

IWMI

CELEBRATING 25 YEARS OF RESEARCH ACHIEVEMENTS



IWMI
International
Water Management
Institute

IWMI Celebrating

25
years
1985-2010

A large, stylized blue wave graphic that flows from the top left, loops around the left side, and then curves towards the bottom right. The wave is composed of several layers of blue, creating a sense of depth and movement. It serves as a background for the text.

VISION

Water for a **food-secure** world

MISSION

To **improve** the management
of **land** and **water resources**
for **food, livelihoods** and
the **environment**

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and Directors General)



Introduction



Photo credit: Sanjini de Silva, IWMI.



With growing water scarcity and the demand for water for non-agricultural purposes, “food security” is once again becoming a concern. One of IWMI’s tasks will be to help governments make the transition from the development to the management of water resources. This will not be an easy task but the pressures to move in this direction are increasing.

Randolph Barker
Interim Director General,
IWMI, 1995



The year 2010 saw the beginning of vast devastation as a result of water-related disasters which only increased in magnitude by 2011. Brazil, Australia and Sri Lanka are amongst the countries that have been ravaged by floods, which have left several dead, thousands sick and millions homeless. Dirty water kills approximately 4,000 children a day (World Health Organization (WHO)/WaterAid).

On the other hand, water scarcity is not just a looming threat, but a reality for almost one-fifth of the world’s population who already live in physically water scarce areas. This number will only continue to rise given the growing population, rise in natural disasters and the increased use of water for agricultural, industrial and domestic purposes. In addition, the possibility of a food crisis threatens to further exacerbate the already severe impacts faced by several parts of the world in the wake of the floods.

Water and food have a complex, yet mutually dependent, relationship - one cannot exist without the other. Water scarcity and food insecurity, therefore, require solutions that are integrated across the agricultural, economic and industrial sectors.



Photo credit: Michael Foley Photography.



I'd like to see this new focus on climate change more as an add-on to the water management and the water crisis. We don't want two crises – a climate crisis and a water crisis. These things have to come together - this is very important. That means that you have to look at it from the very long-term planning perspective. Spatial planning. And in spatial planning, integrated water resources management is a very important tool...to bring parties together to look for a common future.

Klaas Jan Beek
Chair, IWMI Board of Governors, 1999-2000



The importance of water management in agriculture, and lack of recognition in terms of water policy issues at both the national and international level, is what contributed to the establishment of IWMI 25 years ago. The early years at IWMI focused on irrigation with an expansion in the following years to a deeper analysis of not only how it sits in a river basin but also how it competes with the environment, cities and industries. The work on water scarcity, supply and demand, and global environmental flows put IWMI on the map.

Today, we're making a mark looking at groundwater, institutions and wastewater. The Institute has come a long way since 1985 given the range of areas within which it works. This too will keep evolving given the new issues and challenges that will surface in the future.



Photo credit: Vladimir Smakhtin, IWMI.



So in the next 30 to 35 years, there'll be another 3 billion mouths to feed. Yet, the share of water that will be available to produce those crops, to produce those livestock, and to produce those fish will be a decreasing share and in many cases the quality of that water will also be lower. What IWMI does, though, of course, is realize that these things have to be addressed, not just through engineering solutions, not just through policy solutions, not just through hydrology, not just through agronomy, but through the ability to integrate those disciplines. So past achievements in being able to bring disciplines together will become even more important. But the key challenge is the fact that we have to feed even more mouths with less water being available to agriculture.

John Skerritt
Chair, IWMI Board of Governors



25 Years – A Lifetime of Ideas

David Molden, Deputy Director General – Research, IWMI



This picture, taken in 1982, is from the *mul saancho* (main key) on the Maili Kulo in the Argali Village in the Palpa District, Nepal. It shows the fixing of a wooden proportioning weir just before the rice plantation and immediately after desilting and maintenance of the main canal. The people around the weir are the shareholders of the system who make sure that the width of the weir is properly fixed according to the proportion of water allocated to each sub-branch. Work with farmer-managed irrigation systems in Nepal was spearheaded by Robert Yoder and Prachanda Pradhan.

Photo credit: Dr. Robert Yoder, former IIMI Researcher.

1. Roots in irrigation

In the beginning, IWMI was IIMI. The 'W' for water would supplant the 'I' for irrigation in 1998.¹ The *raison d'être* for the Institute was to focus on the management of irrigation systems. Billions of dollars had been spent constructing irrigation systems across Asia, but their performance was low. The diagnosis – weak water management. IWMI was conceived to fix those problems.

In the early years, IWMI staff worked closely with irrigation departments, farmers and water user associations in a range of countries including the Philippines, Indonesia, India, Morocco, Nepal,

IIMI was born of two quite different traditions. From the international agricultural research center system came the tradition of multidisciplinary research with training and information exchange, and from the experience of irrigation project planning and operations came the practical, problem-solving perspective, necessary to translate research on irrigation management into tangible gains in performance and productivity.

Thomas Wickham
Director General, IWMI
1985-1989

Access to reliable supplies of clean water is a matter of human security. It's also a matter of national security.

Hillary Rodham Clinton
US Secretary of State,
speaking at the National
Geographic Society,
Washington, DC,
on World Water Day,
March 22, 2010

Nigeria, Sri Lanka, Sudan and Pakistan. Many of the staff were housed within irrigation departments, to learn and be able to influence through the development of relationships and exchange of knowledge and ideas. Action research was the *modus operandi*. IWMI specialized in issues of design, operation, maintenance, sustainable rehabilitation and modernization, reform of irrigation institutions and organizations, and irrigation performance assessment. Even though IWMI has expanded from its original mandate, issues of water scarcity and food insecurity are even more pressing today than they were 25 years ago. Fortunately, there is a wealth of knowledge and capacity that was developed during IWMI's early years that remains in place today.

For more information on IWMI's history and research, have a read through *"Expanding the frontiers of irrigation management research: Results*

¹ Many people struggle with the pronunciation of 'IWMI', but it was decided to have the same pronunciation as 'IIMI', with a silent 'W' as in 'write'.



*This farmer was preparing his paddy land near Balangoda, Sri Lanka.
Photo credit: Karen Conniff, IWMI.*

of research and development at the International Irrigation Management Institute, 1984 to 1995² and “More crop per drop”: Revisiting a research paradigm: Results and synthesis of IWMI’s research, 1996-2005.³

2. It’s about people, institutions and governance

What IWMI quickly learned—and told the world—is that irrigation problems are not solely technical, but mostly stem from institutional problems. An interdisciplinary approach was advocated and IWMI made considerable advances on issues of water rights, pricing and financing, and looking at ways to create positive incentives rather than just cost recovery. In Nepal, for example, IWMI was well-known for its work on farmer-managed systems, understanding how they operate, designing ways to upgrade these systems and using them as models to determine how other systems could be managed. IWMI researchers did some of the early and most significant work on gender and irrigation, culminating in a landmark international conference in Habarana, Sri Lanka, in 1996.⁴ IWMI continues to maintain its strengths in social sciences to address issues of groundwater governance, formal and informal water institutions, and broader issues of water and society.

Over 15,000 irrigation systems in Nepal are operated and managed by farmer groups. More than 60% of the irrigated land is managed by farmers’ Water Users’ Associations.

Amongst irrigation specialists, IWMI is most famous for its work on participatory irrigation management (PIM) and irrigation management transfer (IMT). A landmark was the international conference on participatory irrigation management in Wuhan, China, in 1992^{5,6}. At that time, there was much resistance to this emerging paradigm. Now, PIM is the *status quo* for governments as well as major lending agencies. Recently, IWMI researchers have been questioning whether or not PIM is being carried out effectively, or, indeed, whether PIM is the ‘right’ thing to be doing in much-changed social, economic and geophysical contexts. Moving beyond present practices of PIM, with better consideration of the roles of the government, water users and the private sector, is now an important reemerging topic in the continuing quest to improve irrigation management.

² 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: International Irrigation Management Institute (IIMI). xlii, 228p. http://publications.iwmi.org/pdf/H_22082i.pdf

³ Giordano, M.; Rijsberman, F.; Saleth, R. M. (Eds.). 2006. “More crop per drop”: Revisiting a research paradigm: Results and synthesis of IWMI’s research, 1996-2005. London, UK: IWA Publishing; Colombo, Sri Lanka: International Water Management Institute (IWMI). 273p.

⁴ Merrey, D.; Bavisar, S. (Eds.). 1998. *Gender analysis and reform of irrigation management: Concepts, cases, and gaps in knowledge. Proceedings of the Workshop on Gender and Water, September 15-19, 1997, Habarana, Sri Lanka*. Colombo, Sri Lanka: International Water Management Institute (IWMI). xii, 268p. http://publications.iwmi.org/pdf/H023664_TOCA.pdf

⁵ At IIMI, International Conference on Irrigation Management Transfer, Wuhan, China, September 20-24, 1994. Vol. 3. Draft conference papers. pp.153-159.

⁶ This helped develop IWMI’s long-standing relationship with China.



This photograph was taken above Bujagali Falls in Uganda, looking towards Jinja.
Photo credit: David Molden, IWMI.

3. The basin approach (IIMI to IWMI)

In 1996, IIMI⁷ published the first volume of its flagship Research Report series titled, *"The new era of water resources management: From 'dry' to 'wet' water savings,"* authored by David Seckler, who was the Director General of IWMI at the time. The main message was that, irrigation needs to be considered within a basin context, and other competing users and the environment must also be taken into consideration. IWMI researchers had previously largely restricted their focus to the irrigation system itself. However, with increasing competition for scarce water resources, irrigation could no longer be seen in isolation, and management of irrigation systems needs an integrated perspective.

IIMI to IWMI

November 1998:

Board approves name change to IWMI

2000:

Name change formally approved by the Government of Sri Lanka

IIMI Research Report 1 opened many doors. With this expanded vision of water, IWMI scientists experienced a renaissance in thinking that led to new directions in real and paper water savings, open and closed basins, water accounting, multiple-use water systems, basin institutions, remote sensing analysis and environmental flows. As a newly inducted member of the Consultative Group on International Agricultural Research (CGIAR)⁸, IWMI's mandate changed to generating international public goods, moving away from field-level action research, and focusing more on ideas and policy outreach. IWMI's ideas spread, but with different ideas taking on different trajectories and speed. IWMI is now a recognized leader in the development of these concepts, and contributes to an active literature base and field applications of these concepts. The total number of Research Reports published by the Institute reached 140 in 2010 and IWMI actively contributes to scientific journals.

⁷ The name change was approved by the Board of Governors in November 1998, but formal approval by the Government of Sri Lanka came in 2000.

⁸ IWMI became part of the CGIAR in 1991.

On average, women and children in most developing countries walk 10-15 kilometers per day, carrying up to 20 kilograms of water per trip.

4. Water scarcity – putting water and food on the global agenda

The shocking fact about irrigation - when seen from the basin context - is that the planet already has a high degree of water scarcity. Irrigation is the major driver of this scarcity. Still more shocking is the fact that, if the world is going to feed its growing population, more and much better irrigation systems are needed. And soon... IWMI was well on the path to gaining recognition both within and beyond the irrigation community. However, its water scarcity studies and maps were the main factors that propelled it to being a Center of the global discourse on water.

Amidst the various studies on water scarcity, IWMI's two studies^{9,10} have been unique because they present a simple yet compelling vision of the "water world," both now and in the future. These studies also highlight two types of water problems that go beyond the concept of arid or wet areas. *Physical* water scarcity occurs when demand and use outstrip useable supply. *Economic* water scarcity occurs where people experience water scarcity because access to water is limited and is largely due to socioeconomic reasons, which is the situation prevalent in South Asia and sub-Saharan Africa. The cliché photos of



One woman who was lucky enough to collect some water to fill her container in Bor, Southern Sudan. Photo credit: Karen Conniff, IWMI.

African and Indian women carrying pots of water on their heads illustrates all too well the reality of economic water scarcity for many today.

A first-of-its-kind study on environmental flows produced a global environmental flow map. Both the water scarcity map and the environmental flow map continue to be in high demand and are frequently reproduced in scientific articles, text books, popular publications and the media.

**ONE-FIFTH OF THE WORLD'S PEOPLE
(MORE THAN 1.2 BILLION) LIVE IN AREAS
OF PHYSICAL WATER SCARCITY!**

**THERE ARE 1.6 BILLION PEOPLE WHO LIVE IN
ECONOMICALLY WATER SCARCE BASINS!**

Source: Adapted from Molden, D. (Ed.). 2007. Summary for decisionmakers. In: *Water for food, water for life: A comprehensive assessment of water management in agriculture*. London, UK: Earthscan; and Colombo, Sri Lanka: International Water Management Institute, p.11.

⁹ Seckler, D.; Amarasinghe, U. 2000. Water supply and demand, 1995 to 2025. In: *Annual Report 1999-2000*. Colombo, Sri Lanka: International Water Management Institute (IWMI). pp.9-17.

¹⁰ de Fraiture, C.; Wichelns, D.; Rockström, J.; Kemp-Benedict, E.; Eriyagama, N.; Gordon, L. J.; Hanjra, M. A.; Hoogeveen, J.; Huber-Lee, A.; Karlberg, L. 2007. Looking ahead to 2050: Scenarios of alternative investment approaches. In: Molden, D. (Ed.), *Water for food, water for life: A Comprehensive Assessment of Water Management in Agriculture*. London, UK: Earthscan; Colombo, Sri Lanka: International Water Management Institute (IWMI). pp.91-145.

5. "Crop per drop" - water productivity

... where more crop per drop is our mantra.

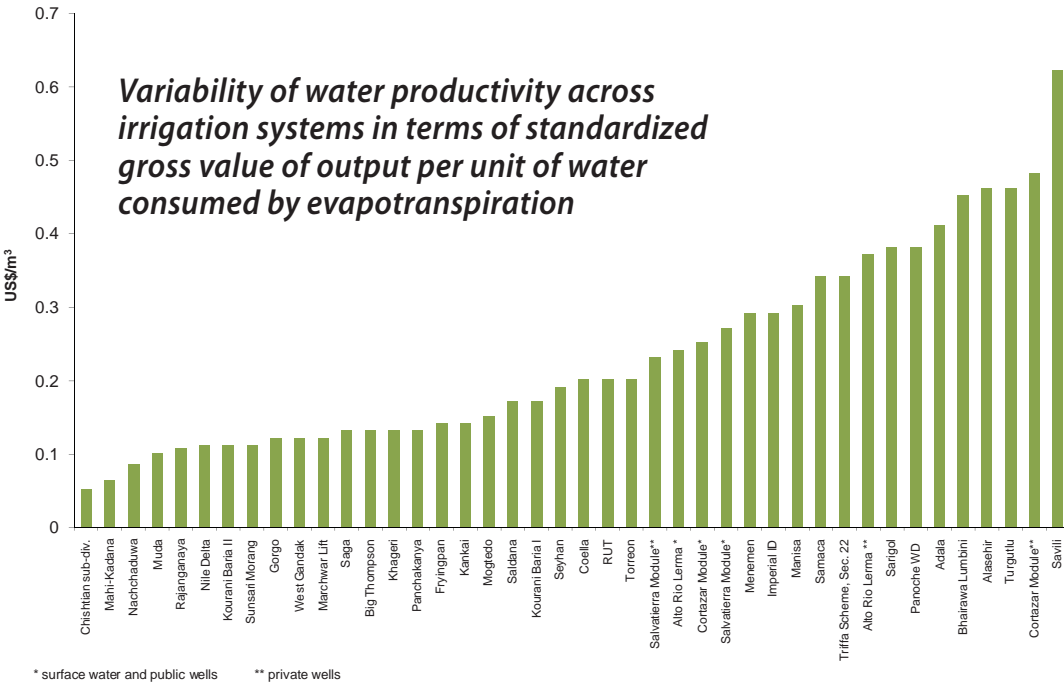
Kofi Annan, former Secretary-General, United Nations, acceptance speech for the Zayed Prize for the Environment in 2006

In his acceptance speech for the Zayed Prize for the Environment in 2006, former Secretary-General, United Nations, Kofi Annan, emphasized that, "we need more crop per drop."¹¹ IWMI lore has it that our former Research Director, Chris Perry, first coined that phrase, but since then other such claims have been made. Now the phrase is ubiquitous. What is more important is that IWMI has spearheaded efforts to define, measure and operationalize the concept.

If we have to grow more food with limited additional inputs, a key response will be to grow more while restricting the amount of water consumed by agriculture, i.e., improving water productivity. In the past, efforts were focused on yield (*land productivity*), but this is no longer sufficient. IWMI has analyzed levels of *water productivity* across the globe and found that in many areas, especially areas where poverty is prevalent, there is much scope for improvement. Beyond analysis, IWMI has provided solutions to improve water productivity considering a range of scales from farm to river basin, and has also highlighted the potential of a range of water management solutions which are suitable for rainfed areas.

It takes about seventy times more water to grow the food we eat everyday than we need for drinking, cooking, bathing and other domestic needs.

Frank Rijsberman, Director General, IWMI, 2000-2007

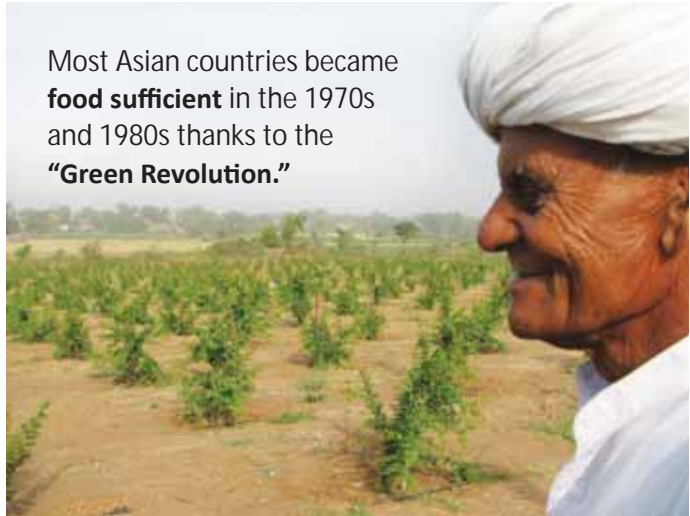


Source: Sakthivadivel et al. 1999¹²

¹¹ Source: www.unep.org/Documents.Multilingual/Default.asp?DocumentID=470&ArticleID=5136&I=en

¹² Sakthivadivel, R.; de Fraiture, C.; Molden, D. J.; Perry, C.; Kloezen, W. 1999. Indicators of land and water productivity in irrigated agriculture. *International Journal of Water Resources Development* 15(1/2): 161-179.

Most Asian countries became **food sufficient** in the 1970s and 1980s thanks to the **“Green Revolution.”**



*A farmer surveys a drip-irrigated pomegranate crop in northern Gujarat, India.
Photo credit: Sharni Jayawardena, IWMI.*

6. The water-food-poverty nexus

Irrigation water was the fuel of the Green Revolution and together with improved seeds and soil fertility, remarkable productivity gains were achieved. It continues to play an important role in alleviating poverty and sustaining rural livelihoods by providing food security through increased production, maintaining low food prices, providing protection against famine and providing employment. Times have changed and irrigation now plays a different role within an environment of growing scarcity, environmental degradation, competition, water conflicts and other opportunities that lie outside the agricultural sphere. The complicated water-food-poverty nexus has to be central to IWMI's work.

Asia contains 70% of the world's irrigated area and 34% of cultivated land is irrigated compared to only 10% in North America and 6% in Africa.

The move away from describing the problem to **finding solutions...**



*The irrigated area of the Kamega public irrigation scheme in the upper east of Ghana.
Photo credit: Ernest Acheampong, IWMI.*

IWMI's studies consistently show that assured access to water for food production remains a powerful means to reduce poverty. However, while water access is necessary, this alone is insufficient to achieve this due to markets, financing, on-farm practices and a host of other site-specific factors coming into play. Secure access is threatened by competition for water and falling water tables, with the rural poor, particularly women, being the most vulnerable. Uptake of promising water practices remains slow for numerous reasons. The focus of IWMI's work on water and poverty is moving away from describing the problem to finding solutions, keeping water access as an entry point and also taking into consideration the range of factors that will make the difference. With recent projects like the Agricultural Water Management Solutions Project¹³, IWMI is returning to its roots of seeking impact, though more strategically searching for key insights, working in partnerships and communicating them to policymakers. This is being achieved through developing uptake strategies within research projects as well as developing regional uptake strategies to keep the momentum going after projects are completed and to provide synthesized messages. These targeted approaches complement IWMI's continuous efforts to make its information and knowledge globally available as broadly as possible, accessible and widely promoted.

¹³ Agricultural Water Management Solutions Project website: <http://awm-solutions.iwmi.org/>

7. Remote Sensing Analysis

Water measurement is a tough job to get right, and data sharing is an equally challenging issue. Measurement and data have been key constraints to better water management. Remote sensing provides a solution. IWMI has explored, and effectively used, remote sensing technology to give a picture of how water is used in agriculture today across landscapes, irrigation systems and across the globe. Notable results have been produced in the analysis of evapotranspiration and water productivity, and it is now possible to

do a complete water accounting exercise using remotely sensed information. The first such study was carried out by R. Sakthivadivel, one of IWMI's long-standing contributors, and the Indian Remote Sensing Agency looked at yields across the Bhakra Irrigation System in India. One of the major products created was the first global irrigated area map of the world based on remote sensing. A surprise outcome of this work was the finding that there is actually more irrigation than previously thought. Even without government investment, farmers need water to enhance productivity and deal with drought.



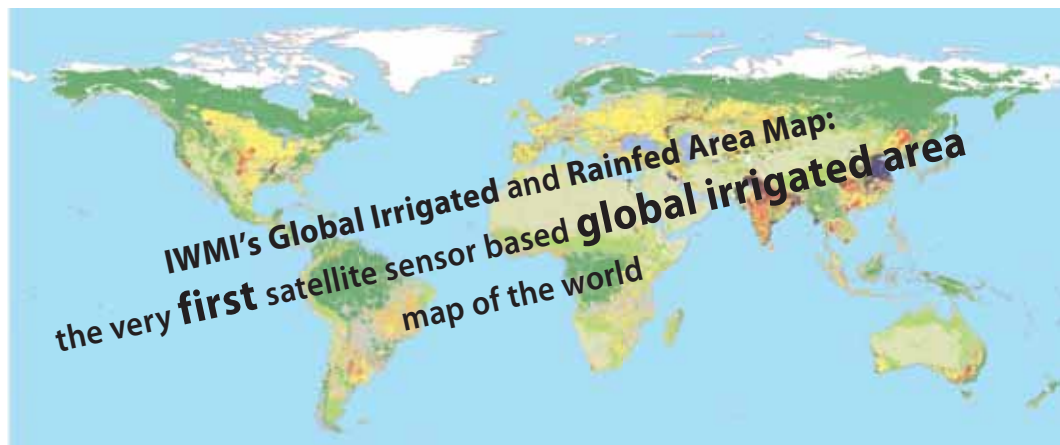
More and more data will be coming through satellites as people on the ground are not willing to share data. We will be able to see failures in water management and be able to track down malpractices, environmental destruction and inequitable distribution of water. This will be like having a "Spy in the Sky," but this data can be used in a beneficial way. It can be used as a basis to improve institutional capacity. As a result, water governance will improve with such data being a guide and helping hand to point the way forward.

Wim Bastiaanssen
Former Research Fellow - Remote Sensing, IWMI, 1998-2001



After the 2004 tsunami, which originated in the waters off Indonesia, the remote sensing team took an emergency "time out" from their global mapping exercise to provide critically needed information about areas impacted by the tsunami to aid relief efforts in Sri Lanka, IWMI's home base.

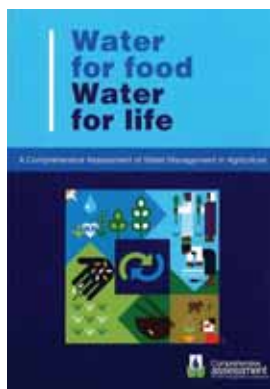
IWMI continues to make advancements in remote sensing¹⁴ and geographic information systems analysis, recognizing the key role of data and information in water resources management.



Source: Adapted from Global Irrigated and Rainfed Area Map produced by GIAM Core Team: Thenkabail, P. S.; Biradar, C. M.; Turral, H.; Noojipady, P.; Cai, X. L.; Li, Y. J.; Velpuri, M.; Vithanage, J.; Dheeravath, V.; Schull, M.; Dutta, R.; Gumma, M. K.; Biggs, T.; and Parthasaradhi, G. R. (IWMI). 2006.

¹⁴ During his initial period at IWMI, some of the work carried out by Wim Bastiaanssen included the remote sensing analysis of evapotranspiration and water productivity. Since then this type of analysis has spread throughout the globe.

8. Partnerships – the Comprehensive Assessment of Water Management in Agriculture and the CGIAR Challenge Program on Water and Food (CPWF)



Frank Rijsberman, a former Director General of IWMI, understood the power of partnerships. Recognizing that there was a divide in thinking between proponents of water for food and water for the environment, he spearheaded the Dialogue on Water,

Food and Environment, the Comprehensive Assessment of Water Management in Agriculture and the CGIAR Challenge Program on Water and Food (CPWF). The Dialogue was to be supported by a knowledge base created by the Comprehensive Assessment and solutions were to be implemented through the CPWF.

... over 1,000 participants put together the Comprehensive Assessment knowledge base, which was fully documented ...

Ultimately, over 1,000 participants put together the Comprehensive Assessment knowledge base, which was fully documented in a series of reports and the acclaimed book, *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture*. The CPWF now draws partners into research for development activities in six major world river basins.

By leading the conceptual design and implementation of these activities, IWMI is well placed to evolve with the emerging CGIAR Research Programs (CRPs).

9. Wastewater – food after the flush

What really happens to all that water after the toilet is flushed? Not many people really want to think about that. The surprising answer is that, in many countries, this wastewater is a true resource for farmers. Exact figures are difficult to determine, but we estimate that about 20 million hectares (Mha) of land area are irrigated, mostly unplanned, using untreated or partially treated

IWMI's insights have changed the way people think about wastewater, including the World Health Organization (WHO), and have led to a new wave of thinking in terms of how best to use and reuse vital water resources.

wastewater.¹⁵ While there are health risks in using this wastewater, there are also clear benefits, such as reliable flow, nutrients, use of a scarce resource and income for poor farmers. A benchmark meeting which looked at the risks and benefits of wastewater use took place in Hyderabad, India, resulting in the well-cited Hyderabad Declaration¹⁶. IWMI's insights have changed the way people think about wastewater, including the World Health Organization (WHO), and have led to a new wave of thinking in terms of how best to use and reuse vital water resources.

Health is a critical water and livelihoods consideration, and over the years, IWMI has created for itself, a niche in health research. In addition to the health implications of wastewater use, groundbreaking research provided insights on how better water management can play a key role in reducing malaria risk. This included work pioneered by the late Dr. Felix Amerasinghe, a Principal Researcher with IWMI at the time (who we still deeply miss), and Prof. Flemming Konradsen, a young trainee from Denmark at that time.

¹⁵ Drechsel, P.; Scott, C. A.; Raschid-Sally, L.; Redwood, M.; Bahri, A. (eds.). 2010. *Wastewater irrigation and health: Assessing and mitigating risk in low-income countries*. London, UK: Earthscan; Ottawa, Canada: International Development Research Centre (IDRC); Colombo, Sri Lanka: International Water Management Institute (IWMI). 404 pp. Available at www.idrc.ca/openbooks/475-8/ (read online); and www.iwmi.org/Publications/books/pdf/Wastewater_Irrigation_and_Health_book.pdf (download).

¹⁶ Reuse of wastewater for agriculture: The Hyderabad declaration on wastewater use in agriculture, November 14, 2002, Hyderabad, India. Available at www.iwmi.org/Research_Impacts/Research_Themes/Theme_3/Hyderabad_Declaration.aspx



About **20 million** hectares are irrigated with **wastewater**.

A polluted drain is also a source of irrigation.

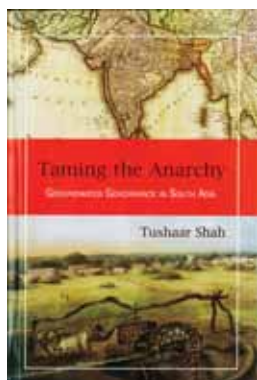
Photo Credit: Karen Conniff, IWMI.

- Irrigation with diluted, partially treated and untreated wastewater takes place on 5-20 Mha globally (ca. 10% of the permanently irrigated area). A new assessment is in the works.
- According to the UN, at least 10% of the world's population consumes food produced by irrigation with polluted water.
- According to available data, the use of untreated wastewater or polluted water is ten times more common than the use of treated wastewater.
- In Vietnam and Pakistan, between 10,000 and 30,000 hectares (ha) are cultivated with undiluted wastewater.
- In Ghana, in and around the City of Kumasi, farmers use polluted water sources on about 12,000 ha - more than twice the area covered by the country's *formal* irrigation schemes.

Day after day, we pour millions of tons of untreated sewage and industrial and agricultural wastes into the world's water systems.

Ban Ki-moon
Secretary-General, United Nations
Message on World Water Day, March 22, 2010

10. Groundwater – Taming the Anarchy



“Taming the Anarchy” is the title of Tushaar Shah’s book that tells the story of groundwater use across the globe. With increased agricultural and urban water use, groundwater levels are plummeting in many breadbasket hot spots across the globe. What is most alarming is

that nobody seems to have the situation under control. IWMI has made important strides in understanding how best to govern groundwater – an area where there has been far too little work given the magnitude of the problem. There are opportunities to sustainably use groundwater for food production across many areas which face food insecurity. IWMI continues to highlight these opportunities. For instance, IWMI demonstrated the growth in the use of cheap pumps. Farmers

prefer these pumps to gravity irrigation because it enables them to use water, wherever and whenever they need it. Tushaar believes that solutions will have to come from outside the water and groundwater sector. One of the most significant outcomes of our research was the idea that rationing electricity for the thousands of groundwater users in Gujarat would reduce groundwater use. The idea was put into action, and the benefits affected not only farmers but also schoolchildren, merchants and poor women.

Epilogue... It’s all about people

Over its 25 years, hundreds of researchers have worked at IWMI. They now hold positions in governments, nongovernmental organizations (NGOs), universities, consulting firms and other international aid organizations. Many have told me how much they valued their time at, or connection with, IWMI as a learning experience. Indeed, it is these people who pass through the doors of IWMI who have to make a difference in this world.



*International group of researchers in Ethiopia's Blue Nile Basin.
Photo Credit: Karen Conniff, IWMI.*



I think IWMI has made a difference between poverty and prosperity for many rural poor people. How this happens can be quite indirect and hard to trace. For example, development workers could use a piece of knowledge they gleaned from IWMI; or government policy could be changed based on ideas IWMI has developed, but the idea may have moved from person to person before it gets into policy. Other times change happens directly through interactions with IWMI researchers and people we work with. So I think if we look back, we can be pretty happy that a lot of lives have been improved one way or the other due to our work.

David Molden
Deputy Director General - Research, IWMI



A New Decade, A New Vision

Dr. Colin Chartres, Director General, IWMI

The Food and Agriculture Organization of the United Nations (FAO) Food Price Index rose for the seventh month in a row to reach 231 in January, topping the peak of 224.1 last seen in June 2008. It is the highest level the index has reached since records began in 1990 (Reuters, February 3, 2011)

Early in 2011, the Financial Times of London published an article saying that food prices are once again at a high level, stocks are declining and food riots have occurred in Algeria and Mozambique. We have also seen warnings that the consequences of further price increases could result in a repetition of the food crises witnessed in 2008. This kind of news is not new to IWMI or the Consultative Group on International Agricultural Research (CGIAR), where helping the world tackle precisely

these issues is the fundamental business of our centers. In the recent past, our efforts have been focused on the issue of water scarcity and spreading the message of the serious implications that it will have on the poorest people across the world if we do not take action. This message - on the importance of conserving, managing and sharing a scarce resource for our future - has been heard by policymakers and investors, as well as the general public.

We live in a fast changing world where our responses need to be collaborative and intelligent if we are to meet the challenges of securing the needs of our growing population. We at IWMI are considering the best ways to use our partnerships and networks to create a model that will have the greatest impact to benefit the world in future years.

We now know what the causes of crises are. Undoubtedly growing population is the most significant factor. World population is currently about 6.8 billion and is forecast to rise to about 9.0 billion by 2050. Rapid economic development of India and China, in particular, has also seen significant dietary changes from cereals and



*Vegetable farmers water crops at the beach in Lomé, Togo.
Photo Credit: IWMI.*

vegetables to meat and dairy products. The latter require significant amounts of animal feed and water to produce. In some countries, government mandated requirements for the substitution of biofuels for fossil energy, also means that these crops compete with food crops for arable land and water resources. Similarly, burgeoning cities also compete with agriculture for land and water resources. These factors, when considered together, suggest that **we are going to have to grow 70% more food and feed to cope with calorific and dietary demands by 2050.**

What this means for water is that we might need to almost double supplies to grow the required amounts of food and feed. Given what we know about current levels of water scarcity, it is extremely dubious as to whether such volumes of water are going to be available in areas with suitable land and climate. In most of Asia, for example, there is just not enough land available for agricultural expansion. Whilst climate change may favor the cultivation of land in more northerly latitudes benefitting developed countries, in many developing countries, it is anticipated that climate change impacts will be negative with respect to water resources availability and food production. It is also apparent that productivity levels in agriculture in many developing countries are low both in irrigated and rainfed agriculture. Therefore, the biggest opportunities are to increase productivity closer to that achieved in western countries. This is often referred to as intensification of agriculture.

Water issues are an urgent concern. Every day of every year for individuals, communities and countries around the world.... Experts predict that by 2025, just 15 years from now, nearly two-thirds of the world's countries will be water-stressed. Many sources of freshwater will be under additional strain from climate change and population growth. And 2.4 billion people will face absolute water scarcity – the point at which a lack of water threatens social and economic development.

Hillary Rodham Clinton
US Secretary of State, speaking at
the National Geographic Society
Washington, DC, on World Water
Day, March 22, 2010

If all stakeholders are able to refer to the same set of facts, a more productive and inclusive process is possible in developing solutions.

Charting our Water Future,
Report of the 2030 Water
Resources Group, McKinsey and
Company, October 11, 2009

It is often stated that we can't continue with business-as-usual in agriculture if we want to feed the world in 2050. Even so, dealing with this productivity gap will require us to tackle issues of limited knowledge and capacity in farming communities, poor seed supply, poor infrastructure and market access, fragmentation of landholdings, and inadequate and sometimes corrupt governance and management systems.

The critical challenge for IWMI is to find new ways to optimize crop productivity from existing water resources in order to achieve food security globally and locally. Fundamental to this challenge is that productivity increases are delivered without further environmental degradation and, at the same time, help lift poor farmers out of abject poverty. As David Molden writes in his article, '25 years – A lifetime of ideas', IWMI made significant impacts in its first 25 years. The complexity and interaction between the causes of food and water scarcity mean that in the next 25 years we will have to seek and deliver solutions that are integrated across the agricultural sector of the economy and competing water-using sectors as well as taking into consideration environmental needs. To us this means more multi- and inter-disciplinary studies with a wider range of partners. Similarly, a greater emphasis will be in the processes and partnerships that disseminate outputs that lead to even more impact.

The program

With these matters in mind, IWMI, together with centers of the CGIAR, the CGIAR Challenge Program on Water and Food (CPWF) and FAO, have developed a new CGIAR Research Program (CRP) on Water, Land and Ecosystems. This Program is focused around the eight research areas that we think will lead to short- to medium-term impact on the key issues of food security, environmental sustainability and poverty alleviation.

IWMI and its partners are united in the belief that overcoming natural resource management problems and adapting to climate change will only be achieved by understanding and managing the dynamics of water and nutrient flows across the whole landscape, and through the complete hydrological cycle.

Solutions to water access, land degradation, nutrient management and ecosystem services have to be developed with a view to what works for communities across landscapes, not just what works on the farm. This is best exemplified by the issue of equitable access to water for all. The CRP, Water, Land and Ecosystems, focuses on three critical issues: water scarcity, land degradation and ecosystem services.

The focus areas and the questions we want to tackle are:

- 1. Rainfed:** How can we improve soil fertility and land and water management to unlock the potential of rainfed agriculture while reversing trends of ecosystem degradation?
- 2. Irrigation:** What must we do to revitalize irrigation in Asia and Africa?
- 3. Resource Recovery:** How can we enhance food security by recovering nutrient and other resources from solid and liquid waste streams?
- 4. Groundwater:** How do we make groundwater use sustainable?
- 5. Pastoral:** What changes in land and water management are needed to support pastoral livelihoods?
- 6. Basins:** How do we manage land and water resources in major agricultural river basins in ways that meet the needs of people and ecosystems?
- 7. Ecosystems:** How do we improve ecosystem resilience and services to support ecosystem resilience, and provide farmers and pastoralists with a production system that has increased adaptability to environmental change?
- 8. Information:** How can we use soil, water and ecosystem information systems to generate information for evidence-based policy recommendations, and also for supporting the implementation, out-scaling, monitoring and evaluation of program outputs?

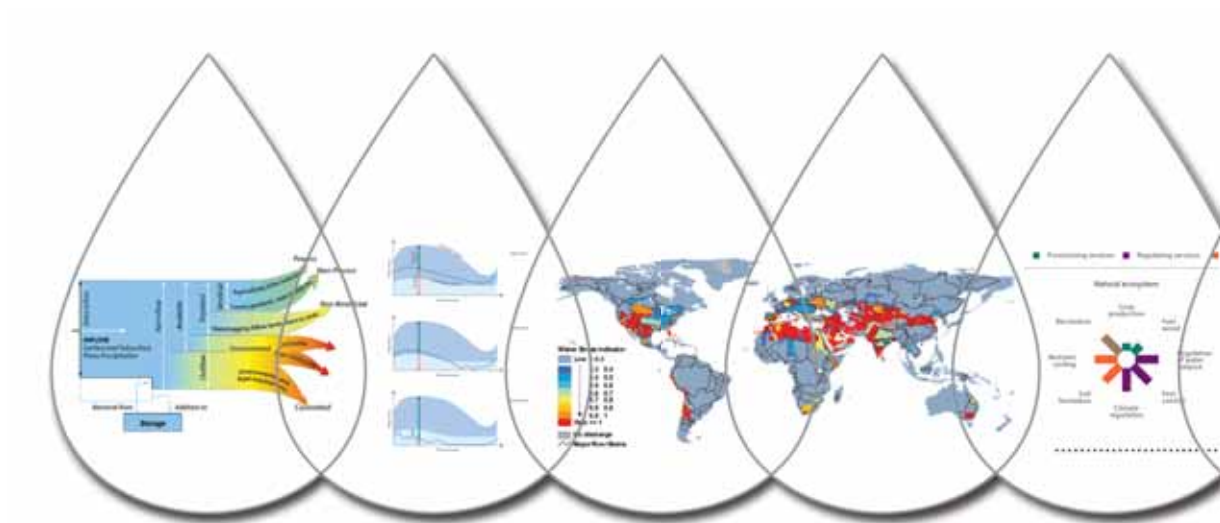
These are all major challenges, but ones that the CGIAR will face up to with greater collaboration than ever before. Thanks to our past experiences, of growing partnerships and increasing understanding of how to impact lives and livelihoods, these are challenges that IWMI is ready to step up to.



Water is not just the key to improving the productivity of agriculture for the poor who own small shares of land and live on subsistence agriculture; it is also crucial at the larger scale of achieving food security to prevent the deaths of millions from starvation and malnourishment.

Colin Chartres, Director General, IWMI, and Samyuktha Varma, Executive Officer, IWMI, Authors, *Out of water: from abundance to scarcity and how to solve the world's water problems*, 2010

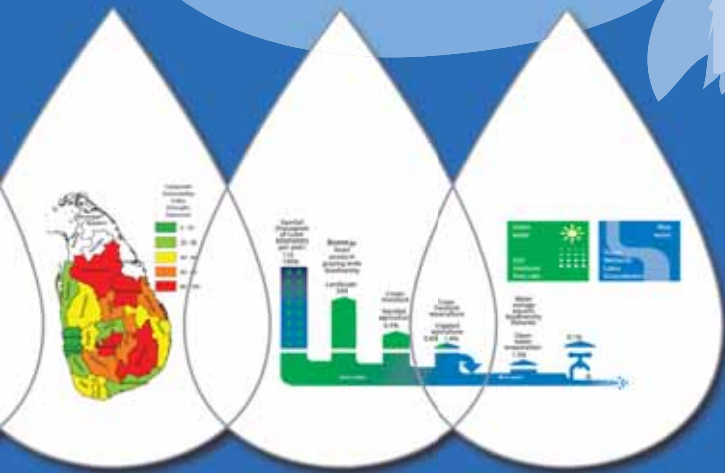




Key diagrams and maps included in this section have been taken from the following IWMI publication:
 IWMI (International Water Management Institute). 2010. *Water Figures: Newsletter of the International Water Management Institute (IWMI)*. Special Issue. 28p.
www.iwmi.org/News_Room/Newsletters/Water_Figures/Landing_pages/WF-2010-Special_Issue.aspx

SHOWCASING

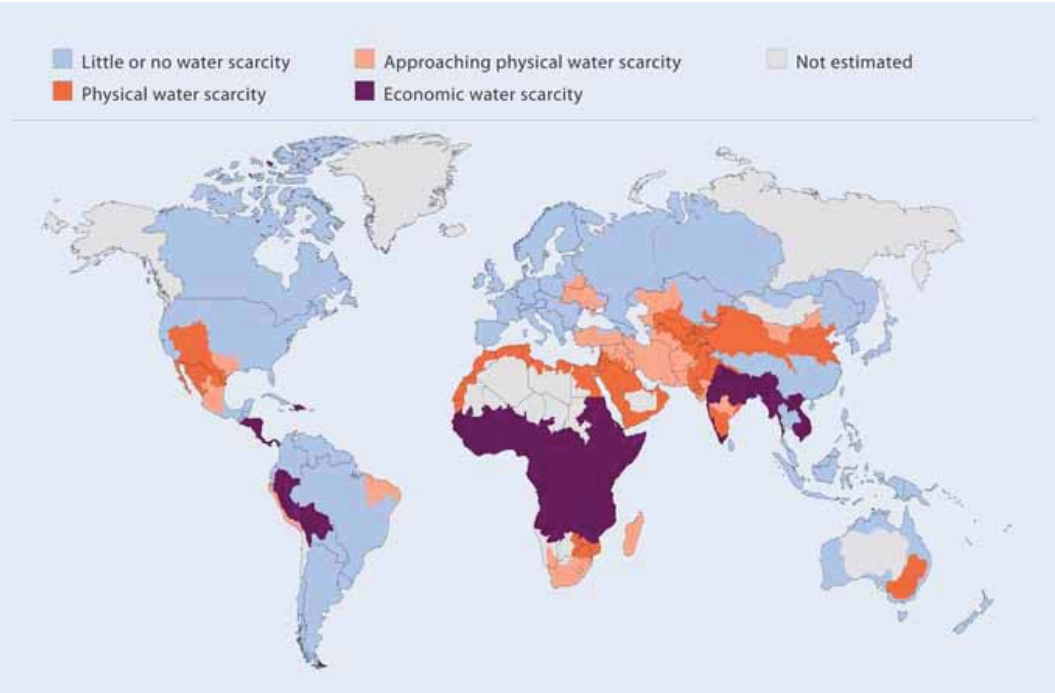
Key Diagrams and Maps from



25 YEARS
of Scientific Research

Where are the World's Water Scarce Areas?

Global Water Scarcity Map



Areas of physical and economic water scarcity (source: Molden, D. (Ed.). 2007. Summary for decisionmakers. In: *Water for food, water for life: A comprehensive assessment of water management in agriculture*. London, UK: Earthscan, and Colombo, Sri Lanka: International Water Management Institute, p.11).

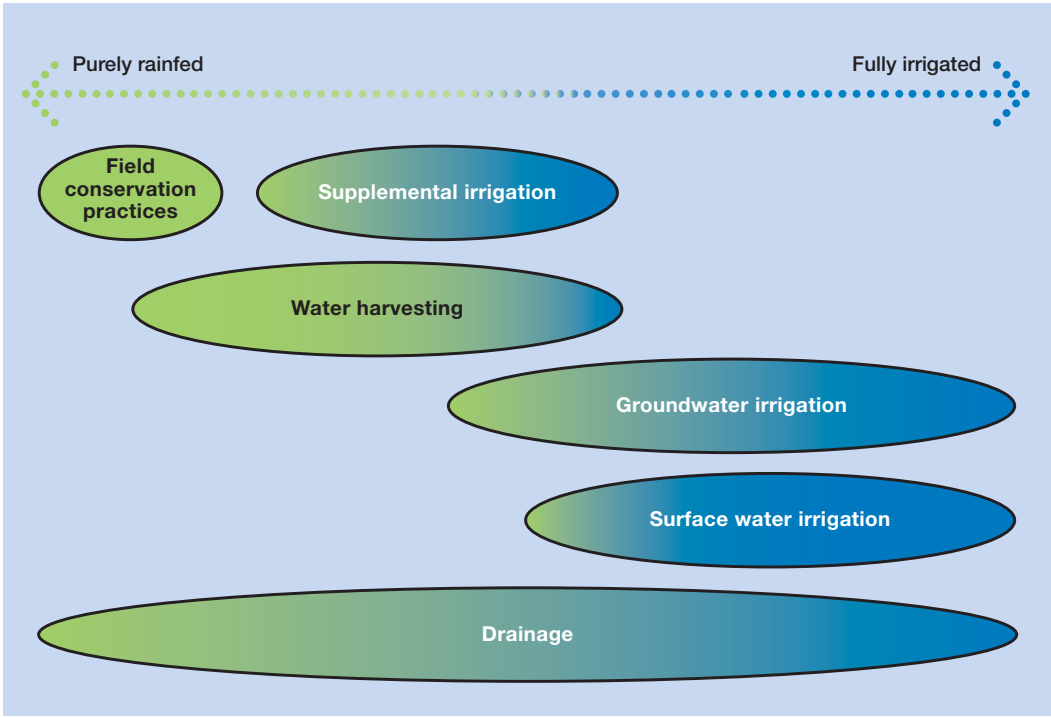
Water scarcity is a critical constraint to agriculture and food security in many parts of the world. Research shows that more than 1.2 billion people live in areas where there is physical water scarcity. Around 1.6 billion people live in water-scarce basins where there is inadequate human capacity or financial resources to make water accessible.

The **Water Scarcity Map** was developed under the Comprehensive Assessment of Water Management in Agriculture, a five-year program that concluded in 2007. This map clearly shows the global availability of water and is one of the most quoted and requested products of IWMI's global public goods. For example, this map has been requested by La Salle University (USA), International Baccalaureate Organization (UK), Stockholm University (Sweden), Arthur D. Little Limited (UK), Center for Security Studies (Switzerland) and Elsevier Publishing Services (India) to name a few. It was requested for use at the Science Museum in London, for an exhibition on 'Atmosphere...exploring climate science' which opened in December 2010.

The map was publicized in key media, including the New Scientist, Financial Times, The Economist, New York Times, the Washington Post, BBC News and SciDevNet.

Managing Water from Rainfed to Irrigated Agriculture

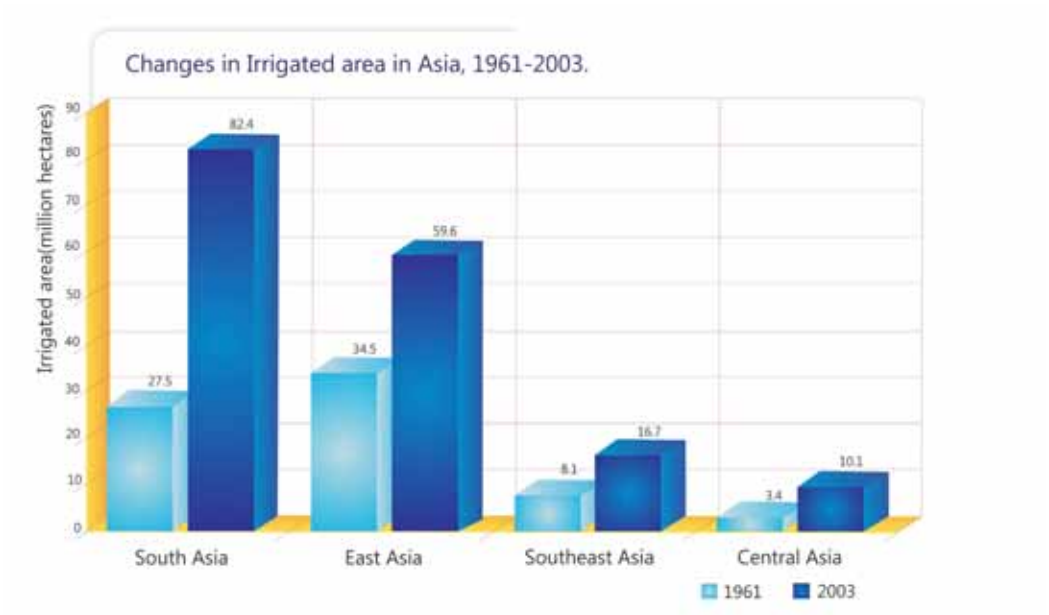
Exploring a Spectrum of Options



The spectrum from rainfed to irrigated (source: Molden, D. (Ed.). 2007. Summary for decisionmakers. In: Water for food, water for life: A comprehensive assessment of water management in agriculture. London, UK: Earthscan, and Colombo, Sri Lanka: International Water Management Institute, p.18).

IWMI's Deputy Director General, Dr. David Molden, created this figure for the Comprehensive Assessment of Water Management in Agriculture (CA). The view of the CA on investments is quite broad and includes a range of options that are depicted in this figure, which shows the diverse options for agricultural water management along a spectrum which ranges from purely rainfed to fully irrigated. This practice begins with fields or grazing land which is entirely dependent on rainwater. On-farm conservation practices focus on storing water in the soil. Moving further along, more surface water or groundwater is added in order to enhance crop production. These sources of additional freshwater create opportunities for multiple uses (which include aquaculture and livestock) within the production system.

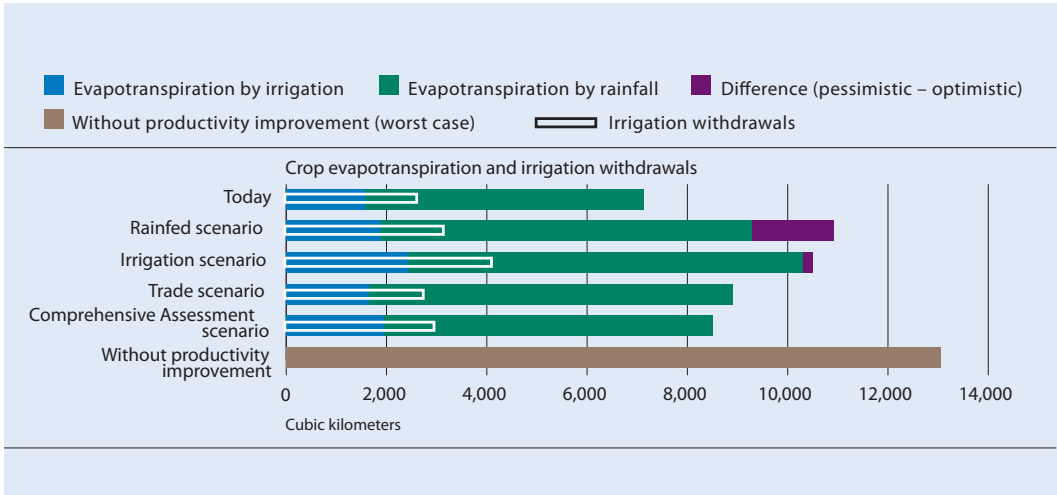
Innovative Solutions Needed for Asian Irrigation



Changes in Irrigated Area in Asia, 1961-2003 (source: Mukherji, A.; Facon, T.; Burke, J.; de Fraiture, C.; Faurès, J.-M.; Füleki, B.; Giordano, M.; Molden, D.; Shah, T. 2009. Revitalizing Asia's irrigation: To sustainably meet tomorrow's food needs. Colombo, Sri Lanka: International Water Management Institute (IWMI); Rome, Italy: Food and Agriculture Organization of the United Nations (FAO). p.10).

Asia accounts for 70% of the world's irrigated area. Between 1961 and 2003 the extent of irrigated land has more than doubled, with South Asia accounting for the bulk of irrigated land. Following the Green Revolution, most Asian economies became self-sufficient in food. Large-scale irrigation projects increased productivity and helped rural communities escape poverty. However, these gains came at a cost to the environment, resulting in loss of fertility, soil and water pollution, salinization and waterlogging, and declining groundwater tables. Upstream irrigation also had negative impacts on downstream users. Future irrigation development needs to adopt innovative methods and technologies to reverse the degradation that has occurred in the past, and soil and water productivity must be improved to meet the future food demand of the region's growing population.

Mapping Land and Water Use Now and for the Future

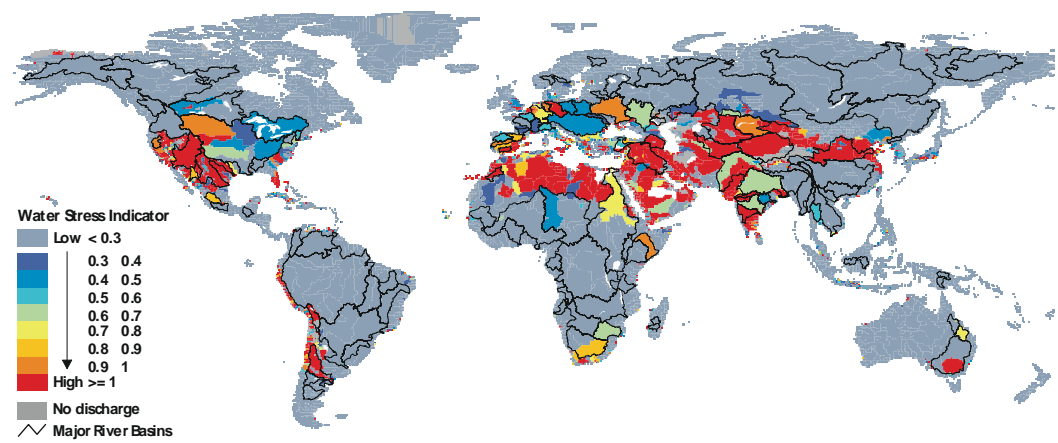


Land and water use today and in the future under different scenarios (source: Molden, D. (Ed.). 2007. Summary for decisionmakers. In: Water for food, water for life: A comprehensive assessment of water management in agriculture. London, UK: Earthscan, and Colombo, Sri Lanka: International Water Management Institute, p.15).

This figure shows projected amounts of land and water requirements under different scenarios, and was created by Dr. Charlotte de Fraiture for the Comprehensive Assessment of Water Management in Agriculture. This graphic shows how much more water would be needed based on different scenarios. We can meet future food and fiber demand with existing land and water resources by investing to increase production in rainfed agriculture, investing in irrigation, conducting agricultural trade within and between countries, and finally reducing gross food demand by influencing diets, reducing post-harvest losses, and including industrial and household waste.

Stressed Out

Map of the World Showing Water Stress in the Earth's River Catchments

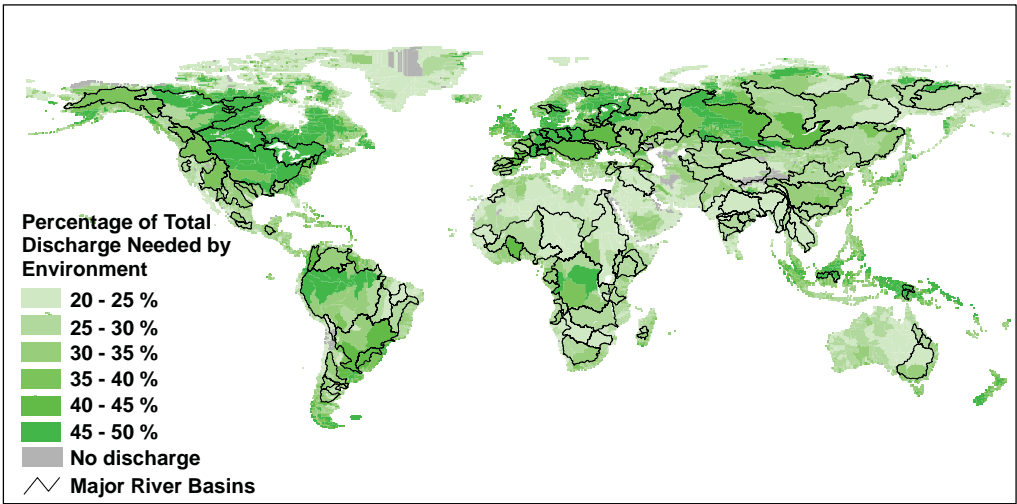


A map of a water stress indicator which takes into account EWR (source: Smakhtin, V. U.; Revenga, C.; Döll, P. 2004. Taking into account environmental water requirements in global-scale water resources assessments. Colombo, Sri Lanka: International Water Management Institute (IWMI), 29p. (Comprehensive Assessment of Water Management in Agriculture Research Report 002).

Physical water scarcity puts pressure on planners and managers to develop better ways of managing existing water resources. This map highlights basins where there is insufficient water to meet Environmental Water Requirements (EWR) and is the first global picture of environmental water scarcity at the basin level. Areas shown in red are those where EWR may not be met under current water use. Over 1.4 billion people already live in such water-stressed basins. There are also areas which are approaching the same stress level. This study was widely cited and the map of environmental water stress has been requested by the National Geographic magazine, International Rice Research Institute (IRRI); the World Wildlife Fund (WWF), UK; Wageningen University; and the Food and Agriculture Organization's (FAO's) Aquaculture Management and Conservation Service (FIMA) for projects on land and water use in aquaculture, to name a few.

How Much Water Does a River Basin Need?

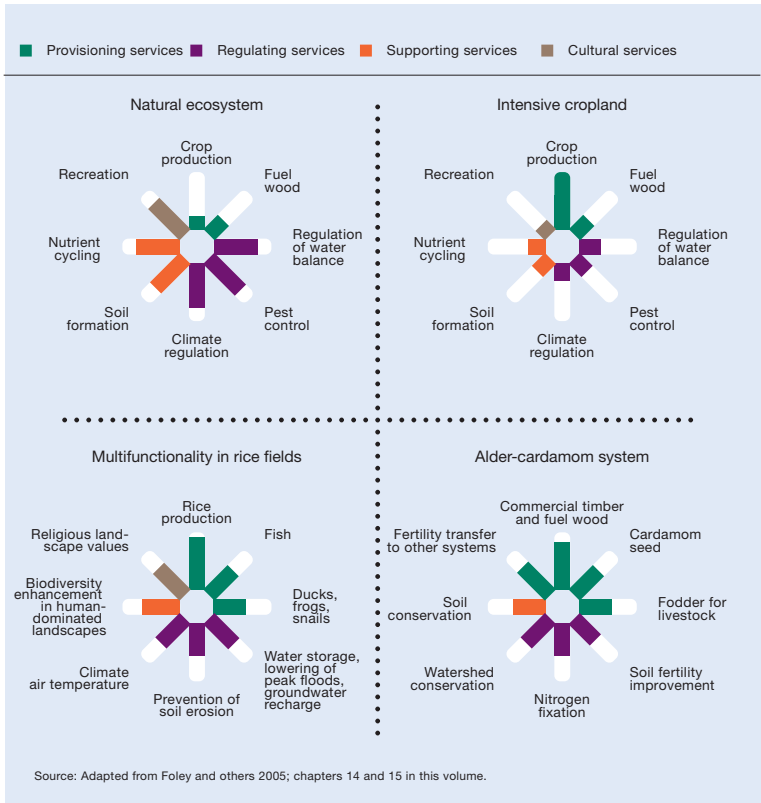
Map of Environmental Flows



Map of Environmental Flows (source: Smakhtin, V. U.; Revenga, C.; Döll, P. 2004. Taking into account environmental water requirements in global-scale water resources assessments. Colombo, Sri Lanka: International Water Management Institute (IWMI), 29p. (Comprehensive Assessment of Water Management in Agriculture Research Report 002).

Research shows that in many parts of the world not enough water is being left in the environment to sustain the useful ecosystem services rivers, lakes and aquifers provide to society. The environment needs water. Excessive withdrawals of water for irrigation and other uses can cause rivers to dry up before they reach the sea, jeopardizing the livelihoods of farmers, fishers and downstream users as well as the bird, animal, fish and plant species that depend on freshwater. Overexploitation of aquifers can lower the water table. Water planners need to allocate water for the environment. For example, the amount of water needed by a river to keep it relatively healthy ranges from 20 to 50% of its mean annual flow. The above map and data showing the total discharge needed by the environment has recently been requested by the Global Water System Project; the National Geographic magazine; World Wildlife Fund (WWF), UK; BASF – The Chemical Company, Germany; LimnoTech Consulting Firm, USA (www.limno.com/); and Ecofys consulting Firm, Berlin, Germany (www.ecofys.com/).

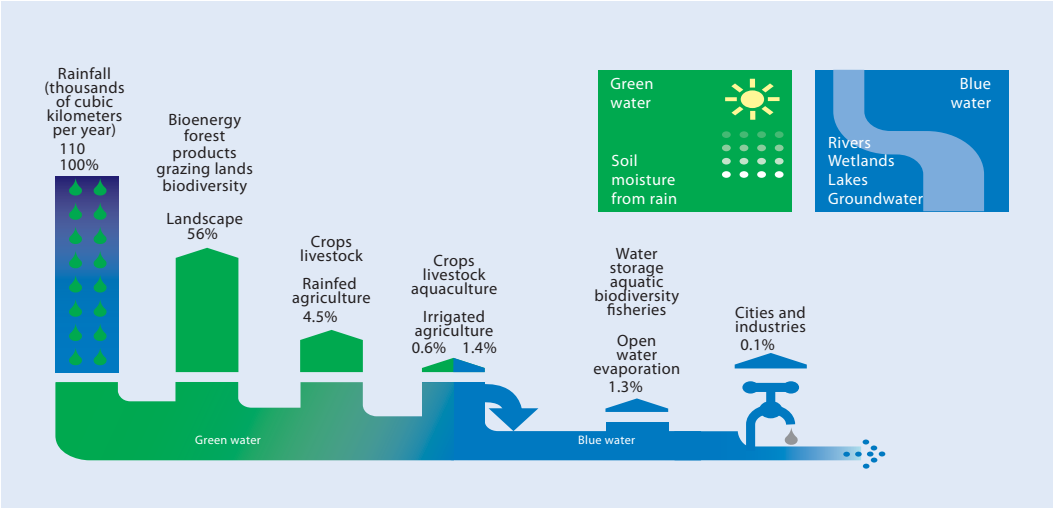
Managing Agroecosystems



Comparison of intensive agricultural systems managed for the generation of one ecosystem service and multifunctionality in agroecosystems (source: Molden, D. (Ed.). 2007. Agriculture, water and ecosystems: avoiding the costs of going too far. Chapter 6 in: Water for food, water for life: A comprehensive assessment of water management in agriculture. London, UK: Earthscan, and Colombo, Sri Lanka: International Water Management Institute, p. 260).

Many agricultural water management systems have evolved into diverse agroecosystems, rich in biodiversity and ecosystem services far beyond food production. For example, areas of paddy rice cultivation are seminatural wetlands that support biodiversity. Croplands or natural ecosystems also provide services that help regulate water balance and soil fertility while providing other services like recreation or fisheries. Diversity is good for ecosystem and economic prosperity. A way to maintain diversity is to manage agroecosystems to mimic as closely as possible their natural character and state, for example, by releasing environmental flows with a pattern close to the original. This diagram (developed by Line Gordon, one of the coordinating lead authors of this chapter) has been requested by, among others, the Food and Agriculture Organization of the United Nations (FAO), Rome, Italy, to be used in one of their technical papers on irrigation.

How Much Water Do We Use Globally?

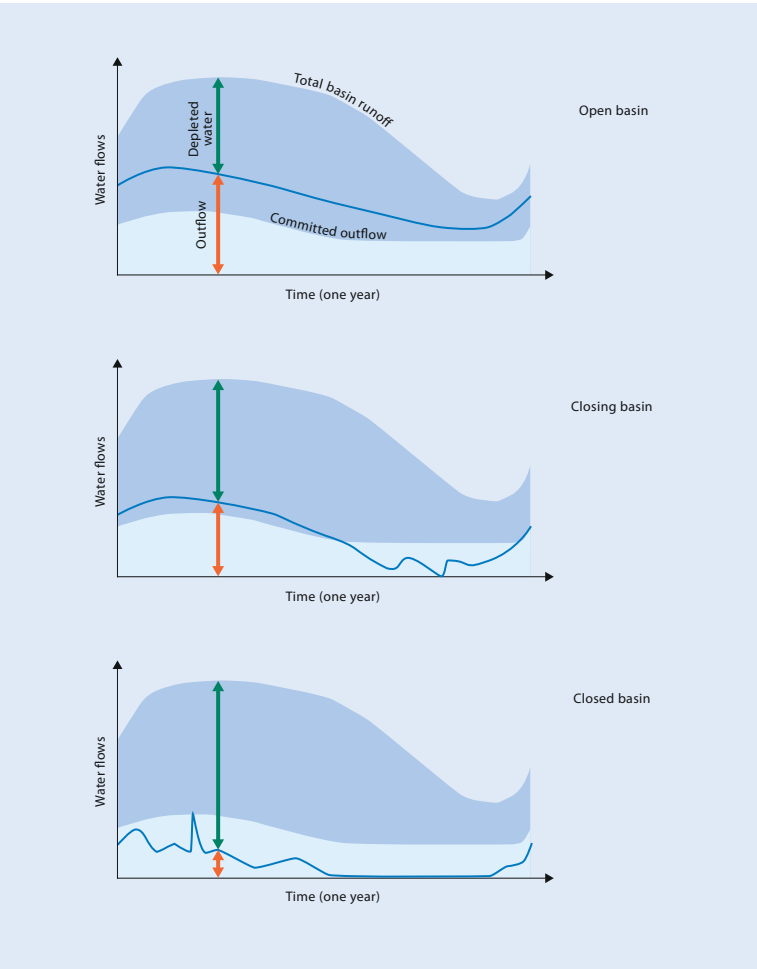


Water use in rainfed and irrigated agriculture (source: Molden, D. (Ed.). 2007. Summary for decisionmakers. In: *Water for food, water for life: A comprehensive assessment of water management in agriculture*. London, UK: Earthscan, and Colombo, Sri Lanka: International Water Management Institute, p. 6).

This illustration shows how water is used globally and the services each use provides. The main source of water is rain falling on the Earth's land surface (10,000 cubic kilometers (km³)). The arrows express the magnitude of water use as a percentage of total rainfall and the services provided. For example, 56% of rainwater is evapotranspired by various landscape uses that support bioenergy, forest products, livestock grazing lands and biodiversity, and 4.5% is evapotranspired by rainfed agriculture supporting crops and livestock. Globally, about 39% of rainfall (43,500 km³) contributes to blue water sources, important for supporting biodiversity, fisheries and aquatic ecosystems. Surface water withdrawals (3,800 km³) are about 9% of total blue water sources, with 70% of withdrawals going to irrigation (2,700 km³). Total evapotranspiration by irrigated agriculture is about 2,200 km³ (2% of rainfall) of which 650 km³ is directly from rainfall and the remainder from irrigation water. Cities and industries withdraw 1,200 km³ but return more than 90% to blue water, often with degraded quality. The remainder flows to the sea, where it supports coastal ecosystems. The variation across basins is huge. In some cases, people withdraw and deplete so much water that little remains to flow to the sea.

What Happens When A River Basin Closes?

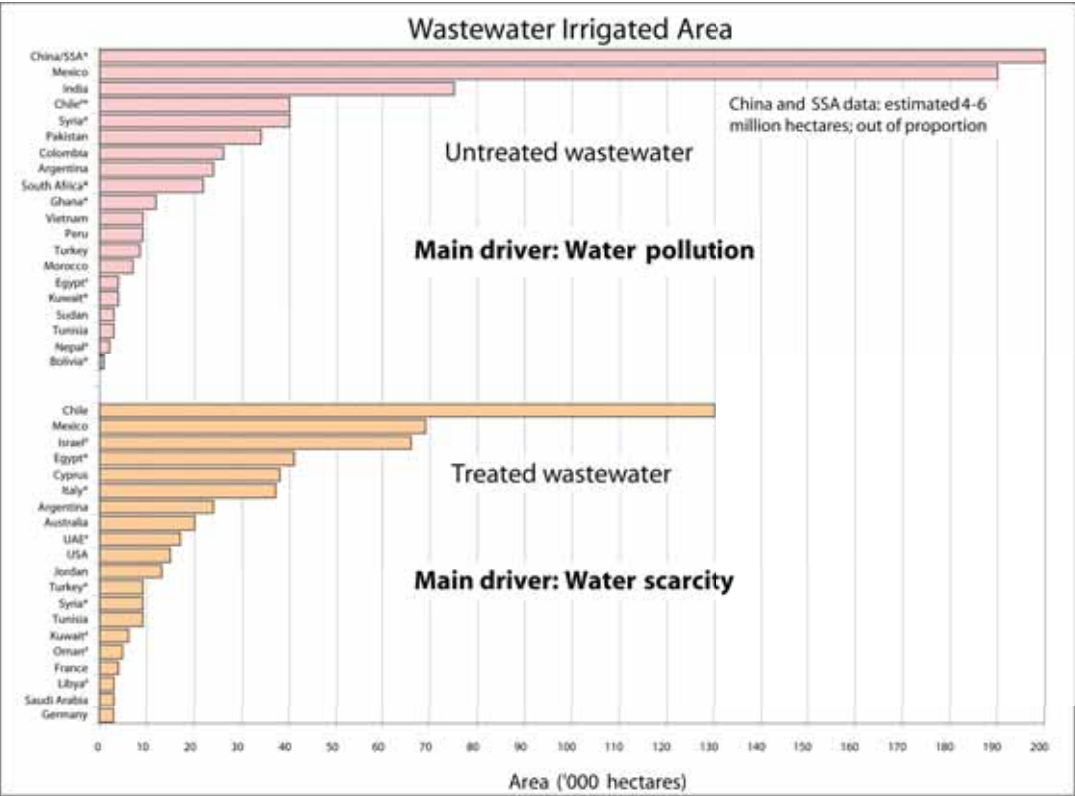
The Basin Perspective



Closing and closed basins - rivers under stress (source: Molden, D. (Ed.). 2007. River basin development and management. Chapter 16 in: Water for food, water for life: A comprehensive assessment of water management in agriculture. London, UK: Earthscan, and Colombo, Sri Lanka: International Water Management Institute, p. 590).

As renewable water resources in a river basin decline 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 linked to the idea of “open”, “closing” and “closed” basins. In “open” basins there are unused or unallocated flows out of the basin. A basin is defined as “closed” when all water is used for human consumption or environmental needs and there is no usable water leaving the basin. This concept helps in determining which management strategies would work best for a particular basin.

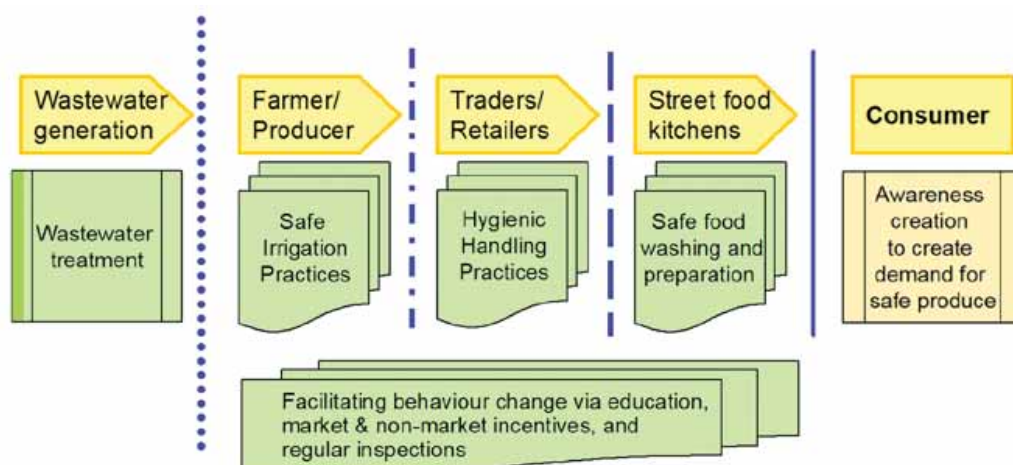
Wastewater: A Rich Resource in a Water–Scarce World



Wastewater Irrigated Area (Source: Modified from Scott, C.; Drechsel, P.; Raschid-Sally, L.; Bahri, A.; Mara, D.; Redwood, M.; Jiménez, B. 2010. Wastewater irrigation and health: challenges and outlook for mitigating risks in low-income countries. In: Drechsel, P.; Scott, C. A.; Raschid-Sally, L.; Redwood, M.; Bahri, A. (ed.), Wastewater irrigation and health: Assessing and mitigation risks in low-income countries. Earthscan-IDRC-IWMI, UK, p. 381-394. Notes: * Data uncertain; # Practice reported (including forestry), data missing; SSA = sub-Saharan Africa; UAE = United Arab Emirates; USA = United States of America).

IWMI's research on the use of wastewater shows that as the demand for limited water resources increases from competing sectors, the sustainable use of urban wastewater will become an issue in overcoming water scarcity. For many poor farmers, nutrient-rich wastewater is their only source of water to grow crops. Making a safe asset out of the increasing volumes of untreated wastewater is one of IWMI's goals. A major task is to understand the associated risks and adopting viable and practical management options for risk mitigation while at the same time maintaining or enhancing crop yields. Often, this wastewater is biologically or chemically polluted, presenting a risk for human, animal and environmental health.

The Multiple Barrier Approach to Microbial Risk Management



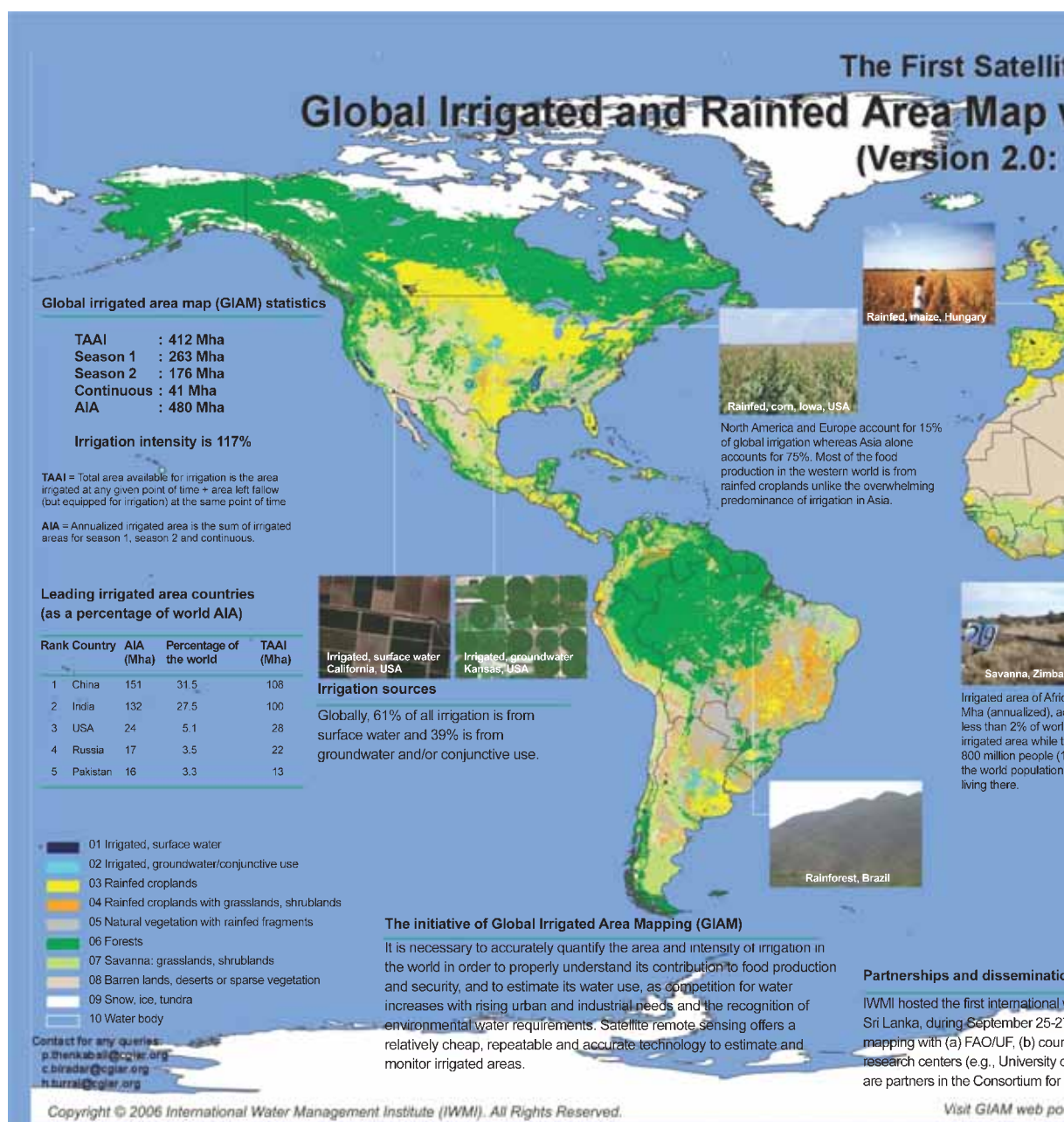
Multiple Barrier Approach in the Wastewater Food Chain where Treatment Alone is an Insignificant Pathogen Barrier (source: Ilic, S.; Drechsel, P.; Amoah, P.; LeJeune, J. 2010. Applying the multiple-barrier approach for microbial risk reduction in the post-harvest sector of wastewater irrigated vegetables. In: Drechsel, P.; Scott, C. A.; Raschid-Sally, L.; Redwood, M.; Bahri, A. (ed.), Wastewater irrigation and health: Assessing and mitigation risks in low-income countries. Earthscan-IDRC-IWMI, UK, p. 239-259).

Microbiological infections of foodborne origin are a major public health problem internationally and a significant cause of death in developing countries (WHO 1996¹, 2006²). Underlying problems of food safety differ considerably between developing countries and the more developed parts of the world. Food safety in developing countries is influenced by several factors. In the context of wastewater irrigation, increasing environmental pollution in urban areas does not support the changing behaviors of urban consumers towards more international diets, in particular fruits and salads that are eaten raw. There is a high risk of contamination at all stages of production, processing and distribution which is very difficult to control through regulations given the common constraints in supporting infrastructure (cool chain) and institutional capacities. A quantitative microbiological risk assessment can help in identifying critical control points. The approach recognizes that while each individual barrier may not be able to completely remove or prevent contamination, and, therefore, protect public health, implemented together, the barriers work to provide greater assurance that the water or food will be safe at the point of consumption.

¹ WHO (World Health Organization). 1996. *Essential safety requirements for street-vended food*, revised edition. Geneva: Food Safety Unit, Division of Food and Nutrition, World Health Organization. Available at http://www.who.int/foodsafety/publications/fs_management/en/streetvend.pdf

² WHO (World Health Organization). 2006. *Guidelines for the safe use of wastewater, excreta and greywater*, Volume 2: Wastewater use in agriculture. Geneva: World Health Organization.

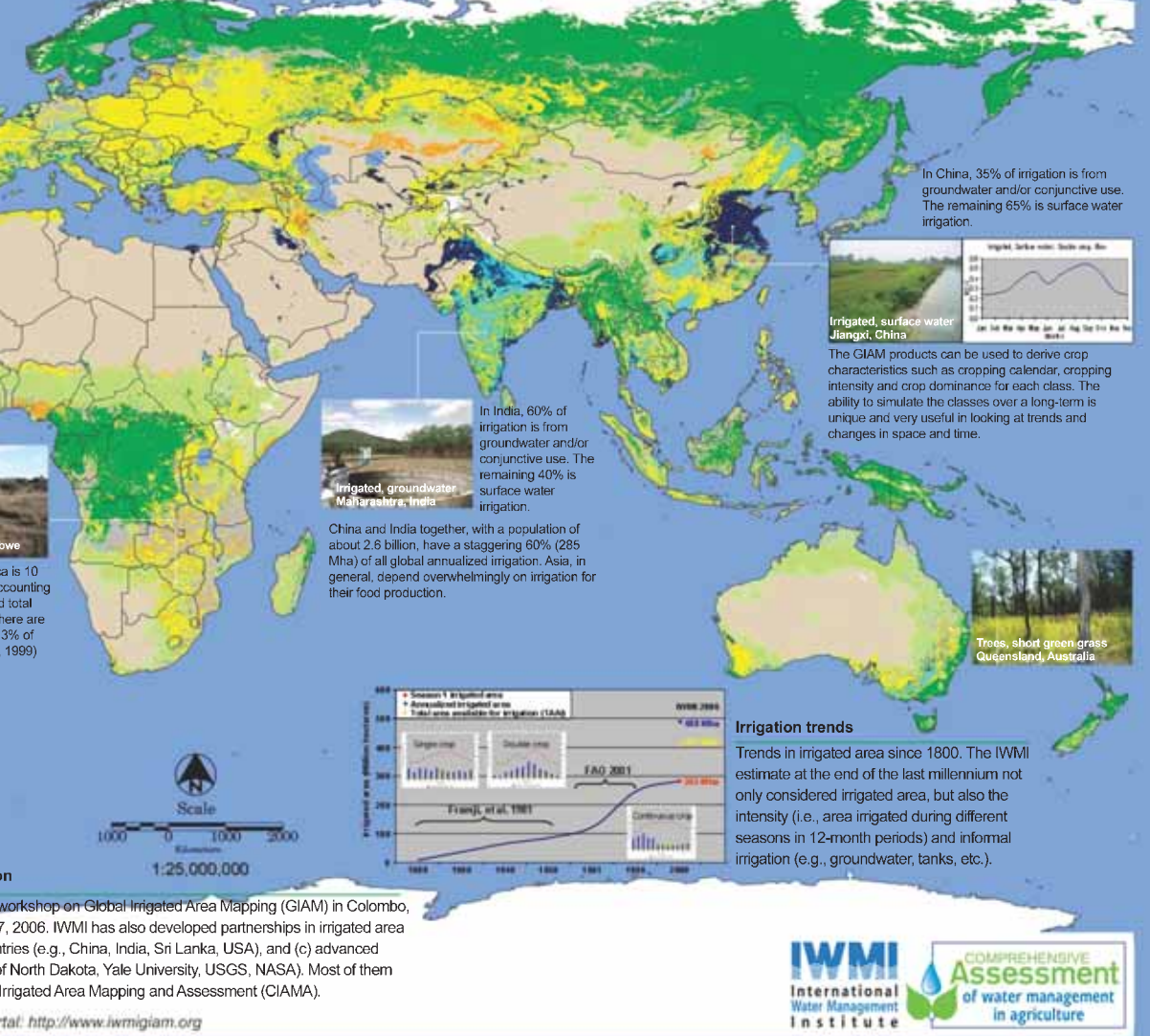
Mapping the World's Water Resources



Global Irrigated and Rainfed Area Map (Source: GIAM Core Team: Thenkabail, P. S.; Biradar, C. M.; Turral, H.; Noojipady, P.; Cai, X. L.; Li, Y. S.)

IWMI's Global Irrigated Area Mapping (GIAM) for the year 2000 was the first of its kind. Multiple satellite sensor data were used to map irrigated areas across the world. The map distinguishes types of irrigated areas, providing distinct classes of irrigation. This detailed analysis and mapping can help governments and farmers use water resources better and reduce hunger. For more details visit www.iwmigiain.org

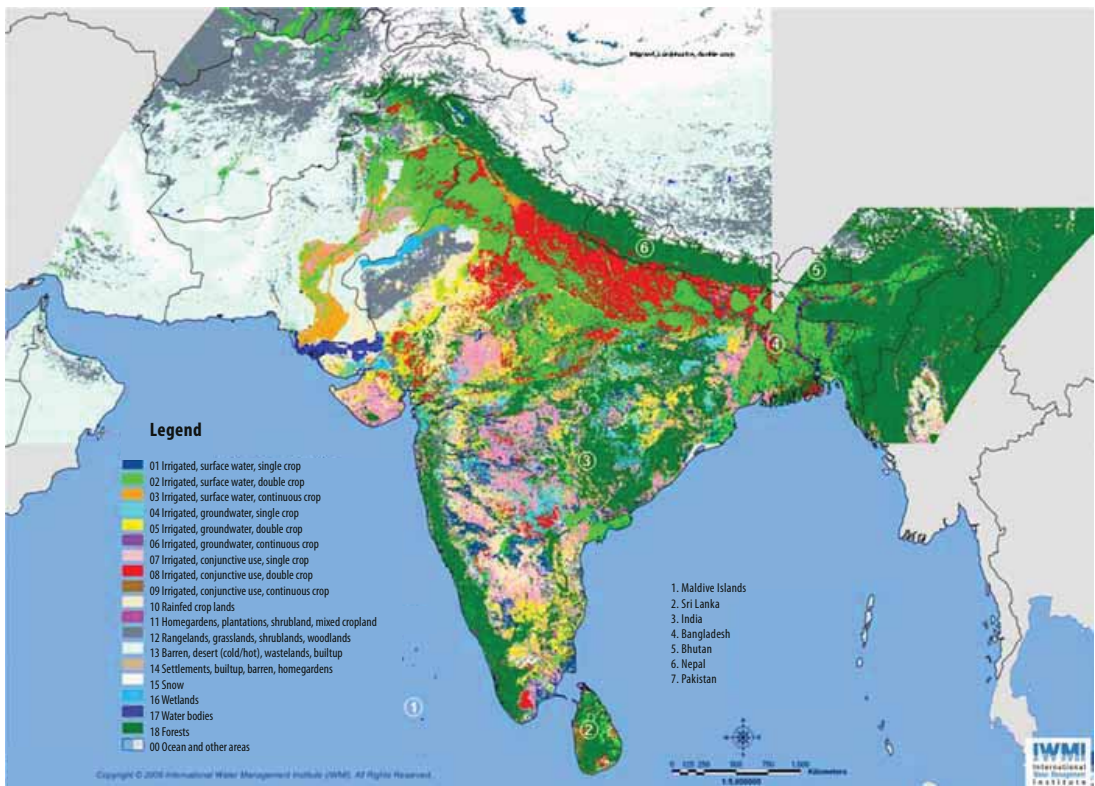
Remote Sensor Based with other Land use/Land cover Classes (10 class map)



J.; Velpuri, M.; Vithanage, J.; Dheeravath, V.; Schull, M.; Dutta, R.; Gumma, M. K.; Biggs, T.; and Parthasaradhi, G. R. (IWMI). 2006).

produce a map at a 10 kilometer (km) scale, showing the extent of land and water resources committed to irrigated agriculture
degree of accuracy will strengthen efforts to make agriculture more productive and sustainable, manage crucial environmental

Global Irrigated Area Mapping: Indian Subcontinent



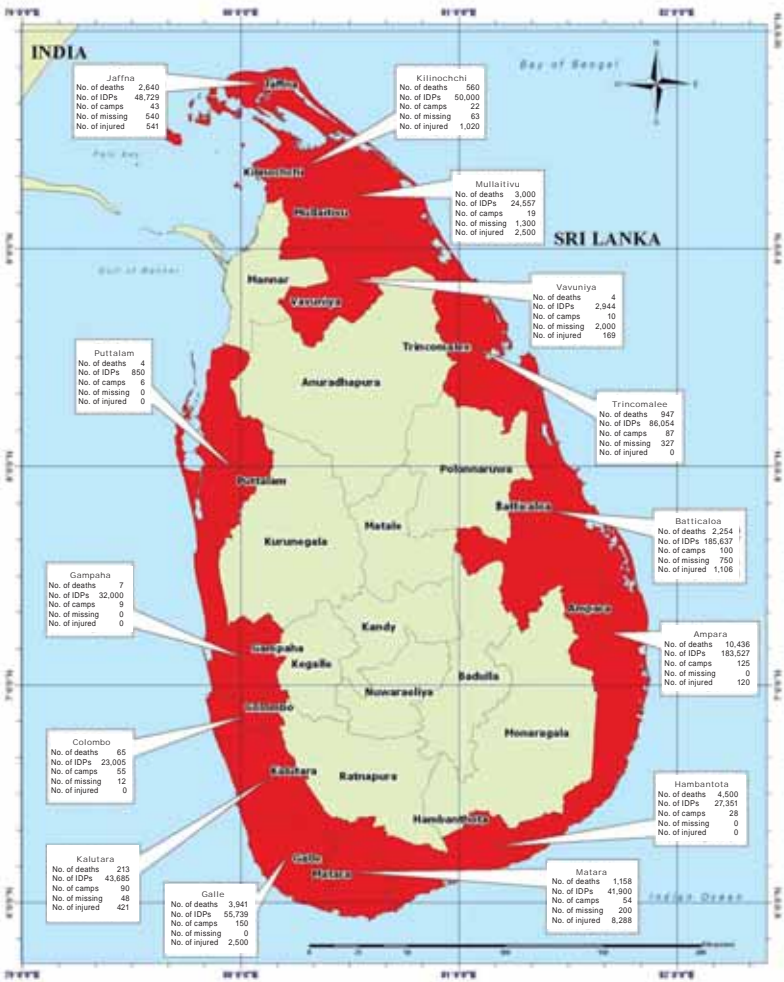
GIAM: Indian Subcontinent (Source: Thenkabail, P. S.; Biradar, C. M.; Turrall, H.; Noojipady, P.; Li, Y. J.; Vithanage, J.; Dheeravath, V.; Velpuri, M.; Schull, M.; Cai, X. L.; Dutta, R. 2006. An irrigated area map of the world (1999) derived from remote sensing. Colombo, Sri Lanka: International Water Management Institute. (IWMI Research Report 105)).

About 60% of global irrigation can be found in six countries, India being the highest with 21.7% of the world's total irrigated area (Droogers 2002³). Satellite sensors offer a potential means of consistent, continuously updated, timely information that meets high standards. The IWMI-GIAM project was initiated to utilize the potential of increasingly sophisticated remote sensing images and techniques to reveal vegetation dynamics which would define the actual irrigated area in the world more accurately, elaborate the extent of multiple cropping over a year (especially in Asia where two or three crops maybe planted in a year but where information about cropping intensity might not be readily or freely available), as well as to develop methods and techniques that allow for consistent information regarding irrigation over space and time globally. This map is a series of products that were developed by the GIAM project. For more details visit: www.iwmi-giam.org

³ Droogers, P. 2002. Global irrigated area mapping: Overview and recommendations. Colombo, Sri Lanka: International Water Management Institute. 54p. (IWMI Working Paper 36).

Sri Lanka in the Aftermath of the Tsunami

Affected Persons Situation Map



Affected Persons Situation Map (Source: Data sourced from CNO, Ministry of Women Empowerment and Social Welfare. IWMI. MapAction UK. 2005).

In the days immediately following the 2004 tsunami, IWMI worked with MapAction UK at the Centre for National Operations (CNO). IWMI and MapAction worked around the clock to provide detailed maps of tsunami-affected areas, displaced persons and other relevant data for the government and other organizations involved in the relief effort. A unique feature of the activity was the physical mapping of the Tsunami Affected Boundary Line (TABL) using Global Positioning System (GPS) technology, to identify and assess the effects of the tsunami on villages.

The Ramsar Tsunami Reference Group was also established involving Wetlands International, World Wildlife Fund (WWF), International Union for Conservation of Nature (IUCN), BirdLife International and IWMI to combine resources, share information and produce timely advice when needed. The immediate priority of this group was to coordinate rapid assessment of the affected areas with the involvement and assistance of all remote sensing specialists, interested agencies and organizations.

Improving Water Productivity in the Water-Scarce Krishna Basin, India

Global Irrigated Area Mapping @ Krishna River Basin

Introduction

This is an irrigated area map of the Krishna River Basin, India.
The map is produced using:

- (A) Landsat ETM+ 30 m data for nominal year 2000;
- (B) MODIS monthly normalized difference vegetation index maximum value composite (NDVI MVC) for 2001–2003; and
- (C) SRTM 90 m digital elevation data.

The overarching goal was to produce irrigated area maps and statistics at various administrative units using satellite sensor data. The study is backed by extensive ground truth data, very high resolution Google Earth Data, and numerous secondary (e.g., rainfall, temperature) from various sources.

The data and products are made available through the International Water Management Institute's (IWMI's) global irrigated area mapping (GIAM) web portal (www.iwmi.org).

Irrigated Area Statistics for the Krishna River Basin

Total Irrigated Area 9.4 Mha

Surface Water Irrig. 3.9 Mha (48%)

Groundwater Irrig. 5.2 Mha (52%)

Krishna River Basin

- Krishna River Basin is located in the south central part of India.
- It extends over an area of 258,948 km² which is nearly 8% of the total geographical area of the country.
- The basin covers three states of Karnataka, Andhra Pradesh and Maharashtra in India.
- The basin has marked diversity in topography. It rises in the Western Ghat hills at an elevation of about 1,337 m and travels about 1,300 km before it flows into the Bay of Bengal.

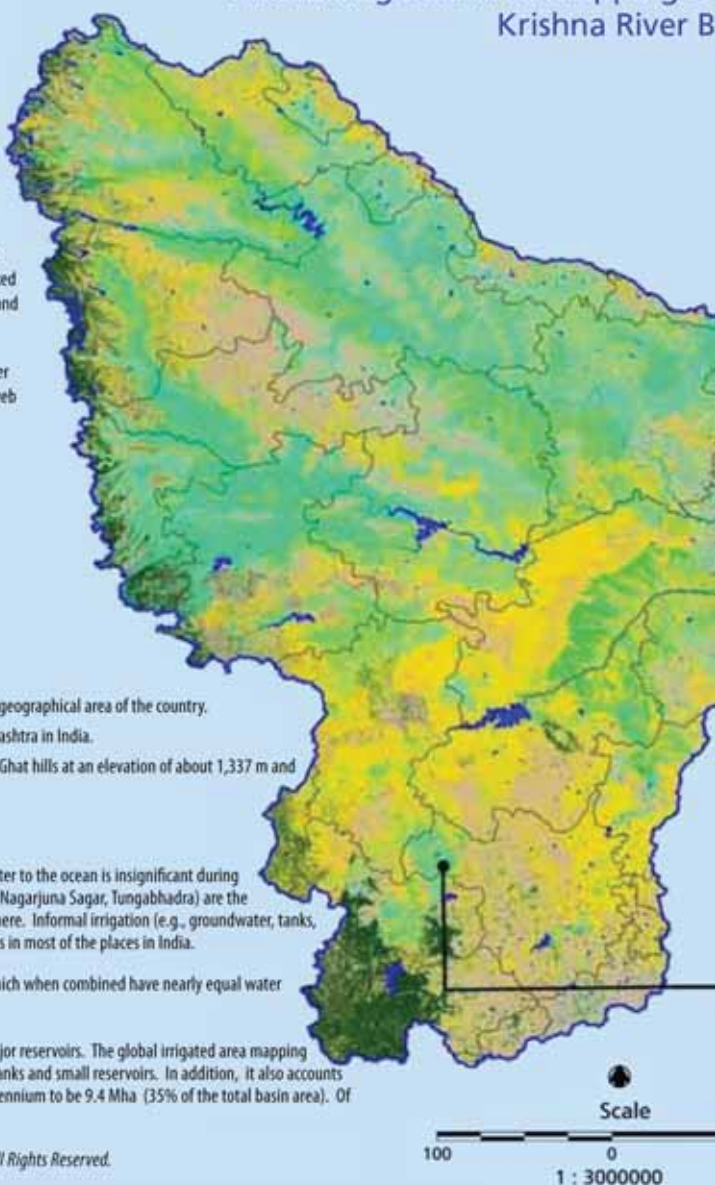
Informal Irrigation Story

The Krishna River is a hydrologically closing basin (i.e., the outflow of water to the ocean is insignificant during normal years). Generally, it is thought that the 12 major reservoirs (e.g., Nagarjuna Sagar, Tungbhadra) are the main causes for this. Our study has shown that the cause could be elsewhere. Informal irrigation (e.g., groundwater, tanks, minor reservoirs) is highly significant or even staggering in Krishna as it is in most of the places in India.

There are about 6,100 small tanks and reservoirs in the Krishna Basin, which when combined have nearly equal water spread area as that of the 12 odd major reservoirs.

Traditionally, irrigation statistics are limited to the command areas of major reservoirs. The global irrigated area mapping (GIAM) project's 30 m work accounts for all the irrigated areas from the tanks and small reservoirs. In addition, it also accounts for groundwater irrigation in the Krishna Basin at the end of the last millennium to be 9.4 Mha (35% of the total basin area). Of this, 52% is from groundwater and 48% from surface water.

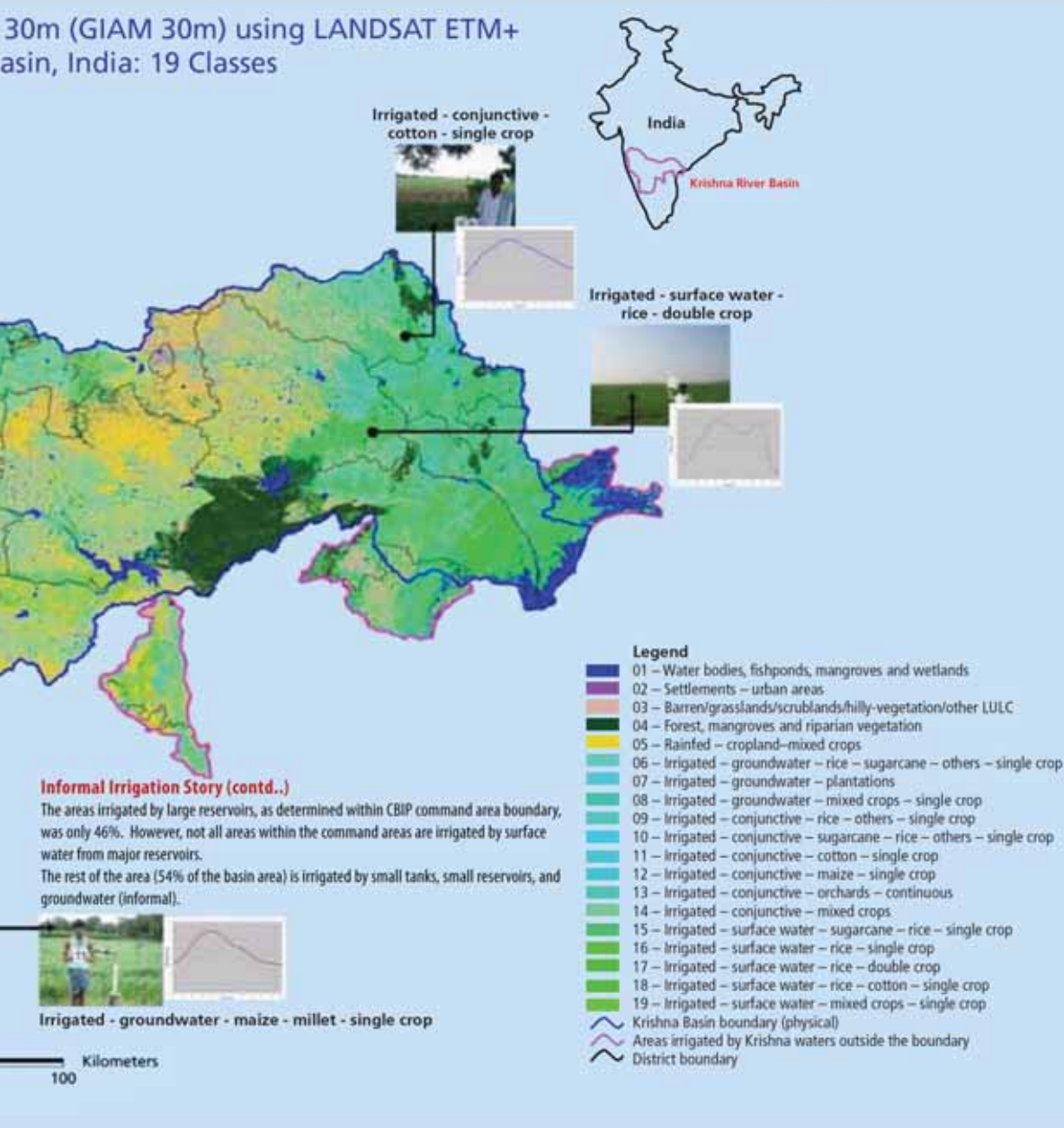
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Remote sensing map of the Krishna Basin (Source: Velpuri, N. M.; Gumma, M. K.; Thenkabail, P. S.; Biradar, C. M.; Noojipady, P.; Tural, H.; Li, Y. J.)

The map shows irrigated areas in the Krishna Basin in India. The Krishna River flows through three riparian states, Maharashtra, Andhra Pradesh, and Karnataka. The map provides policymakers with essential information needed to make decisions on national resource allocation and water allocation scenarios for future allocation options, food production and long-term resource sustainability. A lot of IWMI's research

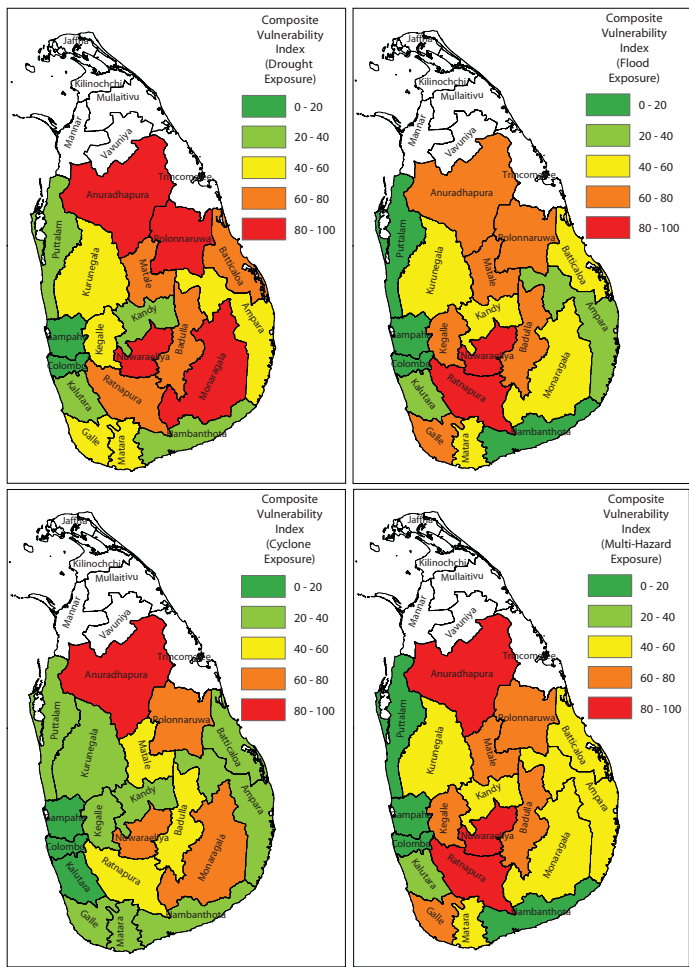
30m (GIAM 30m) using LANDSAT ETM+ basin, India: 19 Classes



; Dheeravath, V.; Vithanage, V.; Xueliang, C.; Dutta, R. (IWMI). 2006). Remote Sensing Map of the Krishna Basin

Pradesh and Karnataka. IWMI uses an integrated approach which considers the physical, social and economic aspects of water. Data is vital to improve water productivity in the water-scarce Krishna Basin. It helps determine the implications of different has gone into developing frameworks to support decision making.

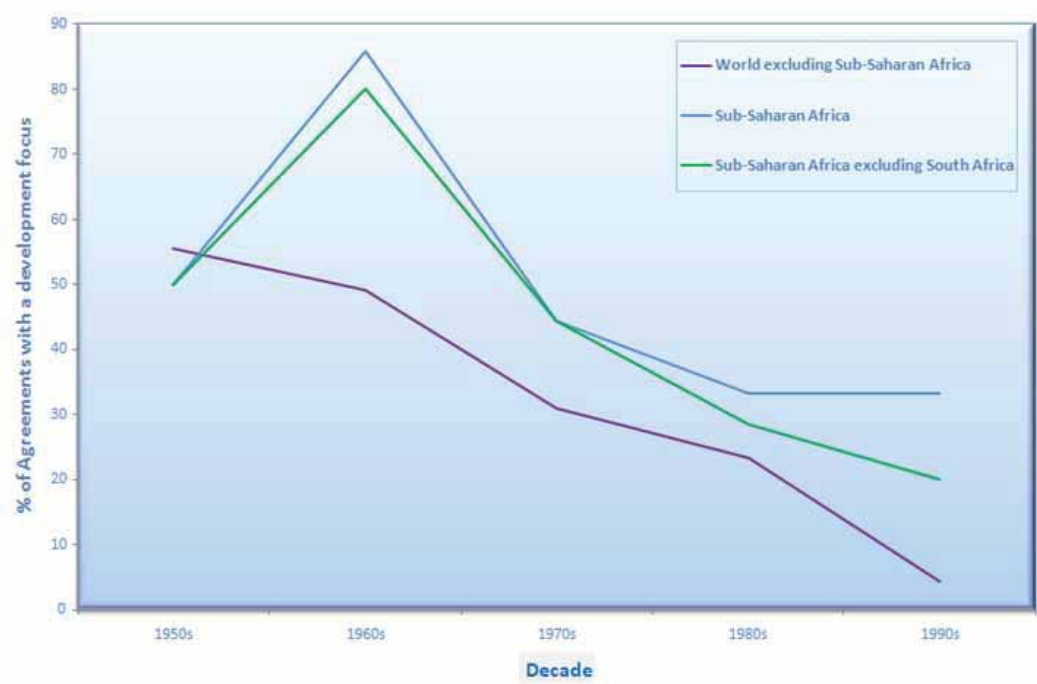
Preparing for the Impacts of Climate Change



Composite vulnerability indices for drought, flood, cyclone and multi-hazard exposure for each district in Sri Lanka (source: Eriyagama, N.; Smakhtin, V.; Chandrapala, L.; Fernando, K. 2010. Impacts of climate change on water resources and agriculture in Sri Lanka: a review and preliminary vulnerability mapping. Colombo, Sri Lanka: International Water Management Institute. 51p. (IWMl Research Report 135).

There is ample evidence to suggest that in Sri Lanka, IWMI’s host country, the climate has already changed. The big question, however, is what Sri Lanka’s climate will look like in 10, 50 or 100 years from now and how prepared the country is to face it. A recent review by IWMI on the status of climate change in Sri Lanka suggests that Sri Lanka’s mean temperature may increase by about 0.9-4 °C over the baseline (1961-1990) by the year 2100 with accompanying changes in the quantity and spatial distribution of rainfall. These changes may lead to an increase in the wet season irrigation water requirement of paddy by 13-23% by the year 2050, compared to that of 1961-1990. The study also identified Sri Lanka’s agricultural vulnerability hot spots. A pilot level climate change vulnerability index with three subindices: exposure, sensitivity and adaptive capacity were further mapped at a district level. These maps indicate typical farming districts in the island that are more sensitive to climate change than the rest of the country, owing to their heavy reliance on primary agriculture. These areas are the most vulnerable to the adverse impacts of climate change in the form of droughts, floods and cyclones.

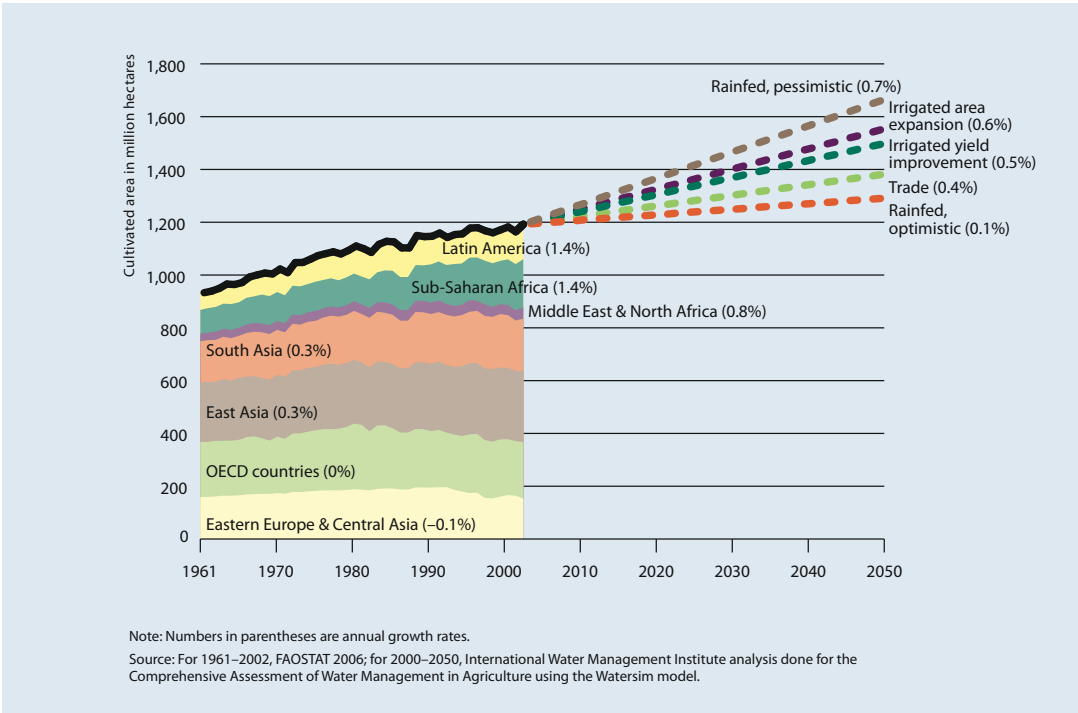
Convergence in Orientation of Transboundary Water Law



Convergence in Orientation of Transboundary Law (Source: Lautze, J., and Giordano, M. 2007. Demanding Supply Management and Supplying Demand Management: Transboundary Waters in Sub-Saharan Africa. Journal of Environment and Development 16(3): 290-306).

The emphasis of the world's transboundary water law has gradually shifted in the past half century from water resources development to water resources management and environmental protection. Sub-Saharan Africa's (SSA's) levels of water resources development, economic prosperity and food security are significantly lower than any other region in the world. Somewhat surprisingly, then, this figure/graph indicates that the orientation of transboundary water law in SSA follows the global transition from water resources development to management. This finding suggests that the nature of SSA's transboundary water law may be largely "handed down" from other parts of the world with different realities than those present in SSA. Recognizing this relationship calls for more tailoring of river basin agreements to the conditions of SSA, and more circumspect policy guidance from international development agencies and developed countries. This graph has been requested and used by (a) staff of the World Bank, in helping to reorient their approach to water resources management and development in Africa; (b) Council on Foreign Relations, to understand issues related to water resources in Africa; and (c) research/researchers, on international waters and international waters in Africa.

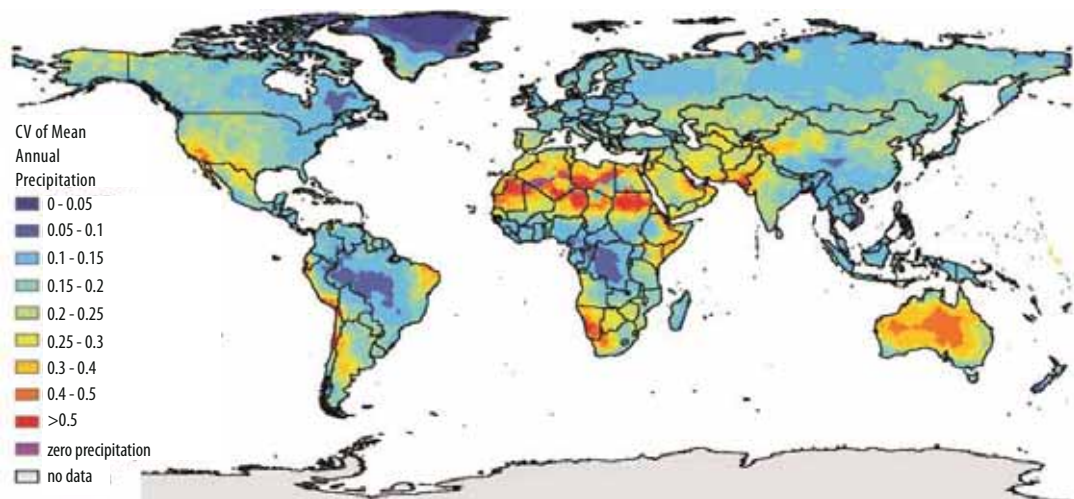
Looking Ahead to 2050: Land Requirements



In the scenarios land requirements increase a total of 6-38% in different regions from 2000 to 2050 (source: Molden, D. (Ed.). 2007. Looking ahead to 2050: scenarios of alternative investment approaches. Chapter 3 in: Water for food, water for life: A comprehensive assessment of water management in agriculture. London, UK: Earthscan, and Colombo, Sri Lanka: International Water Management Institute, p.129).

Terrestrial ecosystems are affected by factors such as food production when forests and savannahs are converted to agricultural land. This figure was created by Charlotte de Fraiture for the Comprehensive Assessment of Water Management in Agriculture and illustrates the required increase in land area in order to cope with demand for food production from 2000 to 2050. An optimistic rainfed approach shows that land requirements will increase by 0.1% annually whereby a pessimistic approach shows that requirements will increase by 0.7% on an annual basis. Such increases can have a substantial impact on the ecosystem services which depend on those habitats and may cause risks such as loss of biodiversity and pollinator species.

Mapping Drought Patterns and Impacts: A Global Perspective



Global distribution of the Coefficient of Variation of long-term Mean Annual Precipitation (source: Eriyagama, N.; Smakhtin, V.; Gamage, N. 2009. Mapping drought patterns and impacts: a global perspective. Colombo, Sri Lanka: International Water Management Institute (IWMI). 23p. (IWMI Research Report 133).

IWMI's Drought Assessment Project which ran from 2006-2008 carried out a study that examined the global patterns and impacts of droughts by mapping several drought-related characteristics. Several maps were produced during the course of this study and the above map is one of them. These maps were created by combining several publicly available datasets. Maps such as this create a discussion which allows for a number of policy relevant messages to be extracted. For instance, one of the findings of this report was that arid and semi-arid areas also tend to have a higher probability of drought occurrence. It also points out that in drought years, the highest per capita loss of river flow occurs in areas that do not normally experience climate-driven water scarcity. It also illustrates that agricultural economies, overall, are much more vulnerable to the adverse impacts brought on by droughts.

Conceptualization of the Physical Water Storage Continuum

Exploring Different Water Storage Options

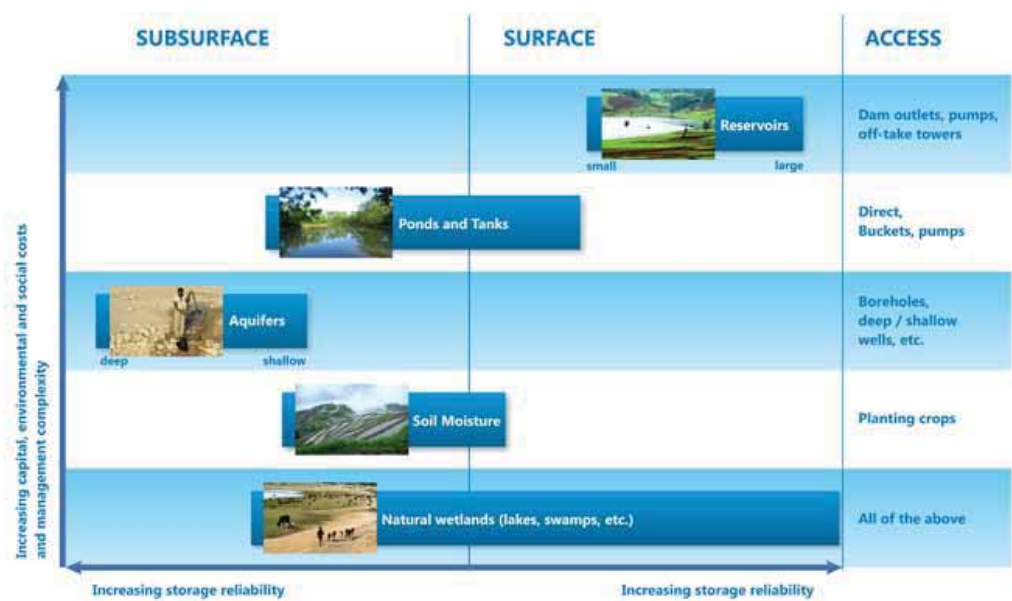


Diagram of water storage continuum (Source: McCartney, M.; Smakhtin, V. 2010. *Water storage in an era of climate change: Addressing the challenge of increasing rainfall variability. Blue Paper*. Colombo, Sri Lanka: International Water Management Institute).

One of the impacts of climate change will be erratic rainfall, often leading to extreme weather conditions like drought or floods. IWMI has been exploring a range of water storage options which can make use of this surplus water and also provide a buffer against times of water scarcity. While large dams are just one of a range of possible water storage options, others include natural wetlands, enhanced soil moisture, groundwater aquifers and ponds or small tanks. This water storage continuum was highlighted in a blue paper launched by IWMI during World Water Week in Stockholm in September 2010 and the visual conceptualization of the water storage continuum is one of IWMI's latest products. For each option, the way water is accessed and who can access it varies. Not all storage types suit all purposes but each has an important role to play and under the right circumstances can contribute to food security and poverty reduction. IWMI recommends a range of water storage options rather than a single option. If one option does not work, farmers then have other options to provide them with a steady supply of water.

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