

WATER FIGURES

TURNING
RESEARCH
INTO
DEVELOPMENT

QUARTERLY NEWSLETTER OF THE
INTERNATIONAL WATER MANAGEMENT INSTITUTE



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ISSUE 2 2007

ANNOUNCEMENT

IWMI's theme, Water Management and Environment, looks at balancing water for food and ecosystems. This issue of Water Figures gives an overview of our work on the theme and an introduction to the projects working in Asia and Africa that explore the issues raised by managing water for food and nature.



EDITORIAL

WATER FIGURES ISSUE 2, 2007




Water for food and ecosystems: a difficult balance

Agriculture and water resources development are seen as major drivers of environmental degradation, reducing the capacity of the ecosystems they alter to deliver services to people. At the same time, our reliance on ecosystems services to secure food and livelihoods, increasingly comes at a price.

IWMI's research on the theme Water Management and Environment is focused on integrated approaches to address the multifunctionality of ecosystems in order to promote sustainable development, support livelihoods and reduce poverty. By taking a closer look at agroecosystems, the theme examines ways to address the water requirements of beneficial ecosystem services in basin water resource development and management. Water development is still a priority in many regions of the world, particularly in Africa where there is a need to invest in dam construction and other water infrastructure to boost economic development. However, such activity is often associated with harsh consequences for the environment and consequent negative impacts for poor people. IWMI's research in this area is directed towards finding better ways of incorporating environmental and social concerns into water resource development and management, in order to avoid the mistakes, and resultant human suffering, of the past. The goal is to meet the demand for social and economic development and simultaneously minimize environmental degradation.

Poverty is central to IWMI's work on the environment. It is often the poorest people who have the greatest dependence on ecosystem services, their livelihoods intrinsically connected to the environment. This means that the poorest are also the most vulnerable to changes in the environment. IWMI's projects examine this issue in the context of agriculture that is supported by wetlands. Local communities that are dependent on wetlands for agriculture have been most affected by changes in these areas. The consequences are often severe and mean a loss in livelihoods. Research focuses on understanding how communities cope with and adapt to changes in wetlands. The research also includes analyses that contribute to improving the inventory and assessment of wetlands that support agriculture—an effort that draws attention to vulnerable areas where sustainable practices need to be promoted.

Our main article (page 4) gives an overview of IWMI's projects in this theme. 

Samyuktha Varma
Editor

The choice of WATER FIGURES as the name of our quarterly newsletter arises from its ability to communicate more than one meaning: "Water figures in the scheme of things..."; "WATER FIGURES as a reference to the science of water management"; "WATER FIGURES as a visual representation of the spaces the resource occupies and the shapes it takes".

EVENTS

WORLD WATER WEEK

Stockholm 12 – 18 August, 2007

This year's theme, 'progress and prospects on water, striving for sustainability in a changing world' looks at the relationship between economics, governance, livelihoods, lifestyles and resource pressures, and the partnerships required to manage water sustainably.

www.worldwaterweek.org



Intrunjabili Wetland, Zimbabwe. Photo Credit: Lisa Rebelo

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Measuring impact: so we know (how much) our work counts

MEREDITH GIORDANO

IWMI's projects and programs aim to produce impact on water and land management for the benefit of food production, livelihoods and nature. We recognize that impact assessment measures can help us systematically evaluate the extent to which we are meeting this goal. IWMI instituted a formal assessment initiative to measure the quality and direct impacts of our research and, together with our partners, to ensure that our knowledge reaches the right people. The initiative is designed to achieve the three key goals of:

- Improving the internal management and priority setting processes.
- Ensuring our research and capacity building programs meet the needs of our stakeholders and partners.
- Acknowledging and learning from the impacts (both the positive and negative aspects) of our activities.

As we reflect on the past contributions of IWMI's research, it is useful to place them within the context of four complementary knowledge roles that the institute has identified to balance the generation of scientific outputs with ensuring those outputs have a positive impact on food production, livelihoods and the environment. We summarize the four knowledge roles below and provide examples of IWMI's outcomes and impacts within each of these roles.

1. Knowledge generation through applied, policy-oriented research.

Knowledge generated by IWMI ranges from conceptual advances to the development of integrated approaches to research on the water-food-environment nexus. While determining the impact of knowledge generated is not an exact science, the demand for IWMI's involvement in regional and global initiatives is one important indicator. For example, IWMI's research on the ecological aspects of agricultural systems has been recognized through its confirmation as the fifth International Organization Partner of the Ramsar Convention on Wetlands, the first from outside the original four conservation NGOs.

2. Knowledge sharing by building a learning organization and making our research findings more widely accessible.

To have widespread impact, IWMI's research results must reach a variety of audiences. IWMI shares its information through many channels, and translates its research findings into policy recommendations through its Water Policy Briefing series. At the project level, active outreach programs also broaden the influence of IWMI research results. For example, IWMI's communication of the positive income and productivity benefits from its program on small-scale land and water interventions in East Africa is helping to spur broader uptake of project findings.

3. Knowledge brokerage by opening a window-on-the-world for researchers through the development of international research alliances, both South-South and South-North.




[http://www.sciencecouncil.cgiar.org/activities/spia/pubs/14\(IWMI\)-Final_1-r.pdf](http://www.sciencecouncil.cgiar.org/activities/spia/pubs/14(IWMI)-Final_1-r.pdf)

There is a growing demand on CGIAR Centers to serve as brokers of international research networks. As an example, IWMI recently facilitated a strategic partnership between the Indian Council of Agricultural Research (ICAR) and the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) on agriculture and natural resource management research, development, and capacity building in East and Central Africa. Rwanda has taken the lead in leveraging the benefits of this partnership by inviting Indian researchers to help design participatory watershed management projects which will serve as learning sites for the region.

4. Knowledge application by establishing impact pathways with development partners to enable broad application of IWMI's knowledge.

IWMI's increasing engagement in national, regional and global development initiatives indicates the growing practical influence of its work. For example, IWMI research on river basin institutions and the linkages between irrigation and poverty alleviation influenced the development agenda of the Asian Development Bank (ADB). IWMI research is cited in ADB documents that convey their strategies to improve water security of the poor, and IWMI is a founding partner of the ADB's Water and Poverty Initiative. At a national and regional scale, IWMI's partnership with the Catholic Relief Service in a drought preparedness project led to the initiation of community-based micro-watershed water supply activities in Afghanistan with a view of further extending this work regionally.

Besides this outreach role, impact assessment has many functional and strategic roles. It helps monitor the achievement of our mission in the context of specific projects, engenders an impact culture within the institute, ensures accountability to donors and funding agencies, and aligns the research agenda with policy changes and stakeholder needs and feedback. Therefore, we are committed not only to assessing the impact of our research but also ensuring that our impact assessment initiative itself delivers the right impact. 

Water Management and Environment: An overview of key projects

THE GLOBAL DATASET OF WETLANDS OF INTERNATIONAL IMPORTANCE

The need for information in support of wetland management is multi-scalar - from global, regional and national assessments to guide policy-making to more local information on specific wetlands to guide management planning processes. However, in many instances baseline wetland inventory is incomplete, and what has been collected is often inconsistent or not readily accessible to those who need it. The Ramsar Convention on Wetlands has long recognised the need to develop techniques that can fill gaps in baseline inventory and has supported the development and application of inventory techniques including the application of remote sensing and GIS.

In order to accomplish meaningful, accurate and up-to-date mapping, inventory and assessment of wetlands at a global scale, it is essential to develop a platform which will allow the many agencies and groups working in wetlands to work together towards this goal. A voluntary multi-stakeholder initiative for global wetlands inventory and mapping has thus been proposed by the FAO, through the Coastal Panel of the Global Terrestrial Observing System (C-GTOS), and IWMI, and accepted by the Ramsar Convention's Scientific and Technical Review Panel (STRP). This initiative has been developed in line with the requirements of the United Nations Commission for Sustainable Development for partnerships that promote sustainable development.

Through this international partnership, and centred on the requirements and interests of the Ramsar Convention on

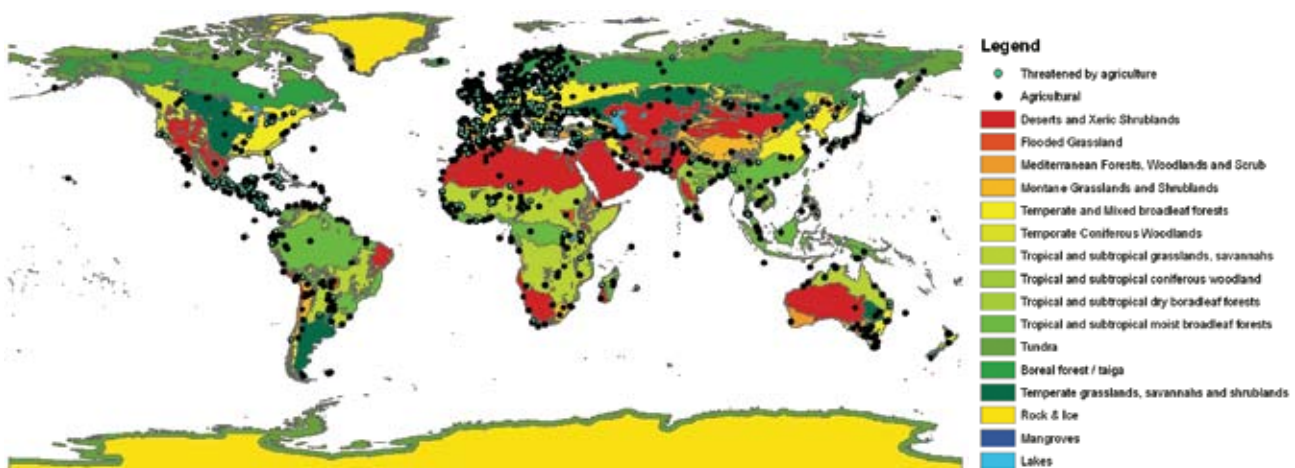
Wetlands, a global wetland inventory is being developed through the application of remote sensing and GIS technologies. The inventory aims to provide information on the extent and condition of wetlands globally, and is being compiled through individual projects conducted at different spatial and temporal scales.

As part of this effort, an analysis of the geographic distribution of wetlands is being undertaken using continental directories largely compiled more than a decade ago with the explicit goal of making these available through the internet for further interrogation and analysis. In conjunction with this effort the Ramsar sites database has been analysed to determine the geographic representivity of sites listed in the database. Whilst the site data is not representative of the areal extent of wetlands globally it does provide a base for considering the proportionate distribution of wetlands across different ecoregions, and is also being used to assess the regional uses of wetlands (in particular for agriculture) and the key causes of wetland degradation.

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IMPROVING PLANNING OF LARGE DAM OPERATION

Improvement in water management through investments in large dams is widely advocated as a key component in strategies for economic development and poverty alleviation in sub-Saharan Africa. Currently, many dams are being planned or constructed (e.g., in Ethiopia, South Africa, Uganda, Mozambique and Sudan). In many places the water regulated by dams is an absolute requirement to meet



Ramsar sites utilised for agriculture and fisheries activities



development objectives. However, past experience shows that the construction of large dams, without a comprehensive understanding of the environmental and social interactions and their consequences, can have devastating impacts on ecosystems, biodiversity and people.

A large number of complex and inter-related issues must be considered for the wise and sustainable use of water stored in reservoirs. This also poses intricate technical and political problems, many of which can be avoided if care is taken in planning and designing a dam and in its operation. Optimizing reservoir releases must take account of water uses upstream and downstream of the dam, including water supply, agriculture (i.e. irrigation and livestock), fisheries and power generation requirements, as well as the requirements of communities that depend on the natural resources of downstream ecosystems, possible health impacts and the needs of aquatic habitats. It is necessary to consider not just physical factors, but also livelihoods and issues of equity. In such situations, the quality of the decision-making process is critical to the sustainability of decisions made.

Funded by the Challenge Program for Water and Food and undertaken over a 4-year period, this project aims to determine how decision support systems (DSS) can improve the planning, design and operation of large dams to ensure sustainable use of river resources and improve equity in the distribution of benefits. Modern DSS can help structure decision processes and support analysis of the consequences of possible decision choices. Some can also promote understanding of system dynamics and facilitate the communication of information to people, so that they can participate more fully in decision-making processes.

The project is conducting case studies in Ethiopia, on the Chara Chara weir at the outlet from Lake Tana, the Koga dam on the Gilgel Abay River and the Koka Dam on the Awash River. One case study is also being conducted in Uganda on the hydropower dams of the Victoria Nile. Guidelines on the use of DSS, with the inclusion of stakeholders in the planning and operation of dams, will be developed based on the experience gained. This project is being implemented by four organizations: Addis Ababa University, Ethiopia; the Ministry of Water Resources, Ethiopia; Southern Waters, South Africa and IWMI.

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INTEGRATED APPROACHES LINKING SPATIAL AND SOCIAL INTERACTIONS IN WETLAND SYSTEMS

The debate on the future of wetlands tends to be polarized into either seeking development or conservation related goals. Effective inventory, mapping and monitoring of wetlands along with the assessment of the ecosystem services they provide, helps to understand the links between the various components that comprise the wetland and support the livelihoods and well-being of people.

IWMI has piloted tested a multidisciplinary and multi-scale approach to monitor wetland change that incorporates both environment and livelihoods and poverty aspects by combining GIS based methodology and livelihoods analyses in a coastal wetland system; it is currently up-scaling and diversifying this approach to use in investigating inland wetland systems. Although other studies have described changes in wetland systems using Remote Sensing and GIS tools and taking socioeconomic data into account, the IWMI study attempts to establish correlations between spatial and social parameters at the scale of the wetland complex through automated algorithms for environmental change detection (customising the ID-RISI – Andes, Land change modeller (LCM)). In addition, the study aims to develop a better understanding of how livelihood systems of local communities at the household scale have changed, because of changes in the overall wetland—thereby linking environmental change detection to the social parameters at different management scales (site-village-household level).

The pilot study was carried out in the Muthurajawela Marsh – Negombo Lagoon (MNNL), an urban wetland complex on the western coast of Sri Lanka. Preliminary results suggest that significant changes in land cover and use patterns occurred in the wetland during the time period under investigation. These were observed through GIS maps that were generated at different scales. For example, the conversion of the lagoon into a shallow water body with sediments and the fragmentation and conversion of marshland into settlements, were clearly visible from the spatial data.

These environmental changes have also been observed and experienced by local communities and have had an impact on their livelihood systems. At the household level, most people perceived environmental changes in the lagoon as a change for the worse, for example, negatively affecting





overall fisheries productivity. However, changes in the marsh were perceived to be both for the better (settlements bringing in new infrastructure) and for the worse (settlements within the wetland experiencing annual flooding). These variations in perceptions are based on how much the household livelihood system directly depended on the environment. The preliminary results indicate that monitoring of wetland systems using this type of multidisciplinary and multi-scale approach helps highlight both environmental and livelihoods aspects, and therefore supports both conservation and development.

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WETLANDS AND LIVELIHOODS IN SOUTHERN AFRICA

The need to avert water shortages has resulted in farmers turning to wetlands for crop production. The wetlands are attractive units for their rich soils and year round soil moisture, which is favorable to crops during both the dry season and drought years. But wetlands also have many functions that are beneficial to the environment and humans, and if used unwisely these benefits will be lost. Wetlands support important environmental functions, including flood control. They are complex and ecologically sensitive environments that are intrinsically linked to the catchments in which they occur. Altering the wetland environment through cultivation, for example, has potential impacts across the wetland and the associated downstream areas. As such, agricultural production in wetlands has traditionally been considered an antithesis to the conservation of wetlands. The perception is that crop production in wetlands causes degradation of

the wetlands, and results in loss of benefits. But agriculture has taken place in some of these wetlands for many years, and farmers, regardless of conservation efforts and restrictions, and driven by escalating unemployment and increasingly unreliable rainfall, continue practicing varying levels of agriculture in marshes and swamps. Long-lasting efforts towards sustainable management and conservation of wetlands cannot focus on conservation alone; it requires that farmers are taken on board.

Two projects currently underway are studying ways in which to improve the sustainable management of wetlands. In Lesotho, Malawi, Mozambique, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe, IWMI is partnered with the United Nations Environment Program (UNEP) under the Global Environment Facility to put in place or to enhance mechanisms that minimize the degradation of wetland ecosystems in order to optimize the ecosystem and livelihood benefits that are generated from wetlands. The project will also generate generic guidelines, tools and methodologies for sustainable land and water management in wetlands. In the Limpopo basin, the Challenge Program on Water and Food (CPWF) supports a study of water use strategies for agriculture (crop and livestock) and fisheries in riverine swamps and is analyzing the trade-offs of these different uses. The results will help develop tools to improve the planning of wetland use and conservation. The focus of the study is facilitating sustainable wetland management and development. The proposal is based on the basic hypothesis that wetlands can be managed in a sustainable manner, and that a balance between protection and agricultural production can be achieved, ensuring optimal use of wetlands.

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Photo Credit Lisa Rebelo



A new project assesses the impact of irrigation infrastructure on poverty in Sri Lanka

Poverty reduction is often cited as one of the main objectives of irrigation development projects. Irrigation has the ability to directly and indirectly contribute to reducing poverty. The extension of irrigation can affect cropping areas and intensity; produce higher yields; grow higher value crops; create employment, higher salaries; increased food supply and consequently improve livelihoods of people by reducing chronic and transient poverty. Seasonal or transient poverty is a common phenomenon in agricultural economies and irrigation can make a significant contribution to reducing this condition. Many studies have been unable to capture the true incremental benefit of irrigation, especially in terms of its poverty reduction ability, because of the difficulty in finding data that illustrates the situation prior to the introduction of irrigation infrastructure. Lack of accurate estimations showing the potential of irrigation in development has meant that irrigation investment has not been made with the best information available.

A study carried out by IWMI and the Japan Bank for International Cooperation (JBIC) from 2000-2002, in the Uda Walawe left bank irrigation project area to evaluate the impacts of irrigation



Uda Walawe Tank
Photo Credit: Sanjini de Silva

infrastructure improvement, produced useful information on its specific contribution to reducing chronic and transient poverty (a full report of the study can be downloaded from the JBIC website, details below). One of the limitations of the study was that it was not able to make the calculation based on information from before and after the infrastructure was put in place, and so compared a similar (in other aspects) area without irrigation to areas that had irrigation. A new study that begins this June will revisit the non irrigated area studied earlier, which is now irrigated, and collect the latest socio-economic data to assess how poverty has been affected since the introduction of irrigation. In addition, the study will extend the analysis of the earlier project by also researching the role of institutions such as cooperatives, credit institutions and other collective actions on irrigation related poverty reduction, and develop case studies to show particular aspects of these institutions' performance. The project also aims to develop a deeper understanding of the impact of irrigation on livelihoods of people, poverty reduction mechanisms and their differences across households with seemingly similar irrigation conditions by performing a Sustainable Livelihoods analysis.



Uda Walawe Tank
Photo Credit: Sanjini de Silva



Impact of Irrigation Infrastructure Development on Dynamics of Incomes and Poverty: Econometric Evidence Using Panel Data from Sri Lanka
JBICI Research Paper No.32, March 2007
JBIC Institute and IWMI
<http://www.jbic.go.jp/english/research/report/paper/index.php>



Photo Credit Sanjini de Silva



Recent Publications

For on-line access to IWMI Research Reports and Working Papers, see <http://www.iwmi.cgiar.org/pubs/mindex/htm>

WORKING PAPER

1. Jehangir, Waqar; Masih, Ilyas; Ahmed, Shehzad; Gill, M. A.; Ahmad, M.; Mann, R. A.; Chaudhary, M. R.; Qureshi, Asad Sarwar; Turrall, Hugh. 2007. Sustaining crop water productivity in rice-wheat systems of South Asia: A case study from the Punjab, Pakistan. Colombo, Sri Lanka: IWMI. 37p. (IWMI Working Paper 115)

BOOKS AND BOOK CHAPTERS

2. Giordano, Mark; Villholth, Karen. (Eds) 2007. The agricultural groundwater revolution: Opportunities and threats to development. Wallingford, UK: CAB International. (Comprehensive Assessment of Water Management in Agriculture series 3)
3. Giordano, Mark; Villholth, Karen. 2007. The agricultural groundwater revolution: Setting the stage. In Giordano, Mark; Villholth (Eds.). The agricultural groundwater revolution: Opportunities and threats to development. Wallingford, UK: CAB International. pp.1-4.
4. Kumar, Dinesh. 2007. Groundwater management in India: Physical, institutional and policy alternatives. New Delhi, India: Sage. 354p.
5. Mai, V. T.; Van Keulen, H.; Hoanh, Chu Thai; Hessel, R.; Roetter, R. P. 2007. Spatial dynamics of nitrogen in shallow groundwater under intensive farming in northern Vietnam. In Van Trinh, M. Soil erosion and nitrogen leaching in northern Vietnam: Experimentation and modelling. Wageningen, Netherlands: Wageningen University. pp.119-135.
6. Masiyandima, Mutsa; Giordano, Mark. 2007. Sub-Saharan Africa: Opportunistic exploitation. In Giordano, Mark; Villholth (Eds.). The agricultural groundwater revolution: Opportunities and threats to development. Wallingford, UK: CAB International. pp.79-99.
7. Shah, Tushaar. 2007. Institutional and policy reforms. In Briscoe, J.; Malik, R. P. S. (Ed.). Handbook of water resources in India: Development, management, and strategies. New Delhi, India, OUP. pp.306-326.
8. Turrall, Hugh; Fullagar, I. 2007. Institutional directions in groundwater management in Australia. In Giordano, Mark; Villholth (Eds.). The agricultural groundwater revolution: Opportunities and threats to development. Wallingford, UK: CAB International. pp.320-361.
9. Shah, Tushaar; Scott, C.; Kishore, A.; Sharma, A. 2007. Energy-irrigation nexus in South Asia: Improving groundwater conservation and power sector viability. In Giordano, Mark; Villholth (Eds.). The agricultural groundwater revolution: Opportunities and threats to development. Wallingford, UK: CAB International. pp.211-242.
10. Saleth, Rathinasamy Maria. 2007. Water rights and entitlements. In Briscoe, J.; Malik, R. P. S. (Eds.). Handbook of water resources in India: Development, management, and strategies. New Delhi, India: OUP. pp.282-305.
11. Villholth, Karen; Giordano, Mark. 2007. Groundwater use in a global perspective – Can it be managed? In Giordano, Mark; Villholth (Eds.). The agricultural groundwater revolution: Opportunities and threats to development. Wallingford, UK: CAB International. pp.243-265.

IWMI ARTICLES IN JOURNALS

12. Bhattarai, M.; Barker, Randolph; Narayanamoorthy, A. 2007. Who benefits from irrigation development in India?: Implication of irrigation multipliers for irrigation financing. *Irrigation and Drainage*, 56:207-225.
13. Gamage, M. S. D. Nilantha; Ahmed, Mobin-ud-Din; Turrall, Hugh. 2007. Semi-supervised technique to retrieve irrigated crops from Landsat ETM+ imagery for small fields and mixed cropping systems of South Asia. *International Journal of Geoinformatics*, 3(1):45-53.
14. Gopalakrishnan, M. 2007. Advances in microirrigation. *Irrigation and Drainage*, 56:363-365.
15. Hussain, I.; Gichuki, Francis; Louw, A.; Andah, W.; Moustafa, M. 2007. Agricultural water management pathways to breaking the poverty trap: Case studies of the Limpopo, Nile and Volta river basins. *Irrigation and Drainage*, 56:277-288.
16. Molden, David; Burton, M.; Bos, M. G. 2007. Performance assessment, irrigation service delivery and poverty reduction: Benefits of improved system management. *Irrigation and Drainage*, 56(2-3):307-320.
17. Namara, Regassa; Hussain, I.; Bossio, Deborah; Verma, Shilp. 2007. Innovative land and water management approaches in Asia: Productivity impacts, adoption prospects and poverty outreach. *Irrigation and Drainage*, 56:335-348.
18. Rosenqvist, A.; Finlayson, Max; Lowry, J.; Taylor, D. 2007. The potential of long-wavelength satellite-borne radar to support implementation of the Ramsar Wetlands Convention. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 17:229-244.
19. Saleth, Rathinasamy Maria; Kadushkin, A.; Ali, T. 2007. Water institutional reforms and the MDGs: Towards an evaluation framework. *Irrigation and Drainage*, 56:227-236.
20. Schousboe, M. L.; Rajakaruna, R. S.; Salanti, A.; Hapuarachchi, H. C.; Galappaththy, G. N. L.; Bygberg, I. C.; Amerasinghe, Priyane; Konradsen, F.; Alifrangis, M. 2007. Island-wide diversity in single nucleotide polymorphisms of the *Plasmodium vivax* dihydrofolate reductase and dihydropteroate synthetase genes in Sri Lanka. *Malaria Journal*, 6(28). 6p.
21. Suzuki, Shinji; Noble, Andrew; Ruaysoongnern, S.; Chinabut, N. 2007. Improvement in water-holding capacity and structural stability of a sandy soil in northeast Thailand. *Arid Land Research and Management*, 21(1):37-49.
22. van Koppen, Barbara; Hussain, I. 2007. Gender and irrigation: Overview of issues and options. *Irrigation and Drainage*, 56:289-298.
23. Wang, J.; Huang, J.; Xu, Z.; Rozelle, S.; Hussain, I.; Biltonen, Eric. 2007. Irrigation management reforms in the Yellow River Basin: Implications for water saving and poverty. *Irrigation and Drainage*, 56:247-259.
24. Yakubov, Murat; Ul Hassan, Mehmood. 2007. Mainstreaming rural poor in water resources management: Preliminary lessons of a bottom-up WUA development approach in Central Asia. *Irrigation and Drainage*, 56:261-276.

