ON TARGET FOR PEOPLE AND PLANET

Setting and Achieving Water-related Sustainable Development Goals

Edited by
Julie van der Bliek
Peter McCornick
James Clarke

CGIAR
RESEARCH PROGRAM ON
Water, Land and Ecosystems

IWMI
International Water Management Institute

International Water Management Institute (IWMI)

Editors
Julie van der Bliek (IWMI)
Peter McCornick (IWMI)
James Clarke (IWMI)

Contributors
All contributors are IWMI staff, unless indicated otherwise.
Writing, copy editing and design by Econnect Communication.

Acknowledgement
The support provided by the CGIAR Research Program on Water, Land and Ecosystems (WLE) is gratefully acknowledged.

CGIAR RESEARCH PROGRAM ON Water, Land and Ecosystems

This work has been undertaken as part of the CGIAR Research Program on Water, Land and Ecosystems. IWMI is a member of the CGIAR Consortium and leads this program.

The CGIAR Research Program on Water, Land and Ecosystems (WLE) combines the resources of 11 CGIAR centers, the Food and Agriculture Organization of the United Nations (FAO) and numerous national, regional and international partners to provide an integrated approach to natural resource management research. WLE promotes a new approach to sustainable intensification in which a healthy functioning ecosystem is seen as a prerequisite to agricultural development, resilience of food systems and human well-being. This program is led by the International Water Management Institute (IWMI) and is supported by CGIAR, a global research partnership for a food-secure future.

van der Bliek, J.; McCornick, M.; Clarke, J. (Eds.). 2014. *On target for people and planet: setting and achieving water-related sustainable development goals.* Colombo, Sri Lanka: International Water Management Institute (IWMI). 52p. doi: 10.5337/2014.226

/ water governance / water quality / groundwater / water resources / water management / domestic water / water policy / water accounting / wastewater / food security / energy / sustainable development / ecosystem services / climate change / flooding / drought / farmers / economic growth / social aspects / women / river basins / Africa South of Sahara /

ISBN 978-92-9090-801-2

A free copy of this publication can be downloaded at **www.iwmi.org/sdg-book**

ON TARGET FOR PEOPLE AND PLANET

Setting and Achieving Water-related Sustainable Development Goals

Edited by
Julie van der Bliek
Peter McCornick
James Clarke

International Water Management Institute (IWMI)

Foreword

The year 2015 will be critical for humanity. The United Nations is set to agree the global Sustainable Development Goals (SDGs) that will guide investment and social policy for decades to come.

There is still a long way to go in the political process of finalizing the SDGs, but the issues are sufficiently well defined to start preparing. The International Water Management Institute (IWMI), with its long-standing commitment to partnerships and dialogue, has expertise to contribute to implementing the SDGs and thereafter to work with countries on the indicators, monitoring and practices necessary to meet their individual national targets.

Of all our natural resources, water underpins sustainable development perhaps more than any other. This importance is reflected in SDG 6: 'Ensure availability and sustainable management of water and sanitation for all'. But a quick glance at the 17 proposed goals (http://sustainabledevelopment.un.org/focussdgs.html) confirms that water will be critical to achieving several more. In agriculture, economic development and environmental protection, for instance, its role will be central. And the role of managing rainwater, a key water resource for millions of the world's poor, is not yet fully recognized in the goals.

This underlines the need to take a more holistic look at how we manage water. IWMI has responded to this challenge through its new strategy and mission to deliver 'a water-secure world'. We began three decades ago as an institution devoted to a single aspect of water management: improved irrigation performance. Since then our focus has broadened to seek, through water management, sustainable solutions to poverty, food security and environmental degradation. IWMI's diverse scientists and multiple partners now have research results about water management in relation to a wide range of pressing global challenges.

It is this breadth of expertise that has inspired this book. To deliver on the SDGs we need to be smart and inclusive. We must support the goals and implementation plans based on solid evidence. We believe that, as part of a global network of stakeholders, we can make a major contribution to this process. The sections in this book offer critical analyses of how national SDG targets on water can be defined in ways that are both meaningful and achievable and how these targets might be met. Each section is written by leading specialists in the field, both from IWMI and its collaborators, and reflects the most up-to-date thinking on evidence-based water policy for policy makers, investors and water professionals.

To deliver on the SDGs we will need to engage not just across sectors, but also across borders. Our unique network of cutting-edge researchers, engaged with partners from all sectors, is ready to be a part of that global discussion.

IWMI will be producing a series of annual flagship reports that will synthesize current thinking on major water issues. It is my belief that these will become indispensable resources for policymakers, investors and water professionals grappling with our global ambitions for a more just and sustainable world. Moreover, I see them as important conversation starters. We welcome your participation in this ongoing conversation.

JEREMY BIRD
Director General, IWMI
September 2014

Contents

1 Introduction

Introduction

Authors: Julie van der Bliek and Peter McCornick

The SDG development process has been extensive and inclusive in its attempt to establish consensus among countries and other stakeholders on universal goals and targets. While the global SDGs will be finalized over the coming year, the shape of them is emerging and it is possible to envisage key elements of the water-related SDGs. Through this book we aim to contribute to the next steps in the SDG process: setting national targets, achieving those targets in countries, measuring progress, and, in particular, exploring contributions of the science community through evidence-based support.

In the Millennium Development Goals, water security for direct human needs received prominence. In the development of the SDGs there is additional focus on sustainable management of water for economic growth and on water risks, in particular, water-related disasters. Placing the water-related SDGs in the broader context of water security will provide the basis for a more comprehensive framework. This can then address the water needs of all sectors, cross-sectoral challenges, and risks.

Governments will require support from the science community to achieve and monitor the SDGs.

IWMI's new strategy, to deliver 'a water-secure world', also recognizes the need to position its agricultural water management research agenda within this broader context of water security, emphasize intersectoral dependencies and synergies and ensure the resilience of ecosystems. This opens new challenges for research and partnerships and opportunities to find solutions to complex development challenges in rural and urban settings as well as at river basin scale.

Our specific focus in this book is on securing water for sustainable food production. This links to sustainable water resources management, delivering on the water supply and sanitation requirements and provisioning water for energy and the urban sector. A specific intent is to ensure that the realities in low- and middle-income countries in Africa and Asia are recognized and to provide practical pathways to change that fit these realities and the aspirations of those countries. This will help to prepare for the next step in the SDG process: devolving the SDGs to the national level. It will also provide an input into the development of the universal SDGs by exploring realistic targets and indicators.

Focusing on Delivery—Addressing Some of the Contextual Realities:

- ***Recognize Economic Water Scarcity:*** In sub-Saharan Africa (SSA), but also in several countries and regions in Asia, economic water scarcity is hampering further development and food security. For example, water storage capacity in SSA is low, but careful and innovative development of this will increase water security and improve resilience to climate change. A further example is groundwater, which is an over-exploited resource in a number of critical food-producing areas of the world. Further development of this resource in much of SSA, Southeast Asia and even in south Asia can make an important contribution to food security. Hence there is a need to provide enough opportunities in the SDG targets, not just for water conservation and increased efficiencies, but for water resource development as well. (See section 2 case studies and sections 6, 7 and 9.)
- ***Balance Development and Conservation Needs:*** In countries with relatively rapid economic growth, the need to develop water resources for irrigation, energy, urban areas and industry is negatively affecting ecosystem services provided by rivers, lakes, wetlands and aquifers. There is no standard prescription for achieving a balance between development and conserving the natural environment, but understanding the relationship between ecosystems and livelihoods and the likely consequences of changes is essential. Future SDGs should provide the right incentives to balance these needs. (See sections 4, 6, 8 and 9.)
- ***Explore Pragmatic Solutions:*** Water resources management is context-specific, complicated by the interconnections between water and energy, economic growth and the demand for food. So in resource-poor countries, pragmatic approaches to development will be needed. For example, conventional wastewater treatment is costly and relatively rare in the developing world. This makes it unlikely to be an effective intervention in many poor countries. Similarly, while there is a need to formalize water governance institutions, we also need to respect cultural and informal water rights. Water pricing may be a more elegant solution to overuse, but it can only function well with robust institutions, typical of more developed water economies. (See sections 3, 5 and 8.)

OVERARCHING MESSAGES

Given these constraints, the challenges may appear daunting. But there is tangible political will behind the SDG process, and what has been developed so far is encouraging. Four key challenges are now emerging:

1. Partnerships

Achieving all water-related goals will require a broad partnership within the water sector and beyond. These partnerships and alliances will need to raise funds, provide access to existing and new knowledge, craft effective policies and programs, implement solutions and monitor changes. Different sectors will need to be represented, and a comprehensive understanding of the interaction and complementarity of water security will be vital. This focus on common purpose, goals and targets and an overall incentive for collaboration within and across sectors have been lacking in the water sector to date. Partnerships will need to be strengthened both within and between countries to encourage learning. The inclusion of the science community, with an emphasis on developing practical solutions, will be important to ensure the generation and sharing of new knowledge. (See sections 2, 4 and 8.)

2. Opportunities for Growth

The emphasis of the proposed water-related and other sector targets on increasing efficiencies (water, energy, etc.) is based on improving the use of existing systems, with only limited allowance for further developing water resources. Many countries in SSA and Asia have not had the capacity to invest in the infrastructure, programs and institutions to utilize their water resources effectively. The goals and targets need to practically accommodate the growth requirements of Asian and, in particular, African countries and recognize that further wise development of the resource is a fundamental aspect of sustainable water resources management. The emphasis should be on facilitating a sustainable and equitable growth path. (See section 9.)

3. Balancing the Scales

The increasing importance of small-scale farmers, especially women, for food security in SSA and Asia deserves special attention. The International Year of Family Farming (2014) highlights that most people in the world rely on food produced on family farms, generally smallholdings. Their increased use of surface and groundwater resources to boost production offers opportunities as well as challenges. It is imperative that policies and investments support the sustainable development and productivity of these small-scale producers. Similarly, large-scale investments in water resources and agriculture need to complement, rather than undermine, small-scale producers. (See sections 2, 3, 5, 6, 7 and 9.)

4. Integration

One of the basic foundations of the SDGs is that more emphasis is needed on integration. Yet efforts to incorporate integration into the complex context of water management, including the links between water, energy and food, have proved challenging. While separate nexus goals and targets may not now be attainable, thinking across sectors and out of the 'sectoral boxes' has produced practical solutions where more textbook approaches had failed. At the country level there is a need for coherent and integrated policies. This can be done, at least in part, by taking a nexus approach to analyzing resource constraints and opportunities. (See sections 2 and 8.)

NEXT STEPS

Governments will require support from the science community to set national targets, choose sound investments and implement effective programs to achieve and monitor the SDGs. Researchers can contribute by:

1. Supporting National Governments to Set National Targets

National-level targets will be set to complement the universal goals and targets. Several ideas on how these national targets could be derived from and align with the universal goals and targets have been presented and discussed internationally. However, whatever approach is taken, countries will need to identify aspirational yet achievable targets for their own circumstances. To identify feasible targets and development pathways, different models will need to be developed. Scenarios should be based on assessments of available water resources, investment levels, investment choices, national priorities and policy options, including the water-related requirements of achieving the other SDGs, such as food security. The science community should support national governments with data, decision-support tools and scenarios.

2. Achieving Water and Food Security–related SDGs

Making the right investment choices should be based on the latest research insights considering efficiency, equity and sustainability. These are not always unambiguous choices and will require balancing the needs of different sectors, user groups and ecosystems.

3. Measuring and Tracking Progress

Clear and measurable indicators, linked to monitoring mechanisms, will be the key to successful implementation of SDGs. However, the usefulness and relevance of any indicators will be as important as the ease of measurement. The stated aim of the SDGs to be more integrated and sustainable than previous goals will add to the complexity. (See sections 4 and 8.)

It is proposed that indicators will track progress on more efficient water use in agriculture, sustainable use of water (withdrawal-to-availability ratio), storage capacity, access to irrigation, water quality, (aquatic) ecosystems services, impacts of water-related disasters and water governance. In the Water Metrics section, the proposed indicator "water use efficiency" has been explored rather than other indicators. (See sections 4, 6, 7 and 8.)

Innovative thinking and applying new technologies are essential. The data revolution has transformed international goal setting. Cost-effective ways of providing data through new developments in remote sensing and mobile technologies need to be further explored, as do enhanced methods for governments and their citizens to directly gather valid information from the field. (See sections 4, 7 and 8.)

2 Water–Food–Energy Nexus

2 Water–Food–Energy Nexus

Lead author: Jeremy Bird
With contributions from: Felix Dodds (Global Research Institute), Peter McCornick, Tushaar Shah

WATER, FOOD, ENERGY: NEXUS SOLUTIONS

The availability of water is central to the future security of food, energy, domestic and industrial water supply and the environment. This relationship is the 'nexus' between a set of competing demands and interactions. Producing more food and energy, and having sufficient water for our fast growing population—projected to reach 9.5 billion by 2050—means managing water, food and energy differently.

The proposed SDGs on water, food and energy security all include targets on increasing efficiencies. Yet the water–food–energy nexus has multiple dimensions that, if managed in isolation, will compromise a nation's ability to achieve the full portfolio of SDGs.

Climate change introduces additional uncertainties, further increasing tensions between sectors for access to water. Conventional energy and food production are emitters of greenhouse gases, but measures to reduce emissions—including renewable energy interventions, such as subsidies for biofuel production—can have adverse consequences on food prices.

Irrigation plays a central role in the nexus where improvements in one sector may involve trade-offs in another.

To achieve desirable and sustainable outcomes for water, food and energy requires investigating these elements as an integrated whole, across sectors and scales. The nexus approach is part of broader systems thinking; it features a pragmatic focus on the relatively limited number of policy choices that are constrained by political realities. This approach recognizes and minimizes trade-offs, builds synergies and increases resource use efficiencies.

REFLECTING MULTIPLE DIMENSIONS AND SCALES

A nexus approach means that when governments and industries determine policies in one sector—whether it is energy, agriculture or water—they take into account the implications in other sectors. Similarly, policy and planning processes within each sector would account for different scales, from local to transnational.

Nexus Interventions at Policy Level

In the food production chain, for example, irrigation plays a central role in the nexus where improvements in one sector may involve trade-offs in another. Introducing irrigation increases land productivity, but pumping water increases energy demand compared to rain-fed agriculture.

Groundwater irrigation is a classic nexus case. Underground water is extracted for agriculture production worldwide using millions of electric and diesel pumps that can compromise water availability in conventional shallow wells used for drinking and domestic purposes. Two contrasting cases from India, one of over-abstraction and the other of underuse, demonstrate the scope for solutions across sectors. In both cases, the advent of lower cost, more efficient solar pumps is adding new potential to groundwater irrigation.

CASE STUDY: Innovative Electricity Scheme Reduces Power Subsidy and Groundwater Use and Boosts Agricultural Production

Gujarat is one of India's driest states, and during the 1980s the government encouraged groundwater irrigation by subsidizing farm electricity supply. A common power line served all domestic, agricultural and commercial connections. During the peak irrigation season, theft of power by farmers was rampant, causing reduced voltage for homes, schools, businesses and hospitals. By the 1990s, groundwater supplies were heavily depleted, the state electricity board was nearly bankrupt and powerful agricultural lobbies resisted a metered electricity tariff. The removal of electricity subsidies, a policy intervention frequently promoted by development agencies, was politically untenable.

With involvement of IWMI researchers, the state government implemented a new policy in 2003 under a scheme called Jyotigram Yojana, or 'lighted village'. Electricity lines for agricultural and non-agricultural users were separated, allowing electricity supplies to farms to be rationed for eight hours a day while enabling continuous supply to domestic and industrial users. To overcome farmer resistance, researchers suggested supplying full voltage and uninterrupted power to farms during the rationed hours. Farmers could then keep to their irrigation schedules, conserve water, save on pump maintenance costs, use labour more efficiently and expand their irrigated agriculture rapidly.

Gujarat's agricultural GDP rose by almost 10%, the highest in India, in the seven years following the project's inception, due in part to Jyotigram Yojana. At the same time, groundwater levels are recovering. Now the national government is setting Gujarat's Jyotigram Yojana project as a flagship scheme to address burgeoning electricity demand, unsustainable water use and increasing demand for food.

CASE STUDY: Reformed Groundwater Policy Improves Smallholder Farm Production

In India, pumping groundwater aquifers for agriculture is growing at an astonishing rate. The country has an estimated 20 million tube wells, and a new one is dug every 15 seconds. Yet, in the Ganges Basin of eastern India where water is plentiful, groundwater is still under-used. In West Bengal, in the Ganges Basin, tanks and ponds are often dry by January, leaving little surface water available for crops until the June monsoon rain. Yet access to the plentiful groundwater that is recharged annually is often limited.

In 2004, the West Bengal State Government legislated for farmers to apply for permits to use tube well pumps, with a view to sustainable groundwater use. However, applying for an abstraction permit and getting an electricity connection was costly and time consuming. As a result, poor farmers were forced to hire expensive diesel pumps for irrigation. Agricultural growth in the state slumped from 6% per year in the 1990s to just under 2%.

IWMI researchers analyzed the economics of smallholdings, farmer behavior and the costs and benefits of the various options for providing groundwater to small farms. Based on IWMI's advice in September 2011, the state government scrapped small pump licenses in districts with renewable and safe groundwater resources and introduced a flat connection fee.

This policy reform is improving smallholder farmer access to water. IWMI is now researching the effects the new policy has had on the power sector and on groundwater levels.

TAKING A RIVER BASIN APPROACH TO MANAGING WATER ACROSS NATIONAL BOUNDARIES

At the transnational scale, the growing pressure on water resources in many river basins is complicating the trade-offs between upstream and downstream uses. The rising cost of fuel and the effects of climate change are putting a complex array of pressures on water and food systems. Increasing the use of renewable sources to generate energy—such as water for hydropower and biomass for bioenergy—can have positive economic and mitigation benefits. But it can also negatively affect already stressed water and food supplies, especially where nations share natural resources. Innovative solutions to resolve hydropower and irrigation conflicts though the underground storage of water are being explored in Central Asia.

> **CASE STUDY: Pilot Study on Underground 'Water Banking' in Central Asia's Fergana Valley**
>
> The Fergana valley basin spans Kyrgyzstan, Uzbekistan and Tajikistan and has long been the population and agricultural heartland of Central Asia. It forms part of the catchment of the Syr Darya River—the longest river in Central Asia—that runs through all three countries.
>
> The natural flow of the river is high in summer and low in winter. However, upstream–downstream issues emerged in the 1960s when irrigation water withdrawals more than doubled in the basin and reservoirs were constructed to regulate and divert the flow. The biggest change was in the winter of 1992–93, when an upstream reservoir shifted from providing summer irrigation water to generating hydropower to satisfy increased demands for power, particularly in the winter.
>
> Hydropower production in the upstream increased by 30%, but cotton yields downstream plummeted by 46%, and some of the land was taken out of production due to shortages of irrigation water and increasing salinity.
>
> IWMI researchers conducted pilot field experiments in Uzbekistan's Fergana Valley to 'bank' the winter flows released for hydropower from upstream Kyrgyzstan into underground aquifers and then extract the stored water for irrigation in the summer months. Depending on the hydrogeological conditions, developing such groundwater management strategies can be a feasible practice for dealing with competing sector demands for energy and food.

An important nexus dimension is the choice of energy generation technologies in response to climate emission targets, as this can impact both water demand and food production.

INTRODUCING NEXUS THINKING IN ACHIEVING THE SDGS

Nexus thinking is useful for setting SDG targets and implementing programs that span a number of SDGs, for example, programs that:

- ensure access to energy for all and year-round access to food for all while ensuring sustainable levels of freshwater abstraction and integrating biodiversity conservation measures, including for wetlands
- double the share of renewable energy while ensuring food security
- improve water quality while sustaining economic growth and encouraging industrial development.

The proposed SDGs target for efficiency of water and energy are clearly interlinked: savings in energy generation can result in water savings and reduction in greenhouse gases. An important nexus dimension for countries is the choice of energy generation technologies in response to climate emission targets, as this can impact both water demand and food production, as in the case of increased biofuel production.

Expected targets to improve wastewater management and increase recycling and reuse can lead to other nexus benefits, such as reduced energy required to produce and transport chemical fertilizers and the recovery of nutrients that would otherwise be dumped.

In the next phase of the SDG process, the focus will be on selecting indicators and setting national targets. Programs to achieve the SDGs will be developed and implemented. Selecting appropriate indicators to measure nexus-friendly goals for energy, agriculture and industry sectors could encourage more integrated and effective outcomes.

3 Water Governance: Context is Crucial

Water Governance: Context is Crucial

Lead author: Tushaar Shah
With contributions from: Claudia Sadoff (World Bank), Peter McCornick, François Molle, Madar Samad, Diana Suhardiman, Barbara van Koppen

We face daunting water management challenges as demand for water hits the limits of supply and competition increases between agriculture, industry, urban needs and the environment. Climate change is an additional factor impacting water availability.

To be effective, water governance needs to directly identify and respond to local problems and needs. Such governance needs to take into account the local institutions, knowledge, socioeconomic, political and environmental conditions in the setting of targets and indicators.

Water governance needs to evolve over time, involve people and be cross-sectoral in its approach. Off-the-shelf solutions—whether technical, institutional or all encompassing, such as Integrated Water Resource Management (IWRM)—need to be critically evaluated according to the specific context.

To be effective, water governance needs to directly identify and respond to local problems and needs.

The proposed SDG on water recognizes the need for improved governance of water resources through a target on integrated water resource management and improved water management across national boundaries. We assume here that good governance of natural resources, including environmental sustainability (not explicitly mentioned in the SDGs), is accepted to be a cornerstone of sustainable development, with integrated water resources management providing a more tangible target.

WATER GOVERNANCE AND INTEGRATED WATER RESOURCES MANAGEMENT

According to the Global Water Partnership, water governance refers to "the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society." Water governance is also concerned with rule-making and enforcement, the political economy and cross-sectoral linkages. It is not something that the state decrees; rather, it is an ongoing process shaped by the inner workings of society.

Internationally, great store has been placed on implementing IWRM as a means to improve water governance, and it is now a proposed SDG target. IWRM's philosophy is about society-wide participation in managing water as a scarce resource, along with other natural resources, to equitably improve livelihoods and protect ecosystems.

Integrated Water Resource Management

Principles: Integration, decentralization, participation, economic and financial stability, basin as unit for decision making

Practices as packaged: Overall water policy and law, water rights, water licensing, permits and pricing, water allocation, participation in decision making, restructuring territorial into basin organizations

The IWRM principles provide a good overall framework for managing water resources. However, in applying these principles it is crucial to be flexible and to consider the local context. For example, reaching consensus from differing views can help solve local problems where local people are engaged in managing their scarce resources, but sometimes participation in decision making is not necessary for achieving viable solutions, as shown in China.

CASE STUDY: Top-down Approach in China Improves Rice and Water Productivity

In China's Hubei Province, a top-down approach has been remarkably successful in improving water management by rice farmers. Faced with the growing demand for water caused by rapid urbanization, officials simply allocated more water to cities, forcing farmers to respond by building their own ponds to capture runoff and reducing the overall amount of water they used for irrigation. Rice productivity increased and water productivity skyrocketed. This hierarchical approach is incompatible with IWRM's principle of inclusive decision making.

Implementation of IWRM as a prescription for poor water governance and management has been largely donor-driven, with limited adjustment to on-ground realities. The implementation of IWRM needs to be country-specific and pragmatic.

CONSIDER THE COUNTRY'S LEVEL OF ECONOMIC DEVELOPMENT

Understanding the physical, social and political context is critical. For example, the level of economic modernization of a society is a critical consideration (see Table 1). Rich countries have highly formal water industries that function within a robust and relatively well-resourced regulatory framework, while poor countries have highly informal water economies that are hard to regulate and govern.

Most water users in a highly formal water economy are secondary users, connected with the water governance regime through organized service-providing primary users amenable to regulation. Those in a predominantly informal water economy are mostly primary users, drawing water directly from nature to meet their personal and productive water requirements. Implementing formal approaches to water management through laws and higher level institutions will not work without a basic level of infrastructure and service provision being in place.

The intent of externally driven IWRM discourses is often to transform, all at once, a predominantly informal water economy into a predominantly formal one as a route to improving water governance. But evidence across the world suggests that there is no shortcut for a poor society to morph its informal water economy into a formal one; this process is organically tied to wider processes of economic growth. When countries try to force the pace of formalization, interventions fail. Interventions are more likely to work if they aim to improve the working of an informal water economy.

TABLE 1. **Evolution from informal to formal water economics**

	STAGE 1 – Fully informal	**STAGE 2 – Largely informal**	**STAGE 3 – Rapidly formalizing**	**STAGE 4 – Fully formal water industry**
Example	Congo, Afghanistan, Lao PDR	Gujarat, Bangladesh	Turkey, Mexico, South Africa	Sweden, Canada, Australia
Dominant mode of water service provision	Self-provision	Public and self-provision	Public provision with self-supply declining	Modern water industry with zero self-supply
Rural population as a % of total	80–90	50–80	20–50	5–10
Agricultural water use as a % of total managed water	>90	80–90	70–90	60–70
% of total water use self-supplied	>90	70–90	20–70	0–20
Water management capacities	+	++	+++	+++++
Utilities' cost to serve water	+	++	++++	+++++
Institutional arrangements in water sector	Informal self-help and mutual help; community institutions dominate	Informal exchange institutes dominate; water markets coexist with community institutions	Organized service providers crowd out mutual help and community institutions	Modern water industry; community institutions and self-help declined
Priorities of water governance	Infrastructure creation and operation in welfare mode	Improve service management without cost recovery	Improve infrastructure and service management with cost recovery	Integrated management of water service, infrastructure and resource with full cost recovery

Source: Shah 2014

UNDERSTAND FACTORS THAT HELP OR HINDER

Specifics of each country determine what is possible to do and what is not. For example, the approach to groundwater governance in any society is contingent on a variety of internal and external factors that policy makers and implementers cannot ignore. Strong local authority structures enable China, for example, to experiment with pilot administrative procedures in a way that Pakistan, which has no such village governance structures, would find hard to emulate.

Table 2 offers a list of factors that influence the way different countries respond to groundwater overexploitation. Countries where public systems actively manage the groundwater economy by proactively intervening through demand- as well as supply-side initiatives tend to have most or all of the enabling factors present.

Where many or all of the hindering factors dominate, groundwater governance tends to be absent, primitive, perverse or dependent on indirect instruments, which achieve a socially desired outcome without forcing individuals to change their behaviors. These contextual realities help explain why different countries choose different policy instruments to govern their groundwater economies.

TABLE 2. **Factors influencing groundwater governance regimes**

	HINDERING FACTORS	HELPING FACTORS
National and local authority structures	Weak	Strong (China, Vietnam)
Organization of the groundwater economy	Numerous small users	Few large users
Proportion of the population dependent on farming	High	Very small
Groundwater's significance to national food and livelihoods security	High	Low (USA, Mexico, Spain)
Capacity, reach, and effectiveness of water bureaucracy	Low (South Asia)	High (China, Mexico)
Perverse incentives in groundwater irrigation (energy and tube well subsidies)	Present (India, Iran, Syria, Mexico)	Absent (China, Pakistan, USA, Australia)
Productivity of groundwater irrigation	Low (South Asia)	High (China, Mexico, USA [California], Spain)

Source: Shah 2014

There is no shortcut for a poor society to morph its informal water economy into a formal one.

LOOKING OUTSIDE THE WATER SECTOR

Water issues can be caused by perverse policies in other sectors, such as energy subsidies. To succeed, a water governance regime needs to take a cross-sectoral integral approach to managing water resources. It is often assumed that water problems can be resolved by integrating policies and institutions within the water sector alone, ignoring, for example, the integration of water and land rights or associated energy issues (see section 2).

It is important to focus on the actual water problems within a country and the national priorities. Emphasizing the development of IWRM plans has sometimes imposed governance reform at the cost of investigating real water needs. For example, efforts to implement IWRM in sub-Saharan Africa have failed to recognize that most of African agriculture is based on informal water rights. This will likely reduce the responsiveness of African farmers to improved water use measures rather than improve the situation. Finding pragmatic solutions to water management problems is more important than following specific principles.

Even within one country, there will be different needs in different regions. For example, India is the biggest user of groundwater in the world, but groundwater management varies across the country. Some drier areas urgently need to regulate groundwater use to make it more sustainable (see section 2, Gujarat case study, p. 11); other wetter areas could help poor farmers boost incomes through improved groundwater access.

EXPLORING COUNTRY-SPECIFIC TARGETS AND INDICATORS

Meaningful indicators, country-level targets and preferably also country-specific indicators next to global indicators will be important to stimulate and measure progress (see section 4). The choice of indicators will be crucial to avoiding rigid implementation. The danger with indicators is that boxes can be ticked off (e.g., displacement plans for dam development in place, national IWRM plans in place) without the situation improving. It will be important to find pragmatic ways to assess if progress is being made, that plans relevant to the local context are being implemented and the interventions are being sustained.

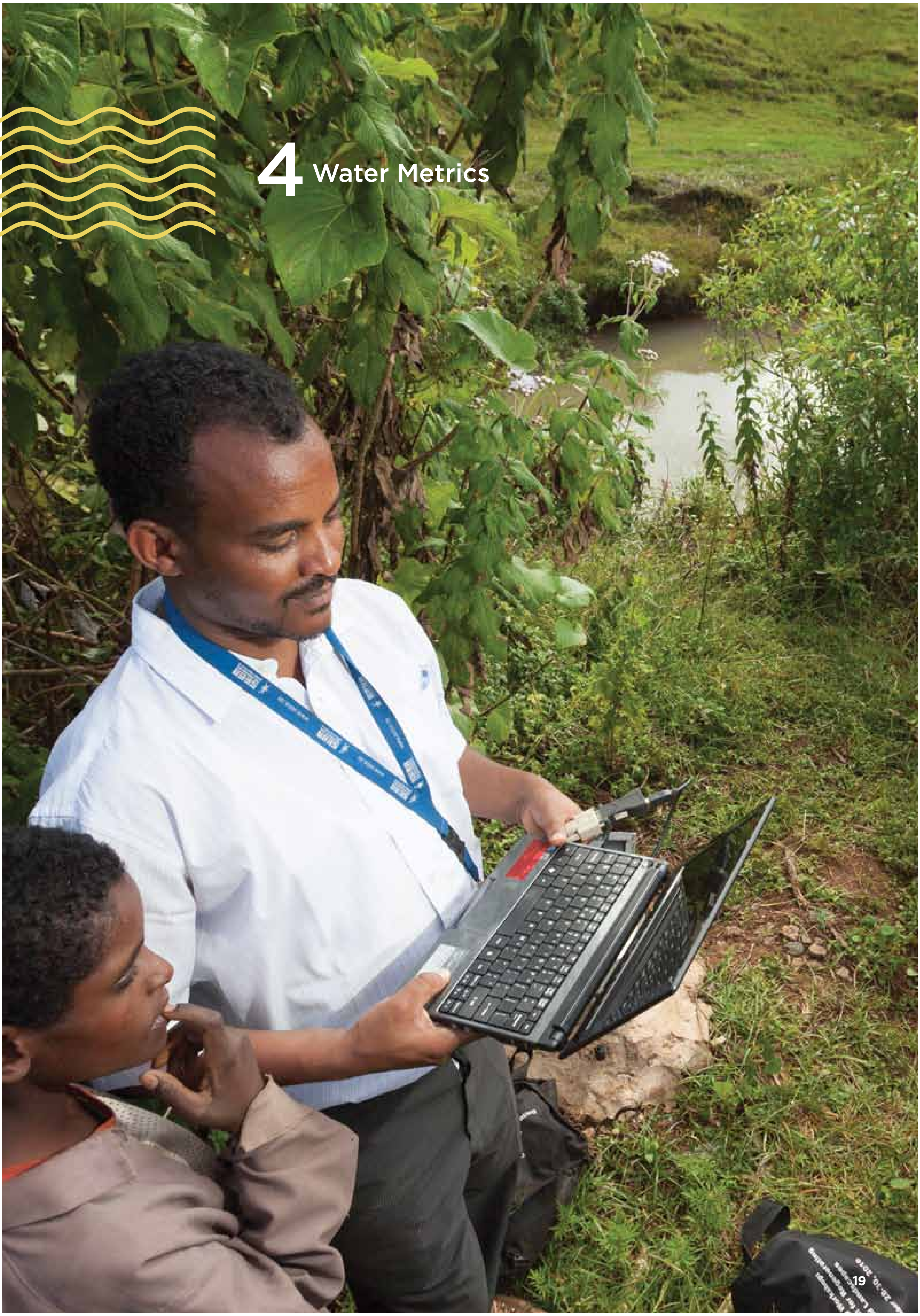
Given that water governance is tied to the overall socioeconomic evolution of a country, prescribing a single set of water governance targets for SDGs will not work. A more meaningful approach will prescribe different targets for countries at different stages of economic development, as outlined in Table 3. Even within a single country the context, as indicated by the four stages, varies from one setting to another.

TABLE 3. **Recommended SDG targets for countries at different stages of economic development**

SDG targets	STAGE 1 – Fully informal	STAGE 2 – Largely informal	STAGE 3 – Rapidly formalizing	STAGE 4 – Fully formal water industry
TARGET 1 Investment	Invest in local infrastructure to improve water access	Invest in meso-level infrastructure for sustainable development of water resources	Invest in improving water productivity and waste recycling	Invest in 100% coverage in high water quality water service provision
TARGET 2 Institutional	Make informal water institutions equitable	Integrate informal water institutions with formal ones in private or public sector	Create meso-level participatory water institutions	Create a full-fledged water industry with proactive regulator
TARGET 3 Policy and legal regime	Establish basic water information system	Establish water policy and legal regime	Establish basin-level water allocation mechanism	Full-fledged basin management authorities
TARGET 4 Financial sustainability	Establish the principle of water as a social and economic good	Provide a subsidy on operational and maintenance costs to 50%	Apply a 75% service fee for recovery of operational and maintenance costs of water infrastructure	Apply 100% water service as well as resource fee for management, operations and maintenance costs

Source: *Shah 2014*

4 Water Metrics



4 Water Metrics

Lead author: Lisa-Maria Rebelo, Jean-Marc Faurès (FAO), Poolad Karimi (UNESCO-IHE), Wim Bastiaanssen (UNESCO-IHE Institute for Water Education)
With contributions from: Meredith Giordano, Vladimir Smakhtin, Peter McCornick

SETTING, MEASURING AND MANAGING SUSTAINABLE DEVELOPMENT WATER TARGETS

Society has a universal need for water that crosses all sectors of activity. We need to be able to measure progress towards sustainable water for all by working towards targets that consider the different dimensions of water resources and use, including water quantity and quality.

A suite of indicators that reflect water use by different sectors is needed to measure progress towards the forthcoming SDGs' water-related targets. Such indicators will need to rely on national data, must consider the variation in data availability and can be complemented with new cost-effective ways for data collection.

Remote sensing measurements, smart field sensors, ICT technologies and open access databases create new opportunities to more accurately, cost-effectively and transparently quantify water resources. However, the usefulness and relevance of any indicators will be as important as the ease of measurement.

The challenge in progressing towards the water-related targets is to ensure that a balance is achieved between the competing uses of water, meeting human needs while maintaining ecosystem health.

SUITE OF INDICATORS NEEDED TO MONITOR PROGRESS

Indicators are needed at the national scale to allow comparisons between countries, to monitor progress and to aggregate at the global scale. The use of specific indicators, such as water use efficiency or water productivity, can mask the complexity and trade-offs required to achieve the respective development outcomes. It is not feasible to express the use of water in complex river basins with just a handful of indicators.

A suite of indicators, rather than a single indicator such as water productivity, should be used for monitoring the progress towards the water SDG for *all* users, while also maintaining healthy ecosystems. These need to be designed to reflect the variety of water situations within a country.

MAKING MORE EFFICIENT USE OF WATER—IMPROVING WATER PRODUCTIVITY

Improving water-use efficiency across all sectors is proposed as a global target, reflecting current and likely future constraints on our water resources.

Water Use Efficiency vs. Water Productivity: Water use efficiency (WUE) is used primarily by agronomists and breeders and depicts the output/unit of transpiration or evapotranspiration at the field scale (kg/m^3). In the SDGs, WUE is also promoted as a goal for other sectors. Water productivity (WP) evolved from WUE and measures how systems convert water into goods, services or nutrition, in other words, production (in physical quantity or economic value)/water used. WP offers a broader concept and opportunities for analysis at larger scales.

Agricultural Water Productivity: Agriculture is the number one user of water (70–90%). The world relies on irrigation, with 20% of the land producing 40% of the food. Agricultural water productivity is the ratio of the net benefits from crop, livestock and mixed agricultural systems to the amount of water used to produce those benefits. The objective is to produce more food, income, livelihood and ecological benefits at less social and environmental cost per unit of product or service. The denominator of the water productivity equation is expressed in terms of either water supply or water depletion. Water is depleted when it is evaporated, incorporated into a product, flows to a location where it cannot be readily reused or becomes heavily polluted. Globally, the amount of water needed to produce goods and services from agriculture directly depends on gains in water productivity: the higher the productivity, the less pressure on the resources and the ecosystems.

In conditions of water scarcity, and in particular when all the water in a river basin is allocated to different users, any change in water use will result in winners and losers. Increasing agricultural water productivity in upstream reaches of river basins through better rainfall capture and more check dams reduces downstream flows supporting other farmers, fishers, household users and wetlands. Producing more food often means putting more water into irrigation and taking it out of other uses. Water productivity analysis at a basin scale can highlight these trade-offs to help decision makers develop strategies where the benefits exceed the costs and where both are clearly assessed and quantified.

Achieving water productivity is further complicated by factors outside the water sector, such as changing prices for agricultural commodities, increasing demand for biofuels, urbanization and changing diets with rising incomes. Policies influencing such factors will also influence water use and thereby influence the scope for gains in water productivity.

Good water accounting is needed to identify the major water-related processes and understand better which water resources are available and exploitable for a river basin and its tributaries.

NEW WATER ACCOUNTING TOOLS—OPPORTUNITIES FOR BASIN-SCALE MONITORING

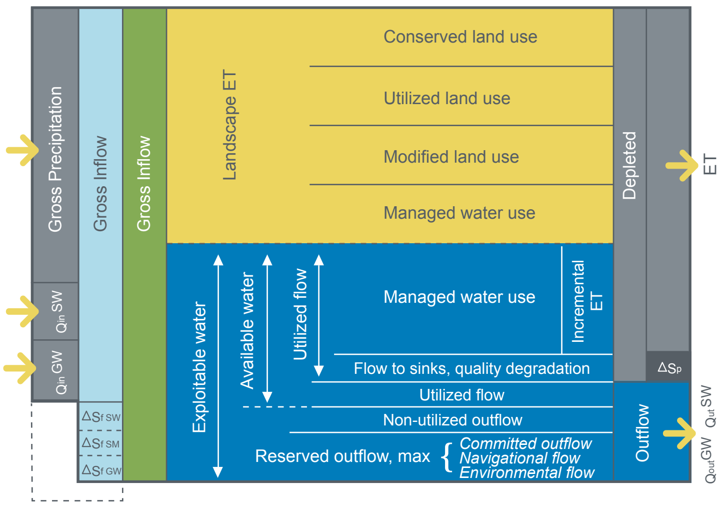
Water productivity is an indicator of the efficient use of water; *water accounting* is a monitoring tool. We pay specific attention here to water accounting and productivity, as recent science has contributed to new opportunities to make use of these concepts in the context of the SDGs.

Good water accounting is needed to identify the major water-related processes and understand better which water resources are available and exploitable for a river basin and its tributaries. Water accounting is a water resources assessment report given at regular time intervals (months, seasons, years). It is a framework, rather than a number of indicators, and provides a more balanced view of water supply and demand and groundwater conditions. Quantified water accounts can be used to set management targets and subsequently monitor these targets. Examples of water accounting frameworks are the System for Environmental-Economic Accounting for Water, the IWMI's Water Accounting (WA) and Water Accounting Plus (WA+) and the Water accounting and auditing guidelines of the Food and Agriculture Organization (FAO); these provide principles and approaches to assist water institutions with implementing and increasing the effectiveness of investments.

New Insights in Water Accounting

Several organizations, including FAO, United Nations Educational, Scientific and Cultural Organization - Institute for Water Education (UNESCO-IHE) and IWMI are working towards better and more effective monitoring of water. Water Accounting Plus (WA+), developed by IWMI and partners, explores the wealth of global open access data and the development of an international standard to express complex water management issues. WA+ uses satellite-derived estimates of land use, rainfall, evaporation, transpiration, interception, water levels of open water bodies, biomass production, crop yield and measured basin outflow to produce a low-cost and reliable water account. These data are supplemented with the outputs of global hydrological models that provide access to explicit data on surface water networks and aquifers. These data inputs allow calculation of explicit water flows by different land use types, water consumption by the natural landscape and net water withdrawal processes in complex river basins. A data repository (www.wateraccounting.org) is being developed that presents the data in different sheets, allowing easy and quick access to particular topics, such as agricultural production, ecosystem services, useable flows and groundwater depletion. A complex river basin is thus expressed in simple sheets that policy makers, lawyers, economists, agronomists and environmentalists understand. Remote sensing data, FAO's AQUASTAT data and GlobWat model provide input to the WA+ sheets.

FIGURE 1. **Schematic presentation of the resource base sheet (Water Accounting+)**



Source: *Karimi, Poolad; Bastiaanssen, W. G. M.; Molden, D. 2013. Water accounting plus (WA+) – a water accounting procedure for complex river basins based on satellite measurements. Hydrology and Earth System Sciences, 17(7):2459-2472*

Specific indicators, such as water use efficiency or water productivity, can mask the complexity and trade-offs required to achieve development outcomes.

NEW METHODS AND TECHNOLOGIES

Any effort towards establishing water-related targets as part of the SDG process will require substantial efforts to establish a monitoring capability that can provide quality, policy-relevant information. Today, water monitoring is well below the levels needed to measure progress. Many countries have let their water monitoring networks decline for decades due to underfunding and low priorities. There are only scattered examples of water quality monitoring, and few countries have adopted sound and conceptually valid water accounting mechanisms. The global synthesis of water data performed by FAO's AQUASTAT information system will continue to operate, but it relies mostly on countries that can only offer scattered, incomplete or outdated information. Radical changes are needed alongside increased funding to improve spatial and temporal coverage of existing datasets and incorporate data requirements of new indicators.

At the same time, it is now possible to take advantage of the low-cost opportunities to tap into the vast quantities of data collected through remote sensing and near sensing and to collect and disseminate data through mobile technologies. Satellites measure the actual land surface conditions with very advanced instruments, and the accuracies attainable are frequently of similar quality as those of a routine handheld device or buried sensor in the soil. Moreover, the data are available to everyone. Such solutions will help to cost-effectively develop baselines, strengthen national reporting systems and monitor progress towards achieving the SDGs. For example, remote sensing data from the last 30 years can be used to thoroughly study changes in water, land and ecosystems. Advances in technology have helped experts use satellites to measure crop water consumption, crop production and soil water status and water levels in reservoirs.

One of the main challenges in developing these new sources of information will be to ensure their ownership and full integration within the national water monitoring and reporting mechanisms.

5 Social Inclusion

5

Social Inclusion

Lead authors: Nicoline de Haan, Fraser Sugden
With contributions from: Barbara Schreiner (Pegasys Institute), Barbara van Koppen, Everisto Mapedza, Jayne Curnow, Sonali Senaratna Sellamuttu, Floriane Clement

INCLUDING WOMEN AND THE POOR IN WATER MANAGEMENT SYSTEMS

Providing everyone with access to water—whether male, female, wealthy or poor—is vital to achieving the SDGs on health, livelihoods and economic growth. This is especially important in rural and urban fringe areas. Once such people have water access, they need to be able to manage the benefits for both domestic and productive use.

Countries need to implement economic and social policies at a national scale that include, protect and promote the specific needs and livelihoods of women and minority groups. Water technologies and programs will increase access to water for sustainable productive use, and change to societal structures can eliminate discrimination and increase access to water. Governments, development agencies and the private sector may assume their interventions are gender- or class-neutral, but in fact they can widen the gender gap.

A series of strategic solutions and policies need to promote social inclusion to achieve the SDGs:

1. Train policy makers, water planners and those in water organizations to actively understand and consider women's and poor farmers' needs for water

2. Train and build the capacity of women and marginalized socioeconomic groups so that they have more active decision-making and leadership roles in water management systems, at both the household and community levels

3. Develop specific technologies and inclusive institutions and policies so women and poor farmers can participate in water use and management systems in the context of prevailing gender norms and local realities

4. Improve women's access and rights to water, through informal channels (e.g. strengthening women-owned and -operated management committees for water resources) and legal mechanisms (e.g. advocating for equal rights of women to land ownership).

DESIGN AND IMPLEMENT GENDER-INCLUSIVE POLICIES TO BOOST PRODUCTIVITY

It is well recognized that women need access to water for reliable and safe domestic use (drinking, childcare, cooking, cleaning and washing). However, it is important to move beyond the stereotype that women's water needs are limited to domestic uses, especially if water management is to contribute to achieving SDGs.

Proactively including women in water management decisions and supporting female farmers increases agricultural productivity. It also helps reduce gender-based discrimination and provides opportunities for women to gain confidence and control over their lives, which enhances their general productive potential.

Our research shows that:

- agricultural production increases when both male and female producers directly control production factors—labor, land, water, irrigation technologies, inputs, credits and markets—and reap the benefits of their efforts
- women are as efficient agricultural irrigators as men, provided women have equal access to resources and human capital
- water management projects can completely fail if women are not included
- alternative income opportunities reduce the vulnerability of women to exploitation
- women can contribute to more sustainable agriculture by integrating their knowledge and experiences on resource management and agriculture.

TARGET THE INDIVIDUALS AND THEIR NEEDS IN WATER MANAGEMENT SYSTEMS

Governments and water agencies need to know who the farm decision makers are and what they need to improve their livelihoods and wellbeing. Only then can governments ensure buy-in of the end users and of women in particular, who are ultimately the keys to success of the interventions.

Water management interventions typically target a region or a community, rather than a household or an individual in a household. If they do, there is a tendency to target men, who are often not from the poorest households. Water managers, planners and policy makers—and often technical staff, such as hydrologists and engineers—see their interventions as gender neutral or class neutral.

However, the number of households where women are the main decision makers on agriculture water issues can be considerable and is increasing, due to out-migration of men and/or the AIDS epidemic (e.g., in areas of southern African countries, the proportion of female-headed rural households and women-led farms may go up to 50–90%). As a result, women have new responsibilities for farming, including managing water for increased production. Yet gender or equity concerns are not considered an important element of planning and implementation.

The number of households where women are the main decision makers on agriculture water issues is increasing.

It cannot, however, be assumed that women want and should play a more important role in managing productive water use. It may increase women's work burden, so governments, communities and development agencies need to develop policies reflecting these considerations.

Practical Solutions for Targeting and Including Individuals

- Assess the needs, constraints and values of men and women farmers from different socio-economic groups prior to designing or recommending interventions.
- Increase consultation with the men and women affected by water management, especially those most marginalized but likely to benefit.
- Recruit more female workers and social and technical experts in public irrigation agencies.
- Provide targeted training on inclusivity and gender mainstreaming for members of irrigation bureaucracies.
- Develop closer links and capacity of water managers to react to the changing dynamics and demands for water in agriculture and gender roles.

CASE STUDY: Water discrimination against women

In Peru, female farmers had to irrigate at night, in spite of a rule that night turns should be equally distributed among irrigators. However, men were often more successful in negotiating day turns because they had better relations with the irrigators' committee.

In the Chhatis Mauja irrigation scheme in Nepal, IWMI researchers found that the male-dominated irrigation committee excluded women from the formal decision-making process over water use and therefore prevented their access to water. This led to women 'stealing' water and avoiding being involved in the committee which might further reduce their ability to access water.

In the Bauraha irrigation system in Nepal, female-headed households preferred the rotation system of distributing water compared with an on-demand system during periods of relative water scarcity, as the former required much less negotiation with the water guard.

ADDRESS THE STRUCTURAL CONSTRAINTS TO WATER ACCESS

Constraints to water access and control are often rooted in both institutional and social structures as well as political and legal issues about land water ownership and tenure arrangements such as norms, class, caste and cultural practices. Unequal land ownership or exploitative tenure arrangements are a primary reason why certain groups benefit more from public irrigation investments than others.

Social inclusion in water will require governments and policy makers to reform discriminatory institutional policies and practices through broader structural changes. Reforms will also need to take into account any informal rights that men and women have secured.

Governments and policy makers need to design water schemes for multiple uses and ensure that trade-offs do not further marginalize particular social groups.

Practical Solutions to Address Structural Constraints:

- Challenge economic and political systems that exclude or restrict women and poor farmers from fair and affordable access to water, both as a resource and as an infrastructure service, through better understanding and data on how the systems work. At the same time, ensure that reforms do not marginalize them further.
- Create incentives for civil servants in water planning so they actively include and address gender and inclusivity issues.
- Increase awareness and understanding of institutional and legal aspects to rights to water.
- Experiment in the collective management of land and water resources, where women and poor farmers can work together to achieve economies of scale.
- Involve women at a higher level within water bureaucracies and water management committees, beyond solely being members.
- Ensure that training and resources underpin any social-inclusion measures—the decision-making and management ability of women and the poor depends on their ability to assert themselves in often unfamiliar roles and settings.

INTEGRATE DOMESTIC AND PRODUCTIVE WATER USES

In the daily reality of poor rural communities, the same water source, whether called 'domestic' or 'productive' water, typically meets multiple needs. Both men and women need access to water for domestic use and income-generation.

Governments and policy makers need to design water schemes for multiple uses and ensure that trade-offs do not further marginalize particular social groups. For example, large-scale irrigation schemes or hydropower projects add to agricultural and energy production, but they can take water away from fisheries, which are often the domain of the poorest (often landless) socioeconomic groups and women.

Interventions can be designed to meet specific needs, or appropriate alternative livelihood options can be made available. For example, irrigation schemes that are well planned and designed for multiple uses save women and men time in collecting water for domestic use (bathing, washing and even sometimes drinking) and for livestock, fodder, fish and other income-generating activities.

FIGURE 2. **The domestic-plus water ladder**

SERVICE LEVEL	VOLUME *(Litres per capita per day)*	WATER NEEDS MET	DISTANCE OR TIME OF
High Level MUS	100-200	All domestic needs; combination of livestock, garden, trees and small enterprise	At homestead
Intermediate MUS	50-100	All domestic needs; livestock, garden, trees or small enterprise	< 150m or < 5min
Basic MUS	20-50	Most domestic needs; some livestock, small garden or trees	< 500m or < 15min
Basic domestic	5-20	Very few domestic needs, basic livestock	> 500m or > 15min

Source: *The multiple use services ladder - Renwick et al., 2007; van Koppen et al., 2009.*

Practical Solutions for Integrating Water Uses

- Identify irrigation technologies that are appropriate for women and poor farmers and that are efficient and provide a high return per land unit.
- Identify technologies and associated cropping patterns suitable for smallholdings.
- Ensure information and training reach both female and male farmers, for example, by targeting different forums with the same information and training or identifying socially acceptable places and times for women to gather for meetings.
- Identify multiple uses of water while planning irrigation or other large-scale water management projects to account for different needs. This may include activities in the domain of women and/or marginal socioeconomic groups, such as fishing or aquatic plant collection.
- Encourage public agencies responsible for different water uses (e.g., drinking water, irrigation, livestock) to institutionalize multiple-use water services to enhance the benefits and sustainability of these systems, for example, by widening up the subsidies and technical support of changing single-use water systems to meet multiple needs.
- Design appropriate technologies and water access arrangements that specifically address intersections between gender and poverty and that target women, marginal farmers and traditionally excluded groups.

6 Sustainable Development and Ecosystem Services

6 Sustainable Development and Ecosystem Services

Lead authors: Matthew McCartney, Max Finlayson (Institute for Land, Water and Society, Charles Sturt University), Sanjiv de Silva
With contributions from: Priyanie Amerasinghe and Vladimir Smakhtin

SUSTAINABLE DEVELOPMENT AND ECOSYSTEM SERVICES

The key to sustainable development is achieving a balance between the exploitation of natural resources for economic development and conserving ecosystem services that are critical to everyone's wellbeing and livelihoods. There is no blueprint for obtaining this balance but it is essential to understand how ecosystem services contribute to livelihoods and who benefits and who loses from changes arising from development interventions.

The SDGs proposed for water and sanitation and ecosystems have specific targets for restoring and maintaining ecosystems to provide water-related services. The targets explicitly mention the need to integrate ecosystem values into planning, development processes and strategies for reducing poverty.

ECOSYSTEM SERVICES– THE BENEFITS

Ecosystem services are the benefits people get from nature. Tangible benefits include those from the supply of food and freshwater, flood mitigation and improvement of water quality. Less tangible benefits include those from contributions to local cultures.

Ecosystems often provide 'bundles' of interlinked benefits. The way this occurs is complex and specific to the type of ecosystem. Many ecosystem services depend on water and are affected by changes in water flows. Though it is often difficult to put a monetary value on an ecosystem service (some are irreplaceable), economists are increasingly demonstrating the value of different services. In 2005, the Millennium Ecosystem Assessment (MEA 2005) found that about 70% of the 1.1 billion people surviving on less than USD 1 per day depended directly on natural ecosystems. Most of these people, especially those living in rural areas, are underserved by government institutions, which intensifies their dependence on nature for their basic human needs.

Nature also contributes to the resilience of communities, by being part of defenses against natural hazards and supplying food and water following a disaster.

DEGRADING ECOSYSTEMS—THE COSTS

Many ecosystem services are perceived as public goods, accruing outside monetary systems. Until recently, many went unrecognized in planning processes, and they continue to be undervalued. Consequently, ecosystems continue to degrade at an increasing rate.

Infrastructure built primarily to provide people with water for irrigation and domestic, commercial and industrial purposes is crucial for economic growth, for alleviating poverty and for attaining many of the proposed SDGs. However, this infrastructure—especially dams—has significant impacts on aquatic ecosystems and, by altering flows of water, sediment and nutrients, can weaken the ecosystem services on which poor communities depend.

STRIKING A BALANCE

Modifying ecosystems to facilitate socioeconomic development is necessary, but how can we avoid damaging important ecosystem services? The key challenge for sustainable development is to assess trade-offs and find a balance between socioeconomic development and sustaining the more important of the ecosystem services. As a prerequisite, we need to comprehensively understand how ecosystem services contribute to people's livelihoods and wellbeing. In considering ecosystem services, the intent is not to deny people opportunities and condemn them to a life of poverty; rather, it is to identify interventions that offer people possibilities and improve their livelihoods over the long term.

Management approaches must be inclusive, negotiated and flexible.

SHIFTING OUR THINKING—AN ECOSYSTEM APPROACH TO DEVELOPMENT

There is no blueprint for finding the balance between conservation and development but in every development situation it is essential to understand how ecosystem services contribute to people's livelihoods and who will benefit and who will lose if these services change.

The Millennium Ecosystem Assessment synthesis found that:

> [C]ross-sectoral and ecosystem-based approaches to wetland management—such as river (or lake or aquifer basin-scale management, and integrated coastal zone management—that consider trade-offs between different wetland ecosystem services are more likely to ensure sustainable development than many existing sectoral approaches and are critical in designing actions in support of the Millennium Development Goals.
>
> **Source:** *MEA 2005: iii*

This finding remains relevant for designing the SDGs.

By focusing more on ecosystem services, land-use planners can determine the values people place on different parts of the landscape. Currently, these values tend to go unrecognized by wider society, and a proposed land use change for development often has consequences for the poor that are not adequately compensated. The 'working wetland potential' concept is an example of an ecosystem approach to development.

CASE STUDY: Cultivation of Dambos in Southern Africa: Providing Sanctuaries from Drought

In southern Africa people have to cope with seasonal shortages of water every year. Water retained in dambos (seasonally saturated wetlands common throughout the region) is an important resource, both for domestic supply and agriculture. However, wet patches inter-mixed with dry areas mean working dambos in a uniform way is difficult and methods of large-scale farming are inappropriate. Attempts by European colonists in the first half of the twentieth century to produce uniform conditions within dambos resulted in soil erosion, environmental deterioration and eventually desiccation of many dambos, undermining their value not just for agriculture, but also for the other ecosystem services that they provide.

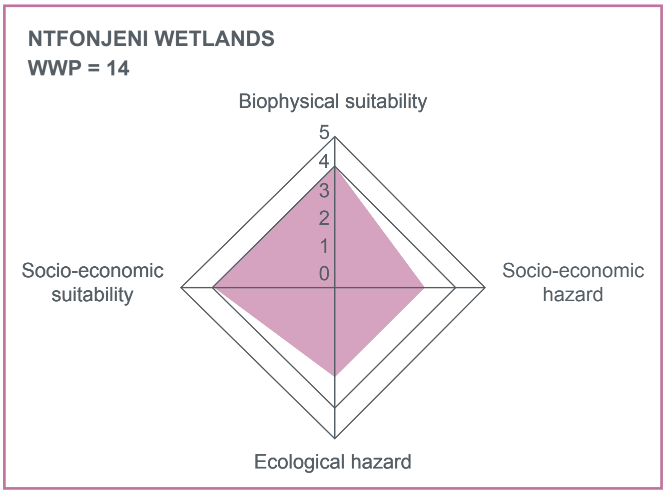
In contrast, at a small scale, farmers can use each part of the dambo in a different way, thereby reducing the risks of crop failure. The sustainable use of dambos requires flexibility in approach because the extent of moisture retention varies not just across each dambo but also from year to year, depending on the rainfall. Indigenous farming practices that combine dry upland farming with wetland cultivation have adapted to this variability. Across southern Africa many thousands of hectares of dambo are cultivated in small gardens, growing maize, rice and vegetables.

Evaluating Trade-offs in Wetland Agriculture—an Ecosystem Approach to Development

The working wetland potential (WWP) is a pragmatic approach for considering agriculture in the context of sustainable wetland development. It can be used to identify, organize and analyze the complex factors that link people, agriculture and wetlands. The approach seeks to add value to the benefits (i.e., ecosystem services) that the wetland provides, without undermining its biophysical or socioeconomic sustainability; that is, it supports the *wise use* of the wetland for agriculture, while preserving the essential elements of its ecology. The potential of proposed wetland development activities is considered in relation to the long-term use of the wetland.

The WWP approach is based on a multicriteria analysis that integrates the biophysical and socioeconomic aspects of wetland use in a single index to give an initial assessment of how suitable a wetland is for agriculture.

FIGURE 3. **Suitability for agriculture of Ntfonjeni Wetlands using working wetland potential framework**



Source: *McCartney et al. 2005*

New thinking is also needed in the construction of water infrastructure, as the resulting benefits are themselves dependent on ecosystem services. For example, the performance (i.e., yield, reliability, resilience and vulnerability) of a dam will be affected by the natural flow-regulating services in its catchment. Although their effectiveness has been questioned, schemes whereby local communities are paid to safeguard important ecosystem services are increasingly being promoted. For example, in Vietnam hydropower companies pay local communities to protect forests that, in theory, reduce sediment inputs to their reservoirs.

Also, development aimed at alleviating poverty is not simply a question of expanding the amount of built water infrastructure; we must take into account the role of ecosystems. One approach is to consider ecosystems as 'natural infrastructure' and, taking this concept further, consider how to design, plan and manage 'portfolios' of natural and built infrastructure to maximize the full suite of benefits. For example, reservoirs are not simply inert bodies of water but are also ecosystems that provide water for food, energy and—importantly—other ecosystem services.

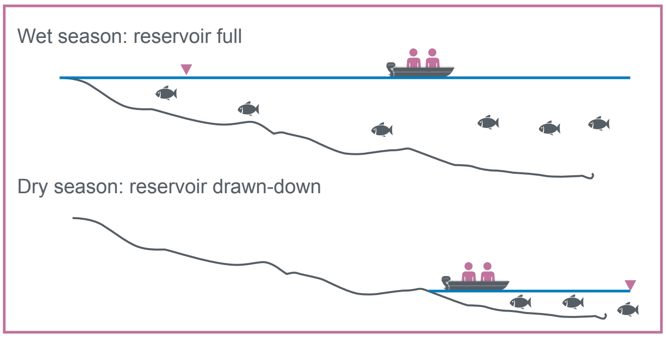
Enhancing Fisheries by Creating Wetlands on Reservoir Drawdown

Increased fish production is often promoted as a benefit of reservoirs created for hydropower, irrigation or water supply. But reservoir fisheries rarely live up to expectations or compensate for the loss of downstream fisheries.

An idea being tested in an IWMI study in Lao PDR is to increase fish production by building small wetlands on the drawdown zone of a reservoir, which is the area exposed during the dry season.

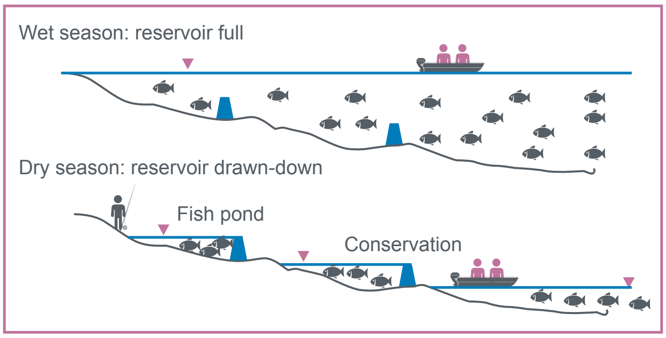
The premise is that when the water level drops, these wetlands will create more diverse habitat and provide refuges and breeding areas for fish, leading to greater fish production within the reservoir, reducing fishing effort and improving people's returns and livelihoods.

FIGURE 4. **Reservoir without wetlands**



Source: *IWMI 2014*

FIGURE 5. **Reservoir with created wetlands**



Source: *IWMI 2014*

The key challenge for sustainable development is to find a balance between socioeconomic development and ecosystem services.

We need to consider how to design, plan and manage 'portfolios' of natural and built infrastructure to maximize the full suite of benefits.

A FLEXIBLE APPROACH TO MANAGEMENT

To manage natural resources sustainably, we must be flexible and able to adapt as circumstances and conditions change. Formal adaptive management approaches are iterative decision-making processes for coping with high levels of uncertainty and are based on monitoring to inform management. The challenge lies in finding the balance between gaining knowledge to improve management in the future and achieving the best short-term outcome based on current knowledge.

Ultimately, people need to manage their own ecosystems in sustainable ways. This requires them to be able to self-regulate the different uses and respond to incentives, such as demonstrable incomes or clear livelihood benefits, to support sustainable management. To be sustainable in the long term, incentives should come from market opportunities (e.g. selling wetland products) rather than, for example, subsidies. Management approaches must be inclusive, negotiated and flexible, empowering local people to manage ecosystems in their own landscapes, to the benefit of both current and future generations.

Perceptions of ecosystem value are changing slowly, but if these services are to help achieve the SDGs, policy makers and other decision makers must rapidly address the direct and indirect drivers that threaten ecosystems. Due to the intricate web of relationships that sustain ecosystems and generate services, trade-offs involving these services are unlikely to be linear: the undermining of one characteristic or ecosystem service is likely to lead to the loss of many.

7 Managing Water Variability: Floods and Droughts

Managing Water Variability: Floods and Droughts

Lead author: Vladimir Smakhtin
With contributions from: Paul Pavelic, Giriraj Amarnath, Matthew McCartney, Bruce Campbell (CGIAR Research Program on Climate Change, Agriculture and Food Security [CCAFS])

If people are prepared, they are much more resilient to natural disasters. This means knowing the global hotspots and quantifying the risk of disasters.

Water variability manifests itself in floods and droughts whereby people die, crops are lost, livelihoods destroyed and economies damaged.

In many of the world's regions, the variability of water resources is projected to increase with climate change, increasing the risk of disasters and outstripping the capacity of societies to adapt.

The variability in water availability impacts the sustainability of development. The ongoing SDG discussions support the need for early warning and disaster risk reduction systems, adaptation to climate change, strengthened resilience, adequate facilities and infrastructure and appropriate policies.

The types of solutions for managing water variability are especially relevant to the SDGs of food security, water security, economic growth and action to address climate change.

COMMUNITY RESILIENCE NEEDED FOR INCREASING RISK OF FLOODS AND DROUGHTS

In wet tropical regions, more intense rainfall is likely to increase flood risk, and large floods will probably surpass historical events in size and/or frequency. In contrast, many mid-latitude arid and semi-arid regions are likely to receive less rainfall, with droughts becoming more spatially extensive and longer than those observed since 1900.

Floods and droughts are the most economically and socially destructive of all natural disasters (Figure 6), accounting for about 90% of people affected by all natural disasters, 95% of whom are in Asia. Global economic damage from natural disasters is close to USD 165 billion a year—more than all current aid flowing from developed to developing countries. By 2030, the damage from floods and droughts may exceed USD 450 billion, most of it from floods.

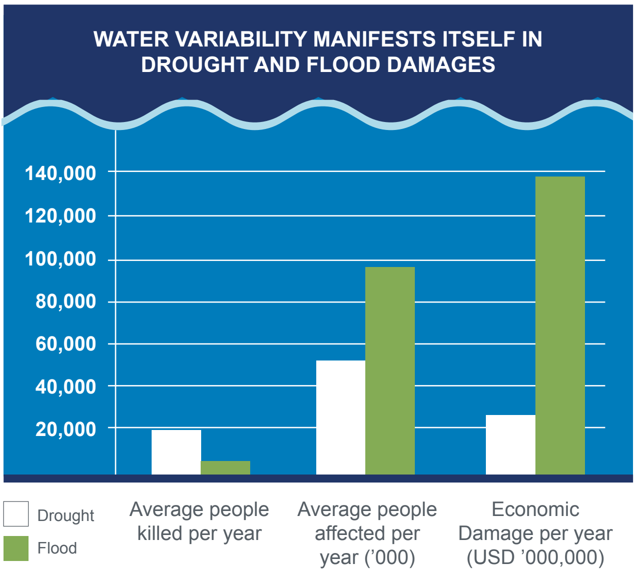
The evidence points towards an increase in the number of climate-related disasters, which is likely to outstrip the capacity of societies to adapt and exacerbate inequalities, with poor and vulnerable communities bearing a disproportionate share of the impact.

Increasing people's resilience to such disasters is important for achieving SDGs. If people are prepared and able to respond in a coordinated way, they are much more resilient to natural disasters. Part of this preparedness is knowing the global hotspots and quantifying the extent and risk of disasters.

To protect against floods and to provide for dry times, we need to manage variability by being creative about water storage; although, variability has positive effects too. For example, floods are good for fisheries and floodplain agriculture while droughts may kill pests. For rivers to be healthy, the timing, frequency and range of high and low flows are important. The management challenge is to alleviate negative aspects of variability while retaining those aspects that are essential for the health of ecosystems.

Most importantly, to reduce vulnerability and increase people's resilience to climatic shocks and stresses, we need to holistically manage floods and droughts at the basin scale.

FIGURE 6. **Floods and droughts are the most economically and socially destructive of all natural disasters.**



Source: *EMDAT (2013)*

IDENTIFYING FLOOD HOTSPOTS AND QUANTIFYING THE TIMING, EXTENT AND RISK

As the proposed SDGs assert, to alleviate flood damage it is important to understand changes over time with flooding.

IWMI has developed a tool that uses near real-time satellite data to map flood inundation over time. Maps can be generated during a flood, allowing decision makers to assess the progression of floodwaters and the severity of the situation and to quantify the damage. The tool can also be used proactively to study flood vulnerability, areas prone to waterlogging and the impact on critical agricultural production zones. In contrast to similar systems that have been developed to date, this tool uses data captured by sensors that can operate day and night and in almost any weather.

In Sudan's Gash Basin IWMI is trialing a prototype flood forecasting tool—the first of its kind in the region—to deliver flood information directly to farmers via mobile phone SMS technology.

Flood risk products that take into account inundation extent, depth and duration can also be useful for determining flood insurance payouts.

CASE STUDY: Mapping Flood Extent in Near Real Time in Pakistan

Himalayan rivers have flooded more frequently and disastrously in the past 20–30 years, in part due to climate change, and also because of increasing population and economic growth in flood-prone areas. In 2010 and 2011, Pakistan was affected by major floods caused by heavy rainfall during the monsoon period. Land-use change has disturbed the river systems, leading to more severe floods. More than 2500 people died, 27 million people were affected, 17 million acres (~6.9 million hectares) of Pakistan's most fertile crop land was submerged, 200,000 livestock died and massive amounts of grain and animal fodder were washed away. The economic losses were estimated to be USD 7.4 billion.

A time series of flood maps (Figure 7) is useful for identifying changes in flood cycles over time at a regional scale. Maps of flood vulnerability and the long-term flood cycle (Figure 8) can be used to assess flood-risk zones.

FIGURE 7. **The maximum inundation extent in the lower Indus.**

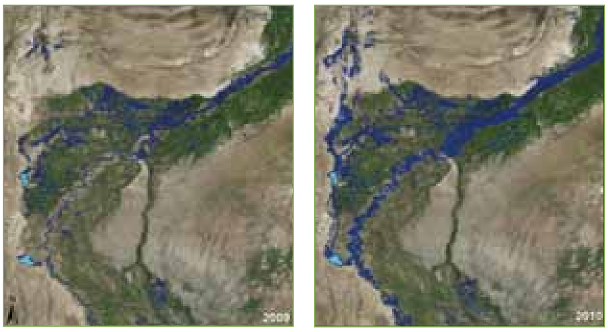
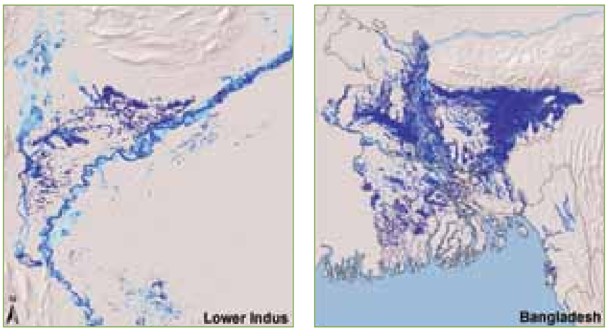


FIGURE 8. **Flood risk areas for the period 2000–2011. Dark blue areas are more frequently flooded.**



Source: *Giriraj, A., Ameer, M., Aggarwal, P., Smakhtin, V. (2012) Detecting spatio-temporal changes in the extent of seasonal and annual flooding in South Asia using multi-resolution satellite data. In: Civco DL, Ehlers M, Habib S, Maltese A, Messinger D, Michel U, Nikolakopoulos KG, Schulz K (eds.) Earth resources and environmental remote sensing/GIS applications III: Proceedings of the International Society for Optics and Photonics (SPIE), Vol. 8538, Amsterdam, Netherland, 1-6 July 2012. Bellingham, WA, USA: International Society for Optics and Photonics (SPIE) 11p.*

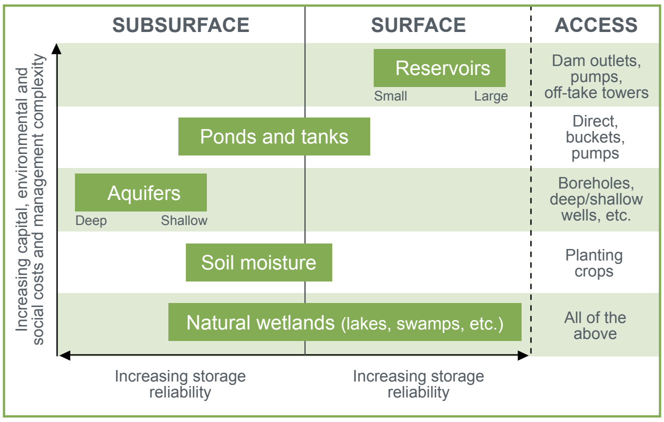
RETHINKING WATER STORAGE

Water storage has a vital role to play in managing water variability, ensuring global food security and building resilience for adaptation to climate change. To meet SDGs, countries with low per capita water storage, especially those in sub-Saharan Africa (SSA), will have to invest in new water storage.

Climate change and sustainable development needs will require a fundamental rethinking of the way water storage is planned and managed. This needs to be done from a basin perspective, be responsive to the needs at the local community levels and meet both current and future water storage needs. A variety of storage options need to be considered and tailored for the specific context.

The emphasis has previously been on large-scale infrastructure, but other options need to be considered that incorporate the beneficial aspects of such features as natural wetlands, soil moisture, groundwater aquifers, ponds, small tanks and reservoirs (Figure 9). The effectiveness of each option varies, and neither is likely to be a solution on its own but, broadly, the deeper and/or larger the storage, the more reliable the water supply that can be provided; and the more 'natural' it is, the less complex and less costly it is to develop and access.

FIGURE 9. **Having a range of storage types across a basin will increase resilience to climate change.**



Source: *IWMI Water Policy Brief 31, Flexible Water Storage Options and Adaptation to Climate Change*

How Much Water Storage Does sub-Saharan Africa Need for Agriculture?

All of the possible agricultural water storage options are used throughout SSA. While there have been systematic efforts in both the development of larger dams and programs on smaller scale storage options, much of the existing capacity has developed in an 'organic' manner, through private, community and local initiatives. In some cases, reservoirs have silted up, wells have gone dry and people have contracted malaria from mosquitoes breeding around storage structures.

The greatest need for storage is in the Sahelian zone, the Horn of Africa and southern Africa, with more localized hot spots in southern Angola, Rwanda, Burundi, Uganda, Malawi and Mozambique.

In Ethiopia and Ghana, the greatest need is in areas with the highest population density rather than the areas with the least rainfall.

MANAGING FLOODS AND DROUGHTS AT THE BASIN SCALE

If floods and droughts are managed at the basin scale, monsoon water can be stored underground in upstream areas and used for irrigation in the dry season while maintaining the supply–demand balance downstream. This approach would also offer protection from flooding impacts.

Storing water underground and recovering it later on a basin scale requires the necessary physical conditions as well as effective policies, institutional arrangements and incentives that are robust, socioeconomically sustainable and recognize the rights of the relevant stakeholders.

CASE STUDY: Harvesting Floodwater in Thailand's Chao Phraya Basin

In Thailand's Chao Phraya Basin, major catastrophic flooding events are regular and episodic. Yet basin aquifers upstream of the flood-affected areas have become depleted by over-abstraction. Harvesting floodwater, storing it in aquifers upstream of the flood-prone areas and using groundwater to grow cash crops in the dry season is technically viable. This would also reduce the magnitude of flooding of high value assets downstream, such as industries and urban centers.

About 28% of the coastal discharge—equivalent to the third largest storage in the basin—could be harvested one year in four, on average, without affecting existing major storages or the riparian and coastal environment. The system has the potential to recover its investment within 14 years while generating around USD 250 million/year in export earnings for the country and boosting the livelihoods of some of the poorest people in the community.

The approach could be used in similar basins in Thailand and other parts of Asia. For example, an analysis of the Ganges Basin reveals that around 40% of the basin has biophysical and socio-economic characteristics well suited to such an approach.

Climate change and sustainable development needs will require a fundamental rethinking of the way water storage is planned and managed.

8 Water Quality: The Chance to Avert a Global Crisis

8

Water Quality: The Chance to Avert a Global Crisis

Authors: Javier Mateo-Sagasta, Sara Marjani Zadeh (FAO), Birguy Lamizana (UNEP) and Pay Drechsel

Given the scale of water pollution, the SDG targets related to water quality need to be ambitious and comprehensive if they are to prevent a global water quality crisis.

Targets for controlling pollution and mitigating impact need to be achievable and affordable for countries and should give them flexibility in choosing options.

Monitoring wastewater, fecal sludge and water quality is challenging because many countries have no data, patchy data or unreliable data. Countries/donors should invest in increasing the capacity of countries to generate reliable data.

Hopeful signs of viable approaches based on resource recovery from waste and safe reuse for beneficial purposes are already emerging around the globe. Economics and institutional capacity development are key for replicating and scaling up such approaches.

Resource recovery from wastewater and sludge must occur jointly with the development of guidelines and policies on safe reuse and must be complemented with broader programs for controlling water pollution and mitigating impact.

Rethinking Water Quality Targets

Every day, humans generate millions of tons of solid and liquid waste, much of which is discharged untreated to water bodies, severely polluting the water and damaging human health, ecosystems and industries. The impacts of waste and wastewater have been poorly considered in the global development agenda and the Millennium Development Goals.

Water quality targets now need to go beyond access to sanitation facilities to address the fate of wastewaters and their impacts on the environment and be relevant for developed and developing countries alike.

We need to:

1. make the SDG targets on water quality relevant and realistic at the national level
2. measure and track progress towards the targets
3. support countries in reaching the targets.

Water quality–related targets include targets for collecting, treating and reusing sludge and wastewater and, more broadly, for controlling water pollution and mitigating impacts on human health, ecosystems and economic activities.

SETTING AMBITIOUS BUT REALISTIC TARGETS

In developing countries, little—if any—wastewater or fecal sludge is treated. For example, 92% of the sewage generated in low-income countries and 72% in lower middle-income countries is discharged untreated to water bodies. Industry dumps an estimated 300–400 million tons of heavy metals, solvents, toxic sludge and other waste into the environment. Huge amounts of agrochemicals, sediments from eroded soils and saline drainage water from agricultural activities also end up in water bodies. To address this complexity of threats and to prevent a global water quality crisis, the SDG targets related to water quality will need to be ambitious and comprehensive.

Standard solutions to control water pollution that work in industrialized countries have not always succeeded elsewhere. Attempts to implement conventional wastewater treatment plants often fail due to poor operation and maintenance, related to:

- limited institutional capacities
- unsuitable (e.g. energy-intensive) technology
- poor cost recovery strategies
- people's inability and unwillingness to pay for water services.

These experiences show that realistic, affordable targets must be set for controlling pollution and mitigating impact. Supplying and implementing adequate and affordable technologies will be a challenge for the wastewater industry sector.

Globally, a lot of untreated wastewater and sludge is used directly, with little or no measures to protect health, or released into the environment and reused indirectly (diluted), and sometimes unintentionally, posing risks for farmers, food consumers and ecosystems. Informal irrigation with raw or diluted wastewater is common, particularly in the developing world (as shown in the photo on p39), and represents up to 90% of all current wastewater use. The challenge is to make this practice safe by implementing cost-effective health and environmental protection options, including non-treatment options. Solutions will need to be highly contextualized. Targets should give countries the flexibility to transition to safe forms of excreta and wastewater management relevant to their context. For many regions, the cost of building sewerage networks and conventional treatment facilities will remain prohibitive, and these regions will need options. On-site sanitation facilities and safe fecal sludge management will probably remain the most affordable option.

Monitoring and evaluating progress of highly contextualized approaches will be a challenge. However, measurable targets that track progress over time can galvanize the sector and catalyze national and donor investment.

MONITORING WASTEWATER, FECAL SLUDGE AND WATER QUALITY

We know little about how much wastewater and sludge are produced, collected, treated, used and disposed of globally. We know even less about the proportion of valuable resources (water, organic matter, energy, nitrogen and phosphorus) embedded in these waste streams that is recovered and safely reused for activities such as agriculture.

Many different global organizations support different global assessments and monitoring initiatives related to wastewater, sanitation and water quality. The WHO/UNICEF joint monitoring program, for example, generates national data on access to water and sanitation facilities based on national household surveys. However, it is unlikely that that program can monitor wastewater, because householders have little knowledge of its fate. FAO and IWMI, through AQUASTAT, systematically collect, select and harmonize national data on municipal wastewater production, collection, treatment and reuse. But countries do not use uniform terms to describe wastewater and its fate, making it difficult to compare data and to establish a fully homogenous global inventory. Furthermore, some countries, particularly developing countries, have no data collection systems in place, so their data are patchy.

Monitoring fecal sludge from onsite facilities such as septic tanks requires significant investment. Data are scarce and unreliable, and there is no global monitoring system. Many countries lack information on the location and condition of onsite systems, on the amount of waste they collect and on the fate of the collected waste. The data on the use of untreated waste is particularly deficient, partly because the practice occurs informally or, in some cases, there is an unwillingness to disclose data. Farmers may fear difficulties in trading their produce, and governments may not want to acknowledge a malpractice.

At regional and global levels, monitoring the state and trends of water quality is a big challenge. The UNEP Global Environment Monitoring System (GEMS), through GEMStat, collects comprehensive surface and ground water quality data submitted by governments and other organizations. Nevertheless, many countries have very limited or inexistent water quality monitoring systems, or their data are not publicly available or they lack quality control, so the data are not comparable or cannot be used for monitoring trends.

Unless countries improve their data collection, we cannot:

- adequately diagnose the health and environmental risks associated with disposing of or using untreated wastewater and sludge
- quantify the potential for recovering resources from these wastes
- plan solutions
- assess their success.

We advise countries/donors to increase the capacity of countries to generate reliable data on wastewater and sludge cycles and support them with standard definitions and methods for generating data. The sooner countries can set target baselines the better. In the interim, or in parallel, remote sensing and modeling approaches should be considered for extrapolating water quality data.

WHO, UN-Habitat and UNEP are developing a global monitoring mechanism that aligns with the anticipated SDG target and indicators for wastewater and water quality. They will be working with existing monitoring initiatives as well as investigating new data collection methods and remote sensing and modelling approaches to fill data gaps.

Many well-established, low-cost and decentralized solutions are available to the least developed countries, as long as past institutional failure is not repeated.

REACHING THE TARGETS RELATED TO WATER QUALITY

To reach their water quality targets, countries will need to choose institutional and technical solutions that are validated and context-specific and that can work at scale. Countries will also need to create the environment that allows these solutions to be sustainable.

Fortunately, many well-established, low-cost and decentralized solutions are available to support progress even in the least developed countries, as long as past institutional failure is not repeated.

Another positive sign is the emerging understanding that economics is as important as technical solutions for scaling up resource recovery and safe reuse (RRR) of wastewater and sludge. IWMI and its partners have developed suitable scalable RRR business models based on the study of 200 empirical cases that bridge the sanitation and agricultural sectors. The business models are being tested for feasibility in 10 cities across the globe.

IWMI and its partners also support public and private entities by designing innovative low-cost technologies that can work at scale in low-income countries, support livelihoods, enhance food security, support green economies and contribute to cost recovery in the sanitation service sector (Figure 10). However, resource recovery from wastewater and sludge must occur jointly with developing guidelines and policies on safe reuse and must be complemented with broader programs for controlling water pollution and mitigating impact, as supported by WHO, UNEP and FAO.

COLLABORATING FOR SAFE AND PRODUCTIVE WASTEWATER REUSE

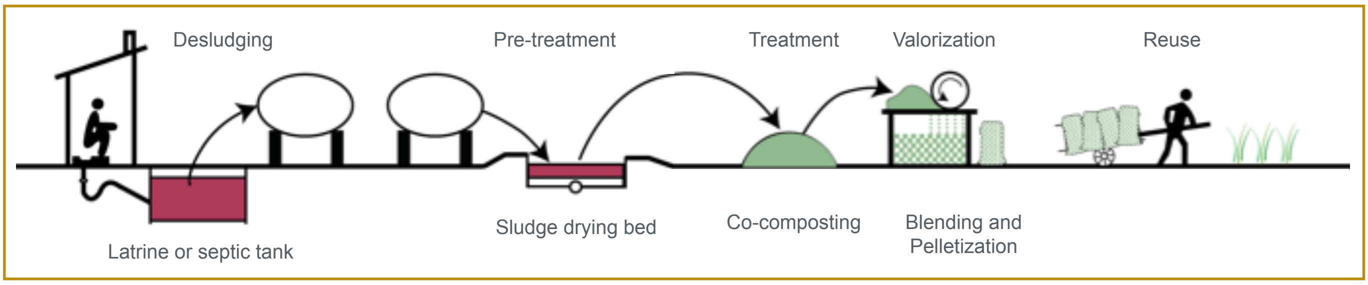
Science-based solutions, capacity development and awareness-raising are key elements that IWMI and its collaborators will be addressing to avert a water quality crisis.

IWMI tested low-cost options for safely using wastewater in informal irrigation. The results assisted WHO in developing guidance notes for its 2006 *Guidelines for safe wastewater use* and the related Sanitation Safety Planning approach and were used by FAO to develop a training handbook for Farmer Field Schools.

IWMI continues to support the wastewater database within FAO's AQUASTAT and contributes to the UNEP-led Global water quality initiatives under the umbrella of UN-Water.

Between 2011 and 2013, 160 people from 73 UN member states in Asia, Africa and Latin America took part in workshops about using wastewater safely and productively. This capacity development was supported by IWMI, the UN University, WHO, FAO and UNEP. An ambitious second phase is being planned in anticipation of the SDGs.

FIGURE 10. **Example of reuse-oriented fecal sludge management model as implemented in Ghana.**



Source: *IWMI 2013*

9 Accessing and Putting Water to Productive Use in Sub-Saharan Africa

9

Accessing and Putting Water to Productive Use in Sub-Saharan Africa

Lead author: Timothy O. Williams
With contributions from: Bai-Mass Taal (African Ministers' Council on Water [AMCOW]), Karen Villholth, Robyn Johnston, Meredith Giordano

Access to water for productive agricultural use remains a challenge for millions of poor smallholder farmers who constitute the majority of producers in sub-Saharan Africa (SSA). In 2006, 225 million hectares of land was cultivated in SSA. However, the total area equipped for irrigation was 7.2 million hectares—only 3.2% of the total cultivated area.

Hunger, malnutrition and poverty still persist, particularly in rural areas, despite recent growth in agricultural GDP. Improved access to water, coupled with the removal of economic and institutional constraints, can allow millions of smallholder farmers to adopt irrigation and successfully grow their way out of poverty and at the same time reduce hunger and malnutrition.

Attention to water access for productive use will help governments and international agencies achieve many of the proposed SDGs.

There is a need to implement four interrelated measures to improve water access for productive use:

- Increase investment in sustainable water infrastructure (from small scale to large scale) and technologies to augment water supply.
- Guarantee water and land rights for poor smallholder farmers, including women and youths.
- Include smallholder farmers in viable value chains and improve their access to adequate financial and extension services and markets.
- Increase water use efficiency and agricultural productivity.

These measures are essential if SSA governments are to attain the SDGs of ending poverty and hunger and achieving food security and improved nutrition by 2030.

Improving availability and supply of water will be meaningless if women and poor farmers are denied the right to make productive use of water and land.

INCREASED AVAILABILITY: A PREREQUISITE FOR INCREASED ACCESS TO WATER

Public and private sector investments in infrastructure, technologies and tools to augment and stabilize water supply is the first step towards improving and extending access to water for productive use in SSA. Investments are needed to:

- improve water harvesting
- develop and sustainably manage groundwater resources
- develop a variety of built and natural water storage infrastructure at farm, community and basin levels.

Groundwater, in particular, remains a relatively abundant but underused resource, with less than 5% of the water used for irrigation coming from groundwater. The major constraints to using groundwater include paucity of information on hydrogeological conditions, lack of access to affordable energy sources to drill and lift water and concerns over the capacity to sustainably manage the resource over the long term.

Increased and stable water supply from all sources will help to expand sustainable irrigation at small, medium and large scales.

Irrigation in SSA – Many Different Scales and Dimensions

The irrigation landscape in SSA is characterized by a pluralistic system. In many countries, small-scale, farmer-managed irrigation systems producing high value horticulture crops for urban and peri-urban centers co-exist with large-scale public irrigation systems growing staple food and cash crops for domestic and regional export markets. In between these two extremes are medium-scale systems, often community-managed, growing staples, fruits and vegetables for domestic and regional markets. These irrigation systems differ in terms of organizational capacity needed to run and maintain them; their economic performance, including benefits and costs of operation and maintenance; and the implications they hold for livelihoods, food security and the environment.

Many smallholder farmers, including women and youths, engage in small-scale irrigation without government support and use their own resources to buy irrigation equipment, either individually or in small groups. They access water that is available in shallow groundwater, rivers, lakes and reservoirs. This farmer-driven irrigation system has proven successful, cheap and adaptable and is expanding rapidly. It provides significant direct and indirect benefits to poor farmers. For instance, in Burkina Faso, dry season small-scale irrigated vegetable and rice production increased incomes by USD 200–600 per farm household over one dry season. But small-scale irrigation is growing in a spontaneous, unplanned and unregulated manner and faces several challenges.

Following a sharp decline in investments in the early 2000s, there is now a renewed interest in large-scale public irrigation schemes by governments, donors and development banks. This is partly driven by the volatility in food prices and the risk this poses to millions of vulnerable poor people. Commercial large-scale irrigation schemes are also being developed to accompany the wave of foreign investment in agricultural land in SSA.

A recent evaluation of large-scale public irrigation schemes in Sahelian West Africa showed mixed results in terms of contribution of these schemes to national food security and cost–benefit performance. While there is room for large-scale irrigation schemes in SSA, new investments must be guided by lessons learned from the failure of earlier schemes in Africa and Asia. For new schemes to succeed, sound technical, institutional and policy measures are needed, as is the use of new tools and techniques (e.g. remote sensing and satellite images) to improve water management and water use efficiency and reduce environmental problems.

GOVERNANCE SYSTEMS ARE NEEDED TO GUARANTEE WATER AND LAND RIGHTS FOR WOMEN AND OTHER POOR FARMERS.

Millions of poor farmers, including women, hold tenuous and unsecured water and land rights in many parts of SSA. Existing customary and institutional factors as well new drivers, such as large-scale foreign investment in agricultural land that displaces poor land users, have exacerbated this situation. Any effort to improve availability and supply of water will be meaningless if women and poor farmers are denied the rights to make effective and productive use of water and land.

Research by the Food and Agriculture Organization (FAO) indicates that if women had the same access to resources as men, they could increase yields on their farms by 20–30%; globally this would help to reduce the number of people who are hungry by 150 million.

Forward-looking governance systems are needed to strengthen and guarantee the water and land rights of poor rural farmers, including women, to promote equity and to enable them to make productive use of available water to enhance food security and their livelihoods.

Increased and stable water supply from all sources will help to expand sustainable irrigation.

EXPAND ACCESS TO SERVICES, VALUE CHAINS AND MARKETS

Putting water to productive use means using water to create value. However, entrepreneurial poor farmers face a multitude of challenges that prevent them from making effective use of water to create products for markets and consumers. Lack of accurate and timely information and technical advisory services constrain their ability to:

- assess the risks and benefits of irrigation
- make informed investment decisions.

Also, upfront costs impede many smallholder farmers from investing in irrigation and water storage facilities. All producers—big or small—face obstacles in gaining access to domestic, regional and international markets.

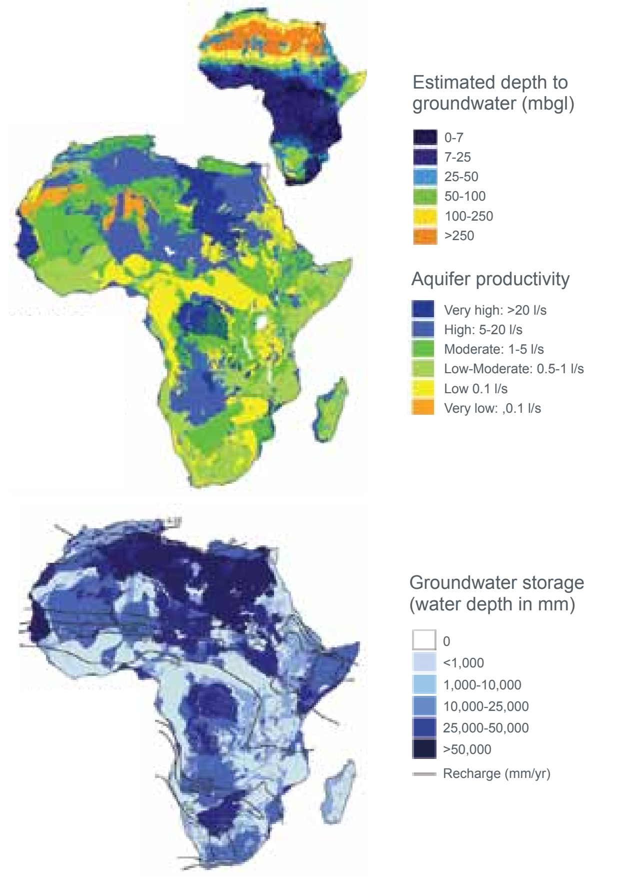
If they can access technical advisory and financial services, farmers will gain the incentive and confidence to invest in irrigation. Such services might include innovative credit and finance schemes or support for the expansion of markets. These services will help the farmers diversify and intensify their farming enterprises, leading to improved livelihoods and household and national food security.

MORE EFFICIENT WATER USE MEANS MORE WATER FOR BOTH PRODUCTIVE USE AND THE ECOSYSTEM

When access to water is increased, it is important that the available water is used efficiently so as not to waste the valuable resource. Improving the efficiency of water use in agriculture can lead to having more water available for other productive uses and may minimize the impacts on the ecosystem. Through a mix of technical improvements, appropriate policies and economic incentives, increased water use efficiency and agricultural productivity can also lead to tangible net water gains for other users as well as the sustenance of ecosystems.

New efficient irrigation technologies, such as drip and sprinkler irrigation plus better agronomic and soil management practices, can lead to improved water use efficiency in agriculture. If this is combined with the full suite of crop inputs—organic and inorganic fertilizers and pesticides—yields per hectare and water productivity will both increase. Appropriate policies and economic incentives can help improve water allocation and motivate water users to conserve and use water efficiently.

FIGURE 11. **Groundwater irrigation potential in Africa**



Source: *MacDonald, A.; Bonsor, H.C.; Dochartaigh, B.E.; Taylor, R.G. 2012. Quantitative maps of groundwater resources in Africa. Environmental Letters, 7(2).*

WATER USE EFFICIENCIES WILL HELP ATTAIN SUSTAINABLE DEVELOPMENT GOALS

There is a growing realization that water is the missing or ignored link in the drive for a green revolution in SSA. It is therefore crucial to understand, augment and stabilize the supply of water and to simultaneously improve access of poor smallholder farmers, including women, to land and water, financial and advisory services and markets. This must be coupled with incentives to enable them to adopt and use new technologies (e.g., solar and wind-powered pumps) and practices and information to expand the area under irrigation and improve water use efficiency. By implementing these and other complementary measures, SSA countries will be well placed to attain the SDGs of ending poverty and hunger and achieving food security and improved nutrition while laying the foundations for sustainable agricultural growth.

In the long run, the development and allocation of water resources to ensure balanced growth and environmentally sustainable use of water will depend on sound decision making. Governments will need to invest in data collection and in monitoring and evaluation to allow this to occur (see section 4).

10 Bibliography and Photography Credits

Bibliography and Photography Credits

BIBLIOGRAPHY

Water–Food–Energy Nexus

Hoff, H. 2011. *Understanding the nexus*. Background paper for the Bonn2011 Nexus Conference: The Water, Energy and Food Security Nexus. Solutions for the Green Economy, November 16-18, 2011, Stockholm Environment Institute, Stockholm, Sweden.

Karimov, A.; Smakhtin, V.; Mavlonov, A.; Borisov, V.; Gracheva, I.; Miryusupov, F.; Djumanov, J.; Khamzina, T.; Ibragimov, R.; Abdurahmanov, B. 2013. *Managed aquifer recharge: The solution for water shortages in the Fergana Valley*. Colombo, Sri Lanka: International Water Management Institute. 55p. (IWMI Research Report 151) (in English and Russian).

Mukherji, A.; Shah, T.; Verma, S. 2010. Electricity reforms and their impact on ground water use in states of Gujarat, West Bengal and Uttarakhand, India. In: *On the water front: Selections from the 2009 World Water Week in Stockholm*, (ed.), Lundqvist, J. Stockholm, Sweden: Stockholm International Water Institute (SIWI) Pp. 100-107.

Ringler, C.; Bhaduri, A.; Lawford, R. 2013. The nexus across water, energy, land and food (WELF): Potential for improved resource use efficiency. *Current Opinion in Environmental Sustainability* 5(6): 617-624.

Shah, T.; Verma, S. 2008. Co-management of electricity and groundwater: An assessment of Gujarat's Jyotirgram scheme. *Economic & Political Weekly* 43(7): 59-66.

We would also like to refer to the following conference:

The Water Institute; Gillings School of Global Public Health; University of North Carolina. 2014. *Building integrated approaches into the Sustainable Development Goals. A declaration from the Nexus 2014: Water, Food, Climate and Energy Conference in the name of the Co-directors held at the University of North Carolina at Chapel Hill, March 5-8, 2014*. Submitted to the UN-Secretary General on March 27, 2014. Available at http://nexusconference.web.unc.edu/files/2014/08/nexus-declaration.pdf (accessed on September 12, 2014).

Water Governance: Context is Crucial

Giordano, M.; Shah, T. 2014. From IWRM back to integrated water resources management. *International Journal of Water Resources Development* 30(3): 364-376 (Special issue: Integrated Water Resources Management).

Molle, F. 2009. River-basin planning and management: The social life of a concept. *Geoforum* 40(3): 484-494.

Mukherji, A.; Shah, T.; Giordano, M. 2012. *Managing energy-irrigation nexus in India: A typology of state interventions.* IWMI-Tata Water Policy Research Highlight, 36. 9p. Available at http://www.iwmi.cgiar.org/iwmitata/PDFs/2012_Highlight-36.pdf (accessed on September 12, 2014).

Shah, T. 2009. Can the anarchy be tamed? In Taming the anarchy: Groundwater governance in South Asia. Washington, DC, USA: Resources for the Future; Colombo, Sri Lanka: International Water Management Institute (IWMI) Pp. 187-207

Shah, T. 2014. *Groundwater governance and irrigated agriculture*. GWP Background Paper No. 19. Stockholm, Sweden: Global Water Partnership (GWP). Available at http://www.gwp.org/Global/Toolbox/Publications/Background%20papers/GWP_TEC_19_web.pdf (accessed on September 16, 2014).

Water Metrics

FAO (Food and Agriculture Organization of the United Nations). 2011. *Coping with water scarcity: An action framework for agriculture and food security*. Rome. (FAO Water Reports 38).

Karimi, P.; Bastiaanssen, W.G.M.; Molden, D. 2013. Water accounting plus (WA+) – a water accounting procedure for complex river basins based on satellite measurements. *Hydrology and Earth System Sciences* 17(7): 2459-2472.

Karimi, P.; Molden, D.; Bastiaanssen, W.; Cai, X. 2012. Water accounting to assess use and productivity of water: Evolution of a concept and new frontiers. In: *Water accounting: International approaches to policy and decision-making*, eds., Godfrey, J.M.; Chalmers, K. Cheltenham, UK: Edward Elgar. Pp. 76-88.

Molden, D.; Oweis, T.; Steduto, P.; Bindraban, P.; Hanjra, M.A.; Kijne, J. 2010. Improving agricultural water productivity: Between optimism and caution. *Agricultural Water Management* 97(4): 528-535 (Special issue: Comprehensive Assessment of Water Management in Agriculture).

Rebelo, L-M; Johnston, R.; Karimi, P.; McCornick, P.G. 2014. Determining the dynamics of agricultural water use: Cases from Asia and Africa. *Journal of Contemporary Water Research & Education* 153(1): 79-90.

Social Inclusion

Ahlers, R.; Zwarteveen, M.Z. 2009. The water question in feminism: Water control and gender inequities in a neo-liberal era. *Gender, Place and Culture* 16(4): 409-426.

Harris, L. 2009. Gender and emergent water governance: Comparative overview of neoliberalized natures and gender dimensions of privatization, devolution and marketization. *Gender, Place and Culture* 16(4): 387-408.

Meinzen-Dick, R.; Zwarteveen, M.Z. 1998. Gendered participation in water management: Issues and illustrations from water users' associations in South Asia. *Agriculture and Human Values* 15(4): 337-345.

Mukherji, A. 2007. Implications of alternative institutional arrangements in groundwater sharing: Evidence from West Bengal. *Economic and Political Weekly* 42(26): 2543-2551.

Sultana, F. 2009. Fluid lives: Subjectivities, gender and water in rural Bangladesh. Gender, Place and Culture 16(4): 427-444.

van Koppen, B.; Hussain, I. 2007. Gender and irrigation: Overview of issues and options. *Irrigation and Drainage* 56: 289-298.

Zwarteveen, M.Z. 1997. Water: From basic need to commodity: A discussion on gender and water rights in the context of irrigation. *World Development* 25(8): 1335-1349.

Zwarteveen, M.Z.; Neupane, N. 1996. *Free-riders or victims: Women's nonparticipation in irrigation management in Nepal's Chhattis Mauja irrigation scheme.* Colombo, Sri Lanka: International Irrigation Management Institute (IIMI). 26p. (IIMI Research Report 007).

Sustainable Development and Ecosystem Services

Falkenmark, M.; Finlayson, M.; Gordon, L.J.; Bennett, E.M.; Chiuta, T.M.; Coates, D.; Ghosh, N.; Gopalakrishnan, M.; de Groot, R.S.; Jacks, G.; Kendy, E.; Oyebande, L.; Moore, M.; Peterson, G.D.; Portuguez, J.M.; Seesink, K.; Tharme, R.; Wasson, R. 2007. Agriculture, water, and ecosystems: Avoiding the costs of going too far. In: *Water for food, water for life: A comprehensive assessment of water management in agriculture*, ed., Molden, D. London, UK: Earthscan; Colombo, Sri Lanka: International Water Management Institute (IWMI). Pp. 233-277.

IUCN (International Union for Conservation of Nature); IWA (International Water Association). 2014. *Nexus dialogue on water infrastructure solutions: Building partnerships for innovation in water, energy and food security*. Gland, Switzerland: Gland, Switzerland; The Netherlands. Available; The Netherlands. Available at http://cmsdata.iucn.org/downloads/2014_nexus_flyer__en.pdf (accessed on September 12, 2014).

IWMI (International Water Management Institute). 2014. *Wetlands and people*. Colombo, Sri Lanka. 32p.

MEA (Millennium Ecosystem Assessment). 2005. *Ecosystems and human well-being: Wetlands and water synthesis*. Washington, DC: World Resources Institute.

Russi, D.; ten Brink, P.; Farmer, A.; Badura, T.; Coates, D.; Förster, J.; Kumar, R.; Davidson, N. 2013. The Economics of Ecosystems and Biodiversity (TEEB) for water and wetlands. London and Brussels: Institute for European Environmental Policy (IEEP); Gland, Switzerland: Ramsar Secretariat.

Managing Water Variability: Floods and Droughts

Giriraj, A.; Ameer, M.; Aggarwal, P.; Smakhtin, V. 2012. Detecting spatio-temporal changes in the extent of seasonal and annual flooding in South Asia using multi-resolution satellite data. *Proceedings of the International Society for Optics and Photonics (SPIE): Earth resources and environmental remote sensing/GIS applications III. , Vol. 8538, Amsterdam, Netherlands, July 1-6, 2012*, (eds.), Civco, D.L.; Ehlers, M.; Habib, S.; Maltese, A.; Messinger, D.; Michel, U.; Nikolakopoulos, K.G.; Schulz, K. Bellingham, WA, USA: International Society for Optics and Photonics (SPIE). 11p.

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 (IWMI). 14p.

McCartney, M.; Cai, X.; Smakhtin, V. 2013a. *Evaluating the flow regulating functions of natural ecosystems in the Zambezi River Basin*. Colombo, Sri Lanka: International Water Management Institute (IWMI). 59p. (IWMI Research Report 148).

McCartney, M.; Rebelo, L-M.; Xenarios, S.; Smakhtin, V. 2013b. *Agricultural water storage in an era of climate change: Assessing need and effectiveness in Africa*. Colombo, Sri Lanka: International Water Management Institute (IWMI). 37p. (IWMI Research Report 152).

Pavelic, P.; Srisuk, K.; Saraphirom, P.; Nadee, S.; Pholkern, K.; Chusanathas, S.; Munyou, S.; Tangsutthinon, T.; Intarasut, T.; Smakhtin, V. 2012. Balancing-out floods and droughts: Opportunities to utilize floodwater harvesting and groundwater storage for agricultural development in Thailand. *Journal of Hydrology* 470-471: 55-64.

Water Quality: The Chance to Avert a Global Crisis

Amoah, P.; Keraita, B.; Akple, M.; Drechsel, P.; Abaidoo, R.C.; Konradsen, F. 2011. *Low-cost options for reducing consumer health risks from farm to fork where crops are irrigated with polluted water in West Africa*. Colombo, Sri Lanka: International Water Management Institute (IWMI). 37p. (IWMI Research Report 141).

FAO (Food and Agriculture Organization of the United Nations). 2012. *On-farm practices for the safe use of wastewater in urban and peri-urban horticulture. A training handbook for farmer field schools in West Africa*. Rome.

Libhaber, M.; Orozco-Jaramillo, A. 2012. *Sustainable treatment and reuse of municipal wastewater for decision makers and practicing engineers*. London: IWA Publishing.

Mateo-Sagasta, J.; Raschid-Sally, L.; Thebo, A. 2015 (Forthcoming). Global assessment of wastewater and sludge production, treatment and reuse. In: *Wastewater: Economic asset in an urbanizing world*, (eds.), Drechsel, P.; Qadir, M.; Wichelns, D. Springer Publishers.

Murray, A.; Drechsel, P. 2011. Why do some wastewater treatment facilities work when the majority fail? Case study from the sanitation sector in Ghana. *Waterlines* 30(2): 135-149.

Sato, T.; Qadir, M.; Yamamoto, S.; Endo, T.; Zahoor, A. 2013. Global, regional, and country level need for data on wastewater generation, treatment, and reuse. *Agricultural Water Management* 130(C) 1-13.

WHO (World Health Organization). 2006. *Guidelines for the safe use of wastewater, excreta and greywater*. Geneva: World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), United Nations Environment Programme (UNEP).

Accessing and Putting Water to Productive Use in Sub-Saharan Africa

Douxchamps, S.; Ayantunde, A.; Barron, J. 2014. Taking stock of forty years of agricultural water management interventions in smallholder systems of Burkina Faso. *Water Resources and Rural Development* 3: 1-13.

Giordano, M.; de Fraiture, C.; Weight, E.; van der Bliek, J. (eds.). 2012. *Water for wealth and food security: Supporting farmer-driven investments in agricultural water management. Synthesis report of the AgWater Solutions Project*. Colombo, Sri Lanka. International Water Management Institute (IWMI). 48p.

Pavelic, P.; Giordano, M.; Keraita, B.; Ramesh, V.; Rao, T. (eds.). 2012. *Groundwater availability and use in sub-Saharan Africa: A review of 15 countries*. Colombo, Sri Lanka: International Water Management Institute (IWMI). 274p.

van Koppen, B.; Hope, L.; Colenbrander, W. 2013. Gender aspects of smallholder private groundwater irrigation in Ghana and Zambia. *Water International* 38(6): 840-851.

Villholth, K.G. 2013. Groundwater irrigation for smallholders in sub-Saharan Africa – a synthesis of current knowledge to guide sustainable outcomes. *Water International* 38(4): 369-391.

Williams, T.O.; Gyampoh, B.; Kizito, F.; Namara, R. 2012. Water implications of large-scale land acquisitions in Ghana. *Water Alternatives* 5(2): 243-265.

PHOTOGRAPHY CREDITS

Cover
Hamish John Appleby / IWMI

Joe Ronzio / IWMI (p2)

Introduction
Hamish John Appleby / IWMI (p5), Jim Holmes / IWMI (p6), Joe Ronzio / IWMI (p8)

Water–Food–Energy Nexus
Hamish John Appleby / IWMI (p9), Felix Antonio / IWMI (p10), Neil Palmer / IWMI (p11)

Water Governance: Context is Crucial
Hamish John Appleby / IWMI (p13), Faseeh Shams / IWMI (p14) David Brazier / IWMI (p15), Graeme Williams / IWMI (p17)

Water Metrics
Petterik Wiggers / IWMI (p19), Matthew McCartney / IWMI (p20)

Social Inclusion
David Brazier / IWMI (p23), Nana Kofi Acquah / IWMI (p24), David Brazier / IWMI (p25),
Hamish John Appleby / IWMI (p26), Neil Palmer (IWMI) (p27)

Sustainable Development and Ecosystem Services
Jim Holmes / IWMI (p28), Faseeh Shams / IWMI (p29)

Managing Water Variability: Floods and Droughts
Sajjad Ali Qureshi / IWMI (p34), Hamish John Appleby / IWMI (p37)

Water Quality: The Chance to Avert a Global Crisis
David Brazier / IWMI (p38), Nana Kofi Acquah / IWMI (p39)

Accessing and Putting Water to Productive Use in Sub-Saharan Africa
Kristian Buus / Stars Foundation on Flickr (p42), Practical Action/Martha Munyoro Katsi (p43),

Bibliography and Photography Credits
Hamish John Appelby / IWMI (p46), Neil Palmer / CIAT (p47), Petterik Wiggers / IWMI (p51)

RESEARCH PROGRAM ON
Water, Land and Ecosystems

International Water Management Institute (IWMI)
PO Box 2075, Colombo, Sri Lanka
127 Sunil Mawatha, Pelawatte, Battaramulla
Colombo, Sri Lanka
t +94-11 2880000, +94-11 2784080
f +94-11 2786854
e iwmi@cgiar.org
www.iwmi.org

ISBN 978-92-9090-801-2