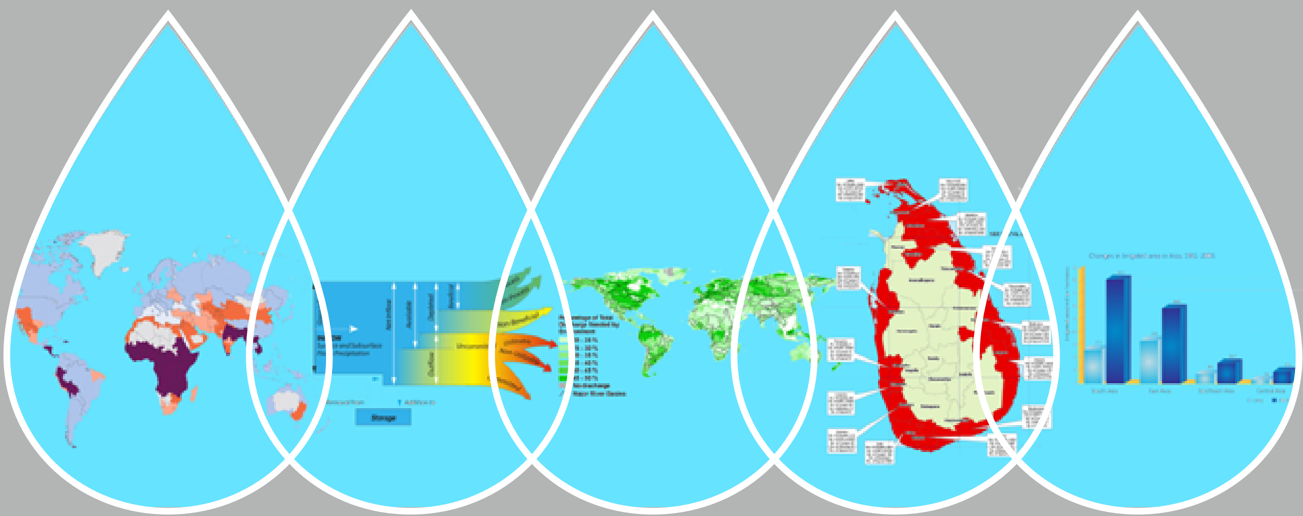
WATER FIGURES

TURNING RESEARCH INTO DEVELOPMENT



CONTENTS:

SPECIAL ISSUE
2010

Celebrating 25 Years of Research

Selected Diagrams and Maps

For 25 years, IWMI scientists have been developing new concepts and products to help manage land and water resources for food security, livelihoods and the environment. This special issue showcases some of IWMI's most sought after products, and is dedicated to the scientists who contributed to IWMI's rich knowledge base and to those who continue to make a splash with new thinking year after year.

www.iwmi.org

IWMI
International Water Management Institute

IWMI Celebrating 25 years

EDITORIAL

WATER FIGURES SPECIAL ISSUE, 2010

The Legacy of a Lifetime

For many people, a 25th anniversary means a multitude of things. It means a better grasp of life's issues. It marks a period gone by and a future ahead. It is also a time for connecting with the tangible things that revive the glory moments of their past. Treasured photos, letters, trophies and the people they've known through the years come to mind. For the International Water Management Institute (IWMI), the tools, the maps and charts, the tables, the diagrams and models that the Institute has created are "trophies" of past achievements. They are also IWMI's legacy for the future.

Maps, tools and tables are more than scientific outputs. They help us digest the realities of our world almost instantly. We study a map and see at a glance where water is scarce in the world. We examine a graph and understand how rainfall is affecting food production. A diagram shows us where all the water in a river basin goes and who is using it the most. A model helps us "see" into the future and predict a drought. Yet, we often miss the big picture.

Behind every great product is a scientist or team of scientists. Behind the scenes, they've spent weeks and months or even years collecting and putting together all the data that makes the picture come alive for us. They take hours or days or months to perfect a tool. They go out to the field, most often under tough conditions, gathering information, searching…analyzing. That's the life of a researcher. There is no record of the obstacles they've faced or the sacrifices they've made. We only see their finished work.

There's an even bigger picture. Somewhere out there, a child in Africa, a farmer in Asia or a community in a drought-prone land has benefited because IWMI's research has helped guide policymakers, development specialists or donors in making more informed decisions or investments for their welfare. Because of the research, issues have been addressed and action has been taken. The impacts are like ripples that go on gathering momentum. Each of the products have been endowed with a life of their own by the scientist who created them. A life that reaches out and gives to the world, and continues to reap a harvest.

This issue of Water Figures celebrates this "harvest" of research and tells its story. Above all, it honors the men and women behind the research: the scientists of IWMI and its partners. As you go through each page, you will see some of IWMI's most popular and most requested "mementos" showcased here. There are many more products that have been produced. This is just a sampling.

Dawn Rodriguez
Editor

EVENTS

Upcoming events/international days

February 2: World Wetlands Day

Wetlands and Forests is the theme for World Wetlands Day 2011

This was especially chosen because 2011 is also the United Nations International Year of Forests

March 22: World Water Day

Urban Water Management is the theme for World Water Day 2011

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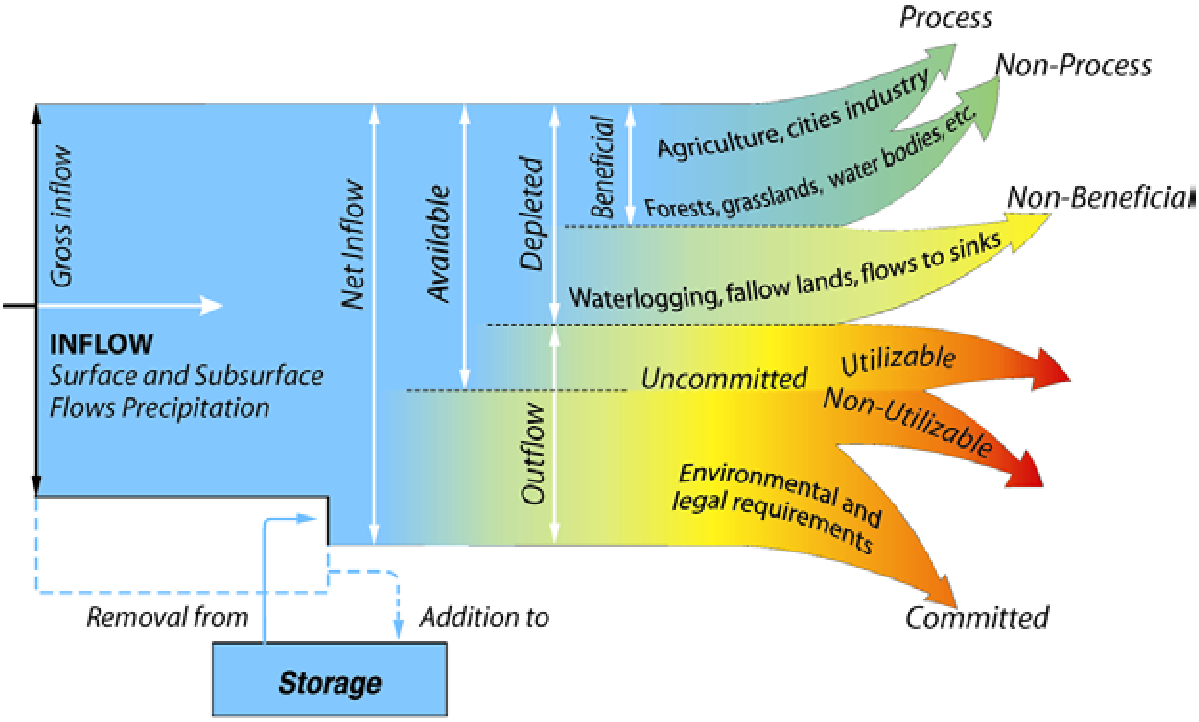
Where Does All the Water Go?

Basin-Scale Water Usage

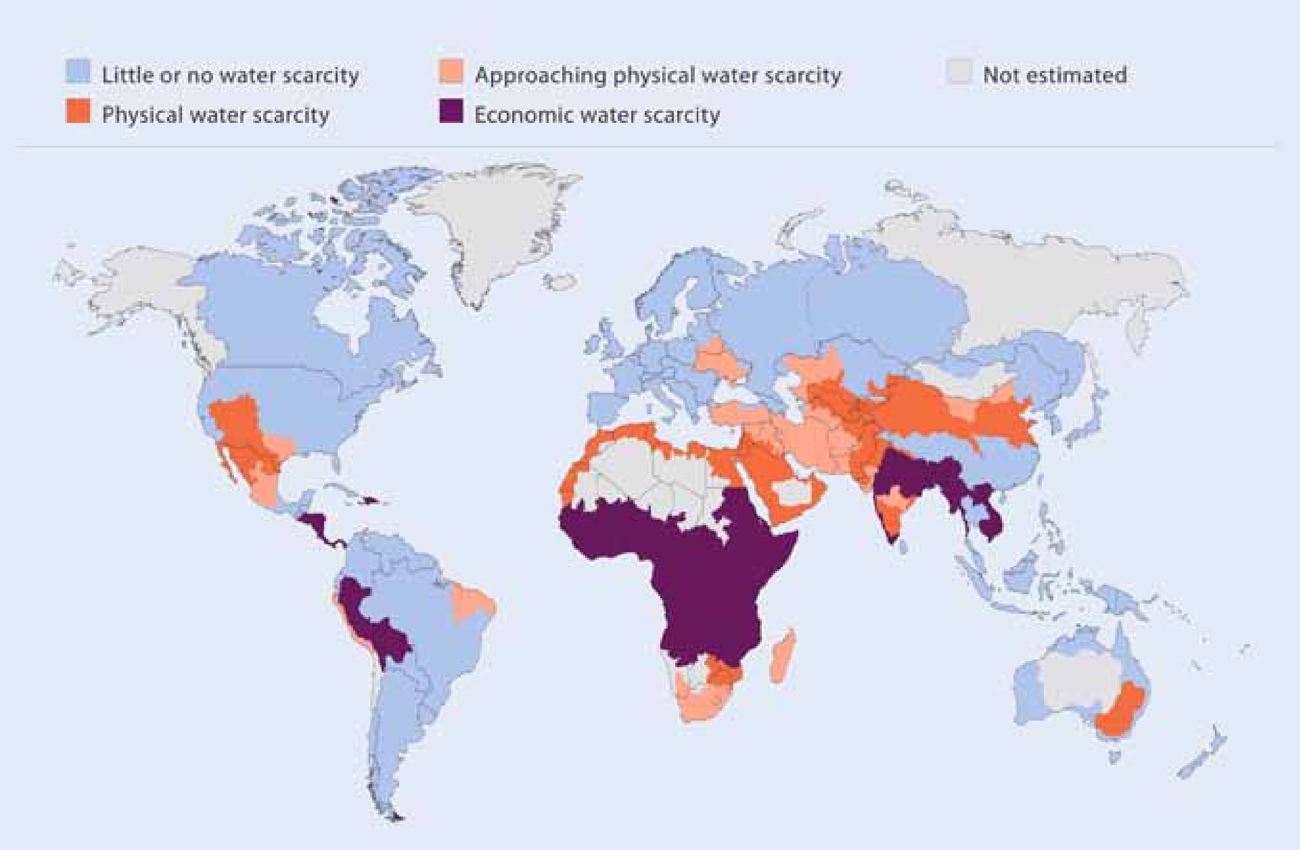


Water Accounting System (source: After Molden, D. 1997. Accounting for water use and productivity. Colombo, Sri Lanka: International Irrigation Management Institute (IIMI). 23p. (SWIM paper 1).

The **Water Accounting System** helps water planners determine the amount of potentially usable water that is available in a river basin, where the water is going, who is using it and how productive it is in terms of cost per cubic meter. Different users include agriculture, cities and industry. Water is also needed for forests, grasslands, rivers and lakes. Research shows that by improving the productivity of water on irrigated and rainfed lands, we can have enough water for cities, industry and the environment. However, this requires a commitment to institutional and management reforms, and substantial investment in water resources management, crop research, technology and infrastructure.

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).

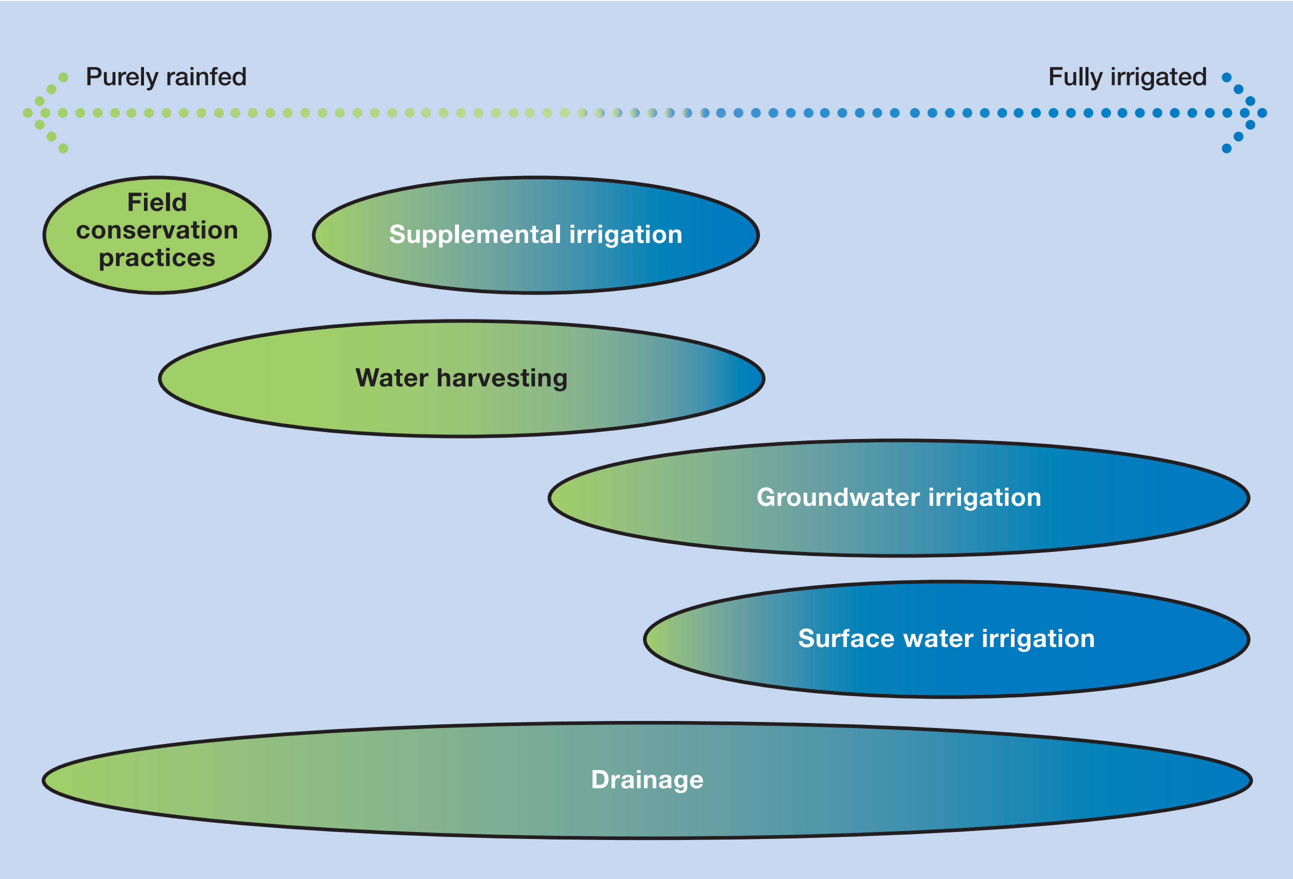
Water scarcity is a critical constraint to agriculture and food security in many parts of the world. Research shows that more than 1.2 billion people live in areas where there is physical water scarcity. Around 1.6 billion people live in water-scarce basins where there is inadequate human capacity or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

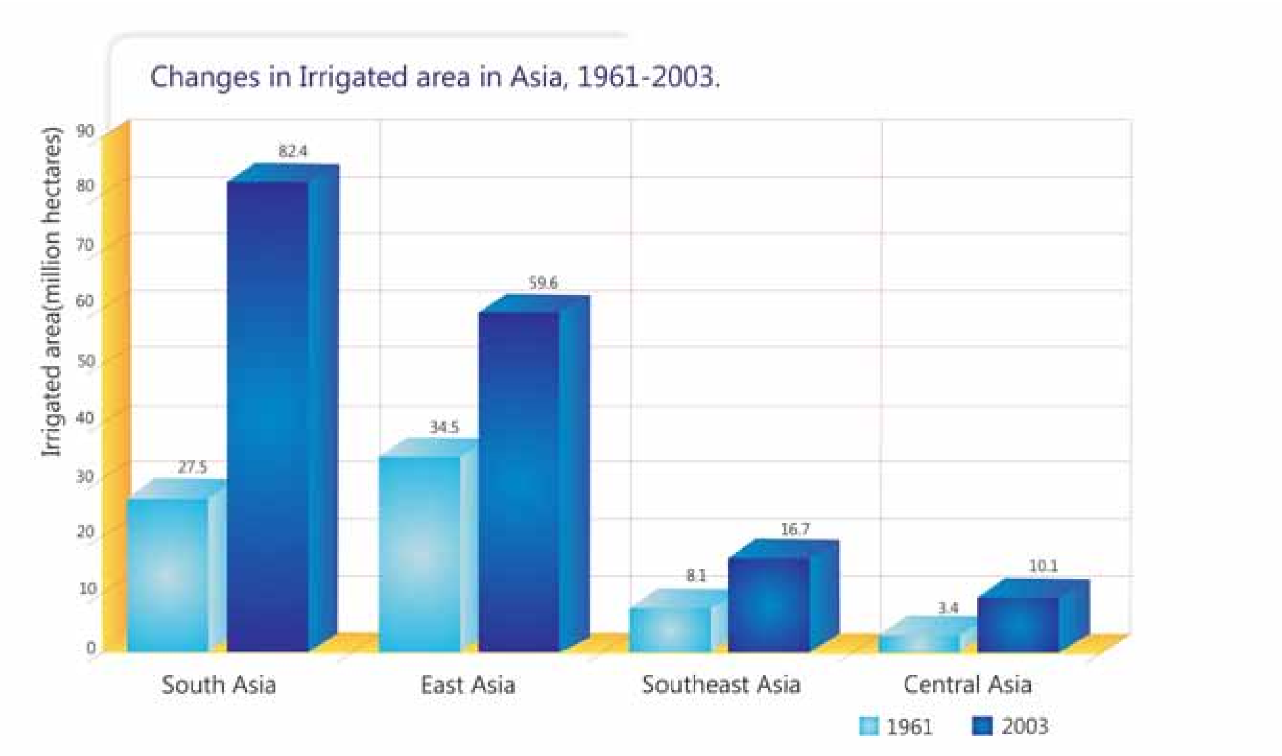
Exploring a Spectrum of Options



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 own 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.

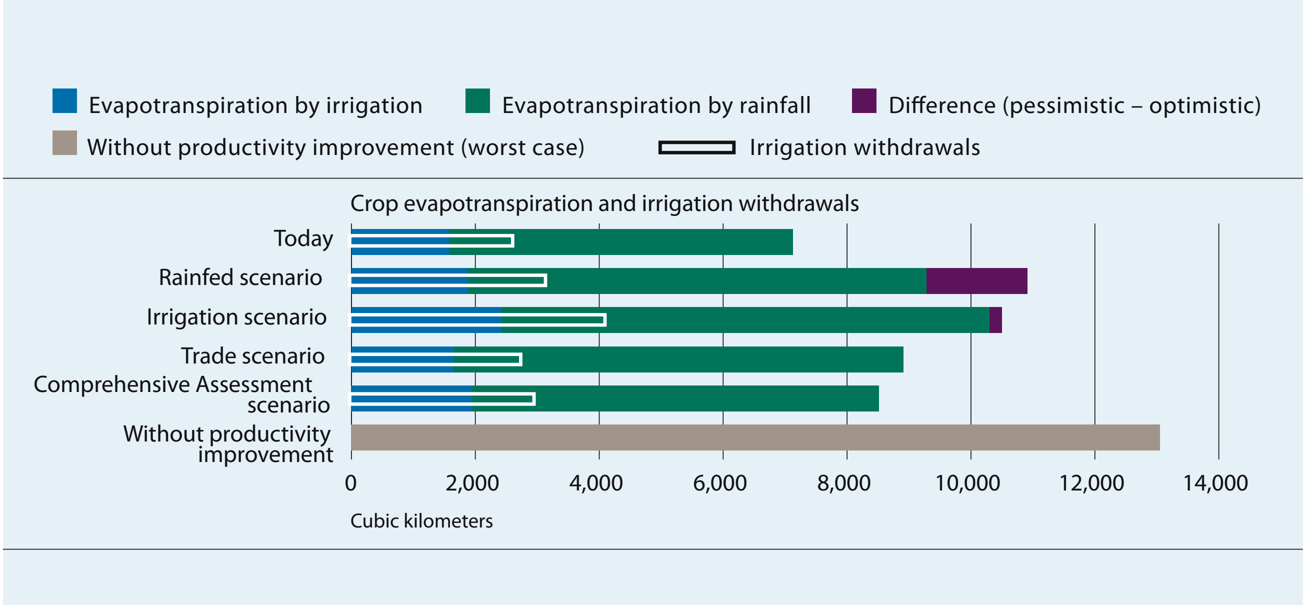
Innovative Solutions Needed for Asian Irrigation



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 positive 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

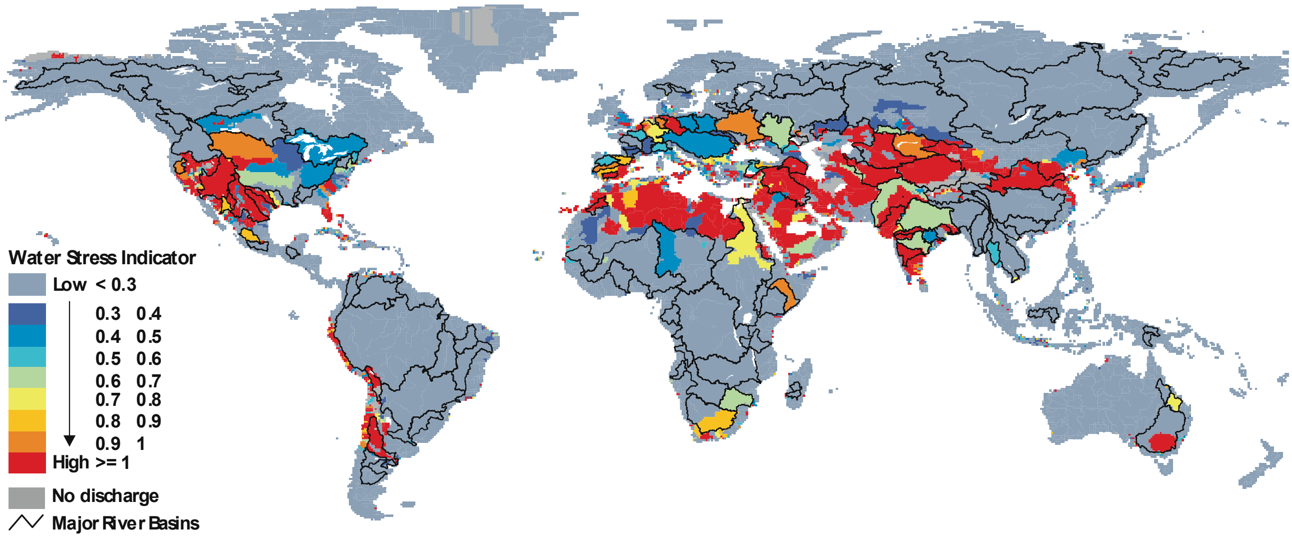


Land and water use today and in the future under different scenarios (source: Molden, D. (Ed.). 2007. Summary for decisionmakers. In: Water for food, water for life: A comprehensive assessment of water management in agriculture. London, UK: Earthscan, and Colombo, Sri Lanka: International Water Management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

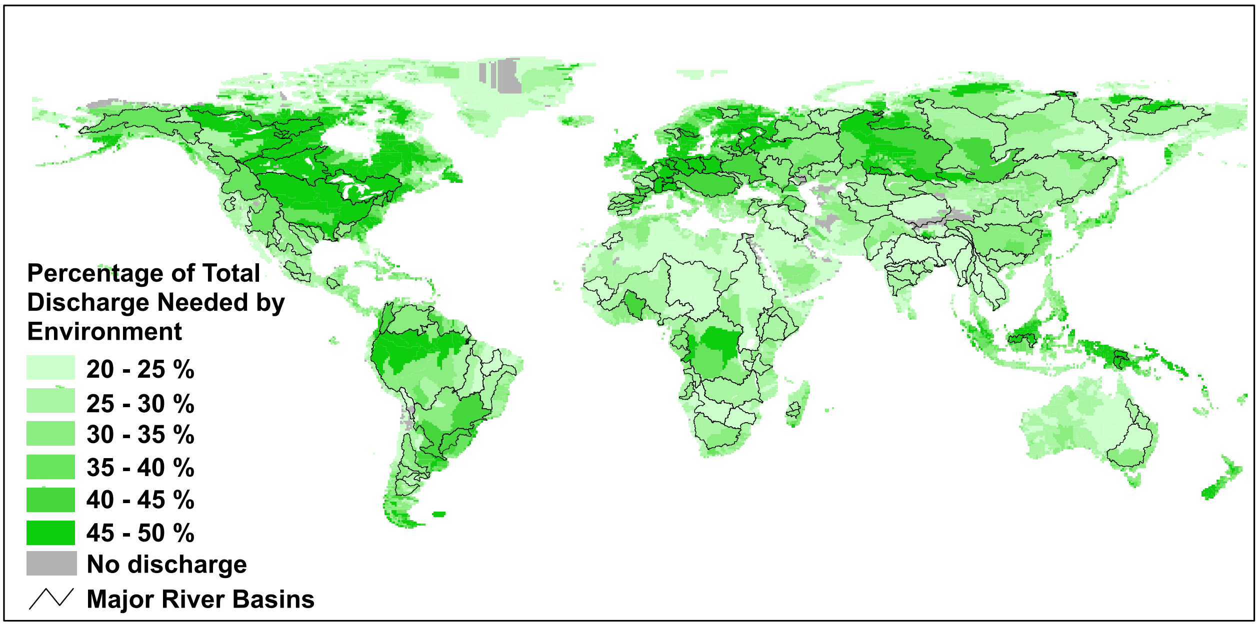


A map of a water stress indicator which takes into account EWR (source: Smakhtin, V. U.; Revenga, C.; Döll, P. 2004. Taking into account environmental water requirements in global-scale water resources assessments. Colombo, Sri Lanka: International Water Management Institute (IWMI), 29p. (Comprehensive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

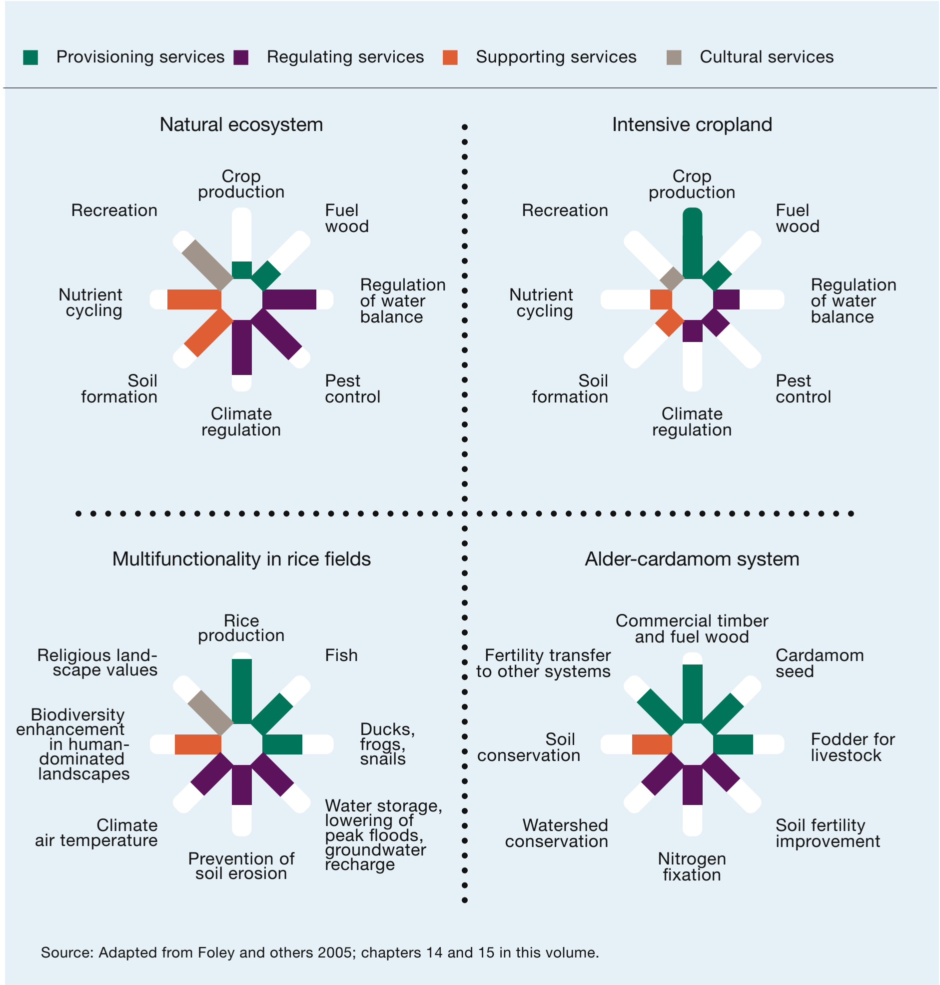
Map of Environmental Flows



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/).

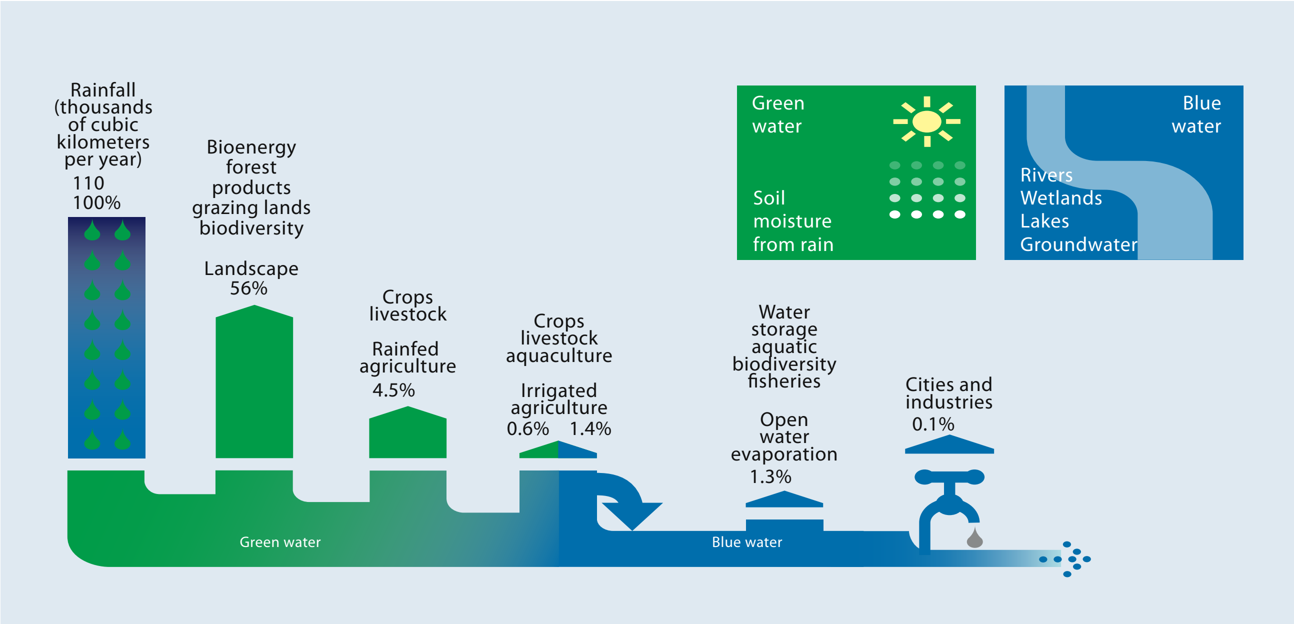
Managing Agroecosystems



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 the Food and Agriculture Organization of the United Nations (FAO), Rome, Italy, and others.

How Much Water Do We Use Globally?

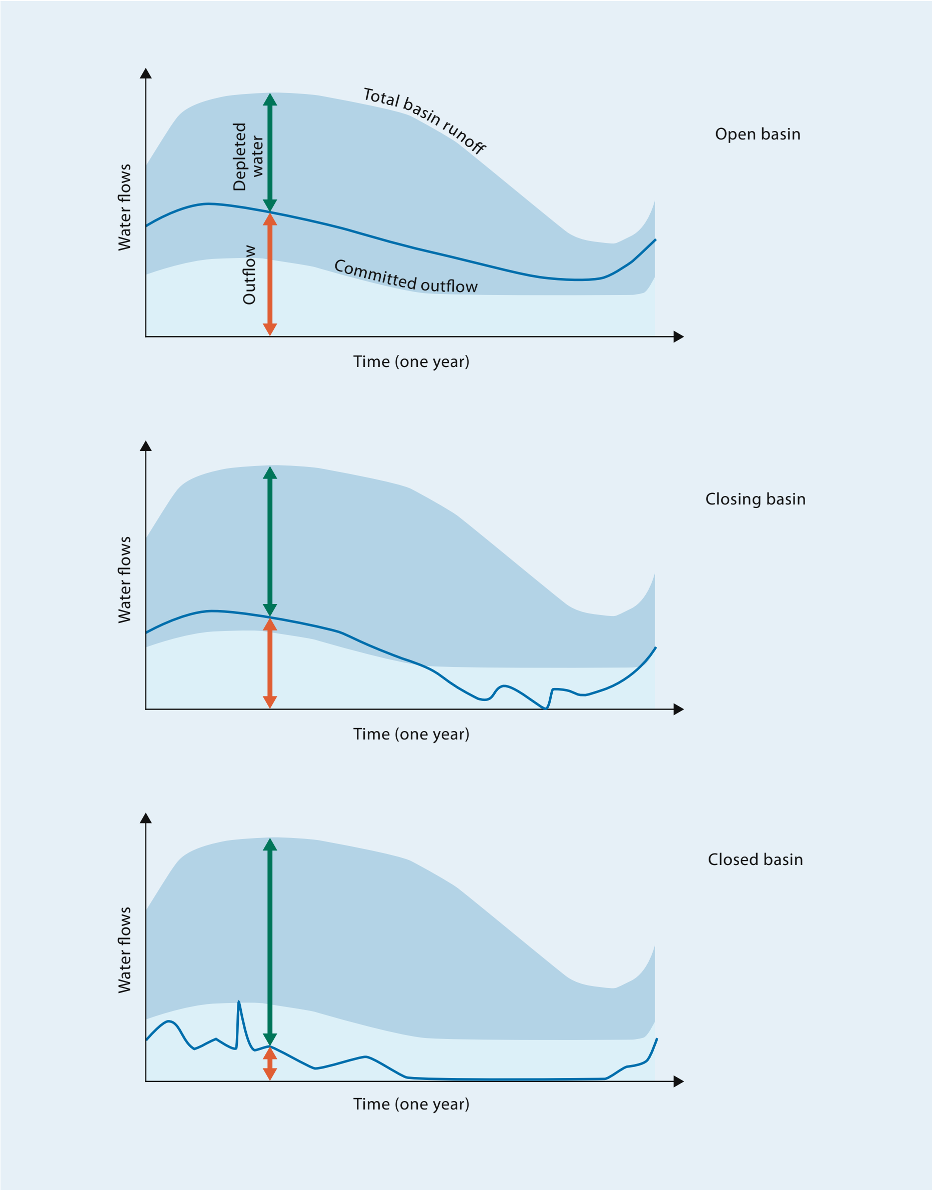


Water use in rainfed and irrigated agriculture (source: Molden, D. (Ed.). 2007. Summary for decisionmakers. In: Water for food, water for life: A comprehensive assessment of water management in agriculture. London, UK: Earthscan, and Colombo, Sri Lanka: International Water Management Institute, p. 6).

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 (km^3)). 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 km^3) contributes to blue water sources, important for supporting biodiversity, fisheries and aquatic ecosystems. Blue water (surface water) withdrawals are about 9% of total blue water sources (3,800 km^3), with 70% of withdrawals going to irrigation (2,700 km^3). Total evapotranspiration by irrigated agriculture is about 2,200 km^3 (2% of rainfall) of which 650 km^3 is directly from rainfall (green water) and the remainder from irrigation water. Cities and industries withdraw 1,200 km^3 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?

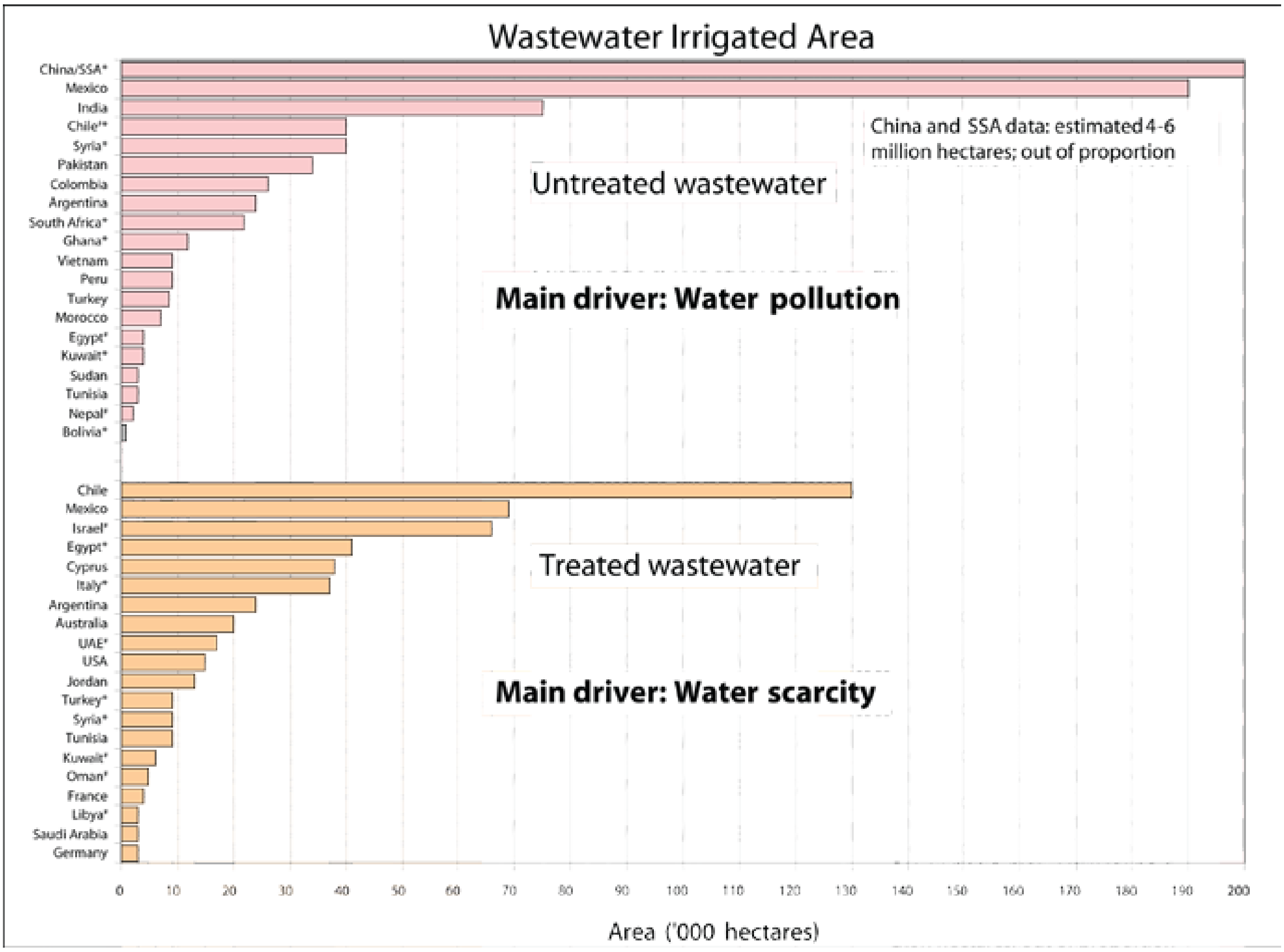
The Basin Perspective



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.

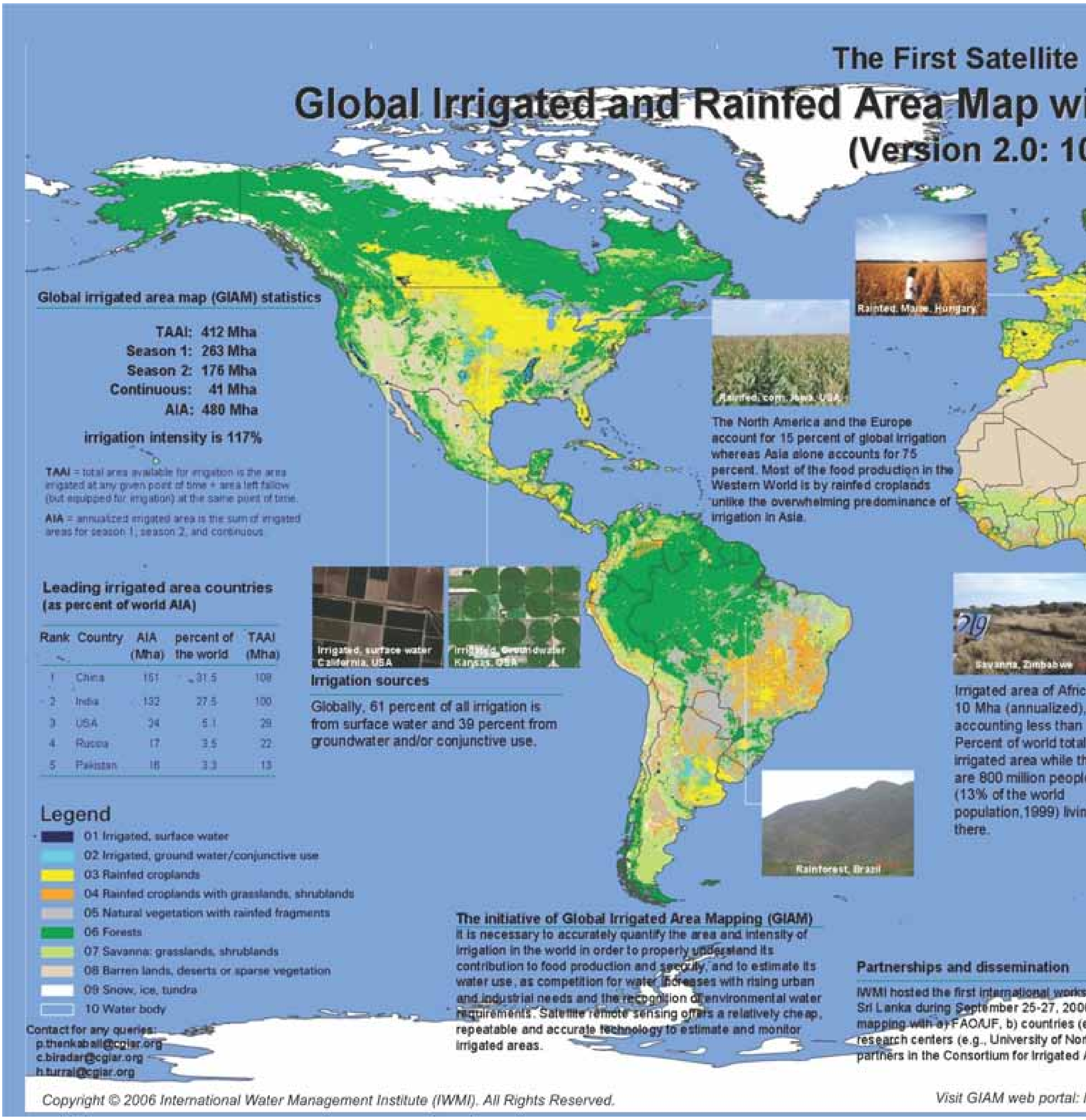
Wastewater: A Rich Resource in a Water–Scarce World



*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).*

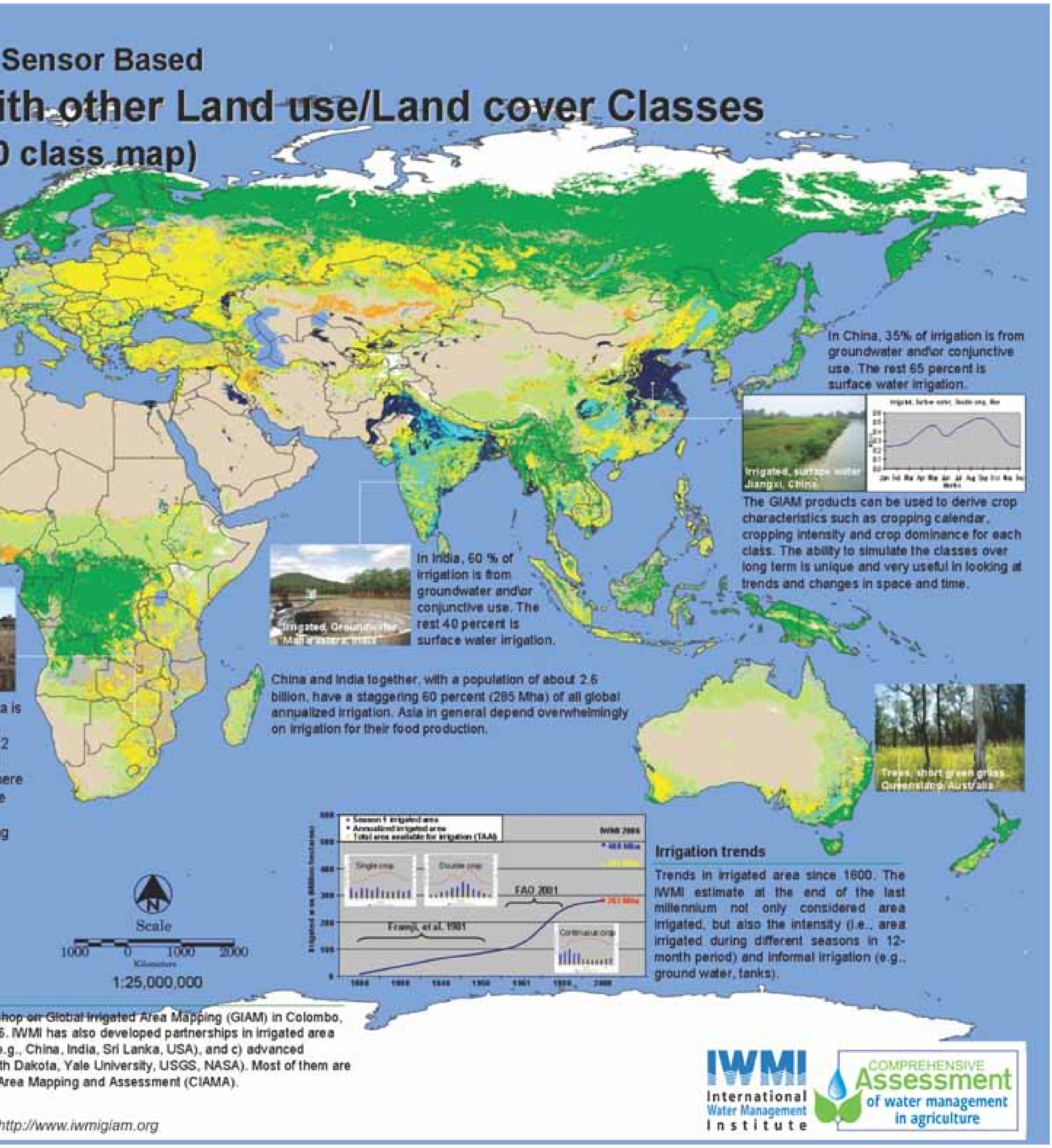
IWMI's research on the use of wastewater shows that as the demand for limited water resources increases from competing sectors, the sustainable use of urban wastewater will become an issue in overcoming water scarcity. For many poor farmers, nutrient–rich wastewater is their only source of water to grow 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.

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. J.; Ve

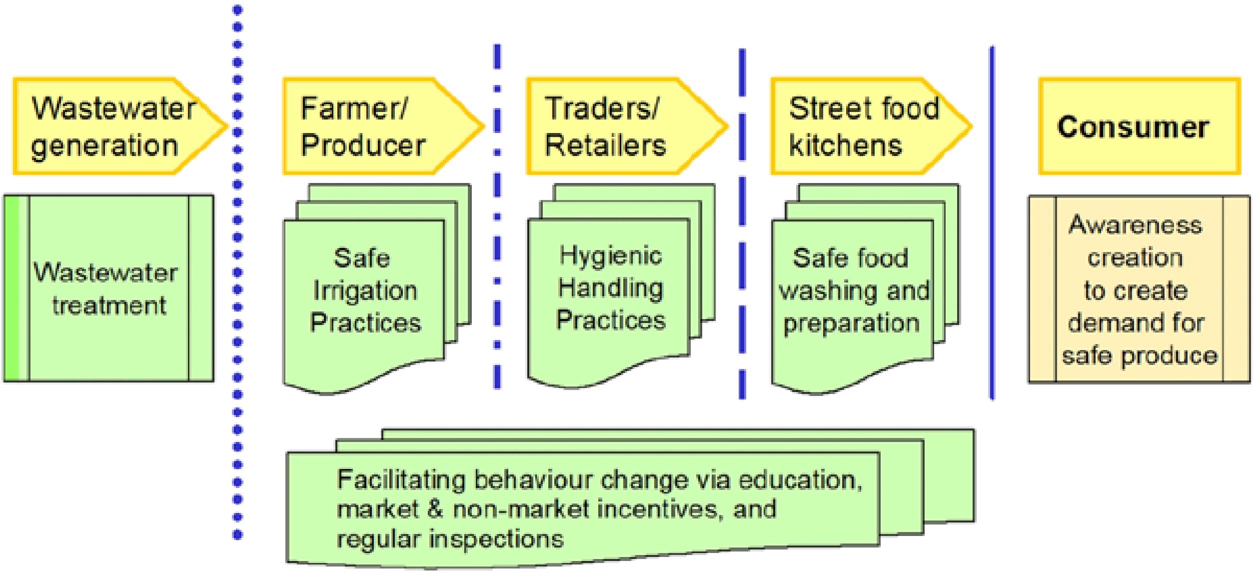
IWMI's Global Irrigated Area Mapping (GIAM) for the year 2000 was the first of its kind. Multiple satellite sensor data were used to proc across the world. The map distinguishes types of irrigated areas, providing distinct classes of irrigation. This detailed analysis and deg resources better and reduce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



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

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

The Multiple Barrier Approach to Microbial Risk Management



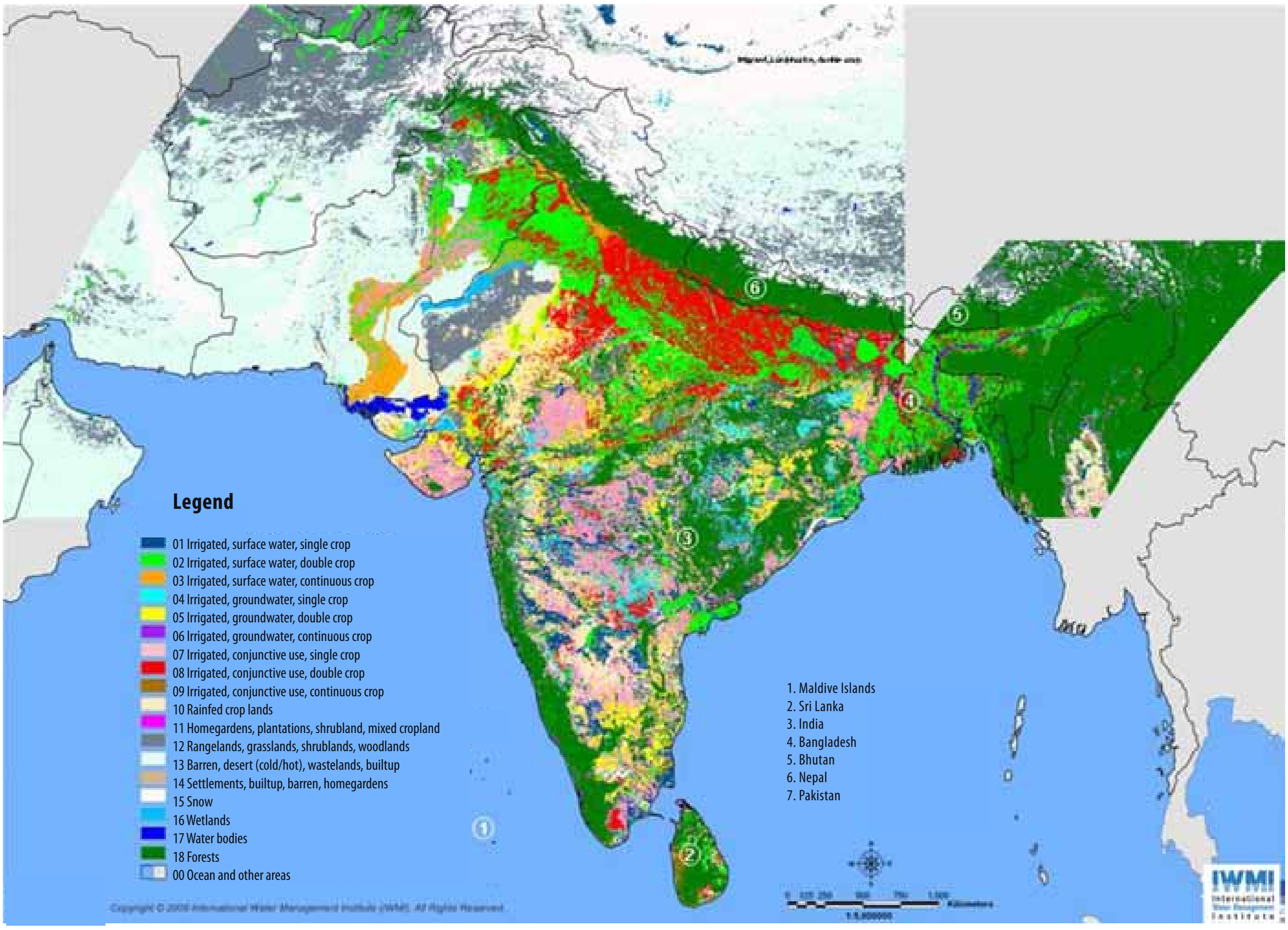
Multiple Barrier Approach in the Wastewater Food Chain where Treatment Alone is an Insignificant Pathogen Barrier (source: Ilic, S.; Drechsel, P.; Amoah, P.; LeJeune, J. 2010. Applying the multiple-barrier approach for microbial risk reduction in the post-harvest sector of wastewater irrigated vegetables. 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 1996[1], 2006[2]). Underlying problems of food safety differ considerably between developing ocuntries 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-vendored 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.*

Global Irrigated Area Mapping: Indian Subcontinent

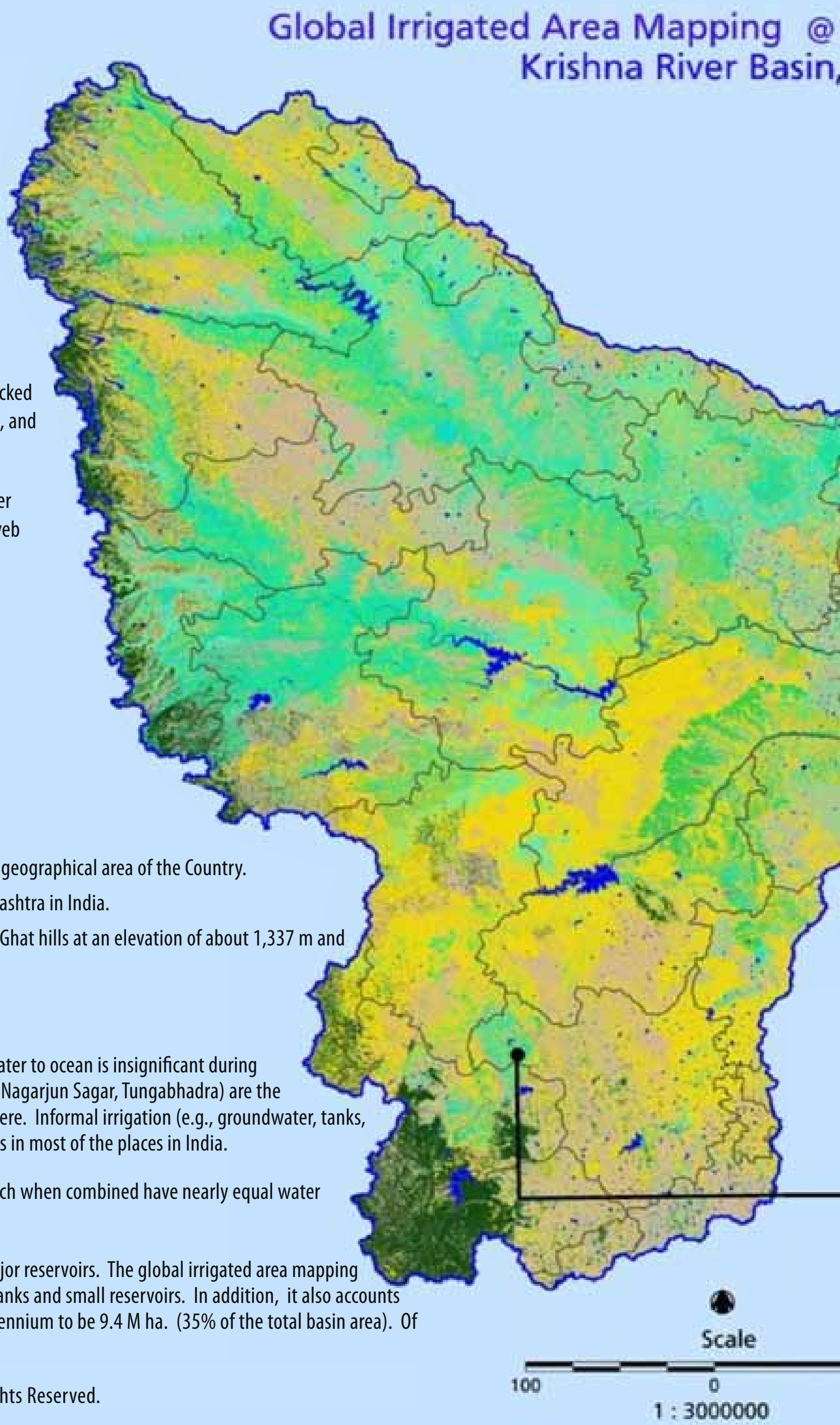


GIAM: Indian Subcontinent (Source: Thenkabail, P. S.; Biradar, C. M.; Turral, H.; Noojipady, P.; Li, Y. J.; Vithanage, J.; Dheeravath, V.;Velpuri, M.; Schull, M.; Cai, X. L.; Dutta, R. 2006. An irrigated area map of the world (1999) derived from remote sensing. Colombo, Sri Lanka: International Water 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 2002[3]). 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.iwmigiam.org

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

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



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 normal 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 sense or data. The study is backed by extensive groundtruth data, very high resolution in 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

Irrigated Area Statistics for the Krishna River Basin

Total targeted Irrigated Area 9.4 Mha
Surface Water Irrig. 3.9 M ha (48%)
Ground Water Irrig. 5.2 M ha (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 raises in the Western Ghat hills at an elevation of about 1,337 m and travels about 1300 km before it flows into the Bay of Bengal.

Informal Irrigation Story

The Krishna river is a hydrologic ally closing basins (i.e., the outflow of water to ocean is insignificant during normal years). Generally, it is thought that the 12 major reservoirs (e.g., Nagarjun Sagar, Tungabhadra) 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 6100 small tanks and reservoirs in the Krishna basis, 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 M ha. (35% of the total basin area). Of this, 52% is from groundwater and 48% from surface water.

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

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

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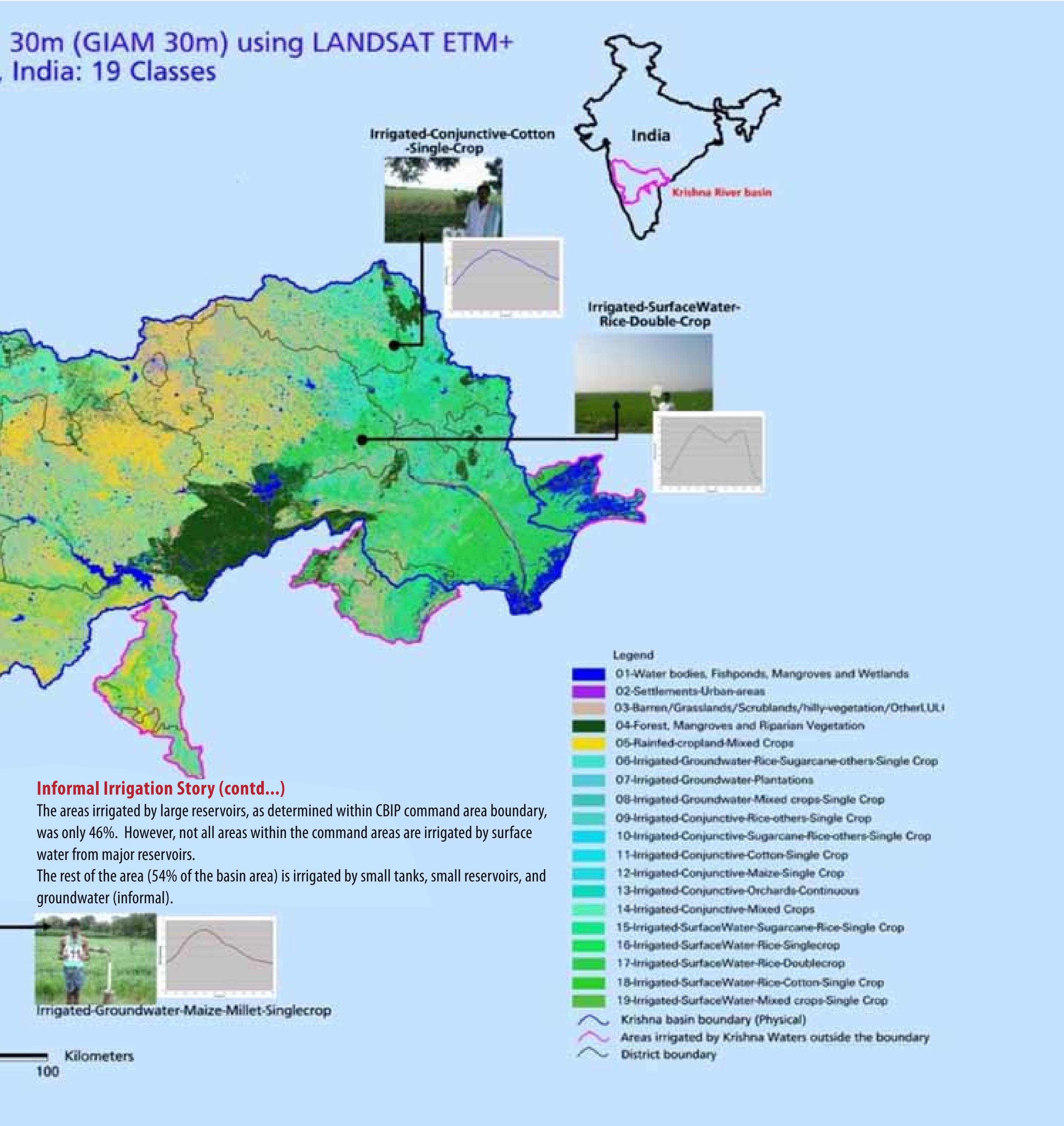
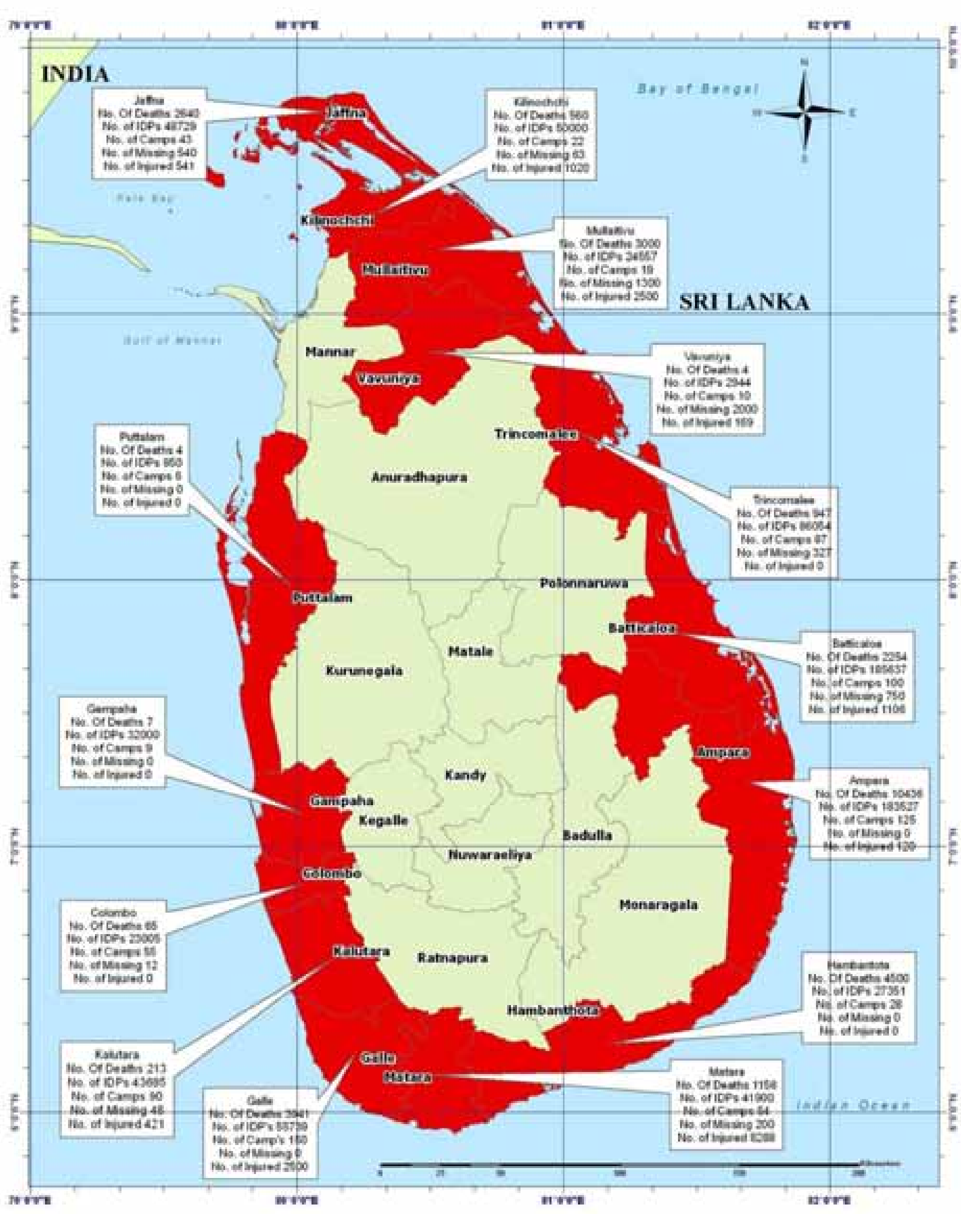


, Y. J.; Dheeravath, V.; Vithanage, V.; Xueliang, C.; Dutta, R. (IWMI). 2006). Remote Sensing Map of the Krishna Basin

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

Sri Lanka in the Aftermath of the Tsunami

Affected Persons Situation Map

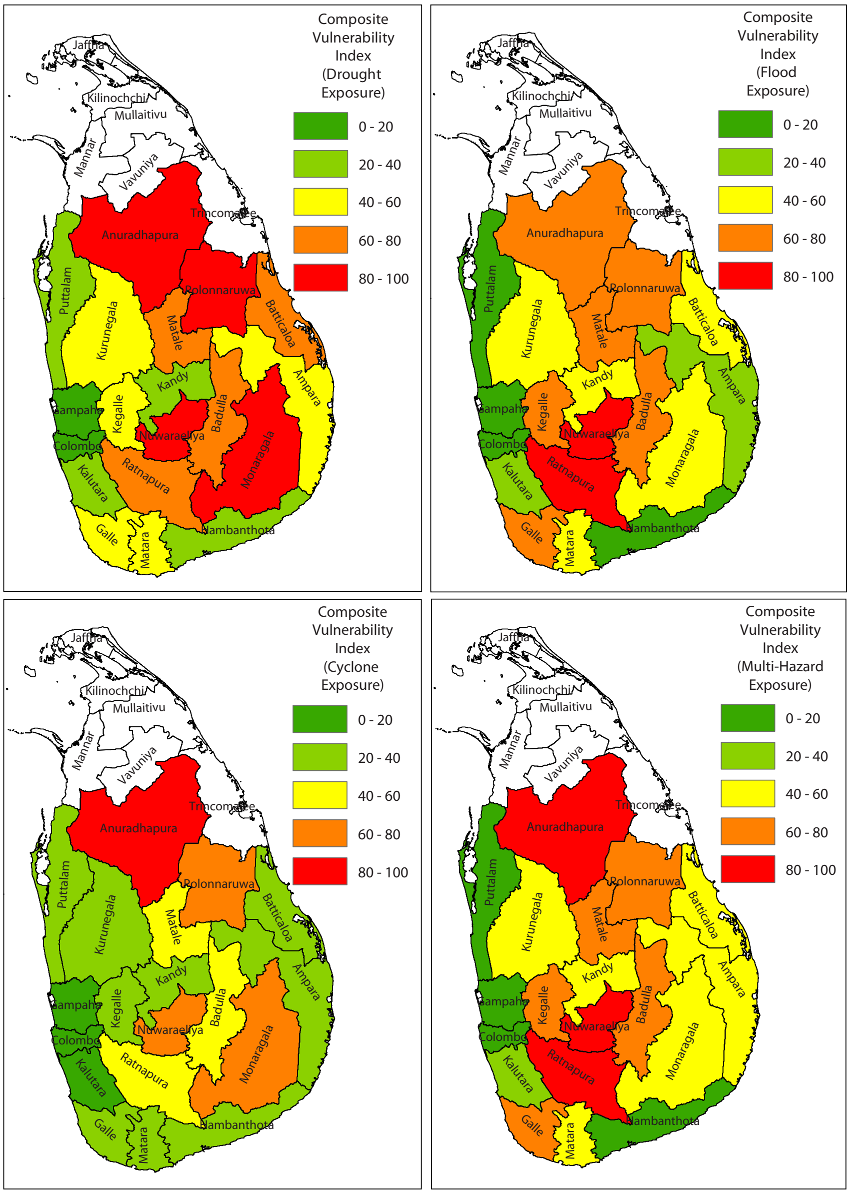


Affected Persons Situation Map (Source: Data sourced from CNO, Ministry of Women Empowerment and Social Welfare. IWMI. MapAction UK. 2005).

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 highest and 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.

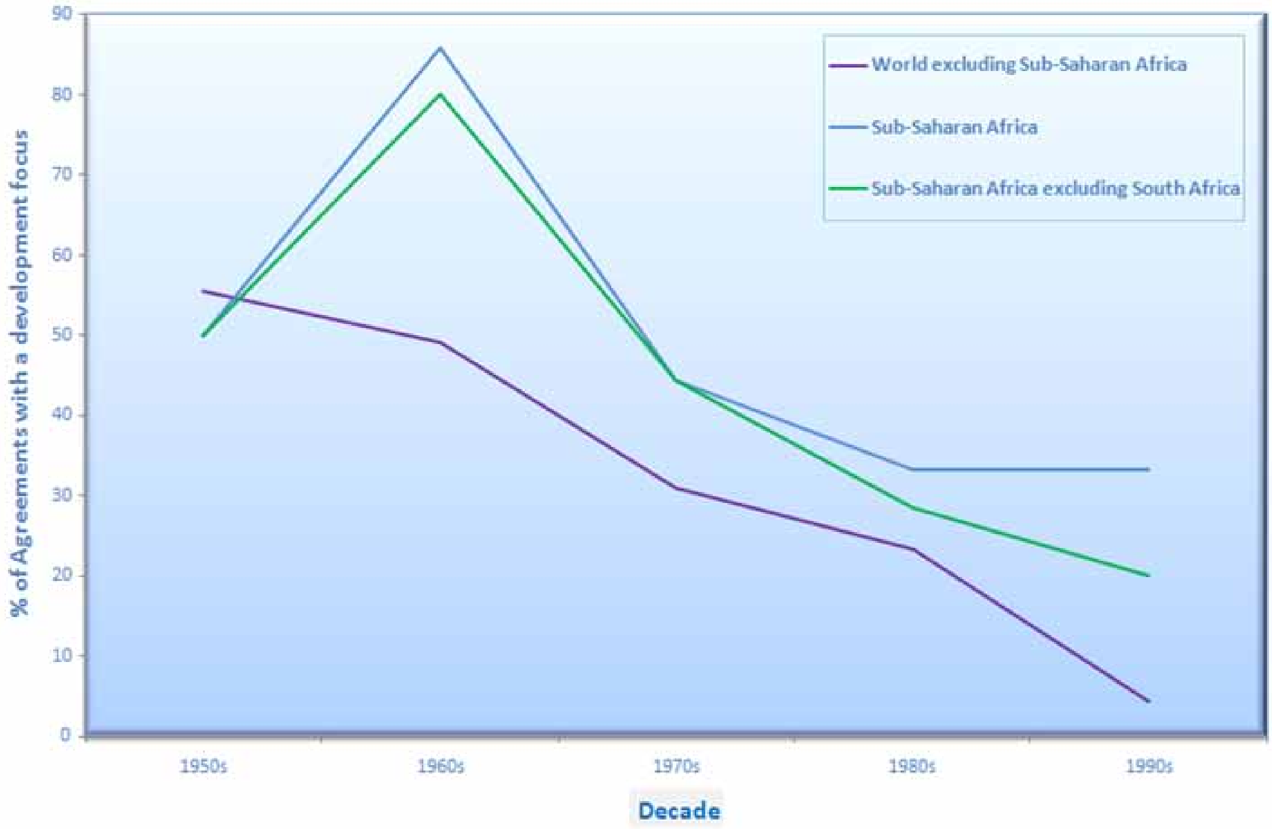
Preparing for the Impacts of Climate Change



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. (IWMI 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.

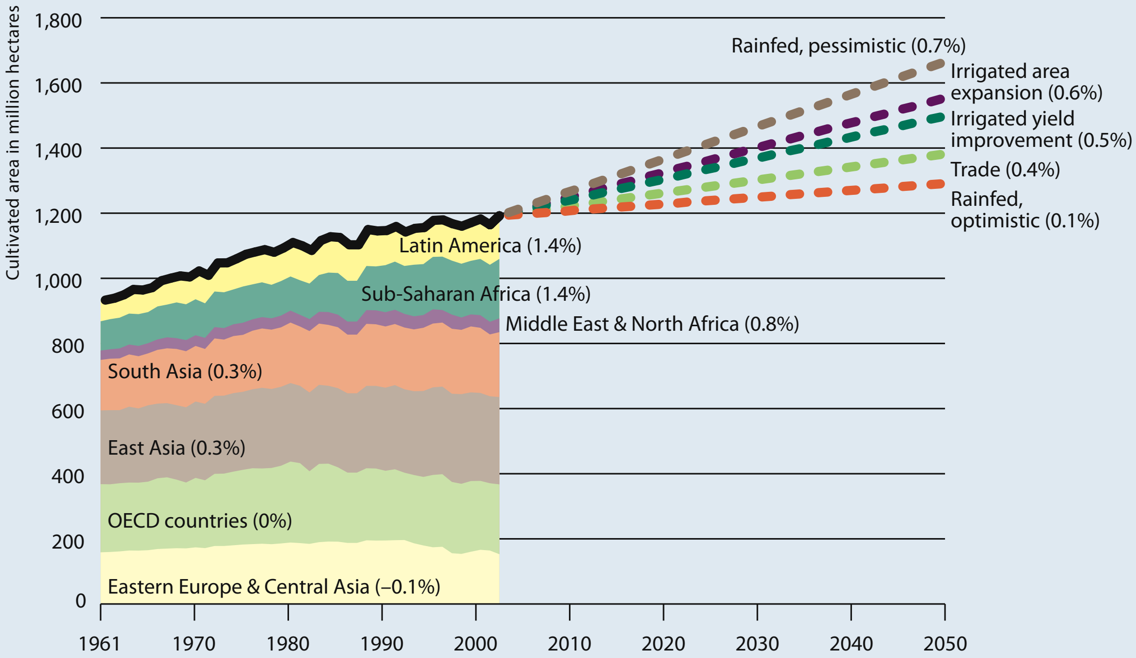
Convergence in Orientation of Transboundary Water Law



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



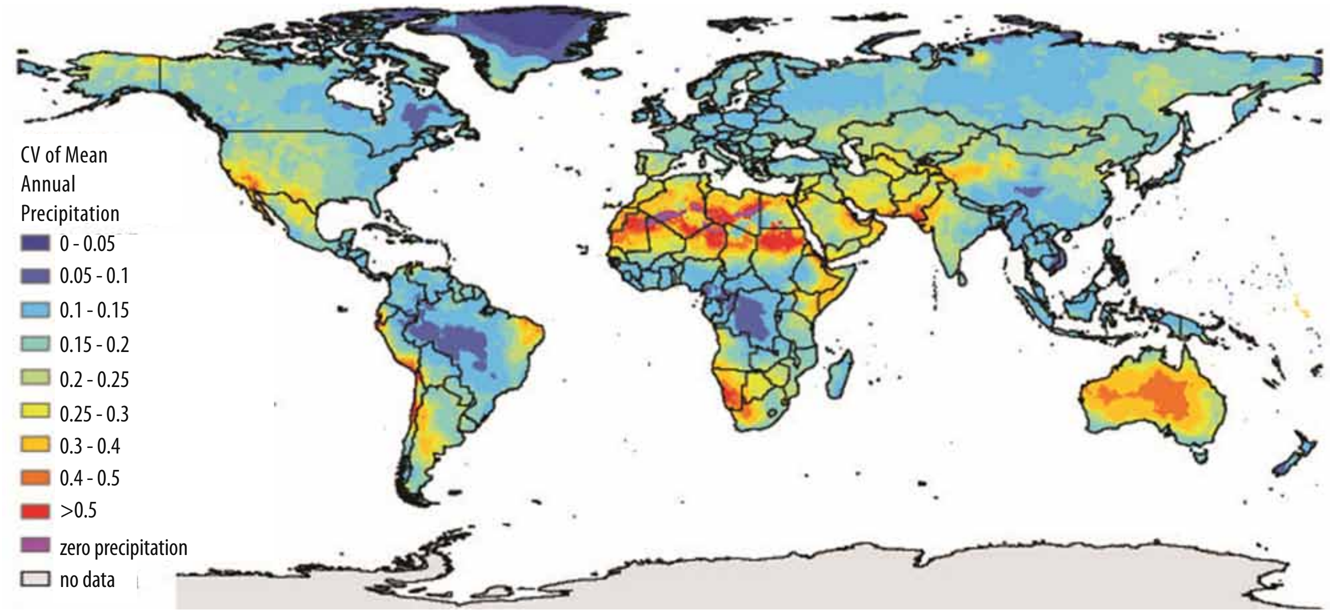
Note: Numbers in parentheses are annual growth rates.

Source: For 1961–2002, FAOSTAT 2006; for 2000–2050, International Water Management Institute analysis done for the Comprehensive Assessment of Water Management in Agriculture using the Watersim model.

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

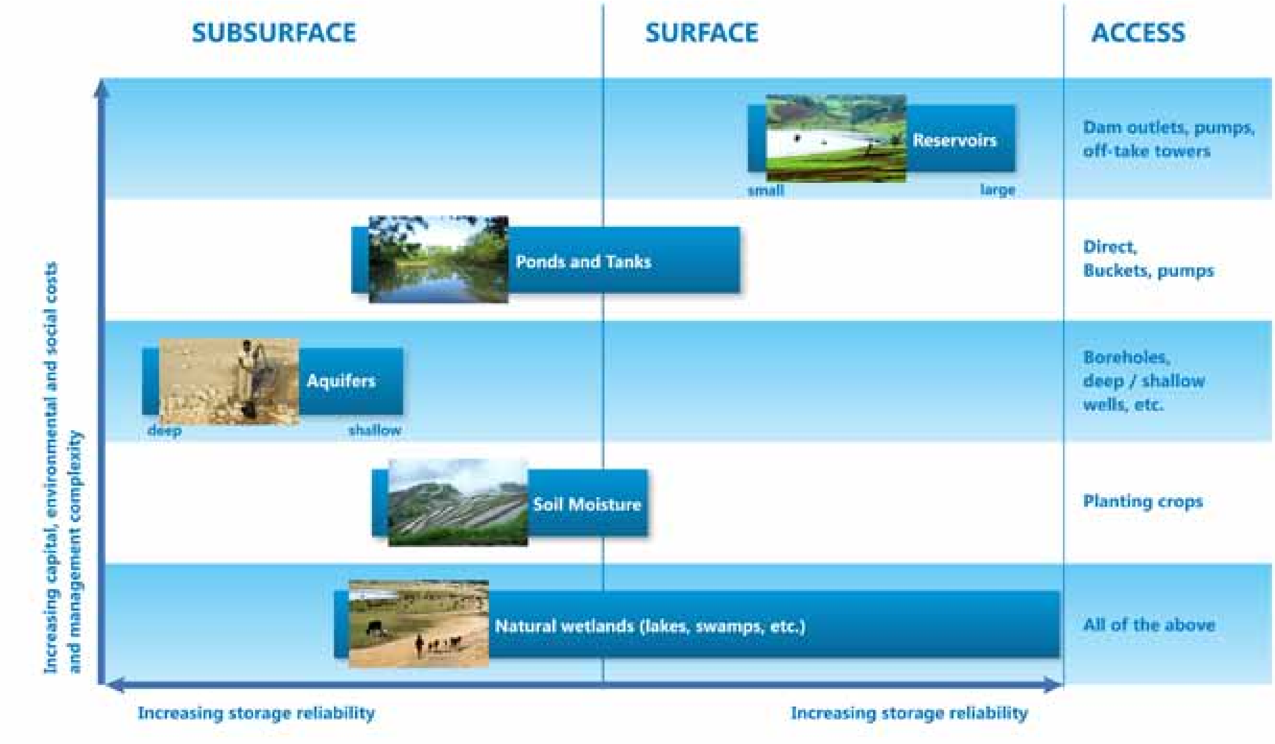


Diagram of water storage continuum (Source: McCartney, M.; Smakhtin, V. 2010. Water storage in an era of climate change: Addressing the challenge of increasing rainfall variability. Blue Paper. Colombo, Sri Lanka: International Water Management Institute).

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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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 (IWMI). 43p. (IWMI Research Report 135)
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Books

Chartres, C.; Varma, S. 2010. *Out of water: from abundance to scarcity and how to solve the world's water problems.* Upper Saddle River, NJ, USA: FT Press. 230p.
www.iwmi.org/OutOfWater/

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Evans, A.; Raschid-Sally, L.; Cofie, O. O. 2010. Multi-stakeholder processes for managing wastewater use in agriculture. In: Drechsel, P.; Scott, C. A.; Raschid-Sally, L.; Redwood, M.; Bahri, A. (Eds.). *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). pp.355-377.
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www.sage-ereference.com/geography/Article_n194.html.

Mukherji, A. 2010. Common property resource management. In: Warf, B., (Ed.), *Encyclopedia of geography*. London, UK: Sage.
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de Fraiture, C.; Molden, D.; Wichelns, D. 2010. Investing in water for food, ecosystems, and livelihoods: an overview of the comprehensive assessment of water management in agriculture. *Agricultural Water Management* 97(4): 495-501 (special issue with contributions by IWMI authors).

de Fraiture, C.; Wichelns, D. 2010. Satisfying future water demands for agriculture. *Agricultural Water Management* 97(4): 502-511 (Special issue with contributions by IWMI authors).

Drechsel, P.; Evans, A. 2010. Wastewater use in irrigated agriculture. *Irrigation and Drainage Systems* 24(1-2): 1-3 (special issue with contributions by IWMI authors).
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