THE WORLD BANK

A COLLABORATIVE PROGRAM OF AFDB, FAO, IFAD, IWMI, AND THE WORLD BANK

Investment in Agricultural Water for Poverty Reduction and Economic Growth in Sub-Saharan Africa

Synthesis Report

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THE WORLD BANK
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Foreword

This report summarizes the results of a Collaborative Program of a group of international development agencies—AfDB, FAO, IFAD, IWMI, and the World Bank—to review the experience to date of agricultural water investment in sub-Saharan Africa and to identify the conditions for successful investment in sustainable, cost-effective agricultural water development.

The Collaborative Program

In 2001, AfDB, FAO, IFAD, IWMI, and the World Bank identified the low level of investment in agricultural water in sub-Saharan Africa as a major development issue. The agencies, therefore, decided on a joint Collaborative Program to review the current state of agricultural water development and experience gained to date in Sub-Saharan Africa in order to: (a) better understand its performance and potential, (b) identify changes in the development context, and (c) develop recommendations to improve investment performance. The objective was to improve the quality of assistance to governments and induce greater investment flows, as well as influence the assistance provided by bilateral donors.

As a first step, in June 2001 a stakeholders' workshop was convened in Harare to define the problems and to chart the scope and course of the Collaborative Program. At the workshop, stakeholders identified factors contributing to low levels of investment. The principal concerns were perception of low economic returns compared to alternative investments; a lack of financial viability; poor sustainability; and the relative wastefulness of agricultural water use. The program was thus designed to assess the validity of these perceptions and to propose ways to overcome the underlying constraints.

At the Harare workshop, it was also decided that there were a number of strategic topics that required study before the overall question of how to catalyze increased investment in agricultural water development for crop production in sub-Saharan Africa could be addressed. Guided by a steering committee and a working group, detailed component studies were prepared on the following topics:[1]

- Demand for products of irrigated agriculture;
- Assessment of potential of agricultural water management for food supply;
- Agricultural water development for poverty reduction;
- Costs of agricultural water development;
- Private sector participation in agricultural water development;
- Health and environmental aspects;
- Irrigation development planning and implementation; and
- Integrated water-livestock-crop production.

In 2002, New Partnership for Africa's Development (NEPAD) developed the Comprehensive Africa Agricultural Development Programme (CAADP), which gives a central place to the development of agricultural water. With FAO support, NEPAD member states are currently preparing National Medium-Term Investment Plans proposing a significant increase in investment in agricultural water. This report is expected to support these planning processes.

Synthesis Report

This Synthesis Report has been prepared on the basis of the detailed component studies and other sources as an input to a process of discus-

1. The reports on component studies are listed in Annex 1.

sion and decision making aimed at increasing investment in agricultural water in sub-Saharan Africa. The Report represents the consolidated views of the agencies concerned on how to improve the effectiveness of agricultural water development in the region and thereby increase investment levels.

The report analyses the contribution to date of agricultural water management to poverty reduction and growth in the region, the reasons for its slow expansion and apparently poor track record, as well as the ways in which increased investment in agricultural water management could make a sustainable contribution to further poverty reduction and growth.

Chapter 1 places agricultural water management in the context of the Millennium Development Goals and paths to poverty reduction through agricultural growth. Chapters 2 to 5 contain a regional diagnostic that looks at the role of agricultural water management in sub-Saharan Africa, examines the contribution that investment projects have made, reviews the changing institutional context, and assesses the potential for further development. Chapter 6 then summarizes the lessons and recommendations for increasing the contribution of agricultural water management to poverty reduction and growth in the region.

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2. IFAD consultant (also member of Working Group).

3. World Bank consultant.

4. World Bank.

Acronyms and Abbreviations

ADB	Asian Development Bank
AfDB	African Development Bank
CAADP	Comprehensive Africa Agriculture Development Program
CP	Collaborative Program
CPIA	Country Policy and Institutional Assessment
DFID	Department for International Development (UK)
DRC	Domestic resource cost
ERR/EIRR	Economic Rate of Return/Economic Internal Rate of Return
EAP	East Asia and the Pacific
ECA	Europe and Central Asia
EU	European Union
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
HYV	High-yielding variety
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IPTRID	International Program for Technology and Research in Irrigation and Drainage
IRWR	Internal Renewable Water Resources

IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
LAC	Latin America and the Caribbean
MCM	Million cubic metres
MDG	Millennium Development Goal
MENA	Middle East and North Africa
M&E	Monitoring and evaluation
NEPAD	New Partnership for Africa's Development
NGO	Non Governmental Organization
NMTIP	National Medium-Term Investment Plan
O&M	Operation and Maintenance
PPAR	Project Performance Assessment Report
PPP	Public-private partnership
PRSP	Poverty Reduction Strategy Paper
SA	South Asia
SADC	Southern African Development Community
SSA	Sub-Saharan Africa
SWAp	Sector-wide approach
TRWR	Total Renewable Water Resources
WARDA	West African Rice Development Agency
WB	World Bank
WP	Working Paper
WUA	Water Users' Association

Glossary

Agro-ecological zones are defined by FAO on the basis of average annual length of growing period for crops, which depends *inter alia* on precipitation and temperature. The lengths are: humid > 270 days; moist sub-humid 180–269 days; dry sub-humid 120–179 days; semiarid 60–119 days, and arid 0–59 days.

Deficit irrigation is the application of less irrigation water than that required for maximum plant growth, to optimize yield per unit of water rather than land—in other words, to optimize water productivity.

Diversification is defined as a modification of the farm enterprise pattern to exploit new or existing market opportunities, thereby to increase farm income or reduce income variability.

Drainage is the removal of excess water from agricultural land.

Dryland crops are those crops grown under naturally occurring rainfall without irrigation, drainage, or taking advantage of rising or falling water tables. Dryland crops are sometimes referred to as rainfed crops.

Empowerment is defined as strengthening the social and economic rights of people—and helping them gain the confidence to assume a meaningful role in developing their own livelihoods. It involves enabling people, by providing them with the necessary skills and knowledge to influence all decisions that affect their livelihoods and by building institutions (i.e., policies, legal frameworks and organizations, including community-based organizations) that are responsive their needs.

Farmers' Field Schools are a way of testing and adapting new technologies. They consist of a community-based, practically oriented, field study program, involving a group of farmers, facilitated by extension staff (public or private) or, increasingly, by other farmers, in which farmers learn together and test and adapt practices, using practical, 'hands-on' methods of discovery learning that emphasize observation, discussion, and analysis to combine local indigenous knowledge with new concepts.

Food security is the condition of being able supply one's food needs either from one's own production or by buying from other sources, whichever is more economically advantageous. Food security may be expressed in terms of the household, the nation, or the region.

Food self-sufficiency is the condition of being able to meet one's food needs from own production without resorting to other sources. Food self-sufficiency may be expressed in terms of the individual household, the nation, or the region.

In-field rainwater management consists of operations to enhance the effectiveness of rainfall for dryland crop growth.

Integrated Water Resources Management is the approach that evolved from the 1992 *Dublin Statement on Water and Sustainable Development* that called for an integrated, intersectoral approach to water management and allocation. The IWRM approach emphasizes: (a) the need for a whole catchment approach to development and subsidiarity in planning and decision making; (b) the pivotal institutional role of women; (c) basic human rights to clean water and sanitation at an affordable price; and (d) the need for economic efficiency in water use.

Intensification is defined as producing more per unit of land.

Irrigation consists of operations to supply additional water to agricultural land to augment rainwater (if any) for the purpose of crop growth. Irrigation water may be supplied from groundwater, surface water, agricultural drainage wastewater or other wastewater (including that from domestic or industrial use). For the purpose of this report, reference to irrigation should also be taken to include drainage where appropriate.

Large, medium, small, and micro-scale. For the purposes of this report, 'large-scale' refers to an irrigated area of 1,000 hectares and more; 'medium-scale' refers to an irrigated area of at least 100 hectares but less than 1,000 hectares; 'small-scale' refers to an irrigated area of more than 1 hectare but less than 100 hectares; 'micro-scale' refers to an irrigated area of up to 1 hectare, such as irrigated vegetable gardens.[1] Each of these categories could be operated by either the public or private sector, although the smaller areas are usually operated by individuals or groups of individuals.

Market links are defined as arrangements under which agricultural processing or marketing companies enter into mutually beneficial contract arrangements with producers to provide technical support and inputs in return for an assured throughput of produce.

Supplemental (or supplementary) irrigation involves providing water to augment rainfall for crop growth. Most irrigation is supplementary, except where it is provided entirely within a dry season.

Water harvesting (or rainwater harvesting or runoff harvesting) is the collection and concentration of runoff, with or without storage, for use in irrigating crops. The use of large, medium, and small dams and weirs for irrigation may be considered as a form of water harvesting, but the term is generally used to refer to the collection of runoff from very small catchment areas (from as small as the roof of a house to as much as 200 hectares).

Watershed management consists of operations to conserve catchment areas by sustainable land use practices to maintain or enhance the quality and quantity of their water flows.

1. The definition of 'large' in the context of scale of agricultural water developments varies from country to country.

Executive Summary

Poverty and Agricultural Growth

The multiple facets of poverty can be divided into two broad types: income poverty and non-income poverty. Because people who are income poor tend to also be poor in other respects, the Millennium Development Goals consider poverty in terms of income and use a *per capita* income of $1/day[1] as the threshold for extreme poverty. This is significant because it focuses attention on the overarching importance to poverty reduction of increasing household incomes.

Although the world as a whole is roughly on track to do so, sub-Saharan Africa is unlikely on present trends to reach Target 1 of the MDGs—i.e., to halve, by 2015, the number of people living on less than $1/day. Indeed, if nothing changes, the absolute numbers of poor in the region will continue to increase and by 2015 close to one-half the world's poor will live in this region.

Eighty-five percent of sub-Saharan Africa's poor live in the rural areas and depend largely on agriculture for their livelihoods. Agricultural growth is therefore clearly key to poverty reduction; it can also help drive national economic growth. Yet agriculture in the region remains a

1. All dollar figures are US dollars.

largely subsistence activity, production has not kept pace with population growth, food self-sufficiency has declined, the household income required to afford bought-in food has not been generated; and the numbers of malnourished people are consequently rising.

Agricultural Water Development, Growth, and Poverty Reduction

Investment in agricultural water can contribute to agricultural growth and reduce poverty directly by: (a) permitting intensification and diversification and hence increased farm outputs and incomes; (b) increasing agricultural wage employment; and (c) reducing local food prices and hence improving real net incomes. It can also reduce poverty indirectly via increased rural and urban employment as a result of the multiplier effect on growth in rural and urban non-farm economies—and the potential multipliers from agricultural water investment are generally higher than those from comparable investment in dryland agriculture.

And yet sub-Saharan Africa's agricultural water remains underdeveloped: there are only 9 million hectares of land under water management in the region today, representing just 5 percent of the total cultivated area of 183 million hectares—by far the lowest proportion of any region in the world. Of this, 7 million hectares are equipped for full or partial irrigation—less than one-fifth of the estimated physical potential of 39 million hectares—while the balance of 2 million hectares is under 'other forms of water management' such as flood recession cropping. Only about 70 percent (5 million hectares) of the equipped area is operational. Water withdrawals for agriculture are therefore limited—less than 3 percent of total renewable resources—and although a number of basins are currently experiencing or are approaching water scarcity, this is mainly because of a lack of storage rather than absolute scarcity.

One of the reasons for underdevelopment of the subsector is that there has in the past been a lack of strategic vision linking agricultural water development to poverty reduction and growth. Water sector strategies (including those based on integrated water resources management (IWRM) principles) are generally neutral—or even negative—toward agricultural water use, possibly because of perceptions of economic and water use inefficiency. Furthermore, even though most poverty reduction strategies are predicated on agricultural growth, agricultural water development has generally not been seen as a vehicle for achieving this; consequently it has had a low profile in PRSPs.

Cost and Performance of Irrigation Development

Although the cost of public irrigation development in sub-Saharan Africa has been excessively high in the past, a new generation of well-designed and implemented irrigation projects has proved to be only marginally more costly than those of other regions. However, irrigated cropping in the region continues to be characterized by low productivity and hence low profitability. This has serious implications for poverty reduction and growth, because without profitability the necessary income gains cannot be achieved and without profitability there is unlikely to be economic viability—without which projects will not contribute to national economic growth.

Low productivity is correlated with unreliable water supplies, low input use (sub-Saharan African farmers use an average of only 9 kg/ha fertilizer compared with 100 kg/ha in South Asia and 135 kg/ha in East Asia) and difficulty in accessing profitable output markets. Low productivity can also be attributed to inadequate assessment and mitigation of negative environmental and health impacts—including the impact of HIV/AIDS. Yet, where water supplies have been reliable with good access to markets and a conducive institutional environment—all of which have encouraged investment in yield-enhancing inputs—productivity has proved comparable with that of post-Green Revolution Asia. Clearly, providing irrigation water alone will not guarantee increased productivity: not only must water supplies be reliable but they must be provided as part of a comprehensive and sustainable package that empowers farmers to commercialize their yields and production, as well as giving them incentives to do so—including improved access to input and output markets.

Irrigation for Cereal Crops

The demand for cereal crops will expand rapidly in the coming years, and unless domestic production can be increased, imports will continue to rise. Since more than one-half of the currently irrigated area is already used for growing cereals, recent policy analyses have considered irrigation as a means of reducing these imports. Irrigated rice cultivation has proved profitable, at least for the local market, where yields are relatively good and investment costs are not too high. But at the yields typically obtained by smallholders, other cereals—such as maize and wheat—have proved less profitable under irrigation, particularly with the continuing decline in world prices. If investment in expansion of irrigation for non-rice cereal crops is to be justified, significant productivity improvements or cost reductions will have to be achieved, failing which any increased supply of these crops from within the region is likely to have to depend largely on improving dryland production.

In-Field Rainwater Management

Recent decades have therefore seen increased interest in technologies for in-field rainwater management for dryland crops, the objective of which is to increase the effectiveness of rainfall to stabilize and enhance yields. The most promising of these are the various types of conservation farming, including deep tillage, reduced tillage, zero tillage, and various types of planting basins, all of which have been successfully demonstrated in many parts of the region, both in the semi-arid and dry sub-humid zones. The results have been impressive, particularly when the various technologies have been combined with use of yield-enhancing inputs. Yet adoption by smallholders has generally been poor, except where it has been possible to establish a market link with a processor (e.g., for cotton) that has been prepared to provide technical support, in-kind credit, and a viable guaranteed market price. Otherwise, adopters have tended to lose interest in the technology once project support has ended. Either the technology was not profitable enough, or there were sector-wide constraints such as a lack of support services and poor access to input and output markets.

Yet the rationale for investment in in-field rainwater management is sound: improved dryland cropping could have as much potential—in terms of cropped area and numbers of potential beneficiaries—as irrigation development. It could also be the answer to meeting the region's mounting food import bills. What is required is to identify profitable technologies and the specific barriers to their adoption and to invest in overcoming these and market-led dissemination of the technology.

Development Potential and Constraints to Further Investment

Since less than one-fifth of the physical potential for irrigation has been developed to date there is clearly significant potential for expansion (although this would require the construction of some additional water storage). In addition, there is potential for improving the productivity of the 5 million hectares currently under irrigation and for bringing back into production the 2 million hectares of land that is equipped for irrigation but currently unused. A mix of interventions is likely to be required to realize these potentials, such as development of new irrigation infrastructure and improvement of existing areas (for large, medium, small, and micro-scale schemes, including water harvesting), as well as improved in-field water management and crop husbandry. There is also potential for improving water control on the 2 million hectares of land under 'other forms of water management'—i.e., in wetlands and valley bottoms. This may require the development of irrigation and drainage schemes shared by a number of farmers, but in many cases the development of small areas by individual smallholder irrigators, using micro-irrigation technologies (e.g., treadle pumps), will be more appropriate. As mentioned, there is also considerable potential—possibly several times greater than that for irrigation, in terms of cropped areas and numbers of beneficiaries—for improving dryland crop production, particularly staple food crops but also cash crops such as cotton, by in-field rainwater management.

The main constraints to developing this potential are interrelated: they are both economic and institutional. Economic constraints include macro-economic and sectoral policies, lack of profitable markets, and the costs of development and production. Institutional constraints include the legal frameworks for land, water and farmer organizations, the organization of public agencies for investment and management, and lack of empowerment of farmers to manage their water resources and access effective agricultural support services, finance, and markets. Without reforms, productivity and farm level profitability will continue to be constrained. However, reforms require capacity building, time, and consistent approaches by both governments and donors, and the inclusion of other stakeholders—especially farmer representatives.

Agro-Ecological Zones, Farming Systems, and Targeting

The major farming systems of the region broadly correspond with the main agro-ecological zones. Although the arid and semi-arid zones cover 39 percent of the land area of the region, the share of agricultural population of these zones is only 16 percent. The great majority of people depending on agriculture for their livelihoods therefore live in the higher potential sub-humid and humid zones—which consequently also coincide with the greatest pressure for agricultural intensification. The greater opportunities for poverty reduction and growth are therefore likely to be found in the more humid zones than in the arid and semi-arid zones. The corollary is that it is not necessarily pro-poor to target the drier agro-ecological zones, where agricultural water development is often more costly—and markets more remote—than the more humid zones, making profitability, economic viability, and sustainability difficult to achieve. That said, where land, water, and markets combine favorably, agricultural water development in the drier areas can be successful. The key is to ensure that this combination is in place for investments in these areas.

Targeting the Poor and Women

Past attempts at targeting the poorest socioeconomic stratum have not been very successful. It has been found instead to be better to adopt a more inclusive approach based on principles of equity but geared to maximizing profitability and household incomes. Since the vast majority of people in the rural areas fall within the category of 'extreme poor' (i.e., they subsist on less than $1/day), such an inclusive approach results in most beneficiaries being drawn from this category anyway. Also, the inclusion of some of the better-off can help to drive profitability and household incomes for the less well-off. Furthermore, where the poorest cannot for some reason benefit directly as participants, they can benefit directly from increased agricultural wage employment.

However, specific measures are necessary to ensure that the poorest (as distinct from the 'poor') are not excluded or further marginalized, and that if the poorest do not benefit as producers or through wage employment, they do so in other ways, such as improved access to domestic or livestock water or possibly crop by-products for livestock feed. It is also essential to recognize the important role played by women in most production systems. Specifically targeting women and encouraging their participation in governance structures has been found to enhance productivity and poverty reduction impacts.

Monitoring and Evaluation

Monitoring and evaluation of the implementation of agricultural water investment projects has generally been poor. Effective M&E is required not only to provide details of how well the project is managing its resources to achieve intended results or targets, but also the extent to which the achievement of targets actually contributes to the overall objective of the project. Moreover, this information is required by all of the actors involved, including farmers, implementers, project supervisors, and financiers.

Monitoring such key production indicators as input and output prices, use of inputs, yields, areas planted, and production is also essential for subsequent farm management purposes because farmers need to know how profitable their application of resources and technology is from season to season to enable them to make adjustments as required. Monitoring these indicators is also necessary to permit estimates of changes in household incomes and evaluation of income poverty reduction. Qualitative proxies will not do. It is also necessary to monitor other factors that affect yields and production such as water availability.

The general lack of effective M&E of implementation and subsequent performance of the investment to date is likely to have had a negative impact on project outcomes because those responsible have not been alerted to weaknesses soon enough to enable them to take effective remedial action. While farmers are better placed than anyone else to carry out monitoring at the farm level, projects have an important role to play in establishing farmer-based M&E systems and carrying out higher level monitoring.

Implementation and Supervision

The design and implementation of projects—large, medium, small, and micro-scale—has in the past been largely top down. The quality of projects has been reduced by common weaknesses in preparation, particularly poor treatment of the key land and water security issues, lack of evaluation of markets and profitability, lack of an agricultural support package, over-estimation of institutional capacity, and poor technical design. However, recent more participatory approaches have begun to produce better, more sustainable results, and quality has improved as the arrangements for project design, implementation, and management have reflected the comparative advantages of the public sector, private sector, NGOs, and farmers. Supervision by government and donors has too often focused on reaching physical and disbursement targets at the expense of development effectiveness, and has not been supportive and flexible enough to help managers to deal with the complex technical, financial, and social problems that arise during implementation.

Key Recommendations

Adopt a Strategic Vision

The governments of sub-Saharan African countries should promote national agricultural water development strategies that recognize: (a) the potential contribution of agricultural water to poverty reduction and growth; (b) the imperatives of farm-level profitability and economic viability; and (c) the need for a conducive institutional environment (i.e., policies, legal frameworks, and organizations that foster profitable, sustainable water-managed farming by smallholders).

The strategies should be supported by analyses of institutions, identifying: (a) the respective roles of the public and private sectors, the organization and incentives for the public organizations involved, and ways to foster participation of the private sector; (b) the rules of engagement of the public sector, including its role in investment and management, and the place of subsidies; and (c) the barriers to commercialization of agricultural water management by smallholders and specific ways to overcome them.

The strategies should also analyze the various investment options, including:

- Increasing the productivity and profitability of existing irrigation schemes;
- Expanding or developing new viable large, medium, small, and micro-scale irrigation systems (including systems based on water harvesting);
- Testing and dissemination of viable, farmer-financed in-field rainwater management technologies as a low-cost alternative to irrigation;
- Developing sustainable supply chains for micro-scale irrigation and in-field rainwater management equipment; and
- Investing in research on agricultural water management, both adaptive research at the national and regional levels, and basic research at the regional level.

The new strategies should then be incorporated into wider sectoral strategies—for agriculture, rural development, and water. Water strategies should be based on IWRM principles, making an economically efficient allocation of water to the agricultural sector, and ensuring that water allocation and management takes account of the needs of the poor and providing for effective participation by smallholders in basin planning. The whole should then be clearly reflected in PRSPs or similar national development strategies.

Invest in Institutional Reforms

The new sectoral strategies should then form the basis for sectoral programs that should combine investment in infrastructure with investment in institutional reforms, including reforms to macro-economic policies, legal frameworks, and organizations for agricultural water management. In some cases the changes may involve public sector reform: integrating or better coordinating the responsibilities of government organizations for infrastructure development (e.g., a ministry of water) with those for irrigated farming (e.g., a ministry of agriculture); developing the instruments needed for PPP; making transparent the role of farmers in cost sharing and in operation and maintenance; and building capacity and incentives for public agencies to adopt a new agricultural water development paradigm.

Responsibility for development should as far as possible be decentralized, based on the principle of subsidiarity. Therefore, in almost all cases, reforms will focus on empowering potential users of agricultural water to cope effectively with their new roles and responsibilities, and to deal effectively with service providers, including irrigation agencies (who should now become accountable to their farmer clients), credit organizations, and input supply and output markets. This should be accompanied by investment in capacity building for farmer organizations.

Such programs of institutional reform—which will require time and patience—should, where possible, be implemented through sector-wide approaches that encourage harmonization of development efforts.

Invest Only in Viable and Sustainable Projects and Design for Maximum Profitability

Avoid long-term subsidies and unviable investments for 'social' or 'strategic' purposes. Future designs and investment decisions should be based solely on considerations of economic viability, farm-level profitability, and sustainability. Unviable investments for so-called 'social' or 'strategic' purposes should be avoided. Where subsidies are necessary, these should be limited to: (a) items having a medium to long-term economic life span (e.g., headworks and main canals on larger schemes), the cost of which is beyond the capacity of most smallholders to pay, rather than for lower-cost investments with a short economic lifespan (e.g., treadle pumps or on-farm development for improved in-field rainwater management); and (b) technology development and promotion. Subsidies for support services and/or O&M should preferably be avoided or otherwise carefully targeted and provided only in the short-term (e.g., for a single season) to 'kick start' commercial production.

Provide agricultural water as part of a comprehensive package, where possible, market linked. Agricultural water should only be provided when all necessary conditions for its sustainable, profitable use are in place, including: empowered farmer organizations; sustainable, efficient, and accountable agricultural support services; and accessible, profitable markets. Where such conditions are not already in place, investment in agricultural water should be part of a comprehensive package that provides for them to be established on a sustainable basis (i.e., for at least the intended economic life of the investment and not just for the life of the project).

Inclusively target the poor and women. Socioeconomic and production systems surveys should be carried out as part of project preparation studies to provide an understanding of how agricultural water management, as an input to the farming system, could assist the various socioeconomic strata of communities to improve their livelihoods to mutual advantage. Equipped with this knowledge the approach to targeting should be inclusive, rather than exclusive. The priority should be to focus on making the investment 'pro-poor' by selecting technology that is low risk and affordable to the poor, and by seeking to maximize farm-level profitability and agricultural wage employment, as well as other, indirect, employment opportunities. In addition, institutional design should ensure that the development is equitable, that the poorest socioeconomic stratum is not excluded or further marginalized, and that the important role of women in production systems and their management is taken into account and built on.

Ensure that the proposed management arrangements are sustainable. Where possible, farmers should own, finance, operate, and maintain schemes. Capacity building and development of the needed cost recovery arrangements should be an integral part of project design. The management arrangements for large schemes should follow modern best practice by giving responsibility to water user associations for operation and maintenance below, for example, secondary canal level, and should wherever possible provide at some stage for transfer of management and financing of higher level operations, or even of the entire scheme. Major infrastructure that is clearly beyond the capacity of the users to operate and maintain (with or without a service provider) should be managed jointly by an agency and users, or by an agency accountable to the users.

Management transfer on existing irrigation schemes should be attempted only where it can be demonstrated that irrigators can sustainably bear the on-going O&M costs, including any subsequent replacement costs. Thus, not only should the costs be covered by incremental farm incomes, but there should be sufficient margin to leave irrigators with an incentive to operate and maintain the facilities. The users should be fully empowered to own and operate the system. Capacity building will be needed, for which adequate time should be allowed prior to transfer.

Attempt to maximize socioeconomic benefits while minimizing negative environmental and health impacts. The social, environmental, and health costs and benefits of agricultural water investments should be taken fully into account in appraisals and investment decisions. The challenge is to design, implement, and manage projects in such a way that socioeconomic benefits are maximized while negative impacts are minimized. Project designs should therefore not only assess and provide mitigation measures for potentially negative impacts (such as conflicts with pastoralists) but also seek to exploit potential synergies and positive impacts (such as providing water and feed for livestock). Since, in many cases, the effectiveness of mitigation measures, or measures to exploit positive impacts, will be constrained by institutional weaknesses, support should be provided where possible for reforming and strengthening the institutions concerned. Project designs should specifically address the attrition of staff and farmers from HIV/AIDS-related infections.

Translate Project Designs into Effective Development

Improve implementation arrangements. Implementers and implementation arrangements should be oriented to achieving maximum development impact for target group households, in terms of production and incomes. Where investment is in a program of sub-projects to be selected during implementation of an overall project, mechanisms for sub-project screening, appraisal, and approval should be designed to avoid non-viable investments, with clearly defined objectives, roles, and responsibilities for those involved in the process. Local authorities and/or farmer organizations should be empowered to participate fully in sub-project identification, feasibility studies, appraisal, selection, and implementation. The arrangements for the provision of any technical services required to support project and sub-project implementation should be based on the respective strengths, weaknesses, and accountability of the public sector, the private sector, NGOs, and farmers. Where services are contracted out, the terms of reference should clearly specify the intentions with regard to the 'deliverables' and accountability for them, as well as the proposed exit strategy. In particular, services for design and construction supervision of infrastructure should be obtained from the best qualified source, regardless of origin—whether this be domestic, regional, or international. These providers should also be given clear terms of reference specifying the intentions with regard to the quality and cost-effectiveness of technical designs, the objective of providing agricultural users with reliable water supplies, and accountability for defective design and construction supervision.

Overcome the neglect of monitoring and evaluation. Monitoring and evaluation should be regarded as an essential management tool for farmers, implementing agencies, and financing partners. The current weaknesses and neglect of M&E should therefore be addressed as a matter of urgency. Systems should be farmer-based and designed in such a way that they can be used for both farm management and project management decisions to measure the contribution of agricultural water development to achievement of the MDGs and to inform future strategic planning and project design. As a minimum requirement, M&E systems should, therefore, measure inputs, costs, and changes in production, incomes, employment, health, and the environment. It is usually not practical to prepare a detailed design for an M&E system at appraisal, therefore the requirements should be clearly spelled out in the loan or grant agreements and followed up effectively by supervision missions as a matter of priority.

Focus implementation and supervision on quality assurance, productivity, profitability, and increased household incomes. Much greater importance should now be attached by the financiers (including farmers, governments, and others), implementers, and supervisors to ensure that implementation effectively achieves the purpose of the project and contributes to the overall objective as intended. Supervision should be strengthened to provide effective implementation support and quality assurance, focusing on achieving the intended outcomes of sustainable productivity, profitability, and income poverty reduction (as well as demonstrating this by reliable M&E).

CHAPTER 1

Rural Poverty and Agricultural Water Development in Sub-Saharan Africa

1.1 The Millennium Development Goals, Agricultural Growth, and Rural Poverty

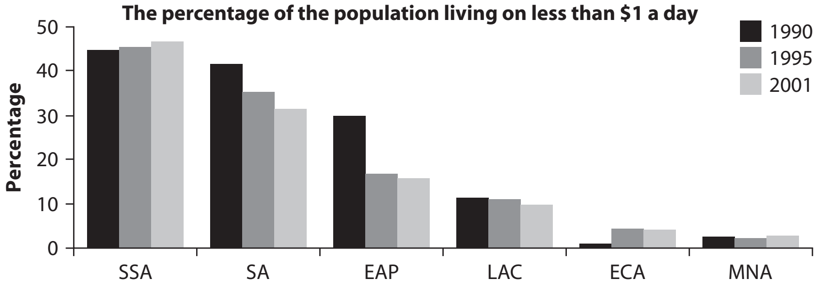
In 2000, the Millennium Declaration committed countries—rich and poor—to eradicate poverty. The first of the Millennium Development Goals (Annex 2) is to eradicate extreme poverty and hunger, with targets of halving, by the year 2015, the proportion of people: (a) whose income is less than $1/day[1] and (b) who suffer from hunger.

Although the world as a whole is roughly on track to reach these key development targets, sub-Saharan Africa is unlikely on present trends to do so. If nothing changes, the absolute numbers of poor in the region will continue to increase (Fig. 1.1) and by 2015 close to one-half of the world's poor will live in sub-Saharan Africa.

Meanwhile, agriculture in the region remains a largely subsistence-based activity and production is concentrated in low-value food crops. Overall, in money terms, cereals, roots, and plantains account for more than two-thirds of the region's agricultural output and higher value traditional and non-traditional agricultural export crops for

1. All dollar figures are US dollars.

Figure 1.1 Sub-Saharan Africa is the Poorest Region in the World

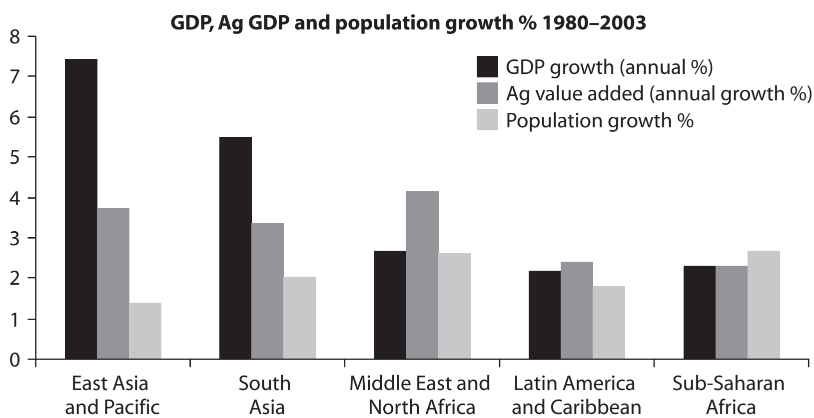


Source: Based on World Bank data.

only 8 percent (FAO 2006).[2] Agricultural productivity is the lowest in the world, with per capita output only 56 percent of the world average (FAO 2006). Output has not kept pace with population increase (Fig. 1.2; FAO, 2003a; Rosegrant et al., 2005) and growth has taken place largely through expansion of harvested area: over 80 percent of output growth since 1980 has come from expansion of cropped area compared to less than 20 percent for all other regions (Fig. 1.3).

Farm families have remained locked in a low input-low income system, with yields low and stagnating (NEPAD, 2005a; Rosegrant et al., 2005).

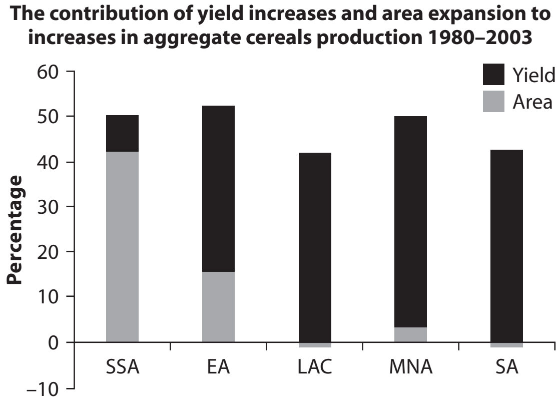
Figure 1.2 Population Growth in Sub-Saharan Africa Has Exceeded the Growth of Both Overall and Agricultural GDP so that the Population Has Become Poorer



Source: World Bank.

2. Underlining denotes a report on component study for the Collaborative Program.

Figure 1.3 Area Expansion Has Been the Biggest Source of Agricultural Growth by Far in Sub-Saharan Africa



Source: Based on FAO data.

There has been little technology-driven jump in productivity. As population outstrips production, the numbers of malnourished are rising. Food self-sufficiency has declined (from 97 percent in the mid-1960s to 82 percent in 1997/79) without the household income being generated to afford purchased food (NEPAD, 2005a; FAO, 2003a). Agricultural markets have remained segmented and transaction costs are high. The agricultural 'extensification' process has also produced some negative consequences for the environment, such as loss of forest and rangeland, soil depletion, and catchment degradation.

Agricultural growth is clearly the key to income poverty reduction.[3] Rural poverty accounts for 83 percent of the total extreme poverty in sub-Saharan Africa, and 85 percent of the poor depend for their livelihoods at least partly on agriculture. Agricultural income growth is therefore key to rural poverty reduction. It will also help drive national economic growth (Timmer, 1997; Mellor, 2001; Diao et al., 2003; Byerlee et al., 2005; IWMI, 2005g).

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3. Participatory poverty assessments have found that poor people define their poverty in terms of material deprivation (i.e., not enough money, employment, food, clothing, and housing), inadequate access to health services and clean water, and non-material factors such as security, peace, and power over decisions affecting their lives (Robb, 1999; cited in IFAD, 2001). These components of poverty are usually divided into income poverty and non-income poverty.

Reducing income poverty enables households to achieve food security, accumulate assets, reduce vulnerability to external shocks, and provide for the future. Reduction of income poverty often also improves access to education, health services, and clean water. Thus, although poverty is a multi-faceted condition, this report, in line with the Millennium Declaration, considers poverty in terms of the $1/day income threshold for extreme poverty rather than the other aspects of material deprivation or lack of access to services.

1.2 Agricultural Water, Growth, and Farming Systems

Intensification and diversification are expected to become the major sources of future agricultural growth and poverty reduction in the region, and agricultural water will play a major role. Growth and poverty reduction in agriculture will come principally from two sources (Dixon et al., 2001; World Bank, 2005m):

- Intensification, i.e., producing more per unit of land, either by the generation and adoption of technologies such as improved in-field water management or by investments that relax key binding constraints, such as water availability; and
- Diversification, i.e., adjustment of the farm enterprise pattern, exploiting new market opportunities or existing market niches in order to increase farm income or to reduce income variability.

FAO, in its perspective on world agriculture toward 2015/2030 (FAO, 2003a), concluded that 73 percent of the growth in crop production expected for sub-Saharan Africa by 2030 would come from yield increases and increases in cropping intensity. The remaining 27 percent was expected to come from expansion of the area under crops—mainly for maize—in the limited number of countries that still have room for this.[4]

The potential for agricultural growth and poverty reduction varies by farming system and agro-ecological zone. The potential for agricultural growth and the mechanisms by which growth and poverty reduction will occur differ according to farming system. Fifteen major farming systems have been identified for the region (Map 2, Annex 3, and Dixon et al., 2001). These broadly fit within the main agro-ecological zones (Map 3) defined by FAO on the basis of average annual length of growing period for crops,[5] although local factors—particularly market access—create potential for more intensive farming or for diversification within the zones. In the region as a whole, the arid and semi-arid

4. FAO (2003a) focuses on increases in crop production rather than on farm income growth and does not quantify the expected growth impacts of diversification. The message is consistent: agricultural growth in sub-Saharan Africa will come predominantly from improved use of production factors on existing farms. An indication of the relative scope for expansion is provided in Summary Table 1, which shows that at least 13 of the 48 countries in sub-Saharan Africa are already cultivating more than 50 percent of their cultivable land, while a further five are approaching the 50 percent mark. Moreover, the total for cultivable land includes land in the drier agro-ecological zones, meaning that the pressure on higher potential land might be greater than suggested by Summary Table 1.

5. For definitions see Glossary.

agro-ecological zones (crop growing period less than 120 days) cover 43 percent of the land area; and the sub-humid and humid zones (growing period greater than 120 days) cover 53 percent of the land area (Dixon et al., 2001 and Annex 3).

Irrigated farming systems have high growth potential but cover a limited area. Only one of the 15 farming systems identified is predominantly irrigated. In this system, which covers just 1 percent of the land area and 2 percent of the farming population—about 7 million people—poverty is limited and growth potential is high. Apart from expansion of the irrigated area, the principal sources of growth under irrigated systems are expected to be continued intensification and diversification, for which further market development and improved in-field water management will be vital factors.

Market-oriented intensification and diversification in the humid and subhumid zones will drive agricultural growth and poverty reduction, although the prospects are limited for some farming systems within these zones. Prospects for growth and poverty reduction in the Highland Perennial system (covering 8 percent of the agricultural population of the region) are limited and off-farm income and exit from agriculture will be the principal household strategies. For systems that have high or medium potential for growth and poverty reduction such as the Cereals-Root Crop Mixed (15 percent of the agricultural population), Maize Mixed (15 percent), and Root Crops (11 percent), production is likely to continue to be oriented toward production of staples for household consumption and some non-perishable high-value cash crops, but intensification and diversification in these systems could present good opportunities for agricultural growth and poverty reduction. The process of growth could be greatly stimulated by improved market access, which is currently limited by: (a) physical location (producers isolated from densely populated areas with large active markets); (b) inadequate infrastructure and support services (communications, financial services, and extension); and (c) weak purchasing power and demand in the markets themselves. Agricultural water development will be an important factor in aiding market-linked growth, and may range from investment in simple forms of water management to full irrigation, depending on local resources and the needs and profitability of the market opportunity.

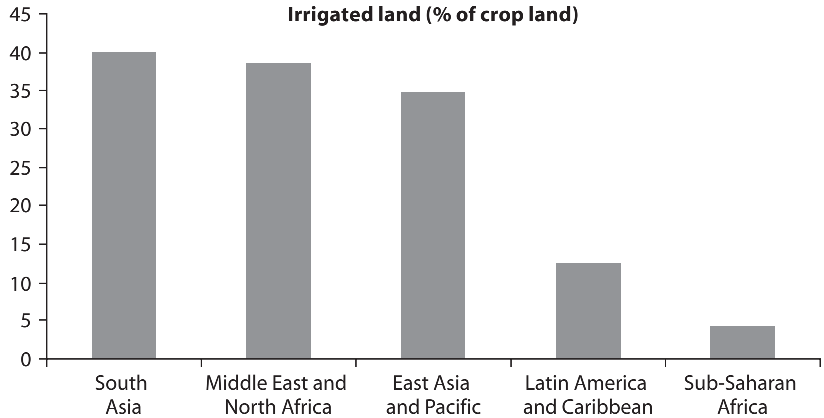
Only limited opportunities for agricultural growth and poverty reduction exist in the lower potential farming systems in the marginal arid and semiarid zones. The lower potential farming systems of the marginal arid and semi-arid areas present quite a different growth challenge. In these farming systems (covering about 16 percent of the population of the region), the sparse population is dependent on subsistence Pastoral and Agro-Pastoral Millet/Sorghum systems characterized by poor access to markets, unstable production, and food insecurity. Some production stability and growth may be achievable where agricultural water can be developed cheaply and markets can be developed. Overall, however, the potential for reducing poverty in these areas is generally low and exit from agriculture is likely to be the predominant household livelihood strategy (Dixon et al., 2001; World Bank, 2005m).

1.3 Agricultural Water: The Global Picture and Sub-Saharan Africa

There has been less agricultural water development to date in sub-Saharan Africa than in any other region. At just 4.9 percent of the total cultivated area of 183 million hectares, the area developed is by far the lowest of any region of the world (Fig. 1.4). Three countries (Sudan, South Africa, and Madagascar) account for two-thirds of the irrigable area developed (Summary Table 5 and Map 4).

Expansion of irrigation has been slow. Over the last 40 years, only 4 million hectares of new irrigation has been developed in the region, far and away the smallest expansion of any region. Over the same period,

Figure 1.4 Sub-Saharan Africa Has a Far Lower Share of Its Arable Land Under Irrigation than Other Regions



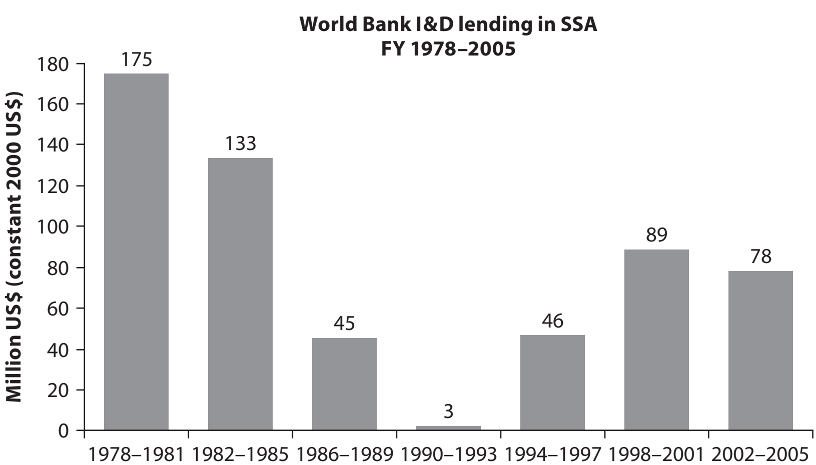
Source: World Bank, 2005b.

China added 25 million hectares and India added 32 million hectares (FAO, 2003a). Between 1994 and 2004, growth in the equipped area in sub-Saharan Africa was only 0.85 million hectares (FAO, 2005a).

Until recently, investments in agricultural water in the region have been declining. Levels and trends of donor financing are conventionally taken as a proxy for investment levels. In the most recent three-year period for which partial data are available (1994–1996), the total cost of projects funded by all donors for irrigation and drainage was less than 10 percent of levels of 20 years previously—just $127 million from all sources. World Bank lending for irrigation and drainage, for example, fell sharply after 1985. Even though lending levels partially recovered in the late 1990s, 2002–2005 lending was still below one-half the level of 1978–1981 (Fig. 1.5). In addition, World Bank lending for irrigation and drainage in the region is very small compared to lending in other regions. Over the period 1996–2005, World Bank lending to sub-Saharan Africa for irrigation and drainage was just 6 percent of the resources directed to irrigation and drainage in Asia.

Investment in agricultural water has received only a small proportion of that for the water sector as a whole. For example, African Development Bank lending for agricultural water over the period 1968–2001 was $630 million, which was only 14 percent of its lending to the water sector as a whole ($4,574 million).

Figure 1.5 World Bank Lending for Irrigation and Drainage in Sub-Saharan Africa Is Only One-Half of Levels 20 Years Ago



Source: World Bank ESSD database.

CHAPTER 2

Profile of Agricultural Water Development

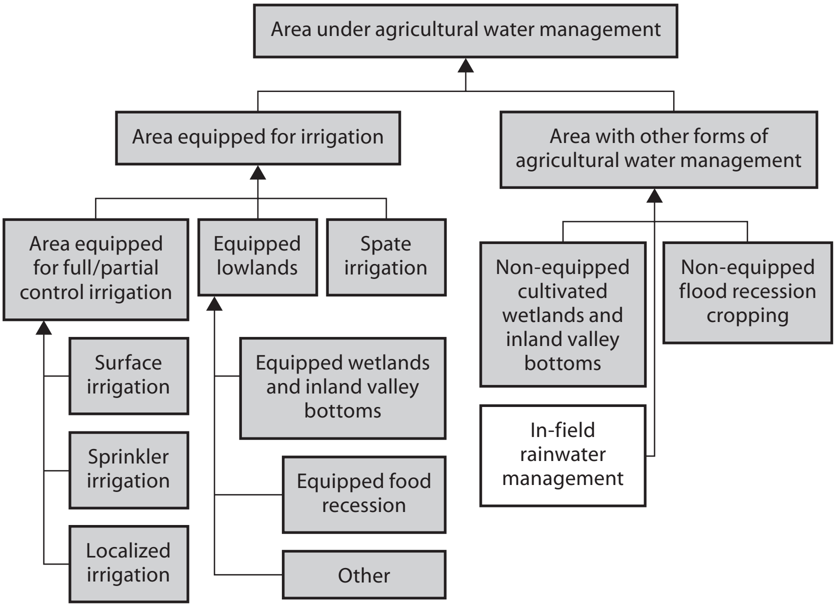
2.1 Agricultural Water Management Typology

The agricultural water management typology used in this report generally follows that adopted by FAO for AQUASTAT, its global database on water and agriculture, (http://www.fao.org/ag/aquastat). The AQUASTAT typology (Fig. 2.1; see also the Glossary) distinguishes between areas 'equipped for irrigation'[1] and those with 'other forms of agricultural water management'.

Although 'water harvesting' has generated considerable interest in recent years, it was not included in the typology shown in Figure 2.1. The main reason was that although it was listed in the AQUASTAT survey questionnaire, few data were received for this type of water management and there were apparently some doubts over their reliability. Part of the problem appeared to be the lack of a commonly accepted definition of the term.

1. According to the terminology adopted in FAO (2005a), 'equipped lowlands' include: (a) cultivated wetlands and inland valley bottoms which have been equipped with water control structures for irrigation and drainage; (b) areas along rivers where cultivation occurs making use of water from receding floods and where structures have been built to retain the receding water; and (c) mangrove swamps developed for agriculture.

Figure 2.1 Agricultural Water Management Typology



Note: Adapted from FAO 2005a (areas in grey correspond to the AQUASTAT typology).

Nevertheless, water harvesting can be defined as the "collection of rainfall for direct application to a cropped area, either stored in the soil profile for immediate uptake by the crop or stored in a reservoir for future productive use" (FAO, 2005a). Thus, in the present context water harvesting consists of the collection and concentration of water for irrigation. What distinguishes it from other types of operations to collect water for irrigation is scale: FAO (2005a) defined three categories of water harvesting on the basis of catchment area, varying from roof catchments to areas of up to 200 hectares. For the purpose of this report, therefore, water harvesting is considered to be *micro-scale collection of rainfall runoff for irrigation* (see also Annex 4 and IFAD 2007). It is therefore assumed to fall under the category of 'areas equipped for irrigation' in Figure 2.1, even though it may not have been fully captured by the AQUASTAT survey.[2]

Because this report is concerned with agricultural water management in its widest sense, it has adopted a modification to the typology

2. This is not to suggest that this type of water development for irrigation is any less important to those who depend on it for their livelihoods.

described by FAO (2005a) (Fig. 2.1) to include 'in-field rainwater management' for dryland crop production. This was not considered by the AQUASTAT survey but is defined here as *operations to enhance the effectiveness of rainfall for dryland crop growth*. What distinguishes it from water harvesting is that instead of *collecting* runoff for irrigation the purpose of in-field rainwater management is to *reduce* runoff and evaporation losses by improving infiltration and storage in the soil profile.

2.2 Agricultural Water Development Characteristics

According to the 2005 AQUASTAT survey (FAO, 2005a), there are about 9.1 million hectares of land in sub-Saharan Africa under some form of water management today. Of the 9.1 million hectares (Table 2.1), 7.1 million hectares are 'equipped' (i.e., developed with irrigation infrastructure). Of this, 6.2 million hectares are under full or partial control irrigation and 0.9 million hectares consist of spate irrigation and equipped lowlands. The remaining 2 million hectares are flood recession and wetland cropping areas not equipped with any water control system. It is estimated that of the equipped area of 7.1 million hectares, only about 75 percent (around 5.3 million hectares) is operational.[3]

More than 33 million people derive their main income from agricultural water managed areas. Although there are no reliable data, it is estimated that at least 6 million households, representing more than 33 million people, live directly on earnings from the subsector.[4] These are almost certainly significant underestimates because AQUASTAT probably under-reports areas under individual private smallholder irrigation (including urban and peri-urban irrigation), micro-scale irrigation (including water harvesting), and 'other forms of water management'. Furthermore, the estimates take no account of those households engaged in wage labor for agricultural water management, including those employed in large-scale private commercial irrigation.

At least twenty countries have more than 100,000 hectares of water managed areas. The distribution of the water managed area by the main

3. The AQUASTAT database is compiled on the basis of national data provided by FAO member countries, with appropriate cross-checking and quality control. However, the quality of data is variable and definitions also often vary from country to country. Hence the statistics quoted should be regarded as indicative rather than firm.

4. This is based on the assumption that at least one-half the total of 9.1 million hectares under water management is operated by smallholders, that each smallholder household averages of 5.5 persons, and that each household cultivates an average of 0.75 hectares of water-managed land.

Table 2.1 Area in Sub-Saharan Africa under Agricultural Water Management by Type

Type of water management	*Area (million ha)*	*Share of area (%)*	*Major countries*	*Other representative countries*
Equipped				
Full water control				
Surface[a]	4.9	54	Sudan, Madagascar, South Africa	Ethiopia, Nigeria, Tanzania, Mozambique, Senegal, Mali, Angola, Somalia, Zimbabwe, Mauritania
Sprinkler	1.2	13	South Africa	Zimbabwe, Kenya, Malawi, Côte d'Ivoire, Swaziland, Zambia, Mauritius
Localized	0.2	2	South Africa	Zimbabwe, Zambia, Malawi
Sub-total full control	6.2	69		
Partial water control				
Lowlands	0.6	6	Mali, Zambia, Guinea, Niger, Nigeria	Côte d'Ivoire, Senegal, Burundi, Guinea Bissau
Spate	0.3	3	Somalia, Sudan	Eritrea, Cameroon
Sub-total partial water control	0.9	9		
Total equipped area	7.1	78		
Non-equipped[**]	2.0	22	Nigeria, Angola	Sierra Leone, Chad, Zambia, Rwanda, Burundi, Mauritania, Malawi, Mali, Uganda
Total water managed area	9.1	100		

a. If irrigation type not specified, surface irrigation has been assumed.

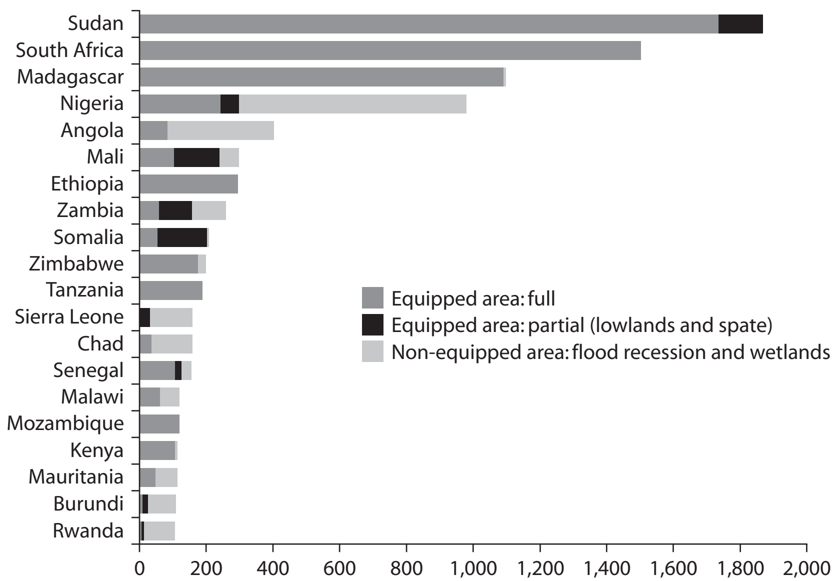
b. Other forms of water management (non-equipped flood recession and wetlands cropping, but excluding in-field rainwater management).

Source: FAO, 2005a.

sub-Saharan African countries where agricultural water management is important is shown in Figure 2.2[5]. Sudan, South Africa, Madagascar, and Nigeria are the main countries for irrigated agriculture (Table 2.1). Other countries with more than 100,000 hectares of full water control irrigation are: Ethiopia, Kenya, Tanzania, Zimbabwe, Mozambique, and Senegal. In several countries, equipped partial control irrigation (spate and lowlands) predominates: Somalia, Malawi, Mali, and Zambia. In Nigeria, Angola, Sierra Leone, Chad, and Zambia, non-equipped flood recession and wetlands cropping systems are important (see also Summary Table 4).

Water withdrawals for agriculture are very limited—just under 2 percent of the total renewable water resource—and water storage is well below levels in other regions. Total withdrawals for agriculture in sub-Saharan Africa amount to 105 billion m^3, less than 2 percent of the total renewable

Figure 2.2 Water Managed Area by Type ('000 hectares)



Source: FAO, 2005a.

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5. Summary Table 4 gives details of irrigated areas for all sub-Saharan Africa countries.

water resource (see Summary Table 3). Most countries in the region have low levels of water storage infrastructure, averaging 543 m^3 per capita, compared to 2,428 m^3 in South America and well below the world average of 963 m^3 per capita. In Kenya, for example, total storage capacity per capita is only 126 m^3 per capita, less than 4 percent of the level in Brazil (based on ICOLD data and on IWMI 2005a, World Bank 2004a).[6]

Surface water is overwhelmingly the water source for irrigation. FAO (2005a) indicates that 90 percent of the area under full or partially controlled irrigation in sub-Saharan Africa is supplied from surface water. There is a concentration of irrigation directly linked to water courses in the Nile, Niger, Orange, Senegal, Volta, and Zambezi river basins.

Groundwater irrigation is also locally important. FAO (2005a) also indicates that approximately 10 percent of the area under full or partially controlled irrigation is supplied from groundwater. However, because groundwater is used extensively by private individual small and micro-scale irrigators, many of whom would not be included in AQUASTAT survey data, this too is almost certainly an underestimate.

Large-scale irrigation schemes have generally been developed and managed by governments.[7] Large-scale irrigation schemes have generally been developed by public agencies in several sub-Saharan Africa countries, particularly Sudan, Madagascar, and Nigeria. On almost all these schemes, public agencies have been responsible for operation and maintenance, often with little or no recovery of costs from farmers. However, in recent years farmer organizations have been increasingly involved in management and operation and maintenance (see section 4.6 below).

Development and management of smaller schemes increasingly involves farmers. Many of the small- to medium-scale schemes were also constructed by government and are managed by public irrigation agencies, although they are increasingly being turned over to farmer-management, for example, in Zimbabwe, Senegal, Mauritania, Niger, Mali and South Africa. In recent years, most small-scale development by the public sector has been done in partnership with farmers, and with the understanding that farmers will take over the scheme's operation and maintenance (see section 4.6 below).

6. In fact, water storage infrastructure for agricultural water is very much less than the figures cited because a significant proportion of the infrastructure is largely for hydropower. In addition, regional averages are inflated by a small number of very large dams.

7. For definitions of large, medium, and small-scale, see Glossary.

At least one-half of the water managed area is privately developed and operated. Privately developed and operated areas include some large-scale sugar estates in Southern Africa, thousands of smaller schemes operated by large-scale commercial farmers, and numerous informal smallholder schemes—as well as many thousands of individually owned and operated areas (mainly gardens). Some private smallholder irrigation is for subsistence (as with Malagasy paddy production in the *bas fonds*, which cover over 800,000 hectares), but some is market-driven agriculture for urban markets, for example in peri-urban areas and in inland wetlands, often dependent on micro-irrigation technologies. *Dambo* irrigation in Zambia, for example, is thought to cover 100,000 hectares.

The total extent of in-field rainwater management in the region is unknown but adoption is thought to have been limited. In-field rainwater management practices such as minimum tillage and other methods of water conservation farming have been promoted in the region, but details of how widely these have been adopted are difficult to find. Nevertheless, it is known that 7.8 percent of smallholder farmers in Zambia, for example, adopted planting basins in the 1999/2000 season (Hageblade et al., 2003). It was also reported that 97 percent of all households in 27 villages surveyed in one district of Niger in the 1990s adopted planting pits, stone bunds, or *demi-lunes* under the Indigenous Soil and Water Conservation in Africa Program (Hassane et al., 2000). "A good number of (smallholder) farmers" also adopted tied ridges to create planting basins for cotton in southern Zimbabwe (Nyamudeza et al. cited in IFAD, 2007). Details of subsequent 'disadoption' were not available, although some of the Zambian farmers gave up after a period of time as a result of being unable to maintain conservation farming practices or when promotional input programs ended (Hageblade et al.). Overall, however, compared with the total area under dryland cropping in the region, adoption of in-field rainwater management for dryland cropping appears limited.[8]

2.3 Water Managed Crops and Productivity

Cereals, largely rice, are the principal irrigated crop. High-value horticulture and industrial crops—largely cotton and sugar—are also important

8. It could be argued that this impression is contradicted by the widespread construction of bunded fields (known as *majaruba*) by rice farmers in East Africa. However, such fields are often constructed as a part of an irrigation system and water management is not strictly for dryland crops (IFAD, 2007).

irrigated crops. Cereals are the predominant irrigated crop in sub-Saharan Africa, accounting for almost 50 percent of the harvested irrigated crop area (Table 2.2). Rice is the principal crop for 25 percent of the harvested irrigated crop area, and is especially important in the humid and sub-humid zones. Other irrigated cereals cover 24 percent of the harvested crop irrigated area and include irrigated maize and irrigated wheat. Irrigated wheat is important in Southern Africa and Ethiopia which together account for 80 percent of sub-Saharan Africa wheat production. High-value horticulture, roots, tubers, and industrial crops—largely cotton and sugar—are also important irrigated crops covering 33 percent of the harvested irrigated crop area. Fodder production and fruit trees together account for 12 percent, largely in Southern Africa, particularly South Africa.

Table 2.2 Harvested Irrigated Crop Area in Sub-Saharan Africa ('000 ha)

Region[a]	*Rice*	*Other cereals*	*Vegetables, roots, tubers*	*Industrial crops*	*Fodder*	*Tree crops*	*Other*	*Total*
Sudano-Sahelian	242	721	181	397	142	5	5	1,693
Gulf of Guinea	28	38	73	50	—	—	32	221
Central	27	8	10	55	—	4	1	105
Eastern	108	193	169	123	—	6	85	684
Indian Ocean Islands	1,062	—	1	38	—	—		1,101
Southern	21	460	344	510	418	77	236	2,066
Total	1,488	1,420	778	1,173	560	92	359	5,870[b]
Share of total cropped area (%)	25	24	13	20	10	2	6	100

a. The regions shown are those adopted by FAO (2005a). The grouping of countries within these regions is based on geographical and climatic homogeneity, which has a direct influence on irrigation. See Map 1 for the groupings.

b. The total cropped area of 5.9 million hectares in this table is commensurate with the equipped area of 5.3 million hectares that is thought to be currently operational, assuming that overall cropping intensity exceeds 100 percent.

Source: FAO, 2005a.

Irrigated production is a small contributor to sub-Saharan Africa's overall staple food production, but plays an important role for import substitution for wheat and rice and for cash crops. Irrigation is important (Table 2.3) for sugar cane (69 percent irrigated), for wheat production (20 percent irrigated), for rice (33 percent irrigated), for horticulture (26 percent irrigated), and for cotton (11 percent irrigated). For production of staple food crops other than rice and wheat, irrigation plays only a minor role complementary to dryland crop production.

Irrigated cereals yields achieved by smallholders are generally low by global standards and have improved only slowly in recent years. In 1997/99, the average paddy yield in sub-Saharan Africa was 1.6 t/ha, compared with 2.9 t/ha in South Asia and 4.2 t/ha in East Asia (Table 2.4). The contrast with yields in North Africa is even more stark: the average paddy yield in Egypt for 2004 was 9.8 t/ha (FAOSTAT). There have been some yield increases in the region in recent years (average paddy yields up 20 percent 1979–1999) but much slower than in Asia

Table 2.3 Percentage of Total Irrigated Production (2005 figures)

Crop	*Total sub-Saharan Africa production (million tonnes)*	*Irrigated production (million tonnes)*	*Share of irrigated in total production (%)*
Sorghum	21.6	0.9	4
Maize	40.7	0.4	1
Wheat	5.0	1.0	20
Rice	12.4	4.1	33
Fruits	57.5	15.0	26
Vegetables	25.4	7.9	31
Sugarcane	69.5	48.0	69
Cotton	4.1	0.5	11

Source: FAO, 2006 based on FAOSTAT data.

Table 2.4 Paddy Yields in Sub-Saharan Africa, South Asia, and East Asia (kg/ha)

Region	*1979/81*	*1989/91*	*1997/99*
SSA	1,347	1,659	1,629
South Asia	1,910	2,602	2,917
East Asia	3,374	4,134	4,180

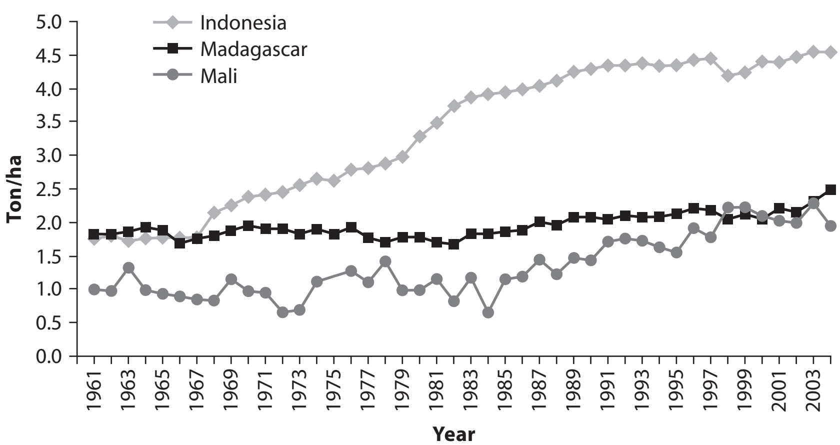
Source: FAO, 2003a.

(South Asia up 53 percent in the same period). Essentially, Green Revolution intensification of paddy cultivation has not yet occurred in sub-Saharan Africa. Average paddy yields in Madagascar, for example, have increased by just 20 percent in the last 20 years to about 2 t/ha, while those of Asian countries that were once at the same level have more than doubled (Figure 2.3). However, in a few large-scale well managed sub-Saharan Africa schemes like the Office du Niger in Mali, yields have attained 'Asian' levels (5–6 t/ha).

Overall, irrigated production in sub-Saharan Africa is characterized by low productivity. Low yields in irrigated production in sub-Saharan Africa can be attributed to unreliable water supplies, poor water control and management, low input use, poor crop husbandry, and to difficulty in accessing profitable output markets. In Madagascar, irrigated paddy yields could be increased by 50–80 percent simply by improved water control and in-field management (Table 2.5). Farmers in sub-Saharan Africa still lag far behind other developing areas in fertilizer use. Average fertilizer use remains at 9 kg/ha in 2002/03 compared with 100 kg/ha in South Asia, and 135 kg/ha in East Asia (FAO, 2004).

In Madagascar, 69 percent of the area under irrigated rice is cropped without any mineral or organic fertilizer applications, and the relation between fertilizer use and yields is transparent (Table 2.6; World Bank, 2003). But perhaps the single most important factor is access to markets: the correlation of low irrigated productivity with remoteness from mar-

Figure 2.3 Paddy Yield in Madagascar, Mali, and Indonesia



Source: FAOSTAT.

Table 2.5 Madagascar: Effect of Water Management on Paddy Yields (kg/ha)

Level of water management	*Lac Alaotra*	*High plateaux*
High	3,282	3,535
Moderate	2,490	3,424
Low	2,139	2,740

Source: World Bank, 2003.

Table 2.6 Madagascar: Regional Comparison of Irrigated Paddy Yields

Region	*Average irrigated yield of paddy (kg/ha)*	*Fertilizer use (% of cultivated area)*
High plateaux	3,200	76
Lake Alaotra	2,632	40
Middle West	1,966	22

Source: World Bank, 2003.

kets is very strong in sub-Saharan Africa. In Madagascar, the distance of a rice plot from a road was found to have a strong negative effect on paddy yields (World Bank, 2003). It is probably the market factor which most influences other determinants of productivity. For example, where market-driven incentives are present, Malagasy farmers will invest in water control structures, fertilizers, and crop husbandry improvements.

Although less is known of dryland crop production under in-field rainwater management practices, the few available results indicate that, as for irrigated cropping, productivity gains can be considerable when farmers also have access to yield-enhancing inputs but declines when access is reduced. Farmer yields obtained from conservation farming plots have often been more than double those from plots on which conventional tillage is practiced.[9] However, these increases appear to be closely connected to the level of extension support and input packages (including HYV seeds) provided by projects. Once project support falls away, so do yields (Hageblade et al., 2003).

9. For example, the mean maize yield achieved by farmers in the 2001/02 season in Thaba Nchu, South Africa was 2.4 t/ha with in-field rainwater management compared with 1.7 t/ha without water management (Botha et al. cited in Beukes et al., 2003). Similarly, mean maize yields in Zambia during the 2001/02 season were 1.5 t/ha with conventional plowing but 2.9 t/ha with planting pits (Hageblade et al.). Mean millet yields for 1991–1996 were 125 kg/ha without water management and 765 kg/ha with *tassa* planting pits (Hassane et al., 2000; see also Annex 4). And maize yields in Tanzania's Arusha Region were two to three times higher with conservation tillage than without (Jonsson et al., 1998).

2.4 Which Crops Have Proved Viable Under Water Management?

Staple Food Crops

Irrigated rice cultivation in sub-Saharan Africa has proved viable, at least for the local market, provided that yields are relatively good and investment costs are not too high. In Sierra Leone, irrigated production shows both good farmer returns and economic viability for local sale (domestic resource costs (DRCs) well below unity, Table 2.7), but not for export (DRCs above unity). In Mali, intensive irrigated rice production (yields of up to 6 t/ha and cropping intensities of 1.2) is competitive for the domestic market and for some border areas of neighboring countries (World Bank, 2005k). In general, irrigated rice production in the sub-humid zones of sub-Saharan Africa is viable if: (a) investment costs are relatively low ($5,000/ha has been suggested as a 'cut-off point' for single-cropped paddy at an average yield of 3.3 t/ha [IFAD, 2007]);[10] (b) more intensive production systems are used (yields up to 5–6 t/ha and double cropping may be needed to justify a high-cost irrigation schemes); and (c) production is for import substitution. Many factors influence the cut off point. For example, investment in rice production with simple run-off and bunding techniques in valley bottoms in Madagascar can be viable even at yield levels of 2 t/ha. Market isolation is another factor because this will increase economic farm gate prices for local rice production and hence the cut off point (IFAD, 2007). Box 2.1 is an example from Mali.

Non-rice cereals have proved less viable under irrigation, particularly with the continuing decline in world prices. The relatively low value of

Table 2.7 Returns to Irrigated Rice Production in Sierra Leone

Crop regime	*Net financial return (US$/ha)*	*DRC[a] import parity*	*DRC[a] export parity*
Boliland with intensive production (including HYVs)	653	0.73	1.33
Riverine flood recession with intensive production (including HYVs)	892	0.72	1.31

a. Domestic resource costs.

Source: World Bank, 2005h.

10. The ceiling cost would be higher if double cropping were possible.

Box 2.1

In Mali, Irrigated Rice with Higher Value Cash Crops and Irrigated Rice Monoculture are Expected to be Profitable

Under the Mali National Rural Infrastructure Project, various types of new irrigation schemes are being developed for rice production, some with cash crops in the rotation, some in monoculture.

At the large M'Bewani scheme, Office du Niger will develop 1,300 hectares of new irrigated land. Paddy yields are expected to be 5.0–5.5 t/ha, and onions, shallots, and tomatoes will also be grown. Cropping intensity is assumed to be 120 percent. For an investment cost of $4,230/ha, the estimated economic rate of return at project appraisal is 16 percent.

Farmer-managed small-scale irrigation perimeters (250–500 ha) are expected to pursue rice monoculture because the schemes are very far from market centers where cash crops could be sold. For the same reason, local rice prices are relatively high. Paddy yields are expected to be 4.0–5.0 t/ha and cropping intensity at 120–150 percent. For an investment cost of $5,000/ha, expected rates of return are 12–18 percent.

Source: World Bank, 2005k.

other cereals on the world market means that domestic market prices may not be high enough to make irrigated production a viable investment in sub-Saharan Africa, particularly because yields are typically below world averages (see section 2.3 above). For example, in Nigeria, most public irrigation schemes were designed for cereals production when priorities were self-sufficiency in food rather than increased farmer incomes and economic viability. With the liberalization of the Nigerian economy and the continued decline of world cereals prices, much of this food crop production (especially on pump schemes) has become uneconomic (World Bank, 2001). That there are 1.4 million hectares of irrigated land in sub-Saharan Africa cropped to non-rice cereals is probably a reflection of subsidies on capital and O&M costs, rather than viability (FAO, 2006 and Annex 5).

Mixed cropping of cereals and cash crops can boost viability. On large-scale schemes in Mali close to markets, for example, combining paddy and cash crops contributes to good rates of return (Box 2.1). Irrigated dry beans have also been found to be highly profitable by smallholders in Southern Africa and can considerably boost viability in mixed cropping systems.

Improving dryland production could be the better option for non-rice cereals—and in-field rainwater management could be the key. Research to date on in-field rainwater management for dryland crop production has demonstrated its agronomic feasibility, but the issue of viability has received less attention. However, monitoring data obtained from a pilot project in Niger (Box 2.2) have provided one of the few opportunities for benefit-cost analysis on in-field rainwater management for dryland crops, i.e., the *tassa* planting pit system. The *tassa* cost approximately \$100/ha to construct and have an economic life of three years, after which they must be re-dug. In a year of poor rainfall, farmer yields of millet from the *tassa* systems were a massive 50–60 times those obtained from the control plot, although the difference was much less in years of good rainfall (Hassane et al., 2000). Taking account of the good and bad years over a 6-year period, an analysis prepared for the component study on poverty reduction (IFAD, 2007) indicated a benefit-cost ratio of 1.9 at a discount rate of 10 percent—meaning that the ERR would have been far greater than 10 percent. This one example shows that investment in in-field rainwater management can be viable for non-rice cereal crops such as millet, even in the semi-arid zones. There is thus good reason to suppose that viable technologies exist or can be found to increase the effectiveness of rainfall for other deep-rooted non-rice staples, such as maize and wheat, produced under dryland conditions.

Horticulture

Irrigated horticulture is a fast growing activity. Markets for irrigated horticulture have been growing, with most production for local markets. In Kenya, for example, total production of fruits and vegetables in 1996 was 3.1 million tonnes, of which more than 3 million tonnes was consumed locally or used as an input to processing, and only 90,000 tonnes were exported as fresh produce (Sally and Abernethy, 2002).

Horticulture is developing especially fast around cities—and even within them. Peri-urban and urban horticulture is a rapidly growing phenomenon. In Accra, for example, an estimated 60 percent of all urban households are engaged in subsistence-oriented backyard farming, while market-oriented urban vegetable production on urban open spaces supplies 60–90 percent of the city's consumption of perishable vegetables, feeding more than 200,000 people every day (Obuobie et al., 2006).

Box 2.2

Improving In-Field Rainwater Management in the Semi-Arid Areas of Niger

In common with many semi-arid areas, Niger has suffered land degradation as a result of population pressure and drought. An IFAD-assisted project tested a number of locally-based technologies to bring land back into production, reduce inter-annual variability of output, and enhance the resilience of farming systems to climatic risk. One key success was the development of a modified form of the *tassa* practice. This continued to expand spontaneously to new plots after the project had closed.

The *tassa* practice consists of digging holes some 200–300 mm in diameter and 150–200 mm deep and covering the hole bottoms with manure. This helps to promote termite activity during the dry season, thus improving water infiltration further. Farmers then plant millet or sorghum in them. *Tassas* have allowed the region to attain average millet yields of over 480 kg/ha, in comparison with only 130 ha/kg without *tassas*. As a result *tassas* have become an integral part of the local technology base. The technique is spreading at a surprising rate.

Three main factors contributed to success: (a) an action-research approach that combines flexibility, openness to farmer initiatives, a forward-looking attitude, and willingness to negotiate; (b) a technology that yields quick and tangible benefits, yet is simple, easily replicable, and fits well with existing farming systems; and (c) a technology that can adjust to the changing local context. The *tassa* is based on a local practice that, although not high-performing, is effective.

Tassas appeal to farmers because they yield quick and appreciable results, restoring productivity of land that was previously unfit for cultivation while mitigating agro-climatic risks and increasing food availability in participating households by 20–40 percent. They are easily replicable because they entail only minor adjustments to local hand tools and do not involve any additional work during the critical sowing and weeding periods. Because they can be constructed by individual farmers without external assistance, *tassas* are particularly interesting to youths because they make it possible to cultivate plateau lands, which have become a valuable resource in the face of growing pressure on land.

Source: Mascaretti in Dixon et al., 2001.

As urbanization puts more pressure on the land, intensification of urban and peri-urban gardening is increasing.[11]

Horticultural production for export has become a boom area for some countries, and the poverty reduction impact is significant. High-value irrigated horticulture is bringing ready benefits to smallholders. In countries such as Ethiopia, Kenya, Senegal, Mali, Niger, Zambia, and Mauritania, entrepreneurs have developed new export markets for high-value irrigated produce, and have recruited and supervised smallholder producers to supply customers. Fruits and vegetables are now Kenya's third ranking foreign exchange earner, providing livelihoods to as many as 100,000 small farmers (IWMI, 2005f,; Box 2.3).

The Rural Household Survey (2000) in Kenya found that gross margins per hectare are 6–20 times higher for irrigated French beans for export than for maize-dry bean intercropping. One-half of the French bean growers owned their own irrigation equipment compared to 10 percent for other farmers; and the average per capita income of the

Box 2.3

Horticultural Growth and the Poor in Kenya

In Kenya, data from the 2000 Rural Household Survey suggest that almost all farmers, rich and poor, participate in some form of horticultural production. The percentage contribution of horticulture to income is fairly constant across income and farm size categories. Production is predominantly for market. Even among the poorest 20 percent of Kenyan farmers, 41 percent of the fruit and vegetable output is marketed (Minot:38).

Smallholders account for about 47 percent of Kenya's fresh produce exports. If the farm gate price is 60 percent of the f.o.b. price, this would bring gross revenue of $47 million to Kenya's smallholders annually. Estimates of the number of smallholders benefiting vary considerably, between 20,000 and 100,000 households, so that average horticultural export earnings for a family would be in the range $500–2,350.

Source: IWMI, 2002.

11. However, urban and peri-urban horticulture is often based on the use of untreated wastewater which, in the absence of regulation, is creating some environmental and health risks.

French bean growers was double that of other farmers (Minot in IWMI, 2002). The poverty reduction impact is significant (Box 2.2).

Horticulture is driving profitable investment in irrigation. In Kenya, about 48,000 hectares are under small-scale irrigation schemes, largely for horticulture (FAO, 2005a). Most are farmer organized systems where farmers share the cost of a pump and distribution system (Ngigi in IWMI, 2002). Rapid growth has been accompanied by new irrigation technologies. Small-scale drip irrigation systems have been improved by the Kenya Agricultural Research Institute and disseminated by local NGOs. Several types of treadle pumps costing less than $80 have also been introduced (IFAD, 2007).

Industrial Crops

Crops such as sugar cane and cotton have been proven to be viable under irrigation, but only where relatively high yields are achieved. Large-scale commercial sugar estates throughout the region have demonstrated that investment in irrigation and transport infrastructure as well as processing plants can be viable where water supplies are adequate, the construction of new dam storage is not needed, and relatively high cane yields can be obtained, as in Swaziland where yields averaged 94 t/ha in 2004 (FAOSTAT). Similarly, irrigated cotton can be viable if relatively high yields (e.g., on the order of 3–4.5 t/ha) can be obtained or where the bulk of investment costs have been sunk. Smallholders often cultivate these and other industrial crops as 'outgrowers' under contract arrangements with the processing plants, through which the latter provides inputs, extension advice, and a guaranteed market outlet and price. An example of this type of arrangement is provided by Nakambala sugar estate in Zambia.

Mixed Agricultural Water and Livestock Systems

Livestock are an integral part of most irrigated production systems. In irrigated agriculture in the region, livestock are important for animal products and for draft power and manure in irrigated crop production (IWMI-ILRI, 2005e). In Madagascar, for example, irrigated paddy yields are positively correlated with the availability of animal draft, and areas of animal concentration have a much higher use of manure (World Bank, 2003). Irrigated crop residues are used for animal feed within the region's mixed farming systems and large-scale irrigation systems have the region's highest livestock densities: on the Gezira Irrigation Scheme in Sudan, for example, 90 percent of farmers keep animals, and 30 percent of income is from livestock. Irrigated agriculture also interacts with pastoral systems: crop residues on the Gezira scheme maintain animals during the long trek to the Khartoum market.

However, irrigated fodder production is generally not viable in the region. Livestock production in sub-Saharan Africa depends more on grazing than in other regions of the world. FAO estimate that fodder currently accounts for only 3.5 percent of all crop output in the region (FAO, 2006). Irrigated fodder production is rare except in South Africa (see section 2.3 above). However, where there is good market access, irrigation water can be profitably used to grow fodder crops for fattening and the production of meat and milk—as in the intensive, stall-fed production systems around Mount Kenya. Because most fodder crops are perennial, their production under dryland conditions with in-field rainwater management is probably not an option except where rainfall patterns are bimodal.

CHAPTER 3

Investment Performance and Development Impact

3.1 Performance of Irrigation Projects

Rates of Return

Although there were many failures in the 1970s and 1980s, recent irrigation projects have generally had acceptable rates of return. A component study for this report (IWMI, 2005b) reviewed 45 donor-financed projects implemented in the region from 1970 onwards. The study found that externally financed projects in the 1970s and up to 1984 had often dismal outcomes: investment was largely in development of new large-scale irrigation, with very high costs per hectare and low or negative rates of return. Subsequent to 1985, outcomes improved: of the 22 sub-Saharan Africa projects reviewed that began in 1985 and later, only one had an ERR below 10 percent and others had ERRs ranging up to 60 percent and above.[1]

1. See Annex 6 for details of these projects. ERR calculations for the sample include some projects where storage dams, diversion structures, and long distance conveyance costs were included, and other projects where these costs were sunk. The concentration in the pre-1985 cohort of projects where all costs from storage dam downwards were included is plainly a factor in the lower rates of return recorded in the earlier period.

The key factors associated with higher rates of return include lower per hectare costs, market access, productivity, and institutional design. A number of factors influence rates of return. First, as Table 3.1 suggests, cost matters: the component study found that sub-Saharan Africa projects with higher per hectare costs tended to have lower ERRs, and 'failure' projects (those with ERRs below 10 percent) had, on average, unit costs per hectare four times those of 'successful' projects (ERRs above 10 percent). The component study found that lower-cost 'improvement' projects have higher ERRs than new construction projects (IWMI, 2005b), a finding which is confirmed by the Zimbabwe experience where upgrading cost 20 percent of new gravity development and 40 percent of new pumped supply and where upgrading projects had very much higher rates of return (IFAD, 1999, cited in World Bank, 2005c).[2] Second, market access matters: projects where higher-value crops can be sold profitably do better—in Zimbabwe, projects with good market access have rates of return generally at least three times higher than where market access is poor (IFAD, 1999, cited in World Bank, 2005c). Third, productivity makes a difference: in an example from Malawi, where 28 small-scale schemes were ranked according to the use of production factors, the low input-low output schemes all had significantly lower ERRs—and five had negative ERRs (Malawi Small-Scale Irrigation Development Project). Finally, attention to institutional and software aspects of projects matters, particularly empowerment of farmers and streamlining of the role of public agencies. Systems managed by farmers or jointly by farmers with government have performed significantly better than systems managed solely by a government agency (IWMI, 2005b).

Table 3.1 Rates of Return on Externally-Financed Irrigation Projects in Sub-Saharan Africa, 1970–1999

Parameter	*1970–74*	*1975–79*	*1980–84*	*1985–89*	*1990–94*	*1995–99*
Number of projects	3	9	11	15	4	3
Cost/ha (US$)	4,684	24,496	11,319	7,669	8,287	8,347
Average EIRR (%)	10	2	8	16	17	30

Source: IWMI, 2005b.

2. See section 3.2 below for a discussion of the factors affecting costs.

Sustainability

Returns to investments in irrigation can be high, but the risks are also high, and irrigation projects have a mixed track record on sustainability. Despite the findings of the component study that rates of return for completed projects have by and large improved, the record on sustainability has been mixed. The frequent need for rehabilitation projects in large-scale irrigation in sub-Saharan Africa (Sudan, Madagascar, Mali) is testament to the poor sustainability of some supposedly 50-year investments in the sector. Rates of return calculated for externally financed projects at completion of the construction phase have sometimes had to be revised downward subsequently, and current reports of the performance of projects previously rated as 'successful' are sometimes not encouraging (Table 3.2).

Table 3.2 Comparison of Selected Projects at Completion and Subsequent History

Project and approval year	*ERR at completion (%)*	*Subsequent history*
Mali Office du Niger (WB, 1989)	30	Sustained success, although there are concerns regarding accountability and transparency (Aw and Diemer, 2005)
Madagascar Lac Alaotra (WB, 1984)	25	"The hasty, unilateral and untimely dismantling of the irrigation agency was disastrous for the project. Water distribution has become chaotic, water charges are no longer collected, and farmer organizations have not survived." (PPAR, 1993)
Madagascar Analaiva Sugar Project (AfDB, 1983)	21	ERR recalculated as negative in the PPAR (1995)[a]
Cameroon Second SEMRY Rice Project (WB, 1978)	20	Current report (2005): "Performance is not good at the moment—a sort of pre-reform Office du Niger: parastatals management, no farmer involvement, low productivity, no cost recovery."
Ethiopia Amibara Irrigation Project (AfDB, 1987) and Revised Amibara Project (WB, 1987)	15 (AfDB); 15 (WB)	ERR recalculated as 9% in the PPAR. Current report (2005): "The absence of drainage, high sedimentation and changing river beds have haunted the system. Yields are low now, and maintenance very expensive."

a. PPAR (Project Performance Audit Report) is the instrument used by AfDB and the World Bank to review the outcomes and impacts of projects subsequent to completion of implementation.

Source: Annex 7.

What Sort of Irrigation Projects Have Performed Best?

There have been recent successful project investments in small-scale community-managed irrigation. Examples include:

- Small-scale run-of-the-river rice schemes developed at low cost ($1,070/ha) under the Tanzania Participatory Irrigation Development Project that achieved a rate of return of 22 percent and increased farm incomes by 86 percent (IFAD, 2007); and
- The Ethiopia Social Rehabilitation and Development Fund, where community-based irrigation, supplied largely from earthen dams and river diversions benefited 40,000 households, with visible improvement in the lives of villagers including increased purchase of water pumps, milk cows, and radios, as well as regular schooling for the children (World Bank, 2002a).

Individual market driven investments by smallholders with low-cost technology have also done well. The Niger Pilot Private Irrigation Project spread a variety of both manual and small-scale mechanized irrigation technologies. Manual pumping technology allowed a doubling of the cultivated area and earned a 68 percent ERR (World Bank, 2002b). The DFID-funded Micro-Irrigation Pump Promotion Project (MIPP) and its predecessors created both a demand and a supply chain for treadle pumps in Kenya and Tanzania. The private sector was then able to manufacture and distribute the pumps at a profit but still at a price affordable to farmers (IFAD, 2007).

Support to developing market links combined with reliable water supplies also works well. Under the IFAD-funded Zimbabwe Pilot Market Linkage Project, an NGO facilitated the establishment of grower associations and production of crops under contract to a local canner. Farmers also produced an irrigated crop of grain maize in the summer for home consumption and local sale. With an assured market and reliable groundwater supplies, farmers risked investment in inputs to obtain higher yields and achieved a 265 percent increase in farm income (IFAD, 2007).

One frequent feature of recent investments has been the use of a decentralized 'program approach', in which the criteria for sub-project selection are agreed up front but the process of selection is decentralized, typically to the level of a joint identification and appraisal process between a project unit and irrigator organizations. The 'program' may be restricted to irrigation investments—for example, the Nigeria

National Fadama Development Project—or irrigation may be offered as an item on a broader menu of investments, as in the Batha Rural Development Project in Chad. However, there is a risk of poor investment decisions being taken if adequate provision is not made to build capacity for sub-project appraisals and subsequent cost control and supervision (see below, section 4.4).

The Challenge of Large-Scale Irrigation

There are few examples of successful public investment in large-scale irrigation, owing to top-down planning, shaky economics, and institutional failures. Several sub-Saharan Africa countries have invested heavily in large-scale irrigation. The Sudan Gezira scheme is the largest irrigation area in the world under single management—880,000 ha. Several countries—Madagascar, Sudan, Mali, Kenya—have a history of large-scale irrigation that goes back 50 years or more. Yet it is hard to find examples of successful, or even adequate, results from these investments in recent years, and there have been a number of spectacular failures—for example at Kenya Bura. The case of publicly developed and managed large-scale schemes in Nigeria (Box 3.1) illustrates the problems often encountered: 'top down' planning, poor investment decisions, lack of transparency and accountability in public sector management agencies, inadequate skills to manage schemes, high costs, lack of financial viability (and hence poor farmer motivation), and failure to involve farmers in any of the processes.

Even rehabilitation investments in large-scale irrigation may be marginal if the irrigation technology and cropping pattern are not viable. In Nigeria, for example, rehabilitation of gravity irrigation is only viable up to an investment ceiling of $1,800/ha for rice/wheat systems, and up to $2,500/ha for vegetable production. For some large-scale irrigation schemes in Nigeria that use pumped irrigation, costs are higher than revenues and no rehabilitation can be economically justified (World Bank, 2001: WP8–20).[3]

Physical rehabilitation alone, without institutional change, has been largely unsuccessful. Even in cases where the technology and cropping pattern promise adequate economic returns, rehabilitation projects undertaken without a workable institutional model have proved uneconomic.

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3. In Nigeria, the failure of public sector management has played as important a role as poor economics in undermining the viability of large-scale irrigation.

Box 3.1

The Failure of Public Large-Scale Irrigation Schemes in Nigeria

In Nigeria the public investment program in irrigation initiated during the oil boom of the 1970s included the construction of 162 large dams, enough to irrigate 725,000 hectares. However, only 95,000 hectares of irrigation were developed (13 percent of the potential), mostly in large-scale schemes of up to 15,000 hectares each. Costs were very high, as much as $27,000/ha in 2000 terms.

In 2003/04, only 29,000 hectares of these lands were being farmed (30 percent of the area developed for irrigation and just 4 percent of the irrigable area commanded by the dams). The problems were *economic*, stemming from the basic lack of profitability of the farming system which is dominated by rice, maize, and wheat; *technical* (water control was poor because the schemes were in bad shape); and *institutional*, with weak management, low cost recovery, and little accountability to farmers. Now the government has recognized the importance of making the agencies more service-oriented, involving farmers through WUAs.

Source: World Bank, 2001; FAO, 2004b.

A number of projects that focused on physical rehabilitation turned out to be economic failures—Sudan Gezira Rehabilitation Project (1985), Madagascar Lac Alaotra Rice Intensification Project (1984), and Sudan Blue Nile Pump Scheme Rehabilitation Project (1982).

Transparent, accountable, efficient, and financially self sustaining institutions are key for successful improvement of large-scale irrigation: the improvement conducted by the Mali Office du Niger is a good example of the impact of comprehensive but gradual institutional reforms. The Office has achieved a turnaround from a dirigiste approach to one that is more service oriented and which, by combining selective investment in hardware with institutional change, has produced impressive results—paddy yields up from 1.6 t/ha to 6.0 t/ha (Box 3.2). This experience is a beacon that can show how other large-scale irrigation schemes may be turned around, provided that the underlying economic profitability is there. Other countries have tried similar approaches with less comforting results: in Madagascar the improvement program was compromised by an over-hasty withdrawal of the state without continuing support for user

Box 3.2

Successful Public Large-Scale Irrigation in Mali: The Office du Niger

The Office du Niger (ON), located in the heart of Mali, is one of oldest and largest smallholder irrigation schemes in sub-Saharan Africa. When development of the scheme began in 1932 it had been intended to develop about 1 million hectares over a period of 50 years. By 1982, however, only 60,000 hectares had been developed, of which a large part had been abandoned due to poor maintenance and operation. Cotton production had ceased, and average paddy yields had slumped to 1.6 t/ha. Attempts to rehabilitate the scheme proved successful when physical investments to improve water security were matched with institutional reforms. An impressive turnaround has been achieved: in addition to the 50,000 hectares that was still in use at the time, about 10,000 hectares of previously abandoned land was reclaimed and put to productive use, and average paddy yields have increased to 6 t/ha. O&M cost recovery has reached 97 percent.

These results are attributable to a combination of factors, including:

- irrigation system improvement and modernization;
- improved water control and management;
- adoption of improved technologies—such as high-yielding varieties, fertilizers, and improved husbandry practices;
- liberalization of paddy marketing and processing, facilitated by an improved macro-economic climate;
- improved land tenure security;
- institutional restructuring, including: privatization of most commercial functions, contracting out of maintenance works to the private sector, downsizing of the management agency and concentration on its core activities of bulk water supply, land administration, and agricultural extension; and
- more participatory approaches that engage farmers in management decisions, e.g., on O&M fees.

Underpinning this success were the long term commitment of government and managers, and the sustained support of external partners. The work at ON is, however, not yet complete: there is more to be done on strengthening farmer organizations, improving land tenure security and making the agency more accountable to farmers.

Source: Aw and Dejou, 1996; Couture et al., 2002; Aw and Diemer, 2005.

organizations that were supposed to take over (see section 4.6 below). One reason for the success of Office du Niger was that institutional reforms were introduced gradually, allowing time to overcome resistance to change and allowing time for adjustment, adaptation and fine-tuning.

3.2 Are Irrigation Investment Costs Higher than Elsewhere?

Past studies found the cost of irrigation development in the region to be excessively high. A 1995 study found that World Bank-financed irrigation projects in sub-Saharan Africa cost an average $18,000/ha, compared to an average world-wide of $4,800/ha (World Bank, 1995). These findings reflected the very high cost of the generation of large-scale schemes constructed in the region in the 1970s and 1980s—the nine major donor financed projects in the period 1975–79 had an average cost per hectare of $24,500 (Table 3.1). Not surprisingly, governments and financiers tended to view irrigation investments as high cost and uneconomic, particularly large-scale investments that also carry greater environmental and social risk. Investment behavior has been risk averse in recent years and investment in irrigation has dropped (see section 1.3 above).

The component study on irrigation investment costs (IWMI, 2005b)[4] found that the new generation of irrigation projects in sub-Saharan Africa is not much more costly than those in other regions. Irrigation projects that could be called 'successful' because their rate of return at completion was more than 10 percent did not have costs that were very much higher than those of developing countries as a whole (Table 3.3). For new construction, sub-Saharan Africa 'successful' projects cost somewhat more than successful projects in Asia, but less than those of the highest cost region, the Middle East and North Africa.[5]

The cost of 'failure' projects in sub-Saharan Africa was significantly higher than for developing countries as a whole. The costs of 'failed' projects in the region (EIRR < 10 percent) averaged $16,000–23,000/ha. However, as noted above, project performance appears to have improved

4. The study analyzed 314 projects from a world-wide sample (of which 45 were in sub-Saharan Africa), and assessed the costs per hectare of the 226 'successful' projects (of which 25 were in sub-Saharan Africa), defined as those which had EIRRs of 10 percent or higher. See Annex 5 for a list of the sub-Saharan Africa 'successful' projects.

5. This result was confirmed by an FAO study (FAO, 2005b) that reviewed the cost of 256 projects on the FAO database and found that the "purely physical costs of irrigation development in sub-Saharan Africa are only slightly higher than in other regions." The FAO study did, however, find somewhat different mean costs (in constant 2000 terms) of $6,500/ha for new schemes and only $1,900/ha for rehabilitated schemes.

Table 3.3 Average Unit Cost of 'Successful' Projects 1970–1999 (constant 2000 terms)

	New construction (US$)		*Upgrading (US$)*	
Projects	*Total cost/ha*	*Hardware cost/ha*	*Total cost/ha*	*Hardware cost/ha*
Successful projects in the entire sample	4,785	3,748	1,969	1,488
Successful projects in sub-Saharan Africa	5,726	3,566	3,488	2,303

Source: IWMI, 2005b.

in recent years—only one post-1990 project appears among the 'failures' in the sample.

Main Factors Affecting Costs

The biggest determinant of project costs is the type of irrigation investment financed. The range of costs in the sample for the component study is huge—from $225/ha for simple rehabilitation to $55,000/ha for a large-scale multi-purpose project. The principal reason for the lower unit costs of projects in recent years is the move away from the construction of large-scale schemes in the 1970s and 1980s to rehabilitation projects and, more recently, to small-scale and micro-irrigation projects. Evidently, the lessons of the past have, to some extent at least, been learned. This change is also linked to the continuing decline in cereals prices and hence to the deteriorating economics of large-scale irrigation for staples, and to the improving economics of horticulture, for which smaller scale and micro-irrigation is well adapted (IWMI, 2005b).

The evidence on economies of scale is mixed. The component study found that unit costs vary inversely with project size, i.e., there are economies of scale, but that within larger projects smaller scale schemes had higher economic returns (IWMI, 2005b). By contrast, an FAO study (2005b) found only weak correlation between project size and unit costs. Although the sample sizes in the studies are too small and the population too heterogeneous to establish very clear conclusions, it is likely that the region's high software costs do reduce when apportioned over larger projects.

Community empowerment may keep costs down—and improve performance. The component study found that community involvement in decision making keeps costs down and improves performance. Projects where farmers themselves made larger capital contributions and managed irrigation systems, or shared management with a government irrigation agency, record significantly better results in terms of project performance and unit costs (IWMI, 2005b).

To some extent, these lessons on keeping costs down are already being reflected within recent projects. More recent projects are selective in choice of technology and are often decentralized and farmer-driven, with higher farmer contributions, leading to lower unit costs. For example, for new development at Mali's Office du Niger, farmers were asked to contribute 20 percent of the total cost. As a result, development costs, which have typically exceeded $10,000/ha for large scale development, were only $2,518/ha (Aw and Diemer, 2005).

3.3 Experience of Design and Implementation

The component study on the design and implementation processes (IWMI, 2005d) found that project design in the past was largely top down, although newer projects are adopting more participatory approaches. Although there was a wide divergence of experience, the study found that past project design was generally characterized by a lack of fit of projects to goals, lack of consideration of alternatives, and lack of demand drive. Schemes developed by governments were often based on imperfect understanding of markets, farming systems, and livelihood strategies. The component study found that newer projects have adopted a less top-down approach. In some countries, a start has been made on integrating user participation (intellectual and financial) into project planning and implementation.[6] Some of these projects are carried out through decentralized units as part of larger community driven rural development programs. In fact, many of the donor-financed projects that have been evaluated as successful on completion in recent years have been characterized by both decentralized and participatory approaches. It is, however, too early to tell whether these approaches consistently improve project performance and if decentralization has encountered problems (see section 4.5 below).

The quality of projects has been reduced by common weaknesses in preparation. Weaknesses include: (i) poor treatment of the key land and water security issues, (ii) lack of adequate environmental assessment (see section 3.6 below); (iii) lack of evaluation of markets and profitability;

6. For example, the Bewani scheme in the Office du Niger area, and the Dodicha Small-scale Irrigation Project in Ethiopia (IWMI ,2005d).

(iv) lack of a related realistic agricultural support package; (v) overestimation of institutional capacity, evidenced by too complex designs and too many components; and (vi) poor technical design and overoptimistic hydrological analysis (IFAD, 2007). This last weaknesses has resulted in technology choices and costs that were not appropriate for the market prospects of the crops grown (IWMI, 2005d).

Farmer empowerment appears to improve project quality. Underlying these weaknesses, the study found a pervasive top-down approach and neglect of farmer ownership. By contrast, approaches that empower farmers by taking them in as partners and decision makers from the beginning and supporting their development as commercial agents equipped to deal in the market place from the beginning appear to have the potential to improve the economics and prospects for sustainability of projects. Approaches to empowerment found to significantly improve project quality at entry include moving responsibility and capacity for project implementation and services to the local level, increasing the participation of disadvantaged groups in decision making, improving the accountability of service providers, and helping smallholders form strong organizations (IWMI, 2005d; World Bank, 2005m).

Weaknesses in institutional capacity have impaired project implementation. The study found that implementing agencies have often proved inadequate to the tasks they were given. In many cases, weaknesses reflect the complexity of the organizational structures set up and the performance of the staff involved. Public agencies have often lacked the skills, resources, and incentives to do the job assigned to them, and the comparative advantage of the private sector or NGOs for certain tasks has been generally ignored. Project agencies also had difficulty in coping with design changes as implementation proceeded. A particularly difficult challenge has been dealing with the social and cultural problems encountered where institutional changes such as irrigation management transfer or private sector participation were part of project implementation (IWMI, 2005d; FAO, 2006).

Inadequate support to the implementing agencies has also been a cause of poor quality. In general, the component study found that governments and donors have provided a supervision process that did not match the challenge of implementation under conditions in the region, and this support has stopped too early in the cycle. There has been overemphasis on reaching physical and disbursement targets at the expense of development effectiveness (IWMI, 2005d; IFAD, 2007). Even where promising new approaches such as decentralization and participation were incorporated into projects, success has not been automatic: problems of technical, financial, and social feasibility have constantly arisen during implementation. The managers of even well implemented projects have sometimes lost sight of the poverty reduction and cost effectiveness imperatives. In general, governments and donors have not reacted with a supportive and flexible approach to help managers trying to implement projects.

Weaknesses in the learning process have made it hard to assess project impacts and to rectify shortcomings as they have occurred. Monitoring and evaluation have generally been poorly handled, with design only loosely tied to the Log Frame, which should form the basis for the monitoring and evaluation system. Implementation of M&E systems has typically started far too late in the cycle and there has been an almost complete failure to recognize that: (a) information systems are not only a fundamental requirement for project-level M&E but also for farmers' enterprise management purposes, and (b) that farm-level information systems are required to feed into project-level M&E systems. Thus, although many projects have poverty reduction objectives, almost none has monitored indicators of income such as input levels, yields, production, and prices (IWMI, 2005d). In a study of six projects in the region, in not one single case were inputs, yields, prices, and farmer incomes systematically measured. As a result it was not possible for farmers to accurately judge the effectiveness of improved technologies, nor was it possible for the projects to provide adequate ex post justification for the investments made. No realistic assessment of the poverty reduction impacts of these projects could be made. Moreover, the lack of monitoring applies equally to environmental and health aspects (see section 3.6 below), despite their obvious relevance to sustainability (IFAD, 2007).

Poor sustainability in subsequent operations reflects weaknesses in design and implementation. The component study found that weakness in scheme operations after completion of the physical works largely stemmed from weaknesses earlier in the project cycle: over-estimate of water resource availability, poor design and construction, inadequate attention to institutional arrangements and agricultural support services, and above all, the general neglect of farmer empowerment and underlying conditions of profitability. The most telling indictment is that in many cases farmers have refused to take over responsibility for operation and maintenance of schemes supposedly developed for their interests (IWMI, 2005d; FAO, 2006).

3.4 Performance of In-Field Rainwater Management for Dryland Crops

Projects intended to promote in-field rainwater management in the past have been mainly funded by NGOs and/or bilateral donors and have not necessarily been investment oriented. The promising results of various in-field rainwater management practices were mentioned above in section 2.3, but these results are largely based on research studies and pilot projects. Apart from the experience in Niger discussed in section 2.4, there has been little or no involvement of the international financing institutions in this type of water management in sub-Saharan Africa, possibly because there was no perceived need for infrastructure investment and the support of these institutions was neither offered nor sought. As a result, although a wealth of academic and research literature on the topic exists, there has been a dearth of investment analysis. There have, for example, been few if any project appraisals, project completion reports, or evaluations of the sort carried out for irrigation investment projects. The knowledge base is therefore thin in respect to investment performance analysis and evaluation.

The component study on agricultural water development for poverty reduction in Eastern and Southern Africa (IFAD, 2007), however, included field and desk studies of alternative interventions to irrigation, including in-field rainwater management. The results were mixed. A wide range of technologies was reviewed, including deep planting pits and trenches in Kenya, Tanzania, and Zimbabwe; fanya juu/chini terracing and negarim micro-catchments in Kenya; low-gradient broad-crested contour ridges and furrows in wetlands in Zimbabwe; and tied ridges and other forms of conservation farming in South Africa, Zambia, and Zimbabwe.

The wide adoption of <u>fanya juu/chini terracing</u> in East Africa has been well documented. However the component study concluded that because there appeared to be little or no evidence that the intervention increased the availability of soil moisture for cropping, its main purpose was soil conservation. As for the other techniques considered, the component study found little evidence that <u>deep planting pits and trenches</u> had any impact on the availability of water for crops—a finding that appeared to be reflected by negligible adoption. Similarly, demonstrations of <u>negarim</u> were unsuccessful. <u>Low-gradient, broad-crested contour ridges and furrows</u> in Zimbabwe, which required heavy machinery for their construction, made double cropping possible. But the site visited had been abandoned and there had been no adoption elsewhere—no doubt because of the high cost of development, estimated at $3,600/ha, which was beyond the reach of smallholder farmers.[7] Many of the interventions seen had clearly been supply-led by projects, rather than demand-led by farmers, and the promoters had given inadequate thought to physical feasibility, affordability, profitability, and replicability by farmers.

Despite this rather bleak assessment, the component study did find some successes. Four years of field trials of tied ridges in southern Zimbabwe showed an average increase of 20 percent in the yield of sorghum and maize. Yet tied ridges rarely improved yield on the shallow sandy soils that are widespread in the semi-arid areas of Southern Africa and there was a lack of adoption despite considerable efforts to promote such systems. The high labor requirement was apparently an important constraint: analysis indicated that the construction of ridges and ties was not seen as profitable by farmers, unless they had access to a (subsidized) mechanical ridger (Twomlow et al., 1997 cited in IFAD, 2007). Nevertheless, there had been successful adoption for the production of cotton on the heavier soils. The key here appeared to be the involvement of a private sector cotton marketing company that had supported on-farm trials and vigorously promoted the crop by providing technical support and in-kind credit. The crop then became profitable enough for farmers to invest in tractor power for land preparation (Nyamudeza et al., 1992 cited in IFAD, 2007).

The most promising prospect, however, appeared to be the various types of conservation farming. These cover a range of non-inversion practices from zero to reduced and deep tillage. The potential yield gains for dryland field crops can be impressive—in the case of Zambia as much as double those obtainable by conventional tillage (Hageblade et al., 2003). But these gains come at a cost—part of which includes increased investment in implements and yield-enhancing inputs such as HYV seeds, fertilizer, crop protection chemicals and sometimes higher labor costs or lower yields in the first few seasons (because of increased weed pressure unless investment is also made in herbicides). And the initial additional labor costs had obviously been perceived as a disadvantage by some Zambian farmers: one smallholder farmer, for example, com-

7. It could be argued that this was a case in which a government subsidy would be justified, but the component study estimated that investment would result in a benefit-cost ratio of only 0.1 at a discount rate of 8 percent, whereas the minimum requirement would have been a benefit-cost ratio of unity.

mented that the labor demands of conservation basins caused him to "lose a lot of energy and grow thin" and another suggested that digging basins "reduces the lifespan of an individual" (Hageblade et al., 2003). The researchers' response to this was that conservation farming represents a 'long-term investment'. Nevertheless, unless investment in physical works was accompanied by access to the necessary equipment[8] and investment in yield-enhancing inputs, the results were much less impressive and farmers lost interest—raising doubts over replicability and sustainability.

The *tassa* system promoted in Niger and referred to earlier (section 2.4) appears to be a much lower input-lower output system that that promoted in Zambia—possibly reflecting the differences in agro-ecological conditions between the two countries.[9] The results have been just as impressive, although adoption depended to some extent on the provision of food-for-work for construction of the planting basins and demi-lunes (Hassane et al)[10], again raising doubts over replicability because governments and/or donors cannot be everywhere with food relief, particularly if, as mentioned, the economic life of the investment is only three years.

Overall, the indications are that there are in-field management technologies that are potentially viable and sustainable for enhancing dryland crop production but that there are barriers to adoption that need to be identified and overcome. It is possible that the barriers are sectoral in nature, affecting agricultural production in general, and revolve around institutions, empowerment, and access to input and output markets.

3.5 Agricultural Water Projects and Poverty Reduction

Direct and Indirect Impacts on Income Poverty Reduction

Investment in agricultural water management can reduce income poverty directly and indirectly. The first <u>direct effect</u> is on <u>farm incomes</u>: agricultural water management can increase yields, allow an increase in the

8. Referring to a land management program in Tanzania, other research found that conservation tillage is a "non-starter" if the required implements are not available to farmers (Jonsson et al., 1998).

9. The *tassa* were promoted in the semi-arid zone for the production of millet, while in Zambia the technologies were promoted for maize and cotton entirely in the dry sub-humid or moister zones.

10. In fairness, it was reported that food-for-work was only provided in dry years. However, because the program was located in the semi-arid zone it might have been expected that almost every year was a dry year.

intensity of cropping and a change to higher value crops, and hence increase farm outputs and incomes. Farm outputs and incomes can also be increased because irrigation itself justifies the use of complementary yield-enhancing inputs.

For example, the component study on agricultural water development for poverty reduction in Eastern and Southern Africa (IFAD, 2007) reviewed five irrigation development programs in Madagascar, Tanzania, and Zimbabwe[11]. Average increases in *per capita* farm incomes 'with project' on rice projects in Madagascar and Tanzania were found to be in the range of 86–220 percent, while incomes on non-rice projects in Zimbabwe increased between 14 percent and 600 percent (see also Annex 8). The average increase in *per capita* farm incomes across the sets of case study projects was 226 percent.

Investment in irrigation in these cases more than trebled average *per capita* incomes. Moreover, none of the projects studied was achieving anywhere near optimum yields and outputs. For example, the weighted average paddy yields 'with project' at one project studied (Upper Mandrare Basin Project, Madagascar) were only 1.9 t/ha and 1.3 t/ha respectively for the main and off-season crop—clearly well below potential (see above, section 2.3). Similarly, average irrigated grain maize yields at three non-rice projects studied in Zimbabwe were only 2.5–3.4 t/ha—also well below potential. The lesson is clear: even moderately performing investment in irrigation can have significant impacts on farm incomes and hence on poverty reduction. The corollary is that such projects could have a far greater impact on poverty reduction if they performed better.

The second direct effect of agricultural water management on income poverty is via rural employment: additional demand for labor is created first for construction and on-going maintenance of canals, wells, pumps, and the like (or land preparation in the case of investments in in-field rainwater management), and second for crop production and farm-to-market activities. Thus, agricultural water development increases both the numbers of workers required and (because of multiple cropping) their period of employment (Lipton et al., 2003). In the projects analyzed in the component study (see Annex 8), investment in irrigation was found to have resulted in an incremental 45 days/ha of wage labor on average, over and above farm family labor, valued at approximately \$1/labor-day (IFAD, 2007).

11. Two of the component studies of the Collaborative Program (IFAD, 2007 and IWMI, 2005g) provided material for the analysis in this sub-chapter.

The third direct effect is via food prices: increased food output can reduce local food prices and so improve real net incomes among net food purchasers, including both rural and urban poor. At the same time, positive effects on real net incomes will still be experienced by net food producers and wage laborers provided the effect of reduced prices is offset by increased output and employment. On the other hand, negative effects may be experienced by surplus producers in remote dryland cropping areas when agricultural water development is introduced. However, because the majority of the poor in sub-Saharan Africa are net food purchasers, the overall net effect of reduced food prices on income poverty reduction and hunger can be expected to be positive (Lipton et al., 2003).

The indirect impacts of agricultural water development on income poverty can include those obtained via rural and urban employment as a result of growth in the rural and urban non-farm economy. Agricultural growth can influence non-farm activity in at least three ways: through production, consumption, and labor demand links (Rosegrant et al., 2005). Income and employment multipliers within the surrounding non-farm economy can be particularly large: between 1.5 and 2.0[12] in Asia (Haggblade et al., 1989 and Hazell et al., 1991; both cited in Rosegrant et al., 2005), although they are only about one-half as large in Africa (Dorosh et al., 2000 and Haggblade et al., 1989; both cited in Rosegrant et al., 2005). Lower multipliers in Africa were attributed by Dorosh et al. to low per capita incomes, poor infrastructure, and farming technologies that required few purchased inputs—in other words, to a less developed agriculture sector.

Water-managed agriculture intrinsically involves higher levels of inputs—including labor—and results in greater employment, outputs, and incomes than dryland agriculture. Thus the multipliers from successful agricultural water investment are likely to be higher than those for investment in dryland agriculture in general. Although no information was available on the non-farm employment impacts of agricultural water development in sub-Saharan Africa, non-farm employment in India has been found to be higher in irrigated villages than in non-irrigated villages (Dasgupta et al., 1997; Jayaraj, 1992; Saleth, 1996, all cited in Rosegrant et al., 2005). At the large-scale Muda Irrigation Project in Malaysia, for example, for every dollar of income generated

12. That is, each $1.00 increase in agricultural value leads to an additional $0.50 to $1.00 of additional income created in the local non-farm economy.

directly by the project, another 83 cents was generated in the form of indirect or downstream income benefits (Bell et al., 1982, cited in Rosegrant et al., 2005).

To sum up, even moderately successful investment in agricultural water development can treble per capita farm incomes and provide additional wage employment of approximately 45 labor-days/ha—which in itself has a significant impact on income poverty reduction. Every dollar of income so generated probably generates at least US$ 0.40–0.50 in the form of indirect income benefits. And this is so even for investment projects that perform no better than modestly.

Agricultural water development could also be one of the better alternatives for poverty reduction. Clearly, investment in agricultural water development can have substantial impacts on income poverty reduction, but is it the best of the available alternatives? As discussed in Chapter 1, when up to 90 percent of rural people are poor and rely on agriculture for their primary livelihoods, significant growth in agriculture is a necessary step toward poverty reduction. Although improved primary education, better health services, clean water and better roads are all important and appropriate investments, they are not sufficient in and of themselves to generate increased rural incomes (Brooks, 2005). Since agricultural growth is so important for poverty reduction when compared with the available alternatives, agricultural water development could be even more so, since the potential income growth per hectare from successful investment in agricultural water is greater than that from dryland agriculture. Although data are not available to prove the validity of this assumption for sub-Saharan Africa, differences in the rate of growth of average agricultural output per unit of crop area were important in explaining cross-state differences in rural poverty reduction in India, for example, where the impact of irrigation in reducing poverty was found to be even higher than that of rural literacy and significantly higher than roads, fertilizers and modern varieties (Datt et al., 1997, cited in Rosegrant et al., 2005). If this is the case elsewhere, there would appear to be no reason why the same should not apply in sub-Saharan Africa.

Furthermore, the income poverty reduction impacts of agricultural water investment can induce positive impacts on other MDGs. The income poverty reduction impacts of agricultural water investment induce important positive impacts on other MDGs, including reduced hunger, improved access to primary education, safe drinking water, and basic sanitation, as well as a contribution to improved maternal health, reduced child mortality, and generally better nutrition and health (IFAD, 2007 and Box 3.3).

Box 3.3

Irrigation Considerably Enhances Farm Incomes, Livelihoods, and Employment Opportunities at Irrigation Schemes in Tanzania and Zimbabwe

At the Participatory Irrigation Development Project in Tanzania, irrigator households achieved an increase of 86 percent in income with the project, which enabled them to enjoy better quality housing, acquire agricultural and household assets, access health services, and finance children's education. In four representative sub-project areas (totaling approximately 400 ha), ownership of ox carts and cattle increased considerably, the number of grinding mills increased from two to 12, and the number of shops increased from two to 74.

Irrigator households at the EU-funded Maunganidze Irrigation Scheme in Zimbabwe increased their incomes by over 200 percent and turned a food deficit into a surplus sufficient to feed two additional households. Farmers' own investments in new housing and in water and sanitation were the most obvious signs of improved livelihoods, with a number of modern two or three room houses, ventilated pit latrines and, in a number of cases, their own protected water well. Traders reported increased sales of agricultural inputs and implements, and increased demand for groceries and house building materials and construction services. New grinding mills had been established, as well as new workshops for manufacturing farming equipment such as ox carts. There was no doubt that these impacts were the result of investment in irrigation because there were no other sources of income in the area. Excellent road access, for example, by itself had not had any discernible impacts on poverty in the area.

Source: IFAD, 2007.

Targeting the Poor and Women

Some irrigation project designs of the past two to three decades have attempted—usually unsuccessfully—to target the poorest. Defining extreme poverty in terms of the MDG income poverty level has now simplified targeting. Where targeting the poorest socioeconomic stratum has been specified in the past, it has rarely been implemented as planned (IFAD, 2007). Either the technology was inappropriate for the poorest, the targeting methodology was weak, or implementation staff had not fully understood the intentions or found it socially infeasible to carry out because of the socio-geographical and political implications of excluding the less poor. Defining extreme poverty in terms of per capita income of less than $1/day (see section 1.1 above) has simplified targeting, as most rural people in the region have to subsist on less than this amount. For example, in the Madagascar, Tanzania, and Zimbabwe cases cited above, no attempt was made at targeting, yet it is clear that it was mainly the extreme poor who benefited because average without-project farm incomes ranged from only $0.03 to $0.13 per capita-day (Annex 8).

Agricultural water investments, even without targeting, will therefore mainly benefit the extreme poor, although in a range of different ways. It is likely that the vast majority of the rural populations of sub-Saharan Africa fall into the category of 'extreme poor' and almost any agricultural water development based on principles of profitability and equity will benefit a majority of poor people. However, different poor people may benefit in different ways: some will benefit from direct participation as producers, others will benefit directly from agricultural wage employment, others from access to crop by-products for livestock and others from employment in upstream and downstream economic activities generated by the investment. Moreover, it is usually the poorest stratum that benefits most from the additional wage employment opportunities generated by investment in agricultural water (IFAD, 2007).

There are, however, a number of ways in which the poverty reduction impacts of investments can be enhanced. The first step is to understand the socioeconomic profile of the communities, how they derive their livelihoods, what their constraints are, how they interact socioeconomically, and how agricultural water management can improve their livelihoods. Based on this knowledge, measures can be included to make projects more pro-poor. These measures include: (a) capacity building and empowering the poor to participate effectively, (b) ensuring that the voice of the poorer segments of communities is adequately heard in participatory planning and land and water allocation decisions; (c) minimizing involuntary resettlement and ensuring that the poor are not excluded or further marginalized by the development; (d) strengthening the bargaining powers of the poor though institutional reform and facilitating their access to land and water; (e) targeting the poor with extra technical support; (f) ensuring that the entry price is affordable to the poorest stratum, for example, by the use of affordable technologies; (g) ensuring that cost-recovery arrangements/water charges are not unfairly weighted against the poorest stratum; and (h) optimizing the potential for direct and indirect employment gains. Annex 8 provides a checklist (based on World Bank, 2005b) for improving the pro-poor impacts of agricultural water projects.

Targeting agro-ecological zones and farming systems with high agricultural potential and concentrations of poverty can also be pro-poor. It was found that when arid and semi-arid zones had been targeted for poverty reduction, the results were mixed, mainly because of the generally high costs of water development in such zones, their general remoteness from markets and their sparse populations (IFAD, 2007). In contrast, the more humid agro-ecological zones, which also coincide with high incidences of poverty, provide better potential for investing in agricultural water for poverty reduction (Dixon et al., 2003). This perhaps surprising suggestion may be explained by considering that, as population densities increase, farmers gradually shift from extensive to increasingly intensive production systems. The trend is encouraged once significant market opportunities emerge. Where population densities are high, where a process of intensification has already started, and where market opportunities are emerging, investment in agricultural water development is therefore likely to be more successful than in the drier zones. This does not, of course, exclude the possibility that there will be opportunities for investment in agricultural water management in the arid and semi-arid zones and that these could also make a significant contribution to poverty reduction and growth—provided they are demonstrably economically viable and physically sustainable.

In addition to considerations of gender equity, targeting women can also enhance poverty reduction impacts. Women contribute 60–80 percent of labor for food production in sub-Saharan Africa, typically with a major role in planting, weeding, application of fertilizers and pesticides, harvesting, threshing, food processing, transporting, and marketing, while men are generally responsible for land clearing and preparation, including plowing (FAO, 2003a). This division of labor also applies in irrigated agriculture. In many Southern African countries, the proportion of female-headed rural households and women-led farms may exceed 50 percent (IWMI, 2005g). At selected schemes in Zimbabwe, for example, 20–64 percent of the plot holders were female-headed households (IFAD, 2007). In rice-growing areas in West Africa and parts of Southern and Eastern Africa, paddy cultivation is increasingly becoming a 'female farming system' in which women are often the decision makers on formerly male-managed farms as a consequence of male migration to towns for work (IWMI, 2005g). Women often take the lead in fruit and vegetable production (Box 3.4), as well as in production support activities such as savings groups (IFAD, 2002). Studies have shown that gender-equitable agricultural production boosts productivity (IWMI, 2005g). Clearly, targeting women for training and support services and ensuring their equitable participation in the benefits of agricultural water investments can improve productivity and enhance poverty reduction.

Yet despite the rhetoric, most staff in support services are male and policies and communications strategies are biased toward males. Projects can compensate for these biases by building gender considerations into design and implementation from the outset (IWMI, 2005g).

3.6 Environmental and Health Aspects of Agricultural Water Projects

The component study on environmental and health aspects (*IWMI, 2005c*) found that well-designed and well-implemented agricultural water development can have positive impacts. Environmental benefits of agricultural water development can include reduced flooding and reduced soil erosion and silt loads. In addition, intensification (rather than 'extensification') of agriculture may preserve natural areas of intrinsic worth from development. Agricultural water development also directly improves nutrition and health through higher incomes and improved food supply, and can have a particularly marked impact when targeted at

Box 3.4

Women and Treadle Pumps for Fruit and Vegetable Production in Tanzania

Monitoring of treadle pumps sold in Tanzania for fruit and vegetable production found that 95 percent of pumps sold were bought by men. At the start, 40 percent of these pumps were managed by women, but this share went up to over 60 percent within a year. One explanation is that proceeds from the newly irrigated agriculture had enabled the men to move on to other income generating activities.

Source: IFAD, 2007.

the poor and at women. Health and food security may also be improved indirectly by strengthening institutions associated with agricultural water development.

But failure to manage environmental impacts has sometimes reduced productivity and even led to the failure of some agricultural water projects in the region. There are multiple and reciprocal interactions between agricultural water and the environment; failing to manage environmental factors has sometimes been a cause of reduced productivity and even failure of projects. At the 350-hectare Gem-Rae rice scheme in Kenya, deterioration in the catchment led to such large sediment flows that farmers were clearing sediment daily instead of farming. The scheme has been virtually abandoned. At the Chokwe irrigation scheme in Mozambique, poor drainage has led to the loss of about 5,000 hectares out of a total 30,000 hectares due to salinization. In Somalia, the Jowhar off-stream reservoir constructed to collect flood flows for dry season irrigation has become so silted up that large-scale irrigation in southern Somalia has virtually collapsed.

Some hydraulic developments have also harmed the health of the population. In Ethiopia, the construction of small dams in the semi-arid northern region of Tigre led to increased spread of malaria, even at altitudes over 2,000 meters. In Burkina Faso, around 1,500 small dams have been constructed since 1974 but no measures were taken to control adverse health impacts, and urinary schistosomiasis has spread. Although individual environmental impacts may be small, the cumulative environmental impacts of many small interventions therefore need to be taken into account. Potential health impacts require public sector forethought at the design stage: evidence shows that farmers are often aware of environmental and health problems as they emerge but that corrective actions are beyond the capability of small farmers.

Many of these problems are attributable to the weaknesses of public sector institutional capacity for regulating environmental and health aspects. The regulatory and enforcement framework in countries in the region is often inadequate. National procedures may be too weak (Box 3.5), and national institutions may lack the capacity to handle environmental, social, and health aspects. Often, adverse consequences occur because schemes are developed in isolation from other developments in the basin, and all too often environmental flows have been neglected. Where externally financed projects are concerned, donors have their requirements but these differ among donors and usually do little to build national consciousness and institutional capacity. Negative environmental and health

Box 3.5

In Nigeria Large-Scale Irrigation, National Procedures Are Not Adequate to Protect the Environment or Reduce Social Harms

In Nigeria, the basin authorities did not give adequate attention to the environmental impacts of the large-scale irrigation schemes they constructed in the 1970s and 1980s. As a result, these schemes have done considerable environmental damage. Downstream hydrology has been severely modified, especially in the north, wiping out extensive areas of *fadama*, capture fisheries, and wildlife habitat. Now Environmental Impact Assessments are required for irrigation schemes or wetland drainage over 100 hectares, but the adverse environmental effects of earlier development persist. The economic benefits from irrigation upstream of the Hadejia-Nguru wetlands were significantly outweighed by economic losses arising from the damage caused to the wetlands by the irrigation scheme.

Most large schemes in Nigeria have also run into serious social problems. Fulani herdsmen generally have no security of tenure, and as irrigation schemes expanded, Fulani were forced out, creating conflicts. Also disadvantaged were families displaced by dams and reservoirs. Resettlement was not organized, and the dispossessed were basically left to their own devices.

Source: World Bank, 2001; Barbier et al., 1991.

outcomes may also result from unregulated private agricultural water development (Box 4.1). The problems are not lessened by decentralization and private sector development: small-scale projects and informal peri-urban irrigation using wastewater can cause environmental and health problems too. Lack of environmental and health monitoring is also a very considerable learning weakness (see also section 3.4).

However, many environmental and health risks can be managed at the project level. Many adverse socio-environmental and health effects can be prevented by carrying out integrated and participatory impact assessments during preparation to identify alternative designs or mitigation measures. For example, a watershed management component may be added to a project to tackle anticipated siltation problems (World Bank, 2006a); a closed conduit system may be implemented in place of

Box 3.6

Engineering *Schistosomiasis* Control into Irrigation

In the Mushandike scheme in Zimbabwe, the need to control schistosomiasis determined the final design of a 400-hectare smallholder irrigation scheme. The scheme was located as far as possible from villages. Canals were all lined with concrete with a flow velocity sufficient to dislodge snails. Hydraulic structures were designed to allow quick drainage and so avoid standing water. In the operation of the system, regular drying out of the canals, water level fluctuation in night reservoirs and routine cleaning contributed to the continuous control of snails. As a result, snail hosts have been greatly reduced, and a 10-year study showed both snail populations and schistosomiasis infection rates lower than in comparable villages where only treatment was used.

Source: IWMI, 2005c.

open canals to reduce the breeding ground for mosquitoes; or a drainage system may be added to avoid water logging and salinization. Box 3.6 describes how an irrigation project was engineered to reduce disease risk. Project level monitoring and evaluation systems can capture environmental and health impacts.

Agricultural water management also needs to take account of HIV/AIDS. The scourge of HIV/AIDS has a pervasive impact on life in the region. Agricultural water management has an important role to play in mitigating the impacts—increased incomes and food availability are recognized as being key to helping people fight HIV/AIDS-related infections. One important negative factor is the loss of skilled engineers, professionals, and farmer leaders responsible for the development, operation, and maintenance of schemes. There is a need for specific strategies within agricultural water projects, especially increased capacity building and, where possible, health components to address the attrition of staff and farmers.

CHAPTER 4

The Changing Institutional Context

4.1 Transboundary Water

Given the high level of transboundary resources in sub-Saharan Africa, agreement on their use is key to sustainable agricultural water investment. Current processes are therefore emphasizing cooperative and mutually beneficial development. Shared basins cover 63 percent of the land area of sub-Saharan Africa and 12 countries of the region depend on external resources for more than one-half of their total water resources. With this large proportion of shared water resources, regional planning and coordination for transboundary resource allocation, for IWRM, and for catchment management are particularly important (FAO, 2006). A number of states have been cooperating under various programs. For example, Mauritania, Senegal, and Mali established the Organisation de Mise en Valeur du Fleuve Senegal (OMVS) in 1972, and have since constructed dams at Daima in Senegal and Manantali in Mali for irrigation, hydropower, and navigation. Lake Victoria faces the threat of environmental degradation which may be aggravated by increased irrigation upstream, and although there is as yet no formal treaty relationship, riparian states are cooperating on the preparation of a joint 'Vision and Strategy Framework' for its management (Box 4.1). This framework,

Box 4.1

Kenya Begins Cooperation with Lake Victoria Riparians on Environmental Issues

Kenya shares over one-half its rivers, lakes, and aquifers with neighboring countries, but has not yet entered into any formal agreement with any riparian state. However, Kenya is keen to develop the water resources of the Lake Victoria Basin for agriculture and other uses and has joined with other riparians in preparing a joint 'Vision and Strategy Framework' for its management. Collective action is being triggered by the increasing eutrophication of the lake from excess nutrient loads, a substantial portion of which stems from Kenya fertilizer use.

Source: World Bank, 2004a.

however, may prove inadequate to stem negative impacts on the environment arising from, for example, releases for hydropower that are causing lake levels to drop excessively. An initial focus on the benefits of cooperative management—say, for water flow and quality—and of agreed or cooperative development for irrigation and hydropower can lead in due course to more formal relationships and viable transboundary institutions.

This creates opportunities for optimizing investment strategies at the basin scale, and partnerships for joint management and development of a number of shared basins in sub-Saharan Africa have been created. For example, to achieve sustainable water security, Nile Basin riparians are working on shared waters. The Nile Basin Initiative offers considerable potential for major cooperative development of the basin, including large-scale irrigation and hydropower development. In addition, opportunities for regional cooperation and integration in a range of activities beyond the river have arisen as a consequence of strengthened relations built up from the Initiative (World Bank, 2005f; World Bank, 2005b).

Regional organizations and donors have helped to forge these partnerships and have provided investment support, for example, for the OMVS and the Nile Basin Initiative. With donor support, the SADC countries agreed a Protocol on Shared Watercourses in 1995 as a basis for regional integration in water resources management and investment. This led to the 1998 Regional Strategic Action Plan for IWRM in SADC countries and has now triggered the Zambezi Process among the eight riparian states and the establishment of a permanent Zambezi Watercourse Commission (World Bank, 2005c). These partnerships give priority to investment in agricultural water and hydropower.

4.2 Strategic Planning and Agricultural Water

The last decade has witnessed important changes in approaches to international development assistance. These have included the unprecedented consensus on development objectives in the form of the MDGs, as well as the commitment in Paris in 2005 by a large number of development assistance stakeholders as to how those objectives may be pursued more effectively.[1] Poverty reduction strategy papers (PRSPs) or other forms of strategies for poverty reduction have provided the point of reference for national development efforts in most sub-Saharan Africa countries.

However, not all poverty reduction strategies have recognized the role that agriculture can play in poverty reduction and few have acknowledged the importance to the sector of agricultural water development. Early PRSPs did not always explicitly recognize the critical role of the agriculture sector in poverty reduction and growth, although more recent examples have done so. They have, however, generally still not assigned much prominence to agricultural water development. Consequently, the subsector has tended to be neglected in investment programs for the agriculture and water sectors. The reason for this neglect lies partly in the negative perceptions of agricultural water referred to earlier in this report (see section 3.2 above) and partly in the fact that in many countries agriculture and water are served by separate ministries, which, because of divided responsibility, has too often led both to neglect the subsector (IFAD, 2002).

On the other hand, agricultural water development strategies have, in the past, not been entirely consistent with PRSP objectives. Specific poverty reduction objectives have not featured prominently in water sector and irrigation strategies, and often they have not reflected the poverty reduction objectives of the PRSPs. For example, the 1995

1. At the Paris High Level Forum on aid effectiveness held in February/March 2005, the international community endorsed the *Paris Declaration on Harmonization and Alignment*, making a commitment to a series of measures to achieve greater aid effectiveness: (a) countries should take responsibility for setting *country-led development strategies*; (b) aid should be *harmonized* through common arrangements for financing and technical assistance; (c) aid should be *aligned* on national development strategies and institutions and on strengthened country systems; (d) aid should be *managed by results*; and (e) there should be *mutual accountability*, for example, through joint assessments of donor actions.

Mozambique National Water Plan mentions smallholder irrigation only briefly, despite the prominence given to the subsector in the PRSP.

There has been an absence of a strategic approach to investment in agricultural water. In general, a strategic approach to agricultural water has not been adopted, and agricultural water investment programs have often been poorly integrated with overall development objectives and policies (IWMI, 2005d). In some cases, projects have been selected in pursuit of goals such as food sufficiency and have lacked basic economic viability. An example is the development of pump irrigation schemes for cereals production in Nigeria discussed above (see sections 2.3 and 3.1).

However, a new generation of irrigation strategies in sub-Saharan Africa has begun to emerge in recent years. These respect the need for an integrated, strategic approach to agricultural water development and take advantage of potential synergies with macroeconomic and sectoral policies (World Bank, 2005b). The best of these strategies also reflect the new development paradigms and recognize the need for community empowerment and participation in design and implementation, as well as a market driven approach (Box 4.2). In particular, they acknowledge that productivity and profitability are the keys to sustainability and that it is necessary to remove constraints to their achievement. They emphasize the need for farmer initiative and financing, with a reduced but tactical role for public financing. The irrigation strategies of Ethiopia and Zambia are good examples of this new generation. Although it is taking time for these strategies to be fully owned and agreed by stakeholders—both national and donor—some results are now being achieved. In the case of Mali, for example, the integrated strategy exercise has resulted in a switch of irrigation investment away from large-scale public projects to participatory approaches, public private partnerships, and more emphasis on smaller scale schemes.

The strategic planning process has also received impetus from the preparation of National Medium-Term Investment Programs under CAADP (IWMI, 2005d; AfDB/FAO, 2005). At the regional level NEPAD's 2002 CAADP adopted land and water management as the first of its four pillars for priority investment and proposed extending the area under "sustainable land management and reliable water control systems" to 20 million hectares (i.e., approximately double the area currently under water management in sub-Saharan Africa) by 2015,[2]

2. NEPAD has since proposed extending this time horizon.

Box 4.2

Recent Irrigation Strategies are In Line with a Market-Driven Approach

Working with the FAO, six West African governments—Mali, Mauritania, Senegal, Ivory Coast, Niger, and Burkina Faso—have developed irrigation strategies with approaches in common.[a] These include:

- A redefinition of the roles of the state, farmers, and the private sector, with a new emphasis on liberalization, farmer empowerment and minimal government involvement;
- Participatory approaches from identification of projects through to management of the works;
- Prioritization of individual or small group schemes;
- Review of more alternative interventions to find solutions that are least cost and most profitable for farmers;
- Accounting for environmental impacts and social equity;
- Requirements that farmers cover O&M costs and a share of the capital costs;
- Removal of administrative and fiscal obstacles; and
- Promotion of demand driven research.

a. Mali Stratégie de l'Irrigation 1999; Mauritanie Stratégie du Développement Rural 1997; Senegal Stratégie de Développement de la Petite Irrigation 1999; Ivory Coast Stratégie de Développement de la Petite Irrigation 1999; Niger Stratégie Nationale de Développement de l'Irrigation et de Collecte des Eaux de Ruissellement 2001; and Burkina Faso Stratégie de Développement Durable de l'Agriculture Irriguée 2004.

Source: Gadelle in Sally et al., 2002.

although the rationale for this was principally to reduce national and regional food imports, rather than poverty reduction per se. The main emphasis was investment in infrastructure rather than institutions. However, a 2005 progress review drew attention to the low level of investment actually achieved since CAADP's launch in 2002 (only $0.5 billion, compared with its target of $9.9 billion, with only a modest pipeline). The review observed that a lack of implementation capacity in public agencies and private service providers was a constraint and concluded, inter alia, that CAADP needed to be rescheduled to take account of this. The review also observed that increased productivity could not be achieved through investment in water management infrastructure alone. There needed to be investment in a package of institutional measures and market access/post-harvest rural infrastructure (AfDB/FAO, 2005). Currently, countries in the region are preparing, with FAO assistance, National Medium Term Investment Plans and a portfolio of bankable projects (Annex 9).

4.3 Policy Reforms and Agricultural Water Development Strategies

Macroeconomic and Public Sector Reforms

A number of countries have undertaken policy reforms intended to improve the macroeconomy and performance of the productive sectors. These have often included liberalization of exchange rates and controls, removal of tariff barriers, market liberalization, and a generally pro-enterprise framework. Public sector reforms have involved redefinition of the core functions of government—essentially allowing it to concentrate more on policy matters, strategic planning, regulation, and facilitation of development and less on being an investor, implementer, and service provider—with greater reliance on the private sector and the market.

Agriculture Sector Reforms

In parallel with the above, a number of countries of the region have prepared new agriculture sector development strategies and embarked on reforms intended to promote agricultural growth. The emphasis has been on increasing <u>productivity</u> and <u>profitability</u> in the smallholder sector (Box 4.3) and greater recognition of the role that the private sector—from smallholder farmers to large-scale commercial estates and agribusinesses—can and does play in the agriculture sector (IFAD, 2002).

Nevertheless, the impacts of agriculture sector reforms have not yet reached their 'steady state' and delivered the anticipated benefits. In particular, reductions in the scope and operations of public agricultural support services have in some cases left smallholder farmers without the technology or financing to increase their productivity (although this is not to say that the previous level of service was in any way adequate). At the same time, although the withdrawal of the state from marketing has removed some distortions that would often have disadvantaged smallholder producers, it has often left farmers unprepared to deal with the market. Preparing smallholders to meet this challenge is critical for success in agricultural development generally. Hence, organizational

Box 4.3

Reforms Under the Agriculture Sector Development Strategy, Tanzania

Tanzania's Agriculture Sector Development Strategy (ASDS), which was published in October 2001, comprises a set of innovative and practical actions intended to stimulate agricultural growth and reduce rural poverty. These include a focus on commercialization of the agriculture sector and increasing its productivity and profitability.

Arrangements for implementation of the ASDS are elaborated in the Agriculture Sector Development Program (ASDP) Draft Framework and Process Document (September 2002). At the heart of ASDP is a sector-wide approach to changing the function of central government from an executive role to a facilitating one, to empowering local government and communities to reassume control of their planning and implementation processes, and to encouraging private sector participation in all aspects of agriculture—including investment, processing, and marketing. Under this new approach, 70–80 percent of public (government and/or donor) funding of the sector will now be managed by district councils and utilized through District Agricultural Development Plans (DADPs). Greater use will be made of outsourcing through contracts with private sector service providers, and greater awareness of cross cutting issues, including gender and the environment, will also be promoted.

The new approach will require a transformation in the way public investments in the smallholder irrigation subsector are analyzed, planned, and implemented. In conformity with the ASDS and ASDP, planning and implementation of smallholder irrigation subsector investment projects must now be based on the need for them to be driven by irrigators (or potential irrigators), responsive to market opportunities, coordinated at the local level, and profitable. This implies a need for more critical analysis of proposed investments and greater farmer participation in this process and that of their subsequent planning and implementation. It also implies a need to recognize that participation means more than mere consultation and that it takes time. It furthermore implies a need to recognize that farmers are the best judges of their own investment priorities and that these may not necessarily include investment in physical irrigation works, which do not always present the best opportunities for increasing output and incomes. Farmers may instead, for example, have identified a marketing opportunity or constraint that, if seized or addressed, would achieve their objectives more effectively.

Source: Ministry of Agriculture and Food Security, Tanzania, 2003.

development, training, and capacity building to link smallholder farmers to markets have now become at least as important as infrastructural development (Box 4.4; IFAD, 2003).

Efforts are being made to help small farmers meet the challenges posed by reforms. These include efforts to empower smallholders to develop their own capacity to respond to their needs for financial services through membership-based organizations such as savings and credit cooperatives and credit unions. These farmer-owned organizations are proving particularly well-suited to the financing of individual irrigation investments, where the entry cost can be as low as $15 (Table 4.1) and where success can generate the credit rating and cash flow that allow an irrigator to progress to higher levels of investment. Some farmer-owned organizations, for example CECAM in Madagascar, have developed

Box 4.4

Supporting Policy Reform in Tanzania

The $42 million Agricultural Marketing Systems Development Program, co-financed by AfDB, IFAD, Ireland Aid, and others, has been assisting the government of Tanzania in bringing about a comprehensive change in the agricultural marketing sector with the objective of making rural markets work better and empowering smallholders within them. The program is: (a) strengthening about 1,000 producer groups to enable them to enjoy a stronger bargaining position and more leverage on policy formulation, identification of marketing opportunities and price negotiations for both inputs and outputs; (b) supporting local government reforms by capacity building intended to lead to rationalization of regulation and taxation regimes to promote improved efficiency in the marketing system as a whole; (c) improving market infrastructure through construction or rehabilitation of 700 kilometers of rural roads, 200 kilometers of access roads, and 30 market centers, and through financing of post-harvest facilities; (d) strengthening the capacity of the Ministry of Cooperatives and Marketing (now the Ministry of Marketing); (e) helping producer groups, grass-roots institutions, traders, and processors to access loans from commercial banks for promotion of marketing activities; and (f) establishing and strengthening market links between producer groups, grass-roots institutions, processors, local marketing chains, and exporters.

Source: IFAD, 2001.

Table 4.1 Investment and Working Capital Requirements for Intensive Irrigated Production in Kenya

System	*Area irrigated (m^2)*	*Investment cost (US$)*	*Production costs (US$)*
Bucket kit—drip irrigation	50	15	< 9
Drum kit—drip irrigation	500	110	< 95
Treadle pump	6,000	185	< 880
Motorized system (4 HP)	10,000	610	< 1,480

Source: Financing Small Scale Irrigation in Sub-Saharan Africa, interim results of a World Bank/GTZ study.

products such as leasing that are well adapted to individual irrigation investment. In Niger, local artisans have supplied treadle pumps to farmers on a hire-purchase basis.

Smallholders have also been empowered to access extension services, through a range of service providers contracted directly by farmers, as well as participatory approaches such as farmer field schools (Box 4.5).

Efforts are also being made to empower smallholders and their organizations to collectively engage with input and output markets. These include attempts to develop market links in which the various actors—private commercial entities (such as agri-processors and exporters, smallholder producers, the public sector and NGOs)—are brought together into 'win-win' partnerships intended to ensure equitable returns to both smallholders and the private sector entities concerned (Box 4.6). Establishing a supportive policy and legal framework, as well as capacity-building to help smallholders adapt to transformation, is essential.

Water Sector Reforms

The many functions and interrelated impacts of water require an integrated inter-sectoral planning approach. As elsewhere in the world, agriculture is the largest user of water in most countries of sub-Saharan Africa. Its use therefore has the most interactions and impacts with other parts of the hydrological, environmental, social, and economic system and must fit within a rational allocation of water resources between the environment, agricultural, hydropower, urban, and industrial withdrawals, as well as for other economic uses such as transport and tourism.

The 1992 Dublin Statement on Water and Sustainable Development reflected international consensus that, in light of intersectoral competition for water use and growing water scarcity worldwide, effective management of water resources was essential. The Dublin Statement called for an integrated, intersectoral approach to water management and allocation, from

Box 4.5

Farmer Empowerment through Farmer Field Schools in Kenya

The Integrated Production and Pest Management Program in Kenya was implemented by the Ministry of Agriculture in Kenya with the collaboration of the Global IPM facility of FAO and financial support from IFAD. It adopted the Farmer Field School approach, which can be described as a community-based, practically oriented field study program involving a group of farmers, facilitated by extension staff (public or private) or, increasingly, other farmers. The FFS provides an opportunity for farmers to learn together and adapt practices, using practical hands on methods of discovery learning that emphasize observation, discussion, analysis, and collective decision making. The process aims to build self-confidence and to improve group and community skills. The knowledge acquired during the learning process enables farmers to adapt their existing technologies to be more productive, profitable, and responsive to changing conditions, or to test and adopt new technologies.

The IPPM-FFS Program was implemented over three seasons in three districts of Kenya's Western Province—all of them poor districts, badly affected by HIV/AIDS, high population densities, declining farm sizes, and deteriorating soil fertility. In total 471 FFSs were established under the program, with an average of 25–30 members each, or a total of about 13,000 farmers, of which approximately 60 percent were women. Self-targeting resulted in the vast majority of the membership being drawn from the middle and poorest socioeconomic stratum.

The most important lessons learned were:

- FFS encouraged communities to validate and adapt improved technologies and empowered them to find solutions to their problems.
- Farmer management of FFS funds, particularly payments for extension services, substantially improved the accountability and performance of extension providers.
- The promotion of farmer-led FFS, with farmers (rather than extension staff) as facilitators allowed the program to reach a much larger number of farmers than would otherwise have been the case.
- FFS empowered communities and raised their profile at a district level, hence increasing their ability to influence local level planning.
- Women seemed to especially value the approach, owing to its practical, field-based learning focus and the social value of the FFS groups.

Source: Khisa et al. in Penning de Vries et al., 2005.

Box 4.6

Win-Win Partnerships for Market Links in Zambia, Zimbabwe, and Niger

Despite abundant land and water resources, Zambian agriculture is poor, with weak markets and rudimentary irrigation techniques. The Zambia Agribusiness Technical Assistance Centre (ZATAC) has promoted outgrower horticulture schemes directly linked to ready markets through agribusinesses. This strategy offers small growers an opportunity to be partners in the value chain and offers agribusinesses a chance to increase their supply base and benefit from economies of scale without the associated capital investment. ZATAC helped override the water constraint by providing credit for irrigation equipment. For the first time in the history of Zambia, smallholders now grow fresh vegetables for markets in Europe in an alliance between smallholder producers and agribusinesses.

Farmers at Maunganidze and Mupangwa/Mutaradzi irrigation schemes in Zimbabwe have benefited from an IFAD grant-assisted pilot market link support program implemented by a national NGO. This focused on contract growing of various crops such as tomatoes and Michigan Pea Beans (for baked beans) for a local canner. The NGO facilitated contract negotiations for the growers' associations, under which: (a) the canner would provide crop inputs against a deposit of 10 percent of the total costs paid into a bank account operated jointly by the canner and the association, (b) the association would undertake to deliver a quota of crops grown, and (c) the canner would purchase the crop at a fixed price. The NGO for its part also provided technical support to the growers.

In Niger, an entrepreneur has set up a grading and packing plant with a capacity of 60,000 tonnes for export of the prized Galmi onion. A small nucleus estate is providing about 10,000 tonnes of onions. The firm is contracting with outgrowers for the balance, and is providing extension advice and credit.

Source: IFAD, 2007; World Bank, 2005a; World Bank, 2005b.

evolved. Significantly, the IWRM approach emphasizes inter alia the need for economic efficiency in water use.[3] Five sub-Saharan African countries have responded by adopting IWRM as a policy instrument, and several others plan to do so.

3. The IWRM approach also emphasizes: (a) the need for a whole catchment approach to development; (b) subsidiarity in planning and decision making; (c) the pivotal institutional role of women; and (d) basic human rights to clean water and sanitation at an affordable price.

IWRM approaches are increasingly needed as water constraints grow to reduce the social, economic and political costs of unmanaged appropriations, uncertain water rights, and environmental externalities. In Kenya, for example, the costs of a lack of integrated water management have been high (Box 4.7), with social costs from unmanaged water appropriations, economic costs from hydrological variations and unclear water rights and allocations, and political costs from uncertainties over transboundary water resources. These costs arise from a vicious circle of lack of integrated resource management, underinvestment in infrastructure and management, consequent degradation of catchments, and limited buffering capacity for extreme events, and consequent reductions in growth (World Bank, 2004a).

IWRM has presented operational challenges. It is not clear, for example, that the agriculture sector has effectively engaged in IWRM stakeholder debates. In some instances, national agriculture policy has been silent on water development for the sector. In addition, while water reforms may have addressed historic imbalances in access to agricultural water by providing decentralized catchment planning authorities and agricultural water user associations, it is not clear that implementation of IWRM practices to date has empowered disadvantaged groups to participate effectively in water allocation and use decision processes (Perry et al., 1997; Derman et al., 2002). Although IWRM considers the basin as the unit for planning, the experience so far with basin level approaches in

Box 4.7

Kenya Needs IWRM to Manage Irrigation Expansion

Uncontrolled irrigation expansion in Kenya's Laikipia district, is destroying downstream livelihoods and habitats. In the period 1990–93 there was a 300 percent increase in water use in the district arising mainly from an expansion of irrigated agriculture. Over 90 percent of these extractions were unauthorized. Downstream, the median flow of the Ewasso N'giri River in February has dropped from 9 m^3/sec to just 0.9 m^3/sec (a 90 percent reduction). Now downstream users can no longer obtain essential water, the ecological functioning of the river is impaired, lakes and wetlands are drying up, and fish catches—a source of protein for the poor—are declining.

Source: World Bank, 2004a.

the region has been mixed. Some river basin organizations have played more of a development and operational role than a resource planning and management role. The Nigerian River Basin Development Authorities, for example, began not only as water resources managers but also as major investors in large public schemes, both dams and irrigation.

Notwithstanding these challenges, the issue is not whether IWRM and an inter-sectoral planning approach should be adopted, but how to improve the process to obtain the best possible results for agricultural use and poverty reduction. Central to the IWRM concept is a decentralized, inter-sectoral approach to water resources management, as well as self-regulating and self-enforcing mechanisms for sustainable management that consider all needs within a catchment and ensure that smallholder farmers are adequately represented in governance, stakeholder debates, and allocation decision making. The challenge is to put such approaches into practice. IWRM needs to build on and integrate traditional and indigenous water practices where appropriate. Full accountability of river basin organizations will be essential (World Bank, 2001).

4.4 Role of the Public and Private Sectors in Agricultural Water

Private investors have proved more successful than public ones. The countless private schemes all over the region are testament to the ability of the private sector to identify viable opportunities, implement projects, and manage them sustainably. Private schemes range in size and nature from agribusiness estates such as the world's largest irrigated sugar estate—the Kenana scheme in the Sudan—through smallholdings successfully supplying high-value horticulture for export from many countries, to traditional small-scale paddy irrigation schemes in Madagascar. Key factors in success have been investment choices based on confirmed demand, and subsequent ability to manage the investment profitably and sustainably (NEPAD, 2005).

By contrast, public investment has encountered problems of both implementation and subsequent management. Although the reasons for these problems are many and various, the principal have been: (a) the pursuit of multiple objectives such as resettlement or poverty reduction that have led planners to take investment decisions that neglected basic conditions of economic viability, profitability, and sustainability; (b) high capital costs due to over-design and implementation cost overruns; and (c) lack of a sustainable model for operation and maintenance. The best performing public investments have been those where farmers had a large say in design and implementation, and subsequently took over responsibility for management.

A new development paradigm is emerging in which market-driven profitability and private investment play a larger role. Across the region, governments have increasingly adopted a market driven, private sector led vision of agricultural development (see section 4.2 above) in which the role of the public sector is to help the private sector to serve commercial farmers and concentrate public resources increasingly on serving the poor. Under this approach, market-driven profitability is the over-riding concern, in which the private sector—from smallholder to major business—is the investor and manager of choice. Governments play a role in facilitating private market-driven development and investing in economically viable and financially sustainable schemes where the private sector cannot and where there is a clear public interest of poverty reduction. With this approach, smallholders are expected to become essentially commercial farmers. Governments, therefore, have a major role to play in empowering smallholders to participate fully in commercial agriculture. A good example of this approach is the Green Scheme in Namibia, where since 1994 government has developed basic water delivery infrastructure and allocated 50 percent of the irrigated area to larger scale farmers who then provide water and other services to smallholder commercial farmers.

Governments can promote private investment by developing the legal and institutional framework and investing in infrastructure and research and development. Experience has shown that governments can take specific steps to promote private investment in agricultural water by both large and smallholder investors. A priority is to develop secure arrangements for land and water tenure that encourage private, long-term investment and the development of efficient land and water markets. The promotion of financial market development is also important, ranging from encouraging the development of local financial organizations that can serve smallholder needs (see section 4.3) to formal sector instruments such as guarantees. Infrastructure development to reduce market transaction costs is also important. Finally, investment in market-oriented research and development, wherever possible in partnership with the private sector, helps to develop cost-effective technology for agricultural water management for commercial production.

Best practice public investment is based on economic criteria and the presumption of future handover to farmers. Recent best practice public investments follow criteria for economic viability, profitability, sustainability, and poverty reduction, basing schemes on farming systems and farmers' livelihood strategies, involving farmers as partners from the start and—except where scale is too great—handing over completed schemes for subsequent farmer management. Clear arrangements for any 'co-management' and co-financing of operation, maintenance, and replacement costs are needed if there is an essential public role such as managing major headworks and networks.

Partnerships with private investors and service providers have been successfully based on public interest and comparative advantage. Co-investment with the private sector has worked well where governments underwrite part of the costs of a small-scale initiative that is later taken to scale by the market (for example, promotion of a treadle pump supply chain). In some cases, governments have successfully shared the costs of major investments with the private sector in order to stimulate growth (for example, the development of the Markala dam by the government of Mali and the private investment in developing the irrigated area). There has not yet been a case in the region of a 'build-own-operate' or 'build-own-transfer' arrangement in agricultural water, where the government taps the investment resources and management skills of private entrepreneurs to implement a public interest project, but examples from Morocco and Egypt indicate the potential. Governments have also promoted the development of private or NGO service providers, delegating some otherwise public service functions to them. Box 4.8 lists some typical public-private partnership arrangements that have been successfully implemented in the region.

Governments have special responsibilities in the most resource-poor areas. In the marginal semi-arid areas, agricultural water investment opportunities are generally limited. Although in the longer run household livelihood strategies are likely to be predominantly off-farm diversification and out-migration where economically viable and financially sustainable agricultural water technologies are available, public investment is justified in promoting sustainable land and water use practices to use scarce resources optimally. The justification for government support is all the stronger where there are significant externalities, for example, investment in land and water conservation on hill slopes under watershed management programs.

4.5 Sector-Wide Approaches

The development effectiveness of past project approaches has often been limited. Past public investment in agricultural water has been principally

Box 4.8

Public Private Partnerships in Agricultural Water

Examples of public private partnership (PPP) in agricultural water include:

- Partnerships for research and development of new technologies, for example through NGO/SME partnerships with NGOs or small enterprises for treadle pump promotion.
- Partnerships to help the private sector develop supply chains to enable smallholder irrigation farmers to respond to market opportunities such as the Smallholder Irrigation Market Initiative.
- Partnerships to promote links between small and large enterprises as in the Green Scheme in Namibia, Swaziland LUSIP, or contract farming at Maunganidze in Zimbabwe.
- Partnerships in irrigation management and service provision.
- Partnerships in development and operation of major agricultural water infrastructure.
- Partnerships in irrigation development such as the partnership in Mali where government has invested in the Markala Dam and a private enterprise is developing 25,000 hectares for sugar cane plantation.

Source: IWMI, 2005f.

through individual projects, often financed in part by donors. The development effectiveness of project approaches has been limited not only by problems of design and implementation, but by their inherent fragmentation and duplication. At the policy and institutional level, project approaches have lacked shared strategy and prioritization, and have given inadequate attention to systemic issues and structured institutional development. At the implementation level, projects have often reflected a donor-driven agenda and resource allocation, and have created parallel systems and 'project empires' rather than building national capacity. The transaction costs of project approaches have been high.

Sector-wide approaches (SWAps) generally, and agricultural SWAps in particular, are intended as a means to coordinate and harmonize efforts at policy dialogue, institutional reform. and efficient investment. In recent years, a number of countries in the region have begun to develop sector-wide approaches, moving progressively away from project to program approaches within a coherent strategic framework, a movement strengthened by the Paris agreements on aid effectiveness (see section 4.1 above). Sector-wide approaches are based on a partnership between: (a) the government, which is expected to provide leadership and develop a coherent sectoral strategy; (b) international development partners, who are expected to align their support on the country-led strategy and, to the extent possible, harmonize their support through common arrangements for financing and technical assistance; and (c) other stakeholders, including civil society and the private sector. In contrast to earlier approaches, sector-wide approaches are intended to focus not only on the financing of a comprehensive investment program, but also on policy dialogue and change, and on the provision of support to, and reform of, national institutions (IFAD, 2007).

The potential benefits from sector-wide approaches are, essentially, enhanced development impact and lower transaction costs. At the strategy level, this should be characterized by stronger country ownership and leadership, a coordinated and open policy dialogue, and prioritized and rational resource allocation. At the institutional level, the approach should help strengthen national capacity, systems, and institutions. At the implementation level, scaling up of best practice and benefits to the entire sector should be easier. There should be sector-wide accountability, ultimately with common fiduciary practices and environmental and social safeguards; and there should be a focus on results and reduced duplication in reporting and transactions.

Such approaches have potential but are hard to put together and experience if sectoral approaches to agriculture or water in the region are limited.[4] The approach could be adopted to address the specific problems identified throughout this report, particularly strategic planning, institutional development and capacity building, and cost-effective public investment. In most countries in the region, the fiduciary pre-conditions for budget support are absent, but there have been attempts to bring all stakeholders behind a coordinated irrigation sector strategy and program. In Niger, for example, several years of effort have produced consensus on the national irrigation strategy, and the related action plan was adopted by Presidential Decree in late 2006. A permanent secretariat is responsible for coordination and follow-up. However, even with this background, donors have been slow to commit financing within the program framework.

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4. A number of countries have applied the approach in the health and education sector (Zambia, South Africa, Ghana, Mozambique, Tanzania, Uganda, Ethiopia, and Burkina Faso).

4.6 Decentralized Development

Traditionally, the governments of most developing countries have employed conventional public sector organizations to provide infrastructure and services at the local level. However, alternative approaches to local development have evolved over the past two to three decades. As part of wider public service reforms, a number of countries in the region have engaged (or plan to engage) in decentralization of their public development efforts to increase the participation and ownership of rural communities in planning, budgeting, and implementing public rural development programs, including those for agricultural water.

Essentially, two forms of decentralization have evolved: 'decentralized sectoral' and 'decentralized local government'. Under the first of these, development is budgeted, coordinated, and implemented by sectoral ministries through their local level (i.e., provincial and/or district) staff.[5] Under 'decentralized local government' approaches, however, a proportion of public (government and/or donor) sectoral funding is managed by local authorities and utilized through locally prepared development plans.

Decentralization is not an end in itself; it is rather a means to developing effective, responsive, demand-led services and, in particular, to making government services more locally accountable to rural people. Taken in isolation there is no particular reason why decentralization should enhance accountability; on the contrary, it may well entrench the influence and power of local elites—and it may lead to even greater inefficiencies than before (Box 4.9). The key to successful decentralization is to empower rural people, enabling them to develop the skills, knowledge, confidence, and the organization that they require to participate in local political processes and hold government and private service providers accountable to them. Thus, while decentralization could enhance the development impact of agricultural water investments, it presents a complex political, technical, and administrative challenge to governments and demands strong management capacity to guide the process forward. It needs to be accompanied by programs of support to develop good governance, as well as capacity building and empowerment (IFAD, 2002).

5. This approach is sometimes referred to as 'deconcentration' to distinguish it form decentralized local government.

Box 4.9

Decentralized Agricultural Water Development without Empowerment

The 5-hectare Dombolidenje Dam and Irrigation Scheme in Zimbabwe was financed through a national project but was planned and decided upon at district council level following a lengthy participatory process that included extensive training and capacity building for local communities. Implementation was managed by district council staff with the support of district-level line ministry staff. It cost $82,000/ha and earns farmers 1 cent/day.

The experience suggests that decentralization and participation do not on their own guarantee good outcomes. In this case, the communities concerned had not been empowered to take an informed investment decision. Had they been aware of the costs and alternative investment options, they may well have chosen a more profitable use of the available funds. Neither had they been empowered to ensure cost control, because the service providers—both public sector and private—were not accountable to them. The experience not only highlighted a lack of empowerment, but also a lack of capacity within the local planning structures for sub-project screening, appraisal, approval, and subsequent implementation.

Source: IFAD, 2007.

4.7 Management of Publicly-Financed Irrigation Schemes

As in most other regions, the sustainability of publicly-funded irrigation schemes in sub-Saharan Africa has been poor, mainly because of overreliance on government support for scheme management and O&M, declining government budgets for recurrent costs, and low levels of cost recovery from the users. As discussed above (section 3.1), governments in many countries of the region have, in the past, not only financed the capital costs of irrigation projects—large, medium, and small-scale—but they have then played a major role in scheme management, particularly of the larger schemes, and have also taken responsibility for the bulk of O&M costs. Public management of schemes has been plagued by numerous problems. Water service has often been poor, and many schemes have needed rehabilitation to make up for delayed maintenance.

In recent years, the trend has been to encourage the users of publicly financed irrigation schemes, who belong toq WUAs, to take responsibility for their management and O&M. Although this has applied to both new and existing developments (see Box 3.2 for the case of the Office du Niger), the extent to which this responsibility is accepted by scheme users depends on a variety of factors, including the scale and complexity of the scheme, its technical suitability for farmer-management, the capacity of the users, and the intrinsic profitability of the scheme. In the case of new development, therefore, it is now usual to ensure that technical designs are appropriate for farmer-management, with estimated O&M costs that can be afforded from the proceeds of crop sales while still leaving sufficient margin to provide an incentive to irrigate. It is also common practice to adopt participatory processes for identification, design, and implementation of schemes to promote user ownership and commitment, as well as to establish sustainable farmers' organizations—such as water users' associations (WUAs)—to take over full management and O&M responsibility (although this is unlikely to be achieved without secure land tenure, as well as clarity regarding legal rights over infrastructure and equipment).

Small- to medium-scale interventions are generally intrinsically more suited to farmer management than large-scale schemes. Small- to medium-scale schemes are intrinsically easier for farmer organizations to manage than larger ones, although capacity building for scheme management is essential even for small-scale schemes. The Participatory Irrigation Development Project in Tanzania, for example, facilitates the establishment of WUAs on a demand-driven basis and works with them to upgrade existing small-scale irrigation schemes or develop new ones, on the understanding (recorded in memoranda of understanding) that the association accepts full responsibility for O&M.[6]

There will be, however, cases in which important economies or market opportunities are presented by new investment in larger scale developments which may be beyond the ability of WUAs to manage, operate, and maintain. In these cases, there may be a continuing role for government in scheme management and O&M in partnership with a federation of WUAs, an irrigation district or the like, with government taking responsibility for the major infrastructure, and user organizations responsible for secondary or tertiary units. The latest innovations, for example, will include that of the Lower Usuthu Smallholder Irrigation Project,

6. The experience has been used as the basis for new guidelines for decentralized participatory irrigation development that have been prepared by the Ministry of Agriculture and Food Security (Government of Tanzania, 2003).

an 11,500-hectare smallholder sugar project in Swaziland, where it is intended that the entire system, including a diversion weir, off-river storage, and canal system, will be governed by an irrigation district that will contract out O&M to a private sector water service provider (Box 4.10).

The experience with farmer-management of public irrigation schemes has been mixed. WUAs formed for small-scale rice schemes under the Upper Mandrare Development Project in Madagascar were only weakly established and unclear as to their responsibility for repairs in the event of flood damage to the headworks. At the Participatory Irrigation Development Program in Tanzania, although WUAs were aware that they were responsible for major repairs, they were not clear how they would finance such repairs should they become necessary. At Maunganidze in Zimbabwe, although the WUA was well-established and well-organized, it would probably have found it difficult to raise the cash for major repairs to borehole pumps. In none of these cases, therefore, was financial sustainability—one of the principal objectives of farmer management—assured (IFAD, 2007). In both cases, greater effort needed to have been made to ensure that the O&M costs were really within the users' capacity to sustain in the long term.

Irrigation management transfer on existing schemes has also not always proceeded according to plan. For example, on the Petits Perimetres Irrigués

Box 4.10

Swaziland's Innovative Approach to Water Service Provision and Cost Recovery

The 11,500-hectare Lower Usuthu Smallholder Irrigation Project is intended to be operated by smallholder organizations for commercial sugar cane production. The main, secondary, and tertiary infrastructure will be grant-funded by the government. Farmer organizations will pay 100 percent of the capital cost of on-farm works by taking commercial loans to be repaid from the proceeds of sugar cane production. In addition, they will pay a charge that covers the cost of O&M by a private-sector water service provider contracted by the farmers' apex organization, replicating an existing arrangement by large-scale private estates in the parallel Mhlume basin. Part of these costs may be cross-subsidized by the existing large-scale sugar cane growers who currently pay nothing for water drawn from run-of-river supplies.

Source: IFAD, 2001a.

Project in Madagascar, water user groups were set up to manage O&M and subsequently to take over the schemes from government. However, formal transfer was extremely slow, a relatively small percentage of schemes were transferred, and less than 10 percent of the user groups remain in operation (IWMI, 2005g:34).

In some cases, the state has exited too rapidly after irrigation management transfer and farmers have been left to pick up the pieces; they were unprepared for the task, with severely negative productivity consequences. Sometimes irrigation management transfer has failed when irrigators simply inherited a scheme for which financial profitability and institutional capacity for sustainable irrigation did not exist (Box 4.11). For example, in Madagascar, the government passed a law in 1990 governing irrigation management transfer and embarked on a program, with donor support, to rehabilitate schemes, increase cost recovery, and hand over to WUAs. However, by 2003, only 3 percent of the public sector scheme area had been transferred (8,607 hectares out of a total of 270,000 ha). Meanwhile, government expenditures for O&M decreased from 50 percent of the budget of the Ministry of Agriculture to just $42,000, and very little advisory or management support had been provided. Irrigation service charges had been set at just $6/ha, so far below the required level (at least $23–38) that schemes were not being maintained. In effect, the process resembled abandonment more than transfer, and this undermined production. Consequently previously highly

Box 4.11

Examples of Poorly Handled Transfer of Irrigation Management

In the Arabie-Olifants scheme in South Africa, the cropped area declined by 70 percent the year after the Agricultural and Rural Development Corporation withdrew. Smallholders were unable to access the working capital to pay for inputs and services.

In the handover of pump schemes in Niger, land ownership was not transferred. Irrigators could be evicted and replaced, so they had no incentive to invest and no sense of ownership of the scheme they were supposed to pay for and operate.

Source: IWMI, 2002.

productive schemes in which the nation had heavily invested for more than 50 years have been almost completely lost (World Bank, 2003).

The problems encountered are not inherent in the concept of irrigation management transfer. Much of the irrigation management transfer in the region has failed simply because it was badly handled and did not respect essential institutional and financial preconditions. Too often governments and projects stopped short of genuine capacity building and farmer empowerment, and service providers (public sector or private) have not been accountable to farmers for the services (such as design and construction, extension, water supply, O&M) they provide.

Successes in WUA formation and irrigation management transfer do exist, and they indicate pathways for the future (Box 4.12). For example, in the irrigation management transfer program in Senegal supported under the World Bank-financed Fourth Irrigation Project 1988–1993, a number of large-scale schemes in the Senegal River Delta were transferred to Unions Hydrauliques, which had been set up to manage electric pump stations and recover costs from farmers. After a difficult start, these organizations succeeded in obtaining bank credit to finance operations and improved the water service; they also reduced theft. The Unions invested in research and extension, and with new rice varieties from WARDA, profitability improved and output revived. Now the Unions are moving into input supply and output processing and marketing in order to increase value added and incomes. The keys to this success appear to have been: continuing capacity building from the state and NGOs; access to working capital; and a sense of ownership that brought out the needed entrepreneurial and management skills within the Unions (Ibrahima Dia, Private Irrigation in the Senegal River Delta, in IWMI, 2002:121ff).

In most cases government funding for scheme management and O&M is unlikely to increase, the issue is not whether schemes should be farmer-managed, but how to ensure that schemes are effectively managed and O&M costs recovered. Although it is unlikely that farmers will be able to meet the capital costs of major infrastructure, it is essential for sustainability that they at least meet the full O&M costs. Ideally, schemes should be entirely farmer-managed, or managed by their apex organizations.

Success depends on: (a) the intrinsic profitability and physical sustainability of the scheme; (b) capacity building for scheme management, operation, and maintenance; (c) secure land and water rights; and (d) careful management of the WUA formation/management transfer process, including post-handover support (Box 4.11). Cases like that of Niger, where 25 years after cooperatives took over, they still need

Box 4.12

Examples of Successful Irrigation Management Transfer

In South Africa, the Small Growers Development Trust runs a program of financial, training and support services that has helped 42,000 smallholder cane growers in Natal/Kwazulu and KaNgwane to take over and manage their irrigation schemes.

IPTRID studied irrigation management transfer in 12 rice schemes in five West African countries (Burkina Faso, Mali, Mauritania, Niger, and Senegal). Schemes were all pump then gravity distribution models. The study found that despite many problems, farmers had found ingenious solutions with the help either of state irrigation agencies or NGOs. Examples include: contracting (with the help of the state irrigation agency) with a local engineering firm for water distribution, maintenance, and financial management; using software to calculate the optimum cropping calendar and water scheduling (with the help of an NGO); and acquiring a rice mill and selling high quality rice direct to groceries in the capital at a substantial premium (Ingrid Hermiteau, Assisting Sustainable Irrigation Management Transfer, in IWMI, 2002).

A group of smallholders at Hereford in South Africa took over their irrigation scheme. They received support from an NGO, Africare, which enabled them to develop a contract farming arrangement for vegetables for export to Hong Kong and France and for sale to the national market. The export company provided a strict planting program and extension advice. Incomes increased and farmers were able to finance the O&M of the scheme and improve their standard of living.

Source: IWMI, 2002.

support—and the schemes still need periodic rehabilitation—demonstrate the difficulty of achieving these conditions. Where scale and complexity preclude full farmer management and there is no alternative to management by a government agency, the agency needs to be financially self-sustaining. Water service charges must be adequate to cover the real costs of O&M, and overhead costs need to be kept to the minimum. Above all, the agency needs to be transparent and accountable to the users—a condition that can usually only be achieved when there is genuine participation of the users in its management. The case of the Office du Niger (Box 3.2) shows that these conditions, although difficult, can be achieved in the region.

CHAPTER 5

Development Potential, Market Demand, and Investment Opportunities

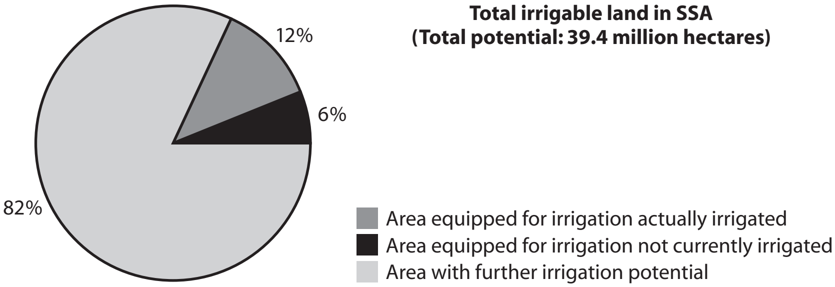
5.1 Physical Potential for Agricultural Water Development

According to FAO (2005a), the total physical potential for irrigation in sub-Saharan Africa is estimated at 39.4 million hectares (Summary Table 1). As mentioned (section 1.3 above), approximately 18 percent—or 7.1 million hectares—of this has already been developed. The remaining physical potential for new irrigation is therefore approximately 32.4 million hectares.[1]

Not all of this will be suitable for development, mainly for economic reasons. Almost one-third of the potential is concentrated in two very humid countries, Angola and the Democratic Republic of the Congo—although the humidity of these countries does not necessarily mean that they do not need irrigation or other forms of water management (the already large areas of wetlands cultivation and flood recession planting in Angola are testament to this). The remaining potential in the other countries of the region is therefore on the order of 23 million hectares (Summary Table 1). This is not evenly distributed: some countries, notably Madagascar, Mauritius, Somalia, South Africa, and Sudan, have

1. This includes the potential for 'water harvesting', which, as discussed in section 2.1, is considered to be water development for small- and micro-scale irrigation.

Figure 5.1 Irrigation Potential in Sub-Saharan Africa



Source: FAO, 2005a.

already developed more than 60 percent of their potential for irrigation (Summary Table 1).[2]

Current water abstractions in the region as a whole are low—but a growing number of countries risk becoming water scarce. Current abstractions for all purposes amount to only 2.2 percent of the total renewable resource (Summary Table 3 and Map 5). Abstractions for agriculture (mostly irrigation) are less than 2 percent of the total renewable water resource (section 2.1 above and Summary Table 2). If the full irrigation potential of 39.4 million hectares was to be developed the demand for agriculture would increase from 2 percent to only 12 percent of the total renewable water resource.[3] Even if an annual growth in demand for urban and industrial water supplies of 5 percent was to be factored in, total abstractions for all purposes for the region as a whole would still only reach 13 percent of renewable resources by 2030 (Summary Table 3). However, the region-wide average of water availability masks considerable variation between countries. If all the irrigable area were developed by 2030, renewable water resource availability would vary from a massive 114,000 m^3 of available water per person per year (Democratic Republic of Congo) to a minimal 68 m^3 per person per year (South Africa). If all the area were developed, 19 of the 48 countries in the

2. As opposed to ‘other forms’ of water management in the AQUASTAT terminology (other countries may use more than 60 percent of their potential if these other forms of water management are taken into account).

3. This assumes that development and utilization of the remaining 32.4 million hectares would consume an additional 630 billion m^3/year (at an average of 16,000 m^3/ha/year). From Summary Table 2 the Total Renewable Water Resource for the region is 5,450 billion m^3/year. Thus at full development the demand for agriculture would amount to 630/5,450*100 = 11.6 percent of the total.

region would risk falling below 1,000 m^3 per person per year, which is usually considered to be the threshold of water scarcity.

Surface water resources are often concentrated in a seasonal window and can be extremely variable. In the upper Zambezi, for example, some 80–90 percent of water resources occur as stream flow in the wet season between December and May while in the six months from June to November stream flow is either rapidly falling or extremely low or nonexistent. Rice farmers on run-of-river irrigation schemes in Tanzania, for example, often complain of water shortages between and within seasons, with dramatic variations in the areas that can be fully irrigated from year to year (Box 5.1). Climate change is likely to aggravate the situation.

In an increasing number of river basins, there is also competition between different users. Despite the overall 'abundance' of water implied by the low rates of abstraction, cases are emerging of competition between users. This can lead to shortages, friction, sub-optimal production and environmental degradation (Box 5.2). In some cases the problem is institutional—a lack of a regulatory framework, water rights, and organizations to cooperate over water resource allocation and management.

In many cases, however, the problem is not absolute water scarcity but a lack of infrastructure to regulate supplies for use in dry seasons and dry years. Most sub-Saharan Africa countries have low levels of water

Box 5.1

Run-of-the-River Improvements Are Not Enough for Rice Development in Tanzania

Farmers at run-of-river rice schemes developed under the Participatory Irrigation Development Project (PIDP) in Tanzania complained that one of their main constraints was irrigation water. Government and farmers had just invested more than $1,000/ha to improve the diversion and distribution of irrigation water, but this had not improved water availability or reliability. In some years, only one-quarter of the command area could be irrigated, and it was too risky for farmers to invest in inputs, so that even in a year of adequate irrigation supplies, average paddy yields (3.3 t/ha) remained below potential. Farmers are now pressing for dams to regulate flow to the schemes.

Source: IFAD, 2007.

Box 5.2

Competing Demands for Water in Tanzania

The Great Ruaha River is the lifeline of the Ruaha National Park and its ecosystem. It also drives the Mtera and Kidatu hydropower stations that provide 85 percent Tanzania's power supply. However, upstream irrigation development in the Usangu plains competes for Ruaha water.

Smallholder irrigation systems in Usangu were developed by smallholder farmers from the 1940s, mostly for wet season irrigation of rice. As Tanzania's demand for rice increased, a number of large-scale parastatal rice farms were also developed. Water shortages in the Ruaha began to occur and in 1993 the river dried up in the Ruaha National Park. Flows for hydropower generation were also reduced, which resulted in electricity cuts in Dar es Salaam. Upstream irrigation development was blamed for the shortages.

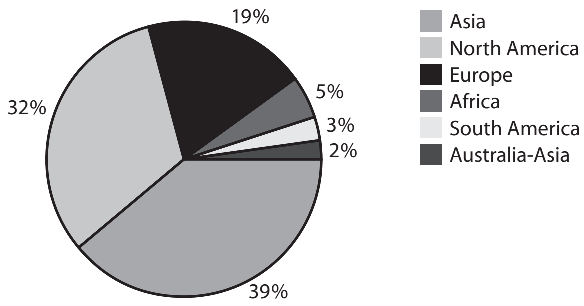
The river basin authority then had to arbitrate between the competing water demands of agriculture, power, the environment, and tourism, although research by Sokoine University, the University of East Anglia, and IWMI indicates that electricity shortages were primarily the result of poor management of the hydropower dams rather than upstream irrigation extractions. There is considerable scope for increasing upstream water-use efficiencies, but options for improved water management in the plains wetlands also need to be considered.

Source: Lankford, 2004; Fox, 2004.

storage infrastructure: only 5 percent of the world's dams are located in sub-Saharan Africa (see Figure 5.2 and World Bank, 2005c). The implication is that in many countries development of the physical potential for irrigation will have to be accompanied by the construction of new storage to cope with seasonal variability and local water scarcity.

The potential for further groundwater irrigation could also be important—particularly for private individual irrigators. In most of the region, the transmission of the underlying geology tends to be too low to furnish reliable quantities of water for irrigation on any scale. There are notable exceptions, for example in the *karstic* aquifers of the Zambian Copperbelt, and there are limited reserves of renewable groundwater in most countries, which are extensively used by individual private irrigators mainly for gardens. Despite the localized nature of these resources, there could be substantial scope for expansion of this type of irriga-

Figure 5.2 Breakdown of Dams by Geographical Zone



Source: World Registry of Dams.

tion (Giordano, 2005).[4] In Zimbabwe, for example, where smallholders are already exploiting shallow groundwater with low-cost technology in the *dambo* wetland areas, renewable groundwater resources could potentially irrigate a further 80,000 hectares—an area equal to about one-quarter of the official estimates of remaining irrigable land. At the Office du Niger, irrigation of paddy in the wet season results in groundwater replenishment that is lifted by individually-operated groundwater pumps for dry-season irrigation when water deliveries by the Office are in short supply. Similar opportunities are likely to exist in many other rice growing areas.

In-field rainwater management could become as important as the other alternatives, particularly for the production of non-rice cereals. The FAO estimates of potential exclude in-field rainwater management for dryland crops. Although it is thought that the total area currently under this type of agricultural water management is small compared with the area under irrigation, in-field rainwater management could in theory be practiced on all cultivable land that is not already developed for agricultural water management. In practice, however, physical, agro-ecological, and market constraints will limit such development. Assuming that it was possible to develop in-field rainwater management for dryland crops on only 25 percent of the land currently cultivated, the indicative physical potential would amount to approximately 46 million hectares.[5]

4. For the present report, however, it is assumed that the indicative potential for new irrigation discussed above includes groundwater potential.

5. This is based on the assumption that such development would take place mainly in the dry sub-humid zone and partly in the semi-arid zone and is the equivalent of 25 percent/100*182.7 million hectares.

5.2 Current Region-Wide Development Proposals

Recent reviews of Africa's development status have highlighted the trend of underinvestment in agricultural water and the need for concerted and immediate efforts to reverse this trend. In 2005 the Commission for Africa recommended doubling the area under "irrigation" in sub-Saharan Africa by 2010. CAADP (see section 4.2 above) was recently revised to call for investment in improved water control on an even larger incremental area of 15.9 million hectares by 2030. Of this, 6.6 million hectares would be expanded irrigation schemes as well as water-managed wetlands and valley bottom systems, 2.1 million hectares would be rehabilitated large irrigation schemes, and 7.2 million hectares would be in new "water harvesting and soil and water conservation" interventions (Table 5.1).[6] This implies a rate of increase in the water-managed area (excluding irrigation rehabilitation and water harvesting and soil and water conservation) of approximately 260,000 hectares annually, more than three times the current rate of increase (section 1.3 above and FAO, 2005a). As discussed above in section 4.2, NEPAD, with FAO assistance, is currently reassessing actual national

Table 5.1 CAADP Program for Investment in Agricultural Water to 2030

	Area of investment by type ('000 ha)					
Region	*New large-scale irrigation schemes*	*Rehabilitation of large-scale irrigation schemes*	*New small-scale irrigation schemes*	*Wetlands and inland valley bottoms*	*Water harvesting/ soil and water conservation*	*Total*
Sudano-Sahelian	208	1,200	516	729	1,684	4,337
Gulf of Guinea	68	110	350	1,061	2,109	3,698
Central	40	99	163	281	169	752
Eastern	110	143	411	914	1,570	3,147
Southern	208	485	533	443	1,566	3,235
Islands	39	77	332	200	100	748
Total	673	2,114	2,305	3,628	7,198	15,917

Source: AfDB/FAO, 2005.

6. In this context, 'soil and water conservation' is interpreted to mean 'in-field rainwater management'.

potential for increasing the equipped area by developing National Medium Term Investment Programs, and will reassess the original targets by building up from this base.

5.3 Market Demand and Economics of Investment

Market Demand

Demand for basic staples and other foods will increase strongly. While sub-Saharan Africa is currently self-sufficient in most of its major staples and imports less than 5 percent of its needs for food other than rice and wheat—the only food crops for which irrigation is currently important (see section 2.2)[7]—domestic food markets are expected to double in volume by 2015, with some increase in demand for superior foods as incomes rise. At current levels of productivity and rates of growth, net imports of wheat and rice are expected to reach 40 million tonnes by 2030 (Table 5.2), while imports of maize and vegetable oils are also expected to increase substantially. Overall, on a region-wide basis, cereals self-sufficiency is expected to decline marginally from 82 percent in 1997/99 to 81 percent in 2030 (FAO, 2003a:68).

There will be some growth in world demand for sugar and cotton, but while cotton prices may rise, sugar prices are likely to remain volatile. Irrigated industrial crops, especially sugar and cotton, will continue to supply domestic and export markets (Table 5.3). Growth in domestic demand will continue to expand and cotton export prices could rise strongly if US and EU protection and subsidies are reduced under the Doha Round (FAO, 2006; Diao et al., 2003). However, the combined impact of the EU sugar policy reform and an increase in global demand (partly driven by demand for ethanol) could increase prices for sugar, but with increased volatility.

Horticulture demand will continue to grow. There are substantial growth prospects for irrigated horticulture because the range of potential products is vast (over 80 different commodities in the 'vegetables and fruits' UN trade classification) and sub-Saharan Africa's current share of world trade in these products is small (Diao et al., 2003:61). There are many high-value niches to explore for exports, although the market is highly competitive and risky. However, low wage rates are

7. Food imports are predominantly wheat, rice, and vegetable oil. Cereals imports currently total 24 million tonnes, of which 21 million tonmes are from commercial imports and the remaining 3 million tonnes from food aid.

Table 5.2 Projected Regional Net Trade in Cereals in 2030 (tonnes)[a]

Crop	*Central*	*Eastern*	*Gulf of Guinea*	*Islands and others*	*South Africa*	*Southern*	*Sudano-Sahelian*	*Total Sub-Saharan Africa*
Wheat	(4,373,200)	(3,646,700)	(6,249,900)	(664,500)	(500,000)	(1,388,700)	(4,311,700)	(21,134,700)
Rice	(2,329,100)	(1,212,900)	(7,848,200)	(912,400)	(1,078,000)	(400,200)	(4,233,900)	(18,014,700)
Maize	(1,475,900)	(1,749,000)	(268,000)	(339,600)	1,000,000	(1,926,800)	(830,000)	(5,589,300)
Barley	(380,700)	(270,300)	(253,500)	(48,400)	(300,000)	(71,800)	(130,300)	(1,455,000)
Millet	(200)	(2,400)	7,100	(300)	0	300	(70,000)	(65,500)
Sorghum	(76,900)	(126,400)	0	(3,000)	2,800	(40,400)	(85,000)	(328,900)
Other	(16,500)	(33,200)	(56,200)	(14,500)	(10,800)	(79,900)	(174,300)	(385,400)
Total	(8,652,500)	(7,040,900)	(14,668,700)	(1,982,700)	(886,000)	(3,907,500)	(9,835,200)	(46,973,500)

a. The regions shown are those adopted by FAO (2005a). See Map 1 for the groupings.

Source: FAO, 2003a cited in FAO, 2006.

Table 5.3 Projected Water-Managed Production in 2030 ('000 tonnes)

Crop	*Baseline 1998*	*Projected 2030*	*Increase (%)*
Sugarcane	32,411	80,807	149
Wheat	1,697	2,281	34
Rice	3,800	10,097	166
Fruit	3,975	2,784	(30)
Vegetables	6,239	11,688	87
Potatoes	1,583	425	(73)
Citrus	1,681	850	(49)
Cotton	413	1,079	161
Groundnut	491	838	71
Bananas	351	469	34
Sorghum	750	1,564	109
Tobacco	18	13	(28)
Tea	21	65	210
Barley	41	18	(56)
Sunflower	28	0	(100)
Soybean	23	25	9
Pulses	184	253	38
Maize	830	978	18
Coconut	9	65	622
Coffee	4	17	325

Source: FAO, 2006.

likely to preserve the region's comparative advantage and exports could grow fast. The large domestic market, which absorbs most horticultural production, will also expand steadily.

Demand for fodder will increase—but from a small base. Fodder production is expected to account for only 4.7 percent of total crop output by 2030 (FAO, 2006 and section 2.4 above), of which only a small proportion is likely to be irrigated. Although fattening and intensive stall-fed systems for milk and meat can be highly profitable where demand for meat and dairy products is firm, and although the projected increase in demand for these commodities is higher than other developing regions and the world as a whole, the increase will be from a relatively small base. Nevertheless, some increase in irrigated production of feed barley, maize, alfalfa, and other green fodder crops is likely.

Box 5.3

Why Economic Viability Is Imperative for Agricultural Water Investments

First, investment that results in an economic return less than the opportunity cost of capital can only lead to an increase in a country's debt burden that will act as a brake on all sectors of the economy, constraining economic growth and poverty reduction. Economic viability is an essential condition for an investment to contribute to economic growth. The corollary is that investment in non-viable projects is a sure way to limit development.

Second, a policy of investment in non-viable projects often results in agricultural water development at any cost. Annual maintenance costs are usually directly proportional to the initial capital cost, therefore development at any cost often translates into annual maintenance costs that cannot be supported by the users. Unless public funding is then made available, maintenance is deferred to the point that the investment will no longer function without new investment in rehabilitation. By definition, this is not sustainable development.

And third, economic efficiency (or maximizing the net benefit of an investment to the economy) is one of the guiding principles of IWRM.

Source: Current study.

Whether this growing demand creates opportunities for viable investment depends on economics. Strong market demand for cereals and the benefit of natural protection and low labor rates indicate some potential to displace imports, particularly for rice and, in the more temperate zones, perhaps for wheat. However, although sub-Saharan African countries may have more leeway to apply domestic support under the Doha Round, there is no indication that real prices of cereals will improve (FAO, 2006; Diao et al., 2003). It is thus unlikely that the economic viability of cereals under irrigation will change much in the foreseeable future. Rice-based schemes and those where other cereals are produced with higher value crops are likely to prove more viable than non-rice cereal monocrop schemes. At the average capital cost of recent well-designed projects (i.e., $6,000 per hectare), and current productivity levels, new irrigation development is unlikely to be viable for growing non-rice cereal crops. Thus growth in irrigated cereal production is likely to be mainly rice, and to a lesser extent wheat (Table 5.1).[8] Other crops (such as cotton, sugar, and horticulture) and certain investments (such as irrigation improvement and run-of-river schemes) will be more viable, even at moderate levels of productivity, although this will be highly specific to sites and market opportunities.

Nevertheless, the benefits of agricultural water investment are often underestimated. Project appraisal techniques have in the past failed to capture the full benefits of agricultural water investment, particularly the benefits induced by the multiplier effect (see section 3.5 above). Where these benefits can be quantified and valued the return to agricultural water investment may be much higher than previously thought. Although no comparable study is available for sub-Saharan Africa, a study on Pakistan found that while the on-site productivity of irrigation water was \$0.04/m^3, this increased to \$0.24/m^3 when other local benefits were factored in, and to \$0.48/m^3—12 times the on-site benefits—when all quantifiable national-level economic and social benefits were accounted for (IWMI, 2005h; World Bank, 2005a:149).

Also, the economics of investment can improve if investments are multi-functional. Multi-functional projects can sometimes bring otherwise unviable rates of return to agricultural water investment up to acceptable levels. There are often opportunities to invest in irrigation development that, on their own, would be judged unviable, but when combined, for example, with small to medium hydropower generation could result in an acceptable economic rate of return (World Bank, 2005f: 9). The association of irrigation with livestock (Box 5.4) or fisheries is another example of potentially mutually reinforcing economics (IWMI-ILRI, 2005e).

Some storage investments will be justified economically, but past skepticism needs to be overcome. Development of the physical potential on any significant scale will require the construction of new storage, it will thus be necessary to overcome the prevailing skepticism regarding the viability of such investments and their associated social and environmental costs. In fact, the thousands of privately financed irrigation dams in Southern Africa (and even publicly financed dams such as those constructed under the Mara Region Farmers' Initiative Project in Tanzania [IFAD, 2007]) are proof that such investment, if soundly and cost-effectively designed, can be viable and sustainable. Furthermore, the World Commission on

8. The projected imports of 18 million tonnes of rice in 2030 (Table 5.2) could be met from an additional 6 million hectares of new irrigation single cropped at an average yield of 3 t/ha.

Box 5.4

Taking Account of Livestock in Agricultural Water Investments

Crops and livestock are closely linked components of irrigated production systems, and both can be potentially fast growing and profitable enterprises where rapid urban growth generates demand. Growth in associated irrigated crop and livestock production is most likely in countries and areas with large animal populations and good access to urban markets.

To exploit possible complementarities between agricultural water development and livestock production, planners should work with stakeholders to assess ex ante the likely impact of irrigation development and correlated changes in land use on livestock keepers. Taking account of livestock in this way will minimize costs to livestock keepers of lost access to land and water resources and passageways, and mitigate any social tension or risk of impoverishment. In most cases it will also allow complementary investment and management that can improve livestock productivity—access to watering points, land and paths zoned for livestock, and encourage the adoption of cropping patterns that have significant quality residue for use as animal feed or the development of zero-grazing systems based on irrigated crops and residues. Beyond the irrigation scheme itself, it may be possible to integrate management of upland catchment areas with downstream agricultural water service, which may involve investments and management to ensure that upstream pastoral systems remain profitable while conserving soil and water resources.

Source: IWMI-ILRI, 2005e.

Dams (Annex 10) has also acknowledged that dams can make an important contribution to human development and that negative externalities can be minimized or mitigated with careful planning.

5.4 Possible Investment Opportunities

There are significant opportunities for development and a wide range of water management investments are possible. As discussed, the theoretical potential for new irrigation, including groundwater irrigation, amounts to approximately 32 million hectares—almost five times the area currently developed. In addition, the prospect of bringing back into production the 2 million hectares of land that is equipped for irrigation but currently unused presents an opportunity to benefit from significant sunk costs. Improving water control on the 2 million hectares of land under 'other forms of water management' in wetlands and flood recession areas also presents a similar opportunity for relatively low-cost investment. Finally there is the potential for improving in-field rainwater management on existing dryland crop areas, which currently extend to more than 176 million hectares (Summary Table 1). There is thus a very wide range of opportunities for investment in agricultural water development, from rehabilitation and expansion of existing irrigation schemes, to the development of new irrigation from surface and groundwater resources, improved water control in cultivated wetlands and flood recession planting areas, to improved in-field rainwater management for dryland crops. There may also be opportunities for investment in watershed management to conserve catchments and stabilize or enhance flows for irrigation.

Development of new irrigation could take several forms and benefit many people. New irrigation development could consist of a wide range of technologies, ranging from individually operated micro-scale irrigation (e.g., using treadle pumps at very low cost) through to large scale. In many cases the development of small areas by individual smallholder irrigators using micro-irrigation technologies will be appropriate. Small- to medium-scale communally managed schemes also have potential, although where these conveyance structures are needed, they may require some public investment support. Large-scale irrigation would probably only be developed in cases where economies of scale and specific market links can be exploited (e.g., for industrial crops such as sugarcane).

Some development is likely to require new storage, which again might range from micro-scale water harvesting systems to large dams, providing opportunities to exploit synergies between irrigation and other uses (e.g., domestic and livestock water supplies, fisheries, or hydropower). Other development is also likely to involve complementary investment in associated watersheds.

New irrigation is likely to be used for a range of crops from rice to horticulture or other high-value crops. The range of costs is very great, depending on the water management technology employed (see Tables 3.1, 3.3, and 4.1). At an assumed average holding size of 0.75 hectares per household, investment in 32 million hectares of new irrigation development could directly benefit some 43 million irrigator households (or approximately 237 million people) plus a further 10–20 million households that would engage in increased opportunities for agricultural wage labor (Table 5.4).[9]

The revival of equipped but currently unused areas could also benefit many people. A mix of interventions is likely to be required to bring back

Table 5.4 Indicative Summary of Opportunities to Invest in Agricultural Water Development

Type of opportunity	*Theoretical potential (million ha)*	*Possible crops*	*Potential direct beneficiaries (million households)*[a]	*Indicative cost ($/ha)*[b]	*Scope for investment (million dollars)*
New irrigation	32	Rice, sugar, cotton, dry beans, fodder, horticulture, other high-value crops	58	6,000	192,000
Irrigation rehabilitation[c]	2	Rice, sugar, cotton, dry beans, fodder, horticulture, other high-value crops	4	3,500	7,000
Improved water control in wetlands and flood recession areas	2	Rice and non-rice cereals, cotton, dry beans, fodder	4	2,000	4,000
Improved in-field rainwater management for dryland crops[d]	46	Barley, maize, wheat, cotton, teff, dry beans, coffee, fodder	20	250	11,500
Totals	82		86		214,500

a. Assumes an average of 0.75 ha/household on irrigated land, wetlands, and flood recession areas and 2.5 ha/household on dryland areas. Also that direct beneficiaries increase by 25–50 percent on irrigated land, wetlands, and flood recession areas and by 10 percent on dryland areas, as a result of increased agricultural wage employment resulting from investment.

b. Includes both software and hardware where applicable.

c. Likely to be an underestimate because some of the 5 million hectares currently under irrigation could be in need of rehabilitation.

d. Assumes only 25 percent of current cultivated area will be developed.

Source: Current study.

9. This assumes that for every household benefiting directly from irrigation an additional 0.25–0.50 households would benefit from incremental wage employment.

into production the 2 million hectares of land that is equipped for irrigation but currently not used. This land is located in large-, medium- and small-scale schemes and will require interventions such as rehabilitation and upgrading of physical works, changes in the institutional setup, and improved water management and crop husbandry. At an average cost of $3,500/ha for recent well-designed rehabilitation projects, these investments could prove economically viable. However, these schemes would involve similar O&M costs to those for new irrigation schemes, and the cropping pattern would have to be sufficiently high value to cover those costs and provide an incentive income to farmers. Again, at an assumed average holding size of 0.75 hectares per household, investment in these schemes could directly benefit some 2.7 million households (or 15 million people) plus a further 0.7–1.3 million households engaging in increased agricultural wage employment.

There is potential for improving water control in wetlands and flood recession areas. Improving water control on the 2 million hectares of land under 'other forms of water management' in wetlands and flood recession planting areas might involve the development of flood protection and drainage systems, or even irrigation systems. However, in many cases the development of small areas by individual smallholder irrigators, using micro-irrigation technologies (such as treadle pumps) will be appropriate. Such investments are likely to involve lower capital and O&M costs than new or rehabilitated irrigation schemes and may be justified by the production of lower-value crops. Cropping patterns could include rice and other cereals, cotton, dry beans, fodder and, in a number of cases, horticulture. Average land holding could be similar to that for new irrigation and the total numbers of direct beneficiaries could be of a similar order to those from investment in the rehabilitation or upgrading of existing, but unused, irrigation schemes—perhaps a total of 4 million households region-wide.

Solving the problem of low productivity on existing irrigated land presents a major investment opportunity. As discussed in section 2.3, irrigated production in sub-Saharan Africa is characterized by low productivity, constrained by unreliable water supplies, poor water management, low input use, and poor crop husbandry, as well as poor access to input and output markets. Apart from unreliable water supplies, the constraints highlighted are mainly institutional and require investment in software rather than hardware. This opportunity would therefore involve only a fraction of the cost of physical works suggested in Table 5.4 and represents a first class investment opportunity.

Finally, improving in-field rainwater management for dryland crops clearly presents a further major opportunity. Improving in-field rainwater management is an attractive possibility because of the vast areas that might be involved, so that even a small yield increase could have a large production impact. For example, the area currently planted to dryland maize is 24 million hectares (FAO, 2005a). An incremental yield of just 250 kg/ha on this area would be 6 million tonnes—i.e., more than the total projected imports of maize in 2030. In addition, the poverty reduction impact would be immediate because dryland farming is the production system of the poor. Improvements could involve a range of interventions, although all would have the common objective of increasing the effectiveness of rainfall for dryland crops.

As discussed, various technologies have been successfully demonstrated in the region but, apart from one or two cases (e.g. the *tassa* in Niger and conservation tillage in Zambia) adoption has been poor. The constraints to wider adoption by smallholders are likely to be similar to those that are thought to currently limit productivity on irrigated land—i.e., a lack of farmer empowerment to access input and output markets, poor agricultural support services (including extension and credit), and a lack of supply chains for implements and equipment. The theoretical potential is 174 million hectares. For the present purpose it has been assumed that 25 percent of the currently cultivated area, or 46 million hectares, might eventually be developed. Success is likely to be greater in the higher potential agro-ecological zones, particularly in the dry sub-humid zone, but the experience from Niger suggests that good results can also be achieved in the semi-arid zone. Although the possible impact of this development on overall runoff, streamflow, and ecosystems has not been quantified, it is unlikely that this would be significant.

5.5 Choices Facing Governments at the Country Level

At the country level, there are many constraints to developing the physical and economic potential identified. These constraints and some examples are typically economic (the identified projects are not economically viable), financial (investment costs are too high for available finance), institutional (the institutional model is unlikely to deliver good water service or will not prove financially and socially sustainable), environmental (irrigation is viable but the regulatory framework cannot control adverse environmental impacts), capacity-related (local capacity to implement projects efficiently is weak), and poverty related (poor farmers cannot invest in profitable agricultural water technology to improve productivity because they are resource poor and risk averse). These many possible constraints operate in every country in different degrees.

For each country situation, institutional and investment responses need to be devised to allow the potential to be realized despite the constraints. Essentially, choices will be required that reflect the development priorities and absorptive capacity of each country. The general principles that can guide governments in preparing strategies for agricultural water use were discussed above in section 5.4. In each country adapting these principles to the specific opportunities and constraints that exist will require a painstaking iterative process.

CHAPTER 6

Lessons and Recommendations for Engagement in Agricultural Water

6.1 Farm-Level Profitability, Viability, and Sustainability

Lesson. *Agricultural water development in sub-Saharan Africa can make an important contribution to poverty reduction and growth. It can, however, only do so when investments are profitable at the farm level, economically viable, and sustainable.*

Without farm-level profitability, income poverty reduction cannot be achieved, and without financial, social, and environmental sustainability, there can be neither economic viability nor farm level profitability. Investments for so-called 'social' or 'strategic' purposes—for example, to increase national production of staples—cannot contribute to growth or poverty reduction if they are not economically viable. While public subsidy for the capital costs of smallholder irrigation infrastructure can be justified, subsidized services and/or O&M have rarely proved sustainable.

That said, conventional project analysis techniques have tended to ignore the 'downstream' benefits of agricultural water investment induced by the multiplier effect, which when quantified and valued can result in total benefits being much higher than would otherwise be thought. Also, there are often opportunities to invest in agricultural development that, on their own, would be judged unviable but which, when combined, for example, with small to medium hydropower generation, could result in an acceptable economic rate of return. The association of irrigation with livestock or fisheries is another example of potentially mutually reinforcing economics.

Recommendation. *Future designs and investment decisions—including those for major infrastructure—should be based solely on considerations of economic viability, farm level profitability, and sustainability. However, where 'downstream' benefits can be quantified these should taken into account in the analysis. Similarly, where there are opportunities for multi-purpose investments these should be taken advantage of and accounted for in project costs and benefits.*

Sustainable farm-level profitability and economic viability—based on cost-effective design and realistic assumptions of yields, production, and prices—should be the principal concerns in investment decisions. Technology, and therefore costs, must be appropriate for the market prospects of the crops grown. 'Downstream' benefits and any additional benefits arising from multiple uses should be quantified, valued, and taken into account in the analysis. They should not, however, be used to obscure any intrinsic weaknesses in the economic justification of the agricultural water component of the investment, and unviable investments that are proposed on the basis of so-called 'social' or 'strategic' reasons, or those that will depend on long term subsidies, should be avoided.

6.2 Opportunities for Further Public and Private Investment

Investing in Irrigation

Lesson. *There is physical potential to expand the irrigated area by a factor of nearly five, although some expansion will require construction of additional water storage. There is also potential for bringing back into production land that is equipped for irrigation but currently not used, as well as improving the productivity of land already under irrigation and land under 'other forms of water management'. The constraints to this development are mainly economic—i.e., costs, productivity, and access to profitable markets.*

The theoretical physical potential for new irrigation development is estimated to be more than 32 million hectares—almost five times the area currently developed. There is potential for all forms of irrigation development, from individual micro-scale irrigation to large-scale—the choice depends on whichever is the best investment in terms of physical conditions and possible economies of scale. Some development is likely to require new water storage, some of which could provide opportunities to exploit synergies between irrigation and hydropower.

In addition to new irrigation development there is potential for improving the productivity of the 5 million hectares currently under irrigation and for bringing back into production the 2 million hectares of land that is equipped for irrigation but currently unused. A mix of interventions is likely to be required to realize this potential—which is in large, medium and small-scale schemes—such as improvements to the physical works, and improved water management and crop husbandry. There is also potential for improving water control on the 2 million hectares of land under 'other forms of water management'—i.e., in wetlands and valley bottoms. Some of this may require the development of irrigation and drainage schemes, but in many cases the development of small areas by individual smallholder irrigators, using micro-irrigation technologies (e.g., treadle pumps), will be more appropriate. The main constraints to developing the potential for irrigation are economic—i.e., costs, access to profitable markets, and potential productivity in supplying these markets.

Since more than one-half of the currently irrigated area is used for growing staples, recent analyses have considered irrigation as an option for reducing the region's future food imports. However, at the average capital costs of new irrigation (even recent well-designed irrigation) and the yields typically obtained by smallholders, economic returns and profitability may be adequate for rice, particularly for local markets enjoying natural protection, but would generally be too low to justify investment for crops such as maize and wheat. The expansion of irrigation for staple food crops will therefore require either productivity improvements that increase returns or substantial reduction in costs. The expansion of irrigation for higher value crops such as cotton, sugar, and horticulture is likely to be more viable, but returns will be highly specific to sites and market opportunities.

Recommendation. *The potential for irrigation should be seen as an opportunity to achieve poverty reduction and economic growth. However, irrigation should be reserved for the production of irrigated crops (including rice) for which there is a comparative advantage, rather than as a means of reducing the region's imports of non-rice staples for which lower cost interventions would be more appropriate.*

The existence of 2 million hectares of land that has already been equipped but is not currently used should be regarded as an opportunity to take advantage of significant sunk costs. Similarly, the 2 million hectares of land under 'other forms of water management' in wetlands and valley bottoms should be regarded as an opportunity to improve water control at relatively low cost.

Improving Dryland Farming

Lesson. *A range of low-cost in-field rainwater management technologies is also available for stabilizing and increasing the yields of dryland crops. The results of demonstrations and pilot projects to date have been promising and the potential for scaling up—especially for production of non-rice staples and possibly cash crops such as cotton—could be considerable. Because dryland farming is the predominant production system, improving its productivity could have a very substantial impact on production and poverty reduction. However, adoption rates have so far been poor.*

Dryland farming is far and away the largest production system, and even a small improvement in yield would have a large impact on production and poverty reduction. The technologies involve very low capital investment costs (usually on the order of \$100/ha) and can be shown to be viable for the production of non-rice staples and possibly other deep-rooted cash crops such as cotton. However, they typically have a rather short economic life, suggesting that public financing of on-farm works would be impractical. Yet unless the constraints that have so far discouraged farmers to invest their own resources in the technologies are removed, adoption can be expected to remain poor. These constraints are probably similar to those faced by the agriculture sector as a whole and are likely to include a lack of empowerment, weak or non-existent agricultural support services, poor access to input and output markets, and weak or non-existent supply chains for equipment.

Recommendation. *Investment in in-field rainwater management for dryland crops should be considered as an alternative to irrigation for non-rice staples and, possibly, other deep-rooted cash crops. Future public investment should concentrate on developing promising technologies, facilitating the establishment of sustainable supply chains where necessary, removing the constraints to adoption, and supporting dissemination and market-led adoption.*

Agricultural water development strategies should now consider the development, dissemination and adoption of in-field rainwater management technologies as an opportunity to stabilize and increase the yields of non-rice staples under dryland production. Because it would be impractical for government to finance the on-farm works required (because government would be obliged to repeat the financing every few years) it is essential that the technologies should be suitable for and attract farmer-financing. This implies that the technology should not only be technically feasible but affordable and profitable at the farm level. The various constraints to affordability and profitability that have discouraged adoption to date should be identified and investments made to establish the conditions that will remove them. The next step in most countries should be renewed research and development programs to identify replicable technologies, combined with monitoring and evaluation to pinpoint the constraints to widespread adoption.

6.3 Designing and Implementing Better Investment Projects

Agricultural Water as Part of a Comprehensive Package

Lesson. *Investment in agricultural water is not on its own sufficient to ensure optimal yields, productivity, and incomes. Water supplies must be reliable and provided as part of a comprehensive package that enables farmers to maximize productivity and profitability as well as creating the incentives for them to do so.*

Investment in agricultural water requires accompanying investment in agricultural support services, including extension and credit to provide farmers with the necessary skills and resources to enable them to make the best use of infrastructure provided and to invest in yield-enhancing inputs. Agricultural water supplies must also be sufficiently reliable and access to output markets sufficiently profitable for farmers to invest confidently in using these inputs.

Ensuring that water supplies are reliable, although extremely important, could be the easiest of the above requirements to meet. It merely involves procurement of competent technical advice and following it—which is usually a matter of good project management and supervision. The other requirements will be more difficult to meet. Reductions in the scope and operations of public agricultural support services as governments have redefined their core functions have made the provision of technology and financing to smallholder farmers a major challenge in recent years. At the same time, the withdrawal of the state from marketing has left smallholder farmers unprepared to deal with both input and output markets. The provision of agricultural support services by projects is not a satisfactory long-term solution. The arrangements need to be sustained beyond project completion.

Recommendation. *Financing agencies, including governments, should make project financing available only for those projects that, apart from providing a reliable supply of agricultural water, also provide support to enable farmers to use it to maximize the profitability of crop production on a sustainable basis.*

Project designs should provide for farmers to obtain access to competent, commercially oriented, efficient, and accountable agricultural support services on a permanent basis. This may involve facilitating market links in which a private sector processor provides agricultural support in return for a guaranteed throughput, or it may involve building the capacity of farmers to either provide these services themselves or obtain them from private sector service providers. Project design should provide for capacity building to empower farmers and their organizations to adapt to their new role and collectively negotiate with input and output markets beyond project completion. Sustainable and accountable local financial services should be promoted, both for seasonal and investment finance.

Targeting the Poor and Women

Lesson. *The design of agricultural water investments should address all strata within the community, ensuring that all benefit to their mutual advantage. Exclusively targeting the poorest socioeconomic stratum is not necessarily effective in reducing poverty, although specifically targeting women can be. Similarly, targeting the driest agro-ecological zones is not necessarily 'pro-poor'.*

Experience suggests that exclusively targeting the 'poorest of the poor' is not necessarily the most effective way of reducing rural poverty. The vast majority of the rural population of the region subsists on less than a dollar a day (and are therefore categorized as the 'extreme poor' in terms of the MDGs), a more inclusive approach is likely to bring better results. In this way, all strata within the community—including the poorest—can benefit from investment to their mutual advantage.

Understanding the socioeconomic profile of the target group, how they derive their livelihoods, what their constraints are, how they interact, and how agricultural water management, as an input to their farming system, can assist them in improving their livelihood status is therefore essential for pro-poor design. In addition, because more than 50 percent of farmers and rural laborers are women, specifically targeting support to women and encouraging their participation in governance structures can enhance productivity, profitability, and hence poverty reduction.

Targeting the arid and semi-arid agro-ecological zones is not necessarily pro-poor because the greater scope for reducing poverty and hunger, in terms of population density, incidence of poverty, agricultural potential, and the available pathways for households to increase their agricultural incomes, lies in the areas of high potential, particularly in the sub-humid and humid zones.

Recommendation. *Project studies and designs should be geared to enhancing the prospects for all strata of the community, including women, to benefit from the investment to mutual advantage without marginalization of the poorest stratum. Targeting areas of low agricultural potential should be avoided, unless clearly market-linked, viable opportunities for development are available.*

Socioeconomic and production systems surveys should be carried out to provide an understanding of the profile of the target population and its intra-community dynamics, with a view to exploiting these to the mutual benefit of all members of the community, including women. Special care should be taken to ensure that the investment takes account of the role of women in the production system and does not exclude or further marginalize the poorest stratum. Attention should focus on ensuring that the investment will be 'pro-poor' by seeking to maximize farm-level profitability, employment, and incomes, and by devising mechanisms to empower the poorest, including women, and improve their access to land, water, and services. Investments should generally be targeted at the sub-humid and humid zones except where land, water, and markets combine favorably in the drier zones to ensure viability and sustainability.

Implementing and Managing Public Investments

Lesson. *Organizational arrangements for project design, implementation, and management are more efficient when they reflect the comparative advantages of the public sector, farmers, NGOs, and the private sector. Sustainability is best achieved by involving farmers throughout and by handing over schemes to farmer organizations once complete. In many cases it can be more efficient to obtain implementation services from the private/NGO sector than to build public sector institutions for the purpose, even where local private/NGO sector capacities are weak.*

Weaknesses in public sector organizations have impaired the quality of project preparation, implementation, and management, and inadequate support by governments and donors through the supervision process has also been a cause of poor quality. Experience of organizational arrangements for project development and management has shown that farmer involvement improves design and reduces costs, and that the most profitable and sustainable schemes are those where farmers are able to take over operation and maintenance once the scheme is developed. Private/NGO sector service providers can also play an effective role in agricultural water development, mainly because they can be held more accountable for their services than public sector service providers, although they need effective supervision. The choice is essentially a pragmatic one: which organization—public, NGO, or private—can provide the most efficient and accountable service?

Recommendation. *Farmer management of schemes should be the first option, and clear arrangements need to be agreed for any joint management. Service provision arrangements and supervision thereof should be based on the respective strengths of the public sector, the private sector, NGOs, and farmers. Governments and donors should improve the supervision process.*

Farmers and their organizations should be involved from the first conception of a project. In all cases, farmer management of schemes once they are complete should be the first option, and clear arrangements for any joint management and co-financing of operation, maintenance, and replacements are needed if there is a task beyond farmer capacity such as managing major headworks and networks. Farmer organizations will need to be strengthened and empowered to participate in project design, implementation, and management. Where NGOs or the private sector are contracted to provide services, terms of reference should clearly specify the intentions with regard to the 'deliverables' and accountability for them, as well as exit strategies. Engineering design and construction supervision services should be obtained from the best qualified source, regardless of origin (i.e., national, regional, or international), the objective being solely to ensure that farmers are provided with competent services. Supervision should be geared to quality assurance and keeping activities focused on the overall objectives. Governments and donors need to support implementation with adequate time and technical resources, and to be flexible enough to adjust in the light of experience.

Social, Environmental, and Health Impacts

Lesson. *Agricultural water development can have both positive and negative social, environmental, and health impacts. The challenge is to design,* *implement, and manage projects in such a way that socioeconomic benefits are maximized while negative impacts are minimized.*

Agricultural water development can produce positive social, environmental, and health impacts such as improving pastoralists' access to water and feed, safeguarding natural habitats, improving nutrition, improving access to health facilities and health service provision, and providing water for domestic purposes. Agricultural water management can help mitigate the impacts of HIV/AIDS through increased incomes and better nutrition.

However, negative social, environmental, and health impacts of agricultural water developments are widely documented. Inadequate assessment of potential impacts and absence of design measures to mitigate them, as well as weaknesses in the public sector institutions responsible for regulating environmental and health aspects, can lead to reduced productivity, project failure, and increased human suffering.

Recommendation. *Improved planning and management of social, environmental, and health impacts is a prerequisite for ensuring the sustainability of future agricultural water development. Project designs should not only assess and provide mitigation measures for potentially negative impacts but also seek to exploit potentially positive impacts. Project designs should also, if necessary, make provision for strengthening the public sector institutions responsible.*

Project designs should not only assess and provide mitigation measures for potentially negative impacts (such as conflicts with pastoralists, or spread of water-borne diseases) but also take advantage of opportunities for potential synergies and positive impacts (such as providing water and feed for livestock, or improving watersheds). In this way, projects can improve their prospects for productivity and sustainability, and may also contribute to the achievement of the MDGs for child mortality, maternal health, combating HIV/AIDS, malaria and other diseases, as well as the environment (including water and sanitation). The economic costs and benefits of environmental impacts need to be taken fully into account in appraisals and investment decisions. Given the links within catchments, consideration must be given to the potential environmental impacts on projects as well as the impacts they cause, and also to the potential cumulative effect of a number of projects.

In many cases the effectiveness of mitigation measures, or measures to exploit positive impacts, will be constrained by institutional weaknesses, so support should be provided for reforming and strengthening institutions, possibly through sector-wide approaches. Public agencies also need to be equipped to manage the environmental impacts of private irrigation development. Methods of rapid appraisal need to be developed for small-scale interventions where it is unrealistic to expect full environmental and health assessments to be conducted. Initiatives that build local-level awareness of the social, environmental, and health issues associated with agricultural water development should be encouraged. Specific strategies are needed to address the attrition of staff and farmer leaders from HIV/AIDS-related infections.

Monitoring and Evaluation

Lesson. *Monitoring and evaluation of project performance has been neglected in the past and needs to be improved in future to inform future strategic planning and project design, as well as to measure the contribution of agricultural water development to achievement of the MDGs.*

To measure the contribution of agricultural water investments to poverty reduction and the attainment of the MDGs, good monitoring information is needed, not only on inputs and outputs but also on outcomes like changes in income and employment, and on broader and longer-term impacts such as those on poverty, hunger and health, and the environment. However, monitoring and evaluation has been one of the most common weaknesses in project design and implementation in the past. There is also a need for greater accountability by all concerned, including government and financing agencies, to ensure that monitoring and evaluation intentions at design are carried through on implementation.

Recommendation. *Monitoring and evaluation as a management tool for farmers, implementing agencies and financing partners should now be given priority.*

Monitoring and evaluation, not only of physical and financial targets but also of changes in incomes and employment and of impacts on poverty, hunger and health, and the environment should be given priority. Systems should be designed in such a way that they can be used as a management tool for farmers, project implementers, and supervisors.

6.4 Institutional Reforms

Lesson. *Institutional reforms can enhance the performance of agricultural water development and its contribution to sustainable agricultural growth* *and poverty reduction. However, reforms require time and consistent approaches by both governments and donors. Decentralizing development responsibility can also enhance impact. Reforms need to be accompanied by effective capacity building to equip the actors to cope with new roles and responsibilities.*

Institutional reforms can improve the performance of agricultural water investments, including large-scale irrigation. Without reforms, farm-level profitability will generally be constrained and disincentives to investment will persist. Reforms to <u>macroeconomic policies</u> facilitate business and encourage investment in agricultural intensification. Reforms to <u>food security policies</u> create efficient food markets and improve the ability of the poor to feed themselves. <u>Water sector reforms</u> ensure water entitlements and sustainable water resources management. Both <u>private and public sector</u> have a role to play. Governments have an essential role in establishing a institutional framework conducive to private enterprise and investing in key infrastructure where the private sector will not; the private sector will have a key role in investment (either in PPPs or on their own), manufacturing, service provision, and market links. <u>Decentralization</u> can promote greater responsiveness to local needs and markets—although it has proceeded somewhat erratically to date and there is a need for support to develop good governance, capacity building, empowerment, and improved mechanisms for subproject approval and appraisal.

Reforms to <u>legal and organizational frameworks for large-scale irrigation projects</u> have indicated pathways for success. These have included improved land tenure; downsizing management agencies and improving transparency and accountability to farmers; farmer participation in management; and contracting out to private sector agencies for non-core activities such as scheme maintenance. Some attempts at <u>transferring management responsibility to farmers</u> have not yielded the expected results. However, successful cases show what conditions are needed—a partnership approach between policy makers, irrigation agency, and water users; a supportive policy and legal framework; scheme profitability and financial autonomy; the strengthening of user organizations; and a clear plan and timetable, with careful management of the process including post handover support; and political and managerial commitment.

Institutional reforms take time and patience, but experience has shown that a coordinated approach to reforms, applied gradually with consistency between governments and donors, can be successful. Most reforms need to be accompanied by programs of capacity building to enable the actors to adapt to and capitalize on the change. Some reforms may be achievable within the context of a discrete project; for others a sector-wide approach may be appropriate.

Recommendation. *The on-going process of reforms to macroeconomic policies, legal frameworks, and organizations for agricultural water management should be supported and strengthened, with capacity building where appropriate to create a favorable environment for profitable investment, engage the energies of the private sector and farmers, and make service providers accountable. Such reforms require time and consistent approaches by both governments and donors, for which sector-wide approaches may be appropriate.*

The on-going process of reforms to macroeconomic policies, legal frameworks, and organizations for agricultural water management should be supported and strengthened, where appropriate, with capacity building to create a favorable environment for profitable investment. Particular areas for institutional reform should include:

- Completing reforms of macroeconomic, food security, and water sector policies to promote profitable investment and employment in agricultural water, and encouraging greater involvement by the private sector through policies that favor enterprise and through public private partnerships;
- Ensuring systematic attention in project design to issues of land and water governance and tenure;
- Supporting decentralized development through capacity building for local authorities, decentralized agencies, and farmer groups;
- Developing coherent and sustained approaches to organizational reform of the large-scale irrigation sector, including best practice on user involvement, private sector participation, and irrigation management transfer; and
- Empowering farmer organizations to enable them to function in liberalized economies, ensuring that service providers are accountable and responsive to their needs, and that organizations are able to participate in project design, implementation, and management, and to compete in markets.

Building in Incentives for All Partners to Change

The design of programs for institutional reform should recognize that time and sustained commitment are required. All partners involved in sector need to work to a harmonized common agenda, to align support on national programs and institutions, as well as to invest in capacity building.

6.5 Strategic Vision

Lesson. *A strategic vision for agricultural water development has been lacking. Consequently, significant opportunities for achieving agricultural growth and poverty reduction are being missed. There is considerable potential for further development of agricultural water, but also significant constraints, of which only some can be overcome.*

Although perceptions that agricultural water development has been inefficient—in terms of water use and economics—were probably justified in the past, a number of recent projects have demonstrated that, with careful project identification, design, and appraisal, this need not always be the case. However, water sector strategies and programs are generally neutral—or even negative—toward agricultural water development and use. They typically assign greater priority to other uses. Most poverty reduction strategies are predicated on agricultural growth, but agricultural water development generally has a low profile in PRSPs—possibly because of the negative perceptions referred to above. In effect, there has been a lack of a strategic vision for agricultural water development.

There are, as mentioned, economic and institutional constraints. Some of these can be resolved at the level of programs and projects, others need to be resolved at the sectoral level or in the wider macroeconomy. Other constraints are difficult or impossible to alter, and provide a context within which the strategic vision needs to be developed. They include poor terms of trade, limited and high-cost access to world markets, the dispersed population, and poor agricultural potential in many areas, particularly in the arid and semi-arid zones.

Recommendation. *Sub-Saharan African countries should now develop national strategies for the agricultural water subsector that recognize both its importance for agricultural growth and poverty reduction and the economic realities referred to in this report, as well as the need for water to be developed within a broader framework that promotes agricultural growth through profitable investment and market-oriented production. Agricultural water strategies should be integrated with both broader water resources management strategy and with poverty reduction strategy. Strategies need to be supported by analysis of the role of public and private investment, ways to foster* *private investment, and the range of public investment options incorporated into an investment plan to be implemented wherever possible through sector-wide approaches.*

Sub-Saharan African countries should now develop a strategic vision for the agricultural water sector. This vision should be incorporated into a national strategy for agricultural water development as a key component of both national agriculture policy and water policy. The profile of agricultural water development should also be raised in water and agriculture sector strategies. Agricultural water development strategies should be linked to **water sector strategies** and based on IWRM principles, respecting and supporting transboundary water agreements, with investments optimized at the basin scale. IWRM approaches should strike a balance between demand and supply management, providing for new investments in supply where it is economically, socially, and environmentally justified. They should also ensure that water allocation and management take account of the needs of the poor and provide for greater participation in sectoral and basin planning by smallholder farmers. Agriculture water development strategies also need to figure prominently in poverty reduction strategies, as set out in PRSPs, to focus the attention of both governments and potential donors.

The strategies should be supported by a comparative analysis of the various investment options, including:

- Investment in increasing productivity and profitability of existing schemes.
- Expansion or new construction of large, medium, small, and micro-scale irrigation schemes (including water harvesting) linked to profitable markets, following best practices for new storage and based on viable institutional models.
- Testing and scaling-up of technologies for in-field rainwater management, provided these are proven to be technically and financially feasible and replicable by smallholder farmers on a sustainable basis.
- Development of sustainable supply chains for micro-scale irrigation and in-field rainwater management equipment.
- Investment in research on agricultural water management, both adaptive research at the national and regional levels and basic research at the regional level. Particular emphasis will be needed on three components: (a) the technology, profitability, affordability, and replicability of in-field rainwater management for dryland crops; (b) crops and crop husbandry improvements for staples; and (c) monitoring

and evaluation of the performance of agricultural water investments on a region-wide basis in order to provide the basis for rapid scaling-up of emerging successes.
- Investment in institutional reforms, including those for decentralized development and all necessary capacity building.

All these investments should, if practically possible, be pursued using sector-wide approaches to ensure consistency of approach between government and donors.

Where existing policies and strategies reflect the strategic vision outlined above, they should become the basis of **new investment programs**. Where they do not, policies and strategies should be revised and new investment programs prepared. If external assistance is necessary for the formulation of the new strategies and investment programs, this should be sought from international development agencies. Phased investment programs should be based on: (a) the available physical potential, the available markets, and the feasibility of achieving levels of productivity and profitability that will justify the likely investment costs; (b) identifying where economic viability, farm level profitability, and sustainability can best be achieved by the different investment options mentioned above; and (c) indicating the measures necessary to promote profitability. The programs should be prioritized according to prospects for achieving farm level profitability, economic viability, sustainability, and, hence, poverty reduction and growth.

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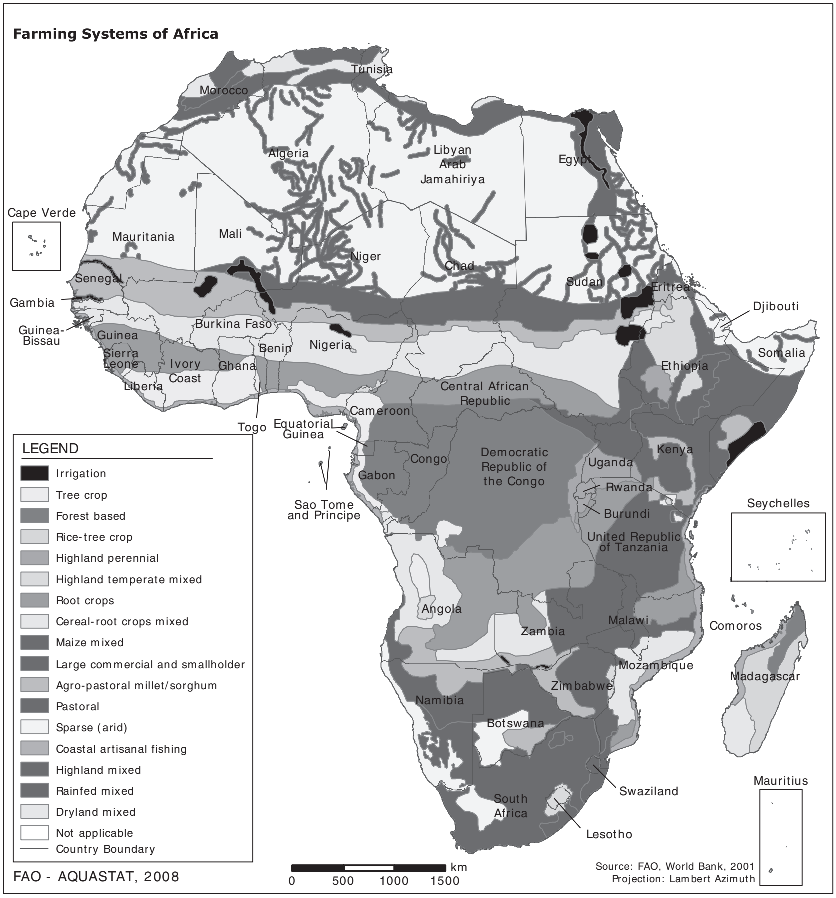
Maps

Map 1. Sub-Saharan Africa: Regional Groupings Adopted by FAO (2005a)

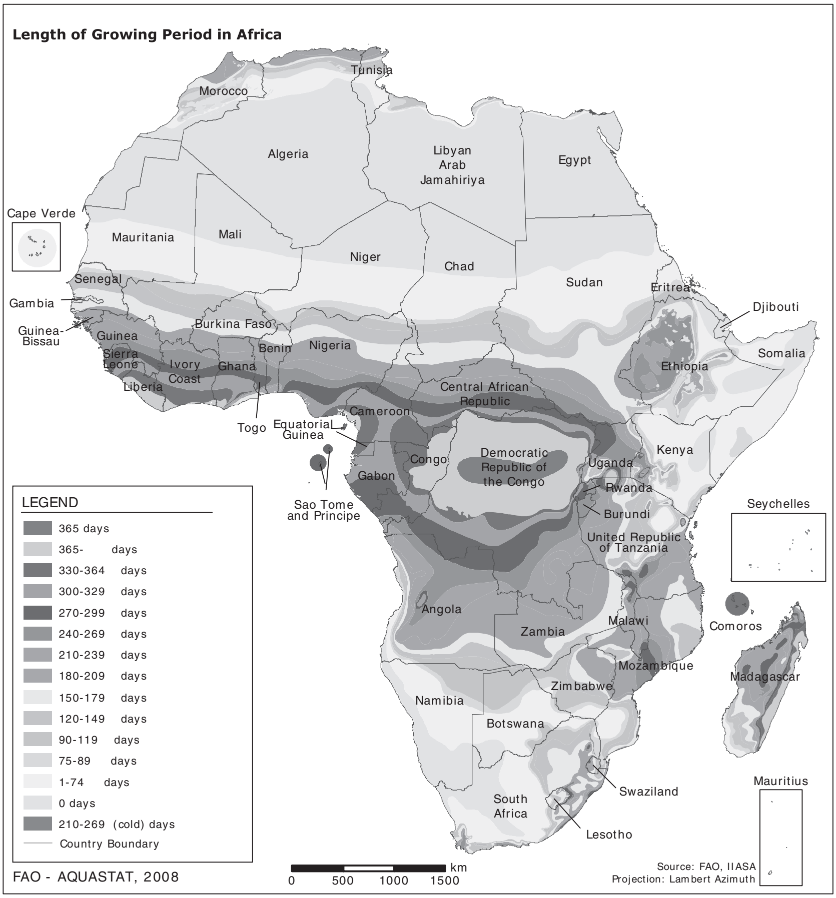
Source: FAO.

Map 2. Major Farming Systems



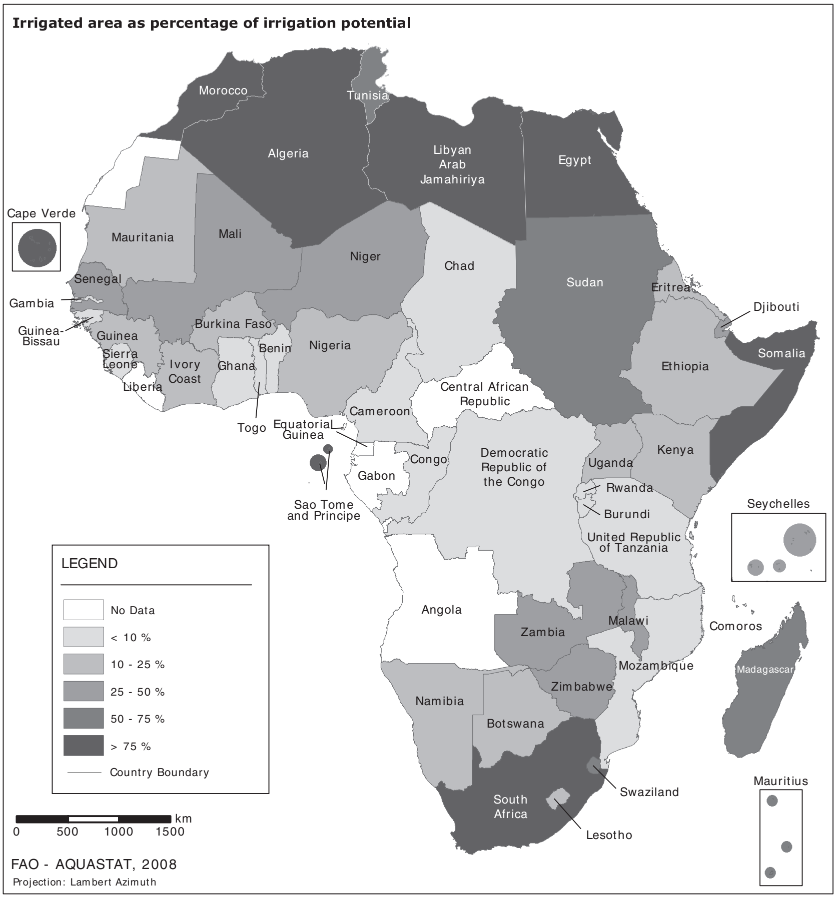
Source: FAO and World Bank, 2001.

Map 3. Agro-Ecological Zones (Length of Growing Period)



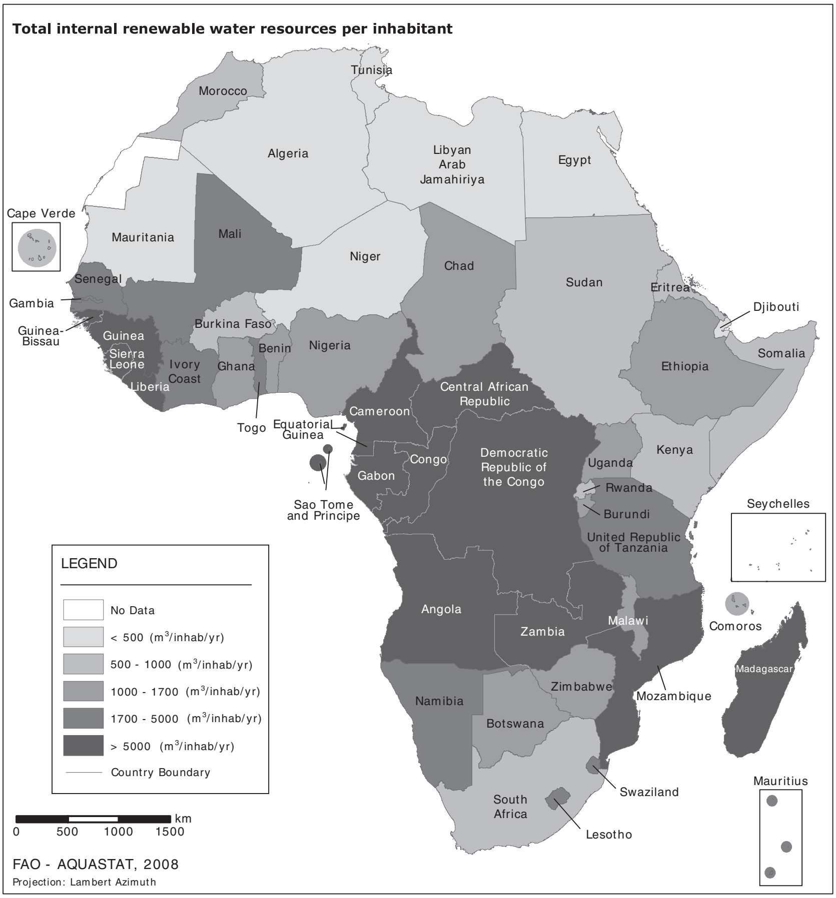
Source: FAO.

Map 4. Water Managed Area as Percentage of Irrigation Potential



Source: FAO.

Map 5. Total Internal Renewable Water Resources per Inhabitant and Dependency Ratio



Source: FAO.

Summary Tables

Summary Table 1. Cultivated Area, Irrigation Potential, and Currently Irrigated Area

	Cultivable area		*Cultivated area (2002)*		*Irrigation potential*		*Currently irrigated area*		
	Hectares (3)	*Hectares/ inhabitant (4)*	*Hectares (5)*	*Hectares/ inhabitant (6)*	*Hectares (7)*	*Share of cultivable area (%) (8)=100 x (7)/(3)*	*Hectares (9)*	*Share of cultivable area (%) (10)=100 x (9)/(5)*	*Share of irrigation potential (%) (11)=100 x (9)/(7)*
Angola	32,000,000	2.27	3,300,000	0.23	3,700,000	11.6	80,000	2.4	2.2
Benin	7,000,000	1.01	2,815,000	0.41	322,000	4.6	12,258	0.4	3.8
Botswana	2,980,650	1.62	380,000	0.21	13,000	0.4	1,439	0.4	11.1
Burkina Faso	9,000,000	0.67	4,400,000	0.33	165,000	1.8	25,000	0.6	15.2
Burundi	1,400,000	0.20	1,351,000	0.19	215,000	15.4	21,430	1.6	10.0
Cameroon		—	7,160,000	0.44	290,000	1.9	25,654	0.4	8.8
Cape Verde		—	45,000	0.10	3,109	4.4	2,780	6.2	89.4
Central African Republic	15,000,000	3.83	2,024,000	0.52	1,900,000	12.7	135	0.0	0.0
Chad	19,000,000	2.15	3,630,000	0.41	335,000	1.8	30,273	0.8	9.0
Comoros		—	132,000	0.17	300	1.8	130	0.1	43.3
Congo		—	240,000	0.06	340,000	2.3	2,000	0.8	0.6
Cote d'Ivoire	21,000,000	1.24	6,900,000	0.41	475,000	2.3	72,750	1.1	15.3
Democratic Republic of Congo	80,000,000	1.47	7,800,000	0.14	7,000,000	8.8	10,500	0.1	0.2

Djibouti	6,000	0.01	1,012		2,400	40.0	1,012	100.0	42.2
Equatorial Guinea	850,000	1.68	230,000	0.45	30,000	3.5			
Eritrea	1,600,000	0.37	503,000	0.12	187,500	11.7	21,590	4.3	11.5
Ethiopia	13,200,000	0.18	10,671,000	0.15	2,700,000	20.5	289,530	2.7	10.7
Gabon	15,155,000	11.22	495,000	0.37	440,000	2.9	4,450	0.9	1.0
Gambia	430,000	0.29	255,000	0.17	80,000	18.6	2,149	0.8	2.7
Ghana	10,000,000	0.47	6,331,000	0.30	1,900,000	19.0	30,900	0.5	1.6
Guinea	6,000,000	0.70	1,540,000	0.18	520,000	8.7	94,914	6.2	18.3
Guinea-Bissau	1,100,000	0.72	548,000	0.36	281,290	25.6	22,558	4.1	8.0
Kenya	9,942,000	0.31	5,162,000	0.16	353,060	3.6	103,203	2.0	29.2
Lesotho		—	334,000	0.19	12,500	1.3	2,637	0.8	21.1
Liberia		—	600,000	0.17	600,000	12.0	2,100	0.4	0.4
Madagascar	8,000,000	0.45	3,550,000	0.20	1,516,819	19.0	1,086,291	30.6	71.6
Malawi	3,600,000	0.29	2,440,000	0.20	161,900	4.5	56,390	2.3	34.8
Mali	43,700,000	3.26	4,700,000	0.35	566,000	1.3	235,791	5.0	41.7
Mauritania	1,000,000	0.34	500,000	0.17	250,000	25.0	45,012	9.0	18.0
Mauritius		—	106,000	0.09	33,000	22.0	21,222	20.0	64.3
Mozambique	36,000,000	1.88	4,435,000	0.23	3,072,000	8.5	118,120	2.7	3.8
Namibia	25,000,000	12.43	820,000	0.41	47,300	0.2	7,573	0.9	16.0
Niger	16,500,000	1.33	4,500,000	0.36	270,000	1.6	73,663	1.6	27.3

(continued)

Summary Table 1. ***(continued)***

	Cultivable area		*Cultivated area (2002)*		*Irrigation potential*		*Currently irrigated area*		
	Hectares (3)	*Hectares/ inhabitant (4)*	*Hectares (5)*	*Hectares/ inhabitant (6)*	*Hectares (7)*	*Share of cultivable area (%) (8)=100 x (7)/(3)*	*Hectares (9)*	*Share of cultivable area (%) (10)=100 x (9)/(5)*	*Share of irrigation potential (%) (11)=100 x (9)/(7)*
Nigeria	61,000,000	0.48	33,000,000	0.26	2,330,510	3.8	293,117	0.9	12.6
Rwanda	1,511,400	0.18	1,385,000	0.16	165,000	10.9	8,500	0.6	5.2
Sao Tome and Principe	55,000	0.33	54,000	0.33	10,700	19.5	9,700	18.0	90.7
Senegal	3,800,000	0.37	2,506,000	0.24	409,000	10.8	119,680	4.8	29.3
Seychelles		—	7,000	0.09	1,000	10.0	260	3.7	26.0
Sierra Leone	5,360,000	1.04	600,000	0.12	807,000	15.1	29,360	4.9	3.6
Somalia	8,150,000	0.79	1,071,000	0.10	240,000	2.9	200,000	18.7	83.3
South Africa	18,320,000	0.41	15,712,000	0.35	1,500,000	8.2	1,498,000	9.5	99.9
Sudan	105,000,000	3.06	16,653,000	0.49	2,784,000	2.7	1,863,000	11.2	66.9
Swaziland		—	190,000	0.18	93,220	18.6	49,843	26.2	53.5
Togo	3,400,000	0.68	2,630,000	0.52	180,000	5.3	7,300	0.3	4.1
Uganda	16,800,000	0.63	7,200,000	0.27	90,000	0.5	9,150	0.1	10.2

United Republic of Tanzania	40,000,000	1.06	5,100,000	0.14	2,132,221	5.3	184,330	3.6	8.6
Zambia	16,350,000	1.50	5,289,000	0.48	523,000	3.2	155,912	2.9	29.8
Zimbabwe			3,350,000	0.26	365,624	3.7	173,513	5.2	47.5
Sub-Saharan Africa			182,645,012	0.26	39,413,453		7,105,119	3.9	18.0
Sub-Saharan Africa excluding the three largest irrigation countries			146,730,012		33,612,634		2,657,828	1.8	7.9

Source: FAO, 2005a.

Summary Table 2. Renewable Water Resources

			Annual renewable water resources				
	Average annual precipitation		Internal (IRWR)		Total (TRWR)		
Country[a]	*Depth (mm) (1)*	*Volume (million m^3) (2)*	*Volume (million m^3) (3)*	*Per 2004 inhabitant (m^3/inhabitant) (4)*	*Volume (million m^3) (5)*	*m^3/inhabitant (6)*	*Dependency ratio (%) (7)=100x [(5)−(3)]/(5)*
Angola	1,010	1,258,790	148,000	10,513	148,000	10,513	0.0
Benin	1,039	117,046	10,300	1,489	26,393	3,815	61.0
Botswana	416	241,825	2,400	1,337	12,240	6,819	80.4
Burkina Faso[a]	748	204,925	12,500	933	12,500	933	0.0
Burundi	1,274	35,460	10,060	1,423	15,484	2,191	35.0
Cameroon	1,604	762,463	273,000	16,753	285,500	17,520	4.4
Cape Verde	228	919	300	634	300	634	0.0
Central African Republic	1,343	836,662	141,000	36,043	144,400	36,912	2.4
Chad	322	413,191	15,000	1,694	43,000	4,857	65.1
Comoros	900	2,007	1,200	1,519	1,200	1,519	0.0
Congo	1,646	562,932	222,000	58,146	832,000	217,915	73.3
Cote d'Ivoire	1,348	434,676	76,840	4,548	81,140	4,802	5.3
Democratic Republic of Congo	1,543	3,618,120	900,000	16,539	1,283,000	23,577	29.8
Djibouti	220	5,116	300	421	300	421	0.0

Equatorial Guinea	2,156	60,481	26,000	51,282	26,000	51,282	0.0
Eritrea	384	45,147	2,800	652	6,300	1,466	55.5
Ethiopia	848	936,005	122,000	1,685	122,000	1,685	0.0
Gabon	1,831	489,997	164,000	121,392	164,000	121,392	0.0
Gambia	836	9,451	3,000	2,052	8,000	5,472	62.5
Ghana	1,187	283,195	30,300	1,417	53,200	2,489	43.1
Guinea	1,651	405,939	226,000	26,218	226,000	26,218	0.0
Guinea-Bissau	1,577	56,972	16,000	10,403	31,000	20,156	48.4
Kenya	630	365,633	20,700	638	30,700	947	32.6
Lesotho	788	23,928	5,230	2,906	3,022	1,679	0.0
Liberia	2,391	266,300	200,000	57,356	232,000	66,533	13.8
Madagascar	1,513	888,192	337,000	18,826	337,000	18,826	0.0
Malawi	1,181	139,960	16,140	1,308	17,208	1,395	6.6
Mali	282	349,610	60,000	4,475	100,000	7,458	40.0
Mauritania	92	94,655	400	134	11,400	3,826	96.5
Mauritius	2,041	4,164	2,751	2,231	2,751	2,231	0.0
Mozambique	1,032	827,161	100,300	5,229	217,100	11,318	53.8
Namibia	285	235,253	6,160	3,063	17,715	8,809	65.2
Niger	151	190,810	3,500	282	33,650	2,710	89.6
Nigeria	1,150	1,062,335	221,000	1,739	286,200	2,251	22.8
Rwanda	1,212	31,932	9,500	1,120	9,500	1,120	0.0
Sao Tome and Principe	3,200	3,072	2,180	13,212	2,180	13,212	0.0

(continued)

Summary Table 2. ***(continued)***

			Annual renewable water resources				
	Average annual precipitation		*Internal (IRWR)*		*Total (TRWR)*		
Country[a]	*Depth (mm) (1)*	*Volume (million m^3) (2)*	*Volume (million m^3) (3)*	*Per 2004 inhabitant (m^3/inhabitant) (4)*	*Volume (million m^3) (5)*	*m^3/inhabitant (6)*	*Dependency ratio (%) (7)=100x [(5)−(3)]/(5)*
Senegal	686	135,048	25,800	2,495	38,800	3,753	33.0
Seychelles	2,330	887					
Sierra Leone	2,526	181,215	160,000	30,960	160,000	30,960	0.0
Somalia	282	180,075	6,000	582	14,200	1,377	57.7
South Africa	495	603,926	44,800	991	50,000	1,106	10.4
Sudan	416	1,042,417	30,000	874	64,500	1,879	76.9
Swaziland	788	13,678	2,640	2,438	4,510	4,164	41.5
Togo	1,168	66,302	11,500	2,292	14,700	2,930	21.8
Uganda	1,180	284,427	39,000	1,461	66,000	2,472	40.9
United Republic of Tanzania	1,071	1,012,191	84,000	2,230	93,000	2,469	9.7
Zambia	1,020	767,700	80,200	7,342	105,200	9,630	23.8
Zimbabwe	657	256,729	12,260	948	20,000	1,547	38.7
Sub-Saharan Africa	816	19,808,919	3,884,061	5,427	5,453,293	7,619	

a. Highlighting indicates water-scarce country

Source: FAO, 2005a and current study.

Summary Table 3. Current Annual Water Withdrawals by Sector

		Agriculture		Municipalities		Industries		Total		
Country	Year	Volume (million m^3) (1)	Share of total (%) (2) = 100 x (1)/(7)	Volume (million m^3) (3)	Share of total (%) (4) = 100 x (3)/(7)	Volume (million m^3) (5)	Share of total (%) (6) =100 x (5)/)7)	Volume (million m^3) (7) = (1) + (3) + (5)	Share of IRWR (%) (8)	Share of TRWR (%) (9)
Angola	2000	211	62	76	22	56	16	343	0.2	0.2
Benin	2001	59	45	41	32	30	23	130	1.3	0.5
Botswana	2000	80	41	79	41	35	18	194	8.1	1.6
Burkina Faso	2000	690	86	104	13	6	1	800	6.4	6.4
Burundi	2000	222	77	49	17	17	6	288	2.9	1.9
Cameroon	2000	728	74	178	18	79	8	985	0.4	0.3
Cape Verde	2000	20	91	2	7	0	2	22	7.3	7.3
Central African Republic	2000	1	5	17	77	4	18	22	0.0	0.0
Chad	2000	190	83	40	17			230	1.5	0.5
Comoros	1999	5	47	5	48	1	5	10	0.8	0.8
Congo	2002	4	9	32	70	10	21	46	0.0	0.0
Cote d'Ivoire	2000	604	65	217	23	110	12	931	1.2	1.1
Democratic Republic of Congo	2000	112	31	186	52	58	16	356	0.0	0.0
Djibouti	2000	3	16	16	84			19	6.3	6.3

(continued)

Summary Table 3. *(continued)*

		Agriculture		*Municipalities*		*Industries*		*Total*		
Country	*Year*	*Volume (million m^3) (1)*	*Share of total (%) (2) = 100 x (1)/(7)*	*Volume (million m^3) (3)*	*Share of total (%) (4) = 100 x (3)/(7)*	*Volume (million m^3) (5)*	*Share of total (%) (6) =100 x (5)/)7)*	*Volume (million m^3) (7) = (1) + (3) + (5)*	*Share of IRWR (%) (8)*	*Share of TRWR (%) (9)*
Equatorial Guinea	2000	1	1	88	83	17	17	106	0.4	0.4
Eritrea	2004	550	95	31	5	1	0	582	20.8	9.2
Ethiopia	2002	5,204	94	333	6	21	0	5,558	4.6	4.6
Gabon	2000	52	41	62	48	14	11	128	0.1	0.1
Gambia	2000	21	67	7	22	4	11	32	1.1	0.4
Ghana	2000	652	66	235	24	95	10	982	3.2	1.8
Guinea	2000	1,365	90	117	8	35	35	1,517	0.7	0.7
Guinea-Bissau	2000	144	82	23	13	8	8	175	1.1	0.6
Kenya	2003	2,165	79	470	17	100	100	2,735	13.2	8.9
Lesotho	2000	1	2	21	48	22	22	44	0.8	1.4
Liberia	2000	60	56	30	29	16	16	107	0.1	0.0
Madagascar	2000	14,313	96	423	3	234	2	14,970	4.4	4.4
Malawi	2000	810	80	148	15	47	5	1,005	6.2	5.8
Mali	2000	5,900	90	590	9	56	1	6,546	10.9	6.5
Mauritania	2000	1,500	88	150	9	48	3	1,698	424.5	14.9
Mauritius	2003	491	67	214	30	20	3	725	26.4	26.4

Mozambique	2000	550	87	70	11	15	2	635	0.6	0.3
Namibia	2000	213	71	73	24	14	5	300	4.9	1.7
Niger	2000	2,080	95	94	4	12	1	2,186	62.5	6.5
Nigeria	2000	5,507	69	1,687	21	810	10	8,004	3.6	2.8
Rwanda	2000	102	68	36	24	12	8	150	1.6	1.6
Sao Tome and Principe	1993							7	0.3	0.3
Senegal	2002	2,065	93	98	4	58	3	2,221	8.6	5.7
Seychelles	2003	1	7	8	65	3	28	12		
Sierra Leone	2000	354	93	20	5	7	2	380	0.2	0.2
Somalia	2000	3,281	100	15	1	2	0	3,298	55.0	23.2
South Africa	2000	7,836	63	3,904	31	756	6	12,496	27.9	25.0
Sudan	2000	36,069	97	987	3	258	1	37,314	124.4	57.9
Swaziland	2000	1,006	97	24	2	12	1	1,042	39.5	23.1
Togo	2002	76	45	89	53	4	2	169	1.5	1.1
Uganda	2002	120	40	134	45	46	15	300	0.8	0.5
United Republic of Tanzania	2002	4,632	89	527	10	25	1	5,184	6.2	5.6
Zambia	2000	1,320	76	286	16	131	8	1,737	2.2	1.7
Zimbabwe	2002	3,318	79	589	14	298	7	4,205	34.3	21.0
Sub-Saharan Africa		104,687	87	12,624	10	3,607	3	120,925	3.1	2.2

Source: FAO, 2005a.

Summary Table 4. Area Under Irrigation

Country	*Year*	*Full/partial control of irrigation (ha) (1)*	*Spate irrigation (ha) (2)*	*Equipped lowlands (ha) (3)*	*Total irrigation (ha) (4)=(1)+(2)+(3)*	*Share of cultivated area (%) (5)*	*Part of equipped area actually irrigated (%) (6)*	*Annual rate of increase in equipped area (%) (7)*
Angola	1975	80,000			80,000	2.4	44	
Benin	2002	10,973		1,285	12,258	0.4	23	2.3
Botswana	2002	1,439			1,439	0.4		0.4
Burkina Faso	2001	18,600		6,400	25,000	0.6	100	0.3
Burundi	2000	6,960		14,470	21,430	1.6		2.7
Cameroon	2000	22,450	2,800	404	25,654	0.4		1.6
Cape Verde	1997	2,780			2,780	6.2	66	0.0
Central African Republic	1987	135			135	0.0	51	
Chad	2002	30,273			30,273	0.8	87	5.7
Comoros	1987	130			130	0.1	65	
Congo	1993	217		1,783	2,000	1.0	11	
Cote d'Ivoire	1994	47,750		25,000	72,750	1.1	92	
Democratic Republic of Congo	1995	10,000		500	10,500	0.1	70	
Djibouti	1999	1,012			1,012	100.0	38	4.1
Equatorial Guinea					0	0.0		

Eritrea	1993	4,100	17,490		21,590	4.3	62	
Ethiopia	2001	289,530			289,530	2.5		6.2
Gabon	1987	3,150		1,300	4,450	1.0		
Gambia	1999	2,149			2,149	1.0	65	3.2
Ghana	2000	30,900			30,900	0.5	90	30.1
Guinea	2002	20,386		74,528	94,914	6.2	100	0.3
Guinea-Bissau	1996	8,562		13,996	22,558	5.1	100	14.8
Kenya	2003	103,203			103,203	2.0	94	4.1
Lesotho	1999	2,637			2,637	0.8	3	
Liberia	1987	100		2,000	2,100	0.3		
Madagascar	2000	1,086,291			1,086,291	31.0	100	0.0
Malawi	2002	56,390			56,390	2.3	96	7.3
Mali	2000	97,499		138,292	235,791	5.0	75	20.1
Mauritania	1994	45,012			45,012	9.4	51	
Mauritius	2002	21,222			21,222	20.0	98	2.8
Mozambique	2001	118,120			118,120	2.8	34	1.3
Namibia	2002	7,573			7,573	0.9	100	2.1
Niger	2005	13,663		60,000	73,663	1.6	89	0.9
Nigeria	2004	238,117		55,000	293,117	0.9	75	1.8
Rwanda	2000	3,500		5,000	8,500	0.7		11.4
Sao Tome and Principe	1991	9,700			9,700	23.7		

(continued)

Summary Table 4. ***(continued)***

Country	*Year*	*Full/partial control of irrigation (ha) (1)*	*Spate irrigation (ha) (2)*	*Equipped lowlands (ha) (3)*	*Total irrigation (ha) (4)=(1)+(2)+(3)*	*Share of cultivated area (%) (5)*	*Part of equipped area actually irrigated (%) (6)*	*Annual rate of increase in equipped area (%) (7)*
Senegal	2002	102,180		17,500	119,680	4.8	58	6.7
Seychelles	2003	260			260	3.7	77	
Sierra Leone	1992	1,000		28,360	29,360	5.4		
Somalia	2003	50,000	150,000		200,000	18.7	33	0.0
South Africa	2000	1,498,000			1,498,000	9.5	100	2.8
Sudan	2000	1,730,970	132,030		1,863,000	11.2	43	-0.9
Swaziland	2000	49,843			49,843	26.2	90	
Togo	1996	2,300		5,000	7,300	0.3	86	0.7
Uganda	1998	5,580		3,570	9,150	0.1	64	0.0
United Republic of Tanzania	2002	184,330			184,330	3.6		2.3
Zambia	2002	55,387		100,525	155,912	2.9	100	12.9
Zimbabwe	1999	173,513			173,513	5.2	71	6.9
Sub-Saharan Africa		6,247,886	302,320	554,913	7,105,119	3.9		
Sub-Saharan Africa excluding the three largest irrigation countries		1,932,625	170,290	554,913	2,657,828	1.8		

Source: FAO, 2005a.

Summary Table 5. Water Managed Area

Country	*Year*	*Area equipped for irrigation (ha)*[a] *(1)*	*Non-equipped cultivated wetlands & valley bottoms (ha) (2)*	*Non-equipped flood recession cropping area (ha) (3)*	*Total water managed area (ha) (4)=(1)+(2)+(3)*	*Share of irrigation potential (%) (5)*	*Share of cultivated area (%) (6)*
Angola	1975	80,000	320,000		400,000	6	11.8
Benin	2002	12,258	6,988		19,246	6	0.7
Botswana	2002	1,439		6,500	7,939	61	2.1
Burkina Faso	2001	25,000	21,400		46,400	28	1.1
Burundi	2000	21,430	83,000		104,430	49	7.9
Cameroon	2000	25,654			25,654	9	0.4
Cape Verde	1997	2,780			2,780	89	6.2
Central African Republic	1987	135	500		635	0	0.0
Chad	2002	30,273		125,000	155,273	46	4.3
Comoros	1987	130			130	43	0.1
Congo	1993	2,000			2,000	1	1.0
Cote d'Ivoire	1994	72,750	16,250		89,000	19	1.4
Democratic Republic of Congo	1995	10,500	2,000	1,000	13,500	0	0.2
Djibouti	1999	1,012			1,012	42	100.0
Equatorial Guinea					0	0	0.0
Eritrea	1993	21,590			21,590	12	4.3

(continued)

Summary Table 5. *(continued)*

Country	*Year*	*Area equipped for irrigation (ha)*[a] *(1)*	*Non-equipped cultivated wetlands & valley bottoms (ha) (2)*	*Non-equipped flood recession cropping area (ha) (3)*	*Total water managed area (ha) (4)=(1)+(2)+(3)*	*Share of irrigation potential (%) (5)*	*Share of cultivated area (%) (6)*
Ethiopia	2001	289,530			289,530	11	2.5
Gabon	1987	4,450			4,450	1	1.0
Gambia	1999	2,149	13,170		15,319	19	6.8
Ghana	2000	30,900			30,900	2	0.5
Guinea	2002	94,914			94,914	18	6.2
Guinea-Bissau	1996	22,558	29,368		51,926	18	11.7
Kenya	2003	103,203	6,415		109,618	31	2.1
Lesotho	1999	2,637			2,637	21	0.8
Liberia	1987	2,100	18,000		20,100	3	3.3
Madagascar	2000	1,086,291		9,750	1,096,041	72	31.3
Malawi	2002	56,390	61,900		118,290	73	4.8
Mali	2000	235,791		60,000	295,791	52	6.3
Mauritania	1994	45,012	32,786	30,984	108,782	44	22.7
Mauritius	2002	21,222			21,222	64	20.0
Mozambique	2001	118,120			118,120	4	2.8
Namibia	2002	7,573		2,000	9,573	20	1.2
Niger	2000	73,663		12,000	85,663	32	1.9

Nigeria	2004	293,117		681,914	975,031	42	3.0
Rwanda	2000	8,500	94,000		102,500	62	8.9
Sao Tome and Principe	1991	9,700			9,700	91	23.7
Senegal	2002	119,680		30,000	149,680	37	6.0
Seychelles	2003	260			260	26	3.7
Sierra Leone	1992	29,360	126,000		155,360	19	28.8
Somalia	2003	200,000			200,000	83	18.7
South Africa	2000	1,498,000			1,498,000	100	9.5
Sudan	2000	1,863,000			1,863,000	67	11.2
Swaziland	2000	49,843			49,843	53	26.2
Togo	1996	7,300			7,300	4	0.3
Uganda	1998	9,150	49,780		58,930	65	0.8
United Republic of Tanzania	2002	184,330			184,330	9	3.6
Zambia	2002	155,912	100,000	10	255,922	49	4.8
Zimbabwe	1999	173,513	20,000		193,513	53	5.8
Sub-Saharan Africa		7,105,119	1,001,557	959,158	9,065,834	23	5.0
Sub-Saharan Africa excluding the three largest irrigation countries		2,657,828	1,001,557	949,408	4,608,793	14	3.1

a. From column 4, Summary Table 4.

Source: FAO, 2005a.

Summary Table 6. Projected Annual Water Withdrawals and Balance of Total Renewable Water Resources

		Irrigation demand at full development of potential[a]			*Projected 2030 urban and industrial demand*[b]			*Total urban and industrial irrigation demand*			*Balance of TRWR*	
Country[f]	*Potential irrigation area (ha) (1)*	*Volume (million m^3) (2)*	*Share of IRWR*[c] *(%) (3)*	*Share of TRWR*[d] *(%) (4)*	*Volume (million m^3) (5)*	*Share of IRWR*[c] *(%) (6)*	*Share of TRWR*[d] *(%) (7)*	*Volume (million m^3) (8) = (2)+(5)*	*Share of IRWR*[c] *(%) (9)*	*Share of TRWR*[d] *(%) (10)*	*Volume (million m^3) (11)*	*m^3/2030 inhabitant*[e] *(12)*
Angola	3,700,000	59,200	40.0	40.0	570	0.4	0.4	59,770	40.4	40.4	88,230	3,298
Benin	322,000	5,152	50.0	19.5	292	2.8	1.1	5,444	52.9	20.6	20,949	1,594
Botswana	13,000	208	8.7	1.7	493	20.5	4.0	701	29.2	5.7	11,539	3,383
Burkina Faso[d]	165,000	2,640	21.1	21.1	475	3.8	3.8	3,115	24.9	24.9	9,385	369
Burundi	215,000	3,440	34.2	22.2	285	2.8	1.8	3,725	37.0	24.1	11,759	875
Cameroon	290,000	4,640	1.7	1.6	1,111	0.4	0.4	5,751	2.1	2.0	279,749	9,034
Cape Verde	3,109	50	16.6	16.6	9	2.9	2.9	58	19.5	19.5	242	269
Central African Republic	1,900,000	30,400	21.6	21.1	91	0.1	0.1	30,491	21.6	21.1	113,909	15,323
Chad	335,000	5,360	35.7	12.5	173	1.2	0.4	5,533	36.9	12.9	37,467	2,227
Comoros	300	5	0.4	0.4	24	2.0	2.0	29	2.4	2.4	1,171	780
Congo	340,000	5,440	2.5	0.7	165	0.1	0.0	5,605	2.5	0.7	826,395	113,902
Cote d'Ivoire	475,000	7,600	9.9	9.4	1,413	1.8	1.7	9,013	11.7	11.1	72,127	2,246

Democratic Republic of Congo	7,000,000	112,000	12.4	8.7	1,055	0.1	0.1	113,055	12.6	8.8	1,169,945	11,314
Djibouti	2,400	38	12.8	12.8	69	23.1	23.1	108	35.9	35.9	192	142
Equatorial Guinea	30,000	480	1.8	1.8	454	1.7	1.7	934	3.6	3.6	25,066	26,017
Eritrea	187,500	3,000	107.1	47.6	114	4.1	1.8	3,114	111.2	49.4	3,186	390
Ethiopia	2,700,000	43,200	35.4	35.4	1,388	1.1	1.1	44,588	36.5	36.5	77,412	563
Gabon	440,000	7,040	4.3	4.3	328	0.2	0.2	7,368	4.5	4.5	156,632	61,010
Gambia	80,000	1,280	42.7	16.0	45	1.5	0.6	1,325	44.2	16.6	6,675	2,402
Ghana	1,900,000	30,400	100.3	57.1	1,426	4.7	2.7	31,826	105.0	59.8	21,374	526
Guinea	520,000	8,320	3.7	3.7	657	0.3	0.3	8,977	4.0	4.0	217,023	13,249
Guinea-Bissau	281,290	4,501	28.1	14.5	134	0.8	0.4	4,635	29.0	15.0	26,365	9,021
Kenya	353,060	5,649	27.3	18.4	2,128	10.3	6.9	7,777	37.6	25.3	22,923	372
Lesotho	12,500	200	3.8	6.6	186	3.6	6.1	386	7.4	12.8	2,636	771
Liberia	600,000	9,600	4.8	4.1	202	0.1	0.1	9,802	4.9	4.2	222,198	33,533
Madagascar	1,516,819	24,269	7.2	7.2	2,840	0.8	0.8	27,109	8.0	8.0	309,891	9,110
Malawi	161,900	2,590	16.0	15.1	843	5.2	4.9	3,433	21.3	20.0	13,775	588
Mali	566,000	9,056	15.1	9.1	2,792	4.7	2.8	11,848	19.7	11.8	88,152	3,460

(continued)

Summary Table 6. *(continued)*

		Irrigation demand at full development of potential[a]			*Projected 2030 urban and industrial demand*[b]			*Total urban and industrial irrigation demand*			*Balance of TRWR*	
Country[f]	*Potential irrigation area (ha) (1)*	*Volume (million m^3) (2)*	*Share of IRWR*[c] *(%) (3)*	*Share of TRWR*[d] *(%) (4)*	*Volume (million m^3) (5)*	*Share of IRWR*[c] *(%) (6)*	*Share of TRWR*[d] *(%) (7)*	*Volume (million m^3) (8) = (2)+(5)*	*Share of IRWR*[c] *(%) (9)*	*Share of TRWR*[d] *(%) (10)*	*Volume (million m^3) (11)*	*m^3/2030 inhabitant*[e] *(12)*
Mauritania	250,000	4,000	1,000.0	35.1	856	213.9	7.5	4,856	1213.9	42.6	6,544	1,156
Mauritius	33,000	528	19.2	19.2	874	31.8	31.8	1,402	50.9	50.9	1,349	576
Mozambique	3,072,000	49,152	49.0	22.6	367	0.4	0.2	49,519	49.4	22.8	167,581	4,597
Namibia	47,300	757	12.3	4.3	376	6.1	2.1	1,133	18.4	6.4	16,582	4,339
Niger	270,000	4,320	123.4	12.8	458	13.1	1.4	4,778	136.5	14.2	28,872	1,224
Nigeria	2,330,510	37,288	16.9	13.0	10,792	4.9	3.8	48,080	21.8	16.8	238,120	986
Rwanda	165,000	2,640	27.8	27.8	207	2.2	2.2	2,847	30.0	30.0	6,653	413
Sao Tome and Principe	10,700	171	7.9	7.9	0	0.0	0.0	171	7.9	7.9	2,009	6,407
Senegal	409,000	6,544	25.4	16.9	612	2.4	1.6	7,156	27.7	18.4	31,644	1,611
Seychelles	1,000	16			43			59			—	—
Sierra Leone	807,000	12,912	8.1	8.1	114	0.1	0.1	13,026	8.1	8.1	146,974	14,966
Somalia	240,000	3,840	64.0	27.0	73	1.2	0.5	3,913	65.2	27.6	10,287	525
South Africa	1,500,000	24,000	53.6	48.0	20,140	45.0	40.3	44,140	98.5	88.3	5,860	68
Sudan	2,784,000	44,544	148.5	69.1	5,381	17.9	8.3	49,925	166.4	77.4	14,575	223

Swaziland	93,220	1,492	56.5	33.1	156	5.9	3.4	1,647	62.4	36.5	2,863	1,391
Togo	180,000	2,880	25.0	19.6	365	3.2	2.5	3,245	28.2	22.1	11,455	1,202
Uganda	90,000	1,440	3.7	2.2	706	1.8	1.1	2,146	5.5	3.3	63,854	1,259
United Republic of Tanzania	2,132,221	34,116	40.6	36.7	2,164	2.6	2.3	36,279	43.2	39.0	56,721	792
Zambia	523,000	8,368	10.4	8.0	1,802	2.2	1.7	10,170	12.7	9.7	95,030	4,578
Zimbabwe	365,624	5,850	47.7	29.2	3,477	28.4	17.4	9,327	76.1	46.6	10,673	434
Sub-Saharan Africa	39,413,453	630,615	16.2	11.6	68,723	1.8	1.3	699,338	18.0	12.8	4,753,955	3,495

a. Assumes an average irrigation requirement of 16,000 m^3/ha.

b. Assumes 5 percent per year growth in demand from base year shown in Summary Table 4 to 2030.

c. IRWR = Internal Renewable Water Resources.

d. TRWR = Total Renewable Water Resources.

e. Assumes 2.5 percent growth in population between 2004 and 2030.

f. Highlighting indicates water-scarce country in 2030.

Source: FAO, 2005a and current study.

Annexes

ANNEX 1

Reports on the Component Studies Prepared under the Collaborative Program

No.	Title	Author(s)/Year	Lead Partner(s)
1.	Demand for products of irrigated agriculture in sub-Saharan Africa	FAO 2006 (Riddell, P.J., Westlake, M. and Burke, J.J.)	FAO
2.	Agricultural water development for poverty reduction in Eastern & Southern Africa	IFAD 2005	IFAD
3.	Assessment of potential food supply and demand using the Watersim model	IWMI 2005a (de Fraiture, C.)	IWMI
4.	Costs of Irrigation Projects: a comparison of sub-Saharan Africa and other developing regions and finding options to reduce costs.	IWMI 2005b (Inocencio, A., Kikuchi, M., Tonosaki, M., Maruyama, A. and Sally, H.)	IWMI/ World Bank
5.	Agricultural water development in sub-Saharan Africa: Planning and management to improve the benefits and reduce the environmental and health costs	IWMI 2005c (McCartney, M., Boelee, E., Cofie, O., Amerasinghe, F. and Mutero, C.)	IWMI/AfDB
6.	Improving irrigation project planning and implementation process: Diagnosis and recommendations	IWMI 2005d (Morardet, S., Merrey, D., Seshoka, J. and Sally, H.)	IWMI/AfDB
7.	Investment options for integrated water-livestock-crop production in sub-Saharan Africa.	IWMI-ILRI 2005e (Peden, D., Freeman, A., Astake, A. and Notenbaert, A.)	IWMI/ILRI/ AfDB
8.	Opportunities for private sector participation in agricultural water development and management	IWMI 2005f (Penning de Vries, F., Sally, H. and Inocencio, A.)	IWMI/AfDB
9.	Poverty considerations in agricultural water management.	IWMI 2005g (Van Koppen B. and Safilios-Rothschild, C.)	IWMI/AfDB

ANNEX 2

Millennium Development Goals and Targets

	Goals	*Targets*
1.	Eradicate extreme poverty and hunger	Halve the proportion of people whose income is less than $1 a day Halve the proportion of people who suffer from hunger
2.	Achieve universal primary education	Ensure that children everywhere, boys and girls alike, will be able to complete a full course of primary schooling
3.	Promote gender equality and empower women	Eliminate gender disparity in all levels of education
4.	Reduce child mortality	Reduce by two-thirds the under–five-year-old mortality rate
5.	Improve maternal health	Reduce by three-quarters the maternal mortality rate
6.	Combat HIV/AIDS, malaria and other diseases	Halt and reverse the spread of HIV/AIDS Halt and reverse the incidence of malaria and other major diseases
7.	Ensure environmental sustainability	Integrate the principles of sustainable development into country policies and reverse the loss of environmental resources Halve the proportion of people without sustainable access to safe drinking water and basic sanitation Achieve a significant improvement in the lives of at least 100 million slum dwellers
8.	Develop a global partnership for development	Develop further an open, rule-based, predictable, non-discriminatory trading and financial system Address the special needs of the least developed countries Address the special needs of landlocked countries and small island developing states Deal comprehensively with the debt problems of developing countries through national and international measures in order to make debt sustainable in the long term In cooperation with developing countries, develop and implement strategies for decent and productive work for youth In cooperation with pharmaceutical companies, provide access to affordable, essential drugs in developing countries In cooperation with the private sector, make available the benefits of new technologies, especially information and communications

ANNEX 3

Agro-Ecological Zones and the Major Farming Systems of Sub-Saharan Africa

(To be read in conjunction with Maps 2 and 3)

Agro-ecological zone[a]	*Length of growing period (days)*	*Major farming systems*	*Share of land area (%)*	*Share of agricultural population (%)*	*Principal livelihood*	*Prevalence of poverty*	*Potential for poverty reduction*
Arid and semi-arid	<120	Sparse agriculture (arid)	17	1	Irrigated maize, vegetables, date palm, cattle, off-farm work	Extensive	Low
		Pastoral	14	7	Cattle, camels, sheep, goats, remittances	Extensive	Low
		Agro-pastoral millet and sorghum	8	8	Sorghum, pearl millet, pulses, sesame, livestock, poultry, off-farm work	Extensive	Low
Sub-total			39	16			
Dry sub-humid	120–179	Maize, mixed	10	15	Maize, tobacco, cotton, cattle, goats, poultry, off-farm work	Moderate	High
Sub-total			10	15			
Moist sub-humid and humid	>180	Coastal artisanal fishing	2	3	Marine fish, coconuts, cashew, banana, yams, fruit, goats, poultry, off-farm work	Moderate	Low
		Cereal, root crops mixed	13	15	Maize, sorghum, millet, cassava, yams, legumes, cattle	Limited	Medium

	Root crops	11	11	Yams, cassava, legumes, off-farm work	Limited, moderate	Medium
	Highland temperate mixed	2	7	Wheat, barley, teff, peas, lentils, rape, potatoes, livestock, poultry, off-farm work	Moderate, extensive	Medium
	Highland perennial	1	8	Banana, plantain, enset, coffee, cassava, sweet potato, beans, cereals, livestock, poultry, off-farm income	Extensive	Low
	Rice, tree crops	1	2	Rice, banana, coffee, maize, cassava, legumes, livestock, off-farm work	Moderate	Low
	Forest-based	11	7	Cassava, maize, beans, cocoyams	Extensive	Low
	Tree crops	3	6	Cocoa, coffee, oil palm, rubber, yams, maize, off-farm work	Limited-moderate	Medium
Sub-total		44	59			
Total		93[b]	90[b]			

a. Some farming systems can occur in more than one zone, hence the arid and semi-arid zones, as well as the moist sub-humid and humid zones, have been merged.

b. Balance of land area and agricultural population accounted for by Urban-Based, Large Commercial, and Irrigated systems.

Source: Based on Dixon et al., 2001.

ANNEX 4

Agricultural Water Management Alternatives

Introduction

Interest in alternative forms of water management has grown as it has become increasingly clear that the potential for irrigation development is limited by physical and economic constraints and that, therefore, investment in irrigation alone may not be sufficient to fully meet the MDG1 objective of reducing poverty and hunger. In an attempt to respond to this growing interest, the component study on Agricultural Water Development for Poverty Reduction in Eastern and Southern Africa (IFAD 2005) included a sub-study on 'Alternative Agricultural Water Development'. The purpose of this sub-study was to review lower cost alternatives to irrigation, including "water harvesting and soil moisture conservation". This Annex briefly summarizes the findings of the sub-study.

Definitions

General

The sub-study found that definitions of the alternatives varied widely between countries and between authors. It also found that there was often confusion over the respective meanings of terms such as 'irrigation', 'supplemental irrigation', 'water harvesting', 'rainwater harvesting', 'soil moisture conservation' and the like. In particular, the limits between '*in situ* moisture conservation' and 'water harvesting' and between the latter and 'irrigation' appeared vague and ill-defined. The term 'water harvesting' was often used in the literature without any definition at all, opening the door to a variety of interpretations according to the respective background and interests of the author and/or reader; often what was called water harvesting by one specialist might be referred to as irrigation by another[1]. Difficulties with definitions may have been a reason for the perceived unreliability of water harvesting data submitted to FAO's AQUASTAT database and its consequent exclusion from the results published in FAO 2005a.

Some researchers had suggested that the distinction between water harvesting and irrigation was artificial and that agricultural water management should be regarded as a continuum, with irrigation at one end and *in situ* rainwater management at the other. However, it is not clear that such an approach would necessarily end the debate, bring any further clarity or assist in promoting (a) an understanding of the various technologies, (b) their costs and benefits or (c) increased investment in them. The sub-study concluded that it would be more appropriate to clarify the terminology, so that the potentials of each of the various types of water management could be evaluated in their own right.

Irrigation

The sub-study defined 'irrigation' as follows:

> Operations to supply additional water to agricultural land to augment rainfall for the purpose of crop growth. Irrigation water may be supplied from groundwater, surface water, agricultural drainage wastewater or other wastewater (including that from domestic or industrial use).

'Supplemental' Irrigation

'Supplemental' (or supplementary) irrigation warranted mention because this had been regarded as a new alternative form of water management. Again, however, there appeared to be some confusion over defini-

1. As an example of this, the sub-study team visited the Mara Region Farmers' Initiative Project in Tanzania expecting to see a successful case of water harvesting. Instead, what it found were a number of earth dams that had been constructed to provide water to irrigate small-scale (approximately 40–50 ha each) rice irrigation schemes. The catchment areas for these schemes were typically of the order of 10 km^2.

tions: most irrigation practitioners would consider all irrigation as supplementary—unless practiced in greenhouse conditions—since it supplements rainfall. Further perusal of recent literature revealed that what the proponents of 'supplemental' irrigation meant by the term was what irrigation practitioners would refer to as 'deficit' irrigation, in which the amount of irrigation water applied to a crop is less than that required for maximum plant growth, to optimize yield per unit of water rather than per unit of land (in other words, to optimize water productivity). Deficit irrigation is not a new concept: it is widely discussed in irrigation design literature and has been practiced for many years by large-scale commercial irrigation farmers—and, involuntarily, by many smallholder irrigators, particularly tail-enders on run-of-river irrigation schemes—around the world. Nor is it an alternative to irrigation: it is irrigation.

Although it is widely recognized that making less water go further—or achieving more crop per drop—is essential in water scarce situations, deficit irrigation almost always results in reductions in per hectare crop yields. These reductions are not necessarily proportionate to the possible savings in the cost of the infrastructure (e.g. for dams, diversion works, pumping stations, pumps, canals, and distribution and in-field systems) still required to provide the reduced volume of water required. Deficit irrigation is therefore not necessarily low-cost either. Benefit-cost analysis is required on a case-by-case basis to confirm that, with such yield reductions, the investment will be viable and profitable at the farm level.

Furthermore, the sub-study suggested that involuntary deficit irrigation may contribute to a reluctance by smallholders to use yield enhancing inputs. Benefit-cost analyses for deficit irrigation therefore need to take account of the possibility that low use of inputs might result not only in reductions of per hectare yields but also in reductions of yield per unit of water (which might defeat the intended purpose of this type of water management).

Water Harvesting (or Rainwater Harvesting)

The definition of 'water harvesting' provided by FAO 2005a was adopted, as follows:

> Water harvesting is the collection and concentration of runoff, with or without storage, for use in irrigating crops.

The reference to 'crops' was deliberate: although water harvesting could obviously be used for other purposes such as domestic and livestock water supplies, the subject of the sub-study (and of FAO 2005a as well as the Collaborative Program as a whole) was agricultural water development for crop production.

FAO 2005a distinguished between two types of water harvesting, i.e. roof water harvesting and runoff water harvesting. It described roof water harvesting as being:

> . . . mainly used for domestic purposes and sometimes as a water supply for family gardens

It also described two types of runoff water harvesting, as follows:

> Micro-catchment water harvesting is characterized by a relatively small catchment area C (<1,000 m^2) and cropping area CA (<100 m^2) with ratio C:CA = 1:1 to 10:1. The farmer usually has control over both the catchment area and the target area. These systems are used to irrigate single trees, fodder shrubs or annual crops. The construction is mainly manual. Examples are (planting) pits, semi-circular bunds, Negarim micro-catchments, eyebrow terraces[2] and contour bench terraces.
>
> Macro-catchment water harvesting collects water that flows over the ground as turbulent run-off and channel flow. These systems are characterised by a large catchment area C ('external catchment area of 1,000 m^2–200 ha), located outside the cultivated area CA, with a ratio C:CA = 10:1 to 100:1. The systems are mainly constructed for the production of annual crops. The construction is manual or mechanized. Examples are trapezoidal bunds, large semi-circular bunds and stone bunds.

From the definition of water harvesting provided by FAO 2005a, it would appear that the use of large, medium and small dams and weirs for irrigation could be considered as forms of water harvesting. However, from the descriptions above it seems that the term 'water harvesting' is generally used to refer to the collection of runoff from very small catchment areas—i.e. of less than 200 ha. It is also clear that the common feature of the three types of water harvesting is that each of them collects rainwater from a catchment, concentrates this water and uses it for irrigation of a target area. The target area may be very small—in some cases no more than a garden—but nevertheless the purpose of harvesting (or collecting and concentrating) water is irrigation.

2. Otherwise known as demi-lunes, or half-moons.

The sub-study therefore concluded that water harvesting was not an alternative to irrigation: it was simply a type of water development for micro-scale irrigation. Nor was it necessarily low-cost, since it offered no economy of scale.[3] 'Rainwater harvesting' was simply another term for water harvesting, since in all of the three types described above, the origin of the water harvested in each case would be rainfall.

In-Field Rainwater Management

The sub-study also introduced an additional term, adopted for the purpose of this study, in an attempt to bring some clarity to the topic. In-field rainwater management was defined as:

> . . . operations to enhance the effectiveness of rainfall for dryland crop growth.

What distinguishes in-field rainwater management from water harvesting is that instead of collecting and concentrating runoff for irrigation its purpose is to reduce runoff and evaporation losses by improving infiltration, storage in the soil profile and subsequent uptake by dryland crops. Examples of in-field rainwater harvesting include deep tillage, zero or reduced tillage and other forms of conservation farming practices.

Despite this attempt at clarification, some grey areas remain. For example, Botha *et al* cited in Beukes *et al* 2003, described a practice they referred to as 'in-field rainwater harvesting' which involves leaving a 2-m wide strip of land between rows of crops planted on either side of planting basins. In effect, therefore, for every 1-m wide strip of crops there is a 2 m wide strip of catchment. This technology could be regarded as micro-catchment water harvesting as defined by FAO above, since the catchment to cropped area (C:CA) ratio is greater than 1:1. However, at 2:1, the C:CA ratio is clearly at the bottom end of what FAO regards as water harvesting and although the 2 m wide strip is clearly used to collect run-off which is then concentrated in the planting basin, to all intents and purposes the crop remains a non-irrigated dryland crop (since if there is no rainfall it is not possible to augment soil moisture in the way that would be possible with water harvesting for irrigation). For the purpose of the sub-study (as well as the *Synthesis Report*) the system described by Botha *et al* was considered to be a type

3. For example, 'water harvesting' systems promoted by an NGO in South Africa, consist of a concrete blockwork tank that stores water collected from a small catchment for use in irrigating 100 m^2 of family garden. These cost $2,830 per household to install (M de Lange, personal communication), which translates to a unit cost of $283,000 per ha.

of in-field rainwater management, as are other similar planting basin type systems such as the *tassa* (see below).

Effective Rainfall

Effective rainfall is defined in FAO Irrigation and Drainage Paper 46[4] as follows:

> . . . that part of the rainfall which is effectively used by the crop after rainfall losses due to surface runoff and deep percolation are accounted for.

The effectiveness, or rather ineffectiveness, of rainfall is widely discussed in the literature on water harvesting, with various estimates given of the respective proportions of rainwater 'lost' to runoff, deep percolation and evaporation and that taken up for crop evapotranspiration. To attempt to put the scope for increasing rainfall effectiveness into perspective the sub-study compared rainfall and effective rainfall for a crop of maize in a single location in the dry sub-humid zone. For this purpose data for Dodoma in Tanzania were taken from the FAO CLIMWAT database and used in the FAO CROPWAT program. The planting date selected was 1 November, for harvesting on 16 March the following year. Total rainfall for the growing period was 502 mm (out of a total of 578 mm for the year) compared with effective rainfall (computed by the US Department of Agriculture method used as a default by CROPWAT) of 455 mm. The 'losses' were therefore 9.3 percent over the period of crop growth and 21.2 percent for the whole year. As suggested above, the purpose of in-field rainwater management is to reduce such losses and use the gains productively for crop growth.

Brief Overview of Alternative Agricultural Water Management Practices in Eastern and Southern Africa

Water Harvesting

The sub-study reviewed a number of water harvesting technologies in Eastern and Southern Africa. Of these, the most promising were *silanga*, or small manually excavated tanks, that had been widely adopted in Machakos, Kenya. These were used to trap and store runoff, which was then used to irrigate family gardens—averaging 0.5 hectares—by means

4. FAO. 1992. CROPWAT: A computer program for irrigation planning and management. Irrigation and Drainage Paper 46. Rome.

of treadle pumps. The capital cost of the *silanga* plus pump was $465 (2003 prices), or $930/ha. Those seen were used to grow vegetables for the local market, from which a net annual income of $165 could be earned. Taking account of labor for pump operation and other O&M costs, discounted at 8 percent over 10 years (the estimated life of the tank) the investment showed a benefit-cost ratio of 1.8, indicating that the ERR would have been considerably more than 8 percent. Since they can be constructed progressively by the farmer using own or hired labor, and since treadle pumps too are affordable by farmers in East Africa, the *silanga* are suitable for self-financing by farmers.

A similar, but more expensive, type of intervention was also being piloted in East Africa by the Regional Land Management Unit (RELMA)[5]. The RELMA sub-surface tanks were constructed with burnt bricks, lined with polythene sheeting. They cost approximately $1,000 to construct and could be used to irrigate up to 0.2 ha. Hence the unit cost was approximately $5,000 per ha, more than five times the cost of a *silanga*. Like the *silanga*, the RELMA tanks were intended for families to grow vegetables for the local market, from which a net annual income of $66 could be earned. At this level of benefits, assuming the investment costs were discounted at 8 percent over 15 years, investment in a RELMA tank would show a benefit-cost ratio of 0.5, indicating an ERR considerably lower than 8 percent. At $1,000 each, the RELMA tanks would be unlikely to be affordable or replicable by farmers.

In-Field Rainwater Management

The sub-study also reviewed a representative selection of in-field rainwater management techniques, including: *majaruba* basins in Tanzania; planting pits in Kenya and Tanzania; contour barriers in Kenya and Tanzania, deep tillage in Botswana and Zimbabwe, tied ridges and other forms of conservation agriculture in Zimbabwe, South Africa and Zambia. Field visits were conducted to *Negarim* micro-catchments in Kenya, *fanya juu/chini* contour bunds/infiltration trenches in Kenya and Zimbabwe, as well as low-gradient broad-crested contour ridges and furrows[6] in wetlands in Zimbabwe.

There was wide adoption of *majaruba* basins—an indigenous technology used to catch rainwater where it falls for 'rainfed' rice production—in

5. RELMA was funded by the Swedish International Development Agency.

6. A kind of mechanized up-scaling of traditional wetland cultivation practices, utilizing heavy earthmoving machinery.

Tanzania. It was concluded that the main reason for adoption of this technology was that it was not only affordable to farmers but also a profitable investment. Adoption of *fanya juu/chini* in Kenya had been widely documented, although while the technology is certainly effective in soil conservation no evidence was found that it actually increased the availability of water for cropping. There was no evidence of adoption of trapezoidal bunds, subsurface run-off storage tanks, *Negarim* micro-catchments, planting pits or broad-crested contour ridges and furrows. The study concluded that this was because these technologies were either unaffordable to farmers, or physically/financially infeasible[7] and therefore unprofitable investments.

Conservation farming, however, was found to have been widely and successfully adopted by large scale commercial farmers in Zambia and Zimbabwe. Yet adoption by smallholders appeared limited: the main constraints appeared to be the additional labor requirements (e.g. for weeding or for initial land preparation) or poor access to/unwillingness to invest in yield enhancing inputs, without which the yield increments necessary to justify the investment were not achieved. Nevertheless, there had been good adoption rates where market links had been established, for example for cotton production, when growers had been able to obtain in-kind credit for inputs[8].

Successful In-Field Rainwater Management in Niger

Successful promotion and adoption of improved traditional planting pits (*tassa*) and *demi-lunes* has been achieved in Niger, from where one of the few examples of financial analysis of alternative agricultural water management technologies is available (Hassane *et al*, 2000; Dixon *et al*, 2001). The most commonly adopted technology was the *tassa* (see Box), which cost approximately $100/ha to construct (assuming the use of hired labor) and have an economic life of three years, after which they must be re-dug (Hassane *et al*). The purpose of the *tassa* is to maximize use of seasonal rainfall by capturing it in a very small micro catchment, concentrating it in a planting pit, improving its infiltration and storing it in the soil profile for uptake by crops to balance out within-season dry spells[9].

7. For example, Negarim micro-catchments had been promoted for mango trees, but all the trees seen had aborted their fruit, presumably because it had not rained at the time they fruited and there was therefore no run-off to store and use.

8. For more details see the website of the African conservation tillage network at http://www.act.org.

9. Referring to the FAO typology above, since the ratio of catchment to cropped area of the *tassa* is very small—probably less than unity, it would probably fall within the category of in-field rainwater management.

Annex Box 4.1

Improving In-Field Rainwater Management in the Semi-Arid Areas of Niger

In common with many semiarid areas, Niger has suffered land degradation as a result of population pressure and drought. An IFAD-assisted project tested a number of locally-based technologies to bring land back into production, reduce inter-annual variability of output and enhance the resilience of farming systems to climatic risk. One key success was the development of a modified form of the *tassa* practice. This continued to expand spontaneously to new plots after the project had closed.

The *tassa* practice consists of digging holes some 200 to 300 mm in diameter and 150 to 200 mm deep and covering the hole bottoms with manure. This helps to promote termite activity during the dry season, thus improving water infiltration further. Farmers then plant millet or sorghum in them. Tassas have allowed the region to attain average millet yields of over 480kg/ha, in comparison with only 130ha/kg without tassas. As a result tassas have become an integral part of the local technology base. The technique is spreading at a surprising rate.

Three main factors contributed to success: (a) an action-research approach that combines flexibility, openness to farmer initiatives, a forward-looking attitude and willingness to negotiate; (b) a technology that yields quick and tangible benefits, yet is simple, easily replicable and fits well with existing farming systems; and (c) a technology that can adjust to the changing local context. The tassa is based on a local practice that, although not high-performing, is effective.

Tassas appeal to farmers because they yield quick and appreciable results, restoring productivity of land that was previously unfit for cultivation while mitigating agro-climatic risks and increasing food availability in participating households by 20 to 40 percent. They are easily replicable because they entail only minor adjustments to local hand tools and do not involve any additional work during the critical sowing and weeding periods. Because they can be constructed by individual farmers without external assistance, tassas are particularly interesting to youths, since they make it possible to cultivate plateau lands, which have become a valuable resource in the face of growing pressure on land.

Source: Mascaretti in Dixon et al., 2001.

The financial analysis prepared by Hassane *et al* (converted below into United States dollars for ease of interpretation) reveals the following:

- In a year of good rainfall[10], millet yields in the control plot (no conservation measures and no fertilizer) were low but still good enough to provide a return to labor of $1.55/labor-day, which is assumed to be greater than the local market rate for agricultural labor; in the same year, yields from plots with *tassa* plus manure were 3.3 times higher than those obtained from the control plot, while yields from plots with *tassa* plus manure and fertilizer were five times higher; however, the return to labor with *tassa* plus manure and fertilizer was only 8 percent higher than that for *tassa* plus manure only—indicating that, provided there was no shortage of land for more extensive production, investment in fertilizer would not be worthwhile.
- In a year of poor rainfall[11] millet yields achieved from the control plot amounted to only 11kg/ha, compared with 553kg/ha from *tassa* plus manure and 653kg/ha from *tassa* plus manure and fertilizer (a massive 50 times and 59 times increase respectively); yet the return to labor from the *tassa* was 35 percent higher without fertilizer than it was with fertilizer—indicating again that investment in fertilizer would not be worthwhile.

With such financial results, it was not surprising to learn that there had been such good adoption. However, a note of caution: according to Hassane *et al* (2000), it was initially necessary to incentivize farmers to dig the *tassa* by paying them food-for-work in the years of drought—reported to occur in three out of every four years—which again casts doubt over replicability in the absence of a donor. Furthermore, yields for the control plot plus manure/fertilizer (i.e. without the *tassa*) were apparently not monitored, so it was not possible to say how much of the incremental yield was due to improved soil moisture and how much was due to manure or fertilizer (the gains may have been entirely due to the latter).

If farmers were to meet the full cost of development, they would surely have needed to know the annualized cost of the investment, for comparison with the incremental benefits[12]. From the analysis below,

10. That referred to was 1994, when the project area received 600mm of rainfall.

11. The poor rainfall year referred to was 1996, when only 450mm was received.

12. The concept of farmers thinking along these lines may appear far-fetched. They may well not approach the problem by adopting conventional accounting, but they would certainly consider the investment in terms of its incremental costs and benefits, however estimated.

Annex Table 4.1 Financial Crop Budgets (1 ha) for Millet in Control Plot and with *Tassa*

	Good rainfall			*Poor rainfall*			*Average rainfall*		
Parameter	*Control plot*	*Tassa + manure*	*Tassa + manure + fertilizer*	*Control plot*	*Tassa + manure*	*Tassa + manure + fertilizer*	*Control plot*	*Tassa + manure*	*Tassa + manure + fertilizer*
Yield (kg/ha)	296	969	1,486	11	553	653	154	761	1,070
Producer price ($/kg)[a]	0.16	0.16	0.16	0.20	0.20	0.20	0.18	0.18	0.18
Gross value of production ($/ha)	46	152	233	2	108	128	27	134	189
Cash expenses ($/ha)[b]									
Transport of manure		10	10		10	10		10	10
Fertilizers			24			24			24
Total cash expenses excluding labor ($/ha)		10	33		10	33		10	33
Net value of production excluding labor ($/ha)	46	142	200	2	99	95	27	124	155
Labor (labor-days/ha)									
Tassa maintenance		10	10		10	10		10	10
Weeding, harvesting, etc	30	30	40	30	30	40	30	30	40
Fertilization		10	15		10	15		10	15
Total labor (labor-days/ha)	30	50	65	30	50	65	30	50	65
Return to labor ($/labor-day)	1.55	2.84	3.07	0.07	1.97	1.46	0.90	2.49	2.39
Total labor cost ($/ha @ $1.00/labor-day)	30	50	65	30	50	65	30	50	65
Net value of production including labor ($/ha)	16	92	135	(28)	49	30	(3)	74	90

a. Considers price increases in years of scarcity.

b. Ignoring cost of hand tools.

Source: Hassane et al., 2000.

Annex Box 4.2

No-Till Development Support Strategy: The Brazil Experience

Large-scale expansion in Brazil to the current more than 10 million hectares started in about 1980, after small and local initiatives during the 1960s. Large farmers used methods and equipment first from the Unites States and later from local manufacturers. Small farmers, with animal or small mechanical draught power, followed more than a decade later. During this period, small manufacturers together with innovative farmers designed smaller prototypes and started producing and marketing equipment adapted to small farms, including knife rollers to manage crop residues and combined direct seeders/fertilizer applicators.

The success of NT/CA in Brazil cannot be attributed to technical parameters alone. In conjunction with technical innovation, an effective participatory approach to adaptive research and technology transfer was adopted that tied farmers into a development strategy suited to their specific requirements. Institutional support was demand driven and concentrated on training and education that equipped participating farmers with the skills to adapt and refine NT/CA on their own farms. The cornerstones of the development support strategy were:

- close collaboration between researchers, extensionists, the private sector and farmers for the development, adoption and improvement of NT systems;
- onfarm trials and participatory technology development;
- strengthening farmers' organizations; creation of local "Friends of the Land Clubs" where farmers exchange information and experiences and improve their access to extension and other advisory services as well as input and output marketing;
- close cooperation with existing and new cooperatives concentrating primarily on marketing and training for vertical diversification into livestock and processing;

Annex Box 4.2 *(continued)*

- aggressive dissemination strategy of technical, economic and environmental information through the media, written documents, meetings and conferences—controlled and managed by producers' organizations (Friends of the Land Clubs) with emphasis on farmer-to-farmer exchange of experiences;
- the national NT farmers' organization FEBRAPDP played a significant role in advocating and supporting the promotion of NT/CA on large and small farms. As NT systems are complex to manage and require efficient farm management, training in record-keeping and a holistic understanding of farming systems' dynamics have been an integral aspect of support to small farmers;
- private-public partnerships; agro-input companies (Zeneca and Monsanto) supported demonstration projects in large and small farms through the provisions of inputs and extension services;
- targeted subsidies; short-term subsidies played a significant part in supporting small farmer adoption of NT practices. In Parana much of the hand-held or animal-drawn equipment was acquired with financial support from the state in the context of development programs (mainly World Bank). Subsidized or free equipment is still made available to groups of farmers. Apart from economic constraints to adoption, the rationale for public subsidies has been the generation of the offsite benefits from NT adoption. In some instances, private companies provided equipment for small farmers;
- integration of crops and livestock; special attention has been paid to the incorporation of crops and livestock (including poultry, hog and fish farming). A particular challenge is the development of rotational grazing patterns on cover crops, which do not jeopardize the sustainability of NT systems;
- incorporation of environmental considerations; correcting watershed degradation (e.g. soil erosion, pollution of streams and lakes and road damage) was a key reason for the adoption of NT farming practices. Environmental awareness raising among farmers also resulted in central facilities for the disposal of pesticide containers, household sanitation and recovery of gallery forests.

Source: FAO, 2003.

the incremental benefit from investment in *tassa* plus manure in a year of poor rainfall (as noted above, three out of every fours years will be 'poor' rainfall years) would be $77/ha[13]. The annualized cost of an investment of $100, assuming a discount (or interest) rate of 10 percent p.a. and a discount period of 3 years (i.e. the economic life of the *tassa*), would be $40/ha[14]. Hence, since the incremental benefit would far exceed the incremental cost, the investment would have been deemed sound[15].

Conclusions and Recommendations

It was concluded that the rationale for investment in water harvesting for irrigation and in-field rainwater management for dryland cropping was sound. In particular, in-field rainwater management for stabilizing and enhancing dryland crop yields has considerable potential—in terms of the area that could be covered and the beneficiaries reached—to reduce poverty and hunger. Although there is less scope for water harvesting (since its purpose is irrigation and since the potential for the latter is limited by physical and economic constraints), low cost options are available that could make a considerable difference to livelihoods for individual households. Governments should therefore ensure that support for these alternatives should be included in strategies for development of the subsector.

The question is what form should this support take? The answer probably lies in the nature of these alternatives. Water harvesting systems are relatively high cost but limited in the area they can irrigate. Governments (or even NGOs, as in South Africa) could subsidize the costs, but coverage would be limited by the available funds. But if appropriate low cost technologies (such as the *silanga* in Kenya) could be found, individual households could afford to invest in water harvesting systems themselves—provided profitable markets for produce were available. In the case of in-field rainwater management, the economic life of most systems is relatively short (e.g. three years for tassa) and investment of public funds in physical development would be impractical. Obviously, however, if farmers are to invest their own resources the

13. That is, $49 – (–$28).

14. Using the formula A = 100*{[r/[(1+(r/100))n–1)]]+r}, in which A is the annualized equivalent of the capital cost, r is the discount rate expressed as a percentage and n is the discount period or economic life.

15. In this case, the benefit/cost ratio would be $77/$40 = 1.9.

technologies would need to be demonstrably affordable and profitable. Yet the results of research in the region to date have been inconclusive. The sub-study found that research had failed to address barriers to adoption, including affordability, viability and sustainability and that attempts at dissemination had tended to be project, rather than farmer, driven, which had reduced prospects for replicability. It suggested that government funding for research, promotional campaigns and extension support should in future be geared to overcoming the barriers and facilitation of commercially oriented, farmer-financed adoption. The experience of Brazil in promoting conservation farming provides an example of the kind of activities that governments could support.

ANNEX 5

Agricultural Water Management, Food Security, and the MDGs

How Do the Economics of Irrigation Affect Food Self-Sufficiency and Food Security?

Irrigation is likely to remain a marginal contributor to staple food crop production in sub-Saharan Africa. As discussed above, food crop production in sub-Saharan Africa other than for rice—and in some places possibly wheat—would be unable to compete with imports. The case studies prepared in Tanzania and Zimbabwe for IFAD 2005 reinforced this conclusion—non-rice cereal crops were not economic under irrigation (see Box) although, as noted by FAO 2006, they may be viable in a cropping pattern that is sustained by alternative crops of sufficiently high value (tobacco and maize farming in Zimbabwe are an example).

Irrigation targeted at food self-sufficiency goals has failed. Past irrigation development strategies in several sub-Saharan Africa countries were based on food self-sufficiency objectives rather than on economic viability (see the example of Nigeria discussed in Chapter 3.1). These policies have now largely been changed because of the fundamental realities: (a) irrigated non-rice cereal production cannot generally compete with imports, given the low and declining world prices; (b) protectionist policies are too expensive for sub-Saharan Africa countries, as they bid up

Annex Box 5.1

Irrigated Maize Production at Dombolidenje in Zimbabwe is Not Economically Viable

Irrigators at Dombolidenje Dam and Irrigation Scheme in Zimbabwe were double cropping maize at an intensity of 200 percent and obtaining average yields of 3.3t/ha, or 6.6t/ha per year. The farm-gate price of maize was equivalent to approximately $133/t, reflecting the world market price of approximately $100/t (f.o.b. US Gulf ports). At this intensity and average yield, farmers realized a net farm income of USD530/ha/year after deducting labor costs.

The per hectare investment cost at Dombolidenje was $82,000, including the cost of a dam, equivalent to an annualized cost of $9,034 per hectare if discounted at 10 percent over 25 years. Hence annualized capital costs exceeded annual incremental benefits by a factor of 17, which is clearly unviable. The maximum investment cost that could have been supported at Dombolidenje, at current levels of productivity, assuming it was discounted at 10 percent over 25 years, was $4,900 per hectare (no pumping costs were involved).

Had it been possible to grow a winter crop of wheat at Dombolidenje, financial viability would be slightly improved. However, the message is clear: at current levels of productivity and capital costs similar to those at Dombolidenje, irrigated cereals are marginal in terms of viability. Either higher value crops must be grown in rotation, irrigated cereal yields must be substantially increased or the investment costs must be substantially reduced (rice schemes developed under PIDP in Tanzania cost an average of only USD1,070/ha in 2003 prices).

This economic logic is confirmed by farmer behavior. Except for large scale schemes in South Africa, private farmers do not invest in irrigation for non-rice cereals production.

Source: IFAD, 2007.

the price of food for the consumer and effectively amount to a transfer of scarce national resources to cereals producers; (c) under free market conditions, irrigated non-rice cereals are unprofitable for farmers to produce, and they will produce them only inefficiently, if at all; and (d) lack of financial viability for irrigation schemes that produce non-rice cereals means that the state has to subsidize and manage the schemes, tasks for which governments in sub-Saharan Africa have proven notoriously inadequate.

Food security is better attained through increased incomes from growing irrigated cash crops. There is no track record of success in sub-Saharan Africa in promoting irrigated non-rice cereals production under free market conditions, and therefore it would be illusory to target irrigation development plans at food self sufficiency. Scarce national resources had better be directed at increasing farmers' incomes and wealth through profitable production for which irrigated agriculture has a comparative advantage. The aim of irrigation is not to close the gap in non-tradable staple food production but to spread the economic and financial benefits of irrigated agriculture to a larger number of the rural poor.

Irrigation development—even if the full physical potential were to be developed—would directly benefit only a small proportion of rural households. It is estimated that if the full physical potential for irrigation were to be developed this would directly benefit (as irrigators) only 15–25 percent of the rural population[16]. The remaining 75 to 85 percent would marginally benefit from increased agriculture wage labor demand generated by irrigation development, but the core of their livelihoods will remain highly risky rainfed agriculture.

What Role Then Can Agricultural Water Management for Dryland Crops Play in the Achievement of the MDGs?

It is more economic to grow non-rice staple food crops under dryland conditions but the inherent production risks need to be reduced to encourage smallholders to intensify their production. It is therefore important to develop programs in parallel to those for irrigation to improve the productivity of dryland farming, including improvements to in-field water management to stabilize and improve yields, as well as through the same accompanying investments in rural infrastructure and marketing institutions that are vital to the growth of irrigated agriculture. Agricultural water management for dryland crops may not offer the same levels of opportunity for increased household incomes as investment in irrigation, but it could have a major impact on the MDG1 target for the reduction of hunger and potentially benefit far greater numbers of households.

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16. Based on the ratio of total irrigation potential (39.4 million hectares) to total cultivated land (182.6 million hectares).

To summarize:

- Irrigated agriculture can add only part of the growth needed to meet MDG1—although the opportunities that exist should be exploited
- Accompanying investment programs to boost the productivity of rainfed agriculture will be essential
- Investments in transport and markets are a vital complement to market-driven agriculture and would be a powerful stimulus to investment and productivity of irrigated agriculture

The **main challenge** is then to look for productivity breakthroughs that could change the economics of irrigation and for viable alternative water management technologies to improve rainfed production in sub-Saharan Africa.

ANNEX 6

'Successful' Irrigation Projects in Sub-Saharan Africa (ERR of 10 Percent or More)

Country	*Project*	*Start year*	*ERR at completion*	*Comments*
Niger	Pilot Private Irrigation project	1996	67	WB
Madagascar	Emergency Irrigation Infrastructure Repairs Project	1985	61	AfDB
Nigeria	National Fadama Development Project	1994	40	WB
Niger	Irrigation Rehabilitation Project	1987	37	WB
Mali	Office du Niger Consolidation Project	1989	30	WB
Ethiopia	Small Scale Irrigation and Soil Conservation Project	1987	25	WB/IFAD
Madagascar	Lac Alaotra Rice Intensification Project	1984	25	WB
Chad	Region du Lac Development Rehabilitation Programme	1989	23	AfDB
Tanzania	Smallholder Development Programme for the Marginal Areas	1997	22	IFAD

(continued)

Country	Project	Start year	ERR at completion	Comments
Madagascar	Projet Sucrier d'Analaiva	1983	21	AfDB. Negative ERR at PPAR stage
Madagascar	Upper Mandrare Development Project (Phase 1)	2001	20	IFAD
Sudan	Rahad Irrigation Project	1974	20	WB
Cameroon	Second SEMRY Rice Project	1978	20	WB
Sudan	Gezira Rehabilitation Project	1985	19	WB
Madagascar	Irrigation Rehabilitation Project	1986	18	WB
Madagascar	Tsiribina Irrigated Agricultural Development project	1988	18	AfDB
Mali	Mopti Rice Project	1973	17	WB
Mali	Mopti Rice Project II	1979	16	WB
Ethiopia	Amibara Irrigation Project	1987	15	AfDB
Ethiopia	Revised Amibara Irrigation Project	1978	15	WB
Sudan	New Halfa Irrigation Rehabilitation Project	1982	12	WB
Madagascar	Second Irrigation Rehabilitation Project	1994	12	WB
Tanzania	Mara Region Farmers Initiative Project	1996	12	IFAD
Tanzania	Kapunga Rice Project	1989	11	AfDB
Zambia	Smallholder Irrigation and Water Use Programme	1996	10	IFAD
Sudan	White Nile Pump Scheme Rehabilitation Project	1982	10	WB

Source: IWMI, 2005b; IFAD, 2007.

ANNEX 7

Comparison of Selected Projects at Completion and Subsequent History

Project and approval year	*ERR at ICR stage (%)*	*Subsequent history*
Sudan Gezira Rehabilitation Project (WB, 1974)	20	"Owing to the Gezira's immense sunk costs, the estimated ERR is plausible. However, sustainability is uncertain, owing to unimplemented works, weed growth, and the decrepitude of the Sennar Dam. Cost recovery is far below operation and maintenance costs. Institutional development was negligible" (OED comment on the ICR).
Mali Mopti Rice Project P001696 (WB, 1976)	17	"The low performance of the rice polders questions the future sustainability of this improved flood control cultivation system, particularly when managed by a public agency. After closing of the Credit, only 3 out of 18 polders have been transferred to producer organizations. However, local farmers have a strong interest . . . and AfDB is financing rehabilitation of the rice polders . . ." (OED on the ICR)
Cameroon Second SEMRY Rice Project (WB, 1978)	20	Current report: "Performance is not good at the moment—a sort of pre-reform Office du Niger: parastatal management, no farmer involvement, low productivity, no cost recovery."
Madagascar Analaiva Sugar Project (AfDB, 1983)	21	ERR recalculated as negative in the PPAR
Madagascar Lac Alaotra (WB, 1984)	25	Benefits were not being sustained. "The hasty, unilateral and untimely dismantling of the irrigation agency was disastrous for the project. Operation and maintenance was not taken up by other agencies, public or private. Water distribution has become chaotic, water charges are no longer collected, and farmer organizations have not survived the withdrawal of support from project agencies." (PPAR, 1993)
Ethiopia Small Scale Irrigation and Soil Conservation Project (WB/IFAD, 1987)	25	"Project outcome is satisfactory, sustainability likely and institutional development impact substantial. The main lesson is that farmers will voluntarily form WUAs if they are demand driven and provide clear benefits." (OED comment on the ICR).

Ethiopia Amibara Irrigation Project (AfDB, 1987) and Revised Amibara Project (WB, 1987)	15 (AfDB) 15 (WB)	"The Project looked successful in the first cropping year, when it exceeded the cotton production target envisaged in the SAR. However, delays in drainage construction (due to lack of financing of drainage by the Bank), insufficient inputs, lack of labor led to significant decreases in cotton yields in subsequent years. . . . At appraisal it was assumed that cotton would largely be exported; however, production was consumed domestically to meet increased national demand. . . . Insufficient attention has been given to the silt load carried by the Awash River. This has led to expensive reconstruction required for the irrigation intake structures and to higher operation and maintenance costs for the scheme. . . . The overall Economic Rate of Return (ERR) is 9 percent against an appraisal estimate of 13 percent". (PPAR, 1991).
Mali Office du Niger (WB, 1989)	30	"The government was able to push through difficult institutional reforms . . . participation was strengthened through farmer membership on management committees and overseeing performance contracts . . . no capital cost recovery . . . recovery of O+M costs declined by 14% . . . but was offset by ON's reduction of costs . . . fess declined from 18% to 6% of rice value . . . Sustainability likely." (OED comment on ICR)
Lesotho Phuthiatswana IRDP (AfDB, year??)	9	ERR recalculated as 7% in the PPAR
Niger Pilot Private Irrigation (WB, 1995)	66–68	Surveys conducted by a Monitoring and Evaluation Unit showed manual technologies had increased the areas cultivated by 63% and yields for onion and sweet pepper by 30%. In total it was estimated that 1,100 ha were additionally put in use by both technologies (manual 500 ha, mechanized 600 ha.) Financial analyses of pumpset purchase indicate high financial rates of return to adopters. The technologies are simple, low-cost. Most can be manufactured by local artisans, trained by the project.

ANNEX 8

Agricultural Water Development and Poverty Reduction

Poverty Reduction is About Increasing Household Incomes

Participatory poverty assessments have found that poor people define their poverty in terms of material deprivation (i.e. not enough money, employment, food, clothing, housing and inadequate access to health services and clean water), and non-material factors such as security and peace, as well as power over decisions affecting their lives (Robb 1999, cited in IFAD 2001). These components of poverty are usually divided into income poverty and non-income poverty. Reducing income poverty enables households to achieve food security, accumulate assets, reduce vulnerability to external shocks and provide for the future. It often also improves access to education, health services and clean water.

Thus, although poverty is a multi-faceted condition, the Millennium Declaration considers poverty in terms of household income—with a *per capita* income threshold for extreme poverty of $1 a day—rather than the other aspects of material deprivation or lack of access to services. Nevertheless, few project designs express the anticipated benefits of a project in terms of incremental *per capita* income—and the latter is seldom monitored or quantitatively assessed in *ex post* evaluations.

However, on the basis of field investigations for case studies carried out for the component study on Agricultural Water Development in Eastern and Southern Africa (IFAD 2005) incremental household incomes were estimated for three rice projects and three non-rice projects (Annex Tables 8.1 and 8.2).

Average increases in *per capita* farm incomes 'with project' on the rice projects in Madagascar and Tanzania were estimated to be in the range of 86–220 percent whilst those on non-rice projects were 14–600 percent. The average increase across the sets of case studies was 226 percent.

Although such increments may represent impressive gains, perusal of actual 'without' and 'with project' incomes provides an indication of how much still needs to be done to achieve the MDG1 target of $1 a day—particularly for the poorer segments of society. The box below presents a checklist for improving the pro-poor impact of irrigation projects.

Annex Box 8.1

Checklist for Improving the Pro-Poor Impact of Irrigation Projects

Pro-Poor Policies

- Does the project change land tenure and / or water rights, and if so does it do so in a pro-poor way?
- Do expected increases in yields/marketable surplus/incomes accrue fairly to poor farmers?
- Does the project try to minimize displacement and resettlement of poor communities, by going for smaller infrastructure?
- Are domestic water supply and sanitation in rural areas included as a specific objective of the irrigation project?
- Are other possible income-generating uses of irrigation water (i.e. aquaculture, livestock) enhanced by the project?
- Are complementary services (e.g. credit, education, extension) included in the project and do they particularly target the poor?

Pro-Poor Technologies

- Is the entry price affordable? Do investment and operation costs of the technologies allow access to poor people?

(continued)

Annex Box 8.1 *(continued)*

- Have all available technologies for small holders been considered in the selection process?
- Are there arrangements for pro-poor research and technology transfer?
- Is drainage needed, especially in poorer areas subject to water logging and salinity?

Pro-Poor Water Management

- Is the voice of poor men and women adequately heard in participatory water resources allocation decisions—in selection of the project area), project design, development and operation?
- Are there in place mechanisms to facilitate the creation of groups of poor farmers, which can strengthen their cooperative negotiation power and make their access to water rights and other complementary services (i.e. micro-finance) easier?
- Is adequate technical and administrative support provided to WUAs, and especially to poor men and women?
- Do cost-recovery arrangements (i.e. water pricing) and incentive policies adequately protect the poor (i.e. through block tariffs to protect base water consumption)?
- Are distributional issues, e.g. head-ender/tail-ender problems dealt with in an equitable way?

Direct and Indirect Impacts on the Poor

- Does the project generate extensive additional employment both during construction and during subsequent operations?
- Are environmental impacts that may affect the sustainability of the livelihoods of the poor adequately assessed and dealt with?
- Is water quality management adequately considered (i.e. by safe disposal of drainage water), especially when water is used for drinking purposes?
- Are health impacts (i.e. malaria and bilharzia) considered and mitigated to the extent possible by the project?

Source: World Bank, 2005b.

Annex Table 8.1 Whole Farm Net Income for Selected Rice Projects in Madagascar and Tanzania (mid-2003 US$)

	Upper Mandrare Basin Dev't Project (Madagascar)		*Mara Region Farmers' Initiative Project (Tanzania)*		*Participatory Irrigation Development Programme (Tanzania)*	
Parameter	*Without*	*With*	*Without*	*With*	*Without*	*With*
Area of irrigated farm (ha/household)	0.71	1.42		0.48	0.18	0.60
Area of rainfed farm (ha/household)	1.71	1.00	3.16	3.04	2.70	2.28
Cropping intensity on rainfed farm (%)	50	50	29	29	70	70
Typical household size (members)	5.5	5.5	5.5	5.5	5.5	5.5
Net income from irrigation[a]						
$/ha/year	131	424		576	68	389
$/household/year	93	602		276	12	234
$/household member/day	0.05	0.30		0.14	0.01	0.12
Incremental income from irrigation						
$/ha/year		293		576		321
$/household/year		509		276		221
$/household member/day		0.25		0.14		0.11
Net income from rainfed farm						
$/ha/year	96	96	39	39	77	77
$/household/year	164	96	124	119	208	175
$/household member/day	0.08	0.05	0.06	0.06	0.10	0.09
Net whole farm income						
$/household/year	257	699	124	395	220	409
$/household member/day	0.13	0.35	0.06	0.20	0.11	0.20
Incremental net whole farm income						
$/household/year		441		272		189
$/household member/day		0.22		0.14		0.09
%		172		220		86

a. After deduction of incremental O&M and benefits foregone with project.

Source: IFAD 2007.

Annex Table 8.2 Whole Farm Net Income for Non-Rice Projects in Zimbabwe (mid-2003 US$)

	Dombolidenje		*Maunganidze*		*Mupangwa/ Mutaradzi*	
Parameter	*Without*	*With*	*Without*	*With*	*Without*	*With*
Area of irrigated farm (ha/household)		0.10		0.80		0.68
Area of rainfed farm (ha/household)	3.49	3.39	3.50	2.70	1.18	0.50
Cropping intensity on rainfed farm (%)	43	43	56	56	100	100
Typical household size (members)	5.5	5.5	5.0	5.0	5.5	5.5
Net income from irrigation[a]						
$/ha/year		149		364		609
$/household/year		15		291		411
$/household member/day		0.01		0.16		0.20
Net income from rainfed farm						
$/ha/year	25	25	29	29	50	
$/household/year	86	83	101	78	59	
$/household member/day	0.04	0.04	0.06	0.04	0.03	
Net whole farm income						
$/household/year	86	98	101	369	59	411
$/household member/day	0.04	0.05	0.06	0.20	0.03	0.20
Incremental net whole farm income						
$/household/year		12		268		353
$/household member/day		0.01		0.15		0.18
%		14		265		600

a. After deduction of incremental O&M and benefits foregone with project.

Source: IFAD 2007.

ANNEX 9

NEPAD-CAADP and the NMTIPs

The development of irrigation strategies has been given new impetus by the NEPAD CAADP (see Box). With FAO support, NEPAD is currently working with countries in the region to prepare "national medium term investment plans" (NMTIPs) and a portfolio of "bankable investment project proposals" (BIPPs), and these are also being fitted within larger basin planning frameworks such as that being conducted under the Zambezi process (which involves 8 countries). Forty five countries have completed NMTIPs, and 26 countries have prepared a total of 115 BIPPs.[17] The process is expected to be substantially complete by the end of 2005. The table below gives a sample of projects for the Zambezi basin.

NEPAD, through regional organizations such as COMESA and SADC, is also proposing to set up a regional support capability for irrigation development and modernization and a regional irrigation information system, beginning with an inventory. If this process works as intended, it should bring four advantages: (i) a strategic focus to irrigation in all sub-Saharan Africa countries; (ii) the prospect of increased investment flows to individual countries; (iii) a basin wide perspective to investment and water resource management, with a possible increase in regional projects; and (iv) knowledge sharing on a sub-regional and regional basis.

17. Information from FAO October 12, 2005. The NMTIPs and the BIPPs are available on the FAO website: http://www.fao.org/tc/Tca/nepad/caadp_en.asp.

Annex Box 9.1

The NEPAD Initiative and the CAADP

The New Partnership for Africa's Development (NEPAD) was launched in October 2001 by the African Union as an Africa-led initiative for self-sustaining economic development. Agriculture was the only economic sector included in the first NEPAD Action Programme. In June 2002, a Comprehensive Africa Agriculture Development Programme (CAADP) was approved by the AU as a framework for the restoration of agriculture growth, food security, and rural development in Africa.

CAADP is an integrated framework of development priorities that focuses on investments in five mutually reinforcing pillars, the first of which is "Expansion of the area under sustainable land management and reliable water control systems". As a first step toward implementation of CAADP, the NEPAD Secretariat has formulated action Programmes and initiatives for each of the CAADP pillars. The Programme to improve management of water resources and expand access to irrigation (small and large scale) would include four activities:

- Investment in better management of river basin water resources
- Investment in strategic public infrastructure for water control, creating the opportunity for private sector investment in irrigation
- Investment in small scale water management including rainwater harvesting and drip irrigation
- Establish partnerships with farmer organizations and local administrations to manage access to and use of farm land.

Annex Table 9.1 NEPAD-CAADP Project Priorities for Irrigation Development in the Zambezi Basin

Country	*NMTIP priority water project or program*	*BIPP available*	*Estimated cost (million US$)*
Angola	Irrigation Rehabilitation and Sustainable Water Resource Management		?
Namibia	Harnessing Water Resources for Irrigation and Livestock		?
Malawi	Inputs Development Project (includes irrigation)		?
Mozambique	Small Scale Irrigation Project II		22.4
Mozambique	Small Dam Rehabilitation & Construction		30
Tanzania	District Irrigation Schemes		?
Zambia	Nega Nega Irrigation Scheme		11.2
Zimbabwe	Smallholder Irrigation Development		67.0
Zimbabwe	Rehabilitation of Smallholder Irrigation Schemes		90.7

Source: AfDB/FAO, 2005; World Bank, 2005c.

Annex Table 9.2 A Sample of NMTIPs Prepared under NEPAD CAADP

Country	*Water harvesting infrastructure*	*Specific objectives*
Ethiopia	A target of 360,000 rainwater harvesting structures has been set.	Rainwater harvesting is a top priority and involves capturing and storing rainwater and surface runoff in underground tanks and ponds at household level for domestic and irrigation use. Further technical studies are required for investigation of technical, financial and economic feasibility, as well as maintenance requirements, simple diversion technology, sedimentation control, and low–cost ways of lifting water from storage tanks.
Kenya	127 new sites for development of surface and sub–service water dams, pans and irrigation have been identified. In addition to the government proposed sites, communities in the project area will be expected to come up with their own projects of which some are likely to include mini hydro–power stations.	Promote water harvesting, storage and distribution for domestic use and for agricultural production through construction of small dams along the main river tributaries, development of water pans, roof catchments, and sand dams. The proposed construction of dams along the river tributaries will in addition to storing water for domestic and agricultural production, further be used to generate power locally where technically feasible. The dams will also help to regulate river regimes in order to eliminate the frequent damage to crops and property caused by flooding.

Mozambique	A Programme for rehabilitation/construction of 50 small dams has been developed.	Mozambique is poorly equipped in terms of essential hydraulic infrastructures (dams) for water storage, especially when compared with the neighbouring countries such as South Africa and Zimbabwe. Before 1975 there were about 600 small dams in the country. At present there are less than 50 small dams. Most of the dams have been destroyed due to various reasons including lack of clear policy for their maintenance, hydrological extreme events such as floods, and the 16 years of civil war. The climatic variability explains the high vulnerability of Mozambique to extreme events such as, floods, cyclones and droughts. A Programme for rehabilitation/construction of 50 small dams was therefore developed in order to ensure water storage capacity to address the issue of water requirement for rural water supply (domestic), irrigation, livestock and hydropower.
Sudan	One project within the Programme addresses the retention of concentrated flood flow for increased water supply, covering an irrigable area of some 9,800 ha. Another project would support surface runoff rainwater harvesting activities. This comprises microcatchment (MIC) techniques such as semi–circular and V–shape earth bunds (for the rain–fed area in–situ moisture conservation) on flat to gentle slopes land, and macrocatchment (MAC) techniques such as contour embankments and contour ridges (for collection of rainfall overland/rill flow and interception and control of drainage water flow) in mild slope areas.	The Programme includes a water harvesting component to promote the use of simple, sustainable, community–driven, least costly targeted interventions, benefiting as large numbers of beneficiaries as possible, utilizing potential natural resources. Available water resources in the area, liable to water harvesting harnessing, comprise rainfall/overland water flow, seasonal watercourses flow and water bodies (lakes and ponds).

ANNEX 10

Water Storage Challenges and the World Commission on Dams

In 1997, the World Bank and World Conservation Union (IUCN) sponsored a meeting between the champions and critics of large dams to discuss the implications of the Bank's OED review of 50 Bank-funded large dams. The meeting found sufficient common ground to set in motion a consultative process that led to the formation of the World Commission on Dams. The Commission, which met in Johannesburg in 2000, was established by representatives of governments, the private sector, international financing institutions, civil society organizations and people affected by dams. The members of the Commission were chosen to reflect regional diversity, expertise and stakeholder perspectives. Each member served in an individual capacity with none representing an institution or country. The Commission's objectives were to:

- review the development effectiveness of large dams and assess alternatives for water resources and energy development; and
- develop internationally acceptable criteria, guidelines and standards where appropriate for planning, design, appraisal, construction, operation, monitoring and decommissioning of dams.

The Commission reached the conclusion that there can no longer be any justifiable doubts that:

- dams have made an important and significant contribution to human development, and the benefits derived from them have been considerable; but
- in too many cases an unacceptable and often unnecessary price has been paid to secure those benefits, especially in social and environmental terms, by people displaced, by communities downstream, by taxpayers and by the natural environment;
- lack of equity in the distribution of benefits has called into question the value of many dams in meeting water and energy development needs when compared with the alternatives;
- by bringing to the table all those whose rights are involved and who bear the risks associated with different options for water and energy resources development, the conditions for a positive resolution of competing interests and conflicts are created; and
- negotiating outcomes will greatly improve the development effectiveness of water and energy projects by eliminating unfavorable projects at an early stage and offering as a choice only those options that key stakeholders agree represent the best ones to meet the needs in question.

Recognizing the contribution to development that they have made in the past and could make in the future, the Commission proposed guidelines for viable and sustainable new investment in dams. The guidelines spell out a fully participatory consultation process supported by economic, environmental, and social analysis using tools developed in recent years. The essence of these is to demonstrate that: (a) a dam is the best investment for achieving policy objectives, especially those of poverty reduction and environmental sustainability; (b) a dam is demonstrably better for society than any alternative investment—or no investment at all; and (c) harms can be minimized and mitigated. However, the extra cost of conducting so rigorous a process has to be factored into the cost-benefit analysis.

ANNEX 11

Current Agricultural Water Research in Sub-Saharan Africa

The International Research 'Challenge Programme on Water for Food'

The Challenge Programme on Water For Food, is an international, multi-institutional research Programme coordinated by IWMI, with a strong emphasis on north-south and south-south partnerships. The Programme aims to solve specific problems of water, food, environment and poverty alleviation through five interrelated thematic areas of research: (a) crop water productivity improvement; (b) water and people in catchments; (c) aquatic ecosystems and fisheries; (d) integrated water management systems; and (e) global and national food and water systems). The Programme takes a basin approach, on the view that the river basin is where the water problems and issues converge, especially in the developing world. *Benchmark basins in sub-Saharan Africa are the Limpopo, the Volta and the Nile.*

Programme activities seek answers to the question "how to produce more food and sustain rural livelihoods with less water in a manner that is socially acceptable and environmentally sustainable". Answers are sought from two quarters: the first explores the "food" related part of the challenge, examining issues of agricultural production, biology,

Annex Table 11.1 Research Programs and Projects of CGIAR Institutes Relevant to Agricultural Water Management

Research center	*Specific programs and projects dealing with agricultural water management*
ICRISAT	Under its Agroecosystems Global Theme, ICRISAT is researching low cost agricultural water management improvements that are risk-reducing and income-generating, together with improved policies for efficient water use and management, and community-participatory approaches to agricultural water management.
ICARDA	ICARDA specializes in the issues of agricultural water management in dry areas, including both rainfed farming and mitigation of drought. Under its program Management of Scarce Water Resources and Mitigation of Drought in Dry Areas, ICARDA is researching options for improving the productivity of water and for mitigating drought, including water resource management, drought tolerant and water-use efficient germplasm and agronomic management of cropping systems. ICARDA is also researching policy and institutional environments to support water efficient technologies and drought mitigating practices.
IRRI	IRRI specializes in productivity of rice cultivation. Its research is focusing on natural resource management and water productivity under intensive rice systems. A parallel research program on productivity in fragile environments is researching agricultural water management for rainfed rice ecosystems.
IWMI	IWMI focuses on the sustainable use of water and land resources in agriculture and on the water needs of developing countries. Its work concentrates on the broader issues related to water-food-environmental question. It develops, tests and promotes management practices and tools that can be used to manage water and land resources more effectively and to address food security, livelihood, and environmental issues,
WARDA	WARDA's research program is focused on enhancing the performance of irrigated rice-based systems in Africa, including improved resource-use efficiency, options to mitigate environmental degradation, and improved lines and varieties for African irrigated rice-based systems.

physical science and policy. The second focus is on resource management research at local, community, system, sub-basin, basin, regional and global scales. *Source: IWMI (communication from Pamela George)*.

Annex Table 11.1 ***(continued)***

Research center	*Specific programs and projects dealing with agricultural water management*
CIAT	CIAT's research aims at developing tropical plants that have better tolerance to water stress and/or has increased efficiency in water use.
ICRAF	ICRAF aims to initiate and assist in the generation and dissemination of appropriate agro-forestry technologies.
ILRI	ILRI's research work focuses on understanding livestock-water interactions for improving livestock water productivity and increasing water-use efficiency for food production in river basins.
IFPRI	IFPRI conducts research in water management and sustainable intensification of agricultural production to develop policies related to food security in Africa.
WorldFish	WorldFish research focuses on the role of fish in food security and pro-poor growth in sub-Saharan Africa. It's aim is to assist countries by improving fisheries and aquaculture and focuses on sustainable aquaculture development, enhanced livelihoods in small-scale fisheries, improved food security and health benefits, and managed implications of expanding markets and trade.
IPGRI	IPGRI aims to promote awareness of the importance of conserving and using plant genetic resources in sub-Saharan Africa.
IITA	IITA's work focuses on farming systems in the humid and sub-humid zones of sub-Saharan Africa—the real-life interactions between agriculture, livestock, the environment, and socioeconomic conditions that enable farmers to successfully grow their crops and raise their animals, and the problems that prevent them from doing so.
CIMMYT	CIMMYT's work in Africa focuses on developing, testing and spreading drought tolerant, hardier, more productive and nutritious maize and wheat varieties as well as resource-conserving, productivity-enhancing cropping practices.

Although the world as a whole is roughly on track to reach the MDG targets, Sub-Saharan Africa is unlikely on present trends to do so. If nothing changes, the absolute numbers of poor in the region will continue to increase and by 2015 close to one-half of the world's poor will live in Sub-Saharan Africa.

It is generally recognized that agricultural water could make a substantial contribution to poverty reduction and economic growth. Yet, there has been less agricultural water development to date in Sub-Saharan Africa than in any other region.

This report summarizes past experience of agricultural water investment in Sub-Saharan Africa. The report analyses the contribution to date of agricultural water management to poverty reduction and growth in the region, the reasons for its slow expansion and apparently poor track record, as well as the ways in which increased investment in agricultural water management could make a sustainable contribution to further poverty reduction and growth.

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