View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Research Papers in Economics

# Water Security for Food Security: Findings of the Comprehensive Assessment for Sub-Saharan Africa

Compiled by David Molden[1]

## *Introduction*

Trendlines indicate that we are not doing the right things with our water resources. Inequity in the benefits of water use will grow between haves and have-nots to the detriment of food production. The pollution and depletion of rivers and groundwater will continue. Enough food grown at the aggregate global level does not mean enough food for everyone.

Water scarcity, defined in terms of access to water, is a critical constraint to agriculture in many areas of the world. A fifth of the world's people, more than 1.2 billion, live in areas of physical water scarcity, lacking enough water for everyone's demands (Figure 1)

About 1.6 billion people live in water-scarce basins, where human capacity or financial resources are likely to be insufficient to develop adequate water resources. Behind today's water scarcity lie factors likely to multiply and gain in complexity over the coming years. A growing population is a major factor, but the main reasons for water problems lie elsewhere—lack of commitment to water and poverty, inadequate and inadequately targeted investment, insufficient human capacity, ineffective institutions, and poor governance.

From 1963 to 2000 food production grew more rapidly in developing countries than in developed countries, with growth in food production exceeding growth in population, except in Africa. The average global per capita daily food supply increased from 2,400 kilocalories (kcal) in 1970 to 2,800 kcal in 2000 – enough food for the global population. But the average daily per capita food supply in South Asia (2,400 kcal) and Sub-Saharan Africa (2,200 kcal), while slowly rising, was below the world average of 2,800 kcal in the year 2000.

Many poor people either do not produce sufficient food for their own consumption or do not earn enough to buy the food they need. The share of undernourished people in the developing world varies from about 10% in the Near East and North Africa and Latin America and the Caribbean regions to almost 33% in Sub-Saharan Africa (Figure 2). 850 million people are undernourished, 815 million of them in developing countries

[1] This report draws directly from the book Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture, authored and reviewed by hundreds of practitioners and researchers. It is available at www.iwmi.org/assessment and www.earthscan.com. David Molden is Deputy Director General for Research at the International Water Management Institute and coordinated the assessment program.

representing 17% of the population of these countries (FAO 2004). About three quarters of the undernourished live in rural areas, and most depend on agriculture.

The potential of agricultural water management has not yet been tapped in sub-Saharan Africa. In 2000 in Africa, 5.5% of renewable water was withdrawn from natural systems compared to 20% withdrawals in Asia. 95% of African land is cultivated by rainfed

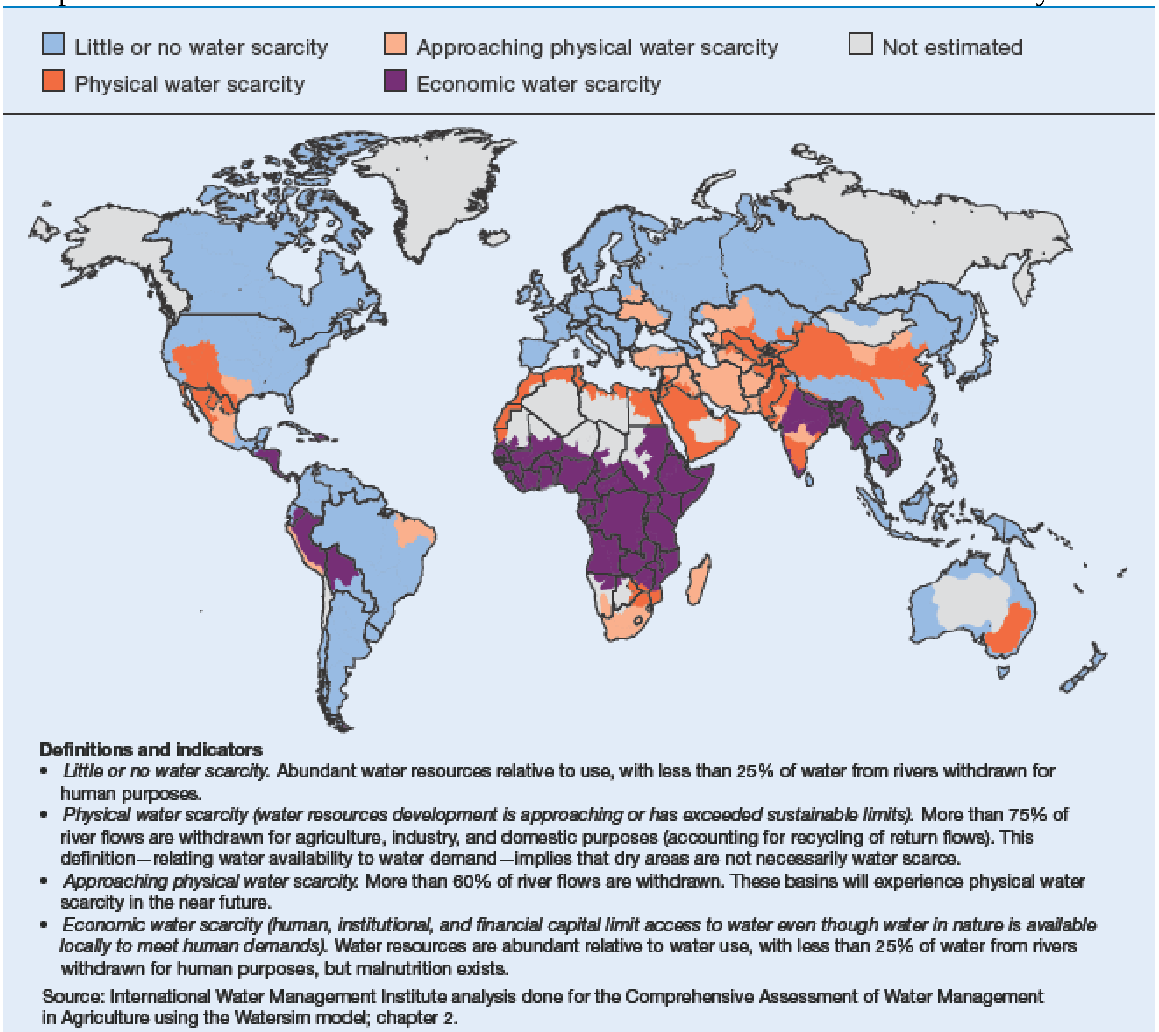



Figure 1: Areas of physical and economic water scarcity

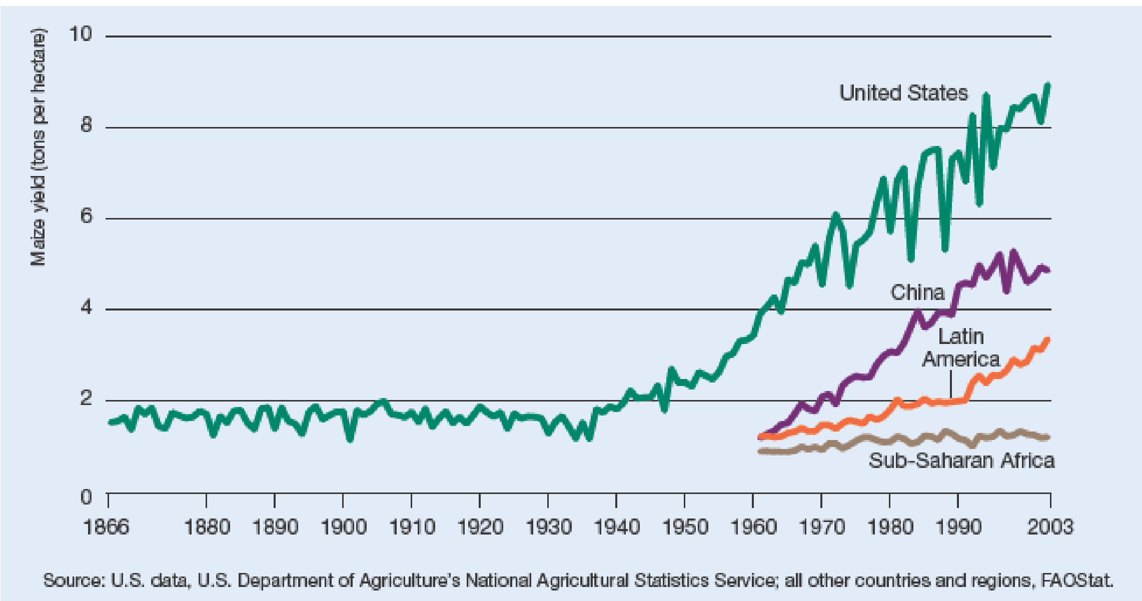
agriculture. Investment in agricultural water in Sub-Saharan Africa has been only a small proportion of the total for the water sector—just 14% of African Development Bank lending to the water sector as a whole during 1968–2001, for example (Peacock, Ward, and Gambarelli forthcoming).,

It is clear that solutions are needed quickly to resolve issues of water, food, livelihoods and environment. As a step, the Comprehensive Assessment of Water Management in Agriculture pulled together five years of work by more than 700 scientists and practitioners from around the world to address issues of water for food, documented in the book Water for Food, Water for Life (CA, 2007). Their strong and urgent message: problems will intensify unless they are addressed—and now.

### *Where is there hope? Increasing access to water and increasing the productivity of land and water*

The hope lies in closing the gap in agricultural productivity in many parts of the world—often today no greater than that on the fields of the days of ancient Carthage and the Roman Empire—and in realizing the unexplored potential that lies in better water management along with nonmiraculous changes in policy and production techniques.

Figure 2: Production differences in maize between N America, Latin America and Sub-Saharan Africa.  Yields in Sub-saharan Africa must turn the corner to approach yields of developed countries.




The hope lies in the fact that there is enough water to produce enough food and propel economic growth across Africa.  Providing access to water to produce food is a key. But world leaders must take action now—before the opportunities to do so are lost.

Insecure access to reliable, safe, and affordable water keeps hundreds of millions of people from escaping poverty. Most of them rely directly on agriculture for their food and income. Unless action is taken, many more smallholder farmers, fishers, herders, and people dependent on wetlands will fall into poverty as rivers dry up, groundwater declines, and water rights are lost.

## What changes are needed?

Such gains, although far from impossible, require significant changes in the policy agenda for water management. That agenda must be grounded in the reality that ensuring food security and protecting ecosystems are vital to human survival and must be achieved in harmony. Water systems must be built for many purposes and managed to provide a wide range of ecosystem services. And there are opportunities—in rainfed, irrigated, livestock, and fisheries systems—for preserving, even restoring, healthy ecosystems. Different strategies are required for different situations. Sub-Saharan Africa requires investments in infrastructure, considering the range of options available.

There are several different pathways out of poverty. In some settings low-cost technologies can be viewed as a stepping stone—they are simple and can be rapidly implemented, reaping quick gains in food security and income for many people. And with favorable institutional and market conditions, other options will arise, such as larger scale irrigation or other income-generating and employment opportunities. But the first step is important.

### *HOW CAN FOOD AND FIBER DEMAND WITH OUR LAND AND WATER RESOURCES?*

The world's available land and water resources can satisfy future food demands in several ways.

1. Investing to increase production in rainfed agriculture.
    a. Increasing productivity in rainfed areas through enhanced management of soil moisture and supplemental irrigation where small water storage is feasible.
    b. Improving soil fertility management, including the reversal of land degradation.
    c. Expanding cropped areas.
2. Investing in new irrigation and modernizing existing ones.
    a. Increasing annual irrigation water supplies by innovations in system management, developing new surface water storage facilities, and increasing groundwater withdrawals and the use of wastewater.
    b. Increasing water productivity in irrigated areas and value per unit of water by integrating multiple uses—including livestock, fisheries, and domestic use—in irrigated systems.
3. Conducting agricultural trade within and between countries.
4. Decreasing food loss in the food chain between field to plate, and changing diets.

Much of the debate on investments in water management revolves around the role of irrigation, and investments into large infrastructure, capacity building or technologies. But clearly we have to look at a range of options available that involve groundwater, supplementing rain, better soil moistre, as well as diverting from rivers and lakes for large scale irrigation.

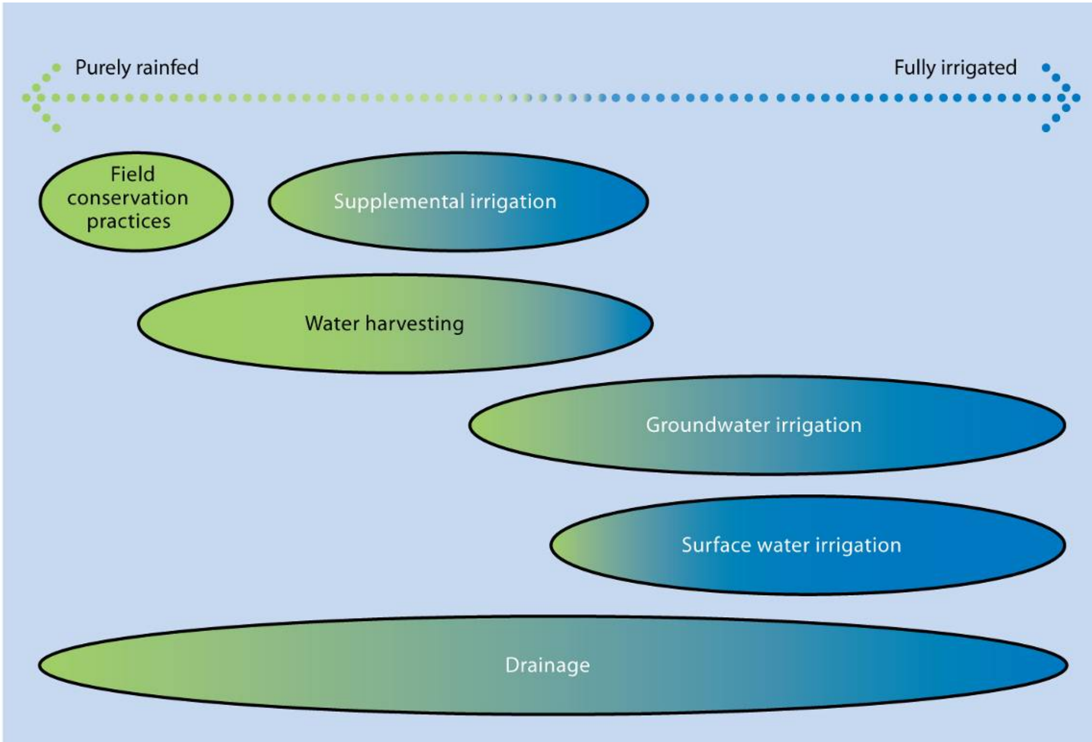



Figure 3. There are a range of water management options to be considered. Much of the potential lies in the area lies between pure rainfed farming, and full irrigated agriculture.

In both Sub-Saharan Africa and South Asia the discussion of investments in water management is highly relevant and debated. In both Sub-Saharan Africa and South Asia improvements in agricultural water management are needed to increase agricultural productivity and reduce the high rates of rural poverty (Hussain and Hanjra 2003, 2004). The Commission for Africa (2005) and the New Partnership for Africa's Development propose doubling the area under irrigation to boost food production and enhance rural development. India is considering a multi-billiondollar Linking of Rivers project, and Pakistan plans to modernize its aging infrastructure in the Indus Basin. Proponents see investments in new irrigation and hydropower as needed to meet rapidly increasing demand for food and energy, and as an important driver of economic growth. Opponents of large-scale irrigation projects suggest improving rainfed areas where the poor will benefit the most. They claim it is cheaper—in financial, environmental, and social terms—to upgrade underperforming infrastructure, increase rainfed production, and import food.

## WHAT ROLE CAN IRRIGATED AGRICULTURE PLAY?

After a decade of decline, international donors have shown renewed interest in irrigation investments, particularly in Sub-Saharan Africa, where irrigation development has remained well below its physical potential (see Faures et al, 2007). The evidence suggests that despite environmental concerns about large-scale irrigation development (Falkenmark and Finlayson et al, 2007), there remain good reasons to invest in irrigation development, improvement, and modernization. These include the potential for poverty alleviation, high potential to improve irrigation performance, maintenance of irrigation capacity, and concerns about climate change and its effects on rainfall variability (see Faures et al, 2007 (chapter 9 on irrigation).

In Sub-Saharan Africa there exists very little irrigation, and expansion seems warranted. Doubling the irrigated area in Sub-Saharan Africa would increase irrigation's contribution to food supply in Africa from only 5% now to an optimistic 11% by 2050. More options are needed besides large scale irrigation to bring about food security.

## CAN UPGRADING RAINFED AGRICULTURE MEET FUTURE FOOD DEMANDS?

Today, 55% of the gross value of our food globally is produced under rainfed conditions on nearly 72% of the world's harvested cropland. In the past, many countries focused their "water attention" and resources on irrigation development. The future food production that should come from rainfed or irrigated agriculture is the subject of intense debate, and the policy options have implications that go beyond national boundaries.

An important option is to upgrade rainfed agriculture through better water management practices (Rockstrom et al, 2007). Better soil and land management practices can increase water productivity, adding a component of irrigation water through smaller scale interventions such as rainwater harvesting. Integrating livestock in a balanced way to increase the productivity of livestock water is important in rainfed areas.

At the global level the potential of rainfed agriculture is large enough to meet present and future food demand through increased productivity (de Fraiture et al, 2007). An optimistic rainfed scenario assumes significant progress in upgrading rainfed systems while relying on minimal increases in irrigated production, by reaching 80% of the maximum obtainable yield. This leads to an average increase of yields from 2.7 metric tons per hectare in 2000 to 4.5 in 2050 (1% annual growth). With no expansion of irrigated area, the total cropped area would have to increase by only 7%, compared with 24% from 1961 to 2000, to keep pace with rising demand for agricultural commodities.

But focusing only on rainfed areas carries considerable risks. If adoption rates of improved technologies are low and rainfed yield improvements do not materialize, the expansion in rainfed cropped area required to meet rising food demand would be around 53% by 2050. Globally, the land for this is available, but agriculture would then encroach on marginally suitable lands and add to environmental degradation, with more natural ecosystems converted to agriculture.

## WHAT IS THE POTENTIAL OF TRADE TO RELEASE PRESSURE ON FRESHWATER RESOURCES?

By importing agricultural commodities, a nation "saves" the amount of water it would have required to produce those commodities domestically. Egypt, a highly water-stressed country, imported 8 million metric tons of grain from the United States in 2000. To produce this amount of grain Egypt would have needed about 8.5 cubic kilometers of irrigation water (Egypt's annual supply from Lake Nasser is 55.6 cubic kilometers). Cereal trade has a moderating impact on the demand for irrigation water, because the major grain exporters—the United States, Canada, France, Australia, and Argentina—produce grain in highly productive rainfed conditions. A strategic increase in international food trade could thus mitigate water scarcity and reduce environmental degradation (de Fraiture et al, 2007, CA Scenario chapter). Instead of striving for food self-sufficiency, water-short countries would import food from water-abundant countries.

Poor countries depend, to a large extent, on their national agriculture sector, and the purchasing power required to cover food needs from the world market is often low. Struggling with food security, these countries remain wary of depending on imports to satisfy basic food needs. A degree of food self-sufficiency is still an important policy goal.

And despite emerging water problems, many countries view the development of water resources as a more secure option to achieving food supply goals and promoting income growth, particularly in poor rural communities. The implication is that under the present global and national geopolitical and economic situation, it is unlikely that food trade will solve water scarcity problems in the near term. It is clear that international trade will continue to play a role, and regional African trade will be a key to opening up markets to improve productivity. But many African countries cannot solely rely on trade for food security of their people.

## *KEY ACTIONS FOR SUB-SAHARAN AFRICA*

### Upgrade rainfed agriculture by adding irrigation and investing in transport and governance

About 70% of the world's poor people live in rural areas where livelihood options outside of agriculture are limited. Many rural poor rely mainly on rainfed farming for food, but variable rainfall, dry spells, and droughts make rainfed farming a risky business (Rockstrom et al, 2007). Better management of rainwater, soil moisture, and supplemental irrigation is the key to helping the greatest number of poor people, for three main reasons:

- It cuts the yield losses from dry spells—which can claim one of every five harvests in Sub-Saharan Africa.
- It gives farmers the security they need to risk investing in other inputs such as fertilizers and high-yielding varieties. Farmers dare not risk the little they have buying inputs for a crop that may fail for lack of water.
- It allows farmers to grow higher value market crops, such as vegetables or fruits. These are more sensitive to water stress and require costlier inputs. Farmers can then move away from low-value staple foods and earn cash incomes.

Improving agricultural productivity in areas that depend on rainfall has the greatest potential to reduce poverty and hunger, especially for Sub-Saharan Africa. Current yields in many rainfed settings are low, and improving rainfed farming could double or quadruple yields. Such yields "gaps" are greatest for maize, sorghum, and millet in Sub-Saharan Africa. Closing those gaps promises huge social, economic, and environmental paybacks.

**Slow uptake**

While numerous studies document the benefits of upgrading rainfed agriculture by soil and water conservation practices, water harvesting, and supplemental irrigation, these tend to be isolated successes. Adoption rates have been low for four main reasons: the low profitability of agriculture, lack of markets, relatively high labor costs, and high risks. Past efforts have not changed national yields very much. Needed now is to improve farmers' access to markets, credits, and inputs (fertilizers). But the first step would be to target water—because without having water where and when it is needed, rural people risk crop failure and hunger.

Investments to reduce vulnerability to water-related risks and improve productivity in rainfed areas are compelling for equity and for the environment. Investment costs per hectare are lower in rainfed areas than in irrigated areas. The systems can be quickly implemented, yield fast and high marginal returns, and slash poverty. The technologies for upgrading rainfed agriculture already exist—and in some cases have been around for thousands of years. For example, conservation tillage, which disturbs the soil as little as possible to avoid soil moisture loss, is practiced on 45 million hectares, mostly in South and North America. In Rajasthan, India, the restoration of traditional water-harvesting structures that had fallen into disuse allowed farmers to gain a second cropping season, improve their productivity, and reduce groundwater pumping costs.

Realizing the potential of existing rainfed areas reduces the need for water withdrawals for new large-scale irrigation development, although improving rainfed production through water harvesting and supplemental irrigation also requires infrastructure, if smaller and more distributed.

Realizing this potential also requires measures of risk mitigation. Agricultural production in semiarid areas is highly vulnerable to variable climate and to future climate change. And too much reliance on rainfall may reduce farmers' ability to adapt to change. Water-harvesting techniques are useful to bridge short dry periods, but longer dry periods may lead to crop failure. Because of this risk, farmers are reluctant to invest in fertilizers, pesticides, and labor, creating a circular pattern of risk and poverty. Adding an irrigation component is often an important element of upgrading rainfed agriculture.

Nor is upgrading rainfed agriculture free of negative environmental consequences. Depending on the setting, harvesting rainwater increases the amount of water depleted by crops, leaving less for runoff to rivers and lakes or for groundwater recharge. Impacts on downstream resources need site-specific assessments.

**Accelerating progress**
But with the right incentives and measures to mitigate risks for individual farmers, water management in rainfed agriculture holds large potential to increase food production and reduce poverty, while maintaining ecosystem services.

Key steps for tapping rainwater's potential to boost yields and incomes:

- *Make more rainwater available to crops when it is most needed*. This can be done by capturing more rainfall, storing it for use when needed, adding irrigation to rainfed systems, using it more efficiently, and cutting the amount that evaporates unused. Water harvesting, supplemental irrigation, conservation tillage, and small-scale technologies (treadle pumps and simple drip-irrigation kits) are all proven options. For example, small investments providing 100 liters per square meter for supplemental irrigation during dry spells when crops are flowering or at the grain-filling stage could more than double agricultural and water productivity. This is much less than what is required for typical full-time irrigation.
- *Build capacity*. Water planners and policymakers need to develop and apply rainwater management strategies, and extension services need the skills and commitment to get rainwater-exploitation techniques out to farmers and to work with them to adapt and innovate for their specific context. This has been a blind spot of river basin management.
- *Expand water and agricultural policies and institutions*. Rainwater management in upper catchments and on farms should be included in management plans, and supporting water institutions are needed. Usually government departments deal with water resources, irrigation, or provide agronomic advice to farmers. Rare are support services to provide guidance on water management a watershed scale.

Groundwater use in agriculture in much of Sub-Saharan Africa is still very slight and concentrated on commercial farms. But groundwater is increasingly important in supporting extensive pastoralism. The general impression among researchers is that groundwater use is insignificant in Sub-Saharan Africa, and its role in supporting livelihoods equally so. Recent explorations, however, suggest that quantities of groundwater annually withdrawn may be smaller than in South Asia or the United States, but groundwater already plays a significant role in supporting livelihoods in Sub-Saharan Africa by sustaining extensive pastoralism (Giordano 2006), irrigated agriculture, and water supply. One reason that smallholder irrigation experienced explosive growth in South Asia but has grown very slowly in Sub- Saharan Africa is the absence of rural electrification combined with the prohibitive costs of importing pump and irrigation equipment in Africa.

## *TARGET SMALLHOLDER AGRICULTURE PRODUCERS*

Broadly conceived, poverty reduction strategies will entail four elements:

- Empowering people to use water better, and targeting the right groups.
- Ensuring the right to secure access.
- Improving governance of water resources.

- Supporting the diversification of livelihoods.

Targeting smallholder producers—particularly in largely rainfed areas, but also in irrigated areas—offers the best chance for reducing poverty quickly in developing countries. Smallholder farmers make up the majority of the world's rural poor. Often occupying marginal land and depending mainly on rainfall for production, they are sensitive to droughts, floods, and shifts in markets and prices. In regions where agriculture constitutes a large proportion of the economy, water management in agriculture will remain a key element in strategies to reduce rural poverty. Smallholder farmers possess the greatest unexploited potential to directly influence land and water use management.

Focusing on livelihood gains by small-scale, individually managed water technologies holds great promise for poverty reduction in the semiarid and arid tropics. These include small pumps and innovative technologies such as low-cost drip irrigation, small affordable pumps, and small-scale water storage. These are affordable even for some of the poorest members of the community and can be implemented almost immediately, without the long delays of large projects. Private investments in pumps have improved the livelihoods and food security of millions of farmers and pastoralists in Africa and Asia. In the long run these can be viewed as a first step, followed by additional investments in infrastructure.

Clarifying water rights can ensure secure access to water for agriculture for poor women and men when carefully implemented. In certain circumstances collective water rights might be preferable to individual water rights. Acknowledging customary laws and informal institutions can facilitate and encourage local management of water and other natural resources. The capacity of people to manage their water resources can be enhanced through specific training. Local management should be integrated with basin, regional, and national institutions—and based within the broader context of rural development.

Where there is equity in resource distribution, the poverty reducing impact of improved water management on agricultural productivity growth has been greater. Inequality, particularly gender-based inequality, tempers the effectiveness of poverty reduction efforts. Women produce an estimated two-thirds of the food in most developing countries, yet they often have inadequate access to land, water, labor, capital, technologies, and other inputs and services. This situation is unjust and prevents women from realizing their full potential as human beings and citizens and compromises efforts to target water management for poverty reduction.

Small water management systems, built and operated by communities or individuals from groundwater, river water, and wastewater, are vital to many poor farmers but often are not officially recognized. Increased visibility of irrigation and water management of these informal systems will influence governments to provide policy and technical support and help to ensure poor farmers' continuing access.

Policymakers need to focus on both design and development of water resources infrastructure from a multiple-use system perspective. By doing so they can maximize the benefits per unit of water for poor women and men and ensure that institutional and legal frameworks guarantee the participation of rural people and marginal groups in all phases of policy development and decisionmaking for infrastructure investments. Multiple-use systems for domestic use, crop production, aquaculture, agroforestry, and livestock effectively improve water productivity and reduce poverty. The contributions to livelihoods, especially for poor households, of these multiple uses are substantial.

Fisheries should be better integrated in water resources management (see Dugan et al, 2007). They are an important source of livelihoods and nutrition. The value of freshwater fish production to human nutrition and incomes is far greater than gross national production figures suggest. The bulk of production is generated by small-scale activities, with exceedingly high levels of participation not only in catching and farming but also in the ancillary activities of processing and marketing. Where small-scale inland fisheries or aquaculture has been supported and well managed, fish-related activities play a critical role in generating wealth and sustaining economic growth (Béné 2006). For example, research in the Zambezi floodplain reveals that inland fisheries generate more cash for households than cattle rearing in most cases and more than crop production in some cases.

Livestock, too, need to be better integrated in water resources management (Peden et al, 2007). In addition to enhancing income and food security, livestock play a big role in livelihood strategies for 70% of the world's rural poor, enabling families to survive crop failure, cope with income shocks, and meet unexpected or major family expenses by selling an animal.

Irrigated mixed crop-livestock systems of Gezira, Sudan, Africa's largest contiguous irrigation scheme, was constructed about 1920. For more than 60 years there were no policies or plans to accommodate animal keeping. Now, livestock keeping provides 36% of farm income (Elzaki 2005). In a study on the feasibility of integrating livestock production with irrigated agriculture in Gezira, Elzaki (2005) argues that adding fodder in the crop rotation could increase farm income, provide animal feed, and boost milk production. She stresses the need for improved feed sourcing strategies within irrigation systems and improved veterinary care. She concludes that the main constraint facing improved investment returns in the irrigation system is the unclear and contradictory policy of the Gezira irrigation scheme management and the conflict between animal keepers and crop farmers. Strategic use of crop residues for feed and enhanced productivity of animals are key entry points for increased livestock water productivity, but contamination of water with pathogens now threatens both people and their animals

Agricultural water management investments alone cannot eliminate poverty. Many poverty reduction gains come from better credit and insurance, better farm practices, stronger links to markets and support services, and improved health care. So water management approaches need to be better integrated into broader poverty reduction strategies.

## *Increase the productivity of water*

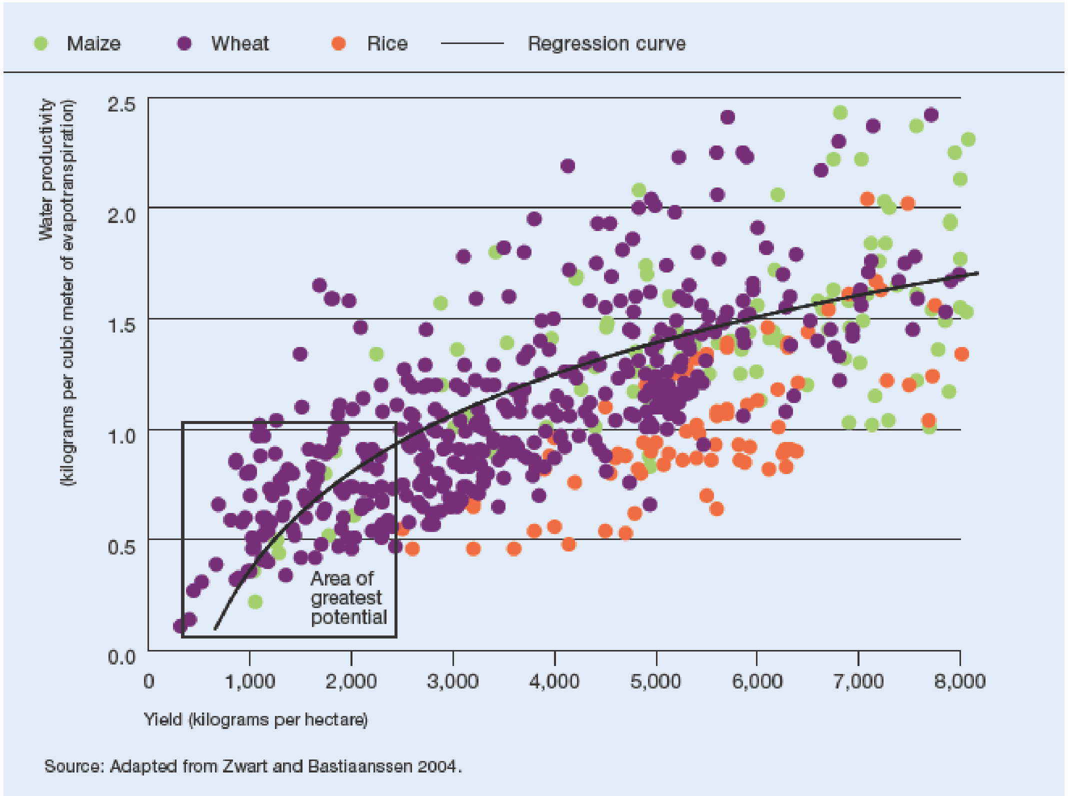
Increasing water's productivity—gaining more yield and value from water—is an effective means of intensifying agricultural production and reducing environmental degradation. There are reasons to be optimistic. There is still ample scope for higher physical water productivity—getting more produce per unit of water—in low-yielding rainfed areas and in poorly performing irrigation systems, where poverty and food insecurity prevail. Good agricultural practices—managing soil fertility and reducing land degradation—are important for increasing crop per drop. Our assessment of livestock and fisheries reveals scope for improvements in these systems as well—important because of the growing demand for meat and fish.

**Reasons for optimism—and caution**

There are many well known crop per drop improvements. These include more reliable and precise distribution and application (such as drip) of irrigation water, supplemental and deficit irrigation, improved soil fertility, and soil conservation practices. In smallholder livestock systems, feeding animals crop residues can provide a severalfold increase in water productivity. Integrated approaches are more effective than single technologies.

The highest potential for physical water productivity gains is areas presently exhibiting low yield (Figure 4). If we are concerned about limiting the amount of water used for agriculture globally, then a focus on low yielding areas is warranted. Across much of sub-Saharan Africa, yields are quite low, and a doubling of yield could lead to a doubling of water productivity. Gains in yield in areas with high land productivity yield little water productivity gains.

Figure 4. The highest potential gains in water productivity are in areas where yields are low – a situation across much of Sub-Saharan Africa.




Investments in soil fertility direcly improve water management. GLASOD estimates, degradation of cropland appears to be most extensive in Africa, affecting 65% of cropland areas, compared with 51% in Latin America and 38% in Asia. Degradation of pasture is also most extensive in Africa, affecting 31% of pasturelands, compared with 20% in Asia and 14% in Latin America. Trends are dire in Africa, where nutrient depletion in some East and Southern African countries is estimated to average 47 kg of nitrogen, 6 kg of phosphorous, and 37 kg of potassium per hectare a year (figure 15.2; Smaling 1993; Stoorvogel, Smaling, and Jansen 1993). Country averages hide important site-specific variation. Where farmers are poor and cannot afford inputs to replenish fertility, nutrient loss through soil mining (and selective erosion) is much higher. Nutrient depletion is now considered the chief biophysical factor limiting small-scale farm production in Africa (Drechsel, Giordano, and Gyiele 2004).

But caution and care must be mixed with the optimism. Water productivity gains are often difficult to realize, and there are misperceptions about the scope for increasing physical water productivity. For example:

- Much of the potential gain in physical water productivity has already been met in high-productivity regions.
- Waste in irrigation is less than commonly perceived, especially because of reuse of water locally or downstream—farmers thirsty for water do not let it flow easily down the drain.
- Major gains and breakthroughs, as those in the past from breeding and biotechnology, are much less likely.

- A water productivity gain by one user may be a loss to another—upstream gain may be offset by a loss in fisheries, or the gain may put more agrochemicals into the environment.

There is greater reason to be optimistic about increasing economic water productivity—getting more value per unit of water. How? By switching to higher value agricultural uses. Or by reducing costs of production. Integrated approaches—agriculture-aquaculture systems, better integrating livestock in irrigated and rainfed systems, using irrigation water for household and small industries—all are important for increasing the value and jobs per drop. One example: better veterinary services can improve water productivity because healthier animals provide more benefits per unit of water.

Inland fisheries, and related export and regional trade, can play a significant role in the economy of regions and countries. The sector contributes 7% to GDP in Cambodia and 4% in Bangladesh. In Africa inland fisheries provide employment and income for several million people. A recent estimate of employment and income for seven major river basins finds that in West and Central Africa alone fisheries provide a livelihood more than 227,000 full-time fishers and yield an annual catch of about 570,000 tons with a first-sale value of $295 million (table 12.1; Neiland and Béné, 2007). The study also estimates that the total potential annual fisheries production for the region (about 1.34 million tons with an annual value of $750 million) is more than twice the estimated actual production.2 Freshwater and brackish water aquaculture also play a major macroeconomic role in some Asian countries, notably as a source of foreign exchange and employment.

With a farmgate value of $28 billion in 2003, some three times that of inland capture fisheries, the contribution of freshwater aquaculture has increased rapidly in recent decades (FAO 2004). It is now the major contributor to inland fisheries production, having overtaken inland capture fisheries in 1986. The geographic significance of aquaculture is still uneven, with the major developments concentrated in Asia and production relatively low in Africa and some parts of Latin America.

Higher physical water productivity and economic water productivity reduce poverty in two ways. First, targeted interventions enable poor people or marginal producers to gain access to water or to use water more productively for nutrition and income generation. Second, the multiplier effects on food security, employment, and income can benefit the poor. But programs must ensure that the gains reach the poor, especially poor rural women, and are not captured by wealthier or more powerful users. Inclusive negotiations increase the chance that all voices will be heard.

Studies show that for every $1 in new farm income earned in Sub-Saharan Africa, at least one additional dollar could be realized from second-round effects. The estimates show that adding $1 of new farm income should boost total household income (including the original $1 stimulus) to $2.57 in Zambia, $2.48 in the Central Groundnut Basin of Senegal, $2.28 in Burkina Faso, and $1.96 in Niger. These estimates depend critically on the selections of a region’s catchment area (local, regional, national) and the classification of commodities in terms of their tradability. Consumption linkages dominate; the share of growth linkages attributable to consumption linkages alone was 98% in Zambia, 93% in Burkina Faso, 79% in Niger, and 42% in Senegal (Delgado and others 1994, 1998).

## *With the right policy and institutional environment*

Many known technologies and management practices promise considerable gains in water productivity. Achieving those gains requires a policy and institutional environment that aligns the incentives of various users at different scales—from field to basin to country—to encourage the uptake of new techniques and to deal with tradeoffs. It requires policies that:

- *Overcome risks*. Farmers face low prices for their output, uncertainties in markets, and uncertainties in water distribution and rain. Managing water reduces some of these risks. Better market access and information help. But some sort of insurance may also be needed.
- *Provide incentives for gains in water productivity*. The incentives of producers (more water for more produce and income) are often much different from those of broader society (less water for agriculture, more for cities and the environment). Rather than trying to charge farmers more for water use, the parts of society benefiting from reallocations may need to compensate farmers for less water use in agriculture.
- *Adjust basin-level water allocation policies*. Changes in practices aimed at increasing water productivity result in changes in other parts of a river basin. Increasing agricultural production by using saved water or increasing water harvesting may leave less water for downstream users—such as coastal fisheries. Before implementing change, there must be an understanding of basin hydrology and an overall perspective on water allocation programs, so that there is a real increase in basin-level water productivity, not just local gains.
- *Target the poor with sustainable, water productivity-enhancing practices*. Wealthier and more powerful users tend to capture gains, especially in ill-devised development or relief programs. A long-term, carefully designed program—to integrate technologies, practices, and markets, to reduce risks, and to ensure profitability—is required for pro-poor gains.
- *Look for opportunities outside the water sector*. Many possibilities exist for addressing the vulnerability, risk, markets, and profitability of agricultural enterprise.

## *Reform the reform process—targeting state institutions*

The state will retain its role as the main driver of reform, but it is also the institution most in need of reform. There are cases of “failing states” in addition to situations where structural adjustment has brought major transformations to the detriment of agriculture and water management. The state must take responsibility for ensuring greater equity in access to water resources and foster investments to reduce poverty. Protecting essential ecosystem services is also vital, especially to poor people’s livelihoods.

The last 30 years of attempts at agricultural water reform have, with few exceptions, shown disappointing results (see Merrey et al, 2007). Despite repeated calls for decentralization, integration, reform, and better governance, implementation has not been entirely successful, and much remains to be done to achieve effective changes.

The approach to reform needs to be reconsidered. Instead of the linear, prescriptive models that have dominated thinking for the past several decades, the Comprehensive Assessment proposes a more nuanced and organic approach to institutional reform—one grounded in the local socioeconomic, political, and physical environment and cognizant of the dynamic nature of institutions.

**Why have previous approaches so often failed?**

Many reforms have not taken into account the history, culture, environment, and vested interests that shape the scope for institutional change. Reforms have focused on formal irrigation or water management policies and organizations and have ignored the many other factors that affect water use in agriculture—policies in other sectors, user institutions, and broader social institutions on "blueprint" solutions—solutions that follow a model that may have been successful elsewhere. Another reason reforms fall short is a focus on a single type of organization rather than the larger institutional context. Focusing on formal irrigation or water management policies and organizations, most reforms have ignored the many other factors that affect water use in agriculture—policies and government agencies in other sectors, informal user institutions, and the macroeconomic environment and broader social institutions.

Other common stumbling blocks include:

- *Inadequate support for reform at required levels*. Change requires support at the policy and decisionmaking level and at the implementation level.
- *Inadequate capacity building and incentives for change*. For individuals and organizations to change their way of doing things, they often need new skills and knowledge.
- *Repeated underestimation of the time, effort, and investment required to change*. Particularly for reforms tied to time-bound, donor-funded projects, there is a tendency to expect too much too quickly. The result: reforms are prematurely judged unsuccessful and are left incomplete or abandoned.

Countries would do well to consider placing more emphasis on developing, managing, and maintaining collaborative relationships for basin governance—building on existing organizations, customary practices, and administrative structures. Implementation has frequently foundered on political opposition, compounded by difficulties in measuring water deliveries and collecting fees from large numbers of small users.

Moving forward requires strategies for institutional and policy reform that take into account today's (and yesterday's) realities. First, reform is an inherently political process. Second, the state is the primary, but not the only, driver in reform. Third, the pluralism and social embeddedness of institutions affect water development, management, and use. Fourth, capacity building, information sharing, and public debate are essential. Fifth, implementation plans must be responsive to new knowledge and opportunities.

## *Deal with tradeoffs and make difficult choices*

Water management today requires making difficult choices and learning to deal with tradeoffs. In reality, win-win situations will be hard to find. But a consultative and inclusive process for reaching decisions can help ensure that tradeoffs do not have inequitable effects.

Reform and change are unpredictable. Even with the best science there will always be a high level of uncertainty about external drivers and about the impacts of decisions. One of the biggest drivers will be climate change, which will affect productivity and ecosystems and will require policies and laws in response to change. Water management institutions must take an adaptive management approach. They need the capacity to identify danger signs and the flexibility to change policy when better understanding emerges.

**Seven imperatives for today's agricultural water management** (Merrey et al, 2007)**.**

1. Get technical water bureaucracies to see water management not just as a technical issue but also as a social and political issue. This would require meeting the multiple water needs of poor women and men—for growing food, for drinking, for enabling hygiene and sanitation, and for generating income through a range of activities.
2. Support more integrated approaches to agricultural water management. Examples include managing water to enhance ecosystem services in addition to crop production, incorporating livestock and fisheries into water management, improving rainwater management and encouraging investments to upgrade rainfed production, and supporting systems and services that encompass multiple water uses, safe reuse of wastewater, and joint use of surface water and groundwater.
3. Create incentives for water users and government agency staff to improve the equity, efficiency, and sustainability of water use.
4. Improve the effectiveness of the state, particularly in its regulatory role, and find the right balance between action by the state and by other institutional actors.
5. Develop effective coordination and negotiation mechanisms among the state, civil society, and private organizations in water development and management and in related sectors.
6. Empower women and marginalized groups who have a stake but currently not a voice in water management. Specific support institutions are needed to progress toward the Millennium Development Goals.
7. Build coalitions among government, civil society, and private and community users—and harness market forces for successful reform. multistakeholder negotiations are required to deal with tradeoffs, and innovative means to apply decisions.

**Making difficult choices**

The state's role in driving reform may be critical, but it cannot make changes alone. Alone, writing new laws or passing administrative orders achieves little. Good governance is rarely triggered by well intentioned policy documents or participatory rhetoric. The Comprehensive Assessment finds that more balanced outcomes are generally reached when there is a mix of political space allowed by the state and active organization of civil society to defend causes or population groups.

There is a need to identify incentives or mechanisms to compensate those who stand to lose in water allocation decisions. The concept of payment for environmental services has given ecosystems a voice in this.

Elements critical for negotiating tradeoffs:

*Foster social action and public debate*. Public debate based on shared information creates more trust, legitimacy, and understanding of the reasons for change—increasing the likelihood of implementation. Such debate creates opportunities to include poor stakeholders—those with the most to gain (or lose), among them the too-often unrecognized landless, fishers, pastoralists, and those dependent on wetland and forest ecosystem services.

*Develop better tools for assessing tradeoffs*. Such tools can help in deciding which ecosystem services in a particular area most benefit society. Existing tools include cost-benefit analyses, valuation of nonmarket services, assessments of risk and vulnerability, and models for estimating the water flows required by wetlands.

*Share knowledge and information equitably*. More data need to be generated, turned into reliable information, and shared widely with stakeholders to empower them through better awareness and understanding—that is, through knowledge. New skills and capacities in water management institutions are critical—at a time when government capacities to attract and hold people with this expertise are weakening.

## *Summary*

Investing in water security for food production is a key to improving livelihoods across Africa. A concerted effort to improve access to water for agriculture and to improve agricultural productivity is needed now. These actions should consider a range of options from small scale water management to large scale irrigation. They need to carefully consider livestock and fisheries as well as crop production. And investments need to target smallholder farmers. Benefits will be realized with supportive policies and institutions, and the human capacity to carry out an intensive effort in agricultural water management.

## *References*


Béné, C. 2006. “Small-scale Fisheries: Assessing Their Contribution to Rural Livelihoods in Developing Countries.” FAO Fisheries Circular 1008. Food and Agriculture Organization, Rome.

Comprehensive Assessment of Water management in Agriculture (CA), 2007. *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture*. Molden, D.J. (Ed.). London: Earthscan, and Colombo: International Water Management Institute.

de Fraiture, Charlotte, D. Wichelns, J. Rockstrom, E. Kemp-Benedict, Nishadi Eriyagama, L.J. Gordon, M.A. Hanjra, J. Hoogeveen, A. Huber-Lee, L. Karlberg, 2007. Looking ahead to 2050:

Scenarios of alternative investment approaches. In Molden, David (Ed.). Water for food, water for life: A Comprehensive Assessment of Water Management in Agriculture. London, UK: Earthscan; Colombo, Sri Lanka: IWMI. pp.91-145.

Delgado, C., P. Hazell, J. Hopkins, and V. Kelly. 1994. "Promoting Intersectoral Growth Linkages in Rural Africa through Agricultural Technology and Policy Reform." *American Journal of Agricultural Economics* 76 (5): 1166–71.

Delgado, C., J. Hopkins, V. Kelly, P. Hazell, A. Mckenna, P. Gruhn, B. Hojjati, J. Sil, and C. Courbois. 1998. *Agricultural Growth Linkages in Sub-Saharan Africa*. Research Report 107. International Food Policy Research Institute, Washington, D.C.

Drechsel, P., M. Giordano, and L. Gyiele. 2004. *Valuing Nutrients in Soil and Water: Concepts and Techniques with Examples from IWMI Studies in the Developing World.* IWMI Research Report 82. Colombo: International Water Management Institute.

Dugan, Patrick, Veliyil Vasu Sugunan, Robin L. Welcomme, Christophe Béné, Randall Brummet et al., 2007. *Inland Fisheries and Aquaculture. Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture*. Molden, D.J. (Ed.). London: Earthscan, and Colombo: International Water Management Institute.

Elzaki, R. 2005. "The Feasibility of Integration of Livestock Production in Irrigated Agriculture in Sudan: Case Study: The Gezira Scheme." PhD Thesis. University of Giessen, Department of Project and Regional Planning.

Falkenmark, M. Finlayson, C.M. and Gordon, L.J. 2007. Chapter 6: Agriculture, water, and ecosystems: avoiding the costs of going too far In**:** Comprehensive Assessment of Water management in Agriculture. *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture*. Molden, D.J. (Ed.). London: Earthscan, and Colombo: International Water Management Institute. Pages 233-277

Faures, Jean-Marc, Mark Svendsen, Hugh Turral and others. *Reinventing Irrigation.* In**:** Comprehensive Assessment of Water management in Agriculture. *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture*. Molden, D.J. (Ed.). London: Earthscan, and Colombo: International Water Management Institute.

FAO (Food and Agriculture Organization). 2006c. *World Agriculture: Towards 2030/2050. Prospects for Food, Nutrition, Agriculture and Major Commodity Groups.* Interim report. Global Perspective Studies Unit. Rome.

FAO (Food and Agriculture Organization). 2005a. AQUASTAT database. [www.fao.org/ag/agl/aglw/aquastat/main/index.stm].

FAO (Food and Agriculture Organization. 2004. *The State of World Fisheries and Aquaculture*. Fisheries Department. Rome.

FAO (Food and Agriculture Organization). 2002. *World Agriculture: Towards 2015/2030: Summary Report*. Rome.

FAOSTAT. 2006. Statistical database. Accessed June 2006. [http://faostat.fao.org/].

Giordano, M. 2006. "Agricultural Groundwater Use and Rural Livelihoods in Sub-Saharan Africa: A First-cut Assessment." *Hydrogeology Journal* 14 (3): 310–18.

Hussain, I., and M.A. Hanjra. 2003. "Does Irrigation Water Matter for Rural Poverty Alleviation? Evidence from South and South-East Asia." *Water Policy* 5 (5–6): 429–42.

———. 2004. “Irrigation and Poverty Alleviation: Review of the Empirical Evidence.” *Irrigation and Drainage* 53 (1): 1–15.

Merrey, D. J., Meinzen-Dick, R., Mollinga, P. P., Karar, E., Huppert, W., Rees, J., Vera, J., Wegerich, K. & Van Der Zaag, P. (2007) Policy and institutional reform: The art of the possible, in: D. Molden (Ed.) *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture* (London, UK: Earthscan; Colombo, Sri Lanka: IWMI). pp. 193-231.
Neiland, A., and C. Béné, eds. 2007. “Tropical River Fisheries Valuation: A Global Synthesis and Critical Review.” WorldFish Center and International Water Management Institute, Penang, Malaysia and Colombo.

Peacock, T., C. Ward, and G. Gambarelli. Forthcoming. *Investment in Agricultural Water for Poverty Reduction and Economic Growth in Sub-Saharan Africa. Synthesis Report*. Collaborative Programme of African Development Bank, Food and Agriculture Organization, International Fund for Agricultural Development, International Water Management Institute, and World Bank. Columbo.
Peden, Don, Girma Tadesse, A.K. Misra and others, 2007. in: D. Molden (Ed.) *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture* (London, UK: Earthscan; Colombo, Sri Lanka: IWMI).

Johan Rockström Johan, Nuhu Hatibu, Theib Y. Oweis, Suhas Wani, and others. 2007. Managing Water in Rainfed Agriculture. in: D. Molden (Ed.) *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture* (London, UK: Earthscan; Colombo, Sri Lanka: IWMI).

xSmaling, E.M.A. 1993. “An Agro-ecological Framework for Integrated Nutrient Management.” Ph.D. thesis. Wageningen Agricultural University, Wageningen, Netherlands.

xStoorvogel, J.J., E.M.A. Smaling, and B.H. Jansen. 1993. “Calculating Soil Nutrient Balances in Africa at Different Scales: I; Supranational Scales.” *Fertiliser Research* 35: 227–35.

Van Dijk, A., R. Evans, P. Hairsine, S. Khan, R. Nathan, Z. Paydar, N. Viney, and L. Zhang. 2006. *Risks to the Shared Water Resources of the Murray-Darling Basin*. Part II. Prepared for the Murray-Darling Basin Commission. MDBC Publication 22/06. Clayton South, Victoria, Australia: Commonwealth Scientific and Industrial Research Organization.

Zwart, S.J., and W.G.M. Bastiaanssen. 2004. “Review of Measured Crop Water Productivity Values for Irrigated Wheat, Rice, Cotton, and Maize.” *Agricultural Water Management* 69 (2): 115–33.