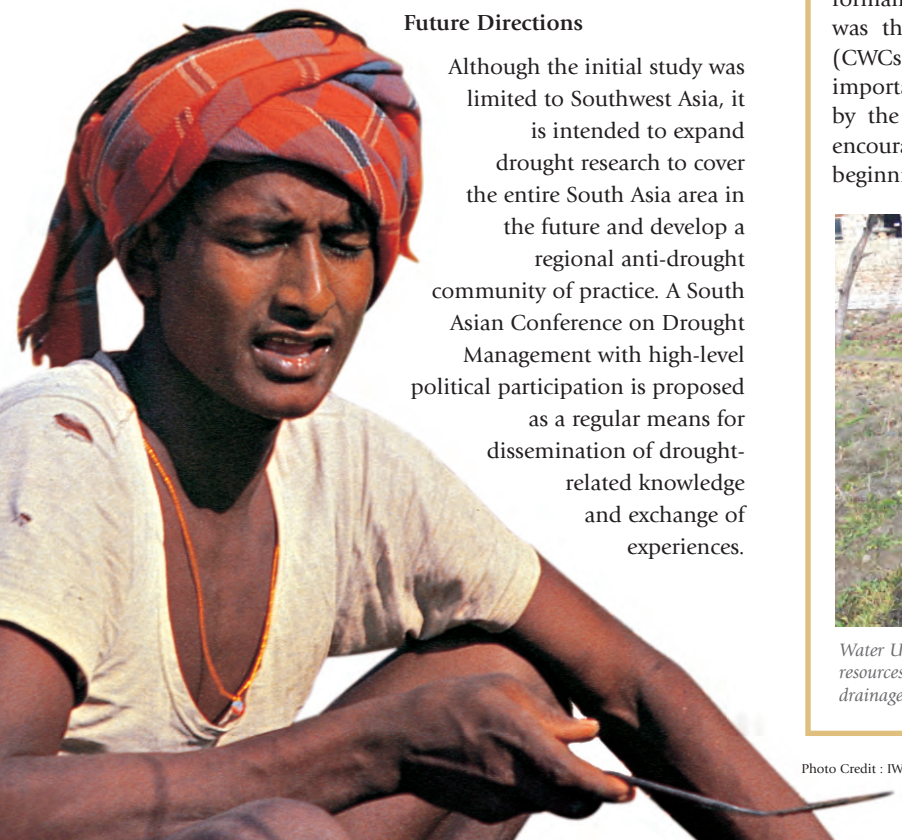


Photo Credit : IWMI Southeast Asia

Detailed quantification and forecasting of drought risks throughout the region is identified as an important direction for future research. Development of a South Asian Drought Encyclopedia is also planned. The common thread uniting these long-term objectives is the firm conviction that there should be a shift from short-term ad-hoc strategies to consistent and sustained drought preparedness.

Introducing Canal Management Organizations and Canal Water Committees in the Ferghana Valley, Central Asia

In September, 2001, IWMI launched a project to introduce IWRM practices in the Ferghana Valley, parts of Kyrgyzstan, Tajikistan and Uzbekistan in Central Asia. For the first time, the concept of organizing water management along hydrographic, rather than administrative, boundaries was initiated. IWMI's partners in this project were the Scientific Information Center of the ICWC, and the ministries of Agriculture and Water Resources of Kyrgyzstan,Tajikistan, and Uzbekistan.

The Ferghana Valley Project focused on separating governance and management functions at the Canal and Water Users' Association levels. It promoted capacity building and identified opportunities for improving land and water productivity within existing resources, while ensuring stakeholder participation through intensive grassroots mobilization.

One significant outcome was the establishment of three new canal management organizations (CMOs), training staff in IWRM principles for water management, and providing other resources, such as manuals, guidebooks, models and other tools. The creation of CMOs is a new management concept for these countries. In Uzbeckistan, this development was formally institutionalized. Another immediate result was the establishment of Canal Water Committees (CWCs) for each of the three pilot canals-another important water management innovation introduced by the project. The success of the pilot project has encouraged donors to fund another three year phase beginning in May 2005.

Photo Credit : Iskandar Abdullaev

Water User Associations (WUAs) in Central Asia pool their resources for the operation and maintenance of irrigation and drainage systems within their jurisdiction.

A new approach to assessing the risk of cadmium contamination in crops

The cadmium contamination of crops from industrial run-off or natural mineral deposits poses a serious threat to human health. The long-term consumption of polluted food, particularly rice, is known to result in irreversible kidney dysfunction. IWMI Southeast Asia, together with the Royal Thai Government, has adopted a proactive approach in tackling this issue

Over the past four years, IWMI and partners carried out an in-depth assessment of cadmium contamination of rice, and associated rotation crops in an isolated area close to the Thai-Myanmar border. In this area, the contamination was traced to suspended sediments in the irrigation waters of a river, which passes through a zinc deposit. The study developed a number of tools to assess the degree of contamination. These were:

- a simple model that explains the uptake of cadmium by rice grain using easily determined soil chemical properties, and
- a model that predicts the degree of contamination by suspended sediments for a cascading irrigation system based on total cadmium levels in the primary fields and irrigation sequence

The project also undertook a comprehensive survey of soil and rice grain cadmium levels, in order to produce a zoning map and policy brief that was submitted to national and provincial decision makers.

Photo Credit : IWMI Southeast Asia

IWMI and partners in Southeast Asia carried out an in-depth assessment of cadmium contamination of rice and associated rotation crops in an isolated area near the Thai Myanmar border. Photo shows a study area.

Sustaining Rice-Wheat Production Systems in Asia

IWMI's research in South Asia was funded by the Asian Development Bank, through the Rice-Wheat Consortium of Indo-Gangetic Plains (RWC), and implemented in cooperation with RWC-CIMMYT, IRRI, and the National Agricultural Research Institutions of Pakistan, India, Bangladesh and Nepal.

The Pakistan component of the project was conducted by IWMI in collaboration with the Pakistan Agricultural Research Council (PARC), On Farm Water Management Punjab (OFWM) and the University of Agriculture, Faisalabad (UAF).

Although rice and wheat are the staple food of more than a billion people in South Asia, stagnant productivity and degradation of resources, particularly the growing scarcity of water, pose serious challenges to future food security.

Photo Credit : IWMI Pakistan

IWMI is looking at options for increasing water productivity and improving crop management practices at field, farm and watercourse command levels in the Indo-Gangetic Plains.

The IWMI project in the Indo-Gangetic plains, which designed systems solutions for site-specific productivity and sustainability issues, was therefore a timely intervention. The Pakistan component, focusing on the Punjab rice-wheat zone, drew to a close last year. The three-year research program assessed the water saving potential of alternative wheat and rice stand-establishment and crop management practices at field, farm and watercourse command levels and the impact of such strategies on groundwater table and quality.

Recommendations:

- The development and promotion of suitable resource conservation technologies (RCTs) for rice-wheat cropping systems to ensure food supplies and more effective use of dwindling water resources.
- On-farm experiments—conducted with the farmer's active participation—to develop new technologies in tune with local socio-economic, water supply, agro-hydrological and institutional circumstances and facilitate speedy adoption.
- Long-term evaluations to ensure the sustainability of rice-wheat cropping systems, before new RCTs are recommended to the wider farming community.
- More research exploring soil salinity changes caused by the increased adoption of RCTs in the Indus basin.
- Further investigation to determine the impact of these technologies on real water savings and water productivity needs at field, farm and irrigation system/basin scales.

The Challenge Program on Water and Food

Moving from inception to implementation

The CGIAR Challenge Program on Water and Food (CPWF) moved from inception to implementation stage during 2004. Over 33 research projects with a total budget (including matching funds) of close to US$ 60 million have now started in the nine benchmark basins. The program even completed its first external review, conducted by the CGIAR Secretariat and the CGIAR Science Council. Their joint report was accepted by the CGIAR Annual General Meeting in October 2004. The final review concluded that the three pilot challenge programs have helped to open up the CGIAR and bring in new funding, and have a good potential to help the CGIAR achieve its goals. The review recommended continued CGIAR support to the three pilot programs for the full five years of their first phase.

The review by the Science Council stimulated an internal reformulation of the CPWF Research Strategy, to give the program a clearer focus in expressing and presenting current work and in ensuring that the program will deliver on its promises. The new strategy was approved at the fifth meeting of the CPWF Steering Committee in Canberra in March of 2005.

The key recommendation in the revised strategy was to make a significant additional investment in strategic research at basin level. This investment has taken the form of "Basin Focal Projects". These will develop a scientific framework for evaluation and scaling up of interventions to alleviate poverty and hunger through improved water productivity. Pilot Basin Focal Projects will start in 2005 in four basins – the Mekong, Volta, Karkheh and Sao Francisco. CSIRO, IRD, IWMI and UC Davis have been invited to lead the development of each project, with support from the basin coordinators and other partners. A fifth "coordination project" will coordinate the four basin projects and ensure compatibility of approaches and methodologies across basins.

Photo Credit : Stefania Grando- ICARDA

Farmers and researchers at farming trials at Serejeka, Eritrea. This is a CPWF funded project.

Photo Credit : Sanjini De Silva

CPWF and partners in action: Dr Winston Andah, CPWF Volta Basin Coordinator, and Esther Wahaga, SARI Social Scientist, discuss the impacts of water scarcity on livelihoods with villagers in the Kasalgo village, Tamale, northern Ghana.

Frank Rijsberman
Chair, CPWF Steering Committee

Making a Practical Impact

The CPWF has progressed enormously with its portfolio of 33 projects, led by 18 institutions (with over 150 partners) in the nine benchmark basins around which the CPWF continues to develop and build its capacity becoming operational. The CPWF's approach to fostering partnerships is demonstrated with 27% of the approved projects led by non-CGIAR institutions, especially NARES, and 45% led by organisations that are not members of the CPWF joint venture consortium.

As the first of the funded projects commenced implementation in June 2004, it's still too early to show how projects and synthesis research are integrated in the Program as a whole. However, some early results from different projects can illustrate the CPWF's practical impact.

- **'Coastal resource management for improving livelihoods'**, led by IRRI, Philippines. Farmers in Batiaghata, Bangladesh planted Aus (dry) season rice for the first time using water stored in the on-farm canal network. Working with the People's Committee of Bac Lieu province in Vietnam, farmers in Bac Lieu can cultivate crops into the drought period due to proper sluice operation. Poor farmers producing wicker handicrafts are being encouraged to harvest sea-grass, a nuisance weed in shrimp ponds, with the promise of exporting their products through interested companies in Ho Chi Minh City.
- **'Strategic innovations in dry land farming'** led by the Savannah Agricultural Research Institute, Ghana. Construction of domestic rainwater reservoirs in pilot sites in Ghana is nearing completion. This will enable verification of survey results that suggest that women in

farming households will use the time saved from not having to collect water, to invest in vegetable farming and other health and income generating activities.

- **'Livelihood resilience in dry areas'**, led by ICARDA, Syria. Several options for supplemental irrigation and water harvesting have been identified, while, a change of farmers' attitudes means that sheep manure is now viewed as a nutrient rather than a waste material and water pollutant. Generally the project is promoting institutional innovation in Iran through its ability to link organizations more easily as part of a partnership focused international program.

Photo Credit : Sanjini De Silva

CPWF Chair, and IWMI DG, Frank Rijsberman, examines a seriously silted up reservoir in the 'Mogtedo system', east of Ouagadougou, Burkina Faso. This system, which urgently needs rehabilitation, is managed by a farmer cooperative with little or no government support.

- **'Multiple water use'** led by IWMI, South Africa. The CPWF has enabled a multi partner approach to forming "learning alliances" in the Limpopo and Mekong basins, with other basins to follow. Action plans are identifying critical requirements in establishing multiple use systems, where the same water serves for use in drinking, hygiene and small-scale horticulture.

- **'Rainwater and nutrient use efficiency'** led by ICRISAT, Niger. Farmers in the Volta basin were exposed to some of the 'best bet' technologies being evaluated, while project partners have acquired skills in using decision support tools and improved their understanding of land degradation issues.

- **'Improving productivity in salt affected areas'** led by IRRI, Philippines. Germplasm exchange and distribution with NARES and other partners including elite lines with multiple tolerance to abiotic stresses has occurred. Field days for farmers in India, and training activities for 300 farmers in Vietnam have been completed. Egyptian partners have decided to implement the project from their own resources demonstrating commitment.

A feature of the CPWF is adding value to international public goods contents through a synthesis of research results, which has already produced several state-of-the-art papers, including two journal issues dedicated to CPWF papers. Other activities include travel grants to young scientists; facilitating interactions between NARES and advanced research institutes; researchers' networks formed in basins to facilitate dialogue; refinement of basin profiles; and continued dialogue with the global environmental change community.

Improving water productivity of cereals and food legumes in the Atbara River Basin of Eritrea.

Photo Credit : Stefania Grando- ICARDA

Professor Frank Rijsberman
Director General - IWMI

10 Years of IWMI Research - An Overview

More Crop Per Drop Revisited

In 1996 David Seckler, then recently appointed Director General of IWMI with a mandate to re-focus the research agenda of the institute, published the first IWMI Research Report (Seckler,1996). This brief note contained many of the basic ideas that have come to characterize what has been coined "the IWMI approach to water for agriculture". It was, in essence, a research agenda around the following three ideas:

1. **Basin focus:** As renewable water resources available for human use become fully committed in a basin, and competition among users increases, the appropriate focus for water management is the basin level, not the field, farm or even the irrigation system level. This concept is closely linked to the idea of open, closing and closed basins – where a basin is defined as 'closed', when there is no usable water leaving the basin;

2. **Recycling:** Many of the water savings achieved at field level may only capture water that would otherwise have been re-used downstream. These are not real water savings, where additional supplies become available ("wet" water savings), but simply a re-allocation of water from downstream to upstream users ("dry" water savings). With this idea comes a focus on the fate of water through recycling and re-use;

3. **Crop water productivity:** Rather than focusing on the potentially misleading idea of increasing irrigation efficiency, the focus should be on increasing water productivity – in essence, the output produced per unit of water consumed. This gave rise to the phrase "more crop per drop".

These ideas, described in more detail below, formed the core of the IWMI research agenda in the 1995-2000 period, culminating in the key publication on water productivity by Kijne et al.,eds (2003).

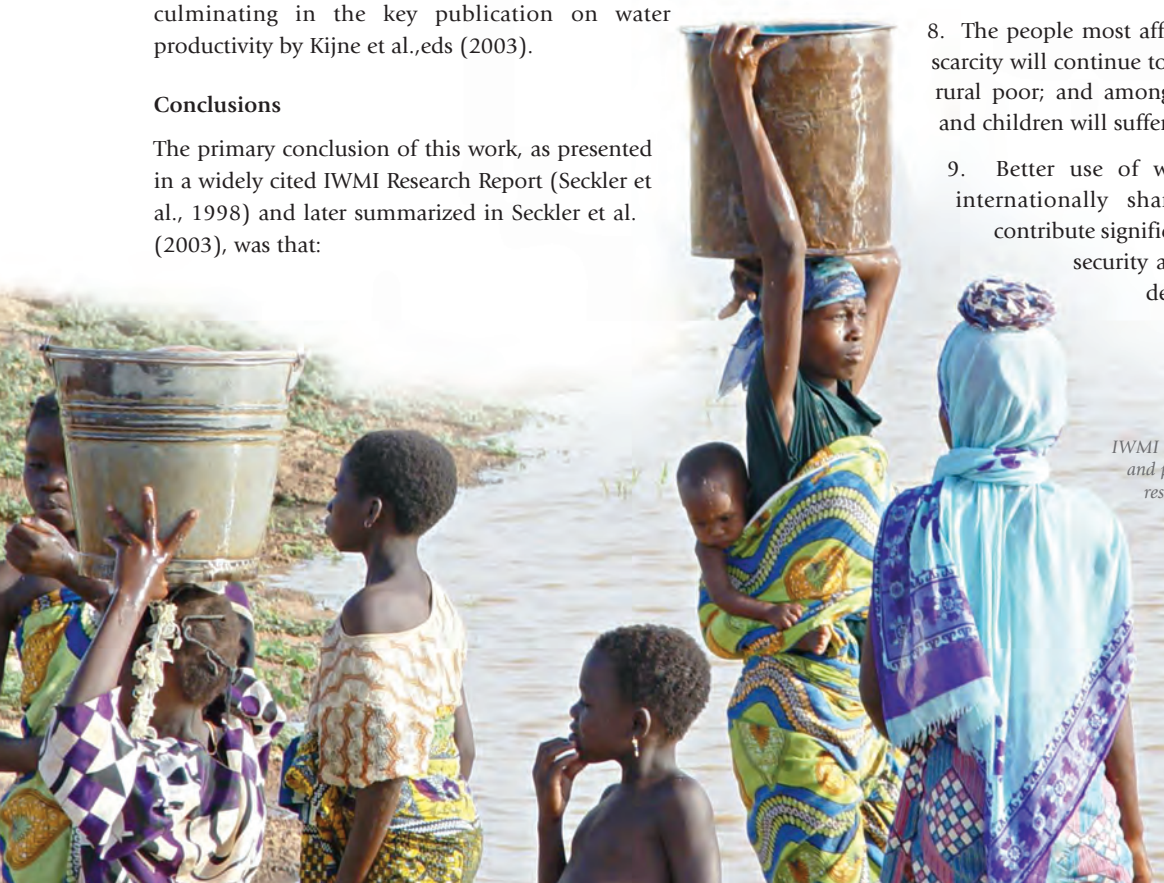
Conclusions

The primary conclusion of this work, as presented in a widely cited IWMI Research Report (Seckler et al., 1998) and later summarized in Seckler et al. (2003), was that:

> *"...one-third of the population lives in regions that have absolute water scarcity, in the sense that they will not have sufficient water resources to meet their agricultural, domestic, industrial and environmental needs in the year 2025…an additional 500 million people live in regions of severe economic scarcity; they have a sufficient amount of potential water resources to meet their 2025 needs, but they will have to more than double their present utilization of these resources through large, expensive and possibly environmentally destructive development projects…"*

The "basic IWMI scenario" was published as the IWMI contribution to the World Water Vision (Cosgrove and Rijsberman, 2000). Its major findings and recommendations were (IWMI 2000):

1. The world's primary water supply will need to increase by 22% to meet the needs of all sectors in 2025.
2. Seventeen percent more irrigation water will be needed for the world to feed itself in 2025.
3. Nearly one-third of the populations of developing countries in 2025, some 2.7 billion people, will live in regions of severe water scarcity.
4. The global community must invest in research to improve crop water productivity (crop per drop).
5. New water infrastructure will have to be developed to meet future food requirements.
6. Groundwater reserves will be increasingly depleted in large areas of the world.
7. Salinization of soils, compounded in many cases by increasingly saline or poisoned groundwater, will seriously affect land that has been highly productive in recent decades.
8. The people most affected by growing water scarcity will continue to be the poor, especially rural poor; and among poor people, women and children will suffer most.
9. Better use of water in several large, internationally shared river basins can contribute significantly to achieving food security and reducing poverty in developing countries.



IWMI is assessing spatial patterns of poverty and poor people's access to land and water resources through poverty mapping. This research also addresses gender issues.

Photo Credit : Sanjini De Silva

Seckler believed that while the solution to water scarcity was to enhance water productivity in irrigated agriculture as much as possible, further development of water supplies for irrigation to meet future food demands was inevitable and would require the widely-cited "17% of additional water for irrigation by 2025". He did not believe there was much potential to improve water productivity in rainfed agriculture. This assumption that the increase in water productivity in rainfed agriculture would be low is a key factor in the relatively high estimate of a 17% growth in irrigation water demands.

Photo Credit : Sanjini De Silva

Poor farmers in urban and peri-urban areas turn to untreated wastewater as an alternative source of irrigation water. Here a farmer in Hyderabad, India tends his crop grown with wastewater.

The ideas IWMI developed and promoted–often referred to as the "more crop per drop" paradigm–have been very influential in academic circles, as well as two large scale research programs based on these concepts: the CGIAR system-wide Comprehensive Assessment of Water Management for Agriculture and the CGIAR Challenge Program on Water and Food. Together these programs have engaged the participation of over a thousand scientists–they are the flagship programs for research on water, agriculture and development.

Limitations of the "More Crop Per Drop" Paradigm

The emphasis on "more-crop-per-drop" in IWMI's work, as outlined above, has undoubtedly been influential, but it also has a number of limitations:

1. It underplays the importance of water quality; the emphasis on potential re-use of the fraction of the water that is not consumed appears to suggest that such re-use can take place without a cost. However, virtually all water withdrawal and application leads inevitably to at least some quality degradation (salinization and other pollution) and costs energy. This explains IWMI's preference to measure water demands by their evapotranspiration, while others maintain a preference for water withdrawals as the key indicator.
2. The crop-per-drop concept does not accommodate the non-crop water outputs, fisheries and environmental services to the other multiple values water serves (from domestic water use to livestock watering). The implication is that while at farm or field level, the focus on crop water productivity can often be justified, on larger scales a broader definition of water productivity, which incorporates all values associated with water use, is needed. Only such a broader definition will serve the management of water across the many uses within a basin.
3. The implicit emphasis on irrigation of crops through renewable water resources, i.e., the part of the water cycle that runs off into rivers and recharges groundwater, (also called "blue water"), tends to underestimate the importance of the other 60% of the hydrological cycle that is stored as soil moisture, (the so-called "green water"). Through the growing importance of groundwater irrigation, small scale irrigation, rainwater harvesting and supplemental irrigation, the once sharp boundaries between rainfed and irrigated agriculture have largely disappeared. This requires a new, unified approach that examines the whole hydrological cycle and looks at water management for agriculture across the rainfed-irrigated spectrum.
4. Increasing water productivity is no more than a means to an end. One key objective is the reduction of poverty and hunger. Increasing water (and land) productivity may well be a significant factor in alleviating poverty in communities strongly dependent on access to productive land and water resources. It cannot be said, however, that improving water productivity will by definition have a positive impact on poverty, since access to resources (and the distribution of any net benefits) also plays a determining role in the final analysis.
5. Similarly, another often linked objective is the sustainable use of natural resources, i.e., the arrest or rehabilitation of resource overuse (groundwater depletion) and degradation (soil erosion or salinization). Increasing water productivity is unlikely to halt over-use of water locally. Indeed, it may in fact encourage resource intensification, as it is likely to increase the profitability of the farmer, whose productivity has increased. On a larger scale, assuming that the total demand for a given product or service stays constant, increased productivity in one location ought to displace water use at a lower productivity elsewhere, but not necessarily increase the sustainability of the resource use in the basin or sub-basin, where the productivity is increased.

Addressing the Limitations

In the period 2000-2005, IWMI has addressed a number of the limitations discussed above as follows:

1. The balance between water for food and water for nature has become the core issue on the agenda, and IWMI has

re-focused its research around the so-called water-food-environment nexus (Rijsberman and Molden, 2001; Rijsberman and Mohamed, 2003; Rijsberman and de Silva, 2004).

2. The linkages between water and land, salinization and soil degradation, water and land quality, nutrient cycling, and re-use of wastewater in peri-urban agriculture have become a central focus of IWMI's work (Scott et al. eds., 2004).

3. The improvement of water productivity across the entire blue-green, rainfed-irrigated, surface-groundwater spectrum has become the norm in the institute's work (Noble et al., 2004). This has also led to a re-assessment of the potential to improve water productivity in rainfed agriculture.

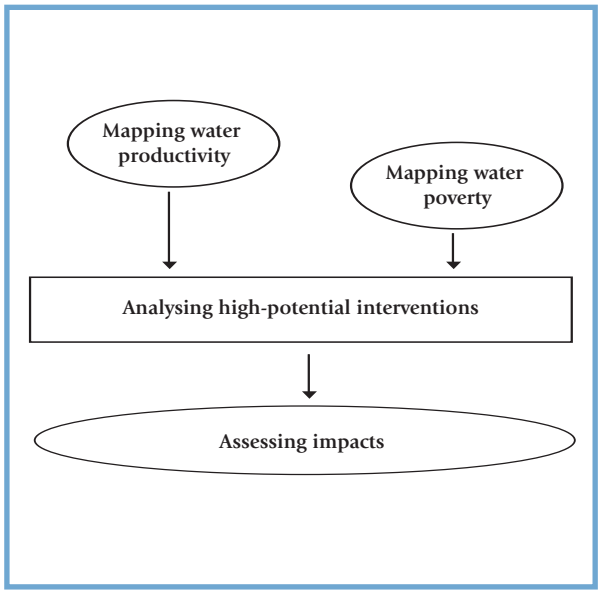
4. Assessing the impact of water productivity on the alleviation of poverty and hunger has become a central theme in IWMI's work as well (e.g., Maria Saleth, 2003).

Five themes were introduced with IWMI's 2000-2005 Strategic Plan:

1. Agricultural Water Management
2. Sustainable Land and Water Management
3. Groundwater Management
4. Water Resources Institutions and Policies
5. Water, Health and Environment

Each of these themes, their focus and research contributions are described in more detail in the following five summary articles.

Figure 1. IWMI Conceptual Framework



Early in 2005, IWMI's thematic structure was further tightened into four themes as follows:

1. Basin Water Management: understanding water productivity;
2. Land, Water and Livelihoods: improving livelihoods for the rural poor;
3. Agriculture, Water and Cities: making an asset out of wastewater;
4. Water Management and Environment: balancing water for food and nature.

Tightening up: the new focus

An external review of IWMI's work, (Wright et al., 2003), and the CGIAR Science Council review of the Challenge Program on Water and Food in 2004, motivated the development of a new, tighter conceptual framework. This is intended to provide a cleaner structure that will allow a sharp focus of the institute's work on its final objectives, i.e., contributing to the Millennium Development Goals related to, primarily, reduction of poverty and hunger and sustainable use of the environment.

Briefly, in this new framework IWMI's work falls into four blocks or activities–see also Figure 1.

1. **Mapping water productivity (WP):** to assess water (and land) productivity at basin level for key crops, (as well as combinations of crops and complementary livestock/fishery outputs, livelihood strategies, and environmental values), spatially disaggregated (to a useful level) across the basin; and to analyse the key variables that explain WP variations, (including soil/land degradation). The key idea is not to suggest that water productivity is a solution, but rather that it provides a valuable framework for understanding productive land and water use.

Photo Credit : IWMI Southeast Asia

Soil degradation affects many rural farmers in Southeast Asia. A discussion on soil remediation measures is led by IWMI and partners in Thailand.

Photo Credit : Sanjini De Silva

Ma Tshepo Khumbane, senior advisor to IWMI in the Water for Food Movement, works with rural women in South Africa, teaching them rain water harvesting, home garden production and food production.

2. **Mapping water poverty (WPv):** to assess spatial patterns of poverty and poor people's access to productive land and water resources throughout the basin. The basic idea is not to presume that increasing water productivity will alleviate poverty, but rather to identify the target group that could benefit from improved access to productive land and water resources.

3. **Analysing high potential interventions:** to identify, assess – and possibly develop – interventions, (technologies or combinations of technologies and institutions/policies, or policies), that can improve water (and land) productivity, as well as the access poor people have to productive water and land resources and the sustainability of natural resource use.

4. **Assessing impacts:** to assess the potential impacts of interventions on water (and land) productivity, as well as on water poverty–i.e., what would be the impact of interventions under different adoption scenarios, knowledge sharing models and development in exogenous variables, on water productivity, livelihoods, health and sustainability of resource use–at basin scales.

This new framework will help tighten the focus of IWMI's work in the years to come.

References

Cosgrove, W.;Rijsberman, F. 2000. Making water everybody's business. Earthscan Publications, London, UK.

IWMI. 2000. Water Issues for 2025: A research perspective. The contribution of the International Water Management Institute to the World Water Vision for food and rural development. IWMI, Colombo, Sri Lanka.

Kijne, J.W.; R. Barker,; Molden, D. eds. 2003. Water productivity in agriculture: Limits and opportunities for development. CA series 1. CABI Publishing, Wallingford, UK.

Noble, A. D.; Ruaysoongnern, S.; Penning de Vries, F.W. T.; Hartmann, C.; Webb, M. J. 2004. Enhancing the agronomic productivity of degraded soils in Northeast Thailand through clay-based interventions. In Seng, V.; Craswell, E.; Fukai, S.; Fischer, K. (eds.), Water in agriculture: Proceedings of a CARDI International Conference "Research on water in agricultural production in Asia for the 21st Century" Phnom Penh, Cambodia, 25-28 November 2003. Canberra, Australia: ACIAR. pp.147-160.

Rijsberman, F.R.; De Silva, S. 2004. Sustainable agriculture and wetlands. keynote address delivered at the 7th INTECOL International Wetlands Conference. Utrecht, the Netherlands, July 25-30.

Rijsberman, F.R.; Mohammed, A. 2003. Water, food and environment: Conflict or dialogue. Water Science and Technology. 47(6): 53-62.

Rijsberman, F.R.; Molden, D.J. 2001. Balancing water uses: Water for food and water for nature. Thematic background papers, International Conference on Freshwater, Bonn, 3-7 December. Pp. 43-56

Saleth, M.; Samad, M.; Molden, D.; Hussain, I. 2003. Water, poverty and gender: an overview of issues and policies. Introduction to the special issue on water, poverty and gender of water policy. 5(5/6):385-388.

Scott, C.A.; Faruqui, N.I.; Raschid-Sally, Wastewater use in agriculture: Confronting the livelihood and environmental realities. CABI Publishing, Wallingford, UK.

Seckler, D., D. Molden and R. Sakthivadivel. 2003. The concept of efficiency in water-resources management and policy. In: Kijne et al. eds. 2003. Water Productivity in Agriculture: Limits and Opportunities for Improvement. CABI Publishing, Wallingford, UK. Pp. 37-51.

Seckler, D.; Amerasinghe, U.; Molden, D.; De Silva, R.; Barker, R. 1998. World water demand and supply, 1990 to 2025: Scenarios and issues. IWMI research report 19. International Water Management Institute, Colombo, Sri Lanka.

Seckler, D. 1996. The new era of water resources management: From "dry" to "wet" water savings. IWMI research report 1. International Water Management Institute, Colombo, Sri Lanka.

Wright, A., ; Del Rosario, B.P.; Vaidiyanathan, A. 2004. Consolidated report on center-commissioned external review. IWMI working paper 67. IWMI, Colombo, Sri Lanka.

Dr. Hugh Turral - *Theme Leader*

Research Theme 1 -

Integrated Water Management for Agriculture

"More Crop Per Drop" Moving from "Dry" to "Wet" Water Savings

Historically, water management for agriculture was equated with the development and operation of water systems and structures, largely for irrigation. However, the rapid growth of urban centers and industry has led to increasing competition for water across sectors. Thus, the key challenge now for agricultural water management is achieving "more crop per drop"–an approach that marked a paradigm shift in IWMI's thinking on how to increase food production for a growing population, while simultaneously meeting the water quality and quantity requirements of other economic and environmental sectors.

Irrigation management has been at the core of IWMI's research agenda since the institute's inception in 1984. Research initially focused on the operation, maintenance and efficiency of irrigation systems at the field and system scales. In response to the need for increased food production, the IWMI Theme "Integrated Water Management for Agriculture" changed in the mid-1990s, when strategies to improve the productivity of water for food and livelihoods became the central focus.

IWMI Research Report #1, *The New Era of Water Resources Management from "Dry" to "Wet" Water Savings* (Seckler, 1996) represented a major change in the Institute's overall view of water management: from one previously focused on system level analysis to a more holistic, basin scale approach. IWMI began to place irrigation management into the overall context of river basins and to examine the interlinking hydrologic, socio-economic and environmental aspects of water management at multiple scales.

The overall focus changed from improving water management from the traditional agronomic perspectives of higher yields and higher total production (land productivity) towards water productivity, where the focus is on improving the output from each unit of water used. IWMI's slogan therefore became "more crop per drop". In more recent times, "more crop per drop" has become an essential part of the larger picture in the valuation of water and its use.

Following from this shift, IWMI pioneered the change in thinking from yields per hectare to yields per cubic meter. Further, the concept of water productivity is now widely used in both scientific and popular writings, and measuring water productivity has become a standard when assessing water management performance, be it at field, system or basin level.

IWMI's Basin Paradigm

IWMI's Basin Paradigm, spearheaded by Dr. Seckler, focused on four implications of moving from irrigation system level to basin level

- **The importance of knowing whether basins are "open" or "closed".** In open basins, there are unused or unallocated flows out of the basin, while in a "closed" basin all water is already used for environmental or human consumption, and there are no further utilizable flows out of the basin. The concept of "open" and "closed" basins helped in determining which management strategies were most suitable.
- **The importance of understanding the recycling of water within river basins.** While individual irrigation systems may be "inefficient", recycling along the length of the basin may re-capture losses, leading to high levels of basin efficiency.
- **The effect of scale on the interpretation and importance of water use efficiency.** Finding ways in which water can be managed at all scales can enhance water productivity. IWMI's work helped develop practical tools for implementing and measuring water use efficiency.
- **The need to look at longer term trends in water supply and demand.** Much of the water used by humans is for agriculture. Therefore, water management practices need constant improvements to meet food targets with increasingly stressed water supplies.

The RIPARWIN project in Tanzania studies the balance between irrigation and wetland ecosystems. IWMI develops tools and methods to manage land and water resources to optimize agricultural production, while conserving freshwater systems.

Photo Credit : Hugh Turral

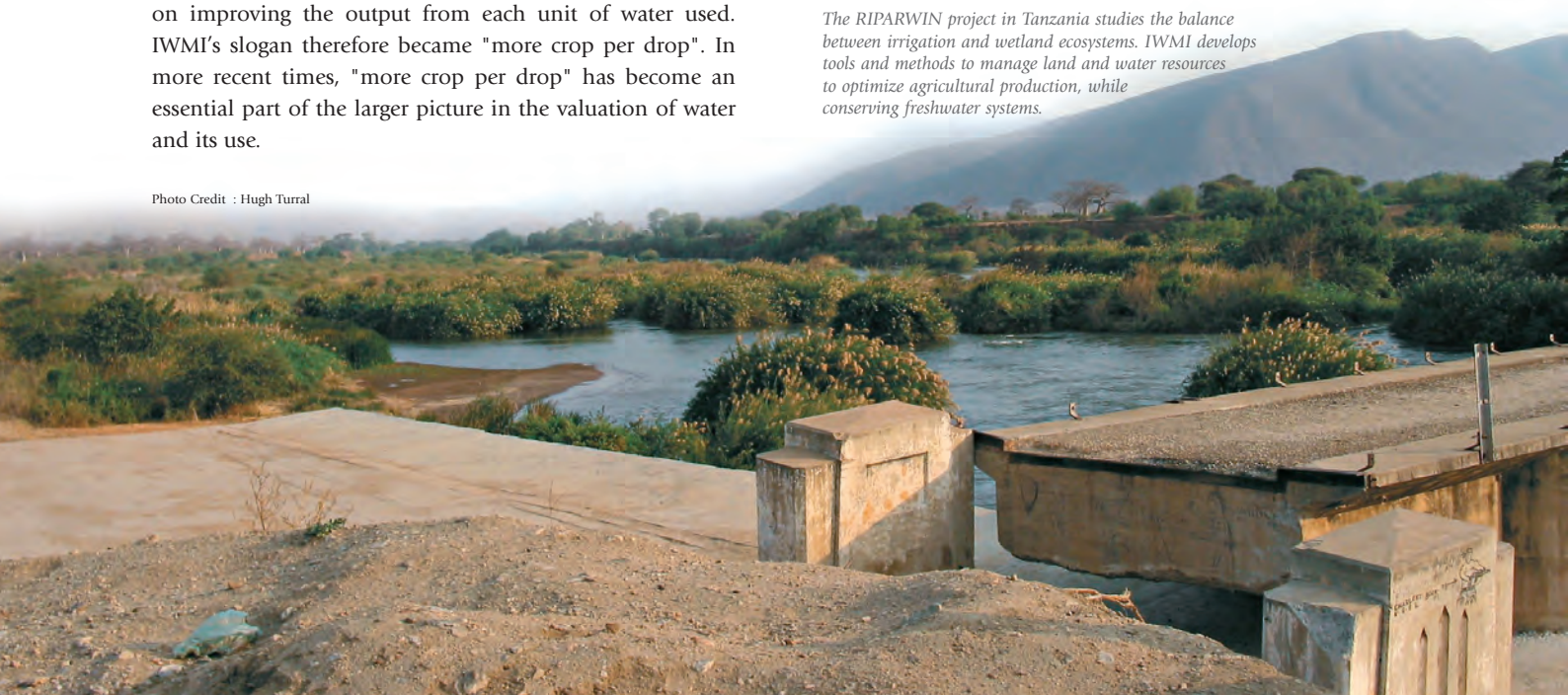


Photo Credit : Hugh Turral

The Pehur High Level Canal in Pakistan, where IWMI is doing work on "Operations Support" for a newly and extensively modernised "down-stream control" canal, supplying 180,000 ha, in NWFP.

Within this broader framework, IWMI's research over the past 10 years focused on 3 key areas:

Water Productivity at Basin Scale

Water productivity is a ratio between crop output and water delivered. Water productivity can be measured with respect to transpiration or water delivered at field, farm-gate or system level and in relation to land productivity. IWMI has made significant contributions to key water management concepts and tools such as water accounting (Molden, 1997) and hydronomic zones (Molden et al., 2001b); water productivity indicators (Molden et al., 2001a) and benchmark values for different crops under different conditions (Hussain et al., 2003); and water saving techniques (e.g., Barker et al., 2001).

Integrated Land and Water Modeling

Complementing IWMI's work on water management concepts and tools has been the development of modeling and analysis tools for improved water management at the basin scale. IWMI has developed an approach to modeling that now enables researchers to study the interactions between different water users within a basin. One high-impact product developed by IWMI is a global water scarcity map, which contributed to the World Water Vision (Cosgrove and Rijsberman, 2000). Further, modeling efforts together with in-house GIS and Remote Sensing expertise have supported the development of a suite of decision support systems for water allocation and management at a variety of scales (see e.g., Bastianssen et al., 1999; Droogers and Kite, 2001).

Operation, Maintenance and Management of Irrigation Systems

Finally, IWMI continues to examine irrigation system management for opportunities to improve performance, flexibility and reliability (e.g., Sakthivadivel et al., 2001). Almost all of IWMI's research on irrigation operation and management has revolved around the issue of level of service. This "level of service " concept accepts that users have a major stake in how water is allocated and delivered and that operation should be structured so that users are satisfied with the performance levels. IWMI's research generally concludes that there are no technical fixes that can overcome the lack of adoption of better service orientation and integrated technical, institutional and governance approaches are required (Research Report 17).

References

B.Bastiaanssen, W. G. M.; Thiruvengadachari, S.; Sakthivadivel, R.; Molden, D. J. 1999.

Satellite remote sensing for estimating productivities of land and water. International Journal of Water Resources Development, 15(1/2):181-196.

Cosgrove, W.J. and Rijsberman, F.R. 2000. World water vision: Making water everybody's business. London, Earthscan.

Droogers, P. and Kite, G. 2001. Estimating productivity of water at different spatial scales using simulation modeling. IWMI research report 53 Colombo, Sri Lanka.

Hussain, I., Sakthivadivel, R. Amarasinghe, U.; Molden, D. ; Mudasser M. 2003. Land and water productivity of wheat in the Western Indo-Gangetic Plains of India and Pakistan: A comparative analysis. IWMI research report 65, Colombo, Sri Lanka.

Molden, D. 1997. Accounting for water use and productivity. IWMI SWIM Paper 1, Colombo, Sri Lanka.

Molden, D.; Sakthivadivel, R.; Habib, Z. 2001. Basin-level use and productivity of water: Examples from South Asia. IWMI research report 49 Colombo, Sri Lanka.

Seckler, D. 1996. The new era of water resources management from "dry" to "wet" water savings. IWMI research report 1 Colombo, Sri Lanka.

Sakthivadivel, R., Amarasinghe, U.A.; Thiruvengadachari, S. 2001. Using Remote Sensing Techniques to Evaluate Lining Efficacy of Watercourses. IWMI research report 46, Colombo, Sri Lanka.

Dr. Deborah Bossio - *Theme Leader*

Research Theme 2 -

Smallholder Land and Water Management

Putting Smallholders on the Road to Food and Livelihood Security

Despite the benefits of the Green Revolution, more than 1 billion people worldwide suffer from food insecurity. Declines in household food production are commonplace for about 60 percent of the rural population in tropical and sub-tropical countries. Land degradation has resulted in low productivity - partially due to poor land and water management practices and inadequate policies. These improper practices in turn directly impact on smallholders and cause off-site damage to downstream producers and the environment. The UN Millennium Development Goals (MDGs) are an urgent call for action to create a better world. IWMI's research on Smallholder Land and Water Management has focused on addressing three of these goals in particular: 1) eradicating extreme hunger and poverty, 3) ensuring gender equality and the empowerment of women, and 7) ensuring environmental sustainability.

The merger with the International Board for Soil Research and Management (IBSRAM) in 2001 brought issues of soil and land management firmly into IWMI's research agenda. It also served to expand IWMI's perspective from a former focus on large irrigation schemes to a broader view of the spectrum of options—large-scale, small-scale, irrigated, rainfed—available to farmers to enhance food production and livelihoods. Thus, in complement to IWMI's Agricultural Water Management Project, a key focal point of the Smallholder Land and Water Management Theme was to research mechanisms to improve water and land productivity of rainfed and small-scale systems at the catchment scale.

Rainfed lands in developing countries tend to be associated with poor farmers. In Sub-Saharan Africa, for example, rainfed agriculture accounts for 95% of the agricultural land and supports 70% of the rural population. Yields from these systems are low, and fertility management and supplemental irrigation can significantly reduce the chronic low productivity and crop failures that characterize the region. (Rockstrom et al., 2003) Further, recent stagnation in the growth of agricultural production in the green revolution areas in Asia has prompted policy makers to look in the same direction, toward rainfed agriculture, to continue the momentum of productivity growth that will be necessary to feed the growing world population. The negative impacts that unsustainable upland farming practices have on downstream populations and resources, and on biodiversity preservation, is an additional driver for this area of research that has lent increasing urgency to the task.

IWMI's research on Smallholder Land and Water Management has concentrated on the essential link between soil and water productivity in three focus areas: rainfed and small scale irrigation systems, catchment management and rehabilitation of degraded lands. The research was divided into the sub-themes, "Smallholder Productivity", which emphasized adoption, adaptation, and equity issues to increase access and productivity of water for smallholders; "Catchment Management", for integrated natural resource management (INRM) research at the watershed scale that encompassed on and off site impacts of resource management; and "Rehabilitation of Degraded Lands", because degradation of natural resources is so important, and because land and water degradation processes are interlinked.

Productivity of Smallholders

This area, identified in IWMI's Strategic Plan 2000-2005 as a sub-theme, provided a nexus on increasing food production to alleviate hunger and poverty, (First recommendation of the UN Hunger Task Force, 2004) and the emerging major opportunities to achieve significant impacts with water and

IWMI Southeast Asia has been working on the application of low cost bentonite clays, which rejuvenate degraded soil. Research has shown an increase in crop productivity where this technology has been used.

Photo Credit : IWMI Southeast Asia

Photo Credit : Sanjini De Silva

Central Asia suffers severe land degradation and water scarcity problems, which threaten the livelihoods of poor farmers. Here, a farmer cultivates his crop of liquorice trees, which hold the soil together while providing a means of income. Inset : Close –up of a liquorice root.

land (Copenhagen Consensus, Economist, June 3, 2004). The theme has analyzed different water and land management technologies and their opportunities and constraints for improving the livelihoods of smallholder farmers (e.g., Sally et al. 2000; Penning de Vries et al., 2002b). The research focus has been on technologies that can be implemented on an individual basis, by single farmers to upgrade their own farming systems, as this type of option has been very attractive to farmers in Asia, with substantial productivity benefits. The treadle pump and low cost drip irrigation have proven very effective in improving both water supply and water productivity in a range of situations. The primary focus for IWMI research was the integration of these technologies into social, biophysical and economic contexts of the smallholder farmer (Badiger, 2003).

Catchment Management

For farmers living in marginal lands in upper catchments, IWMI made significant headway in understanding the complex inter-linkages between the biophysical and socio-economic process that influences local land use practices and their downstream implications (e.g., Maglinao and Valentin 2003). Basic scientific research on erosion has yielded a new understanding of plot level and catchment level processes that are directly relevant to farming systems for sloping lands. These scientific contributions, particularly in the areas of long term effects of erosion, tillage erosion, weed ecology, and relationships between land use and catchment level sediment yields are embedded in an action research agenda that applies these results directly to farming systems (Maglinao and Valentin, 2003). Best practices and guidelines for sloping land agriculture that were developed have been adopted in national manuals and even in legislation in Southeast Asia, and some outcomes have been adopted in practice, such as Conservation Villages. Significant capacity building has taken place as represented by the numerous scientific publications produced by national scientists and students. All researchers in both IWMI's Asialand and MSEC networks have benefited from cross-country exchange, and their perspectives have gained a higher profile within the international scientific community.

Rehabilitation of Degraded Lands– "Learning from Bright Spots"

Finally, IBSRAM and later IWMI research on land degradation and related policy analyses (e.g., Penning de Vries et al., 2002a) has led to a relatively new area of research on 'bright spots,' where scientists are examining existing smallholder and/or community experiences in rehabilitating degraded agroecosystems and the opportunities for replication at different scales and in different locations (multiple manuscripts in preparation). The degradation of land and water resources which includes salinization, erosion, nutrient mining and pollution reduces the global capacity to produce food. It also reduces water productivity and environmental services. IWMI and colleagues looked at this issue from the angle of integrated soil and water management. IWMI's work focused on 1) assessment work focused on learning from 'Bright' spots 2) farm scale rehabilitation of light textured tropical soils and 3) understanding regional and global processes that contribute to land degradation. Looking systematically into the factors that contribute to the development of "Bright Spots", their impact on land and water and how such successes can be repeated elsewhere has become an important thrust of IWMI's research with significant support from other programs, such as the Comprehensive Assessment.

References

Rockstrom, J., Barron,J. Fox,P. 2003. Water Productivity in Rainfed Agriculture: Challenges and Opportunities for Smallholder Farmers in Drought- prone Tropical Agroecosystems. In: Water Productivity in Agriculture: Limits and Opportunities for Improvement, eds. Kijne,J.W., Barker,R., Molden, D. Wallingford (UK): CABI Publishing, pp.145-162.

Sally, H. Saktivadivel,R., and Molden,D. 2000. More crop per drop: considerations for precision irrigation in a basin context. In: Micro-irrigation technologies for developing agriculture. Congress S. Africa. October 2000

Penning de Vries, F.W.T.; Acquai, H.; Molden, D.; Scherr, S.; Valentin, C., and Cofie, O. 2002b. Integrated land and water management for food and environmental security. Comprehensive Assessment Research Report 1, International Water Management Institute, Sri Lanka and Global Environmental Facility, Washington. 70 pp.

Badiger, S. 2003. Poverty focused smallholder water management systems: promoting innovative water harvesting and irrigation systems to support sustainable livelihoods in S. Asia. Final Report to DFID, IWMI, May 2003.

Magliano, A.R., and Valentin, C. 2003. Consortium approach to managing soil erosion in Asia. In : Harwood, D. and Poulsen, J. eds INRM case studies. Washington: CGIAR secretariat 15 pp. In prep.

Dr. Tushaar Shah - *Theme Leader*

Research Theme 3 -

Sustainable Groundwater Management

Unfolding the "Big Picture" on the Groundwater Economy

The use of groundwater revolutionized irrigation in many parts of the world, impacting the lives of millions of rural farmers in South Asia and North China, where over a relatively short period of time, it has become the mainstay of agriculture. In India, groundwater accounts for nearly 60% of the country's irrigated land, overtaking surface water in terms of total area irrigated. In Africa too, groundwater plays an important role within certain farming systems. The rapid growth in groundwater irrigation has brought many benefits to the rural poor. However, the intensification of groundwater irrigation is also threatening the resource together with the lives, livelihoods and ecosystems dependent upon it. IWMI's pioneering work on Sustainable Groundwater Management (SGM) has attempted to uncover the "big picture" of the groundwater economy and helped to fuse resource, user and institutional perspectives towards a better understanding of the groundwater socio-ecology. It has also mainstreamed key policy issues and built a network of local partners, while disseminating policy-relevant research results.

IWMI's groundwater work has been driven by the premise that groundwater management is not possible unless certain questions are asked and answered. What is the size of the national or regional groundwater economy? How much groundwater is diverted for irrigation? What is its opportunity value? Who benefits from it, and who loses from it? What is the technological configuration of the groundwater economy? These questions, seldom asked by either researchers or practitioners, have shaped the scope and direction of IWMI's groundwater research which attempted to expand the groundwater irrigation discourse from one dominated primarily by ecological concerns, to one that incorporates the huge impact of groundwater on livelihoods, incomes, poverty and productivity.

With close links to IWMI's other themes, IWMI's research on SGM, has focused on "the challenge of the balance", i.e., achieving sustainable use and management of groundwater in ways that promote food and livelihood security for poor women and men in Asia and Africa. IWMI's broader overview of the groundwater economy began with an IWMI discussion paper on the "Global Groundwater Situation", which served as a basis for stimulating discussions at the 2nd World Water Forum in the Hague (Shah et al., 2001.). Subsequently, a new body of IWMI literature on groundwater socio-ecology-virtually unparalleled in South Asia—was generated to add more substance and nuance to the emerging "big picture", as summarized in a paper for the 3rd World Water Forum in Kyoto (IWMI, 2003). More recently, IWMI's research on the groundwater socio-ecology has extended to the North China Plains, where groundwater irrigation has become a major factor, as well as to Africa, where the groundwater economy is thought to be evolving rapidly with little knowledge of its current use or management.

Apart from revealing the broader picture of groundwater irrigation, the SGM theme also focused on practical solutions to protect the massive welfare gains that groundwater irrigation has created, particularly in Asia, while minimizing the costs associated with its intensive use in agriculture. (Shah, 2003). This has included bringing the issues of promoting productivity, equity and environmental sustainability in groundwater use to the forefront of global, national and regional discussions. IWMI has also explored alternative institutional and policy approaches to sustainable groundwater management through comparative studies. Research results in all of these areas are summarized below.

Regional assessments of groundwater potential and impacts

IWMI's big picture analysis examined the factors that drove the spread of groundwater irrigation (Shah et al, 2000). For example, in South Asia, research showed that tubewell density closely followed population density and population pressure on agriculture. Research also drew attention to the environmentally unsustainable effects of groundwater irrigation which was dependent only on natural recharge from rainfall and limited surface run-off. Studies showed that the intensification of groundwater use in agriculture produced many beneficial impacts in terms of agricultural productivity, food security and poverty reduction at both macro and micro levels.(Debroy et al., 2003) However, because groundwater irrigation occurred through an informal market driven process, if left to itself, it also produced adverse effects which reduced the net social benefits.

Photo Credit : Courtesy IWMI- Tata Program

Rural woman with her treadle pump. In India, groundwater accounts for nearly 60 % of the country's irrigated land. IWMI is working towards fusing resource, user and institutional perspectives to establish a better understanding of the groundwater socio-ecology.

Photo Credit : Courtesy IWMI- Tata Program

IWMI's groundwater research has extended to the North China Plain, where groundwater irrigation is rapidly expanding. Here a woman "water lord" pumps water from a tubewell.

Groundwater and Public Health

IWMI groundwater research has also raised awareness of the links between groundwater quality and public health. For example, research carried out in Bangladesh revealed that groundwater supplies in 61 out of 64 districts in Bangladesh were contaminated with arsenic and an estimated 35 million people were at risk of being exposed to arsenic poisoning. IWMI initiated some work on this crisis in 1999 by carrying out a literature review based on situation analysis. Two other focal areas included 1) assessing the scale of present and likely future loss of human welfare on account of arsenic contamination and 2) identifying approaches that could be mobilized to eliminate or minimize such welfare losses. The Institute also assessed the prevalence of dental and skeletal fluorosis as a result of fluoride contaminated groundwater in North Gujarat and Southern Rajasthan.

Sustainable groundwater technologies and institutions.

Research on demand and supply management has focused on the range of policies and technologies available to promote more sustainable groundwater irrigation. In India, IWMI's research focused on the efficacy of several approaches including the promotion of micro-irrigation technologies, conjunctive use of surface and groundwater, market-based systems, and decentralized groundwater recharge. IWMI's research on groundwater recharge, for example, showed that earthen irrigation systems can be transformed into highly productive, region-wide groundwater recharge systems at very little cost and that groundwater recharge can ensure crop security and adequate water in times of drought. IWMI has also looked extensively into the water-energy nexus and the opportunities for jointly managing the two resources through indirect supply and pricing policies (Shah et al., 2003). IWMI's cross-country comparisons, however, suggests that appropriate solutions for groundwater management depend on a constellation of factors, and these differences have decisive impact on whether an approach that has worked in one country will work in another with a different context.

Translating Research into Action

The design of institutional interventions is an area where SGM has contributed at both national and regional level. Under the IWMI-Tata Program (ITP), built around a partnership between IWMI and the Sir Ratan Tata Trust Fund, SGM has worked with around 50 NGOs and local research institutions in India and organized over 20 consultations and workshops for researchers and policy makers. Much of the peer reviewed research has been translated into Water Policy Briefs, which are widely distributed among policy makers, researchers, donors and NGOs. At the grassroots level too, ITP's close collaboration with NGOs has made significant inroads in translating research findings into actionable recommendations on the ground.

References

Shah, T.; DebRoy, A.; Qureshi, A.S.; and Wang, J. 2003. Sustaining Asia's Groundwater Boom: An Overview of issues and Evidence. Natural Resources Forum, 27 (2003): 130-140. Earlier version prepared as a key note paper for International Conference on Freshwater, Bonn, Germany, 3-7 December, 2001.

Shah, T. 2003. Wells and Welfare in the Ganga Basin: Public Policy and Pricate initiative in Eastern Uttar Pradesh, IWMI Research Report 54. Colombo, Sri Lanka: Also published in Kamta Prasad [eds] Water resources and sustainable development, Shipra Publications, New Delhi: IRMED.

Shah, T.; Alam, M; Kumar, M. D.; Nagar, R.K.; and Singh, M. 2000. Pedaling Out of Poverty: Social Impact of a Manual Irrigation Technology in South Asia. IWMI Research Report 45 Colombo, Sri Lanka.

Shah, T., Scott, C.; Kishore, A. and Sharma, A. 2003. Energy-Irrigation Nexus in South Asia: Improving Groundwater Conservation and Power Sector Viability. IWMI Research Report 70, Colombo, Sri Lanka. .

DebRoy, A; and Shah, T. 2003. Socio-ecology of Groundwater Irrigation in India. In Llamas, R & E. Custodio (eds) Intensive Use of Groundwater: Challenges and Opportunities, Swets and Zetlinger Publishing Co., The Netherlands.

IWMI, 2003. "Groundwater Governance in Asia: The Challenge of Taming a Colossal Anarchy", Anand: IWMI-Tata Water Policy Program; IWMI Contribution to III World Water Forum, Kyoto for the session on "Water, Food and Environment".

Kumar, M. D.; Singh, O. P. and Singh, K. 2002. Groundwater Depletion and its Socio-Ecology Consequences in Sabarmati River Basin. Proceedings of Symposium on Intensive Use of Groundwater, Valencia, Spain, 10-14 December, 2002.

Shah, T. 2004. Groundwater and Human Development: Challenges and Opportunities in Livelihoods and Environment. Paper presented in 14th Stockholm Water Symposium in Stockholm, August 16-20.

Dr. Madar Samad - *Theme Leader*

Research Theme 4 -

Water Resources, Institutions and Policy

Developing Frameworks and Tools for Good Governance and Management of Water Resources

Water scarcity is a growing threat to food security, human health and the sustainability of natural ecosystems. Research shows that by the year 2025, about one third of the population in developing countries will live in regions of severe water scarcity (IWMI, 2000). Irrigation water, which accounts for about 70 % of freshwater supplies in developing countries, is being increasingly diverted for domestic and industrial purposes. Yet, irrigated agriculture will continue to remain in the foreseeable future a principal means for producing enough food for a growing population and improving the livelihoods of poor men and women. The challenges faced by the water sector are exacerbated by distorted economic and non-economic incentives that have perverse consequences and highly fragmented institutions that are ineffective for allocating water across purpose.

Research on institutions and policies has occupied a prominent place in IWMI's research agenda since the inception of the institute. In the early years, the focus was primarily on two specific sets of activities: a) improving the performance of public organizations managing irrigation systems through improved designs and operational procedures and b) understanding institutional arrangements and management practices of indigenous farmer managed irrigation systems, and analyzing the external and internal stresses that constrain their performance levels. IWMI has done extensive work on these topics, and research reports published by the institute have been frequently used by specialists in designing new strategies for effective water management programs.

With the growing recognition of the importance of policy and institutional issues in irrigation management, a separate research program titled Policy Institutions and Management Program (PIM) was established in 1999 for carrying out research on policy options for optimizing water productivity and issues relating to institutions, poverty, food security, gender and inter-sectoral competition for water (Merrey, 1997). The present theme on Water Resource Institutions and Policy (WRIP) evolved as a logical succession to the PIM program. The primary aim of WRIP was to produce knowledge-based guidelines for best practices in policies, governance frameworks and organizational designs to improve land and water productivity for enhanced food security, livelihoods and environmental sustainability. The second aim was to engage in capacity building of national partners and collaborators to facilitate better research and development, policy formulation and the implementation of interventions for sustainable management of water and land resources.

Over the period 1995 to 2002, IWMI's research on policies and institutions was focused on the following broad areas:

Irrigation Management Reform

Irrigation Management Transfer (IMT) served as the cornerstone of the International Water Management Institute (IWMI) research agenda for nearly a decade. This focus resulted from growing evidence of under-performance of publicly owned irrigation schemes and widespread belief that the transfer of management responsibilities to farmer organizations could improve the management of irrigation systems and make irrigated agriculture more productive and sustainable. IWMI contributions to the topic included literature reviews and analyses of experiences and impacts of past IMT processes, advice to policy makers in planning and implementing IMT, and development of generic IMT guidelines and technical support for governments implementing IMT programs. The results of IWMI's research and related policy and operational recommendations have guided national policies relating to irrigation management in several developing countries. Further, guidelines on Irrigation Management Transfer prepared by IWMI and FAO have served as a reference tool to assist policy makers, planners and technical assistance experts and other stakeholders to design and implement irrigation management transfer programs (Vermillion and Sargadoy, 1999). More specific guidelines on Water User Associations have been developed for use in Central Asia.

River Basin Institutions

As IWMI's research focus evolved from irrigation management to water resources in the river basin context, a key practical outcome of the Institute's studies was that it helped create a greater awareness among stakeholders in the countries in which IWMI worked. New methodologies and

Most irrigated agricultural systems are still home to a large number of poor people. IWMI's research clearly shows that the provision of irrigation is indeed an effective instrument for poverty alleviation and is further enhanced when access to land, markets, education and other social capital are provided.

Photo Credit : Sanjini De Silva

Photo Credit : Iskandar Abdullaev

IWMI is working with partners in the Ferghana Valley and other parts of Central Asia to strengthen Water User Associations and canal management institutions. Photo shows a WUA meeting in progress.

tools developed by IWMI such as "water accounting" (Molden and Sakthivadivel, 1998) and hydro-institutional mapping (Molden, Sakthivadivel and Samad, 2001) and a framework for institutional analysis for water resources management in a river basin context (Bandaragoda, 2000). IWMI's research has shown that there is no single organizational model of water policy and water resources management that applied universally. A country's ability to adopt new policies and institutions is highly contextual and is dependent upon the overall state of the economy, political system, legal system, cultural background and its physical resource base would circumscribe the policies and actions in the water sector. These parameters would also contribute towards determining the style and content of water resources management in any river basin (Bandaragoda, 2005). A Policy Dialogue on River Basin Management in May 2003 brought together senior policy makers and cabinet ministers from 10 countries, which led to the ministers unanimously adopting a declaration stressing the need for effective river basin management.

Mainstreaming Gender Issues

IWMI's research under this theme also addressed gender and water related research issues. A key outcome on gender issues was that research raised awareness and sensitized irrigation managers and policy makers about the needs and concerns of women irrigators in the planning of water allocation. To help translate positive intentions into concrete actions, IWMI pioneered the Gender Performance Indicator for Irrigation (Van Koppen, 2002). This sociological tool diagnoses the gendered organization of farming and gender-based inclusion or exclusion in irrigation institutions. It informs irrigation agencies as to what they can do to support effective change, if necessary. The tool also identifies gender issues beyond a strict mandate of irrigation water provision. The Indicator has been applied and tested by IWMI in nine case studies in Africa and Asia, and serves as one of the few gender studies that offer a practical tool to guide the interventions of policy makers, NGOs and senior irrigation managers wishing to achieve greater gender equity in their development projects.

Water Security for the Poor

Although irrigation has played a central role in poverty reduction, most irrigated agricultural systems are still home to a large number of poor people. Over the past few years , IWMI has implemented programs to analyze the link between water and poverty. An ADB funded project on pro-poor interventions in irrigated agriculture in Asia generated new knowledge and focused on issues that have been identified for further research. IWMI's research clearly showed that provision of irrigation is indeed an effective instrument for poverty alleviation. Poverty-reducing impacts of irrigation are enhanced when other complementary factors such as access to land, markets, education and other social capital are in place (Hussain, 2005).

IWMI was a founding partner of the Water and Poverty Initiative also spearheaded by the ADB and also a key contributor to the development of the Water Poverty Index formulated by HR Wallingford.

Water as a Free Good or Economic Commodity

IWMI's research has argued that water should be defined as both an economic good as well as a social good (Perry at al., 1997) IWMI has pushed for a blend of values and facts in the proper formulation of water policy. This called for a more in-depth and integrated analysis that recognized the fact that the value of water varies substantially over time and space. Recent studies have also addressed conceptual issues related to the economics of water productivity. Finally, IWMI research has examined how economic tools such as pricing, cost sharing and water markets should be designed and applied for the efficient use and conservation of water resources without disadvantaging the poor.

References

Cosgrove, W. J.; Rijsberman, F. R. 2000. World Water Vision: Making water everybody's business. London, UK: Earthscan Publications

Merrey, D. J. 1997. Expanding the frontiers of irrigation management research: Results of research and development at the International Irrigation Management Institute, 1984 to 1995, Colombo, Sri Lanka: IWMI

Vermillion, D. L.; Sagardoy, J. A. 1999. Transfer of Irrigation Management Services, Guidelines. Rome, Itlay: IWMI; GTZ; FAO. FAO Irrigation and Drainage Paper 58

Molden, D. J.; Sakthivadivel, R; Perry, C. J.; de Fraiture, C.; Kloezen,W. H. 1998. Indicators for comparing performance of irrigated agricultural systems. IWMI Research Report 20, Colombo, Sri Lanka: IWMI.

Molden, D.; Sakthivadivel, R.; Samad, M. 2001. Accounting for changes in water use and the need for institutional adaptation. In Abernethy, C.L. (ed.). Intersectoral management of river basins: Proceedings of an International Workshop on Integrated Water Management in Water-Stressed River Basins in Developing Countries: Strategies for Poverty Alleviation and Agricultural Growth, Loskop Dam, South Africa, 16-21 October 2000. IWMI; DSE, Colombo, Sri Lanka: pp.73-87

Perry, C. J.; Rock, M.; Seckler, D. 1997. Water as an economic good: A solution, or a problem? IWMI Research Report 14 Colombo, Sri Lanka, IWMI.

van Koppen, B. 2002. A gender performance indicator for irrigation: Concepts, tools and applications. IWMI Research Report 59 Colombo, Sri Lanka: IWMI.

Sullivan, C. A.; Meigh, J. R.; Giacomello, A. M.; Fediw, T.; Lawrence, P.; Samad, M.; Mlote, S.; Hutton, C.; Allan, J. A.; Schulze, R. E.; Dlamini, D. J. M.; Cosgrove, W. J.; Delli Priscoli, J.; Gleick, P.; Smout, I.; Cobbing, J.; Calow, R.; Hunt, C.; Hussain, A.; Acreman, M. C.; King, J.; Malomo, S.; Tate, E. L.; O'Regan, D.; Milner, S.; Steyl, I. 2003. The Water Poverty Index: Development and application at the community scale. Natural Resources Forum, 27(3):189-199

Barker, R.; Dawe, D.; Inocencio, A. 2003. Economics of water productivity in managing water for agriculture. In Kijne, J. W.; Barker, R.; Molden. D. (Eds.), Water productivity in agriculture: Limits and opportunities for improvement. Wallingford, UK; Colombo, Sri Lanka: CABI; IWMI. pp.19-35

Seckler, D.; Molden, D. J.; Sakhtivadivel, R. 2003. The concept of efficiency in water resources management and policy. In Kijne, J. W.; Barker, R.; Molden. D. (Eds.), Water productivity in agriculture: Limits and opportunities for improvement. Wallingford, UK; Colombo, Sri Lanka: CABI; IWMI. pp.37-51

Dr. Felix Amerasinghe - *Theme Leader*

Dr Amerasinghe passed away on the 7th of June 2005, after a year long battle with cancer. We wish to acknowledge the immense contribution he made to IWMI's research on water, health and environment issues.

Research Theme 5 -
Water, Health and Environment

Balancing Water for Livelihoods, Health and Ecosystems

Water-related diseases kill an estimated 4-6 million people every year but water is also a critical resource that provides food and livelihoods to countless millions. With increased food production and economic development, the human and environmental costs of using water have received inadequate attention. IWMI is committed to alleviating rural poverty and has recognised the vital contribution of agricultural systems to rural communities worldwide. Yet, if agriculture is to thrive, human and environmental health must be protected. It is this recognition that drove the Water Health and Environment (WHE) theme, which has identified ways and means of protecting human and environmental health through multi-disciplinary research. IWMI's research has looked at how irrigation water can be managed in ways beneficial to human health. It has identified opportunities to optimize the use of urban wastewater to improve livelihoods without the associated health risks. Finally, IWMI has also tested interventions to reduce mosquito breeding in streambeds and rivers.

The theme began with an IWMI hosted workshop focusing on the linkages between irrigation and vector-borne diseases in the mid-1980s. By 1987, continued interest in this area led to IWMI being elected as an official collaborating centre of the Panel of Experts on Environmental Management (PEEM). In 1994, through support from DANIDA, health research staff were seconded to IWMI, but not until 1997 was the human health aspect formally included in the mainstream of IWMI research under the 'Health and Environment' banner. Research at this point treated interactions between irrigation and human health and ecosystems independently, and it was only after the formation of the WHE theme that a truly holistic approach was adopted.

Today health and environment issues are well integrated in IWMI's theme research. Staffed by multi-disciplinary researchers cutting across the agricultural engineering, health and environmental divide, WHE since 1994 has concentrated on the sub-themes, of malaria and agriculture, wastewater and agriculture, multiple uses of water, pesticides, and ecosystems. These sub-themes while offering wide coverage, also directly relate to the Millennium Development Goals of combating malaria and other diseases, promoting environmental sustainability and forging global partnerships for development.

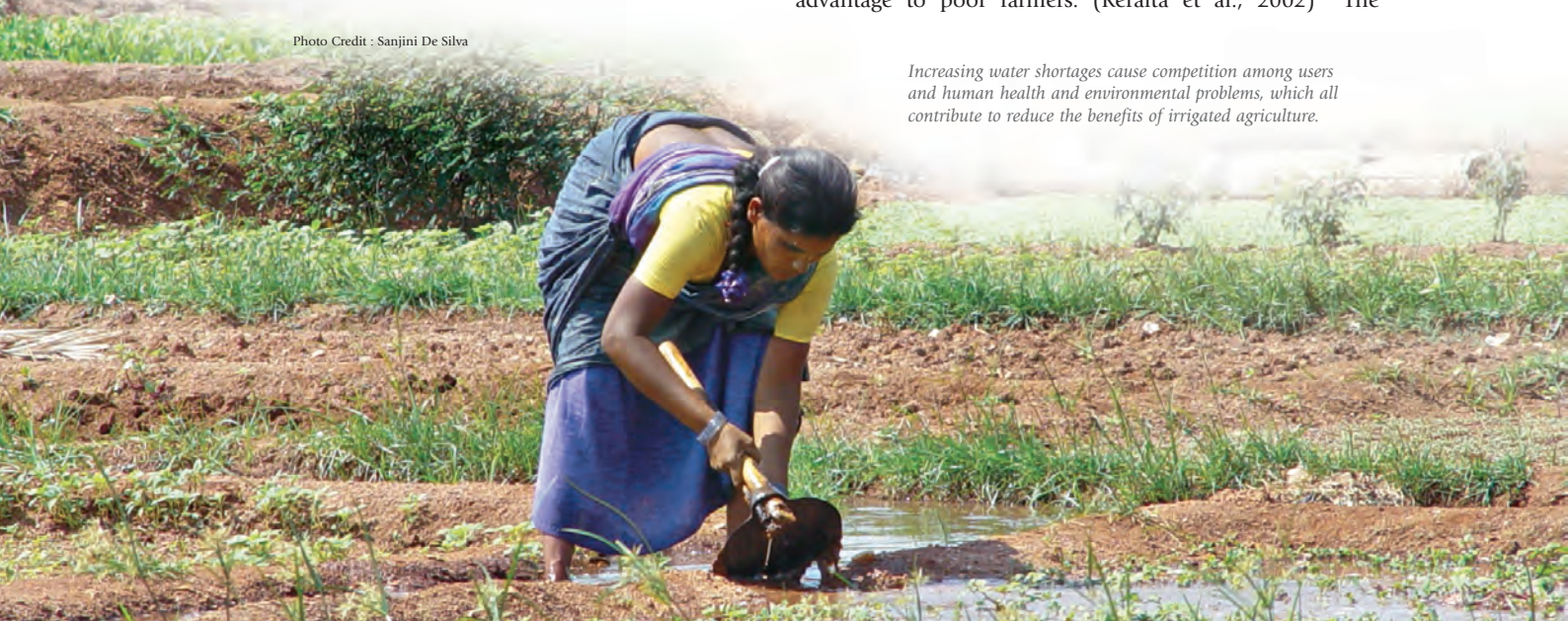
Malaria and Agriculture

Initially limited to Asia and to studying irrigation and its links to malaria (Amerasinghe et al., 1999) this sub-theme has evolved into a broad-based project that studies the interactions between water, land and people and has extended to cover Africa as well. IWMI has investigated the water-agriculture-livelihoods dimensions of the disease. This has generated new knowledge on the ecology of malaria vectors, the risk factors for the disease and feasibility of environmental management interventions to reduce the burden of malaria. For example, research in the Mwea irrigation scheme in Kenya experimented with the use of alternate wet and dry irrigation as a way to reduce malaria vector breeding in rice-growing areas.(Mutero et al., 2000) In the Yan Oya watershed in Sri Lanka, research demonstrated that regulating irrigation water releases could control mosquito breeding.(Matsuno et al., 1999). In Punjab, Pakistan, several studies focused on the problems of water logging and malaria and substantiated the importance of land use changes in the changing malaria patterns. The sub-theme has produced an extensive collection of publications on malaria research, educational audio-visual materials and established numerous links with local NGOs, universities, research institutes and health organizations. For example ,IWMI's GIS based malaria risk mapping initiative has helped personnel engaged in malaria control in Sri Lanka. The CGIAR recognised IWMI's contribution to malaria research by inviting the institution to lead the System Wide Initiative on Malaria in Agriculture (SIMA) in 2001.

Wastewater and Agriculture

Using untreated wastewater for irrigation, though hazardous, is a practical reality for poor urban farming communities worldwide, unable to afford expensive treatment options. Recognising this practice, the Wastewater and Agriculture sub-theme promoted a flexible approach to this practice where potential benefits are greater than the risks. The real extent of wastewater use is unknown and IWMI has been carrying out ground surveys in several countries as well as a global assessment. Based on research in Mexico, Pakistan, India, Ghana and Vietnam, IWMI studies showed that nutrient-rich wastewater gave a significant economic advantage to poor farmers. (Keraita et al., 2002) The

Photo Credit : Sanjini De Silva



Increasing water shortages cause competition among users and human health and environmental problems, which all contribute to reduce the benefits of irrigated agriculture.

Photo Credit : Courtesy IWMI South Africa

Wetlands are important ecosystems central to the lives of many people in rural communities of Southern Africa, who depend on them for their food and livelihoods. Here a woman cultivates her vegetable plot in the Limpopo River Basin.

"Hyderabad Declaration on Wastewater Use in Agriculture" was a key achievement resulting from an IWMI-IDRC conference in 2001. Recent USEPA guideline revisions have included the Declaration and data on the economic benefits of wastewater use provided by IWMI. Finally, Wastewater Use in Irrigated Agriculture, a joint publication by IWMI, CABI and IDRC, which critically evaluated worldwide experience of wastewater use, was a key IWMI output.

Multiple Uses of Water

Apart from water for crops, irrigation systems intentionally or otherwise provide water for domestic consumption, home gardens, livestock and also support other productive uses such as fishing, brick making and a host of other enterprises. However, the fact that irrigation water serves many stakeholders is not adequately recognized by water managers. In a situation of increasing water shortages and competition, this lack of understanding results in increasing conflicts among stakeholders, and in human health and environmental problems, all of which contribute to reduce the benefits of irrigated agriculture. For instance, when the agricultural sector takes measures to diminish water losses, access to water for domestic purposes may be greatly reduced and community health may be adversely affected. (van der Hoek et al., 2001) IWMI research in Kirindi Oya in Sri Lanka has established a framework for examining statutory and customary water rights for multiple users of water and also identified that irrigation water was utilised by a large number of non-farming groups. Research also showed that in areas with saline or brackish groundwater—like the Basse Moulouya irrigation scheme, Morocco or in southern Punjab, Pakistan—irrigation water was the only viable option for domestic use. IWMI's pioneering research in multiple uses of water has helped the issue gain international recognition and demonstrated the institute's strength in carrying out cross-disciplinary research.

Pesticides in irrigated agriculture

Pesticide use and abuse is indirectly influenced by water management decisions and is a serious problem within farming communities. IWMI researched this problem in Sri Lanka and Pakistan with an early-IWMI report making an important contribution to a Presidential Task Force on pesticide abuse in Sri Lanka. More recent IWMI research focusing on six hospitals in the southern region of Sri Lanka found that one third of all deaths in hospitals were a result of acute pesticide poisoning. IWMI has focused its policy work on pesticide poisoning on the regulatory framework aimed at reducing the availability and use of the most toxic pesticides at household level. Also, the possible role of integrated pest management as a means to reduce use in irrigated areas has been studied (Konradsen et al., 2003). National workshops in the two countries provided a forum for health and water management officials to meet and discuss the issue. The Sri Lankan workshop resulted in a publication, which is now a country resource handbook. IWMI in partnership with other international researchers has also provided momentum for policy recommendations like 'minimum pesticide lists', which limit the availability of toxic chemicals internationally.

Agriculture and Ecosystems

IWMI has looked at developing tools and methods to manage land and water resources in a way that optimises agricultural production, while conserving freshwater-dependent ecosystems and their biodiversity. Ongoing research has achieved a number of impacts. IWMI's eco-agriculture project in Sri Lanka has convinced authorities to conserve biodiversity hotspots within irrigation development areas. The hydrological model developed for the Karagan lagoon in southern Sri Lanka revealed risk of flooding due to upstream irrigation developments and resulted in the irrigation agency modifying the design. An ongoing study on environmental flows (Smakhtin et al., 2003) has generated international interest and shows promise of developing river basin scale assessment tools. In Africa, an inland wetlands initiative has looked at improving livelihoods without the usual ecological fallout associated with development. IWMI is now represented on key international bodies like RAMSAR and the Eco-agriculture Secretariat, with the institute's research in this area poised for robust growth and further impact.

References

Amerasinghe P.H.; Amerasinghe, F.P.; F. Konradsen; Fonseka, K.T.; and Wirtz, R.A.;. 1999. Malaria vectors in a traditional dry zone village in Sri Lanka. American Journal of Tropical Medicine and Hygiene, 60, 421-429.

Keraita B.; Drechsel, P.; Huibers, F.; and Raschid-Sally, L.;. 2002. Wastewater use in informal irrigation in urban and peril-urban areas of Kumasi, Ghana. Urban Agriculture Magazine 8: 11-13.

Konradsen F.; van der Hoek, W.; Cole, D.C.; Hutchinson, G.; Daisley, H.; Singh, S.; and Eddleston, M.;. 2003. Reducing acute poisoning in developing countries–options for restricting the availability of pesticides. Toxicology 192: 249-261.

Mutero C.M.; Blank, H.; Konradsen, F.; and . van der Hoek, W;. 2000. Water management for controlling the breeding of Anopheles mosquitoes in rice irrigation schemes in Kenya. Acta Tropica 76: 253-263.

Smakhtin V.U. and Piyankarage, S.C.. 2003. Simulating hydrological reference condition of coastal lagoons affected by irrigation flows in southern Sri Lanka. Wetlands 23: 827-834.

van der Hoek W.; Konradsen, F.; Ensink, J.H.J.; Mudasser, M.; and Jensen, P.K. 2001. Irrigation water as a source of drinking water: is safe use possible? Tropical Medicine and International Health, 6: 46-54.

Matsuno Y.; Konradsen, F. ; Tasumi, M.; van der Hoek, W.; Amerasinghe, F.P.; and Amerasinghe, P.H.. 1999. Control of malaria mosquito breeding through irrigation water management. International Journal of Water Resources Development, 15, 93-105.

Dr. David Molden - *Theme Leader*

The Comprehensive Assessment of Water Management in Agriculture

Investing in Water for Food, Ecosystems and Livelihoods

The role of water in food and livelihood security is a major issue of concern in the context of continued environmental degradation and persistent poverty throughout the developing world. Using more water for agriculture threatens important food production systems and ecosystem services such as fisheries. On the other, hand less water for agriculture could lead to increased malnutrition and food insecurity. The stakes are high, the problems are complex, and there is contention about the best ways of managing and investing in water for agriculture. Assessments are a way to bridge science and policy, and to address complex questions. The Comprehensive Assessment of Water Management in Agriculture has been a major multi-institute initiative—filling gaps in the existing knowledge base to develop consensus on appropriate investment and management strategies to meet food and environmental security objectives in the near future and over the next 25 years.

The Consultative Group on International Agricultural Research (CGIAR) launched the System Wide Initiative on Water Management (SWIM) in 1995 as a major program dealing with broader water management and agriculture issues. In 2000 the initiative, convened by IWMI, was remodeled to bring CGIAR centers, together with a range of partners, to focus entirely on building the Comprehensive Assessment of Water Management in Agriculture (CA). The CA or SWIM-2 expanded the scope of SWIM by focusing on issues of global concern like hunger, poverty, and environment.

The CA critically evaluates the benefits, costs, and impacts of the past 50 years of water development and challenges to water management currently facing communities. It assesses innovative responses and explores the consequences of potential investment and management decisions. The results of the assessment will enable farming communities, governments, and donors to make better investment and management decisions. Ninety institutes worldwide are currently working on the Assessment research through over 40 different projects.

The first phase of the CA concentrated on knowledge gap-filling research and assessment tool development. The CA research agenda closely complements that of IWMI, with many IWMI projects contributing to and receiving support from the CA in the areas of water productivity, integrated water resources management, rainfed agriculture, land and water degradation, groundwater governance, irrigation impacts, and sustainable wetland management. The research agenda is further augmented by the wealth of expertise and projects carried out by CA's partner organizations.

The CA is now in its final phase: developing the Assessment report. Multi-disciplinary, international research teams are synthesizing the results of this massive research effort into the final Assessment report. The Assessment will have 15 chapters, including 8 thematic chapters on Rainfed Agriculture, Irrigation, Groundwater, Low-Quality Water, Fish, Rice, Land, and Basins and 4 cross-cutting chapters addressing water productivity, policies and institutions, ecosystems, and poverty. In addition, the Assessment will include a section on future scenarios and a summary for policy makers. The report will be formally launched in mid-2006 at the Stockholm Water Week and through a number of other forums.

The Comprehensive Assessment is filling in the knowledge gaps on how to address both human and environmental water needs in the face of persistent poverty and environmental degradation throughout the developing world.

Photo Credit : Courtesy the Comprehensive Assessment of Water Management in Agriculture

Assessing the Options

SWIM 2 researchers have been assessing several options put forward to change the "more food=more water" equation through options such as:

- Encouraging water savings and preventing the polluting of rivers and groundwater, reducing waterlogging and salinization and saving water.
- Increasing water productivity to gain more food or more value from the same amount of water.

According to a recent CA global study of environmental water requirements, over 1.4 billion people live in river basins, where high water use levels threaten freshwater ecosystems.

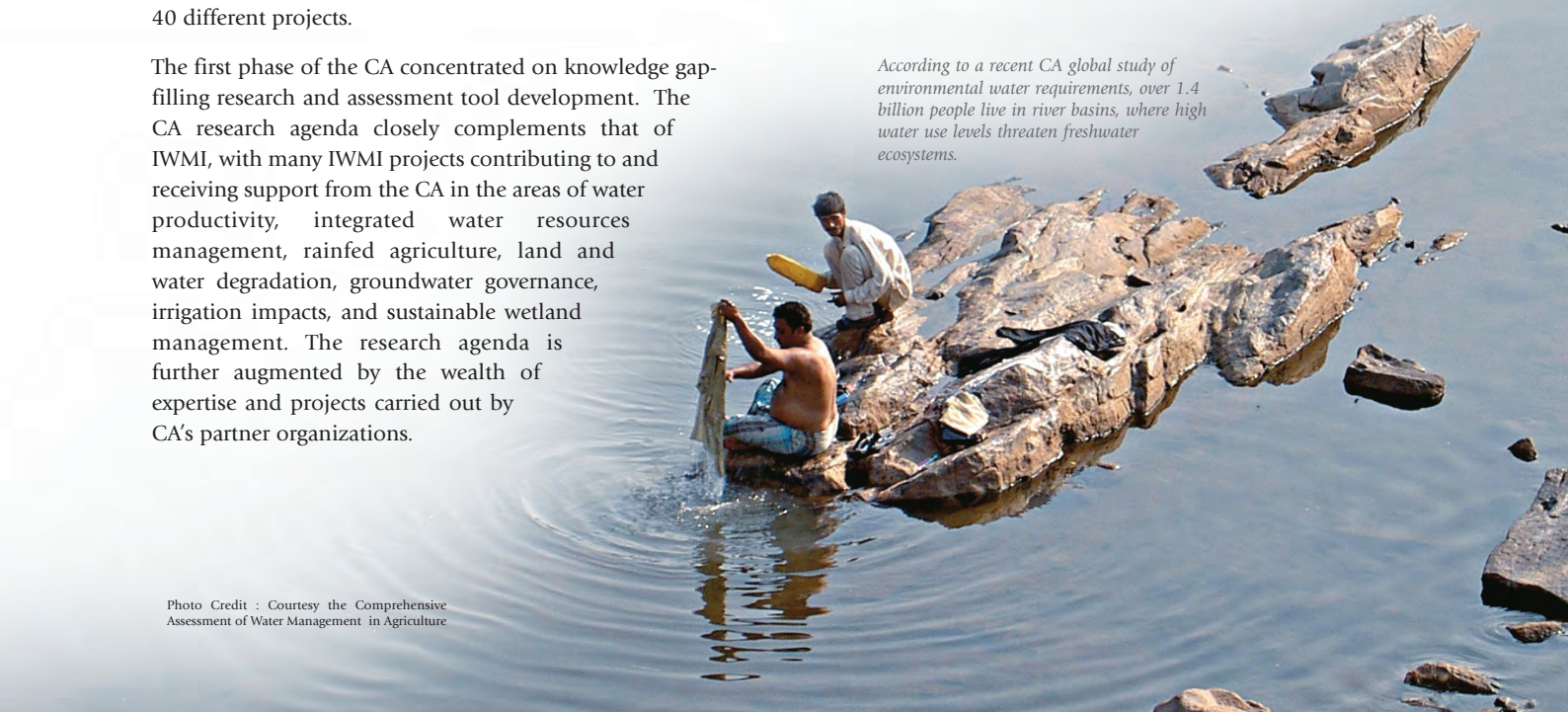


Photo Credit : Courtesy the Comprehensive Assessment of Water Management in Agriculture

- Upgrading rainfed systems by growing more on rainfed land, sometimes with the addition of supplemental irrigation, has the potential to increase water productivity and fight rural poverty.
- Reducing agricultural water consumption by influencing diets. Meat-based diets from grain-fed cattle deplete as much as 5,000 litres per capita per day, while vegetarian diets deplete less than half that amount of water.
- Encouraging trade in virtual water by allowing countries lacking water resources to import staple food from water-abundant countries, thereby saving their scarce water resources for higher value uses.

Of these options, research suggests that increasing water productivity in irrigated and rainfed systems, through innovative techniques and system upgrades offers the greatest potential for immediate, widespread application.

Photo Credit : Courtesy the Comprehensive Assessment of Water Management in Agriculture

Improving the productivity of water in rainfed and irrigated agriculture will leave more water for nature, communities, industrial and farming uses.

Research on Irrigation and Poverty

The CA has already generated a set of refereed research reports and nearly 50 peer-reviewed articles and book chapters. CA research on irrigation and poverty in Asia has demonstrated that while poverty remains an issue in canal systems due to inequitable benefit sharing and poor irrigation performance, irrigated areas tend to have higher productivity and wage rates than rainfed areas (Hussain et al., 2003). Further, research suggests a range of direct and indirect socio-economic costs and benefits accompanying irrigated agriculture not previously documented (Matsuno et al., 2002; Boisvert et al., 2003).

Environmental Impacts of Irrigated Agriculture

The CA has also made important contributions to understanding the environmental consequences of irrigated agriculture through the development of a global framework for assessing environmental flow requirements (Smakhtin et al., 2004) and analyzing the negative and positive externalities associated with an irrigated landscape (Galbraith et al., 2003). According to a recent CA global study of environmental water requirements, over 1.4 billion people live in river basins where high water-use levels threaten freshwater ecosystems (Smakhtin et al., 2004). This first view of environmental water scarcity shows that many countries are already having to make serious environmental tradeoffs to grow food, and that many more will be facing the same dilemma in the next 25 years.

Workshops and Conferences

The CA has played an important role in delivering key water, food, livelihood and environment messages at important workshops and meetings. It played a major role at the Stockholm Water Symposium in 2004, where the Blue Paper on Investing in Water for Food, Ecosystems and Livelihoods was presented. It reviewed several policy and water investment options-along with their livelihood and environmental implications. These preliminary findings were shared to raise awareness that water in agriculture is a pressing issue, that business as usual is not an option, and that there are potential solutions, but they are not necessarily the ones that have received the most attention (Blue Paper, 2004).

References

Hussain, I; Hanjra, M. 2003. Does irrigation water matter for rural poverty alleviation? Water Policy, 5 (5/6):429-442.

Matsuno, Y; Ko, H. S.; Tan, C. H.; Barrer, R.; Levine, G. 2002. Accounting of agricultural and nonagricultural impacts of irrigation and drainage systems. IWMI Working paper 43 Colombo, Sri Lanka.

Boisvert, R.; Chang, H.; Barker, R; Levine, G.; Matsuno, Y.; Molden, D. 2003. Water productivity in agriculture: measuring the positive and negative externalities of paddy rice production. Presented at the Third World Water Forum, Kyoto, Japan and in forthcoming research report.

Smakthin, V.; Revenga, C.; Döll, P. 2004. Taking into account environmental water requirements in global-scale water resources assessments. Comprehensive Assessment Research Report No.2. Colombo, Sri Lanka.

Galbraith, H.; Amerasinghe P.; Huber-Lee, A. 2003. The effects of irrigation on wetland ecosystems in developing countries-A literature review (www.iwmi.org/assesment).

Molden, D.; de Fraiture, C. 2004, Investing in Water for Food, Ecosystems and Livelihoods, Blue Paper, Discussion Draft, Stockholm, Sweden.

Board of Governors 2005

Board Chair

Ambassador Remo Gautschi
Deputy Director General
Swiss Agency for Development Cooperation
Federal Department of Foreign Affairs
Freiburgstrasse 130
CH-3003 Berne
Switzerland
Email : remo.gautschi@deza.admin.ch

Vice - Chair

Ms. Rokhaya Daba Fall
Senior Technical Advisor
Ministry of Agriculture, Forestry & Fisheries
B.P. 6225, Dakar
Senegal
Email : rodabafa@sentoo.sn,
rodabafa@hotmail.com

Ms. Cecilia López Montaño
President
Fundacion Agenda Colombia
Carrera 13A, #41-44
Bogota
Colombia
Email : c.lopezm@cgiar.org

Ms. Joan Joshi
Management Consultant
212 9th Street, SE
Washington, DC 20003-2111
U.S.A.
Email : jhjoshi@aol.com

Prof. Nobumasa Hatcho
Professor
Dept of International Resources
Management, School of Agriculture
Kinki University
204-3327 Nakamachi
Nara 631-8505
Japan
Email : hatcho@nara.kindai.ac.jp

Dr. Walter Huppert
Senior Water Advisor
Department 44, Environment & Infrastructure
GTZ
Dag-Hammarskjöld-Weg 1-5
Box 5180
D-65726 Eschborn
Germany
(With effect till 31.12.2004)
Email : Walter.Huppert@gtz.de

Dr. U. Tan-Kim-Yong
Chairperson
Graduate Program in Man and Environmental
Management (Payao)
Graduate School
Chiang Mai University
Chiang Mai 50200
Thailand
Email: asia@loxinfo.co.th,
asia@chmai.loxinfo.co.th

Dr. Rivka Kfir
Chief Executive Officer
Water Research Commission
491, 18th Avenue
Pretoria 0084
South Africa
Email : rivkak@wrc.org.za

Dr. Margaret Catley-Carlson
Chair
ICARDA & Global Water Partnership
249 East 48th St 8A
New York 10017
USA
917 582 3149
E-mail: m.catley-carlson@cgiar.org

Mr. Tariq Mahmud
Secretary
Ministry of Food, Agriculture and Livestock
Government of Pakistan
14-M Plaza, Al-Markaz F-8
Islamabad
Pakistan
(Until 31.12.2004)

Dr. Sunita Narain
Director
Centre for Science and Environment
41, Tughlakabad Institutional Area
New Delhi 110 062
India
(With effect from 01.01.2005)
Email: sunita@cseindia.org

Mr. Tissa Warnasuriya
Secretary
Ministry of Agriculture, Livestock, Lands & Irrigation
Government of Sri Lanka
"Govijana Mandiraya"
80/5 Rajamalwatte Avenue
Battaramulla
Sri Lanka
E-mail: secagric@sltnet.lk

Prof. Frank Rijsberman
Director General
International Water Management Institute
P.O.Box 2075
Colombo
Sri Lanka
Phone: (94-11) 2787404 / 2784080
Email: f.rijsberman@cgiar.org

Seated from left to right : *Dr. U. Tan-Kim Yung, Dr. Walter Huppert, Dr. Akiça Bahri (left on 31/12/04), Ambassador Remo Gautschi (Board Chair), Ms. Cecilia Lopez Montano, Prof. Frank Rijsberman.*

Standing from left to right: *Mr. Tissa Warnasuriya, Dr. Margaret Catley–Carlson, Ms. Rokhaya Daba Fall, Mr Gerard O'Donoghue (Board Secretary), Prof. Nobumasa Hatcho, Dr. Rivka Kfir, and Ms. Joan Joshi,*

Not present : *Dr Sunita Narain*

Donors 2004

- African Development Bank
- Asian Development Bank
- Australia (ACIAR)
- Belgium
- Canada
- Denmark(DANIDA)
- France
- Germany(BMZ,GTZ)
- IFAD
- International Development Research Center
- InWent
- Ireland
- Japan (JBIC,JICA)
- National Oceanic Atmospheric Administration
- Netherlands
- Norway
- Sir Ratan Tata Trust
- Sweden (SIDA)
- Switzerland(SDC)
- Taiwan
- The OPEC Fund for International Development
- United Kingdom (DFID, DES)
- United Nations Educational Scientific and Cultural Organization
- United Nations Environmental Program
- United Nations Food and Agriculture Organization
- United States of America (USAID)
- World Bank
- World Health Organization

The Governments of Cambodia, China, India, Iran, Nepal, Pakistan, South Africa, Sri Lanka and Thailand provided program support for IWMI-related activities in those countries.

Board Statement on Risk Management

IWMI's Board of Governors has responsibility for ensuring an appropriate risk management process is in place to identify and manage high and significant risks to the achievement of the Institute's business objectives, and to ensure alignment with CGIAR principles and guidelines, which have been adopted by all CGIAR Centers. These risks include operational, financial and reputational risks that are inherent in the nature, modus operandi and location of the Institute's activities, and are dynamic as the environment in which the Institute operates changes. They represent the potential for loss resulting from inadequate or failed internal processes or systems, human factors, or external events. They include low impact (and therefore irrelevance) of scientific activities; misallocation of scientific efforts away from agreed priorities; loss of reputation for scientific excellence and integrity; business disruption and information system failure; liquidity problems; transaction processing failures; loss of assets including information assets; failures to recruit, retain and effectively utilize qualified and experienced staff; failures in staff health and safety systems; and failures in the execution of legal, fiduciary and agency responsibilities.

The Board has adopted a risk management policy, communicated to all staff, that includes a framework by which the Institute's management identifies, evaluates and prioritizes risks and opportunities across the organization; develops risk mitigation strategies which balance benefits with costs; monitors the implementation of these strategies; and periodically reports to the Board on results. This process will draw upon risk assessments and analyses prepared by the Institute's staff, internal auditors, Institute-commissioned external reviewers, and the external auditors. The risk assessments will also incorporate the results of collaborative risk assessments with other CGIAR Centers, System Office components and other entities in relation to shared risks arising from jointly managed activities. The risk management framework seeks to draw upon best practice promoted in codes and standards promulgated in a number of CGIAR member countries, and it is subject to ongoing review as part of the Institute's continuous improvement effort.

Risk mitigation strategies include the implementation of systems of internal control which, by their nature, are designed to manage rather than eliminate the risk. The Institute endeavours to manage risk by ensuring that the appropriate infrastructure, controls, systems and people are in place throughout the organization. Key practices employed in managing risks and opportunities include business environmental scans, clear policies and accountabilities, transaction approval frameworks, financial and management reporting and the monitoring of metrics which are designed to highlight positive or negative performance of individuals and business processes across a broad range of key performance areas. The design and effectiveness of the risk management system and internal controls is subject to ongoing review by IWMI's internal audit service, which is independent of business units and reports on the results of its audits directly to the Director General and the Board through the Board's Audit Committee.

Financial Comment

Mr Gerard O'Donoghue, Deputy Director General (Operations)

The period 2000 – 2003 was a period of unprecedented growth for IWMI. Funding increased from $9.1 million in 2000 to $22.4 million in 2003 - an increase of $13.3 million (246%) or an average annual increase of 35%. During this period IWMI established a number of new regional and sub regional offices in Africa, South Asia and South East Asia and invested heavily in setting up this network of regional offices. The number of researchers trebled and IWMI's core business processes were reengineered. Major new activities are now taking place in these regions. 2004 and 2005 are periods of consolidation for IWMI. We have now entered a period where the advances of recent years are consolidated. However, for IWMI this means that funding for core IWMI activities increased by 7% in 2004 and is projected to increase by 7% in 2005. In particular, during the current reporting period major new projects have come on stream in both India and Central Asia. Activities in Ghana and Ethiopia also continue to expand. There has been a corresponding decrease in expenditures and hence activity in Pakistan.

Unrestricted funding has increased in line with the general increase in funding and has increased from 3.9 million in 1999 to 7.4 million in 2004 and a projected $8.2 million in 2005. We are particularly pleased to note the addition of two new donors to our list of core supporters, namely DfID, with a contribution of $0.55 million in 2004 and $1.1 million in 2005 and the European Commission with a contribution of $1.1 million in 2005.

IWMI's financial position continues to be stable and to improve. Total reserves at the end of 2004 were $4.2 million up from $3.2 million at the end of 2003. They are projected to increase to $4.7 million by the end of 2005.

In recent years, the CGIAR have devised two financial indicators for measuring the financial health of centers. The two measures are the adequacy of reserves for measuring the long term financial stability of the center (recommended range 75 – 90 days) and the short term solvency ratio for measuring the liquidity of the center (recommended range 90 – 120 days). IWMI 's long term financial stability ratio of 77 days at the end of 2004, projected to increase to 78 days at the end of 2005 and a short term solvency ratio of 109 days are within the recommended ranges.

IWMI's long term financial ratio is calculated by taking into account both IWMI core expenditures and IWMI's Challenge Program expenditures. It does not include non-IWMI Challenge Program expenditure as set out in the table below:

Expenditures	2000	2001	2002	2003	2004
			US$'000		
IWMI core	9,483	11,923	16,791	19,452	19,648
IWMI Challenge Program	-		631	2,321	1,671
Total IWMI	**9,483**	**11,923**	**17,422**	**21,773**	**21,319**
Non IWMI Challenge Program	-			2,588	2,106
Total	**9,483**	**11,923**	**17,422**	**24,361**	**23,425**

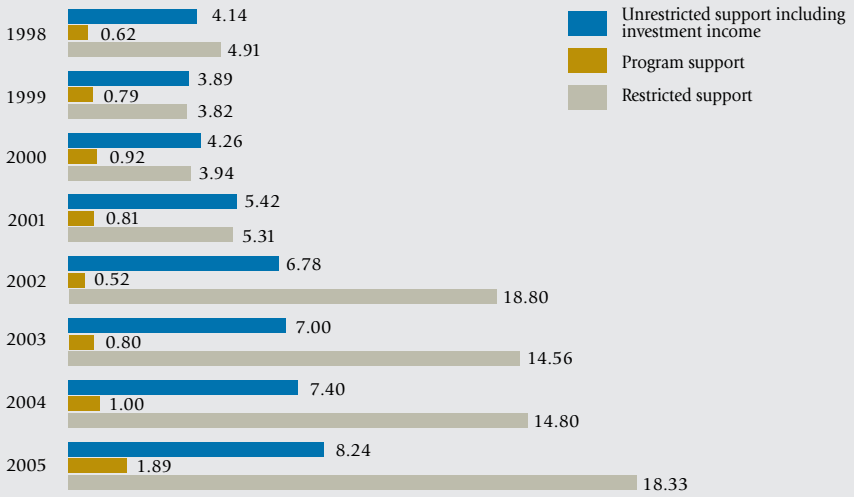
Financial Statements

Income 1998 - 2005

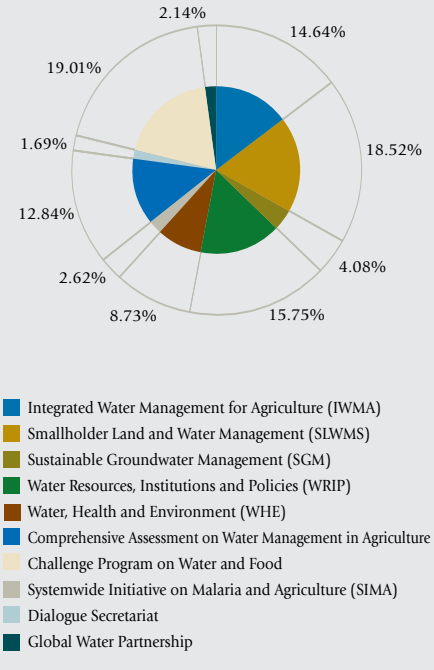
In 2004, the Institute recorded a net surplus of $740,000 compared to the deficit of $724,000 recorded in 2003.

In 2004, the total revenue amounted to $23.2 million. Unrestricted income amounted to $7.4 million.

Income 1998-2005



Direct Research Expenditure by Program - 2004



Auditors' Report

PRICEWATERHOUSECOOPERS

PricewaterhouseCoopers
P. O. Box 918
100, Braybrooke Place
COLOMBO 2
SRI LANKA
Telephone : 94-11-4-719838 (Hunting)
Facsimile : 94-11-2342389

Report of the auditors

To the Board of Governors of International Water Management Institute

1 We have audited the accompanying statement of financial position of International Water Management Institute at 31 December 2004 and the related statements of activities, changes in net assets and cash flows for the year then ended, together with the accounting policies and notes as set out on pages 3 to 24.

Respective responsibilities of the Institute's management and auditors

2 The Institute's management is responsible for preparing and presenting these financial statements in accordance with the recommendations made in the Consultative Group for International Agricultural Research (CGIAR) Financial Guidelines Series No. 2 - CGIAR Accounting Policies and Reporting Practices Manual (revised March 2004). Our responsibility is to express an opinion on these financial statements, based on our audit.

Basis of opinion

3 We conducted our audit in accordance with the International Standards on Auditing, which require that we plan and perform the audit to obtain reasonable assurance about whether the said financial statements are free of material misstatements. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the said financial statements, assessing the accounting principles used and significant estimates made by the Institute's management, evaluating the overall presentation of the financial statements, and determining whether the said financial statements are prepared and presented in accordance with the recommendations made in the CGIAR Guidelines. We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our audit. We therefore believe that our audit provides a reasonable basis for our opinion.

Opinion

4 In our opinion, so far as appears from our examination, the Institute maintained proper books of account for the year ended 31 December 2004, and to the best of our information and according to the explanations given to us, the said statement of financial position and related statements of activities changes in net assets, cash flows and the accounting policies and notes thereto, which are in agreement with the said books and have been prepared and presented in accordance with the recommendations made in the CGIAR Financial Guidelines Series No 2 - CGIAR Accounting Policies and Reporting Practices Manual (revised March 2004) and give a true and fair view of the Institute's state of affairs as at 31 December 2004 and of its activities and cash flows for the year then ended. Supplementary information on pages 25 to 42 are not a required part of the financial statements and have not been subjected to audit procedures applied in the audit of the financial statements.

CHARTERED ACCOUNTANTS

COLOMBO

partners Ms. A. de Soysa ACA, S. Gajendran FCA, Ms. S. Hadgie FCA, Y. Kanagasabai FCA, S. Manoharan ACA, D.T.S.H. Mudalige FCA, Ms. S. Perera ACA, Ms. H.C. Ratnayake FCA, P.D. Rodrigo FCA.

Restricted Research Contracts over US$ 50,000 Awarded in 2004

Krishna River Basin Project (ACIAR) - $861,725 (Australian Dollars 1,120,240) **over 4 years**

To improve water productivity in agriculture in the Krishna Basin by providing technical & economic information & decision support to the Central Water Commission & Ministry of Water Resources, as advisory agents to the Krishna Basin Tribunal, and to the riparian states.

Benchmarking NARBO (ADB) - $86,094 over 2 years

To develop guidelines for benchmarking performance of river basin organizations; and provide a common platform for exchange of data and performance assessments through a web enabled multi-lingual database.

Assessment of hydro-geographical potential of skimming wells (WAPDA) - $61,851 (Pakistan Rupees 2776,210 & US$14,797 **over 1 year**

To delineate areas suitable for skimming wells while estimating the thickness of fresh groundwater lenses above the underlying native saline groundwater layers; and to understand farmers' perceptions regarding the social acceptability; economic viability; and potential for use of skimming wells in saline groundwater areas having different hydro-geological and hydro-salinity conditions.

IWMI-Tata Water Policy Research Program (Switzerland) - $162,520 (Swiss Francs 200,000) **over 1 year**

The IWMI-Tata Program is a partnership between IWMI, Sir Ratan Tata Trust, Mumbai and the Swiss Agency for Development Cooperation. In its fifth year, the Program has emerged as a premier network working with around 100 Indian researchers, NGOs, local research center and government agencies to develop a more refined understanding of India's water challenges and recommend approaches to overcome them.

Water Energy Nexus in Agriculture (WENEXA-II) (USAID) - $210,686 over 4 years

To provide strategic input to the USAID Water Team on bridging the gap between the water and power sectors and address the problems faced by the two sectors through dialogue and policy reform.

Assessment of experience and identification of opportunities (CANADA) - $68,100 (Canadian Dollars95,000) **over 3 months**

Assessment of experience and identification of opportunities for promoting small-scale and micro irrigation technologies, and rainwater harvesting to improve food security in Ethiopia.

Strengthening Consortium for Spatial Information (World Bank) - $465,120 over 3 years

To implement the project–Information and Communication Technology (ICT)/Global Public Goods (GPG)

Program: Consortium for Spatial Information (the Activity), proposed by the CGIAR Center Directors' Committee.

Hub Training Program (World Bank) - $66,374 over 1 year

To enhance the operational understanding of Bank Staff on water, soil, and natural resource management issues, especially in the Africa region, by sharing knowledge on best policy and practices and cutting edge research results while generating issue-based and operation-oriented guidance for current/future research agenda for IWMI, other CG Centers, and partners, especially in Africa. The project will explore options for organizational synergies to link research, policy, and operation.

ICUC Project on underutilised crops research (DFID) - $620,750 (Sterling Pounds 325,000) **over 3 years**

Improving sustainable livelihoods and income generation for small-scale rural farmers. This will be developed and promoted through the production and utilisation of targeted underutilized crops.

ICT-KM E-Publishing Project (World Bank) - $390,000 over 2 years

To implement the project-Information and Communication Technology (ICT)/Global Public Goods (GPG)

Program: E-Publishing Systems (the Activity), proposed by the CGIAR Center Directors' Committee.

SIMA (Systemwide Initiative on Malaria and Agriculture) Mwea Phase II (IDRC) - $424,920 (Canadian Dollars 578,150) **over 2 years**

To better understand the important links that exist between agriculture and malaria and contribute to the identification of opportunities for minimizing malaria risks through agriculture-based interventions.

Comprehensive Assessment

Irrigation Impacts & Poverty in Ethiopia (Government of Austria) - $371,438 (EURO 306,000) **over 2 years**

For a program that will examine the impacts of irrigation on poverty and natural resources.

Challenge Program

DFID(Department for International Development) - $4,666,250 (Sterling Pounds 2,500,000) **over 2 years**

GTZ(Deutsche Gesellschaft fur Technische Zusammenarbeit) - $923,078 (Euro 1,000,000) **over 3 years**

Norway - $441,273 (Norwegian Kronor 3,000,000) **over 1 year**

SIDA (Swedish International Development Cooperation Agency) - $103,732 (Swedish Kronor 683,334) **over 1 year**

Denmark - $363,435(Danish Kroner[DKK]2,100,000) **over 1 year**

Swiss Agency for Development and Cooperation - $631,912 (Swiss Francs 800,000) **over 1 year**

World Bank - $2,500,000 over 1 year

Unrestricted, Restricted 2004

	Grant 2004 US$'000	Grant 2003 US$'000
Unrestricted		
Australia	328	269
Belgium	98	106
Canada	656	451
Denmark	327	448
France	-	91
Germany	290	275
India	38	38
Iran	155	97
Ireland	730	511
Japan	253	296
Netherlands	1,053	869
Norway	74	139
Sweden	413	349
Switzerland	307	157
Thailand	10	-
United Kingdom	536	-
USAID	759	690
World Bank	1,200	2,039
Subtotal Unrestricted	**7,227**	**6,825**
Other Revenue		
Investment income	127	44
Sundry income	43	136
Subtotal Other Revenue	**170**	**180**
Total (Unrestricted Resources)	**7,397**	**7,005**
Restricted		
African Development Bank	596	190
Asian Development Bank	320	694
Austria	127	
Australia/Australian Centre for International Agricultural Research (ACIAR)	212	162
Canada	463	376
Center for Environmental Economics & Policy in Africa (CEEPA)		18
CEMAGREF	-3	22
Denmark	228	114
Food and Agriculture Organization	134	195
France	2,124	1,546
Germany	50	
International Centre for Research in Agroforestry (ICRAF)	59	
IFAR Nourishing Scientific Excellence through the CGIAR		10
International Fund for Agriucltural Development (IFAD)	8	10
India (ICID)	310	
International Development Research Centre (IDRC)	322	198
International Food Policy Research Institute (IFPRI)		3
InWENT (former DSE)	127	
Japan	347	282
Japan Bank for International Cooperation (JBIC)	22	148
National Education Commission (NEC)		12
Netherlands	3,364	4,568
Norway	441	347
OPEC Fund for International Development	91	9
Other Donors	162	107
Royal Government of Cambodia (RGC)		14
South Africa	225	75
Sri Lanka	54	58
Sweden (SIDA)	1,057	627
Switzerland	1,973	1,533
Taiwan	33	42
TATA Foundation	340	310
United Nations Environment Programme (UNEP)		38
UNESCO	3	18
United Kingdom (DFID)	1,793	50
USAID	601	408
United States Department of Agriculture (USDA)		68
Volkswagen Foundation	16	
Water And Power Development Authority (WAPDA)	41	51
World Health Organization	3	
World Bank	460	2,970
ZEF	104	108
ZIL/Switzerland	48	63
	15,818	15,881
AFRICAN WATER DOME		-534
Total (Restricted Resources)	**15,818**	**15,347**
Total Grants	**23,215**	**22,352**

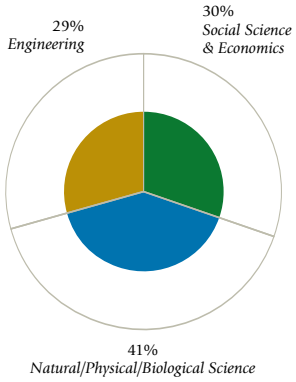
Statement of Financial Position, December 31, 2004 and 2003

	2004 US$'000	2003 US$'000
ASSETS		
Current Assets		
Cash and cash equivalents	15,013	9,323
Accounts receivable: (Net of $100,000 allowance for doubtful accounts)		
Donor	2,437	2,712
Employees	92	195
Other CGIAR Centers	141	94
Others	718	392
Inventories	39	43
Prepaid expenses	288	236
Total current assets	18,728	12,995
Non-Current Assets		
Property, Plant and Equipment, net	2,021	2,231
TOTAL ASSETS	**20,749**	**15,226**
LIABILITIES AND NET ASSETS		
Current Liabilities		
Accounts payable		
Donor	12,116	5,725
Employees	21	71
Other CGIAR Centers	26	237
Others	590	2,086
Accruals	113	43
Total current liabilities	12,866	8,162
NON CURRENT LIABILITIES		
Accounts payable		
Employees	1,659	1,582
Total non current liabilities	1,659	1,582
Total liabilities	14,525	9,744
Net Assets		
Unrestricted		
Designated	3,272	3,270
Undesignated	2,952	2,212
Total net assets	6,224	5,482
TOTAL LIABILITIES AND NET ASSETS	**20,749**	**15,226**

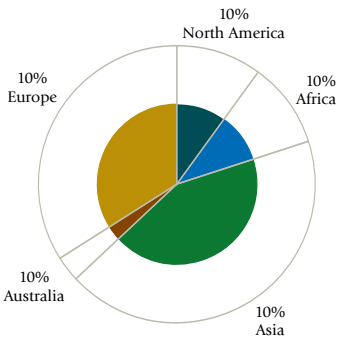
Distribution of Staff by discipline, nationality and region

On 31 January 2005, the institute had 109 researchers of whom 88 were internationally and regionally recruited. The latter includes 6 Associate Experts, seconded by the Netherlands, and Sweden and 8 Post Doctoral Fellows. On 31 January 2005 IWMI total staff numbered 346.

IWMI Researchers
(by Discipline, 2005)



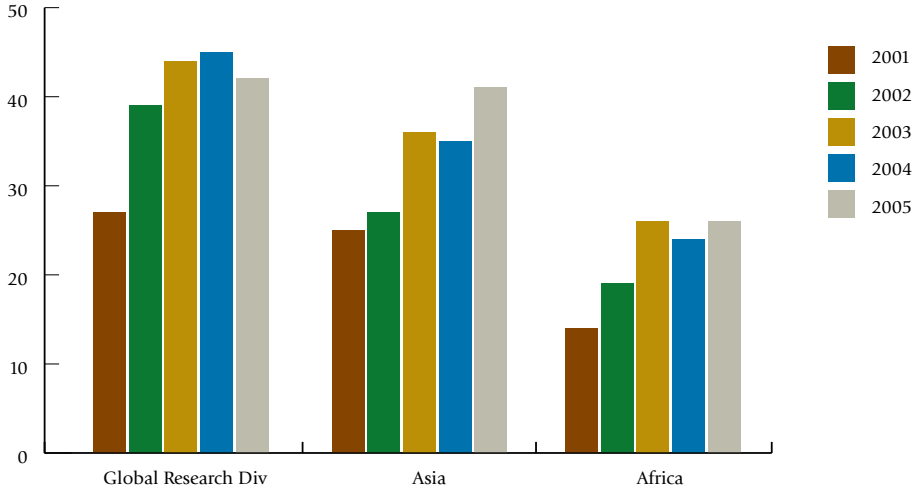
IWMI Researchers
(by Nationality, 2005)



Overview of IWMI Staff by Nationality as of 31 January 2005

Country	Research	Research Support	Non-Research
Australia	3	0	1
Bangladesh	0	1	0
Belgium	1	0	0
China	1	0	0
Denmark	2	0	0
Ethiopia	2	0	0
France	14	0	1
Germany	1	0	0
Ghana	0	5	12
India	13	15	10
Ireland	0	0	1
Japan	2	0	0
Kenya	2	1	1
Nepal	3	0	1
Netherlands	9	0	1
Nigeria	2	0	0
Norway	1	0	0
Pakistan	5	13	20
Philippines	1	0	0
Russia	1	0	0
Senegal	1	0	0
South Africa	1	2	7
Sri Lanka	18	23	99
Sweden	1	0	0
Switzerland	2	0	0
Thailand	2	3	11
Tunisia	1	0	0
U.K.	6	0	2
U.S.A.	10	0	0
Uzbekistan	1	2	5
Vietnam	1	0	0
Zimbabwe	2	0	0
Total	109	65	172

Distribution of Research Staff by Region



Gender & Diversity Staffing

Gender & Diversity balance is one of IWMI's goals. The HR department continues to monitor and to ensure that IWMI's gender & diversity ratios are in line with CGIAR guidelines.

IWMI strategic plan 2004-2008 has set a target to increase the number of women researchers from the south to 40%. We are pleased to report that IWMI is on target where we have increased the number of women researchers from the south from 13 in 2001 to 27 in 2005. In the last quarter of 2004, IWMI advertised for 19 researcher positions in various disciplines. Out of this we made offers to 8 female researchers and 9 to male researchers.

Gender & Diversity Policies

In addition to the existing family friendly policies, the Board approved a new set of policies on Spouse Employment, Flexi-time & Telecommuting at the 2004 Board meeting. These new policies are now implemented and should further assist us in increasing our gender & diversity initiatives.

Mentoring

Owing to the success and the positive feedback from the participants of the first G&D mentoring program, the second program was launched in 2004. The objective of this program is to provide structured development input to young staff members by more senior staff members as mentors. The second batch consists of 17 mentees and 12 mentors. The 17 mentees consist of 13 women and 4 men representing an increase of women mentees from 3 to 13 over the first batch. There are 8 research/research support staff and 9 non research staff, 10 NRS, 3 RRS/IRS. One mentee is from the north and the balance 16 mentees are

Diversity at different organizational levels as at 1 January 2005

	Male			Female			
	North	South	Sub-total	North	South	Sub-total	Total
Board of Trustees	3	1	4	3	4	7	11
	27%	9%	36%	27%	36%	64%	100%
Management Team	3	0	3	2	1	3	6
	50%	0%	50%	33%	17%	50%	100%
Researchers	38	44	82	14	13	27	109
	35%	40%	75%	13%	12%	25%	100%
Breakup of Researchers							
Principal Researcher - I	13	7	20	3	1	4	24
Senior Researcher - I	8	6	14	4	0	4	18
Senior Researcher - R	0	4	4	0	2	2	6
Researcher - I	9	3	12	4	2	6	18
Researcher - R	1	4	5	0	3	3	8
Researcher - N	1	17	18	0	3	3	21
Post Docs/AE's	6	3	9	3	2	5	14
Research Support (NRS)	0	50	50	0	15	15	65
	0%	77%	77%	0%	23%	23%	100%
Non-Research Staff	3	99	102	2	68	70	172
	2%	58%	59%	1%	40%	41%	100%
Breakup of NRS Staff							
Principal Managers/Managers I	1	0	1	1	0	1	2
Senior Managers/Managers-I	1	0	1	1	0	1	2
Senior Managers/Managers-R	1	2	3	0	4	4	7
Senior Managers/Managers-N	0	7	7	0	2	2	9
Senior Officers/Officers-N	0	26	26	1	31	32	58
Staff-N	0	64	64	0	31	31	95
Total	**41**	**193**	**234**	**16**	**96**	**112**	**346**

Gender & Diversity Initiatives

from the south. 11 mentees are from headquarters, 3 are based in Tashkent and 1 each based in South Africa, Ghana and Ethiopia.

Leadership Development

The G&D mentoring program complements the IWMI Leadership Development Program (LDP). The IWMI LDP is a two year training intervention where high potential staff across the Institute, in particular from the South, are identified and inputs through formal courses and close mentoring by senior staff is provided to facilitate their accelerated growth within the organization. The first LDP which was launched in 2003 with 12 mentees and 4 mentors concluded in March 2005. The 12 mentees included 7 women and 5 men, 9 researchers and 3 non research staff, 7 NRS staff and 5 RRS/IRS staff. LDP-1 is considered a success by both participants and IWMI management and the impact of their development over the past two years is already visible in the organization. Considering the success of the first program IWMI LDP-2 commenced with 12 new mentees (along with 4 mentors). The mentee group consists of 6 women and 6 men, 8 researchers and 4 non-research staff, 4 NRS and 8 RRS/IRS.

IWMI's Leadership Development Program (LDP) in session. High potential staff are trained across the institute through formal courses and mentoring by senior staff, to facilitate their accelerated growth within the organization.

Staff from 01.01.2004 to 31.03.2005

HEADQUARTERS

Director General's Office

Dr. Frank Rijsberman, Director General, Dr. Meredith Giordano, Research Director, Mr. Gerard O'Donoghue, Deputy Director General (Operations), **Non-Research:** Ms. Shalini Kumaresan, Senior Secretary, Ms. Coretta De La Zilwa, Senior Secretary

Program Office

Non-Research: Ms. Upeka Kariyawasam, Head, Program Office, Mr. Sanjiv de Silva, Program Officer, Ms. Natalia Abeynayake, Donor Relations Coordinator, Ms. B.A.M. Hasinika Piyasena, Quality Management Systems Coordinator, Ms. Arosha Ranasinghe, Secretary

Information and Knowledge Group

Mr. Stuart Tippins, Head, Information and Knowledge Group, Mr. Michael Devlin, Chief Knowledge Officer, **Communication & Knowledge Sharing: Ms. Sanjini De Silva, Head, Communications & Knowledge Sharing, Mr. Patrick Fuller, Senior Communications Advisor, *Ms. Sarah Carriger, Head, Writer/Editor, Ms. Dawn Rodriguez, Communications Coordinator/Writer, Ms. Charmalee D. Jayasinghe, Web Master/Communications Coordinator, Ms. Sharni Jayawardena, Communications Coordinator, Ms. Tasneem Amirally Akbarally, Communications Officer, Mr. Dominique Michael Perera, Web Services Officer, Ms. Sharmani Gunawardena, Secretary, **E-Publishing:** *Mr. Kithsiri Jayakody, Print Manager, *Ms. Nilmini Matthysz, Traffic and Workflow Coordinator, Ms. Pavithra Amunugama, Administrative Officer - Workflow/Traffic, Mr. Joseph Perera, Production Editor, Mr. Harshana Rambukwella, Production Editor/Entry-level Science Writer, Mr. Nimal Fernando, Manager Special Projects, *Mr. Surendra Wegodapola, Layout and Graphics Specialist, Mr. Sumith Fernando, Layout and Graphics Specialist, Ms. Shyamine Faleel, Layout and Graphics Specialist, Mr. Nimal Attanayake, Layout and Graphics Specialist, **E–Library:** Ms. Ramya de Silva, Head, E - Library, *Ms. Shanthi Sri Nammuni, Information Management Assistant, Ms. Manik de Alwis, Information Management Assistant, Mr. Chandima Gunadasa, Electronic Library Resources Specialist, Ms. Sandya Suriyarachchi, Information Management Assistant, Mr. Kaushalya Moragaspitiya, Information Management Assistant, **Information & Communications Technology (ICT):** Ms. Ruwanthi Fernando, Head, Information and Communications Technology, *Mr. Sunil Weerasinghe, Head, Information & Communication Technology, Mr. Nirudha Perera, Network Administrator, *Mr. G. Rajkumar, Internet Site Webmaster, Mr. M.Z.M. Riazzi, Database Developer/Administrator, Mr. Ranjith Wickremasinghe, Systems Administrator, Mr. Santha Marasinghe, PC Support Technician, Ms. Veronica Lumanauw, Administrative Officer, Mr. Shaminda Illangatilaka, Assistant Network/Systems Administrator, Mr. S.A. Anjitha Senarath, Intranet/Web Services Developer, Mr. Sanjeewa Amarasekara, Help Desk Coordinator, Mr. Arshad Razali Iyne, Help Desk Coordinator, Ms. Woranga Palingu Kumari Atukorale, Software Engineer

Finance & Administration Division

Accounts: Mr. Gamini Halvitige, Financial Controller, Mr. Ranjith Samarakoon, Accountant, Ms. Sanjeevani Perera, Head, Budget, *Mr. Ajith Ratnayake, Senior Accounts Officer, Mr. Kushan Perera, Accounts Officer - Financial Systems, Mr. Manoj Gunasekera, Accounts Officer - Financial Systems, Mr. Manjula Rowel, Accounts Officer - Financial Systems, Mr. Shantha Kumara Gamage, Assistant Budget Officer, Ms. Chanchala Kariyawasam, Time Management/ Administrative Officer, Mr. Tissa Rajanayake, Accounts Officer, Ms. Sriyani G. Seneviratne, Accounts Officer, Ms. Yvonne Weerasinghe, Administrative Officer, Mr. Mahilal Jayawardena, Stores Officer, *Ms. Priyanka Rajakaruna, Data Processor, Mr. Kumara Dharmasiri, Cashier/Accounts Clerk, Ms. Dhanushi Samaranayake, Junior Secretary, Mr. D.M. Gunasekera, Stores Helper, *Mr. Sithira Weeratunga, Accounts Clerk, **Human Resources:** Mr. Sharat Kumar Sadashivpeth, Head, Human Resources, Ms. Shanthi Weerasekera, Deputy Head, Human Resources, Ms. Kamani Rajanayake, Personnel Officer, Mr. David Van Eyck, Training, Career Development & Capacity Building Officer, Ms. Anusha De Silva, Human Resources Administrator, Ms. Thushari Samarasekera, Human Resources Administrator, **Administration:** Mr. Sepala Amarasuriya, Head, Purchasing and Administrative Services, Mr. Upali Karunanayake, Senior Purchasing Assistant, Ms. Shahanaz Makawita, Secretary, *Mr. M. Ramraj, Senior Steward, **Office Support Systems:** Mr. S.M.B. Seneviratne, Manager - Office Support Systems Office, Mr. Ajith Wijayaratne, Distribution Officer, Ms. Sujatha Dassanayake, Receptionist/Junior Secretary, Ms. Viranga Kularatne, Receptionist/Junior Secretary, Mr. A. Joseph, Junior Clerk, Mr. K. Punchibanda, Junior Clerk, Mr. N.S. Ranjithsinghe, Junior Clerk, Mr. S.M. Edirimanne, Production Assistant/Clerk, Mr. Lal Abeykoon, Junior Clerk, Mr. S.M.H.P. Samarakoon, Office Aide/Steward

Transport & Maintenance: Mr. Eardley De Silva, Acting Head, Building and Transport, Mr. Kapila Pathiraja, Assistant Manager, Building Engineering Services & Transport, Ms. Thusitha Jayatilleke, Administrative Officer, Mr. Ravi Dissanayake, Transport Assistant, Ms. Iresha Dharmawardhana, Administrative Assistant, Mr. S. Arockiam, Plumber, Mr. P.W. Pathirana, Electrician, Mr. S. Krishnarajah, Junior Clerk, Mr. P.A. Rezel, Electrician, Mr. Sunil Jayatillake, Carpenter/Fitter, Mr. K.G.S. Kumara, Driver, Mr. Priyantha Chandrasena, Driver, Mr. Ajith Perera, Driver, Mr. Ajantha Perera, Driver, *Mr. Mahinda Karandawatte, Driver, *Mr. Y.K.G. Costa, Driver, Mr. K.K.R. Kumara, Driver, Mr. W.D. Upali, General Labourer, Travel Office: Mr. Nihal Silva, Visa Coordinator, Ms. Nazreen Yousuf, Conference and Travel Officer.

Global Research Division (Sri Lanka)

Principal Manager: Ms. Julie Van der Bliek, Director Global Research Division, **Principal Researchers:** Dr. David Molden, Leader, Comprehensive Assessment of Water Management in Agriculture, Dr. Felix Amerasinghe, Principal Researcher Health and Environment, Dr. Francois Molle, Water Management Specialist, Dr. Vladimir Smakhtin, Principal Eco-Hydrologist, Dr. Hugh Turral, Leader, Theme Basin Water Management, Dr. Francis Gichuki, CP Theme Leader - Integrated Basin Water Management Systems, Mr. Naoya Fujimoto, Principal Researcher/Deputy Coordinator Comprehensive Assessment, Dr. Max Finlayson, Principal Researcher, Wetland Ecology, Dr. Deborah Bossio, Leader, Theme Land, Water, Livelihoods, **Senior Researchers:** Dr. Sarath Abayawardana, Head, Sri Lanka Program, Dr. Charlotte de Fraiture, Head, Global Change, Health and Environment, Environment Analysis, GRD, Dr. Mark Giordano, Head, Policy and Institutions (GRD), Dr. Prasad Thenkabail, Head, RS-GIS Lab (GRD), Dr. Chu Thai Hoanh, Senior Water Resources Engineer, Dr. Rathinasamy Maria Saleth, Senior Institutional Economist, Dr. Robert Zomer, Senior Landscape Ecologist, Dr. Intizar Hussain, Senior Economist, Dr. Liqa Raschid-Sally, Waste Water Specialist, Dr. Karen Villholth, Ground Water Modeling Specialist, Dr. Priyanie Amerasinghe, Biomedical Research Scientist, Dr. Flemming Konradsen, International Health Specialist, Researchers: Ms. Rebecca Tharme, Leader, Theme Water Management & Environment, Mr. K. Jinapala, Institutions Specialist, Mr. Manju Hemakumara, Benchmark Basin Coordinator, Mr. S.C Piyankarage, Chemist, Ms. Dilkushi De Alwis, Junior Hydrologist, Dr. Sitara Atapattu, Coastal Zone Ecologist, Comprehensive Assessment of Water Management in Agriculture, Mr. Parakrama Weligamage, Economist, Mr. Dhananjaya Niriella, Environmental Engineer, Ms. Sophie Nguyen Khoa Man, Fisheries Specialist, Dr. Pierre Marchand, Database Architect, Ms. Domitille Vallee, Water, Food, Environment Specialist/Assessment Facilitator - Comprehensive Assessment on Water Management in Agriculture, Dr. Jean-Luc Sabatier, Water Management Specialist, Ms. Yuan Jie Li, Researcher, Ms. Alexandra Clemett, Researcher-Livelihoods/Water Quality/Waste Water, Dr. Regassa Ensermu Namara, Economist, Mr. Lal Muthuwatta, Hydrologist/Mathematical Modeler, Dr. Mobin-ud-Din Ahmad, Researcher - Hydrologist and Remote Sensing Specialist,

Mr. Olivier Briet, Medical Entomologist, Post-Doctoral Scientists: *Dr. Madhusudan Bhattarai, Applied Economist/Environmental Economist, Dr. Nicolas Roost, Irrigation and Water Management Specialist, *Dr. Francis Canisius, Remote Sensing Specialist, Dr. Lisa Freja Schipper, Post-Doctoral Fellow - Comprehensive Assessment of Water Management in Agriculture, Dr. Line Gorden, Post Doctoral Scientist, **Research Officers:** Mr. P.G. Somaratne, Sociologist, Mr. B.R. Ariyaratne, Benchmark Basin Coordinator, *Mr. Sunil Thrikawala, Agricultural Economist, Mr. Noel Aloysius, Water Resources Engineer, Mr. Shahriar Pervez, GIS Specialist, Mr. Chandana Gangodagamage, Remote Sensing Specialist, Mr. Neelanga Weragala, Water Resources Engineer, Mr. Deeptha Wijerathna, Agricultural Economist, Mr. Priyantha Jayakody, Agricultural Engineer, Mr. M.G.S.D. Nilantha, Remote Sensing/GIS Specialist, Ms. K.H. Thushara Abeysekera, Chemist, Ms. Nishadi Eriyagama, Water Resources Engineer, Ms. Priyanka Dissanayake, Environmental Scientist, Ms. R. Wasantha Kulawardhana, Remote Sensing/GIS Specialist, Mr. Jagath Chandralal Vithanage, Remote Sensing/GIS Specialist, Ms. Shyamalie de Silva, Social Scientist, Mr. Markandu Anputhas, Biometrician, *Dr. Roshan Priyantha De Silva, Water Resource Engineer, **Research Support:** Mr. M. Dayananda, Field Data Collector, Mr. Nihal Dayasena, Field Data Collector, Mr. Sarath Lionalratne, Field Data Collector, *Mr. D.R.G.S.P. Ranasinghe, Field Data Collector, Mr. N.G. Indrajith, Field Data Collector, Mr. A.D. Ranjith, Digitizing Operator, Ms. Thushari Perera, Research Assistant, *Mr. Pradeep Dissanayake, GIS Technician, Mr. D.G.S. Gunasinghe, Digitizing Operator, **Non-Research:** Ms. Sepali Goonaratne, Administrative Officer, Ms. Mala Ranawake, Administrative Officer, Ms. Janitha Godamuduna, Senior Secretary, Ms. Himani Elangasinghe, Senior Secretary, Mr. M. Sadir, Software Developer, *Mr. Nedumaran Balakrishnan, Assistant IT Officer, Mr. Nishath Yapa, Datawarehouse Database Administrator, Mr. Subramaniam Jeyakumaran, Data Warehouse Software Engineer, Mr. Tharmanathan Ramkumar, Data Warehouse Database Administrator, Ms. Ashra Fernando, Secretary, Ms. Samanmali Jayatillaka, Secretary, Ms. Nilupuli Pethiyagoda, Secretary, Ms. Lakmali Wijesinghe, Metadata Assistant, Mr. D.W. Premachandra, Data Entry Clerk.

REGIONAL/SUB-REGIONAL OFFICES

Regional Office Southeast Asia (Thailand)

Principal Researchers: Dr. Andrew Noble, Head, South East Asia, Mr. Ian Makin, Principal Water Management Specialist, *Dr. Randolph Barker, Principal Economist, **Senior Researchers:** Dr. Suraphol Chandrapatya, Agricultural Extension & Development Specialist, *Dr. Amado Maglinao, Farming System Specialist, *Mr. Jean-Pierre Bricquet, Hydrologist, **Researchers:** Dr. Rob Simmons, Soil Scientist, Mr. Jean-Louis Janeau, Soil Scientist, **Associate Experts:** Dr. Mathew Kurian, Institutions/Natural Resources Management Specialist, Post Doctoral Scientists: *Dr. Mohammed Mainuddin, Water Resources Engineer, *Dr. Hans Overgard, Entomologist, Dr. Shinji Suzuki, Soil Scientist, **Research Officers:** Mr. Rungnadhee Phonkarm, GIS Assistant, *Mr. Sirijit Sangunurai, Environmental Engineer, Ms. Wannipa Soda, Agricultural Scientist, Ms. Orn Uma Polpanich, Agricultural Scientist, **Research Support:** Ms. Sararin Klinphonklap, Research Assistant, *Ms. Duangdao Saiyasitpanich, Research Assistant, **Non-Research:** Ms. Sumana Kmolpun, Accountant, Ms. Naiyana Puranachoti, Administrator, Mr. Suparuek Puttakhot, System Network Administrator, *Ms. Darakul Srichoorom, Accountant, Ms. Lakana Sangkhakorn, Information Officer, Mr. Tanadol Compo, Compositor/Graphics Designer, Mr. Pornchai Luechatmatikul, Administrative Assistant, Mr. Narin Peeraoranun, Cashier, Ms. Jutima Anumatratchakit, Office Manager, Ms. Jirapar Boonyasurakul, Group Secretary, Ms. Banyen Taruen, Office Service.

Sub Regional Office - Laos

Principal Researcher: Dr. Christian Valentin, Head, IWMI-Laos, **Senior Researcher:** Dr. Anneke De Rouw, Agronomist, **Researchers:** *Dr. Vincent Chaplot, Soil Scientist GIS Specialist, *Mr. Guillaume Lestrelin, Geographer, Dr. Olivier Ribolzi, Hydrogeochemist, Mr. Jean-Pierre Thiebaux, Hydrologist, Mr. Nobert Silvera, Hydrologist

Sub Regional Office - Vietnam

Senior Researchers: Dr. Didier Orange, Hydrologist & Geochemist, Dr. Pascal Podwojewski, Soil Scientist

Sub Regional Office - Cambodia

Researcher: Mr. L.R. Perera, Social Scientist

Regional Office (Central Asia) Pakistan

Principal Researcher: Dr. Zhongping Zhu, Head, IWMI-Pakistan, **Researchers:** Dr. Muhammad Nadeem Asghar, Senior Agricultural Engineer, *Dr. Waqar Jehangir, Senior Agricultural Economist, **Research Officers:** *Mr. Mujeeb Akhtar, Research Officer, *Mr. Abdul Hamid, Social Scientist, *Mr. Muhammad Kaleem Ullah, Junior civil Engineer, Mr. Abdul Hakeem Khan, Project Manager, Mr. Ilyas Masih, Research Officer, Mr. Zubair Masood, Junior Researcher, *Mr. Shahzad Mahmood, Assistant Engineer, *Mr. Khalid Mehmood, Associate Engineer, Mr. Wagas Ahmad, Assistant Engineer, Mr. Muhammad Hamed Khan, Assistant Engineer, *Mr. Muhammad Mukhtar, Junior Researcher (Malaria), Mr. Sarfraz Munir, Junior Researcher (WM), *Mr. Shehzad Ahmad, Junior Researcher, Mr. Amir Nazeer, Economist, *Mr. Salman Sarwar, Junior Researcher, *Mr. Muhammad Shoaib, Research Officer, *Mr. Abdul Shakoor, Research Officer, Mr. Asghar Hussain, Spatial Data Analyst, **Research Support:** *Mr. Muhammad Arshad, Field Assistant, *Mr. Anwar Iqbal, Senior Research Assistant, *Mr. Shahzad Khan, Field Assistant, Mr. Tariq Mehmood, Research Assistant, *Ms. Nyla Tabassum, Research Assistant, *Mr. Muhammad Shuaib, Assistant Engineer, Mr. Noor ul Amin, Field Assistant, **Non-Research:** Mr. Ata-ur-Rehman, Research Officer, Mr. Tabrez Ahmad, Secretary/Personnel Assistant, Mr. Moghis Ahmad, Accountant, Mr. Siddique Akbar, Maintenance Supervisor, Mr. Abdul Hayee Kashif, Assistant Accountant, Mr. Asif Mahmood, Manager IT, *Mr. Ishaq Muhabbat, Assistant Network Administrator, *Mr. Muhammad Manshah, Purchase Officer, Mr. Muhammad Shafiq, Office Assistant, Mr. Riaz Wicky, Office Aid/General Helper, Mr. Muhammad Yousaf, Cook cum Chowkidar, *Mr. Jacob Yousaf, Driver, Mr. Akram Masih, Sweeper/Cleaner, Mr. Ashraf Masih, Gardener, *Mr. Muhammad Asghar, Laborer, Ms. Saiqa Batool, Communication Assistant, Mr. Eric Benjamin, Travel/Logistics Counselor, *Ms. Ayeshah Bhatti, Technical Editor/Communication Head, Ms. Farzana Taj, Librarian, Mr. Nadeem George, Bearer/Cleaner, *Mr. Mohammad Jabar Iqbal, Driver, *Mr. Mohammad Javaid Iqbal, Driver/Office Assistant, Mr. Pervaiz Ramzan, Transport Incharge, Mr. Muqarab Khan, Driver, Mr. Shireen Wahab, Driver, Mr. Muhammad Javed, Office Boy, Mr. Mohammad Jehangir, Bearer/Cleaner, Mr. Shireen Wahab, Driver.

Sub Regional Office - Iran

Researchers: Dr. Asad Sarwar Qureshi, Head, IWMI-Iran, **Non-Research:** Ms. Atefeh Davarzaman, Secretary, Mr. Masood Badarkhani, Driver.

Sub Regional Office - Uzbekistan

Researchers: Mr. Mehmood Ul Hassan, Head, Central Asia, Dr. Iskandar Abdullaev, Water Management Specialist, Research Officer: *Dr. Bakhtiyar Matyakubov, Research Officer, Ms. Nargiza Nizamedinkhodjaeva, Research Officer, Mr. Murat Yakubov, Research Officer, Non-Research: Mr. Ilhom Babaev, Administrative Secretary, Ms. Liliya Gatina, Accountant, Mr. Alexy Filonenko, IT Specialist/Administrative Support Staff, Mr. Ilya Park, Driver/Office Assistant, Mr. Ilshat Tukhvatullin, Driver/Office Assistant, Ms. Olga Petrova, Cleaner/Office Assistant

Regional Office South Asia (Hyderabad)

Principal Researchers: Dr. Christopher Scott, Director Asia, **Dr. Peter McCornick, Director, Asia, Dr. Madar Samad, Principal Researcher/Head, South Asia Office, **Senior Researchers:** Dr. Herath

Manthrithilake, Researcher - Water Resources Management, **Researchers:** *Mr. Jeroen Ensink, Research Associate, Dr. Marepalli Sivamohan, Visiting Scientist, Mr. Shirish Sinha, Researcher (Water - Energy), Dr. Ranjitha Puskur, Researcher Economics, Dr. Anju Gaur, Researcher - Water Resources Engineering, **Post Doctoral Scientists:** Dr. Trent Biggs, Post-Doctoral Scientist/Water Quality, *Dr. Stephanie Buechler, Livelihoods and Wastewater Coordinator, **Associate Experts:** Ms. Jetske Bouma, Environmental Economist, Mr. Mattia Celio, Associate Expert - Water Management and Policies, **Research Officers:** Mr. P. Narayana, Senior Research Associate - Energy Water Management, Mr. Murali Krishna Gumma, Research Associate (GIS Modeling), Mr. T.P. Gangadhara Rao, Research Associate (GIS Modeling), Ms. Gayathri Devi, Research Associate - Urban Agriculture and Wastewater Livelihoods, Ms. Cecilia Abraham, Communications Officer - Vitual Academy for Semi Arid Tropics, Research Support: Ms. R. Rama Devi, Research Assistant, Ms. Urmila Matha, Research Assistant, Non-Research: Ms. P. Roja Rani, Administrative Associate, Ms. Judith Christiana, Administrative Associate, Ms. Navanita Raghupathi, Administrative Associate, *Mr. Syed Liaqatullah, Driver-cum-General Assistant, Mr. Mohammed Qadir, Driver-cum-General Assistant

Sub Regional Office - New Delhi

Senior Researchers: Dr. B.R. Sharma, Liaison Officer/Senior Researcher, Dr. Upali Amarasinghe, Senior Statistician, **Non-Research:** Ms. Meena Negi, Administrative Associate, Mr. Sanjay Singh Bisht, Driver-cum-General Assistant

Sub Regional Office - Anand

Principal Researcher: Dr. Tushaar Shah, Principal Researcher Groundwater Management, **Associate Expert:** Ms. Bhawana Upadhyay, Gender Specialist, **Research Support:** Mr. Rakesh Tiwary, Consultant, , Dr. O.P. Singh, Junior Consultant, Mr. Jayesh Talati, Junior Consultant, Mr. M.M. Kapadia, Junior Consultant, Mr. Santanu Ghosh, Junior Consultant, Mr. Shekhar Sinha, Junior Consultant, Mr. Dhaval Pandya, Junior Consultant, *Mr. Vaibhav Bhamoriya, Junior Consultant, *Mr. Abhisek Sharma, Junior Consultant, *Ms. Sanjoli Batra, Junior Consultant, *Ms. Archana Londhe, Junior Consultant, *Mr. Rahul Ranade, Junior Consultant, Ms. Amrita Sharma, Junior Consultant, **Researchers:** Mr. M. Dinesh Kumar, Engineer and Project Director North Gujarat Initiative Project, Mr. Avinash Kishore, Social Scientist, Mr. Shilp Verma, Social Scientist, **Post Doctoral Scientists:** Mr. Sunderrajan Krishnan, Post-Doctoral Fellow in Water Resource Systems and Policy, **Non-Research:** Mr. Nayan Rajput, Computer Associate, Mr. Pankaj Kole, Consultant - Project Monitoring and Administration, Mr. P. Reghu, Executive Assistant

Sub Regional Office – Nepal

Researcher: Dr. Dhruba Pant, Head, IWMI-Nepal, **Non-Research:** Mr. Sudarshan Pandey, Office Manager (Nepal)

Regional Office Africa (Pretoria)

Principal Researchers: Dr. Douglas Merrey, Regional Director (Africa), **Dr. Akiça Bahri, Director, Africa, Dr. Frits Penning de Vries, Production Ecologist, Dr. Barbara Van Koppen, Rural Sociologist, Poverty, Gender, and Water, **Senior Researchers:** Dr. Hilmy Sally, Head, Southern Africa, Dr. Cliff Mutero, Senior Researcher and SIMA Coordinator, Dr. Sylvie Morardet, Agricultural Economist, Dr. Dominique Rollin, **Agronomist, Researchers:** *Mr. Charles Crosby, Senior Advisor, *Ms. Marna De Lange, Civil Engineer, Mr. Yogesh Bhatt, Researcher/Outreach Coordinator, Ms. Gayathree Jayasinghe, Biometrician, Dr. Arlene Inocencio, Economist, *Ms. Tshepo Khumbane, Senior Advisor, Mr. Litha Magingxa, Ph.D. Fellow, Dr. Mutsa Masiyandima, Hydrologist, Dr. Matthew McCartney, Hydrologist, **Post-Doctoral Scientists:** *Dr. Nicholas Faysse, Water Resource Economist, *Dr. Nitish Jha, Social Anthropologist, *Dr. Daniel Yawson, Hydrologist, Dr. Amy J. Sullivan, Post-Doctoral Scientist - River Basin Institutions, Research Support: *Mr. Azwidowi Mukheli, Gender and Integrated Water Resources Management, Mr. Tendani Nevondo, Program Officer, SIMA, *Ms. Vivian Phadime, Research Assistant, *Mr. Makgwadi Sylvester, Finance Administrator, *Ms. Gladness Seabi, Senior Secretary, *Mr. Jetrick Seshoka, Research Assistant, Mr. Thulani Magagula, Program Management Officer, **Non-Research:** Ms. Mary Njonge, Office Manager, Mr. Kobus Ras, IT Specialist, Ms. Rachel Mashele, Junior Secretary, Ms. Maite Sotsaka, Communication Coordinator, Mr. Harold Magagula, Driver, Ms. Calorene Pengilly, Senior Secretary, Ms. Carol Valerie, Financial Administrator, *Ms. Portia Ndlovu, Administrative Clerk

Sub Regional Office – West Africa

Principal Researcher: Dr. Pay Drechsel, Leader, Theme Agriculture, Water and Cities, **Senior Researcher:** Dr. Marc Andreini, Hydrologist, Researchers: Dr. Boubacar Barry, Agricultural Engineer, *Dr. Abdul Kamara, Policy Economist, Dr. Olufunke Cofie, Soil Scientist, **Post Doctoral Scientists:** Dr. Adetola Ibidunni Adeoti, Agricultural Economist, Associate Experts: *Ms. Eveline Klinkenberg Health & Water Engineer, Research Officers: Mr. Raymond Kasei, Research Officer, Mr. Bernard Keraita, Irrigation and Water Engineer, Mr. Theophilus Otchere-Larbi, Capacity Building and Training Officer - under RUAF II project, **Research Support:** Mr. George Danso, Agricultural Economist, Mr. Philip Amoah, Environmental Scientist, Mr. Emmanuel Obuobie, Water Engineer, Mr. Gerald Forkuor, Research Assistant, **Non-Research:** Ms. Louise Agyeman-Barning, Admin & HR Manager, *Mr. Siegfried Gbadago, Finance Officer, Ms. Charlotte Amponsah, Finance Officer, Mr. Eric Korankye, IT Officer, Ms. Linda Beccles, Admin. Assistant, Mr. Daniel Ofori, Admin. Assistant (Glowa Volta), Ms. Lydia Amoah, Admin. Assistant (Challenge Program), Ms. Tonya Schutz, Programe Manager, Mr. Eli Sokpli, Driver (Glowa Volta), Mr. Ebenezer Aboah, Cleaner/Gardener, Mr. David K. Ochard, Driver (Glowa Volta), Mr. Martin Ofori, Driver, Mr. Daniel Twumasi, Driver, Mr. Salisu Adams, Driver (Glowa Volta)

Sub Regional Office – East Africa and Nile Basin

Researchers: Dr. Seleshi Bekele Awulachew, Head, East Africa, Mr. Philippe Lemperiere, Agronomist, Dr. Eline Boelee, Health and Irrigation Specialist, Dr. Krishna Prasad, Water Resources Engineer/Sociologist, **Post Doctoral Scientists:** Dr. Godswill Makombe, Post Doctoral Scientist - Water and Land Rights in Smallholder Irrigation Farming in Northern Ethiopia, **Non-Research:** Ms. Nigist Wagaye, Senior Programme Assistant.

HOSTED PROGRAM STAFF

Dialogue Secretariat

Associate Expert: Mr. Marco Blixt, Knowledge Base Manager

Global Water Partnership Secretariat

Non-Research: *Mr. Nanda Abeywickrema, Special Advisor to the DG on GWP, Mr. Lalith Dassenaike, Coordinator, IWMI-GWP Resource Centre.

Challenge Program on Water and Food

Principal Researcher: Dr. Jonathan Woolley, Coordinator - Challenge Program on Water and Food, **Principal Manager:** Ms. Pamela George, Program Manager - Challenge Program on Water and Food, **Non-Research:** Ms. Sharon Perera, Executive Assistant, *Ms. Priyanka Tissaverasinghe, Secretary, Ms. I. Deborah Tracey Koch, Administrative Officer, Ms. Marene Abeyesekere, Finance Administrator, Research Officers: Ms. Priyantha Jayasuriya Arachchi, Data Analyst, *Mr. Sean Perera, Research Officer

International Centre for Underutilized Crops

Non-Research: Ms. Sushila Rajamanie, Administrative Officer

* Staff left in 2004/2005 (period covered – 01 Jan 2004 to 31 March 2005)

** Staff joining/assuming new responsibilities during 2005

IWMI is working towards building research excellence in a corporate and professional manner. The organization is developing its four key knowledge roles of knowledge generation, knowledge sharing, knowledge brokering and knowledge application. At the heart of this endeavor is IWMI's research agenda, which has evolved to include stakeholder priorities and future needs. IWMI is also focusing on professional and institutional capacity building, while promoting a strong organizational culture of impact, performance and service.

Photo Credit : Sanjini De Silva

Core Values

Excellence

Impact-orientation

Partnerships

Teamwork

Knowledge sharing

Respect for diversity

Publications

15 March 2005

- Research Reports
- Comprehensive Assessment Research Reports
- Journal articles
- Editorial, book reviews
- Books
- Book Chapters
- Policy Briefs

RESEARCH REPORTS

1. **Bhattarai, M.** 2004. Irrigation Kuznets Curve, governance and dynamics of irrigation development: A global cross-country analysis from 1972 to 1991. Colombo, Sri Lanka. IWMI. vi, 47p. (IWMI Research Report 78)

2. **Drechsel, Pay; Giordano, M.; Gyiele, L.** 2004. Valuing nutrients in soil and water: Concepts and techniques with examples from IWMI studies in the developing world. Colombo, Sri Lanka. IWMI. v, 33p. (IWMI Research Report 82)

3. **Faysse,.** 2004. An assessment of small-scale user's inclusion in large-scale water user associations of South Africa. Colombo, Sri Lanka: IWMI. 36p. (IWMI Research Report 84)

4. **Molle, F.; Mamanpoush, A.; Miranzadeh, M.** 2004. Robbing Yadullah's water to irrigate Saeid's garden: Hydrology and water rights in a village of Central Iran. Colombo, Sri Lanka. IWMI. vi, 43p. (IWMI Research Report 80)

5. **Quereshi, A.; Turral, H.; Masih, I.** 2004. Strategies for the management of conjunctive use of surface water and groundwater resources in semi-arid areas: A case study from Pakistan. vi, 24p. (IWMI Research Report 86)

6. **Saleth, M.** 2004. Strategic analysis of water institutions in India: Application of a new research paradigm. Colombo, Sri Lanka. IWMI. vi, 37p. (IWMI Research Report 79)

7. **Smakhtin, V. U.; Piyankarage, S. C.; Stanzel, P.; Boelee, E.** 2004. Simulating the hydrology of small coastal ecosystems in conditions of limited data. Colombo, Sri Lanka: IWMI. v, 28p. (IWMI Research Report 77)

8. **Thenkabail, P.; Gamage, M. S. D. N.; Smakhtin, V. U.** 2004. The use of remote sensing data for drought assessment and monitoring in Southwest Asia. Colombo, Sri Lanka. IWMI. v, 25p. (IWMI Research Report 85)

9. **Ul Hassan, M.; Starkloff, R.; Nizamedinkhodjaeva, N.** 2004. Inadequacies in the water reforms in the Kyrgyz Republic: An institutional analysis. Colombo, Sri Lanka. IWMI. vii, 44p. (IWMI Research Report 81)

10. V**ermillion, D. L.; Al-Shaybani, S.** 2004. Small dams and social capital in Yemen: How assistance strategies affect local investment and institutions. Colombo, Sri Lanka: IWMI. v, 28p. (IWMI Research Report 76)

COMPREHENSIVE ASSESSMENT RESEARCH REPORTS

11. **Barker, R.; Molle, F.** 2004. Evolution of irrigation in South and Southeast Asia. Colombo, Sri Lanka. Comprehensive Assessment Secretariat. vi, 45p. (Comprehensive Assessment Research Report 5)

12. **Barker, R.; Ringler, C.; Nguyen. M.T.; Rosegrant, M.** 2004. Macro policies and investment priorities for irrigated agriculture in Vietnam. Colombo, Sri Lanka. Comprehensive Assessment Secretariat. vii, 48p. (Comprehensive Assessment Research Report 6)

13. **de Fraiture, C.; Cai, X.; Amarasinghe, U.; Rosegrant, M.; Molden, D.** 2004. Does international cereal trade save water?: The impact of virtual water trade on global water use. Colombo, Sri Lanka. Comprehensive Assessment Secretariat. v, 32p. (Comprehensive Assessment Research Report 4)

14. **Giordano, M.; Zhu, Z.; Cai, X.; Hong, S.; Zhang, X.; Xue, Y.** 2004. Water management in the Yellow River Basin. Colombo, Sri Lanka. Comprehensive Assessment Secretariat. v, 39p. (Comprehensive Assessment Research Report 3)

15. **Smakhtin, Vladimir U.; Revenga, C.; Doll, P.** 2004. Taking into account environmental water requirements in global-scale water resources assessments. Colombo, Sri Lanka: Comprehensive Assessment Secretariat. v, 24p. (Comprehensive Assessment Research Report 2)

JOURNAL ARTICLES

16. **Abdullaev, I.** 2004. The analysis of water management in Bukhara Oasis of Uzbekistan: Historical and territorial trends. Water International, 29(1):20-26.

17. **Abdullaev, I.; Molden, D.** 2004. Spatial and temporal variability of water productivity in the Syr Darya Basin, Central Asia. Water Resources Research, 40:6p.

18. **Afrane, Y. A.; Klinkenberg, E.; Drechsel, P.; Owusu-Daaku, K.; Garms, R.; Kruppa, T.** 2004. Does irrigated urban agriculture influence the transmission of malaria in the City of Kumasi, Ghana? Acta Tropica, 89(2):125-134.

19. **Ahmad, M.; Masih, I.; Turral, H.** 2004. Diagnostic analysis of spatial and temporal variations in crop water productivity: A field scale analysis of the rice-wheat cropping system of Punjab, Pakistan. Journal of Applied Irrigation Science, 39(1):43-63.

20. **Ahmad, M.; Stein, A.; Bastiaanssen, W. G. M.** 2004. Estimation of disaggregated canal water deliveries in Pakistan using geomatics. International Journal of Applied Earth Observation and Geoinformation, 6:63-75

21. **Ahmad, M.; Bastiaanssen, W. G. M.; Feddes, R. A.** 2004. A new technique to estimate net groundwater use across large irrigated areas by combining remote sensing and water balance approaches, Rechna Doab, Pakistan. Hydrogeology Journal, 6 November: (On-line first)

22. **Ali, G.; Asghar, M. N.; Latif, M.; Hussain, Z.** 2004. Optimizing operational strategies of scavenger wells in lower Indus Basin of Pakistan. Agricultural Water Management, 66(3):239-249.

23. **Barker, R.; Tuong, P.; Li, Y.; Castillo, E. G.; Bouman, B. A. M.** 2004. Growing more rice with less water: China, Paddy and Water Environment, 2:185

24. **Bhattarai, M.; Hammig, M.** 2004. Governance, economic policy, and the environmental kuznets curve for natural tropical forests. Environment and Development Economics, 9:367-382

25. **Birdar, C. M.; Saran, S.; Raju, P. L. N.; Roy, P. S.** 2004. Forest canopy density stratification: How relevant is biophysical spectral response modelling approach? Geocarto International, 20(1):1-7

26. **Boelee, E.; Laamrani, H.** 2004. Environmental control of schistosomiasis through community participation in a Moroccan oasis. Tropical Medicine and International Health, 9(9):997-1004

27. **Bunemann, E. K.; Bossio, D. A.; Smithson, P. C.; Frossard, E.; Oberson, A.** 2004. Microbial community composition and substrate use in a highly weathered soil as affected by crop rotation and P fertigation. Soil Biology and Biochemistry, 36(6):889-901

28. **Chaney, R.L.; Reeves P.G.; Ryan, J.A., Simmons, R. W.; Welch, R.M.; Angle, J.S.** 2004. An improved understanding of soil Cd risk to humans and low cost methods to phytoextract Cd from contaminated soils to prevent soil Cd risks. BioMetals, 17(5):549-553

29. **Chemin, Y.; Platonov, A.; Ul-Hassan, M.; Abdullaev, I.** 2004. Using remote sensing data for water depletion assessment at administrative and Irrigation-system levels: Case study of the Ferghana Province of Uzbekistan. Agricultural Water Management, 64(3):183-196

30. **Cofie, O.; Pleysier, J.** 2004. Ion exchange involving calcium-potasium (Ca-K) and calcium-magnesium (Ca-Mg) in soil and organic matter fractions Communications Soil & Plant Analysis, 35(17-18):2417-2431

31. **De Plaen, R.; Seka, M. L.; Koutoua, A.** 2004. The paddy, the vector and the caregiver: Lessons from an ecosystem approach to irrigation and malaria in Northern Côte d'Ivoire. Acta Tropica, Special Issue: Malaria and Agriculture, 89 (2):135-146

32. **de Rouw, Anneke.** 2004. Yield stability in Sahelian pearl millet farming. Agricultural Systems, 81:73-93

33. **de Rouw, A.; Rajot, J. L.** 2004. Nutrient availability and pearl millet production in Sahelian farming systems based on manuring or fallowing. (Special Issue, "Soil erosion with SOM dynamics and soil biology", Eds. M. Kirkby and D.S. Powlson) Agriculture, Ecosystems & Environment, 104:249-262

34. **de Rouw, Anneke.; Rajot, J. L.** 2004. Soil organic matter, surface crusting and erosion in Sahelian farming systems based on manuring or fallowing. (Special Issue, "Soil erosion with SOM dynamics and soil biology", Eds M. Kirkby and D.S. Powlson,) Agriculture, Ecosystems & Environment, 104:263-276

35. **Dolo, G.; B., O. J.T.; Dao, A.; Traore, S.F.; Bouare, M.** 2004. Sogoba N et al. Malaria transmission in relation to rice cultivation in the irrigated Sahel of Mali. Acta Tropica, 89(2):147-159

36. **Dong, B.; Molden, D.; Loeve, R.; Li, Y. H.; Chen, C. D.; Wang, J. Z.** 2004. Farm level practices and water productivity, in Zhanghe Irrigation System Paddy and Water Environment, 2:217-226

37. **Ensink, J. H. J.; Mahmood, T.; van der Hoek, W.; Raschid-Sally, L.; Amerasinghe, F.** 2004. A nationwide assessment of wastewater use in Pakistan: An obscure activity or a vitally important one? Water Policy, 6(3):197-206

38. **Faysse, N.** 2004. Challenges for fruitful participation of smallholders in large-scale water resource management organizations: Selected case studies in South Africa. Agrekon, 43(1):52-73

39. **Fleck, J. A.; Bossio, D. A.; Fujii, R.** 2004. Dissolved organic carbon and disinfection by-product precursor release from managed peat soils. Journal of Environmental Quality, 33:465-475

40. **Fujimoto, N.** 2004. Water pricing and agricultural water management in monsoon Asia [Monsoon Asia no Nougyou-yousui-kanri to Mizu no Pricing] Journal of the Japanese Society of Irrigation, Drainage & Reclamation Engineering, 72(3):213-216

41. **George, B. A.; Malano, H. M.; Vo Khac Tri; Turral, Hugh.** 2004. Using modelling to improve operational performance in the Cu Chi Irrigation System, Vietnam. Irrigation and Drainage, 53(3):237-249

42. **Ghafoor, A.; Sadiq, M.; Murtaza, G.; Brar, M.S.** 2004. Lead, copper, zinc and iron concentrations in soils and vegetables irrigated with city effluent on urban agricultural lands. Journal of the Indian Society of Soil Science, 52(1):114-117

43. **Gichuki F.** 2004. "Managing the externalities associated with dry season river flows" Water Resources Research, 40(8) 8p.

44. **Gimenez R.; Planchon O.; Silvera, N.; Govers, G.** 2004. Longitudinal velocity patterns and bed morphology interaction in a rill. Earth Surface Processes and Landforms, 29 :105-114

45. **Girardin, O.; Dao, D.; Koudou, B. G.; Essé, C.; Cissé, G.; Yao, T.; N'Goran, E. K.; Tschannen, A. B.; Bordmann, G.; Lehmann, B.; Nsabimana, C.; Keiser, J.; Killeen, G. F.; Singer, B. H.; Tanner, M; Utzinger, J.** 2004. Opportunities and limiting factors of intensive vegetable farming in malaria endemic Côte d'Ivoire. Acta Tropica, Special Issue: Malaria and Agriculture, 89(2):109-123.

46. **Hamid, A.** 2004. Social mobilization and women's participation in water resource management: A case study of Southern Punjab, Pakistan. Journal of Applied Irrigation Science, 39(1):23-41

47. **Herrel, N.; Amerasinghe, F.; Ensink, J.; Mukhtar, M.; van der Hoek, W.; Konradsen, F.** 2004. Adult anopheline ecology and malaria transmission in irrigated areas of South Punjab, Pakistan. Medical and Veterinary Entomology, 18:141-152

48. **Hussain, I.; Mudasser, Muhammad; Hanjra, Munir A.; Amarasinghe, Upali; Molden, David.** 2004. Improving wheat productivity in Pakistan: Econometric analysis using panel data from Chaj in the Upper Indus Basin. Water International, 29(2):189-200

49. **Hussain, I.; Hanjra, M. A.** 2004. Irrigation and poverty alleviation: Review of the empirical evidence. Irrigation and Drainage, 53(1):1-15.

50. **Jayakody, P.; Mowjood, M.; Gunawardena, E.** 2004. Modifying and testing a cascade water balance model using a mini cascade system with two tanks. Tropical Agriculture Research, 16:159-170

51. **Jenson, P. K.; Jayasinghe, G.; van der Hoek, W.; Cairncross, S.; Dalsgaard, A.** 2004. Is there an association between bacteriological drinking water quality and childhood diarrhea in developing countries. Tropical Medicine and International Health, 9(11)1210-1215

52. **Joshi, P. K.; Pangrave, V.; Shiferaw, B.; Wani, S. P.; Bouma, J.; Scott, C.** 2004. Watershed development in India: Synthesis of past experiences and needs for future research. Indian Journal of Agricultral Economics, 59(3):303-320

53. **Kamara, A. B.** 2004. The impact of market access on input use and agricultural productivity: Evidence from Machakos District, Kenya. Agrekon, 43(2):202-217

54. **Kamara, A.; Sally, H.** 2004. Water management options for food security in South Africa: Scenarios, simulations and policy implications. Development Southern Africa, 21(2):365-384

55. **Kamara, A. B.; Swallow, B.; Kirk, M.** 2004. Policies, interventions and institutional change in pastoral resource management in Borana, Southern Ethiopia. Development Policy Review, 22(4):381-403

56. **Karlberg, L.; Penning de Vries, F.** 2004. Exploring potentials and constraints of low-cost drip irrigation with saline water in sub-Saharan Africa. Physics and Chemistry of the Earth, 29:1035-1042

57. **Klinkenberg, E.; van der Hoek, W.; Amerasinghe, F.** 2004. A malaria risk analysis in an irrigated area in Sri Lanka. Acta Tropica, 89(2):215-225

58. **Klinkenberg, E.; Konradsen, F.; Herrel, N.; Mukhtar, M.; van der Hoek, W. Amerasinghe, F. Prashantha** 2004. Malaria vectors

in the changing environment of the southern Punjab, Pakistan. Transactions of the Royal Society of Tropical Medicine and Hygiene, 98(7):442-449

59. **Klinkenberg, E.; McCall, P.J.; Hastings, I.M. Wilson, M.D., Amerasinghe, Donnelly, M.J.** 2004. High malaria prevalence and irrigated urban agriculture in Accra, Ghana. (Abstarct of presentation) American Journal of Tropical Medicine and Hygiene, 71S, p. 9.

60. **Konradsen, F.; van der Hoek, W.; Amerasinghe, F.; Mutero, C.; Boelee, E.** 2004. Engineering and malaria control: Learning from the past 100 years. Acta Tropica, 89(2):99-108

61. **Kumar, M. D.** 2004. Roof water harvesting for domestic water security: Who gains and who loses? Water International, 29(1):43-53

62. **Kumar, M. D.; Singh, O. P.** 2004. Virtual water in global food and water policy making: Is there a need for rethinking? Water Resources Management, pp.1-31

63. **Kurian, M.; Dietz, T**. 2004. Public-private partnerships. Water Policy, 6(2):131-152

64. **Kurian, M.; Dietz, T.** 2004. Irrigation and collective action: A study in method with reference to the Shiwalik Hills, Haryana. Natural Resources Forum, 28(1):34-49

65. **Lankford, B.; van Koppen, B.; Franks, T.; Mahoo, H.** 2004. Entrenched views or insufficient science? – Contested causes and solutions of water allocation: Insights from the Great Ruaha River Basin, Tanzania. Agricultural Water Management, 69(2):135-153

66. **Lesturgez1, G.; Possl, R.; Hartmaan, C.; Bourdon, E.; Noble, Andrew; Ratana-Anupap, S.** 2004. Roots of Stylosanthes hamata create macropores in the compact layer of a sandy soil. Plant and Soil, 260(1-2):101-109

67. **Li, Y.; Barker, R.** 2004. Increasing water productivity for paddy irrigation in China. Paddy and Water Environment, 2:187-193

68. **Loeve, R.; Dong, B.; Molden, D.; Li, Y. H.; Chen, C. D.; Wang, J. Z.** 2004. Issues of scale in water productivity in the Zhanghe Irrigatin system: Implications for irrigation in the basin context. Paddy and Water Environment, 2:227-236

69. **Loeve, R.; Hong, L.; Dong, B.; Mao, G.; Chen, C. D.; Dawe, D.; Barker, R.** 2004. Long-term trends in intersectoral water allocation and crop water productivity in Zhanghe and Kaifeng, China. Paddy and Water Environment, 2:237-245

70. **Malano, H.; Burton, M.; Makin, I.** 2004. Benchmarking performance in the irrigation and drainage sector: A tool for change. Irrigation and Drainage, 53(2):119-133

71. **Marrama, L.; Jambou, R.; Rakotoarivony, I.; Tsi, J. M. L. P.; Duchemin, J. B.; Laventure, S.; Mouchet, J.; Rouxh, J.** 2004. Malaria transmission in Southern Madagascar: Influence of the environment and hydro-agricultural works in sub-arid and humid regions: Part 1, Entomological investigations. Acta Tropica, Special Issue: Malaria and Agriculture, 89 (2):193-203.

72. **McCartney, M. P.; de la Hera, A.** 2004. Hydrological assessment for wetland conservation at Wicken Fen. Wetlands Ecology and Management, 12:189-204

73. **McCornick, P.** 2004. Wastewater reuse in the Middle East and North Africa. Waterlines, 23(1):9-11

74. **Molle, F.** 2004. Defining water rights: By prescription or negotiation?. Water Policy, 6(3): 207-227

75. **Molle, F.** 2004. Technical and institutional responses to basin closure in the Chao Phraya river basin, Thailand. Water International, 29(1):70-80.

76. **Mutero, C. M.; Ng'ang'a, P. N.; Wekoyela, P.; Githure, J.; Konradsen, Flemming.** 2004. Ammonium sulphate fertiliser increases larval populations of Anopheles arabiensis and culicine mosquitoes in rice fields. Acta Tropica, 89(2):187-192.

77. **Mutero, C. M.; Kabutha, C.; Kimani, V.; Kabuage, L.; Gitau, G.; Ssennyonga, J.; Githure, J.; Muthamie, L.; Kaida, A.; Musyoka, L.; Kiarie, E.; Oganda, M.** 2004. A transdisciplinary perspective on the links between malaria and agroecosystems in Kenya. Acta Tropica, 89(2):171-186.

78. **Namara, R. E.; Manig, W.** 2004. Returns to alternative organisational models of wheat breeding research: Simulation results from Ethiopia. Indian Journal of Agricultural Economics, 59(2):231-248.

79. **Ngigi, S. N.; Savenije, H. H. G.; Thome, J. N.; Rockström, J.; Penning de Vries, F. W. T.** 2004. Agro-hydrological evaluation of on-farm rainwater storage systems for supplemental irrigation in Laikipia district, Kenya. Agricultural Water Management, 21p.

80. **Nguyen Khoa, S.; Smith, L. E. D.** 2004. Irrigation and fisheries: Irreconcilable conflicts or potential synergies?" Irrigation and Drainage, 53:415-427.

81. **Piyankarage, S. C.; Mallawatantri, A. P.; Matsuno, Y.; Pathiratne, K.A.S.** 2004. Human impacts and the status of water quality in the Bundala RAMSAR wetland lagoon system in Southern Sri Lanka. Wetlands Ecology and Management, 12(5):473-482.

82. **Podwojewski, P.; Germain, N.** 2004. Evolution of the soil structure in a deep tilled hardened volcanic ash-soil (Cangahua) in Ecuador. European Journal of Soil Science, 39, 39-51

83. **Poulenard, J.; Michel, F.; Bartoli, J. M.; Portal, P.; Podwojewski, P.** 2004. Water repellency of volcanic ash soil from Ecuadorian Páramo: Effect of water content and characterization of water repellent materials. European Journal of Soil Science, 55(3):

84. **Qadir, M.; Oster, J. D.** 2004. Crop and irrigation management strategies for saline-sodic soils and waters aimed at environmentally sustainable agriculture. Science of the Total Environment, 323:1-19.

85. **Qafuku, N., Van Ranst, E., Noble, A.; Baert, G.** 2004. Variable charge soils: Their mineralogy, chemistry and management. Advances in Agronomy, 84:157–213

86. **Qureshi, A.; Akhtar, M.; Shah, T.** 2004. Role of changing energy pricing policies on groundwater development in Pakistan. Journal of Applied Irrigation Science, 39(2):329-342

87. **Qureshi, A.; Asghar, M. N.; Ahmed, S.; Masih, I.** 2004. Sustaining crop production in saline groundwater areas: A case study from Pakistani Punjab. Australian Journal of Agricultural Research, 55:421-431

88. **Raschid-Sally, L.; Parkinson, J.** 2004. Wastewater reuse for agriculture and aquaculture: Current and future perspectives for low-income countries. Waterlines, 23(1):2-4

89. **Saeed, M.M.; Bruen, M.** 2004. Simulation of hydrosalinity behavior under skimming wells. Irrigation and Drainage Systems,18(2):167-200.

90. **Saleth, M.** 2004. Introduction to special section on river basin management: Economics, management, and policy. Water Resources Research, 40(8) 6p.

91. **Saleth, M.; Sastry, G. S.** 2004. Water supply and sanitation sector of Karnataka, India: Status, performance and change. Water Policy, 6:161-183

92. **Samita, S.; Anputhas, M.; De Z. Abeysiriwardena, S.** 2005. Accounting multi traits in recommending paddy varieties for diverse environments. Experimental Agriculture, 41(2):14p.

93. **Schreiner, B.; Mohapi, N.; van Koppen, B.** 2004. Washing away poverty: Water, democracy and gendered poverty eradication in South Africa. Natural Resources Forum, 28(3):171-178

94. **Scott, C. A.; Shah, T.** 2004. Groundwater overdraft reduction through agricultural energy policy: Insights from India and Mexico. International Journal of Water Resources Development, 20(2):149-164.

95. **Shah, T.; Singh, P.** Irrigation development and rural poverty in Gujarat, India: A disaggregated analysis. Water International, 29(2):167-177

96. **Simmons, R.; Pongsakul, P.** 2004. Preliminary stepwise multiple linear regression method to predict cadmium and zinc uptake in soybean. Communications in Soil Science and Plant Analysis, 35(13&14):1815-1828

97. **Sissoko, M. S.; Dicko, A.; Briët, O. J. T.; Sissoko, M.; Sagara, I.; Keita, H. D.; Sogoba, M.; Rogier, C.; Touré, Y. T.; Doumbo, O. K.** 2004. Malaria incidence in relation to rice cultivation in the irrigated Sahel of Mali. Acta Tropica, Special Issue: Malaria and Agriculture, 89 (2):161-170.

98. **Smakhtin, V.; Revenga, C.; Döll, P.** 2004. A pilot global assessment of environmental water requirements and scarcity. Water International, 29(3):307-317

99. **Smakhtin, V. U.** 2004. Evaluating wetland flow regulating functions using discharge time series. Hydrological Processes: (On-line first)

100. **Smakhtin, V. U.** 2004. Simulating the hydrology and mouth conditions of small, temporarily closed/open estuaries. Wetlands, 24(1):123-132.

101. **Stratford, C. J.; McCartney, M. P.; Williams, R. J.** 2004. Seasonal and diurnal hydro-chemical variations in a recreated reed bed. Hydrology and Earth System Sciences, 8(2):266-275

102. **Thoyer, S.; Morardet, S.; Rio, P.; Goodhue, R.** 2004. Comparaison des procédures de décentralisation et de négociation de la gestion de l'eau en France et en Californie. Natures Sciences Societes, 12:7-17

103. **Thenkabail, P.; Enclona, E. A.; Ashton, M. S.; Legg, C.; de Dieu, M. J.** 2004. Hyperion, IKONOS, ALI, and ETM+ sensors in the study of African rainforests. Remote Sensing of Environment, 90(1):23-43.

104. **Thenkabail, P.; Enclona, E. A.; Ashton, M. S.; Van Der Meer, B.** 2004. Accuracy assessments of hyperspectral waveband performance for vegetation analysis applications. Remote Sensing of Environment, 91(3-4):354-376

105. **Thenkabail, P.; Stucky, N.; Griscom, B. W.; Ashton, M. S.; Diels, J.; van der Meer, B.; Enclona, E.** 2004. Biomass estimations and carbon stock calculations in the oil palm plantations of African derived savannas using IKONOS data. International Journal of Remote Sensing, 25(23):5447-5472

106. **Tyagi, N. K.; Agrawal, A.; Sakthivadivel, R.; Ambast, S. K.; Sharma, D. K.** 2004. Productivity of rice-wheat cropping system in a part of Indo-Gangetic Plain: A spatial analysis. Irrigation and Drainage Systems, 18(1):73-88

107. **Upadhyay, B.** 2004. Gender aspects of smallholder irrigation technology: Insights from Nepal. Journal of Applied Irrigation Science, 39(2):315-327

108. **Upadhyay, B.** 2004. Women and water issues in Gujarat. Asian Women, 19:69-83

109. **Valentin, C.; Rajot, J. L.; Mitja, D.** 2004. Responses of soil crusting, runoff and erosion to fallowing in the sub-humid and semi-arid regions of West-Africa. Agriculture, Ecosystems, Environment, 104: 287-302

110. **van der Hoek, W.** 2004. How can better farming methods reduce malaria. Acta Tropica, 89(2):95-97.

111. **van Ittersum, M.K.; Roetter, R. P.; van Keulen, H.; de Ridder, N.; Hoanh, C.T.; Laborte, A. G.; Aggarwal, P. K.; Ismail, A. B.; Tawang, A.** 2004. A systems network (SysNet) approach for interactively evaluating strategic land use options at sub-national scale in South and South-east Asia. Journal of Land Use Policy, 21:101–113

112. **Verma, S.; Tsephal, S.; Jose, T.** 2004. Pepsee systems: Grassroots innovation under groundwater stress. Water Policy, 6(4):303-318

113. **Wassmann, R.; Hien, N. X.; Hoanh, Chu Thai; Tuong, T. P.** 2004. Sea level rise affecting the Vietnamese Mekong Delta: Water elevation in the flood season and implications for rice production. Climatic Change, 66(1-2): 89-107

114. **Yoffe, S.; Fiske, G.; Giordano, M.; Giordano, M.; Larson, K.; Stahl, K.; Wolf, A. T.** 2004. Geography of international water conflict and cooperation: Data sets and applications. Water Resources Research, 40(5):1-12

115. **Zhu, Z.; Giordano, M.; Cai, X.; Molden, David.** 2004. The Yellow River Basin: Water accounting, water accounts and current issues. Water International, 29(1):2-10.

BOOKS

121. **Aerts, J.; Droogers, P. (Eds.)** 2004. Climate change in contrasting river basins: Adaptation strategies for water, food and environment. Wallingford, UK: CABI. 288p.

122. **Ghafoor, A.; Qadir, M.; Murtaza, G.** 2004. Salt-affected soils: Principles of management. Lahore, Pakistan. Allied Book Centre. xxv, 304p.

123. **Moriarty, P.; Butterworth, J.; van Koppen, B. (Eds.)** 2004. Beyond domestic: Case studies on poverty and productive uses of water at the household level. Delft, Netherlands. IRC International Water and Sanitation Centre; IWMI. 242p.

124. **Saleth, R. Maria; Dinar, A.** 2004. The institutional economics of water: A cross-country analysis of institutions and performance. Cheltenham, UK: Edward Elgar. xvi, 398p.

125. **Scott, C. A.; Faruqui, N. I.; Raschid-Sally, Liqa. (Eds.)** 2004. Wastewater use in irrigated agriculture: Confronting the livelihood and environmental realities. Wallingford, UK Colombo, Sri Lanka; Ottawa, Canada. CABI Publishing IWMI IDRC. ix, 193p.

BOOK CHAPTERS

126. **Bhamoriya, V.** 2004. Wastewater irrigation in Vadodara, Gujarat, India: Economic catalyst for marginalised communities In Scott, C. A.; Faruqui, N. I.; Raschid-Sally, L. (Eds.), Wastewater use in irrigated agriculture: Confronting the livewlihood and environmental realities. Wallingford, UK; Colombo, Sri Lanka; Ottawa, Canada: CABI Publishing; IWMI; IDRC. pp.127-134

127. **Biradar, C. M.; Singh, S.; Das, N. K.; Roy, P. S.** 2004. Wildlife-human conflict analysis in protected area: Geospatial approach. In Protected Habitats. Nature Conservators Pub. pp.168-179

128. **Boelee, E; Laamrani, H.** 2004. Multiple use of irrigation water in Northeastern Morocco. In Moriarty, P.; Butterworth, J.; van Koppen, B. (Eds.), Beyond domestic: Case studies on poverty and productive uses of water a t the household level. Delft, Netherlands: IRC International Water and Sanitation Centre; IWMI. pp.119-135.

129. **Buechler, S. J.** 2004. A sustainable livelihoods approach for action research on wastewater use in agriculture In Scott, C. A.; Faruqui, N. I.; Raschid-Sally, L. (Eds.), Wastewater use in irrigated agriculture: Confronting the livewlihood and environmental realities. Wallingford, UK; Colombo, Sri Lanka; Ottawa, Canada: CABI Publishing; IWMI; IDRC. pp.25-40.

130. **de Lange, M.** 2004. Water policy and law review process in South Africa with focus on the agricultural sector. In Mollinga, P. P.; Bolding, A., The politics of irrigation reform: Contested policy formulation and implementation in Asia, Africa and Latin America. Aldershot, England: Ashgate. pp.11-56.

131. **de Rouw, A.** 2004. "Good" and "bad" weeds in shifting cultivation. In Vester, H.; Romeijn, P.; van der Wal, H. (Eds.). Liber Amicorum Prof dr. Ir. R. A. A. Oldeman", Heelsum, The Netherlands: Treemail Publishers. pp 93-97.

132. **Drechsel, P.; Giordano, M.; Enters, T.** 2004. Valuing soil fertility change: Selected methods and case studies. In Shiferaw, B.; Freeman, H. A.; Swinton, S. M. (Eds.), Natural resource management in agriculture: Methods for assessing economic and environmental impacts. Wallingford, UK: CABI. pp.199-222.

133. **Ensink, J., H. J.; Simmons, R. W.; van der Hoek, W.** 2004. Wastewater use in Pakistan: The cases of Haroonabad and Faisalabad In Scott, C. A.; Faruqui, N. I.; Raschid-Sally, L. (Eds.), Wastewater use in irrigated agriculture: Confronting the livewlihood and environmental realities. Wallingford, UK; Colombo, Sri Lanka; Ottawa, Canada: CABI Publishing; IWMI; IDRC. pp.91-99.

134. **Faruqui, N. I.; S., C. A.; Raschid-Sally, L.** 2004. Confronting the realities of wastewater use in irrigated agriculture: Lessons learned and recommendations In Scott, C. A.; Faruqui, N. I.; Raschid-Sally, L. (Eds.), Wastewater use in irrigated agriculture: Confronting the livewlihood and environmental realities. Wallingford, UK; Colombo, Sri Lanka; Ottawa, Canada: CABI Publishing; IWMI; IDRC. pp.173-185.

135. **Hoanh, C.T.; Guttman, H.; Droogers, P; Aerts, J.** 2004. Will we produce sufficient food under climate change? Mekong Basin (South East Asia) In Aerts, J.; Droogers, P. (Eds.), Climate change in contrasting river basins: Adaptation strategies for water, food and environment. Wallingford, UK: CABI. pp.157-180

136. **Rijsberman, F.** 2004. The water challenge. In Lomborg, B. (Ed.) Global challenges, global solutions. Cambridge, UK: CUP. 34p.

137. **Keraita, B. N.; Drechsel, P.** 2004. Agricultural use of untreated urban wastewater in Ghana In Scott, C. A.; Faruqui, N. I.; Raschid-Sally, L. (Eds.), Wastewater use in irrigated agriculture: Confronting the livewlihood and environmental realities. Wallingford, UK; Colombo, Sri Lanka; Ottawa, Canada: CABI Publishing; IWMI; IDRC. pp.101-112.

138. **Matsuno, Y.; Ensink, J. H.; van der Hoek, W.; Simmons, R. W**. 2004. Assessment of the use of wastewater for irrigation: A case in Punjab, Pakistan. In Steenvoorden, J.; Endreny, T. (Eds.) 2004. Wastewater re-use and groundwater quality. Wallingford, Oxfordshire, UK: IAHS Press, Centre for Ecology and Hydrology. pp.28-33. (IAHS Publication 285).

139. **McCartney, M.; Sally, H.; Senzanje, A.** 2004. Integrated water resources management and agriculture in Southern Africa. In Stephenson, D.; Shemang, E. M.; Chaoka, T. R. (Eds.), Water resources of arid areas. A. A. Balkema: Leiden, Netherlands. pp.493-499

140. **McCornick, P. G.; Hijazi, A.; Sheikh, B.** 2004. From wastewater reuse to water reclamation: Progression of water reuse standards in Jordan In Scott, C. A.; Faruqui, N. I.; Raschid-Sally, L. (Eds.), Wastewater use in irrigated agriculture: Confronting the livewlihood and environmental realities. Wallingford, UK; Colombo, Sri Lanka; Ottawa, Canada: CABI Publishing; IWMI; IDRC. pp.153-162.

141. **Moriarty, P.; Butterworth, J.; van Koppen, B.; Soussan, J.** 2004. Water, poverty and productive uses of water at the household level. In Moriarty, P.; Butterworth, J.; van Koppen, B. (Eds.), Beyond domestic: Case studies on poverty and productive uses of water a t the household level. Delft, Netherlands: IRC International Water and Sanitation Centre; IWMI. pp.19-47

142. **Mukherji, A.; Shah, T.** 2004. Socio-ecology of groundwater irrigation in South Asia. In Shauquillo et al. (Eds.), Selected papers on intensive use of groundwater. Dordrecht, Netherlands: Balkema Publishing Co. pp. 67-92.

143. **Phansalkar, S. J.; Verma, S.** 2004. El Manejo del Agua y las Tribus en la India: Oportunidades, Restricciones y Estrategias. In Pena, Francisco (Ed.), Los pueblos indigenas y el agua: Desafios del Siglo XXI. San Luis Potosi: El Colegio de San Luis Mexico y Mexico, D.F.: Obranegra,. [Indigenous groups and water: Challenges for the 21st century. In Pena, Francisco (Ed.) Water management and tribals in India: Opportunities, barriers and strategies] (Chapter 6), pp. 139-161.

144. **Rap, E.; Wester, P.; Pérez-Prado, L. N.** 2004. The politics of creating commitment: Irrigation reforms and the reconstitution of the hydraulic bureaucracy in Mexico. In Mollinga, P. P.; Bolding, A., The politics of irrigation reform: Contested policy formulation and implementation in Asia, Africa and Latin America. Aldershot, England: Ashgate. pp.57-94.

145. **Raschid-Sally, L.; Bradford, A. M.; Endamana, D.** 2004. Productive use of wastewater by poor urban and peri-urban farmers: Asian and African case studies in the context of the Hyderabad declaration on wastewater use. In Moriarty, P.; Butterworth, J.; van Koppen, B. (Eds.), Beyond domestic: Case studies on poverty and productive uses of water a t the household level. Delft, Netherlands: IRC International Water and Sanitation Centre; IWMI. pp.95-116

146. **Raschid-Sally, L.; Tuan, D. D.; Abayawardana, S.** 2004. National assessments on wastewater use in agriculture and an emerging typology: The Vietnam case study In Scott, C. A.; Faruqui, N. I.; Raschid-Sally, L. (Eds.), Wastewater use in irrigated agriculture: Confronting the livewlihood and environmental realities. Wallingford, UK; Colombo, Sri Lanka; Ottawa, Canada: CABI Publishing; IWMI; IDRC. pp.81-90

147. **Rijsberman, F.** 2004. Sanitation and access to clean water. In Lomborg, B. (Ed.), Global crises, global solutions. Cambridge, UK: CUP. pp. 498-527

148. **Saleth, M.** 2004. Water institutions in India: Structure, performance, and change. In Gopalakrishnan, C.; Biswas, A. K.; Tortajada, C. (Eds.), Water resources management-structure, evolution and performance of water institutions. New York, NY, USA: Springer-Verlag, 2003. 33p.

149. **Saleth, M.** 2004. Agricultural strategy for a globalizing economy: Continuity and change. In Krishnaswamy, C. G.; Keshava, S. R.; Tirlapur, R. M. (Eds.) Better impression on globalization, Bangalore, India: Department of Post Graduate Studies and Research in Economics, Bangalore University. pp.69-103.

150. **Scott, C.; Faruqui, N. I.; Raschid-Sally, Liqa.** 2004. Wastewater use in irrigated agriculture: Management challenges in developing countries In Scott, C. A.; Faruqui, N. I.; Raschid-Sally, L. (Eds.), Wastewater use in irrigated agriculture: Confronting the livewlihood and environmental realities. Wallingford, UK; Colombo, Sri Lanka; Ottawa, Canada: CABI Publishing; IWMI; IDRC. pp.1-10.

151. **Silva-Ochoa, P.; Scott, C. A.** 2004. Treatment plant effects on wastewater irrigation benefits: Revisiting a case study in the Guanajuato River Basin, Mexico In Scott, C. A.; Faruqui, N. I.; Raschid-Sally, L. (Eds.), Wastewater use in irrigated agriculture: Confronting the livewlihood and environmental realities. Wallingford, UK; Colombo, Sri Lanka; Ottawa, Canada: CABI Publishing; IWMI; IDRC. pp.145-152.

152. **Valentin, C.** 2004. Overland flow, erosion and associated sediment and biogechemical transports. In Kabat, P.; Claussen, M.; Dirmeyer, P. A.; Gash, J. H.C.; Bravo, L.; de Guenni, M.; Meybeck, R. A.; Pielke, Sr., C. J.; Vörösmarty, R.; Hutjes, W. A.; Lütkemeier, S. (Eds.), Vegetation, water, humans and the climate. A new perspective on an interactive system. Berlin, Germany: Springer verlag, Berlin, (Global Change - The IGBP Series, 2003). Pp.317-322

153. **van der Hoek, W.** 2004. A framework for a global assessment of the extent of wastewater irrigation: The need for a common wastewater typology In Scott, C. A.; Faruqui, N. I.; Raschid-Sally, L. (Eds.), Wastewater use in irrigated agriculture: Confronting the livelihood and environmental realities. Wallingford, UK; Colombo, Sri Lanka; Ottawa, Canada: CABI Publishing; IWMI; IDRC. pp.11-24

154. **Yandle, B.; Vijayaraghavan, M.; Bhattarai, M.** 2004. Income and the race to the top. In Anderson, T. L. (Ed.), You have to admit it's getting better: From economic prosperity to environmental quality. Stanford, CA, USA: Hoover Institution Press. pp.83-108.

EDITORIALS/BOOK REVIEWS

116. **Giordano, M.** 2004. Book review of "The Middle East Water Question" by Tony Allan. The Geographical Journal.170:282.

117. **Kurian, Mathew.** 2004. Book review of "Watershed development projects in India- An evaluation" by John Kerr. Development and Change. 35(1):212-214.

118. **Malano, H. M.; Burton, M.; Makin, I.** 2004. Guest editors' editorial. Irrigation and Drainage. 53(2):117-118

119. **Rijsberman, F.** 2004. Editorial - Growing more rice with less water. Paddy and Water Environment. 2:181-183

120. **van der Hoek, W.** 2004. How can better farming methods reduce malaria? – Guest editorial. Acta Tropica. 89(2):95-97

POLICY BRIEFS

155. **IWMI; ADB.** 2004. Pro-poor intervention strategies in irrigated agriculture in Asia: Issues, lessons and Guidelines. Colombo, Sri Lanka: IWMI; ADB. (IWMI policy briefs: Synthesis lessons and guidelines) 8p.

156. **IWMI; ADB.** 2004. Pro-poor interventions in irrigated agriculture in Bangladesh: Issues, options and proposed actions. Colombo, Sri Lanka: IWMI; ADB. (IWMI pro poor country brief) 6p.

157. **IWMI; ADB.** 2004. Pro-poor interventions in irrigated agriculture in Pakistan: Issues, options and proposed actions. Colombo, Sri Lanka: IWMI; ADB. (IWMI pro poor country brief) 7p.

158. **IWMI; ADB.** 2004. Pro-poor interventions in irrigated agriculture in India: Issues, options and proposed actions. Colombo, Sri Lanka: IWMI; ADB. (IWMI pro poor country brief) 7p.

159. **IWMI; ADB.** 2004. Pro-poor interventions in irrigated agriculture in Vietnam: Issues, options and proposed actions. Colombo, Sri Lanka: IWMI; ADB. (IWMI pro poor country brief) 7p.

160. **IWMI; ADB.** 2004. Pro-poor interventions in irrigated agriculture in Indonesia: Issues, options and proposed actions. Colombo, Sri Lanka: IWMI; ADB. (IWMI pro poor country brief)7p.

161. **IWMI; ADB.** 2004. Pro-poor interventions in irrigated agriculture in China: Issues, options and proposed actions. Colombo, Sri Lanka: IWMI; ADB. (IWMI pro poor country brief) 7p.

Contact Information

Headquarters
127, Sunil Mawatha, Pelawatte,
Battaramulla, Sri Lanka.
Mailing Address:
P. O. Box 2075, Colombo, Sri Lanka.
Telephone: +94-11 2787404, 2784080
Fax: +94-11 2786854
Email: iwmi@cgiar.org

Global Research Division
127, Sunil Mawatha, Pelawatte,
Battaramulla, Sri Lanka.
Mailing Address:
P. O. Box 2075, Colombo, Sri Lanka.
Telephone: +94-11 2787404, 2784080
Fax: +94-11 2786854
Email: iwmi@cgiar.org

Regional Office for Africa
141, Cresswell Street, Weavind Park 0184
Pretoria, South Africa.
Mailing Address:
Private Bag X813, Silverton 0127, Pretoria,
South Africa.
Telephone: +27-12 845-9100
Fax: +27-12 845-9110
Email: iwmi-africa@cgiar.org

Sub–Regional Office for
Nile Basin & Eastern Africa
C/o ILRI-Ethiopia Campus, Wereda 17,
Kebele 21, Addis Ababa,
Ethiopia.
Mailing Address:
P. O. Box 5689, Addis Ababa, Ethiopia
Telephone: +251-1 457222/3 or 463215
Ext: 346
Fax: +251-1 461252/464645
Email: IWMI-Ethiopia@cgiar.org

Sub–Regional Office for West Africa
IWMI Ghana, CSIR Campus, Martin Odei
Block,
Airport Res. Area, Accra, Ghana.
Mailing Address:
IWMI Ghana, PMB CT 112, Cantonments,
Accra, Ghana.
Telephone: +233-(0) 21 784752-4
Fax: +233-(0) 21 784752
Email: iwmi-ghana@cgiar.org

Ghana - Second Office
University Liaison Office,
C/o KNUST, Kumasi, Ghana.
Telephone/Fax: 00233-(0) 51-60206
Email: iwmi-kumasi@cgiar.org

Kenya – Project Office
IWMI - Nairobi,
C/o World Agroforestry Center
P O Box 30677-00100 GPO
Nairobi, Kenya.
Telephone/Fax: +254 20 7224000/+254 20
7224001
Email: iwmi-nairobi@cgiar.org

Regional Office for South Asia
C/o ICRISAT, Patancheru, 502 324
Andhra Pradesh, India.
Telephone: +91-40 30713071
Fax: +91-40 30713074, 30713075
Email:iwmi-southasia@cgiar.org
iwmi-india@cgiar.org

IWMI-TATA Water Policy Program
Anand Field Office,
Elecon Premises, Anand-Sojitra Road,
Vallabh Vidyanagar 388 120, Anand,
Gujarat, India.
Telephone: +91 2692-229311-13
Fax: +91 2692-229310
Email: iwmi-tata@cgiar.org

New Delhi
South Asia Liaison Office,
2nd Floor, NASC Complex, DPS Marg,
Pusa Campus, New Delhi 110 012, India.
Telephone: +91-11 25840811-2
Fax: +91-11 25841294
Email: b.Sharma@cgiar.org

Nepal
Nepal Office,
Department of Irrigation,
Room # 412 & 413,
Jawalakhel, Lalitpur,
GPO 8975 EPC 416, Kathmandu, Nepal.
Telephone: +977-1 5542306 (Direct)
+977-1 5535382 (Ext. 412 & 413)
Mobile Tel: +977-98510-22573
Fax: +977-1 5536219
Email: d.pant@cgiar.org

Pakistan
12KM Multan Road, Chowk Thokar Niaz
Baig,
Lahore 53700, Pakistan.
Telephone: +92-42 5410050-53 (4 lines)
Fax: +92 42-5410054
Email: iwmi-pak@cgiar.org

Central Asia Office
Uzbekistan
Apartment No. 123,
Home No. 6, Murtazaeva Street,
Tashkent 700000,
Uzbekistan.
Telephone: +998-71 1370445 / 1372173
Fax: +998-71 1370317
Email: m.hassan@cgiar.org

Iran
C/o. Iranian Agricultural Engineering
Research Institute (IAERI)
P.O. Box 31585-845, Karaj, Iran
Telephone: +98-261 2716804
Fax: +98-261 2706277
Email: a.sarwar@cgiar.org

Regional Office for Southeast Asia
(Cambodia, China, Indonesia, Laos,
Malaysia, Myanmar, Pacific Islands,
Philippines, Thailand, Vietnam)
7TH Floor, IFRPD Building,
Kasetsart University,
Jetujak, Bangkok 10900
Thailand.
Mailing Address:
P. O. Box 1025, Kasetsart University,
Bangkok 10903,
Thailand.
Telephone: +66-2561-4433
Fax: +66-2561-1230
Email: iwmi-sea@cgiar.org

China
Center for Chinese Agricultural Policy,
Chinese Academy of Sciences,
Building 917,
Datun Road, Anwai,
Beijing, 100101, China.
Telephone: +86-10 64889440, 64856535,
64856837
Fax: +86-10 64856533
Email: i.makin@cgiar.org

Laos
National Agriculture & Forestry
Research Institute (NAFRI),
Ministry of Agriculture & Forestry,
PO Box 811, Vientiane.
Telephone: +856-20 502680
Fax: +856-21 414374
Email: c.valentin@cgiar.org

Vietnam
IRD-IWMI, National Institute for Soils and
Fertilizers (NISF),
Dong Ngac. Tu Liem District, Ha Noi,
Vietnam.
Telephone: +84 (4) 754 32 57
Fax: + 84 (4) 972 06 30
Email: d.orange@cgiar.org

Cambodia
IWMI office
Dept. Of Irrigated Agriculture
Northbridge Street
Phnom Penh
Cambodia
Tel : 855 012 300531
Fax : 855 023 885840
Email : l.perera@cgiar.org

Our vision is that in 2008, IWMI is a world-class knowledge resource center on water, food and environment . It generates knowledge on better water and land management in developing countries, through strategic research alliances with a set of core partners throughout Asia and Africa, and with advanced research institutes in developed countries.
This knowledge is held and maintained as global public goods for the benefit of mankind.

Annual Report Team

Project Leader : Dawn Rodriguez
Writers/ Editors : Sharni Jayawardena
Nicola Perera
Harshana Rambukwella
Dawn Rodriguez
Web Support : Charmalee Jayasinghe
Dominique Perera
Woranga Atukorale
Coordination : Sharmani Gunewardena
Designed by Triad Advertising (Pvt) Ltd
Produced by eMAGEWISE® (Pvt) Ltd
Printed by Gunaratne Offset Ltd