Water and the Rural Poor

Interventions for Improving Livelihoods in sub-Saharan Africa

IFAD
Enabling poor rural people to overcome poverty

FAO
FIAT PANIS

Water and the Rural Poor
Interventions for improving livelihoods in sub-Saharan Africa

Edited by:
Jean-Marc Faurès and Guido Santini
FAO Land and Water Division

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Rome, 2008

Reprinted 2009

ISBN 978-92-5-105982-1

Contents

Foreword

Sub-Saharan Africa is lagging behind in its bid to attain the Millennium Development Goals of eradicating hunger and reducing poverty. Water represents a major constraint on agricultural productivity and rural poverty reduction in the region. The vulnerability of rural people remains considerable owing to a combination of: highly variable and erratic precipitation; poor development of hydraulic infrastructure, management and markets; non-conducive land and water governance; and a lack of access to water for domestic and productive uses.

This publication is the result of a joint effort by the Food and Agriculture Organization of the United Nations (FAO) and the International Fund for Agricultural Development (IFAD) to address the linkage between water and rural poverty in sub-Saharan Africa. It takes stock of past experiences and demonstrates that there are many opportunities to invest in water in support of rural livelihoods. Its aim is to help decision-makers make informed choices on where and how to invest. It emphasizes the need for an approach where investments in infrastructure are matched with interventions in institutions, knowledge and finance in ways that yield optimal returns in terms of poverty reduction. It highlights the extreme heterogeneity of situations facing rural people across the region and the diversity of challenges and opportunities facing different categories of rural operators, stressing the need to adapt responses to these realities. It recognizes the multiple dimensions of the rural water challenge, and shows how people's livelihoods depend on reliable water sources for a wide variety of uses.

Our hope is that similar approaches can be implemented at national and local levels in order to enhance the effectiveness of future water-related interventions in support of poverty reduction in sub-Saharan Africa.

Alexander Müller
Assistant Director-General
Natural Resources Management
and Environment Department
FAO

Kevin Cleaver
Assistant President for Programme
Management Department
IFAD

Acknowledgements

This report is the product of a collaborative effort between FAO and IFAD. It was prepared by Jean-Marc Faurès and Guido Santini of the Water Resources, Development and Management Unit of FAO, in close collaboration with Rudoph Cleveringa and Audrey Nepveu de Villemarceau of the Technical Advisory Division – Water Management and Rural Infrastructure of IFAD.

The following persons contributed to the study and the preparation of the report: Summer Allen, Karen Frenken, Emily Healy, Jippe Hoogeveen, Walter Huppert, Anil Markandya, Theo Rauch and Dennis Wichelns.

The report also benefited considerably from the advice, guidance, support and review provided by: Moses Abukari, Martin Ager, Soukarata Bangoura, Inès Beernaerts, Marta Bruno, Sally Bunning, Jacob Burke, Karel Callens, Alasdair Cohen, John Dixon, Margarita Flores, Nicole Franz, Hubert George, Paolo Groppo, Aruna Gujral, Frank Kenny, Parviz Koohafkan, Hervé Lévite, Patricia Mejias-Moreno, Giovanni Muñoz, Ugo Pica-Ciamarra, Marc Smulders, Moïse Sonou, Pasquale Steduto, Laurent Stravato, Caroline Sullivan, Lamourdia Thiombiano and Vera Weill-Halle.

The report was edited by Julian Plummer. Editorial guidance and art direction, Nicoletta Forlano, layout design, James Morgan, desk to publishing, Monica Umena.

Financial support for the study and preparation of the report was received from IFAD through IFAD–FAO grant GCP/INT/033/IFA, and from the Italian Ministry for Foreign Affairs through the Associate Professionals Programme. They are herewith gratefully acknowledged.

List of acronyms

CIESIN	Center for International Earth Science Information Network
DFID	Department for International Development (UK)
DHS	Demographic and Health Survey
FGGD	Food Insecurity, Poverty and Environment Global GIS Database
GAEZ	Global Agro-Ecological Zone
GDP	Gross domestic product
GNP	Gross national product
HDI	Human Development Index
IFAD	International Fund for Agricultural Development
IIA	Integrated irrigation aquaculture
IIASA	International Institute for Applied Systems Analysis
IPCC	Intergovernmental Panel on Climate Change
LDC	Least-developed country
SSA	Sub-Saharan Africa
UNDP	United Nations Development Programme
WARDA	West Africa Rice Development Association
WHO	World Health Organization
WUA	Water users association

List of tables

List of figures

List of boxes

Executive summary

Insecure access to water for consumption and productive uses is a major constraint on poverty reduction in rural areas of sub-Saharan Africa (SSA). For millions of smallholder farmers, fishers and herders in SSA, water is one of the most important production assets, and securing access to and control and management of water is key to enhancing their livelihoods. This report argues that the potential exists for well-targeted, local interventions in water that contribute to rapid improvement in the livelihoods of the rural poor in SSA and help attain the Millennium Development Goal of eradicating extreme poverty and hunger. It discusses conditions for success and proposes water-based, context-specific, and livelihood-centred approaches to poverty reduction in rural areas.

Given the predominance of rural poverty in SSA, and given that agriculture will remain the main source of livelihood, poverty reduction strategies need to focus on improving productivity in this sector. This report focuses on agricultural water because: (i) it plays a central role in agriculture-based rural livelihoods; (ii) adequate availability and reliable access to water is frequently a constraint on production; and (iii) water provides a focal point around which other interventions can be organized.

Examples of successful water projects in SSA exist, and there are important opportunities for new investments in water. Their success will depend on the development of new models of interventions, centred on enhancing the diversity of livelihood conditions of rural populations. A large part of the success of future investments in water control will depend on a more comprehensive analysis of dynamic opportunities and needs, which are closely linked to the shifting biophysical and socio-economic contexts.

However, there is no "one size fits all" approach for improving livelihoods. Different contexts and needs will require different types of investments, in which market or household food security, prevailing agroclimatic conditions and associated farming systems, and the overall socio-economic and institutional environment will guide the choice from a non-prescriptive menu of appropriate interventions at different scales.

This report identifies and maps 13 major "livelihood zones" in SSA. Each zone offers distinct opportunities for livelihood sustenance and development, has different agro-ecological conditions, and shows different angles for water-related investments for poverty reduction. The predominant scales emerging from this analysis correspond to the household, farm and community watershed levels.

Any rural water strategy will have to deal with the reality of multilocal diversified livelihood systems in which farming, while remaining important, is no longer the sole or even the main source of living. The "new rurality" has serious implications for any water intervention strategy.

In particular, a careful analysis of social groups and target beneficiaries needs to be performed. With regard to farming, this report identifies four main categories of rural people and analyses their specific water-related requirements. The four groups are: (i) the extremely vulnerable; (ii) traditional smallholders, livestock keepers and nomads; (iii) emerging market-oriented smallholders; and (iv) large commercial farmers. The report also stresses the need to analyse off-farm water needs, the needs of women and the elderly, and the implications of HIV/AIDS in crafting water interventions.

The report analyses the prevalence of poverty in rural areas in SSA and reveals substantial differences across the livelihood zones, with a higher prevalence of relative poverty in highland temperate, pastoral and agropastoral zones.

This report also assesses the biophysical potential for further water development in each of the zones. On average, the current level of pressure from agricultural-based livelihoods on water resources is low in SSA, with agricultural water withdrawal representing only 3 percent of renewable freshwater resources. Thus, the potential exists for a substantial increase in harnessing water resources for agriculture, but with major differences between zones. In other zones, water is much scarcer, and interventions will need to focus on substantial increases in water productivity. Environmental degradation requires careful attention in future development plans in these zones.

Looking at the prevalence of poverty, the relative importance of water in productive activities, and the potential for future water development, the report organizes the zones according to three levels of potential for poverty reduction through water-related interventions. In particular, water-related interventions are expected to play a major poverty-reducing role in the cereal–based, cereal–root crop, highland temperate and agropastoral zones. However, the analysis is valid for a regional overview only. At national and district level (or lower), a detailed agro-economic analysis (including market opportunities, stakeholder analysis and preferences) and institutional mapping, together with an analysis of sectoral policies, would allow for much more refined and policy-relevant findings.

The types of interventions that are appropriate rarely involve large-scale irrigation schemes. The focus is on schemes that are easy to operate and maintain locally and that target female and male smallholders. Such interventions will mostly be based in areas of rainfed agriculture. Six categories of possible interventions have been identified in view of their poverty-reduction potential:

- better management of soil moisture in rainfed areas;
- investment in water harvesting and small storage;
- small-scale community-based irrigation schemes;
- improved water access and control for peri-urban agriculture;
- development of water supply to meet multiple water uses;
- an environmentally-aware system of improved water access for livestock in arid and semi-arid areas.

In addition, there is a need to improve existing smallholder-based irrigation systems, which are often used below capacity and in a state of poor maintenance. New market developments, such as contract farming around commercial private irrigation schemes, may also offer options for the more entrepreneurially-gifted rural population. However, clear policies need to be put in place to ensure equitable access to water for smallholder farmers, who also require favourable market linkages and governance conditions.

Investments in water infrastructure alone cannot suffice to improve agricultural productivity in SSA. Farmers need secure access to inputs including fertilizer, better seeds, and credit. They need to be better educated and informed on the use of inputs and the latest techniques. Investments in water control need to be planned and implemented in the much broader framework of agricultural and rural development, where production, markets, finance and infrastructure are conceived in an integrated way and are mutually supporting. In this framework, the multiple use of water in rural areas also requires careful attention. Furthermore, the policy and institutional framework has to ensure fair and equitable access to water resources and effective access to markets for agricultural products. In particular, conflict resolution and settlement of claims need to be part of governance – be it traditional, customary or modern.

Climate change represents an additional challenge to rural people in SSA, and a further reason for investment in water control. In view of their limited adaptive capacity, smallholder farmers, pastoralists and artisanal fishers in SSA are among the most vulnerable to the impact of climate change. While projections on possible changes in annual rainfall vary across Africa, these populations will experience the negative effects of increased temperature on yields, combined with a high vulnerability to extreme events. For them, enhanced control of water will become critical in building resilience to increased climate variability.

Introduction

Goals of the report

The primary goal of this report is to contribute to the development of strategies to reduce rural poverty in sub-Saharan Africa (SSA) through investments in the agricultural water sector. An estimated 75 percent of the world's poorest people – 880 million women, children and men – live in rural areas, and the majority of them depend on agriculture and related activities for their livelihoods (World Bank, 2007a). One-quarter of these rural poor live in SSA, where agricultural output has not kept pace with population growth in recent decades and where yields on land have been stagnant or declining, causing reductions in agricultural income and in per capita food production. Efforts to reduce or eradicate poverty in the region will not be successful without substantial gains in agricultural incomes.

The present report relies strongly on the view that agriculture in SSA is the most promising option for broad-based poverty reduction in rural areas, and sets the role of water improvements in a wider context of overall reforms and investments in agriculture. Several commentators have noted the high cost of developing irrigation projects in SSA, while others have described the high cost of transporting inputs and products along sub-standard roads to farms and markets located far from coasts and rail lines. In the light of these and other problems, it has been suggested that agriculture cannot provide the stimulus needed to achieve economic development in Africa with the speed and extent required to alleviate poverty in the near future. These alternative views propose public and private investments in other sectors.

While recognizing the difficulties and constraints facing the agriculture sector, there is no reason to accept that they cannot be overcome. This report holds that agricultural development is a necessary condition for achieving broad-based economic development, and that investments in smallholder agriculture will reduce poverty and improve livelihoods within a reasonable time. The population of SSA will continue to grow at a rapid rate through to 2050, with some countries doubling and tripling their current populations (Alexandratos, 2005). Successful efforts to prevent widespread deepening of poverty and large-scale, perpetual food crises on the subcontinent must begin very soon. Actions have to be taken on a number of fronts:

- to improve livelihoods in subsistence agriculture;
- to enhance smallholder competitiveness;
- to improve market access;
- to increase employment in agriculture and the rural non-farm economy.

In this package of measures, an important role has to be given to improving access to, and control and management of, water in rural areas.

The report proposes a method for identifying the locations where water constraints are a major factor in determining poverty and where interventions can be made that would take large numbers of poor farmers out of poverty. These locations are determined on the basis of previous work that has divided Africa into different zones, based mainly on prevailing farming systems (FAO and World Bank, 2001). The likelihood of implementing successful interventions in the water sector varies according to the main sources of livelihood of rural populations, dictated in large part by the predominant farming systems, themselves closely related to agro-ecological conditions. Understanding the geographical distribution of rural poor and their relation to livelihood zones helps in designing intervention strategies for improving water management and increasing both the resilience and productivity of agriculture, and for boosting agricultural incomes more generally.

Organization of the report

Chapter 2 reviews the state of knowledge on agriculture and rural poverty reduction, and the role of water. It focuses on the specific conditions of SSA in terms of agricultural productivity, poverty and water resources development. It identifies key challenges for the development of the agriculture sector in the region. In particular, it reviews the linkage between rural development and agriculture in the light of the "new rurality" (Cleveringa *et al. forthcoming*) in which the countryside of the region is rapidly evolving. It reviews the concept of a livelihoods approach to development, and analyses its implications in terms of water access control and management in rural settings. It introduces the concept of "livelihood zoning", and stresses the need for a context-specific approach to interventions in water for poverty reduction. Finally, it stresses the need to place water interventions within the broader context of rural development, and the importance of complementary interventions, in particular in relation to institutions.

Chapter 3 provides a detailed analysis of the SSA region in terms of rural poverty, agriculture and water resources development, and the linkages between them. It demonstrates the large variability in poverty distribution across the region and enables a better understanding of major rural poverty reduction challenges. Through the adoption of a livelihood mapping exercise, the report identifies the main sources of livelihood of rural populations, based on a broad division of the region according to its main farming systems. It analyses 13 "livelihood zones" with regard to rural poverty, agriculture and water resources, and makes use of a simple and transparent criteria analysis to assess the potential for poverty reduction through water control interventions in each livelihood zone.

Chapter 4 discusses a set of typical water intervention options, and analyses their range of application and potential for poverty reduction according to the various livelihood zones. While the emphasis is on interventions that support crop and livestock production, it also considers domestic water and the importance of multiple-use water systems to support a range of productive activities. It discusses the need for a thorough analysis of different stakeholders in designing water interventions, and illustrates in particular the wide range of needs and how they vary from one category of stakeholders to another. It also presents a set of "essential conditions for success" for any water-focused poverty reduction programme and strategy.

Water, agriculture and rural livelihoods

The livelihoods perspective

This report follows a "livelihoods approach" to development. A livelihood may be defined as the sum of ways in which households obtain the things necessary for life, both in good years and in bad. These necessities include food, water, shelter, clothing and health care (with education often included too). Pertinent activities can include crop

Table 1 Shifting towards a livelihoods-based approach in rural water development

Capital	Issue	Production-based Approach	Livelihood-based Approach
Physical	Infrastructure for rainfed and irrigation systems	Rainfed and irrigation livelihood zones improved to increase agricultural production.	Improves decision-making ability through better rainfed and irrigation livelihood zones. Removes risk and uncertainty including maintenance and management of natural capital stocks.
Social	Community approach needed to raising or managing other forms of capital of crucial importance in irrigation management	Communities mobilized to establish (WUAs) to improve agricultural water management.	Identifies poorest households and strengthens participation in, and influence on, community management systems. Creates safety nets within communities to ensure the poor have access to water. Improves rights to land and water and establishes right to access by poor households within communities.
Natural	Land and water availability	Develops new, and enhances existing, water resources using physical and social assets.	Enhanced through training in catchment protection and maintaining natural environment.
Financial	Cash, credit, savings, animals	Develops individual or community-based tariffs and charges mechanisms for water uses.	Secured through access to small-scale credit.
Human	Labour, knowledge (through education, experience)	Trains people in agricultural water management and promotes gender equity.	Knowledge of demand, responsive approaches, community self-assessment of needs, participatory monitoring, gender mainstreaming.

Source: WWAP (2006).

and livestock production, fishing, hunting, gathering, bartering, and other endeavours and income-generating activities (including off-farm work). Livelihoods vary significantly within a country, from rural to urban areas, and across countries. The household is taken as the unit of reference because it is by far the most important institution through which populations anywhere organize production, sharing income and consumption (FAO, 2006a).

A livelihoods approach can be distinguished from a production-based approach in that it makes the household the centre of the analysis, taking an integrated view of the importance of all its assets or forms of capital (physical, financial, human, natural and social). Table 1 shows how a livelihoods approach is applied to these different forms of capital in contrast to the more traditional production-based approach.

Box 1 Describing livelihood capitals and how they can be improved

Human capital

Human capital is about knowledge and skills. Many farmers and their families have adequate knowledge and skills for operating within a given level of technology and given their resource constraints. Efforts to intensify or diversify production require investments in new knowledge and skills. Farmers and households need to enhance their human capital, but many poor households do not have sufficient resources for making such an investment. In such cases, assistance might be provided by a public extension service or a private firm with an interest in boosting agricultural productivity. With regard to water in agriculture, important enhancements in human capital include knowledge of methods for improving water management in both rainfed and irrigated areas. Such methods might involve small changes in existing techniques, or the use of new equipment, crop varieties, and complementary inputs.

Natural capital

Natural capital is about natural resources, mainly land and water. Many poor households rely on the environment for key inputs in their production and consumption activities. Water is perhaps the most important of these inputs. All households require water for consumption. Farming households also require water for producing crops and raising livestock. Households also depend on the quality of soils and rangeland, and many households gather fuelwood and fodder from areas within walking distance of their homes. Rainfall is important in maintaining the quality of rangeland and other common areas. In arid areas with a substantial population density, the demands placed on natural capital can exceed the sustainable supply. Severe degradation of natural resources can reduce the livelihood status of households that depend on them for production or consumption.

Physical capital

Physical capital is about infrastructure. Typically, investments in irrigation enhance physical capital. New or refurbished irrigation systems add to the physical capital of households and communities. So do investments in other forms of infrastructure. Inadequate physical capital can constrain household production for consumption or sale. Physical depreciation owing to inadequate maintenance has caused the decline of many irrigation schemes. The likelihood of maintaining physical capital is strongly related to the other four types of capital available in a given community. Wealthier communities, and those with greater social cohesion, might have greater success in maintaining irrigation infrastructure. Human capital is also helpful in understanding the need for maintenance and the methods required to perform necessary tasks. Natural capital might refer to the quality of the setting in which the irrigation infrastructure is placed. Settings prone to rapid siltation or structural degradation might be associated with more rapid decline of irrigation infrastructure.

Financial capital

Many poor households have inadequate financial capital. This limits their ability to pay for water and the costs of operating and maintaining an irrigation system. Inadequate finance can also prevent households from investing in new methods of crop production and irrigation. In addition, many households are risk averse because they have limited financial ability to respond to unexpected shortfalls in income. Limited finance also prevents farmers from accessing all of the complementary inputs required to maximize the productivity of land and water resources. Farmers with access to affordable credit can purchase inputs. However, in many areas, the risk of a shortfall in production prevents farmers from using that option. This is particularly important in rainfed areas where crop yields can vary substantially with annual rainfall, and where insurances can play an important role.

Social capital

Social capital is about solidarity and community action. Many small-scale irrigation schemes are operated by community associations. These associations, and farm villages more generally, represent a form of social capital that provides value to individual households. For example, a village or community can assist individual households in times of financial stress. Social capital is also helpful in organizing the operation and maintenance of a community irrigation scheme and bringing workers together to perform necessary tasks. Inadequate social capital can leave households more vulnerable to unexpected shortfalls in crop yields. Strong social capital helps in allocating water resources among farm households in ways that are acceptable to community members and beneficial to the community as a whole.

In the case of physical capital, the approach gives prominence to improving decision-making in the households and removing uncertainty through better management rather than simply to improving irrigation systems on their own. In the case of social capital, it emphasizes the importance of including poor households in the decision-making processes and the importance of ensuring access to water rights for the poor, rather than simply setting up water users associations (WUAs) to improve water management. In the case of natural capital, the livelihoods approach complements the building of new water resources by enhanced training in catchment protection. Similarly, for financial capital, this approach seeks to develop small-scale credit programmes, and for human capital, it emphasizes the importance of community self-assessment of needs, participatory monitoring and gender mainstreaming. Box 1 describes in detail the different livelihood capitals and their relation to water and agriculture.

Livelihood strategies and outcomes at the household level depend to a large degree on the amounts and qualities of these assets owned or controlled by the household. Land and water endowments can be viewed as elements of natural capital, while human capital includes the amount and quality of labour available. The optimal combination of investments in the five forms of capital might be viewed as a necessary condition for achieving sustainable rural development (Pender *et al.*, 2004).

Many households in rural areas, and in particular in SSA, have very little physical and financial capital. Their key assets include a small amount of land and their labour. They might also possess a fair amount of "social capital" in the form of kinship and community relationships. While acknowledging the important role of social capital in smallholder households, it remains elusive and difficult to measure. Hence, this study focuses on physical, natural and human forms of capital, which are better documented and measured. In particular, it examines ways in which improvements in agricultural water use can enhance the incremental productivity of land and labour. It also analyses how investing in physical capital, such as building new irrigation schemes and improving water harvesting methods in rainfed areas, can enhance rural livelihoods.

Most people's livelihoods can be characterized by a predominant activity, which is then supplemented by several other activities. In most communities in developing countries, farming-based activities are the principal source of livelihood, and households complement them with other food and income-earning activities.

The adoption of a livelihoods approach (moving away from a top-down engineering-focused approach towards a more holistic, household-centred one) is now widely seen as critical to ensuring success in any future water sector interventions in agricultural development. In Chapters 3 and 4, this report designs its programmes of interventions on the basis of different livelihood zones of SSA, thus placing the livelihoods of farming households at the centre of the proposed strategy.

Rural livelihoods in transition

New dynamics related to rural livelihoods

The rural poor are usually marginalized smallholders who depend partly on subsistence production (mostly not sufficient to sustain their livelihoods) and partly on cash income from selling surplus, from wage labour (mostly not sufficient and not reliable either), and, increasingly, from remittances. They are also the landless people, relying on seasonal jobs as farm workers and on informal non-farm income sources (IFAD, forthcoming). Their poverty is usually characterized by a lack of various assets or resources:

- They are often short of land in terms of farm size, quality and security of access.
- They lack access to clean and safe drinking-water.
- They are often short of family labour (owing to migration or HIV/AIDS) and, therefore, suffer from seasonal labour bottlenecks.

Their lack of assets prevents them from accessing the financial resources they need in order to increase their productivity, and they typically live in remote areas with scarce access to markets and services. All these constraints make them highly vulnerable to shocks, in particular those related to climate variability, health risks, natural hazards, and market fluctuations. Accordingly, their strategies are to avoid risks by diversifying their economic activities, by engaging in low-external-input / low-capital-investment technologies and by investing in social relations to maintain a social safety network. Low-risk livelihood strategies necessarily yield low returns and represent a severe constraint on poverty reduction. These characteristics are not new, but they continue to be relevant for the majority of rural poor.

The new dynamics of rural livelihoods – the new rurality – result predominantly from globalization and deregulation, which create new opportunities but also new threats and limitations. New opportunities for rural smallholders result from access to external markets ("niche markets") with increasing demand for new agricultural products, such as fruits, vegetables, nuts, flowers, fish, shrimps and spices. However, these new opportunities are limited, leading to strong competition for limited market chances. New limitations and risks for rural livelihoods result from increasing competition caused by flooding of domestic markets with world market commodities, resulting in high levels of unemployment (especially in SSA) and limited domestic demand for basic agricultural products. In addition, agricultural and rural service systems (inputs, financial services, and information) are absent or not accessible for poor people as private service providers do not exist to fill the gap left by the abolishment of public services. In some countries, replacement of customary land law by individual tradable property rights tends to increase the risk to poor smallholders of losing their access to land. In addition, environmental degradation and the increasing frequency of natural hazards tend to reduce the assets of the rural poor and so make them more vulnerable.

As opportunities and limitations/risks are not equally spread among rural smallholders, there are winners and losers. The winners can usually be found in central locations in proximity to dynamic markets and among resource-rich rural households that can mobilize additional assets. The losers are those in remote places and those with limited resources. Migration has become a predominant survival strategy for the rural poor. As a consequence, rural livelihood systems in many parts of the developing world have become highly diversified and highly mobile, multilocal livelihood systems. Thus, poor rural families are no longer real smallholder farm households. A consequence of this is the feminization of the rural economy and of agriculture in particular. In many cases, women have to secure the survival of children and aged family members (Vargas-Lundius, 2007).

This pattern has important implications for efforts to promote development based exclusively on agricultural productivity. Young people tend to have limited skills and interest in farming as it is only one – and usually not the preferred – livelihood option. While there is limited long-term investment into farming, people are flexible and tend to take up any income opportunity in farming if it is promising. Despite the diversification of rural livelihoods and increasing urbanization, at least half of the poor people are expected to remain in rural areas by 2035, and a significant number of them will depend on smallholder farming as their main source of livelihood (IFAD, 2001).

Implications for rural water strategies

These "new poverty" patterns have implications for identifying and targeting the rural poor. While high shares of subsistence production and of irregular remittances from migrants may complicate attempts to establish the poverty status by absolute income levels (such as US$1/day), it might be more relevant to identify poor households by their vulnerability or food-insecurity level. Furthermore, any rural water development strategy will have to deal with multilocal diversified livelihood systems with limited capacities for agricultural investment, a predominance of risk-avoiding strategies (IFAD, 2005), female-headed households, high workloads, and rural people's limited ties to their land. Such characteristics and trends have both methodological and strategic implications.

In methodological terms, the complexity of the new rural reality reinforces the need for a livelihoods approach to development. In terms of water, this "means a fundamental shift beyond considering water as a resource for food production to focusing on people and the role water plays in their livelihood strategies" (WWAP, 2006); and implies de facto a multiple-use perspective (Molden, 2007). Any water intervention needs targeting not only according to farming systems but also according to socio-economic categories. Identifying different categories of farmers and rural workers according to the level of their integration into the local economies is necessary in order to ensure the effectiveness of interventions. In addition, other context-related criteria – according to the stage of food self-sufficiency / food security, the share of income from agriculture, and gender – are also relevant.

In strategic terms, these characteristics of the rural poor require that particular attention be given to low capital investment and low external input technologies, taking the limited financial assets of poor households and the weaknesses of rural service systems into account. Building on existing local knowledge and avoiding the introduction of unnecessarily sophisticated farm management systems contribute to a better uptake of technologies and takes into account the part-time nature of many farm activities and the widespread absence of functioning agricultural extension systems. Such interventions and investments should be considered in complement, and not in opposition, to the more conventional large-scale investments in surface water storage and irrigation, which remain a valid option where they can be justified on the basis of market opportunities.

The provision of water for small productive activities, such as home gardens, fruit trees and small off-season vegetable plots, helps in addressing land and labour bottlenecks, in particular of female-headed households in multilocal livelihood systems. Focusing on women (and the elderly who stay in the village) and taking their specific assets, constraints and coping strategies into account is of paramount importance in ensuring the success of water interventions. In short, agricultural water interventions should no longer be based on the assumption of specialized or increasingly specializing irrigation farm units managed by full-time professional farmers, but be prepared to assist in overcoming water bottlenecks in manifold context-specific ways.

Increasing agricultural productivity and impact on rural households

Agricultural production relies on a set of basic inputs (labour, land, water, seeds, fertilizers, chemicals, animal power, machinery, etc.). The productivity of any one of these inputs varies with the availability of one or more of the other inputs. For example, fertilizer is less productive where water is limiting, just as land and water are minimally productive where fertilizer is limiting. Optimal intensification requires that farmers have affordable access to the suite of inputs required to generate desirable crop yields. Improvements in agricultural productivity can provide a pathway out of poverty for rural households in several ways:

- For poor households that own land, increases in crop and livestock yields will generate greater output and higher incomes per unit of land and labour.
- For households that do not own land but provide farm labour, improvements in yields will increase the incremental productivity of labour, thus stimulating the demand for farm labour and raising farm wages.
- For households that do not own land or provide farm labour, improvements in yields will generate greater aggregate output, thus increasing the local supply of agricultural products, with consequent reductions in prices.
- Higher agricultural incomes and higher net incomes in non-agricultural households that are net food purchasers will generate greater demand for food and other goods and services that might be provided by local farmers and other non-farm residents.
- Improvements in crop yields made possible by enhancing water management will increase the incremental productivity of complementary inputs, such as labour, fertilizer, chemicals, animal health services, animal traction, and

machinery. Greater demand for these inputs might stimulate economic activity that benefits households providing non-farm labour.
- Improvements in the yields of crops and livestock might also stimulate labour demand in local processing and marketing activities, particularly in areas near urban centres.

The relative importance of these potential implications of improvements in agricultural productivity will vary among regions with differences in resource endowments, demographic characteristics, marketing opportunities, and labour supply and demand. However, in most cases, the impacts should be such that poor households gain opportunities to improve their livelihoods by generating greater output per unit of owned land and labour, or by earning greater wages for the labour they provide to others. Over time, higher net income will enable poor households to generate savings and invest these funds either in farm-related activities or in efforts to increase the potential return from non-farm and non-rural endeavours.

Water: access, control and management

This section focuses on the role of water in improving agricultural productivity for the following reasons:

- Water is an essential input in crop and livestock production.
- Water scarcity is a feature of many rural livelihood realities.
- The lack of adequate water is linked to poverty – households facing water shortages are more likely to be poor or fall into poverty than households not facing such shortages.
- Actions to address the problem of rural poverty by improving water availability make economic and social sense.

The importance of water as a key input in agriculture and its central role in the panoply of assets, resources and institutional arrangements that farmers need in order to sustain production has already been mentioned. This section elaborates further on this role, on how closely a lack of adequate water is tied to rural poverty, and on the ways in which investments in water have to fit in with investments in other aspects of agricultural production.

Rural and agricultural water use can be analysed in terms of three main components: access, control, and management. Access describes the degree to which a household can obtain water from rainfall (in rainfed conditions), surface water sources, groundwater, surface or subsurface return flows from agriculture, or wastewater from urban or peri-urban areas. Control describes how well a household can move water from a source to the location at which the water is applied. Elements within the control component might include farmer-operated canals and ditches, small pipelines, and sharing arrangements with other farmers. Management describes farm-level decisions and practices regarding the application of water for crop and livestock needs. In the case of crops, farmers must determine the timing and amounts of irrigation deliveries, and the methods used for applying water on farm fields. Decisions regarding crop and livestock water management are influenced by a farmer's human capital, the type of irrigation equipment available (if any), and information describing crop and livestock water requirements.

Although water-scarce areas do not represent a large share of the world's population in absolute terms, semi-arid areas and dry subhumid climates such as savannahs and steppe ecosystems are hosts to many malnourishment hotspots in which rainfed agriculture is the primary source of food, and where water scarcity limits crop growth (Molden, 2007). While few would disagree with this general correlation, the policy implications are less clear concerning the issue of whether an increase in water supply will necessarily lead to increases in output and reductions in poverty. Water is often not the only limiting factor in production. Public agencies planning to intervene by developing irrigation or improving agricultural practices in rainfed areas must also consider the availability of affordable complementary inputs, access to markets, and institutional arrangements that promote farm-level investments in land and water resources. Furthermore, great attention has to be paid to the form in which access to water is increased. There is no "one size fits all" strategy that can be recommended, and each "livelihood condition" must be considered individually and in its historical and cultural context. This is at the heart of the approach developed in this report.

The debate about irrigation and poverty reduction

Irrigation can contribute to poverty reduction primarily by enhancing the productivity of labour and land (Smith, 2004), leading to higher incomes, higher wages, and lower food prices. Hussain and Hanjra (2004) describe three pathways through which irrigation affects poverty: the microlevel, mesolevel, and macrolevel. At the microlevel, irrigation enhances returns to the physical, human and social capital of poor households. It enables farmers to achieve higher yields and earn larger revenues from crop production. Higher net revenues can be invested in productive inputs or used to diversify farm and non-farm activities. The accumulation of net revenues over time can enable poor households to implement measures that reduce their vulnerability to shocks, and possibly to escape from chronic poverty.

The mesolevel impacts include new opportunities for landless labourers to work on irrigated farms or to earn higher wages on rainfed farms. If the availability of irrigation water increases the incremental productivity of labour, the demand for farm workers will increase, all else being equal. The consequent rise in wages will be determined by the amount of idle labour available locally and the degree to which farm workers migrate in search of job opportunities. Mesolevel impacts also include the reduction in local food prices that might occur when irrigation enables farmers to generate greater output per unit of land and per season. Increases in the demand for locally produced non-agricultural goods and services also can generate employment opportunities and stimulate local economic activity (Mellor and Johnston, 1984).

The macrolevel effects occur through interactions in national and international markets. Improvements in agricultural productivity made possible by irrigation can stimulate aggregate economic growth. Such growth can be helpful in reducing poverty and hunger if appropriate policies and investments are implemented by state and national governments. Improvements in productivity and reductions in the average cost of producing crop and livestock products can also provide new opportunities for gaining benefits through international trade.

Similarly, Lipton, Litchfield and Faurès (2003) have described the direct and indirect ways in which irrigation reduces poverty. Direct effects include: higher yields and increased diversity of cropping made possible by irrigation; higher wages from enhanced employment opportunities; and lower food prices. Indirect effects include: stimulation of activity in input and output markets; impacts on non-rural labour and product markets; and reduction over time in the variability of output and economic activities. This stabilization effect of irrigation generates substantial benefits across economic sectors, when operating in a supportive policy environment that ensures that farmers have affordable and timely access to key inputs, and that they receive adequate prices for their output.

Such evidence as there is on the poverty reduction benefits of irrigation comes largely from Asian countries with high population densities and favourable natural resources conditions. Several studies (Hussain, 2007a) have examined poverty incidence in selected Asian countries in settings "with and without" irrigation. In every case, poverty incidence was higher in the non-irrigated setting. The estimated poverty headcounts reported in the studies range from 17 to 64 percent in irrigated settings, and from 23 to 77 percent in non-irrigated settings, which suggests some correlation between the two.

Perhaps the best-known case of irrigation contributing to poverty reduction is the green revolution implemented in India, Pakistan and elsewhere in Asia in the 1960s and 1970s with the goals of increasing food production by promoting rapid increases in agricultural productivity. Irrigation was a key component of the green revolution package of inputs, which also included higher-yielding varieties of rice and wheat, and affordable access to fertilizer, pesticides and energy. Aggregate cereal production increased substantially, improving rural incomes and enabling millions of urban and rural people of Asia to obtain affordable food supplies (Mellor, 1998). While much poverty remains in Asia, the gains in aggregate production and the notable reductions in poverty could not have been achieved without substantial investments in irrigation (Hussain, 2007b).

In terms of poverty reduction, the impact of irrigation will depend on how successfully the poor can share in the benefits of the water that is made available. Typically, poverty incidence is higher at lower reaches of canal systems, where farmers have less secure access to irrigation water (Hussain, 2007a). This is particularly the case in areas where good-quality groundwater is not available as a substitute for canal water supplies in lower reaches, and where farmers have limited opportunities for generating income in non-farm activities. The unequal distribution of land and wealth along some canal systems limits the poverty-reducing impacts of investments in irrigation (Hussain, 2007a, 2007b).

The main conclusion to be drawn from these experiences is that there is a role for irrigation in improving agricultural productivity and in reducing poverty, but it has to be carried out in a more strategic way, with a more in-depth assessment of the costs and benefits, both direct and indirect. It is also essential to have meaningful local participation in the design and operation of the schemes and to provide other supporting interventions (especially access to input and output markets and the promotion of higher value crops) as appropriate (Magistro *et al.*, 2007). Again, there will be significant differences between livelihood zones and agro-ecological zones in what is the right way forward, and a move from a top-down to a bottom-up livelihoods-based paradigm will be key to success in this area. Should a "green revolution" happen in SSA, it is likely to differ considerably from the first one in Asia, given the significant differences in resource endowments, demographics, lack of appropriate technologies, public perspectives regarding government support for intensive agriculture, and the completely different economic context at both local and international level.

The critical role of institutional reforms

Actions needed to reduce rural poverty from a water-based interventions perspective also need to be examined from the perspective of institutional reforms. A shift away from a top-down to a bottom-up approach to investment and policy reforms is widely recognized as essential. At the same time, the public sector cannot be responsible for all the required interventions; some element of private and public partnership will be necessary. In improving access to market, advantage must be taken of the increased opportunities created by new markets, in which the private sector is investing heavily, and which offer smallholders the possibility to have secured sales of high-value products, in some cases through contract farming, with support from the buyers in the form of credit and inputs. Investments in water supply systems can also benefit from public–private partnerships in which community-based or private market-driven schemes are developed through local initiatives.

Some important elements of institutional reforms in irrigation (Kemper and Sadoff, 2003) include:

- better alignment of irrigation and drainage institutions, and transfer of responsibilities for operation, maintenance and management of irrigation and drainage systems to organized local user groups;
- cost-sharing for infrastructure improvement, accompanied with improved financial mechanisms for farmers;
- introduction, where appropriate, of systems of water rights and volumetric delivery for greater efficiency in water use;
- re-dimensioning of irrigation systems where they are not financially or environmentally viable (here, public participation of stakeholders is critical).

It is also necessary to recognize that the benefits of infrastructure investment in water provision cannot be measured in narrow economic terms alone, and that impacts of programmes on poverty, as well as on public expenditures in the form of food aid, must be taken into account. This has implications for the criteria applied in selecting investment projects and programmes. It also implies that projects may be considered socially beneficial even where individuals cannot afford to pay the full cost of the services provided to them. In such cases, incentive-compatible subsidy schemes have to be designed and implemented, again with the support of local communities.

Agriculture and rural poverty in sub-saharan africa

Performance of agriculture in the region

While the overall picture is that of an agriculture that does not manage to keep pace with population growth, not all recent developments in agriculture in SSA have been negative. As macroeconomic conditions have improved since the mid-1990s, agricultural growth has also increased from 2.3 percent a year in the 1980s to 3.8 percent between 2001 and 2005 (World Bank, 2007a). Where this growth has occurred, there have been some declines in poverty. However, population growth has absorbed much of the gain, reducing per capita agricultural growth to 1.5 percent, which has not been enough to prevent an increase in the number of the rural poor. They rose from slightly more than 200 million in 1993 to about 240 million by 2002. Hence, there is a need to accelerate the rate of growth in agriculture, which is feasible but which will require commitments, skills and resources.

Part of the explanation for poor agricultural performances in the region is the specificity of the agro-ecological features of African countries, which leaves them less able to take advantage of international technology transfers, the small size of many of the countries, which prevents them from capturing economies of scale in research and development, and prevailing low population density. New varieties of maize, wheat, rice and other crops have been developed and planted in Africa (Maredia, Byerlee and Pee, 2000; Gabre-Madhin and Haggblade, 2004), but poor quality soils, inadequate use of fertilizer, and unreliable rainfall have limited yields (Eswaran *et al.*, 1997; Sanchez, 2002; Holmén, 2005a).

Other factors have militated against improved yields. With population growth, family farms have been divided up repeatedly among members of new generations, with the result that average farm sizes of many poor households have declined substantially (Jayne *et al.*, 2003). As a result, many poor households have less than 1 ha of land – an area too small to generate sufficient food or income to sustain a household throughout the year.

An important factor that is responsible for the relatively poor performance of SSA agriculture is poor access to reliable services providing inputs and knowledge. Many African farmers do not have access to affordable credit, and they cannot purchase and apply key inputs in a timely fashion (Kelly, Adesina and Gordon, 2003). In some areas, farmers lack the knowledge and access to extension service support to implement optimal crop management practices, with consequent reductions in crop yields (Baïdu-Forson, 1999; Haefele *et al.*, 2001; Wopereis-Pura *et al.*, 2002; Poussin *et al.*, 2003).

Finally, there has been low investment in infrastructure in the sector. (Hayami, 2001; Holmén, 2005b; Larsson, 2005). While a greater provision of infrastructure is necessary, it is not sufficient by itself. It has to be accompanied by greater use of inputs and better access to markets. Within the range of new opportunities, probably the greatest market potential pertains to domestic and regional markets for food staples including cereals, roots and tubers, pulses, oil crops, and livestock products (Diao *et al.*, 2007).

The experience with irrigation schemes has not been a particularly positive one in the region, although it has been improving. Of the 7.1 million ha under full or partial irrigation (i.e. about 3 percent of cultivated area in SSA and 20 percent of the area that is considered as potentially irrigable) only 5.3 million ha have systems that are operational. Previous schemes have had a poor record in terms of high costs of construction and operation, environmental damage, and low increases in productivity for farmers.

However, more recent investments in both large-scale and small-scale systems have performed better. In particular, where they are community-based or private-market-driven by smallholders with low-cost technology, small-scale operations have shown good appropriation by farmers. In some cases, these successful interventions take the form of improved management of water in areas that would still be defined as rainfed (including all schemes that improve and control access to water, such as water harvesting or very small-scale water management at the farm level). In many cases, an important factor for success has been the simultaneous promotion of links to markets for farmers in areas where irrigation is promoted, and the use of a decentralized approach to selecting the method of intervention.

In summary, SSA has made some progress in increasing agricultural output but the rate of progress has not been enough to reduce rural poverty. The combination of a challenging set of initial conditions (geography, soils, and rainfall variability) and a history of inadequate investments in natural and physical assets has limited the pace of agricultural development in Africa, specifically, and economic development more generally (Brown and Lall, 2006). Policies and programmes designed to improve agricultural productivity must acknowledge the many issues that limit crop yields and farm-level income. Efforts to address only one issue will not be successful.

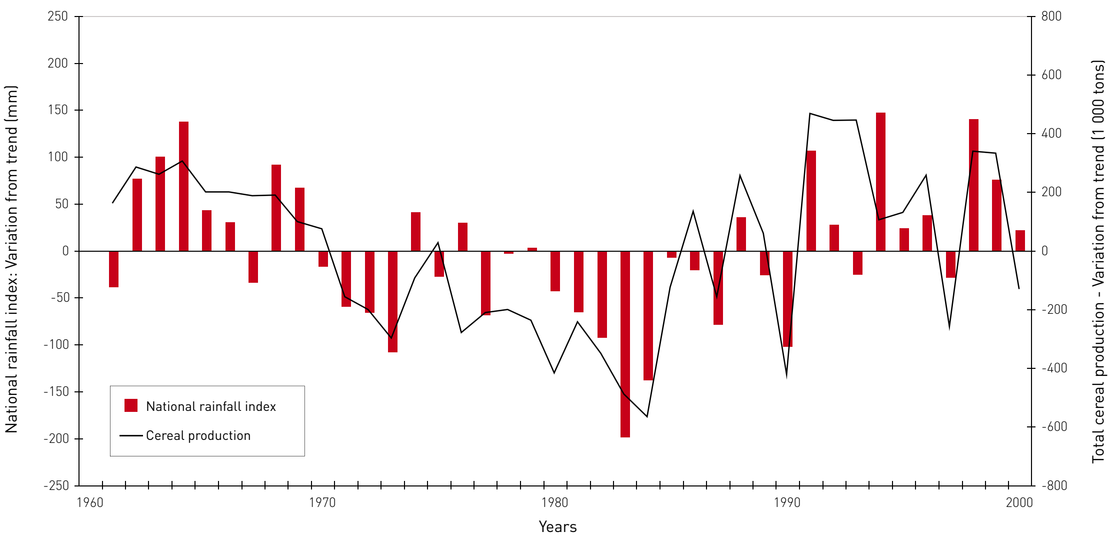
Adopting a broader approach to water control in agriculture

Much of the debate on the future of agriculture in SSA focuses on irrigated and rainfed agriculture. With slightly more than 3 percent of its cultivated land under irrigation, the region shows one of the lowest degrees of investment in irrigation among developing regions, and recent surveys do not show any sign of change, the annual increase in irrigation being slightly more than 1 percent in the period 1995–2005 (FAO, 2006a). The reasons for such situation are numerous and complex, and range from relatively low population density to lack of market access and incentives for agricultural intensification, to low quality soils, unfavourable topography, and inadequate policy environments.

These conditions seriously limit the economic feasibility of irrigation development projects, and recent studies have demonstrated that, on average, the cost of irrigation development in the region is substantially higher than in Asia (Inocencio *et al.*, 2007). While there is considerable scope for further development of irrigation in the region, it is now admitted that a much closer analysis of opportunities and markets is needed in order to ensure the success and sustainability of future irrigation investments (World Bank, 2007a), and that these investments must be accompanied by substantial policy and institutional changes.

As a result of this unfavourable situation, agriculture in large parts of the region remains highly dependent on climate. Figure 1 shows how cereal production in a semi-arid country (Burkina Faso) is extremely dependent on the seasonal variability of rainfall. Such a situation, which is common in several SSA countries, has induced planners to look for alternative ways of addressing the issue of climate dependency of rainfed agriculture in the region. Recently, the Comprehensive Assessment of Water Management in Agriculture (Molden, 2007) has suggested considering a "continuum" of water management practices, from purely rainfed to fully irrigated agriculture. Chapter 4 describes a range of such water management options in more detail and examines their potential range of application.

Figure 1 **Burkina Faso: rainfall and cereal production, 1960–2000**



Source: Molden (2007).

While broadening the scope of water control options offers a much wider choice, it should be clear that there is a direct relation between the level of water control and the cost of these different options. Therefore, the selection of the most appropriate water management options will involve a relatively complex cost–benefit analysis where benefits in terms of increased resilience of farming practices to climate shocks will probably be as important as those resulting from direct increases in production.

Key challenges and issues for the region: a long-term perspective

It is important to recognize the scale of the challenge and the broader issues involved. The population of SSA is expected to increase from 700 million in 2007 to 1 100 million in 2030 and 1 500 million in 2050, while daily food consumption per person is projected to increase from the current 2 200 kcal to 2 600 kcal in 2030 and 2 800 kcal in 2050 (FAO, 2006b). Hence, the region will require substantial increases in food supply in order to support the doubling of population by 2050 and the nearly threefold increase in calories consumed. Without such increases, undernourishment and poverty will increase. Projections indicate that the problem is likely to be particularly severe in countries such as Benin, Burkina Faso, Burundi, Niger and Uganda (Alexandratos, 2005).

The consumption of agricultural commodities in SSA is currently increasing at about 3.2 percent per year, while production increases at 3.0 percent per year, resulting in a net increase in imports of agricultural commodities. Consumption is projected to increase by 2.8 percent annually through to 2030, and by 2.0 percent from 2030 to 2050, while production is projected to increase by 2.7 percent and 1.9 percent in these periods, respectively (FAO, 2006b). The resulting gap may be partly filled by imports but, given the limited capacity of the rural poor to buy food, their situation could worsen as a result of the growing gap between production and consumption.

Increases in agricultural yields are believed to be possible in SSA. Alexandratos (2005) has built scenarios in which yields in 2050 are twice those in 2000. However, this will require significant investment in infrastructure, research, etc. However, if the alternative of not making such investments is likely to be large expenditures on food aid in the future, then the attractiveness of investment in agriculture is considerably enhanced.

In the long term, climate change may well represent an additional challenge to African agriculture. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) presents the state of knowledge on climate change and its impact on different sectors. While the level of uncertainty about possible impacts remains high, recent studies indicate potentially large negative impacts on agriculture in developing regions (Easterling *et al.*, 2007). Projections based on agro-ecological zoning indicate that, in most scenarios, arid and dry semi-arid areas in Africa will expand by about 5–8 percent as a result of climate change by 2080 (Shah, Fisher and van Velthuizen, 2008), and most models predict a decrease in good agricultural land in the region. Many SSA countries already showing a high prevalence of undernourishment are expected to see their cereal production potential reduced, while others will see this potential increase. However, the overall net balance in cereal production potential is expected to be negative in SSA, and negative impacts are expected on overall agricultural gross domestic product (GDP) for the region,

Increased climate variability and droughts may also affect livestock production, and there are risks that temperature increases combined with decreases in precipitation in some regions, including Southern Africa, will lead to increased losses of cattle. Furthermore, the combined increase in heat stress and lower precipitation holds the risk of increased water requirement for cattle in marginal areas, with possible expansion of water grazing around watering points. Potential impacts of climate change on inland fisheries and aquaculture include stress caused by increased temperature and oxygen demand, uncertainty about future water supply, possible negative impact of extreme weather events, and increased frequency of diseases (Easterling *et al.*, 2007).

In summary, temperature increase, associated with increased variability in precipitation and higher frequency of extreme events, is likely to affect agriculture, in particular in low-latitude regions. Smallholders and subsistence farmers in SSA countries, together with pastoralists and fishers, show extremely low resilience to shocks, and their adaptive capacity is generally constrained by their low level of livelihood assets. Therefore, they are most vulnerable to possible climate change and, in particular, to extreme events.

Adaptation by smallholders in SSA calls for increased resilience to shocks and reduced vulnerability. Financial and insurance mechanisms can play an important role in increasing farmers' resilience. However, for smallholders who consume most of their production, they can only provide limited support. Resilience building, in particular in drought-prone areas, implies increased buffering capacity through better management of soil moisture, and a combination of surface water and groundwater storage.

Bioenergy has been advocated as a possible new business opportunity for growth in rural tropical areas, an opportunity for countries to reduce their dependency on energy supply, and a climate-change mitigation opportunity. Little is known about the biophysical and socio-economic impacts of biofuel, and several questions remain. Besides the question of the net impact on greenhouse gas emission, concerns have been raised about the implications for smallholder farmers in developing countries. Future bioenergy-related policies will need to be designed carefully if they are to serve the rural poor and smallholder farmers, and they will need to be integrated with food security policies in order to avoid conflicting situations. In particular, such policies will need to guarantee adequate protection for the poor and positive implications for the food insecure, and develop safeguards to ensure overall environmental sustainability. Therefore, opportunities exist for rural producers, in particular in humid tropics, but the political environment in which bioenergy development takes place will dictate its impact on the rural poor.

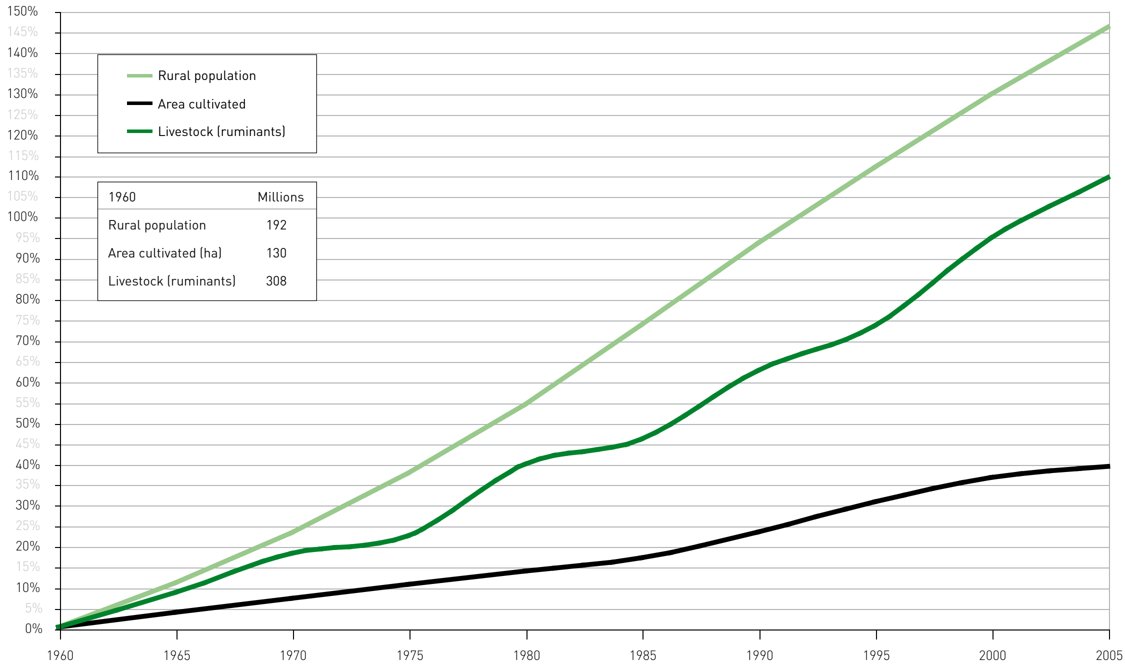
Mapping poverty, water and agriculture in sub-Saharan Africa

Population, natural resources and agriculture

The total area of SSA is 24 million km^2, about 18 percent of the world's landmass. The climate in SSA is influenced by the equator, by the two tropics, and by the two large deserts (the Sahara in the Northern Hemisphere, and the Kalahari in the Southern Hemisphere). Very different climates are in juxtaposition, ranging from very dry to wet equatorial by way of a more moderate climate.

The SSA region contains a total population of about 690 million people (UNDP, 2006), of whom more than 60 percent are classified as rural (Figure 2), higher than the world average (51 percent). In 2000, 300 million Africans, or more than one-quarter of the total population, had no access

Figure 2 **Growth of rural population, cultivated and livestock in sub-Saharan Africa, 1960–2005**



Note: Growth is expressed in percentage change from 1960.
Source: FAOSTAT (2007).

to drinking-water. In the same year, average life expectancy was 41 years in the region.

The region is relatively well endowed with natural resources. Some 234 million ha are cultivated – about one-quarter of the cultivable area. In the region as a whole, the arid and semi-arid agro-ecological zones make up 43 percent of the land area; the dry subhumid zone is equivalent to 13 percent, and the moist subhumid and humid zones jointly account for 38 percent. In West Africa, 70 percent of the total population live in the moist subhumid and humid zones, whereas in East and Southern Africa only about half of the population live in such areas (FAO and World Bank, 2001).

Despite the abundance of natural resources, average GDP per capita in constant prices was lower in 2004 than in 1975, a decrease of 0.6 percent for the period, which is modest but still remarkable for a period when virtually all other regions experienced significant real growth. About two-thirds of SSA countries are ranked among the lowest with respect to the Human Development Index (HDI). Of the 49 poorest countries (least-developed countries – LDCs) in the world, 34 are found in SSA, and income is highly unequally distributed. More than 40 percent of the region's population live on less than US$1 per day, while more than 70 percent have less than US$2/day. In the region as a whole, more than 40 percent of the total population fall below national poverty lines (UNDP, 2006).

Agriculture accounts for 20 percent of the region's GDP, employs 67 percent of the total labour force (FAO and World Bank, 2001), and is still the main source of international exports. Although SSA accounts for barely 1 percent of global GDP and only 2 percent of world trade (down from almost 4 percent in 1970), international trade contributes a relatively large share of regional GDP. Agriculture is the dominant export sector for East Africa (47 percent of total exports), and a significant source of exports in other areas of the region (14 percent of exports in Southern Africa, and 10 percent in West Africa). The region's main agricultural export commodities are cocoa, coffee and cotton. In the region as a whole, agricultural exports make up 16 percent of total exports, while agricultural imports (mainly cereals) account for about 11–15 percent of total imports. In the past three decades, the region has suffered massive losses from the erosion of its share of world trade, aggravated by substantially worsening terms of trade.

Overview of agricultural water management in the region

Annual precipitation in SSA is estimated at an average of 815 mm. Given the wide range of climates in the region, there are consistent disparities between countries, subregions and livelihood zones. Annual precipitation ranges from less than 100 mm in the Sahelian strip (less than 10 mm in northern Niger), eastern Namibia and parts of South Africa, to about 1 000–1 200 mm in the Eastern African highlands (Ethiopia) and in the Lake Victoria basin, and up to more than 2 000 mm in the Gulf of Guinea area (Liberia and Sierra Leone), Central Africa (Gabon and Equatorial Guinea) and Indian Ocean Islands (Mauritius and Seychelles). Central Africa receives almost 40 percent (more than 7 500 km^3/year) of the total precipitation in SSA in an area that accounts for about 23 percent of the total, while the Sudano-Sahelian area receives less than 14 percent of the precipitation in an area that accounts more than 35 percent of the region.

Annual internal renewable water resources for SSA amount to more than 3 880 km^3. Madagascar is the richest country in terms of water resources (5 740 m^3/ha/year). Gulf of Guinea and Central Africa are also well endowed subregions, with 4 490 and 3 520 m^3/ha/year, respectively. They account for 49 and 24 percent of SSA's water resources, respectively. The Sudano-Sahelian subregion is the most deprived with only 186 m^3/ha/year, with Mauritania having only 0.4 km^3/year (3.9 m^3/ha/year). Considering the availability of resources per capita, at country level, the most disadvantaged countries are Mauritania (130 m^3/inhabitant/year in 2005) and Niger (272 m^3/inhabitant/year in 2005), while Gabon, Congo and Equatorial Guinea enjoyed almost 120 000, 57 000 and 50 000 m^3/inhabitant/year, respectively, in 2005.

There has been a decrease in internal renewable water resources per inhabitant since 1960. From 1960 to 2005, owing to population growth, the average decreased from more than 16 500 to 5 500 m^3/inhabitant, with an average decrease of

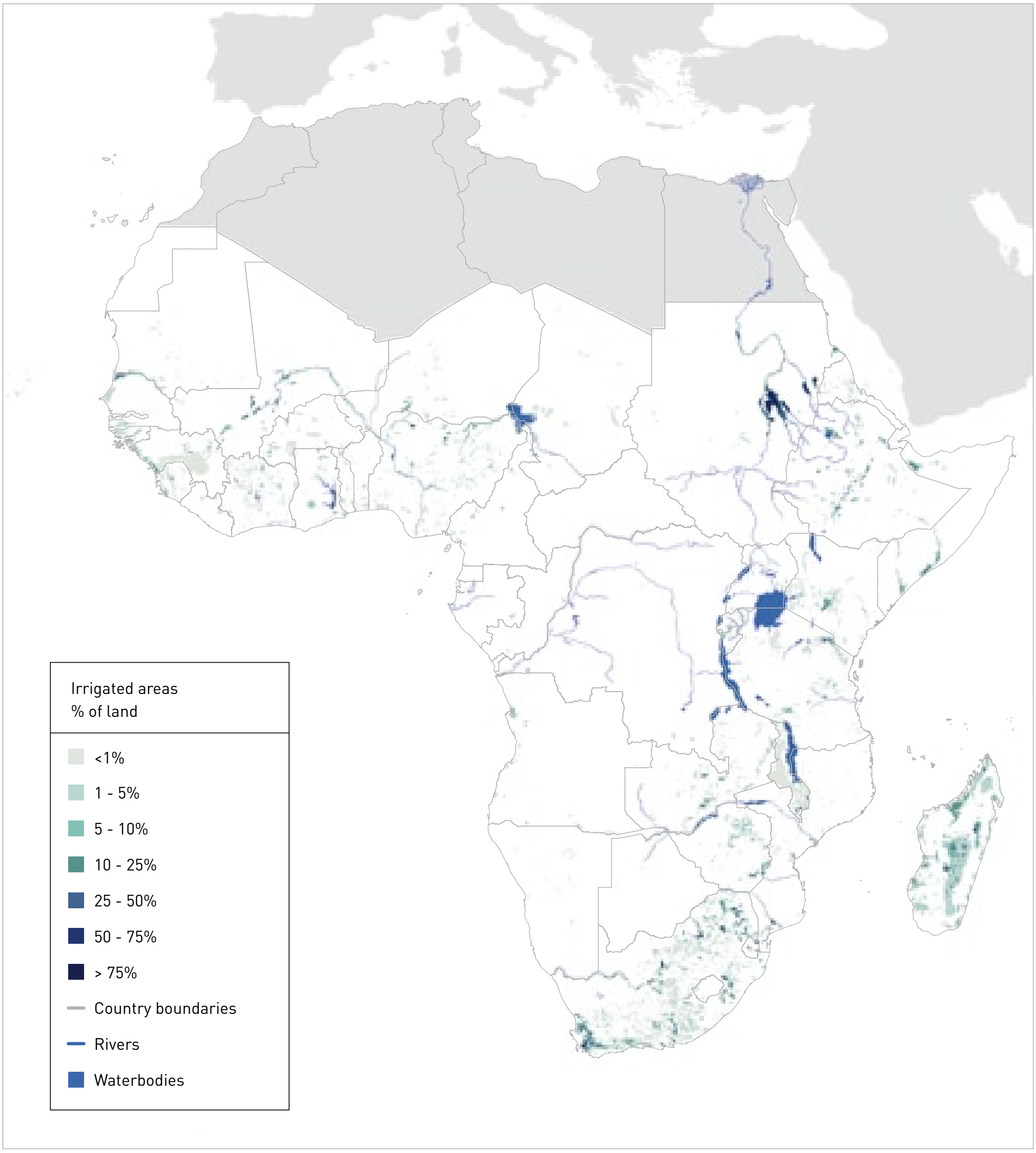
3

Table 2 Water and agriculture in sub-Saharan Africa

Variable	Unit	Sub-Saharan Africa	World	Sub-Saharan Africa as a % of the World
Total area	1 000 ha	2 428 795	13 442 788	18.1%
Estimated cultivated area 2007*	1 000 ha	234 273	1 865 181	12.6%
in % of total area	%	10%	14%	
per inhabitant	ha	0.34	0.29	
per economic active person engaged in agriculture	ha	1.25	1.15	
Estimated total population 2004**	1 000 inhabitants	689 700	6 389 200	10.8%
Population growth 2003–2004**	%/year	2%	1%	
Population density	inhabitants/km^2	28.4	47.5	
Rural population as % of total population***	%	62%	51%	
Economically active population engaged in agriculture	%	27%	21%	
Precipitation	km^3/year	19 809	110 000	18.0%
	mm/year	816	818	
Internal Renewable water resources	km^3/year	3 880	43 744	9.0%
per inhabitant	m^3/year	5 696	6 847	
Total water withdrawal	km^3/year	120.9	3 818	3.2%
agricultural	km^3/year	104.7	2 661	3.9%
in % of total water withdrawal	%	86.6%	70%	
domestic	km^3/year	12.6	380	3.3%
in % of total water withdrawal	%	10.4%	10%	
industrial	km^3/year	3.6	777	0.5%
in % of total water withdrawal	%	3.0%	20%	
in % of internal renewable water resources	%	3%	9%	
per inhabitant	m^3/year	171	598	
Irrigation	ha	7 076 911	277 285 000	2.6%
in % of cultivated area	%	3%	15%	

* Adapted from IIASA and FAO (2000)
**Adapted from UNDP (2006)
***This study
Source: FAO (2006c).

Figure 3 Irrigated areas in sub-Saharan Africa



more than 65 percent. Some countries have been particularly affected, such us Niger, Côte d'Ivoire and Uganda, with decreases of about 75 percent.

In regard to water use, total annual withdrawal of water from rivers, lakes and aquifers was about 121 km^3/year in 2004, about 170 m^3/year per capita. Agriculture is by far the main water user in comparison with domestic and industrial sectors, accounting for 87 percent of the total withdrawal, against 10 and 3 percent, respectively, for the other sectors. The average annual withdrawal from irrigated areas is about 15 000 m^3 per hectare of irrigation. Out of about 105 km^3/year from the agriculture sector, 48 percent is withdrawn in the Sudano-Sahelian subregion, which accounts for only 15 percent of domestic withdrawals. On the other hand, the Southern area accounts for only 15 percent of agricultural withdrawals but 42 percent of domestic ones. In the last 20 years, water withdrawal has increased considerably in the entire region as population and irrigated agriculture have expanded. Agricultural withdrawals have risen by more than 90 percent on average in the entire region, apart from the Southern subregion (which has almost reached the total irrigation potential and where the increase has been only 9 percent). Table 2 gives the basic agriculture and water-related data for the region and for the world, and Figure 3 shows the distribution of irrigation in SSA.

Mapping rural poverty in sub-Saharan Africa

Context

While substantial progress is being made towards achieving the Millennium Development Goal of eradicating extreme poverty and hunger in most of the developing world, very little progress is occurring in SSA, where poverty, hunger, and food insecurity have increased in recent years (Sanchez and Swaminathan, 2005).

Some 1 200 million people worldwide consume less than a "standard" US$1 a day – they are in dollar poverty. Forty-four percent of them live in South Asia, about 24 percent each in SSA and East Asia, and 6.5 percent in Latin America and the Caribbean. Seventy-five percent of the dollar-poor work and live in rural areas; projections suggest that more than 60 percent will continue to do so in 2025 (IFAD, 2001). In fact, the numbers of the rural poor are underestimated as official data overestimate the shift of the poor from the countryside to cities, further strengthening the case for a greater emphasis on rural poverty. A discussion on the different dimensions of poverty is given in Box 2.

Sixty-two percent of people in SSA live in rural areas. In Eastern and Southern Africa, it is estimated that rural poverty accounts for as much as 90 percent of total poverty, and about 80 percent of the poor still depend on agriculture for their livelihood. Although remote areas with marginal agricultural resources are poorer than other places, they have a low population density and, hence, account for a relatively low proportion of total poor people. Of even more concern, the total number of poor people is increasing (FAO and World Bank, 2001).

In the last three decades, undernourishment in SSA has increased significantly, to an estimated 200 million people in the mid-1990s and to about 400–450 million people today. In 1995–97, the average daily SSA diet contained 2 188 kcal/person/day compared with 2 626 kcal/person/day in developing countries as a whole (FAO and World Bank, 2001), and undernourishment had a higher incidence in rural areas than among urban dwellers.

In view of these data, there are good reasons to emphasize rural poverty reduction, and to redirect attention and expenditure towards agricultural development that generates employment. However, there are arguments to the contrary, i.e. that by promoting urban development and targeting urban poverty it is possible to address the problem of rural poverty as well. This would be true if public action were more cost-effective in reducing urban poverty than in reducing rural poverty; if the rural poor gained far more from urban poverty reduction than vice versa; if rural anti-poverty spending discouraged the poor from migrating; or if rural poverty reduction promoted less economic growth than urban poverty reduction.

Box 2 The multiple dimensions of poverty

Poverty can be seen as broad, multidimensional, partly subjective, variable over time, comprising capabilities as well as welfare, and in part relative to local norms, comparisons and expectations. In practice, most poverty measurement focuses on private consumption below an objective poverty line that is both fixed over time and defined in terms of an absolute norm for a narrow aspect of welfare, for example, defining poverty as deprivation of sufficient consumption to afford enough calories, or as dollar poverty. Most studies settle for a simple poverty measure because it can be compared among persons, groups, places and times in a testable way. This is important in evaluating poverty-reducing policies.

Poverty has both physical and psychological dimensions. Poor people themselves strongly emphasize violence and crime, discrimination, insecurity and political repression, biased or brutal policing, and victimization by rude, neglectful or corrupt public agencies (Narayan *et al.*, 1999). Some may feel poor or be regarded as poor if they cannot afford the sorts of things available to other people in their community. A review of 43 participatory poverty assessments from four continents concluded that poor people report their condition largely in terms of material deprivation: not enough money, employment, food, clothing and housing, combined with inadequate access to health services and clean water; but they are also liable to give weight to such non-material factors as security, peace and power over decisions affecting their lives (Robb, 1999).

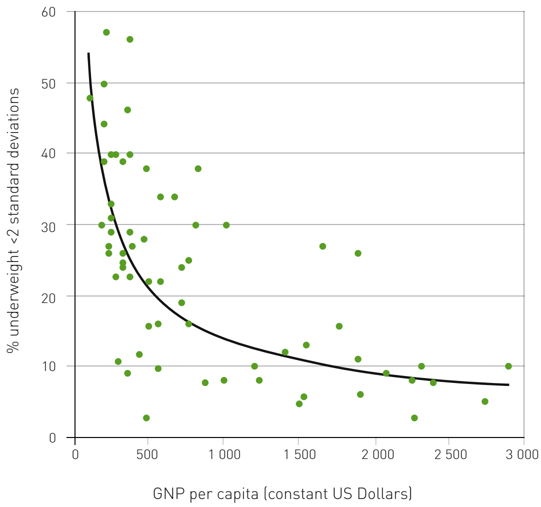
It is necessary to be able to measure poverty consistently in order to make comparisons. Measuring poverty helps policy-makers to target resources to reduce poverty and helps them, and others, to assess progress in reducing poverty. Poverty can be measured in three ways: (i) a scalar approach using a single indicator, such as income or consumption; (ii) a multidimensional-indexed approach, where several indicators are combined in a single index of poverty; and (iii) a vector multidimension, where several indicators are used to classify people as poor on each indicator (e.g. income poor but health non-poor).

Child malnutrition as an indicator of poverty

In spite of the general acceptance of the five livelihood assets, there is no international consensus on what poverty is and how it should be measured. The most commonly used poverty indicator, income level, is of limited value as it does not take into account the multidimensional nature of poverty. Thus, although an income-based or expenditure-based measure of poverty will remain an important indicator, nutrition-based measures are more appropriate for this study. As a measure of rural poverty, this study has adopted the child malnutrition indicator (below). Child malnutrition represents a good proxy of rural poverty and food insecurity (Setboonsarng, 2005).

Health is recognized as another, perhaps more encompassing, dimension of poverty in its own right, and child health is known to have significant long-term effects on human productivity during adulthood. Malnutrition has long been recognized as a consequence of poverty. It is widely accepted that higher rates of malnutrition will be found in areas with chronic widespread poverty (ADB, 2001). Malnutrition is the consequence of limited dietary intake compounded by infection. In turn, limited dietary intake is caused by household food insecurity, lack of safe drinking-water, lack of knowledge on the basics of sanitation, and lack of alternative sources of income. Health condition as reflected by level of malnutrition encompasses all these dimensions.

Figure 4
Relation between GNP per capita and percentage of underweight preschool children



Source: World Bank (2000).

A significant advantage of using child malnutrition as a poverty indicator over income level is that this measure does not have to be adjusted for inflation and would not be affected by any gaps or distortions in the price data. Measuring child nutrition can help capture aspects of welfare that are not sufficiently revealed in other indicators. Child malnutrition standards are universal and pertinent across cultures. Nevertheless, it is important to recognize that there is a strong correlation between income level and nutritional status. Studies show that the relationship is especially strong at the lower incomes. The data assessment of gross national product (GNP) per capita and the prevalence of underweight preschool children from the World Development Report shows that the lower the GNP the higher the likelihood of having a higher incidence of underweight children (Figure 4).

Measuring and mapping rural poverty

The indicator of rural poverty used in this study has been produced by combining several datasets:

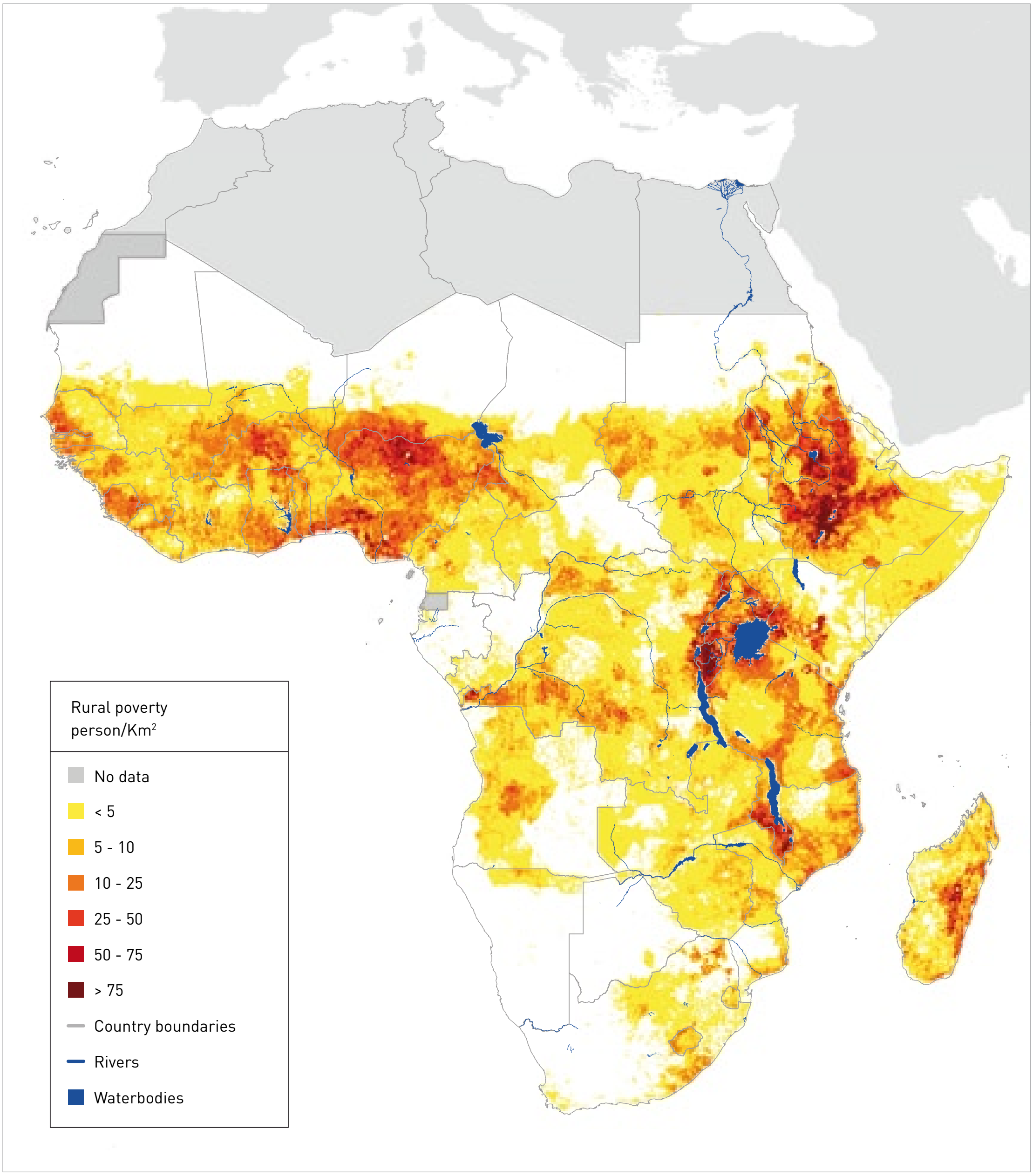
- As part of the Poverty Mapping Project, FAO prepared a Food Insecurity, Poverty and Environment Global GIS Database (FAO-FGGD, 2008) for global analysis of food insecurity and poverty in relation to environment. One of the maps in the database is the FGGD high-resolution rural population density map. This dataset is a global raster data layer with the number of persons per square kilometre in rural areas around the year 2000. The method used to generate this data layer is described in FAO (2006d).

- The child malnutrition dataset was developed by the Center for International Earth Science Information Network (CIESIN, 2008). Children are defined as malnourished if their weight-for-age is more than two standard deviations below the median of the NCHS/CDC/WHO International Reference Population. Prevalence of child malnutrition is expressed as the number of underweight children of 0–5 years old as a percentage of the total number of children of 0–5 years old. The dataset has aggregated data at a subnational level.

- The CIESIN data have been differentiated between rural and urban poverty by using data from the Demographic and Health Survey (DHS, 2008). Country-level data are available for about 55 countries. The findings for the available countries were extrapolated for countries without data. The data were randomly checked against data from the global database of the World Health Organization (WHO) on child growth and malnutrition. Where necessary, corrections were made. The result of this exercise was a map of rural child malnutrition.

Finally, the FGGD rural population density map was multiplied by the dataset on rural child malnutrition to obtain a dataset with the distribution of rural poor at the end of the twentieth century,

Figure 5 **Distribution of rural poverty in sub-Saharan Africa**



expressed as persons per square kilometres, on a grid with a resolution of 30 arc seconds, about 0.85 km^2. The results are presented in Figure 5, which shows how rural poverty is distributed in SSA. It is spread all around the region with a particular concentration in the Eastern African highlands of Ethiopia and the Lake Victoria basin as well as in Madagascar and in the Gulf of Guinea, with particular emphasis in Nigeria, given the high density of rural population. This measure of poverty incidence is represented by the number of rural poor, i.e. malnourished children, but it does not show the degree and depth of rural poverty – i.e. how "deep" their poverty is in terms of how far below the poverty line a group of individuals lies.

Mapping livelihoods in rural areas

This study has adopted livelihood zoning as a conceptual baseline for its analyses. Livelihood zoning consists in identifying areas with homogeneous livelihood conditions, which are formed by considering both biophysical and socio-economic determinants. The main criteria are: the predominant livelihood activities in an area or region; the natural resources available to people; and the prevailing agroclimatic conditions. Patterns of livelihood vary from one area to another. Local factors such as climate, soil and access to markets all influence livelihood patterns. Therefore, the first step of the analysis is to delineate geographical areas within which people share basically the same patterns of access to food (i.e. they grow the same crops, keep the same types of livestock, etc) and have the same access to markets.

In addition to identifying similar patterns of access to food, it is important to recognize that mapping livelihoods at different scales follows different criteria and parameters. Livelihoods can be characterized at regional level differently from country or local levels. For example, at the regional level, given the heterogeneity of large-scale livelihoods, livelihood mapping in rural areas will be based predominantly on the agroclimatic conditions that dictate major farming practices, while such a scale will make it difficult to account for the variety of socio-economic conditions that influence livelihoods locally. Scaling down to the

Figure 6 **Characterizing livelihood zones at different scales**

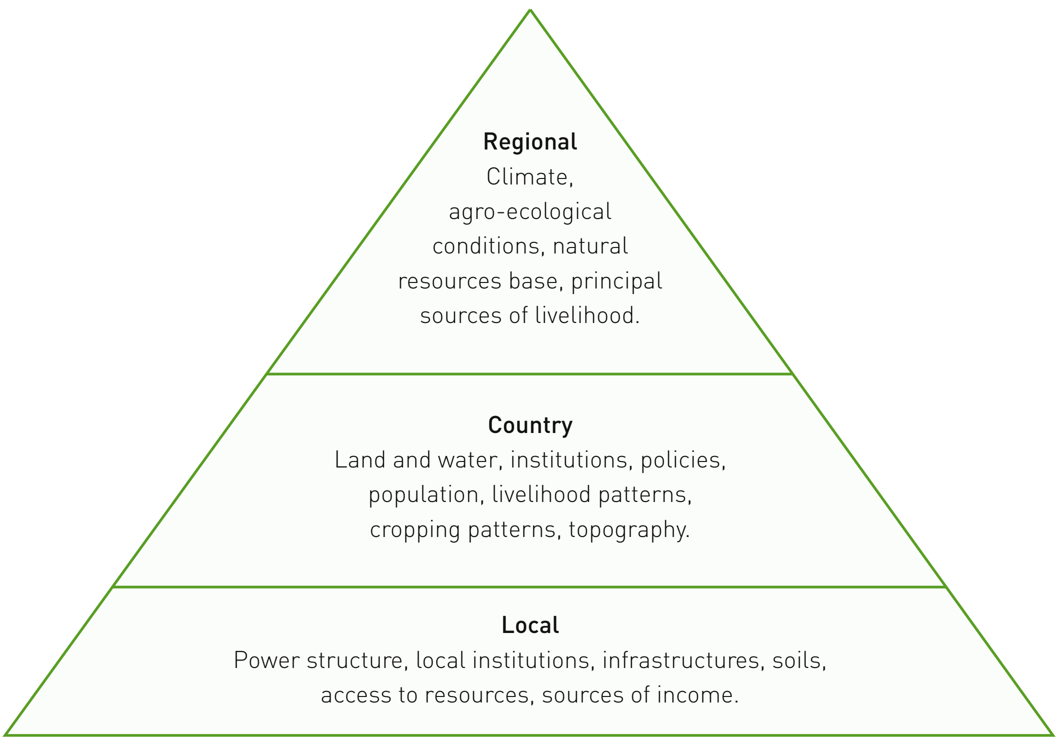


Table 3 Main factors determining livelihood zones at different scales

Parameters	Regional	Country	Local (district, community, village)
Climate	high	low	n.a.
Agro-ecology	high	low	n.a.
Natural resources base	moderate/high	moderate/high	n.a.
Soils	low/moderate	moderate/high	moderate
Topography	low	moderate/high	high
Cropping systems	moderate	high	moderate
Livelihood patterns	low	high	high
Population	low	high	low/moderate
Institutions	n.a.	high	moderate/high
Policies	n.a.	high	moderate/high
Infrastructures	low	moderate	high
Access to markets	n.a.	moderate	high
Access to resources	n.a.	moderate	high
Farm size	low	moderate	high
Power structure	n.a.	low	high

country and local levels, such socio-economic conditions, together with political and institutional parameters, can be taken into account in the delineation of zones of homogenous livelihoods.

Different livelihood options are available to different people depending on where they live (the agro-ecological zone) and the resources they have (land, other infrastructure assets, financial resources, labour, social network, etc.). The possibilities are many but not unlimited; in fact, the range of options is rather limited. People produce food, they exchange things for food, or they earn cash to buy food. Patterns become evident. Once it is evident that a group of people in a certain area share a predominant way of securing their food, then it is possible to characterize the area as, for example, a maize farming zone, or, conversely, as a camel pastoralist zone (USAID, 2008). Figure 6 and Table 3 show the different parameters at the different scales that enable the identifying, mapping out and characterizing of homogeneous livelihood zones.

From farming system mapping to livelihood zoning

Previous works aiming at better targeting development interventions to support rural poverty reduction have used the concept of farming systems as the main source of livelihood for rural people. FAO and World Bank (2001) have proposed a division of the world's developing countries into 70 major farming systems as a basis for understanding the challenges and opportunities faced by rural people in their attempt to escape from poverty and hunger. They define farming systems as "a population of individual farm systems that have broadly similar resources bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate". The activities of any farm within a zone are strongly influenced by the external rural environment, the social network, the institutional context, and market access and linkages. Farms are organized to produce food and to meet other household targets through the management of available resources within the existing social, economic and institutional context. Moreover, farms within rural context are strongly linked to the off-farm and labour economy as well as being interdependent on the urban economy. Off-farm activities make a considerable contribution to the livelihoods of many farms and households.

Depending on the scale of the analysis, a farming system can encompass a few dozen or many millions of households. FAO and World Bank, (2001) recognize that at regional and global levels, a trade-off must be found between the necessity to present and analyse a limited number of broad categories of systems, and the complexity and heterogeneity of local farming situations, which would normally lead to the identification of a large number of discrete, microlevel systems. In so doing, and while recognizing the range of elements that influence household livelihood patterns, they base their classification of farming systems mainly on the available natural resources base, and related dominant patterns of farm activities. In the case of SSA, agroclimatic conditions represent by far the most important factor used in the definition of major regional farming systems.

This report argues that a strong correlation exists between the livelihood zones used in this report and farming systems as defined by FAO and World Bank (2001). While it is important to recognize the dynamics of rural livelihood patterns and the increasing importance of off-farm activities in the household economy, the fact is that, in SSA, farming-based activities remain the primary source of livelihood for rural households, either directly or indirectly. Given this strong correlation and the need to identify a manageable number of distinct livelihood systems, this study has adopted the classification of FAO and World Bank (2001) as the basis for its regional livelihood zoning map (although the boundaries of some zones have been slightly modified on the basis of more recent data). While such a reductive approach is helpful in terms of regional analysis, it should be recognized that the range of assets and constraints and the heterogeneity of situations that characterize livelihoods in rural areas goes much beyond farming considerations.

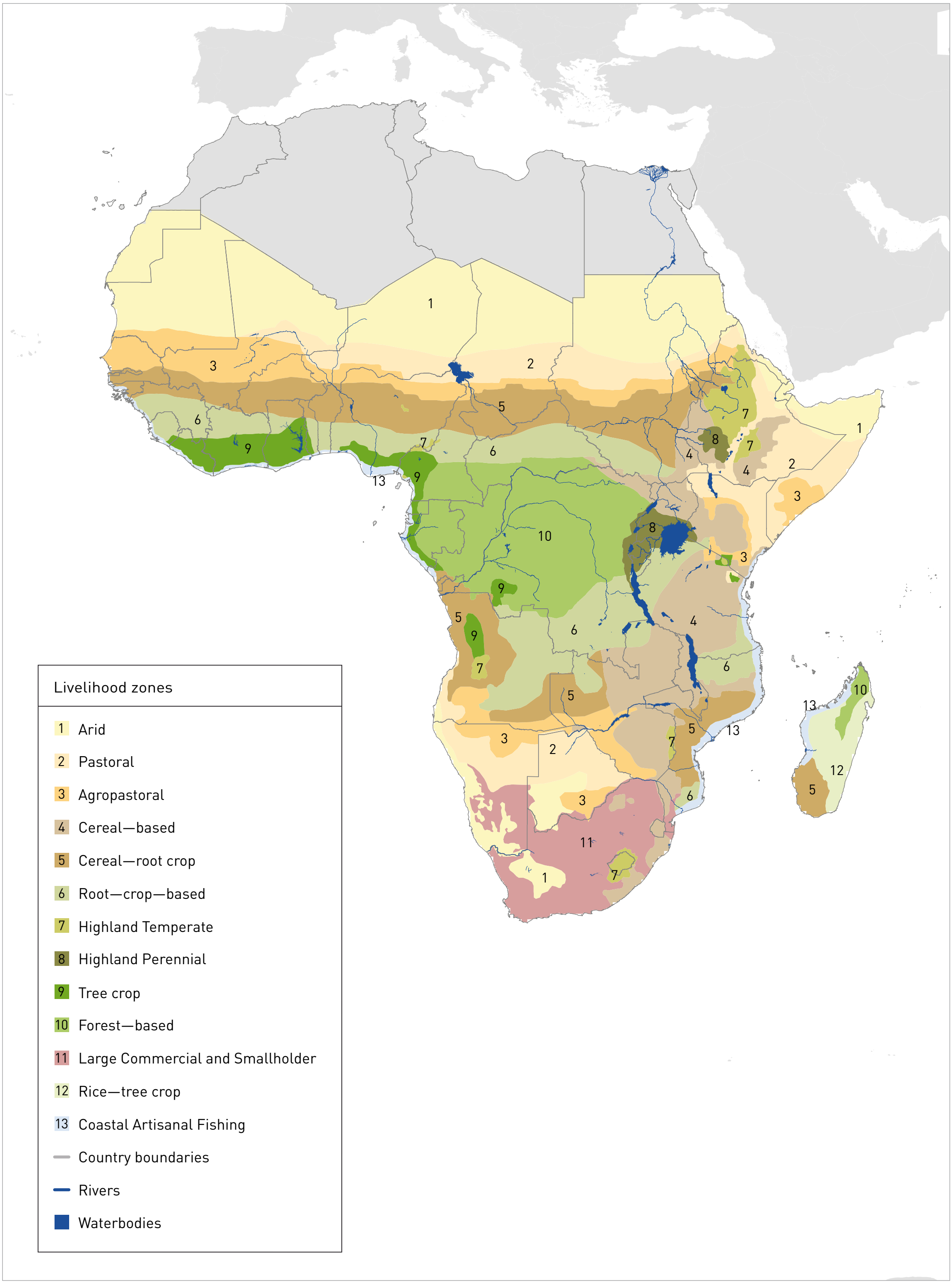
Main livelihood zones and their relation to water in sub-Saharan Africa

Adapting the farming-system maps described above for SSA, 13 regional livelihood zones have been delineated and used as main mapping units for the analysis (Figure 7). The combination of these units with other spatial datasets has enabled to them be characterized in terms of natural resources (land, water and livestock), population and land use and existing spatial linkages among them to be identified.

To these 13 major livelihood zones should be added two small but locally relevant zones: irrigated zones, and peri-urban zones. Given their small size and scattered distribution, these zones have not been mapped out. A detailed description of these 15 livelihood zones is provided in Annex 1. These 15 zones can be grouped into four broad categories:

- Zones characterized by rainfed conditions:
  - rainfed zones in humid areas of high resource potential, characterized by crop activity (notably root crops, cereals, industrial tree crops – both small scale and plantation – and commercial horticulture) or mixed crop–livestock zones;
  - rainfed zones in steep and highland areas, which are often mixed crop–livestock zones;
  - rainfed zones in dry or cold low-potential areas, with mixed crop–livestock and pastoral zones merging into sparse and often dispersed zones with very low current productivity or potential because of extreme aridity or cold.
- Zones characterized by irrigated conditions:
  - irrigated livelihood zones, located around irrigated areas and based on a broad range

Figure 7 Main livelihood zones in sub-Saharan Africa



of food and cash crop production, e.g. vegetables, cotton, rice, and sugar cane;
  - wetland conditions: wetland rice-based livelihood zones, dependent on monsoon rains supplemented by irrigation.
- Zones characterized by farm size and management:
  - dualistic (mixed large commercial and smallholder) livelihood zones, across a variety of ecologies and with diverse production patterns.
- Other zones:
  - coastal artisanal fishing zones;
  - peri-urban zones.

Analysing poverty, water and agriculture across livelihood zones

For the purposes of this study, issues relating to water and rural poverty have been analysed and mapped out in each livelihood zone in order to define linkages and identify the potential of each zone in terms of water development and poverty reduction through water interventions.

Rural poverty

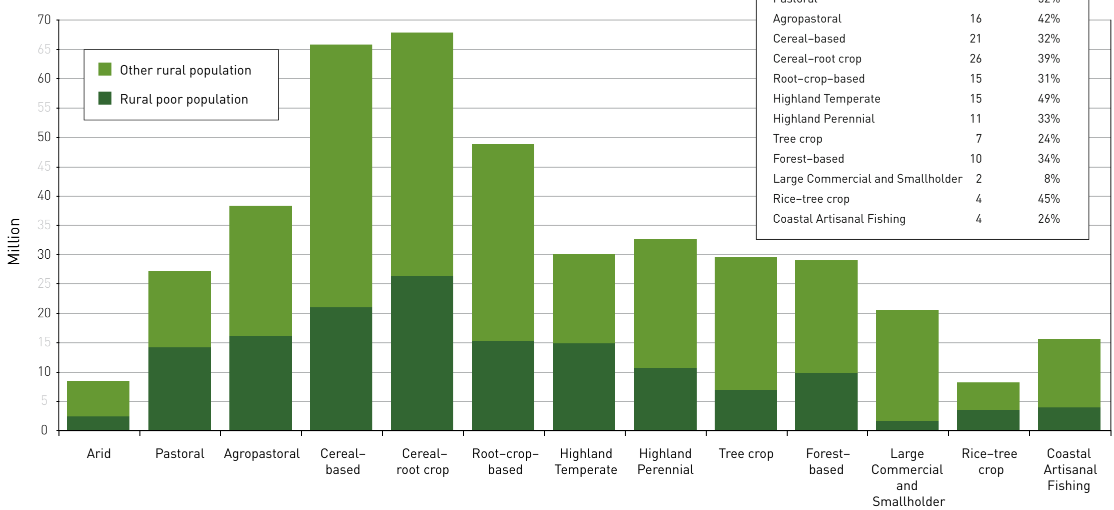
As shown in Figure 5, the rural poor are spread out across the region with a higher concentration in East Africa, the Lake Victoria basin, Madagascar and the Gulf of Guinea.

Figure 8 shows that, in absolute terms, the cereal–root crop zone and the cereal–based zone host the largest number of rural poor, with 26 and 21 million, respectively. This is principally because of the large area and rural population of these zones. Although droughts can occur, poverty is not mainly driven by climate variability in these zones. It is also related to socio-economic factors, such as very small farm size or landlessness, lack of oxen, low off-farm income, and deteriorating terms of trade for maize producers (FAO and World Bank, 2001).

In relative terms, the pastoral zone is the one with the highest share of rural poor (more than 50 percent of rural population is poor). As in the agropastoral zone (42 percent are poor), the main sources of poverty appear to be climate variability and a high vulnerability to droughts. These zones

3

Figure 8
Poor as part of rural population in livelihood zone of SSA



Livelihood zone	Rural poor: Million	Rural poor: % of rural population
Arid	2	28%
Pastoral	-	52%
Agropastoral	16	42%
Cereal–based	21	32%
Cereal–root crop	26	39%
Root–crop–based	15	31%
Highland Temperate	15	49%
Highland Perennial	11	33%
Tree crop	7	24%
Forest–based	10	34%
Large Commercial and Smallholder	2	8%
Rice–tree crop	4	45%
Coastal Artisanal Fishing	4	26%

present similar features – climate represents the main driver for rural poverty resulting in crop failure (in agropastoral areas), famines and food shortages, and livestock weakness, which leads to deaths and price falls. Besides droughts, rural poverty is aggravated by low levels of assets. Better-off households are food secure even in most bad years because their abundant livestock can compensate the lack or loss of grain. Households in the lower stratum are chronically food insecure in both good and bad years because they cannot grow enough grain to feed themselves, and they do not have enough livestock or other assets to exchange for grain. Poverty is also exacerbated by physical isolation and, consequently, the lack of infrastructure, access to markets and health facilities. However, insufficient access to water is a crucial element determining rural poverty.

The highland temperate zone presents severe poverty both in relative and absolute terms. Political instability, migrations and civil conflicts have had a strong impact on the rural poor population of this area. In addition, interannual variability in rainfall has caused several droughts in the last 20 years and, as a result, wide fluctuations in agricultural production have been observed. This has contributed to famines that have been responsible for increases in poverty and a considerable narrowing of the horizons of the country's rural households.The zone is also characterized by ineffective and inefficient agricultural marketing, inadequate production technologies, a lack of developed transport and communication networks, and limited access of rural households to support services. These factors, combined with a lack of participation by the rural poor in decisions that affect their livelihoods, contribute to maintaining high levels of rural poverty.

The rice–tree crop zone also contains a significant percentage of rural poor although the absolute number is limited. Farmers in this zone eke out a living under subsistence agriculture, whose products are hardly enough to feed their families. The average size of a family plot is small (1–1.5 ha). With the population growth in Madagascar, this situation has been aggravated further, and malnutrition has increased. The isolation of the rural population and the lack of adequate infrastructure and markets also contribute to make living conditions hard.

Agriculture and water

In the last 40 years, the cultivated area has expanded at an annual rate of nearly 0.75 percent. This has mostly happened through conversion of forest and grasslands and shortening of fallows. Up until 2030, cultivated land is projected to expand more slowly, but the actual rate of expansion will depend upon the future evolution of livelihood zones (FAO and World Bank, 2001).

The Global Agro-Ecological Zones (GAEZs) dataset developed by the International Institute for Applied Systems Analysis (IIASA) and FAO (IIASA and FAO, 2000) provides spatially distributed information on "cropland", defined as a land cover type. This study has adopted cropland as defined in the GAEZ assessment as the best geo-referenced approximation for cultivated land. However, at the level of the region, there is a discrepancy between the GAEZ cropland area (234 000 ha) and official data on cultivated land (arable and permanent crops, 210 million ha in 2005) as provided by FAOSTAT-2008.

As shown in Figures 9 and 10, cultivated land is mainly concentrated in the agropastoral, cereal–root crop, and cereal–based zones. They account for almost 60 percent (130 million ha) of the total cultivated land in the region, and cover nearly 30 percent of the total land. The cereal–based zone serves as the food basket of the East and Southern Africa region. Both local and hybrid maize is grown (the former often being preferred for home consumption because of its better taste in spite of lower yields) (FAO and World Bank, 2001).

Table 4 Poverty, water and agriculture in livelihood zones of sub-Saharan Africa

Livelihood zone	Area (1 000 Km^2)	Rural population (1 000)	Rural poor (1 000)	Area cultivated (1 000 ha)	Pasture (1 000 ha)	Livestock (1 000 ruminants)	Irrigated areas (1 000 ha)	Irrigation potential (1 000 ha)	Anthropogenic pressure on water resources*	Irrigated areas/ Irrigation potential
Arid	5 144	8 342	2 332	1 545	33 607	8 368	780	2 088	78.4%	37.3%
Pastoral	2 692	27 245	14 129	10 150	190 594	24 224	1 202	2 042	40.8%	58.9%
Agropastoral	2 132	38 432	16 208	42 464	148 440	35 174	917	2 300	8.1%	39.9%
Cereal-based	2 452	65 901	20 912	36 038	137 440	24 497	624	5 182	2%	12%
Cereal-root crop	3 174	67 942	26 434	51 624	194 555	38 576	448	7 759	1%	5.8%
Root-crop-based	2 810	48 712	15 227	28 806	128 651	16 240	187	8 640	0.2%	2.2%
Highland Temperate	439	30 034	14 816	10 275	27 509	12 378	174	1 768	2%	9.8%
Highland Perennial	320	32 755	10 795	7 080	9 883	6 255	54	833	0.8%	6.5%
Tree crop	732	29 625	7 035	13 683	23 944	4 186	116	2 512	0.4%	4.6%
Forest-based	2 624	29 170	9 991	11 007	58 514	3 328	92	6 722	0.1%	1.4%
Large Commercial and Smallholder	1 228	20 439	1 585	15 268	78 494	12 833	1 418	1 390	24.5%	100%
Rice-tree crop	309	8 052	3 654	2 701	20 803	1 153	694	780	4.7%	88.9%
Coastal Artisanal Fishing	387	15 558	4 035	3 631	13 921	1 967	374	1 113	1.7%	33.6%

*Agricular water withdrawal / Total available runoff

Figure 9 **Cultivated land (rainfed and irrigated) of sub-Saharan Africa**

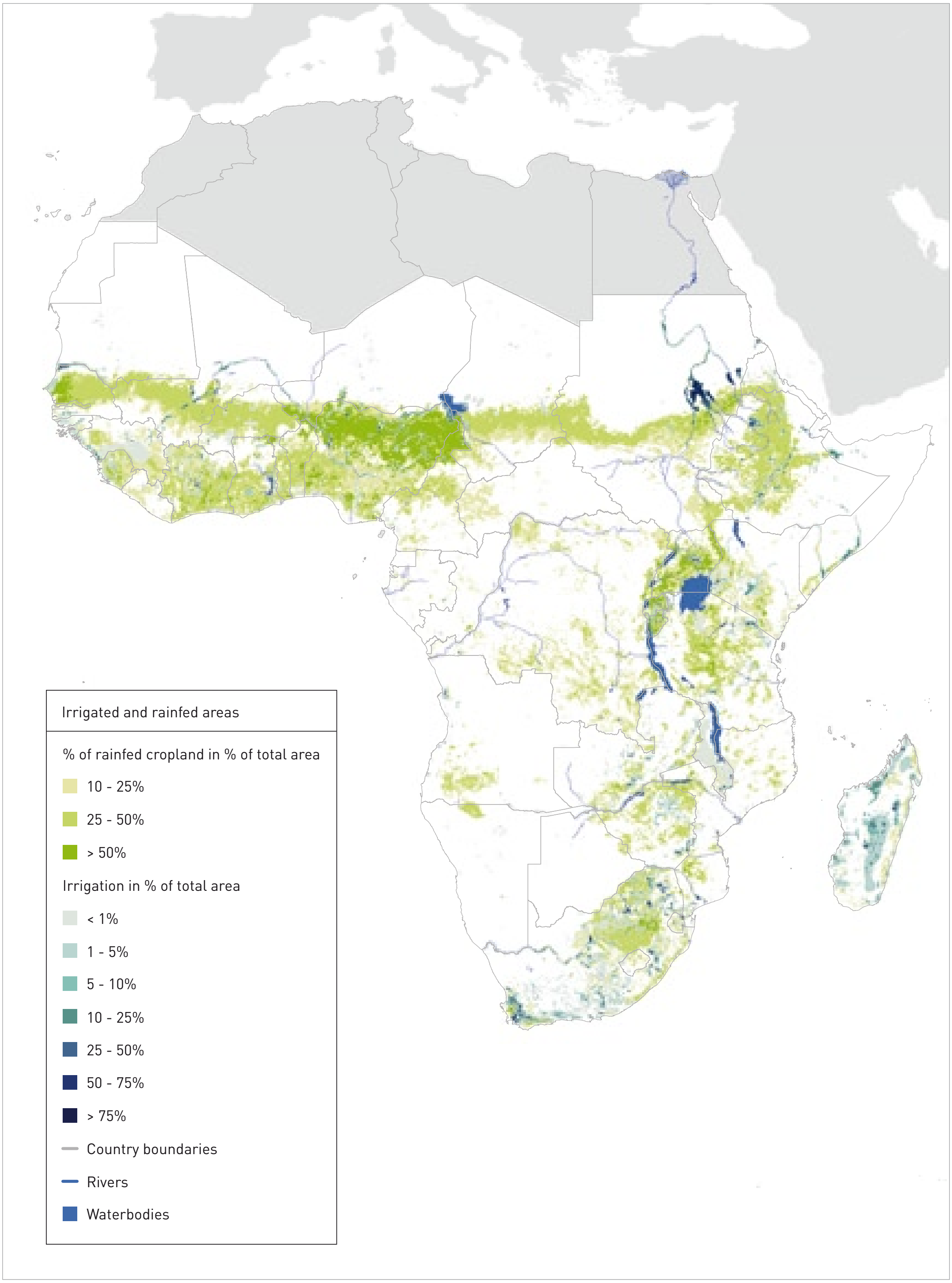
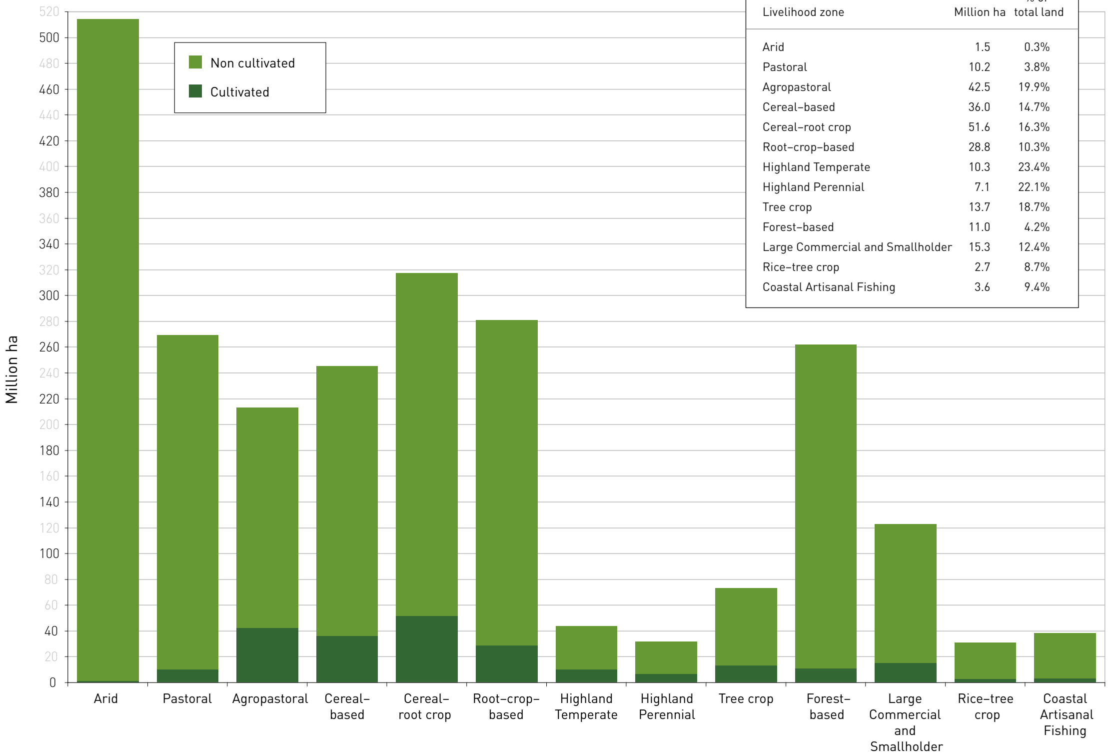


Figure 10 **Cultivated land in livelihood zones**



Livelihood zone	Cultivated land Million ha	Cultivated land % of total land
Arid	1.5	0.3%
Pastoral	10.2	3.8%
Agropastoral	42.5	19.9%
Cereal–based	36.0	14.7%
Cereal–root crop	51.6	16.3%
Root–crop–based	28.8	10.3%
Highland Temperate	10.3	23.4%
Highland Perennial	7.1	22.1%
Tree crop	13.7	18.7%
Forest–based	11.0	4.2%
Large Commercial and Smallholder	15.3	12.4%
Rice–tree crop	2.7	8.7%
Coastal Artisanal Fishing	3.6	9.4%

This zone, together with the cereal–root crop and agropastoral zones, produces the majority of cereals that are consumed in the region.

In terms of resources available for the rural population, the agropastoral zone has by far the highest amounts of both cultivated land and livestock available per head of population, accounting for more than 1.1 ha/person of land and more than 900 head of livestock per 1 000 people. Crops and livestock are of comparable importance in this livelihood zone (Figure 11).

Although the cereal–root crop zone shares some characteristics with the cereal–based zone (mainly the length of growing period), the former has certain characteristics that set it apart:

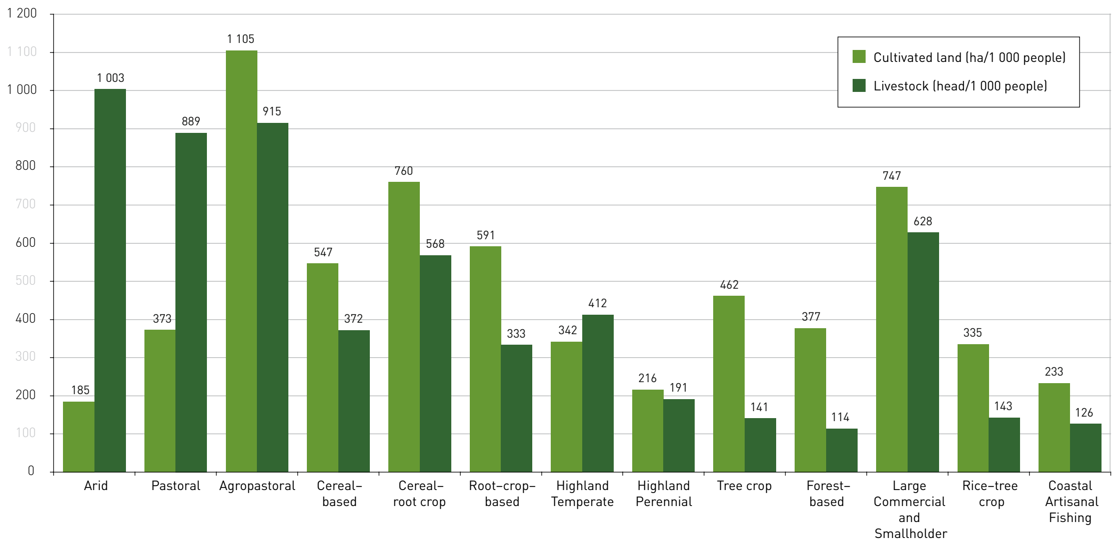
- a relatively low population density;
- abundant cultivated land;
- poor communications;
- lower altitude;
- higher temperatures;
- the presence of a tsetse challenge that limits livestock numbers and prevents the use of animal traction in much of the area (FAO and World Bank, 2001).

The high density of the rural population in the cereal–based zone implies a limited availability for people of both cultivated land and livestock. Finally, livestock numbers per capita are high mainly in the arid, pastoral and agropastoral zones, reflecting their livelihood nature.

Irrigation and water resources

Although renewable water resources in SSA are abundant in overall terms, they are very unequally distributed in time and space. Despite the shortage in many areas, water control is gener-

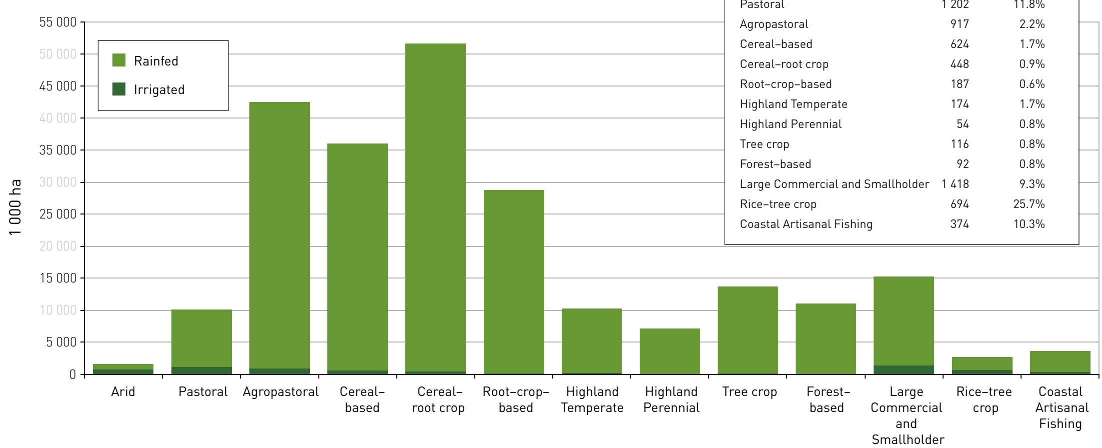
Figure 11 **Land and livestock resources available to rural people in livelihood zones**



ally limited and irrigation plays a minor role in the region. Rainfed farming covers most of the region's cropland (97 percent) and produces most of the region's food. Figure 12 shows the relatively marginal importance of irrigation in SSA agriculture. Water remains an untapped resource for the majority of the region – the actual irrigation area represents only 20 percent of the irrigation potential as estimated by FAO.

Figure 13 shows the irrigation potential that is unexploited in the majority of the livelihood zones. In some zones, abundant and regular precipitations explain the limited investments in irrigation. In other zones, particularly the rice–tree crop, pastoral, arid, and large commercial and smallholder zones, where irrigated agriculture is significant in rural population livelihoods, have almost reached the limit of their potential, and

Figure 12
Irrigated land in relation to total cultivated land in livelihood zones



Livelihood zone	Irrigated area 1 000 ha	Irrigated area % of cultivated land
Arid	780	50.5%
Pastoral	1 202	11.8%
Agropastoral	917	2.2%
Cereal–based	624	1.7%
Cereal–root crop	448	0.9%
Root–crop–based	187	0.6%
Highland Temperate	174	1.7%
Highland Perennial	54	0.8%
Tree crop	116	0.8%
Forest–based	92	0.8%
Large Commercial and Smallholder	1 418	9.3%
Rice–tree crop	694	25.7%
Coastal Artisanal Fishing	374	10.3%

Livelihood zone	Irrigated ares 1 000 ha	Irrigated ares % of irrigation potential
Arid	780	37%
Pastoral	1 202	59%
Agropastoral	917	40%
Cereal–based	624	12%
Cereal–root crop	448	6%
Root–crop–based	187	2%
Highland Temperate	174	10%
Highland Perennial	54	6%
Tree crop	116	5%
Forest–based	92	1%
Large Commercial and Smallholder	1 418	100%
Rice–tree crop	694	89%
Coastal Artisanal Fishing	374	34%

Figure 13 **Irrigated land in relation to potential in livelihood zones**

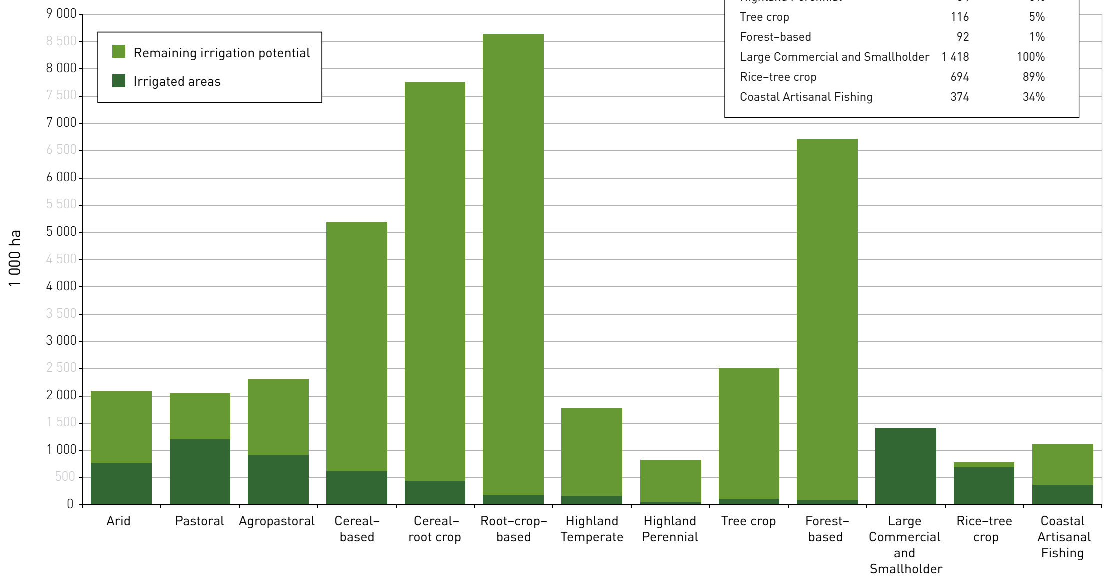
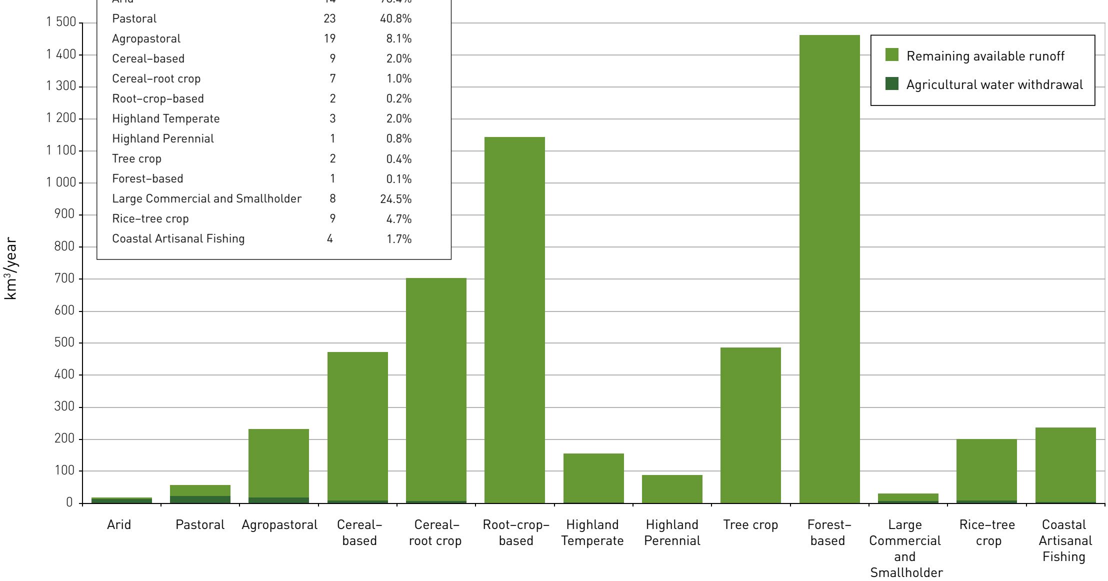


Figure 14
Agricultural pressure on water resources in SSA in livelihood zones

Livelihood zone	Agricultural water withdrawal Km³/yr	Agricultural water withdrawal % of available runoff
Arid	14	78.4%
Pastoral	23	40.8%
Agropastoral	19	8.1%
Cereal–based	9	2.0%
Cereal–root crop	7	1.0%
Root–crop–based	2	0.2%
Highland Temperate	3	2.0%
Highland Perennial	1	0.8%
Tree crop	2	0.4%
Forest–based	1	0.1%
Large Commercial and Smallholder	8	24.5%
Rice–tree crop	9	4.7%
Coastal Artisanal Fishing	4	1.7%



further development of water control may be limited. However, other zones, such as the agropastoral and pastoral ones, where there is a strong human pressure on the limited water resources, might explore other forms of water control, such as soil moisture management, water harvesting and livestock watering. Figure 14 shows that the magnitude of unexploited water resources is substantial in most zones. Table 4 summarizes the data on agriculture, land, water and poverty in the different livelihood zones of SSA.

Assessing the potential for poverty reduction through water interventions

While not always the main limiting factor, water is a crucial input for boosting agricultural production and other water-related livelihood activities. To achieve the greatest efficiency in the use of resources, water investment policies should take into consideration where water interventions can make a difference for rural livelihoods. In other terms, such interventions should be directed to livelihood zones where water is central to mitigating rural poverty.

To this purpose, identifying the areas with the highest potential for water-related interventions to reduce rural poverty becomes of great importance. Given the prevalence of agriculture in SSA livelihoods, the potential for poverty reduction through water should be assessed mainly on the basis of agricultural needs. However, it is important to recognize that water plays a key role in multiple aspects of rural livelihoods. Therefore, agricultural water interventions should be accompanied by complementary interventions that recognize such uses. Different water interventions suit different areas according to the agro-ecological and livelihood conditions. Areas with high potential and extensive poverty should be targeted for such interventions. Contrary to some conventional wisdom, targeting arid and semi-arid agro-ecological zones, despite apparent need, is not necessarily the most effective poverty-reducing option. Greater scope for reducing poverty and hunger, in terms of population density, incidence of poverty, and agricultural potential, might exist in areas of high potential, such as subhumid and humid zones, while alternative livelihood programmes might be needed in areas with less agricultural potential.

On the basis of the livelihood zones described and mapped out in the region and on that of the analysis of poverty, water and agriculture, this study has identified areas with potential for poverty reduction through water-related interventions by assigning a qualitative score (low, moderate and high) to each zone. The potential in each livelihood zone has been assessed on the basis of the following criteria:

- prevalence of poverty;
- water as a limiting factor for rural livelihoods;
- potential for water intervention.

Prevalence of poverty

This criterion takes into account both the absolute number (density) and percentage of rural poor in each livelihood zone. Poverty figures come from the rural poverty map (above). On the basis of these two factors, the prevalence of poverty has been assessed by livelihood zone (Table 5).

Water as a limiting factor for rural livelihoods

This criterion shows where water is the principal binding constraint, mainly for agricultural production but also taking account of other livelihood activities where lack of water may be a constraint. It illustrates how water can make the difference where it is the entry point for agriculture and other livelihood activities. This assessment is based mostly on field experience combined with information gathered from the literature, and on information on the prevalence of droughts and dry spells (and the way they affect smallholders). In densely populated areas, the need for agricultural intensification has also been considered in determining these criteria. The classification is given in Table 6.

Table 5 Prevalence of poverty by livelihood zone

Livelihood zone	Rural poverty prevalence
Arid	low
Pastoral	high
Agropastoral	high
Cereal-based	high
Cereal-root crop	high
Root-crop-based	moderate
Highland Temperate	high
Highland Perennial	moderate
Tree crop	low
Forest-based	moderate
Large Commercial and Smallholder	low
Rice-tree crop	moderate
Coastal Artisanal Fishing	low

Table 6 Importance of water as a limiting factor by livelihood zone

Livelihood zone	Water as limiting factor
Arid	high
Pastoral	high
Agropastoral	high
Cereal-based	high
Cereal-root crop	high
Root-crop-based	low
Highland Temperate	moderate/high
Highland Perennial	moderate
Tree crop	low
Forest-based	low
Large Commercial and Smallholder	high
Rice-tree crop	low
Coastal Artisanal Fishing	low

Potential for water intervention

The criterion represents the physical potential for water control development. It is based mainly on the availability of additional water for agriculture. It is assessed on the basis of existing information on water resources, water withdrawal, current irrigation, and potential for further irrigation development. Specifically, the score has been assigned taking into consideration two indicators: the remaining irrigation potential (ratio between actual and potential irrigation); and the anthropogenic pressure on water resources (ratio between agricultural water withdrawal and total internally renewable water resources). Table 7 presents the results of this assessment.

3

Priority for action

Priority for action is obtained by combining the three criteria presented above. It represents the potential for poverty reduction through water-related interventions in the different livelihood zones. For example, where poverty prevalence is high, and water is the main limiting factor for rural livelihoods, and where enough water

Table 7 Potential for water intervention by livelihood zone

Livelihood zone	Potential for water interventions
Arid	low
Pastoral	low
Agropastoral	moderate
Cereal-based	high
Cereal-root crop	high
Root-crop-based	high
Highland Temperate	moderate/high
Highland Perennial	moderate
Tree crop	high
Forest-based	high
Large Commercial and Smallholder	low
Rice-tree crop	moderate
Coastal Artisanal Fishing	moderate

resources are available, then the potential for poverty reduction is high. At the other extreme, where poverty prevalence is low, and water is either physically scarce or not a limiting factor, there is little potential for poverty reduction through water investment.

Table 8 and Figure 15 show the assessments of the potential by each of the criteria, and the overall priority for action. Combined, the livelihoods zones showing highest priority for water-related interventions are host to 202 million rural people, about 48 percent of the rural population of SSA, and 53 percent of the rural poor. The three levels of priority are discussed in detail below.

Priority level 1: high

Figure 15 shows the location of the livelihood zones with highest priority for effective intervention. These zones extend mainly between the dry and moist semi-arid climates. They are areas where potential production is relatively high. High-potential areas are spread over zones driven by cereal production. Cereal–based , highland temperate, agropastoral and cereal–root crop zones have a high potential for poverty reduction.

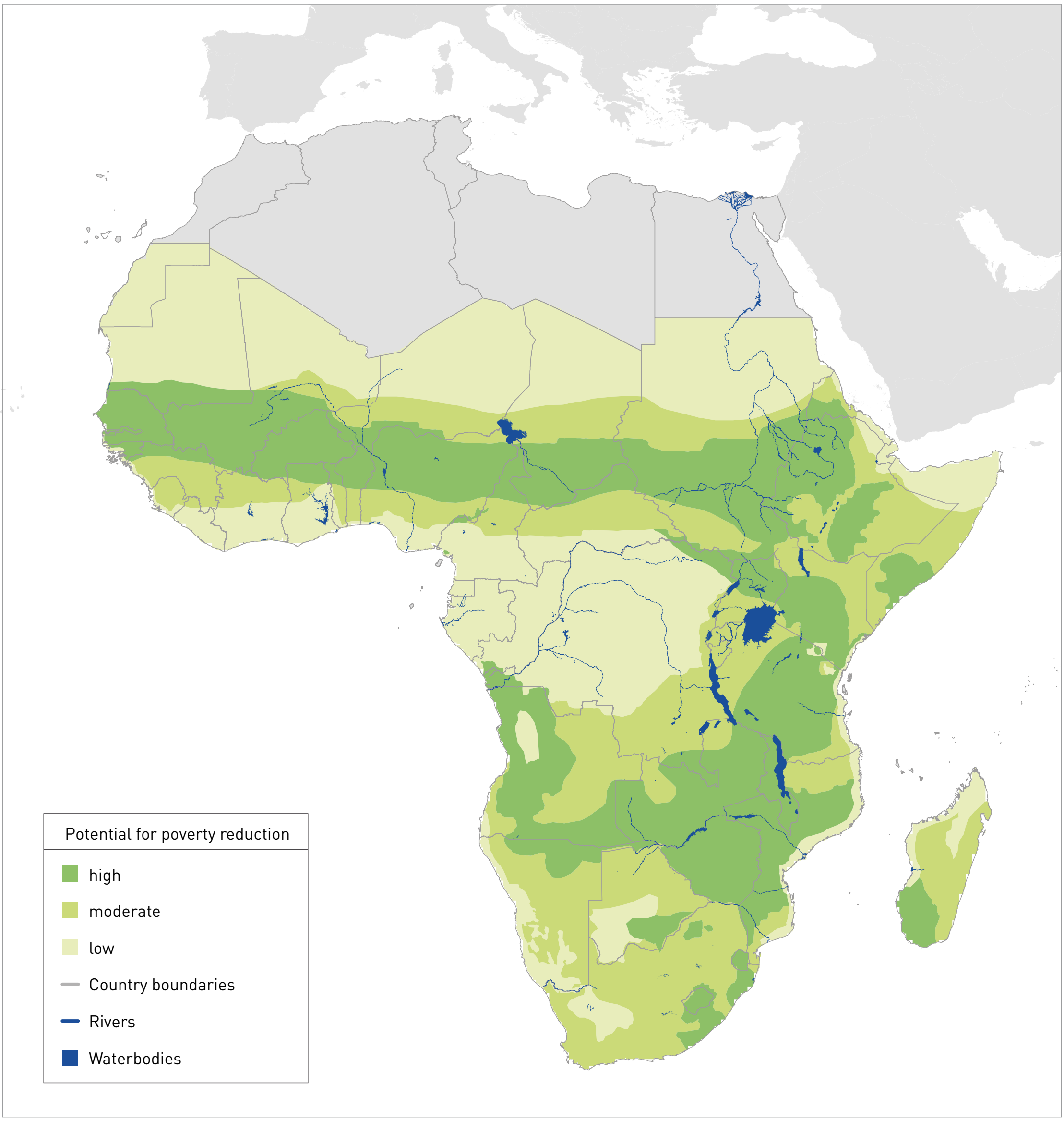
Because of their relatively important natural resource base, high-priority areas are those that offer broad opportunities for agricultural growth. Agriculture is particularly significant in these zones – most of the cereals that feed the region come from these areas. At present, water in these zones is sufficient, but it is subject to an annual and interannual variability that affects agriculture. The zones host many rural people (about 50 percent of the region's total), at a density of about 25 inhabitants/km^2 (higher than the regional average of 17 inhabitants/km^2).

Many of the region's poor and hungry persons live in these areas, accounting for almost 55 percent of total rural poor of the region. Livelihoods, and more specifically agriculture, in these areas depend considerably on water availability and are vulnerable to interannual variability. Water is also a constraint owing to the high population density. The greatest scope for poverty reduction and livelihood improvement in these areas is represented by the untapped agricultural potential, for both farming and livestock. Intervention options should promote not only irrigation but, in the case of the agropastoral zones, exploit the great potential for

Table 8 Priority for action: poverty reduction through water interventions by livelihood zone

Livelihood zone	Rural poverty prevalence	Water as limiting factor	Potential for water interventions	Priority for poverty reduction
Arid low	high	low	low	low
Pastoral	high	high	low	moderate
Agropastoral	high	high	moderate	high
Cereal–based	high	high	high	high
Cereal–root crop	high	high	high	high
Root–crop–based	moderate	low	high	moderate
Highland Temperate	high	moderate/high	moderate/high	high
Highland Perennial	moderate	moderate	moderate	moderate
Tree crop	low	low	high	low
Forest–based	moderate	low	high	low
Large Commercial and Smallholder	low	high	low	moderate
Rice–tree crop	moderate	low	moderate	moderate
Coastal Artisanal Fishing	low	low	moderate	low

Figure 15 **Potential for poverty reduction in SSA through water interventions**



promoting interventions more related to soil moisture management and rainfall harvesting options as well as livestock watering. For all these reasons, such areas offer the greatest opportunities for expanding food production, and they warrant a large portion of rural investment funds, especially through water interventions but also undertaking farm improvements, such as crop diversification and production intensification. Investments and other interventions in water control are needed in order to support farm improvements, and they can make the difference for livelihoods.

In selecting the right type of intervention, it is important to recognize that most agricultural production in SSA, now and in the future, will occur in rainfed areas. There is substantial potential to enhance rainfed agriculture, in particular maize, and to a certain extent sorghum and millet. Managing rainfall variability over time and space will be most important. Upgrading rainfed agriculture requires that technologies be well adapted to local biophysical and sociocultural conditions, accompanied with institutional and behavioural changes. The productivity of rainfall in arid and semi-arid environments can be increased substantially with appropriate water harvesting techniques.

Priority levels 2 and 3: moderate and low

The fact that an area is classified as one of moderate or low potential does not imply that water-related interventions are not needed. Rather, it suggests that the poverty-reduction impact will be minor, either because of the lower prevalence of poverty or because other types of interventions might be more suitable. These areas may have poor soil fertility that needs to take priority in being addressed, or they may be ones where the main livelihood activities are not vulnerable to a lack of, or variability in, water supply. They may also be areas where water it is not a crucial factor for livelihoods, as is the case in the forest–based and tree crop zones. In such areas, a number of interventions are needed. Among these, water-related ones, while not the most important, may nevertheless play a key role. Examples of appropriate policies in such zones are given below.

Areas with good market potential depend on farm-level improvements through intensification and diversification, supported by irrigation and market development. In such zones, farm size must be increased where possible, and holdings consolidated as aggregate productivity is often constrained by land fragmentation.

The same problem exists in highland perennial zones, which have a favourable climate, but also the highest density of rural population. Many farmers in these zones depend on small amounts of land. Although poverty is moderately severe, good opportunities can exist to contribute to alleviating poverty by intensive agricultural growth supported by investments in water control.

Poverty reduction in the rice–tree crop zone will be accomplished largely by diversifying crop, livestock, and fish production and by improving water management. In addition, agricultural intensification and increases in non-farm income through local processing of farm produce may contribute to poverty reduction efforts.

In arid and pastoral zones, where there is very limited potential to develop water control, poverty reduction often depends on seasonal or permanent migration to seek employment as labourers in wealthier zones or urban areas. There is a substantial need for alternative livelihood activities to agriculture or livestock husbandry. Over time, increases in off-farm income and exit from agriculture are likely to be at the core of poverty reduction efforts. In many cases, on-farm diversification and increases in off-farm employment will be more helpful than investments in water control in reducing poverty in these areas.

Livelihood diversification and increased off-farm income will also be the major mechanisms for reducing poverty in rainfed humid livelihood zones. Livestock production and small-scale farmer-managed irrigation will play major roles in diversification and intensification. Poverty reduction in rainfed highland livelihood zones and rainfed dry/cold livelihood zones will also be accomplished primarily through increases in off-farm income and exit from agriculture. Diversification to high-value products with relatively low transport and marketing costs will be helpful in these regions, given the more limited prospects for improving low-value agricultural production.

Interventions in water to improve livelihoods in rural areas

While water control is often not the only limiting factor in crop production in SSA, it is often the starting point for any improvement in agricultural productivity. In many areas, farmers work with poor soils, they have limited financial credit, they apply too little fertilizer, and they are unable to harvest and deliver their crops to market in a timely fashion. However, in many arid and semi-arid regions, the lack of access to water (or inadequate control or timing of water supplies) contributes to the difficulty of generating acceptable yields. In addition, uncertainty regarding rainfall or access to a developed irrigation supply causes farmers to apply less seed and fertilizer than they might otherwise do. Hence, efforts to improve farm-level access to water and control of water deliveries or rainfall will, in the zones identified in the Chapter 3, enable farmers to improve productivity within current cropping patterns and to consider diversifying their crop choices, thus progressively increasing the proportion of their marketable surplus, albeit locally.

Investments and policies that influence how farmers use water in crop and livestock production must be evaluated according to the local conditions in order to ensure that policy guidelines and parameter values address poverty reduction goals effectively. Opportunities to reduce poverty by improving access to water and the types of investments that will be most helpful in increasing agricultural productivity and improving rural livelihoods will vary among regions according to the prevalence of rural, subsistence farming, the types of livelihood zones, agro-ecological zones and climate. So too, will the types of investments and associated institutional measures needed to achieve poverty reduction goals. Decisions regarding water development for agriculture must consider both biophysical and socio-economic aspects of water resource availability and management.

The analysis of poverty patterns in SSA and their links to agricultural practices calls for specific attention to the improvement of rainfed agriculture. In all such areas, intervention programmes must address as a priority the needs of poor smallholder farmers located far from markets and those who lack secure water rights. Some of these rainfed areas could benefit from investments in new, large-scale irrigation infrastructure (especially where better-off producers have access to markets and less well-endowed people can find decent employment in upstream or downstream activities, such as agroprocessing) (FAO, 2006a). In other places, livestock production, inland fisheries and aquaculture, or other types of multiple water-use systems, will need to receive special attention.

When working on a national scale, the range of different livelihood realities has to be taken into account. Large differences can exist in a country between one region and another in terms of agricultural practices, natural resources endowment (in particular soil and water), market opportunities, knowledge and education levels, and the capacity of local institutions. Such differences need to be taken into account in developing water control strategies that match the needs and capacities of local populations. The key term is "context-specificity".

Notwithstanding the differences that are relevant, a key observation is that successful efforts to improve crop yields and farm incomes in SSA will require concerted efforts to intensify crop production on small-scale farms (Abalu and Hassan, 1998). In most cases, when dealing with such farms, investments in improved water control will not be feasible without considering a range of conditions for success. These conditions are discussed below.

Matching the specific needs of different groups

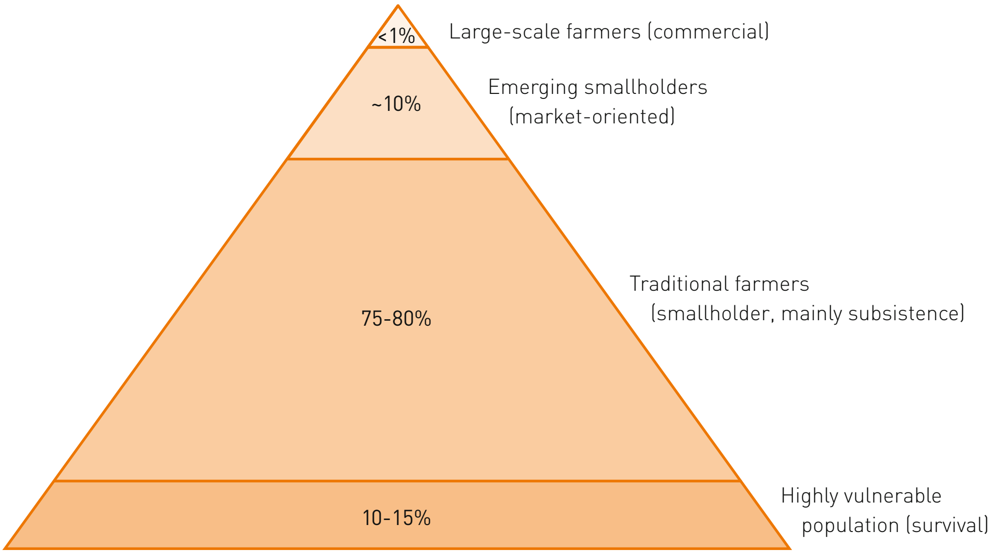
This study has attempted to estimate the relative importance of four main categories of farming populations in SSA (Figure 16). While the estimates are relatively approximate, in most countries of the region, the bulk of the farming population (330 million or about 80 percent) is represented by traditional smallholders, producing mainly staple food for household consumption and with relatively marginal connections to markets. Other major categories include: highly vulnerable people, living at the margin of survival (50 million or 12 percent); emerging smallholder farmers, who may partially subsist from their own production but whose principal objective is to produce a marketable surplus (40 million or 9 percent); and commercial farmers and enterprises oriented towards internal and export markets (less than 2 million or 0.5 percent). In addition, it is estimated that the non-agricultural population represents 7 percent of the rural population in SSA (FAOSTAT, 2008). Each of these groups faces different constraints, and each needs adapted responses in all fields, including water control.

Each of these groups has to be addressed in a different way, as shown in Figure 17. In most cases, the highly vulnerable populations in rural SSA consist of people having no or very limited access to land and other livelihood assets. They are often landless workers, widows, families affected by HIV/AIDS or other diseases, etc. For these people, water interventions should focus on highly subsidized social programmes, including labour-intensive soil and water conservation or watershed management programmes that can provide a return on labour. Domestic water supply and sanitation programmes also have good potential for impact, in part through reduction in water-related diseases and in time spent for fetching water.

The smallholder farmers in rural SSA require investments in rainfed water management and supplementary irrigation where feasible. They need secure land tenure that is stable and reliable, guaranteed access to water, support to the empowerment of local communities, in particular WUAs, and improved access to inputs (through targeted subsidies) and markets. Capacity building, education and agricultural extension are also important, in addition to domestic water and sanitation programmes. Helpful public interventions will include research and development and extension support for maximizing yields with limited resources, diversifying crop production alternatives and producing more than one crop per year, where feasible.

Compared with traditional smallholders, emerging farmers typically have a higher level of technical knowledge and are more receptive to improved technology. They tend to specialize in specific crops, and are often integrated into a production/supply chain with some support from buyers through extension services and input supply. As they progress in market-oriented production, emerging farmers increasingly need to better secure production inputs. Together with fertilizers,

Figure 16 **A typology of farming populations in SSA**



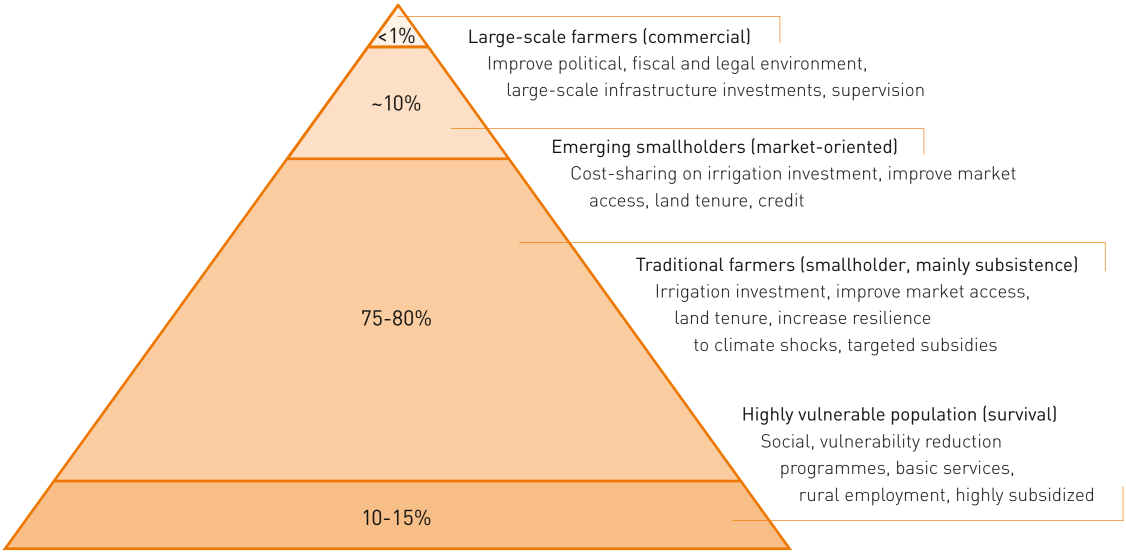
improved control of soil moisture through irrigation is an important element of their production strategy. Therefore, access and control of water are essential, together with improved access to well-adapted financial instruments.

A subcategory of emerging farmers comprises those who produce crops on very small plots of land in home gardens or on other small landholdings, close to local markets. Small-plot irrigation technologies include treadle pump, affordable drip irrigation kits and water storage options (Keller and Roberts, 2004). These technologies are characterized by low initial investment costs, relatively short payback periods, and high farm-level returns on investments (Magistro *et al*., 2007). In addition, widespread use of small-plot irrigation methods can generate employment opportunities on and off farms in rural areas. Treadle pumps and drip systems are somewhat labour-intensive, and local entrepreneurs can establish businesses that build, service and repair the irrigation equipment. Such activities stimulate greater demand for farm products and other non-tradable goods and services.

Finally, there are the commercial farmers. Their activities usually offer local development opportunities, in particular for landless workers, and contribute to local economies. Therefore, commercial farming should be considered as a potentially important element in rural poverty reduction programmes, alongside programmes that address the needs of other categories. Commercial farmers typically benefit from favourable political, institutional and fiscal environments, good transportation, storage and marketing infrastructure, and reductions in international trade barriers. They are also well equipped to enhance the profitability of large-scale irrigation infrastructure. Where provided with the right legal framework, and where a fair and transparent balance of power is guaranteed, commercial and emerging farmers can benefit the rural poor through fair, decent and gainful employment options and, thus, contribute to local poverty reduction.

Beyond the broad categories of farmers described above, a further and more refined distinction between target groups needs to dis-

Figure 17 **Adapting agricultural support strategies to different farmers groups**



Box 3 HIV/AIDS and implications for water interventions

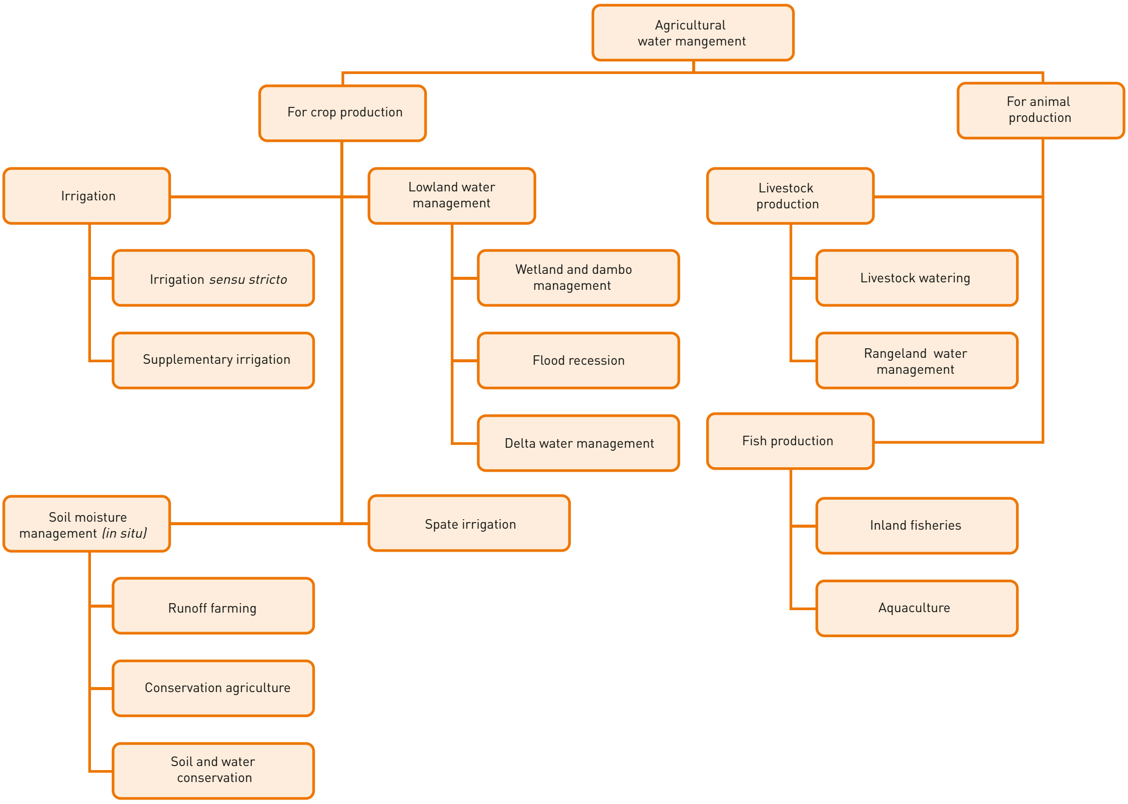
The rapid progression of the HIV/AIDS pandemic is having a particularly devastating effect on the rural poor, and rural women specifically as their traditional care-giving role makes them bear the burden of looking after the sick and orphans while also securing a livelihood for the household. The loss of labour in HIV/AIDS-affected households and the resulting reduction in the area of land cultivated (resulting in lower production), the shift to less labour-intensive crops and delays in agricultural operations all undermine households' food security status.

HIV/AIDS worsens gender-based differences in access to land and other productive resources such as labour, technology, credit and water. In many cases, legal and customary law do not allow widows to retain access and control over land and water. In other cases, their water rights are not respected, protected or fulfilled.

Therefore, the introduction of appropriate and affordable technologies for safe water supply and sanitation is of the utmost importance. An increase in the demand for water is also caused by the need for water for productive use, but the weakening of people affected by HIV/AIDS must be taken into consideration in project design and the choice of technologies.

tinguish between farmers, herders, fishers, and landless and migrant labourers. Gender specificities must be taken into account through a differentiated needs analysis for men, women, children, young and elderly people. Here, the livelihood concept provides a valid framework that enables an understanding of the different types of assets they use to sustain to their livelihood,

Figure 18 **A typology of agricultural water management practices showing the diversity of options**



and, therefore, helps in identifying their specific needs in terms of livelihood assets consolidation. The special case of people affected by HIV/AIDS is highly relevant in several SSA countries (Box 3).

Options for interventions in water

Improved water control and management for poverty reduction in rural areas includes a range of technical options to support cropping, livestock, forestry, aquaculture, domestic and other productive activities. In cropping, interventions range from on-farm water conservation practices that focus on improving soil water storage in rainfed agriculture to more elaborate types of water control, moving along the continuum from purely rainfed to irrigated agriculture, first as a means of securing production through supplementary irrigation, then allowing for an increase in the cropping intensity, and allowing for diversification of crop production through "full control" irrigation. Such systems are not mutually exclusive, and several of them can find their application in a single livelihood context. Thus, irrigation provides opportunities for the multiple use of water, including for domestic consumption, aquaculture and livestock within the production system (Molden, 2007). Figure 18 presents a typology of some of the most widespread agricultural water management options.

Based on the above typology, it is possible to establish a list of water-related interventions.

Table 9 Indicative list of water control and water use technologies

Uses	Technologies			
	Water capture	**Water storage**	**Water lifting**	**Water use/application**
Domestic water use (safe drinking-water water for cooking, bathing, laundry, cleaning)	Shallow tubewells: • dug wells • drilled wells Spring diversion Deep tubewells		Human powered pumps: • hand pulleys and buckets • hand pumps Solar pumps Motorpumps	Water purification methods: • filters (e.g. sand filters) • boilers for drinking-water • chlorination
	Recharge enhancement system: • recharge wells Underground water harvesting system: • cistern or other underground water storage structure fed by a catchment area Above ground rainwater harvesting system: • rooftop tank or jar			
Irrigated crops (including urban and small plot cropping)	Shallow tubewells: • dug wells • drilled wells Spring diversion Deep tubewells	Elevated tanks/drums	Human-powered pumps: • hand pulleys and buckets • hand pumps • treadle pumps Animal-powered pumps: • mohte • Persian wheel Motorpumps: • petrol • diesel	Aboveground: • shallow trenches or ditches • family/drum drip irrigation kit • low cost hose irrigation system Belowground: • porous ceramic jars • porous and sectioned pipe
	Water harvesting systems, composed of: • catchment area and a water storage structure aboveground (e.g. excavated pond, impounded reservoir) • catchment area and a water storage structure belowground (e.g. cistern)			
Supplementary irrigation	Shallow tubewells: • dug wells • drilled wells Deep tubewells	Small dams/reservoirs	Human-powered pumps: • hand pulleys and buckets • hand pumps • treadle pumps	

(continued)

Table 9 *(Continued)*

<table>
<tr><th rowspan="2">Uses</th><th colspan="4">Technologies</th></tr>
<tr><th>Water capture</th><th>Water storage</th><th>Water lifting</th><th>Water use/application</th></tr>
<tr><td>Supplementary irrigation</td><td colspan="2">Run off the river diversion
Water harvesting systems composed of:
• catchment area and a water storage structure aboveground (e.g. excavated pond, impounded reservoir)
• catchment area and a water storage structure belowground (e.g. cistern)</td><td>Animal-powered pumps:
• mohte
• Persian wheel
Motorpumps:
• petrol
• diesel</td><td></td></tr>
<tr><td>Enhanced water management for rainfed</td><td colspan="2">Soil and water conservation and management (runoff farming):
• stone bunds, ridges, broad beds, furrows
• no-tillage
• infiltration pits
• contour bunds (semi-circular, triangular)
• vegetative bunds
• terraces (eyebrow, Negarim)
• mulching</td><td></td><td></td></tr>
<tr><td>Aquaculture and inland fisheries</td><td>Run off the river diversion</td><td>Small dams and reservoirs
Integrated paddy and fish production</td><td></td><td>Basins
Ponds
Water-level control in small streams</td></tr>
<tr><td rowspan="2">Livestock watering</td><td>Shallow tubewells:
• dug wells
• drilled wells
Spring diversion</td><td></td><td rowspan="2">Human-powered pumps:
• treadle pumps
Animal-powered pumps:
• mohte
• Persian wheel
Motorpumps:
• petrol
• diesel</td><td rowspan="2">Watering facilities:
• watering troughs</td></tr>
<tr><td colspan="2">Water harvesting systems composed of:
• catchment area and a water storage structure aboveground (e.g. excavated pond, impounded reservoir)
• catchment area and a water storage structure belowground (e.g. cistern)

Microcatchment water harvesting systems for rainwater runoff:
• contour bunds (semi-circular, triangular)</td></tr>
</table>

Source: Adapted from FAO (1998).

Table 9 is adapted from a matrix developed in the framework of FAO's Special Programme of Food Security (FAO, 1998), and shows options for water control by type of use and available technologies, organized along four main water management components: capture, storage, lifting and application. Well adapted to smallholders, who are the main target beneficiaries of the Programme, Table 9 shows the range of possible options to be used as part of poverty reduction strategies in rural areas. A selection of the most relevant options is discussed in more detail below.

Geographical scales offer another way to classify water intervention options. They have significant operational implications, as changes in scale imply changes in approaches and social organization. Plot-level or farm-level interventions, through improved soil moisture management in both rainfed and irrigated agriculture, will rely primarily on farmers' capacity and willingness to adopt improved practices. At the scale of irrigation schemes, water distribution and management require a higher level of organization, implying the need for effective local water management institutions. Water conservation in small watersheds typically involves several communities along the river, with many social groups having different interests. The level of social organization and institutions needed to address water management adequately increases with the scale of the watershed. Transboundary rivers are the ultimate level of complexity for water management, where political dimensions add to local management issues. While all scales of intervention are important, this study focuses primarily on local-level interventions.

Managing soil moisture at field level in rainfed areas

A key challenge in SSA is to reduce water-related risks posed by high rainfall variability in the semi-arid areas (Rockström *et al.*, 2007). In most areas dominated by rainfed agriculture, there is generally enough rainfall for good yields in rainfed cropping, but it is available at the wrong time and at too great an intensity, followed by dry spells. As a result, most of the rain is lost in unproductive evaporation or surface runoff that causes erosion and loss of soil fertility.

In such areas, investments are needed to assist farmers to establish better control and management of intermittent water supplies (Rockström, 2000; Mupangwa, Love and Twomlow, 2006). These investments should be accompanied by technical assistance for optimizing the use of fertilizer, seeds and other key inputs in rainfed settings when soil moisture management practices are developed. Farmers' risk-aversion strategies, which include low levels of investment in rainfed cropping, can only be modified if their perception of water-related risks changes as a result of such investments.

Especially important in designing soil moisture management investments is distinguishing between droughts and dry spells. In semi-arid and dry subhumid livelihood zones, rainfall variability generates dry spells (short periods of water stress during critical growth stages) almost every rainy season (Barron *et al.* 2003). In contrast, droughts are major reductions in the amount of rainfall, and they occur on average only once or twice every decade in semi-arid regions. While investments in water management can help mitigate the effects of dry spells on crop yields, droughts cannot be bridged through agricultural water management. Instead, they require institutional and social coping strategies, such as cereal banks, insurance schemes and relief food distribution. The range of differences between dry spells and droughts is given in Table 10.

Field-level soil moisture management practices encompass a large range of agronomic practices aimed at better capturing and maintaining water in the rootzone. They include soil and water conservation and "runoff farming" practices (methods aimed at capturing water as it falls on the plot, so as to increase its infiltration rate and reduce runoff). Runoff farming techniques are gaining increasing attention in areas such as western Sudan, where results are very encouraging for improving agricultural production and livelihoods (semi-desert to semi-arid climates). Farmers have obtained significantly improved results when combing traditional moisture control techniques with soil fertility management practices within existing cereal–based livelihood zones. For example, for sorghum production in Mali, Burkina Faso, Niger, etc., improved zai/tassa planting pits catch more of the sparse rainfall, and dung/compost added to the pits enables more efficient use of plant nutrients and moisture. Box 4 gives an example of soil moisture management for rainfed rice production.

The most promising prospect for on-farm moisture management appears to be the various types of conservation agriculture practices that have been developed primarily in Latin America and are

Table 10 Types of water stress and underlying causes in semi-arid and dry subhumid tropical environments

	Dry spell	Drought
Meteorological		
Frequency	Two out of three years	One out of ten years
Impact	Yield reduction	Complete crop failure
Cause	Rainfall deficit of two- to five-week periods during crop growth	Seasonal rainfall below minimum seasonal plant water requirement
Agricultural		
Frequency	More than two out of three years	One out of ten years
Impact	Yield reduction or complete crop failure	Complete crop failure
Cause	Low plant water availability and poor plant water uptake capacity	Poor rainfall partitioning, leading to seasonal soil moisture deficit for producing harvest (where poor partitioning refers to a high proportion of runoff and nonproductive evaporation relative to soil water infiltration at the surface)

Source: Rockström *et al.* (2007).

Box 4 Soil moisture management for rainfed rice production

There is substantial opportunity for enhancing rice production and farm incomes in West Africa and the Sahel by improving farm-level access to irrigation water and improving water management in rainfed conditions, in conjunction with other agronomic and crop management improvements. Researchers at the West Africa Rice Development Association (WARDA) and others have demonstrated significant differences between the rice yields obtained on farms and experiment stations (Haefele *et al.*, 2001; Wopereis-Pura *et al.*, 2002; Poussin *et al.*, 2003). Much of the observed yield gap is a consequence of suboptimal weeding strategies and inappropriate use of nutrients (Haefele *et al.*, 2000). However, yields can also be increased by constructing bunds and canals to improve water management in rainfed conditions (Sakurai, 2006). Extension agents can encourage farmers in the region to implement such measures by demonstrating the risk-reducing characteristics of soil and water conservation efforts (Baïdu-Forson, 1999).

Box 5 Conservation agriculture in sub-Saharan Africa

Conservation agriculture has started to spread in Africa, and it is being adopted in most subhumid regions. Some farmers have doubled or even tripled their grain yields. In Kenya and the United Republic of Tanzania, FAO is implementing a conservation agriculture project with small-scale farmers in eight districts. In Zambia, conservation agriculture has helped vulnerable households survive drought and livestock epidemics, and more than 200 000 farmers are now using this technique. In the 2000–01 drought, farmers who used conservation agriculture managed to harvest one crop, others farming with conventional methods faced total crop failure. In Ghana, more than 350 000 farmers now use conservation agriculture.

now spreading in the SSA context (World Bank, 2007a). Conservation agriculture practices aim to enhance the quality of the soil through practices that reduce, change or eliminate tillage and avoid the burning or exportation of residues (FAO, 2001). Conservation agriculture favours the building up of organic matter in the soil, thus increasing its moisture holding capacity. Conservation agriculture illustrates the interlinkage between soil moisture and soil fertility, and the importance of addressing both issues simultaneously in cropping improvement programmes (Box 5).

A shift from conventional to conservation agriculture requires a package of interventions, including changes in technology (sowing, and weed control), supported by information and training (FAO, 2005). Benefits from conservation agriculture take time to appear, and programmes to promote it among farmers need to be developed with a medium-term perspective. Farmers may need financial support, or assistance in kind, in order to adopt conservation agriculture practices. Subsidies to support adoption of conservation agriculture programmes often find additional justification in the environmental benefits they typically provide at the watershed level.

Rainfed moisture management practices find their application mostly in cereal–based and highland temperate livelihood zones, where rainfall ranges between 500 and 2 000 mm. In more arid areas, e.g. agropastoral zones, they face the double challenge of excessive occurrence of dry periods and competition for scarce biomass for different uses, in particular livestock.

Investing in small-scale water harvesting infrastructure

Water harvesting encompasses any practice that collects and stores runoff for productive purposes (FAO, 1994). It includes three components: a watershed area to produce runoff, a storage facility, and a target area for beneficial use of the water (agriculture, domestic or industry). For the purposes of this study, water harvesting is primarily concerned with the construction of small reservoirs, which can serve different purposes (e.g. supplementary irrigation, livestock watering or fisheries, and aquaculture). Different water harvesting systems can be classified according to the scale of runoff collection, from small check dams and water retention structures to larger external systems collecting runoff from watersheds (Oweis, Prinz and Hachum, 2001). Storage options in rainwater harvesting include surface or subsurface tanks and small dams (Fox and Rockström, 2000).

Water harvesting techniques are used in a range of contexts in drylands to concentrate and make more effective use of rainwater, and to enhance the reliability of agricultural production. However, they are restricted to specific environmental and socioeconomic conditions. There is no clear distinction between in situ soil water control and management and water harvesting, and several authors refer to a continuum of water management practices from rainfed to irrigated agriculture.

The potential for poverty reduction through water harvesting is high in smallholder settings in semi-arid and subhumid areas. Investments in small reservoirs (typically providing 1 000 m3 of extra water per hectare per season) for supplementary irrigation improve farmers' resilience to dry spells, and, in combination with improved soil, nutrient and crop management can substantially increase the productivity of small-scale rainfed agriculture (Rockström *et al.*, 2007).

Water harvesting technologies have been successfully developed over many years by populations seeking to improve water control. Many ancient water harvesting practices are today widely applied and adapted, such as "half-moons" in West Africa. Others have tended to be abandoned, as economies develop and labour costs of maintenance become excessively high. However, there is still scope for better dissemination of a range of water harvesting technologies that are still relatively little known outside their area of origin. Box 6 provides an example of the range of water conservation options that can be adopted in a semi-arid environment.

All new or adapted water harvesting technologies need to take local socio-economic aspects adequately into account. Labour-saving devices are particularly relevant in areas where labour is scarce or losing its work potential, as is the case with people affected by HIV/AIDS in stricken regions of Africa and Asia. Cultural and socio-economic knowledge and an excellent capacity for understanding and exchanging with farmers are fundamental to the sharing of concepts and practices.

A range of successful water harvesting examples show promise for climate change adaptation: reducing the risks of crop production (including trees) associated with high rainfall variability in semi-arid regions; reducing wind erosion; enhancing aquifer recharge; and allowing for careful expansion to areas where rainfall is normally not sufficient.

Improved ploughing techniques have proved effective for large-scale operations for reclaiming degraded lands. Two ploughs, the "Delfino" (dolphin) and the "Treno" (train) adapted to dif-

4

Box 6 The Keita Project: exploring of the range of water conservation options in western Niger

The Keita Project, funded by Italy and the World Food Programme, started its activities in the Ader-Doutchi-Majiya, an arid region of Niger, in 1984. It is a project of unusual scale and duration, and by 1991, it covered an area of 13 000 km^2, with about 300 000 people in 400 villages. The project provided services and infrastructure on a grand scale. By the end of 1999, it had created 50 artificial lakes, 42 dams and 20 anti-erosion dykes, and 65 village wells. It had applied soil and water conservation techniques to about 10 000 ha of land, and had planted 16 million reforestation seedlings. In addition, the project had built a series of infrastructures, including schools, maternity centres, veterinary facilities, shops, and storehouses, and it included women's empowerment programmes, microcredit, and adult literacy courses. The aspects of the project that were most appreciated by the local population were the increased availability of water and fodder, together with the distribution of "food for work" in an area with few work opportunities (Rossi, 2005). Ten years after project completion, most of the hydraulic infrastructure was still in place and functioning for the benefit of local populations (FAO, 2002).

ferent soil types are able to reclaim large areas of degraded land through creating "half-moon" microbasins for water capture. This technology, which has been tested in ten countries (Burkina Faso, Chad, Egypt, Kenya, Morocco, Niger, Senegal, Sudan, Syrian Arab Republic and Tunisia), has potential for extensive land reclamation in the most arid areas of the region. However, it is a highly mechanized technique and, therefore, suitable primarily in areas where labour is scarce.

Water harvesting techniques are most relevant in semi-arid and subhumid zones, in particular in cereal–based , agropastoral and Southern African smallholder zones where water is needed in order to supplement rainfall during dry spells.

Promoting community-based small-scale irrigation

While large public investments in irrigation imply a concentration of production factors in a few selected locations, small-scale water control facilities have the potential to affect poverty reduction at local level, contributing to the development of local markets and rural economies. However, experience has shown that a series of conditions need to exist in order to guarantee the success of such irrigation schemes.

Social cohesion and the absence of political interference are a first condition for the success of small-scale irrigation systems. Too often, the relatively high cost of irrigation investments attracts the attention of local politicians, leading to exploitation by clientele and patronage systems. Where associated with the absence of a strong community governance capacity, such conditions lead to inappropriate decisions, inequity in access to irrigated land, and the rapid degradation of infrastructure owing to a lack of maintenance.

In most cases, the design of small-scale irrigation systems holds the key to their sustainability. Operational simplicity is among the most important criteria for the success of small-scale community-based irrigation schemes. The number of users sharing a common infrastructure should remain low, and be based on existing social constructs. Such systems must also be robust, with low maintenance requirements, and limited physical and financial capital requirements – all factors contributing to an easier appropriation of the technology by the users. The planning and design of small-scale irrigation schemes must also give greater attention to water resources and ensure that the schemes will be provided with adequate water supply throughout the cropping season.

Community participation in the design and realization of small-scale irrigation schemes is the only way to ensure beneficiary appropriation, which in turn will facilitate the sustainable management of the investments (Boxes 7 and 8). In the past, too many irrigation systems were designed without considering people's requirements and management considerations. The result was blueprint designs that were not adapted to local conditions, unnecessarily high operation and maintenance costs, and complex organizational settings.

Such conditions often imply choosing designs that do not correspond to the lowest-cost investment option, but they do guarantee sustainability in the control of infrastructures by the users. Indeed, while unit costs of small-scale irrigation may not be lower than for large systems, i.e. there are economies of scale (Inocencio *et al.*, 2005), adopting smaller-scale schemes in the framework of larger projects could show higher economic returns and have higher impacts than large systems in terms of poverty reduction in rural areas. Small wetlands, dambos and other lowland valley bottoms have always represented a good opportunity for agricultural production, in particular rice, in large areas of SSA, thanks to the availability of water. Wetlands and valley bottoms that have benefited from external investment to improve water control in SSA represent about 555 000 ha and those cultivated directly by farmers without external investments cover about 1 million ha. In addition, flood recession cropping is practised on another 960 000 ha (FAO, 2006c). Substantial improvements can be made through the introduction of simple technologies in lowlands, including small dams, pumps or affordable well digging. Investments can enable farmers to make better use of lowland areas near urban centres, such as planting two crops of rice per year (Erenstein, Oswald and Mahaman, 2006).

With appropriate policies in place and incentives to local producers, investments in small-scale irrigation could maximize the value of recent developments in rice breeding. The "new rice for Africa", known also as NERICA, generates substantially higher yields per hectare than traditional varieties, but it requires optimal

Box 7 Small-scale irrigation in Uganda

Many small irrigation projects have been implemented with the goal of reducing poverty in rural areas where agricultural productivity is constrained by inadequate access to water. Successful examples include a community-run water project in Uganda that provides equitable access to valley tanks for harvesting rainwater, and a wind-powered irrigation system that has improved livelihoods in the United Republic of Tanzania. The latter project provides irrigation and a water supplyline for domestic use to the centre of a village. Farmers were unable to afford the capital cost of investing in such a programme on their own. The success of the project has inspired eight neighbouring communities to replicate it. In Kenya, the Dryland Development Centre of the United Nations Development Programme (UNDP) links poor people of dry areas in Nairobi with people who have knowledge of key topic areas, such as water management.

Source: IFAD (2005).

Box 8 The potential for irrigation development in Ethiopia

The potential for increasing the irrigated area, and associated agricultural outputs and farm incomes, in Ethiopia is substantial. Godswill, Kelemework and Aredo (2007) compared irrigated and rainfed yields in a study involving about 300 households in three small-scale irrigation schemes in the Rift Valley. They observed mean output values of Br2 702 per hectare on rainfed farms (average size 1.5 ha) and Br29 474 per hectare (11 times more) on irrigated farms (average size 0.45 ha). Households with irrigation apply more seed, pesticide, fertilizer and labour than households without irrigation.

In another study, Diao and Pratt (2007) examined the potential economic impacts of expanding irrigated area in Ethiopia using an economy-wide simulation model. They compared an irrigation scenario based on Ethiopia's Irrigation Development Programme, in which irrigated area expands by 274 000 ha by 2015, with a "business as usual" scenario that simply extends the trend in irrigated area observed between 1995 and 2002. The authors concluded that the increase in irrigated area (50 percent of which would be allocated to cereal crop production) would increase the annual economic growth rate from 1.9 to 2.1 percent by 2015. With complementary investments in markets and transportation infrastructure, GDP would increase by 3.6 percent/year.

consumption as a proportion of cereal consumption increased from 14 percent in 1970 to about 25 percent in 1990 (Otsuka and Kalirajan, 2006).

While small-scale community-based irrigation systems are valid options in almost all types of livelihood zones, they are most relevant in areas where water is a constraint on crop production, i.e. in semi-arid to subhumid zones.

Improving existing irrigation systems

Irrigation projects in SSA, in particular large-scale projects, have a reputation of high cost and low sustainability. Although there were many failures in the 1970s and 1980s, more recent projects have generally had acceptable rates of return (World Bank, 2007a). Key factors associated with higher rates of return to irrigation development in SSA include lower per hectare costs, market access, and production systems that use inputs more intensively – the last two being strongly correlated. However, irrigation projects continue to have a mixed track record on sustainability. The frequent need for rehabilitation projects in both large-scale and small-scale irrigation in SSA (Sudan, Madagascar and Mali) shows the poor sustainability of investments in the sector, and the rates of return of externally financed projects have sometimes had to be revised downwards. Today, about 25 percent of the 7.1 million ha of land equipped for irrigation in SSA are out of use for one reason or another (FAO-AQUASTAT, 2008).

The reasons behind the poor performance of existing irrigation schemes have been studied extensively (Aw and Diemer, 2005; Morardet *et al*., 2005). They vary from technical and economic to institutional and social. They include lack of adequate consideration for land tenure and water security issues, overoptimistic hydrological analysis (IFAD, 2005), neglect of water governance and institutional capacity issues, and an absence of adequate environmental assessment. Falling prices of main agricultural commodities, associated with poor evaluation of markets and profitability, and the absence of agricultural support packages were also among major causes for failure. Furthermore, such projects were often characterized by poor and overly complex technical designs, resulting in technology choices and high maintenance costs (Morardet *et al*., 2005; World Bank, 2007a). Typically, there is a range of fundamental socio-economic changes involved with large-scale irrigation. These are often not sufficiently considered during the planning stage. They include the time needed by social organizations to adapt to technological change, which surpasses by far common development project time frames (Diemer and Huibers, 1996).

While several conditions still limit widespread improvement in the productivity of irrigation schemes, rehabilitation of some of the existing infrastructure offers good possibilities where conducted in conjunction with appropriate changes in design and management. Such changes include, in particular, a much more comprehensive involvement of producers at critical stages in the planning process, and the adoption of a management mechanism that empowers farmers and allows for simpler and more efficient water control. Therefore, modernization approaches need to focus on improved infrastructure and management for increased reliability and flexibility in the service of water.

However, success in increasing the productivity of irrigation systems also depends on a range of other considerations that require careful attention. A clear policy and the appropriate instruments to allow farmers to operate in a conducive environment are necessary preliminary conditions. In the case of rice, a fiscal policy that promotes local or regional production is fundamental. Good market linkages, training packages, strengthening of producers' organizations, and well-targeted credit and finance products are key to the success of large-scale irrigated agriculture.

Improving water control for peri-urban producers

Rapid urbanization in Africa provides increasing opportunities for farmers to produce and market crops in peri-urban areas (Drechsel and Varma, 2007). This dynamic sector of activities is often undervalued. Although estimates of existing irrigation activities around cities are unreliable and incomplete, some data indicate that the scale of the activities is large. For example, the area of the 22 formal irrigation schemes in central Ghana is 8 587 ha, while the estimated area of informal irrigation near cities in the same region is estimated at 40 000 ha (Drechsel *et al.*, 2006). In the United Republic of Tanzania, it is estimated that 90 percent of households in representative villages have small plots under informal irrigation.

Informal irrigation around cities grows as a response to good market opportunities. Typically, it is a flexible and demand-responsive production system, mostly run by small-scale farmers producing vegetables and other non-staples (Drechsel *et al.*, 2006). These farmers typically face acute problems of land tenure and access to quality water. Localized sources of water, which include groundwater, streams, urban drains piped water and wastewater, are often heavily contaminated owing to the rudimentary sanitation arrangements and unregulated effluent discharge (Box 9).

Potential capital investments in water control to support small peri-urban farmers range from small check dams and affordable groundwater drilling and casing technologies to small pumps and localized garden irrigation kits. Small irrigation schemes that benefit a small number of producers have also proved successful. They need to be designed for ease of operation and low maintenance costs so that producers groups can manage them easily.

There is probably no other type of investment that requires a more integrated approach than that of peri-urban farming. Paramount to the success of peri-urban agriculture are the successes obtained in securing access to land and water, providing extension in support to diversification, and ensuring the control of health-related hazards.

Investments to support small-scale peri-urban farming are valid across the whole region, and are relevant in all climate conditions. Examples of successful peri-urban horticulture projects range from ones in Kenya (Box 10) to others in Cape Verde and the Democratic Republic of Congo.

Investing in water for livestock production

Livestock are an integral part of the socio-economic fabric of rural poor in all rural areas of SSA. They contribute to the livelihoods of the majority of the rural poor by strengthening their capacity to cope with income shocks (Ashley, Holden and Bazeley, 1999) and providing them with flexible access to cash when needed. Increasingly, global experience indicates that integrating water

4

Box 9 Small plot irrigation

Small plot irrigation or gardening typically ranges from a few square metres to 0.5 ha. It allows single families to produce food for domestic consumption and for the local market, and requires a shallow source of water. For example, treadle pumps and low-cost drip systems can enable farmers to utilize shallow groundwater in some of the 7.5 million ha of dambo wetlands found in Southern Africa (Roberts, 1988). Small-plot irrigation can also reduce women's workloads, create opportunities for women to learn new skills, and reduce the need for family members to migrate away from home in search of seasonal wage labour (Magistro *et al.*, 2007).

Box 10 Urban horticulture in Kenya

In Kenya, the horticulture industry has expanded substantially in peri-urban areas in recent years. Much of the new production takes place on small-scale, irrigated farms. In areas near Nairobi, sprinkler, drip and furrow systems are used on farms ranging in size from 0.1 to about 1.0 ha. Kulecho and Weatherhead (2006) interviewed a sample of small-scale farmers to determine major issues regarding irrigation of vegetables, particularly with low-cost drip systems. The three problems mentioned by most farmers were: lack of adequate technical support when using the low-cost drip kits; inadequate water supply; and the lack of marketing opportunities for the vegetables produced. These results demonstrate that small-scale farmers need adequate technical support, reliable water supplies, and affordable access to markets if they are to maximize the economic and poverty-reducing benefits of low-cost drip systems.

and livestock development creates more sustainable livelihoods zones and increases investment returns in ways that isolated development efforts are unlikely to produce (Molden, 2007).

Water-related investment to support livestock production varies from one livelihood zone to another as a function of the importance of livestock in the production system and of the prevailing climate conditions. In humid tropics, investment needs are limited as water sources are available for livestock, and livestock watering is not a particular concern. In more arid conditions, livestock watering issues becomes more relevant, while livestock play an increasingly important role in the livelihood zone. In relative terms, livestock are most important in arid, pastoral and agropastoral livelihood zones.

Easy access to an ample supply of water is a priority for livestock production. Regardless of how palatable and plentiful the forage or range may be, the livestock using it must have the water they need, or they will not thrive. Water deprivation quickly results in loss of appetite, and death occurs after a few days (3–5 days for zebus, 6–10 days for sheep, and 15 days or more for camels) when the animal has lost 25–30 percent of its weight (FAO, 1986). Inadequate stock water development in pastoral areas contributes to an unstable livestock industry and can lead to serious livestock losses. It also prevents profitable utilization of grazing areas and encourages destructive overgrazing in the vicinity of existing water supplies. In these systems, the development and maintenance of clean water supply systems for livestock is fundamental to enabling sustainable utilization of the forage without affecting the fragile equilibrium of the system.

There is a wide range of surface and groundwater water possibilities for stock water supply. Where conditions are ideal, one or more methods may be considered. The most likely locations for extending drinking-water from surface waters are where natural ponding already occurs. The cost of dug wells is usually high. However, involvement of the users in well digging has proved an efficient way to lower the cost of groundwater development. In many countries, stockbreeders tend to organize themselves through associations or cooperatives, which may be financially involved in groundwater development works (FAO, 1986).

Livestock water programmes need to be designed carefully. In the past, programmes that failed to take the livestock supporting capacity of rangeland adequately into account resulted in severe environmental damage and, in some cases, major problems of feed availability (FAO, 2006e), threatening the lives of entire herds. Typically, the promotion of tubewell drilling in pastoral areas to enable the herds to stay longer in wet season grazing areas may lead to overgrazing, with long-term impacts on the ecology of the area.

Facilitating multiple use of water

In many areas, the volume of water available to households is as important as its quality. Households lacking sufficient water volume often do not implement sanitation practices that prevent the transmission of pathogens, such as washing hands and faces frequently (van der Hoek, Konradsen and Jehangir, 1999; Boelee, Laamrani and van der Hoek, 2007). However, improvements in water supply alone are unlikely to have positive health impacts unless sanitation practices are also improved. Optimal intervention programmes include improvements in water volume, water quality, and sanitation practices. However, the current understanding of water demand for productive uses is weak. Little is known about water use and demand in rural communities, and most of the research and development has focused on water for human consumption. Typically, water supply systems have been designed to provide small quantities of drinking-quality water at a relatively high price (Pérez de Mendiguren Castresana, 2003).

When possible, investments that provide water for more than one household purpose are likely to be more effective than single-purpose investments in improving livelihoods (Box 11). For example, constructing a village pond or investing in a community tubewell might provide water for irrigation, livestock production, and household chores. Such investments might also reduce the time required by household members to obtain water for drinking and other purposes from distant sources. Providing water of suitable quality nearer to homes and villages can reduce drudgery and enable household members to spend more time on productive activities. In Zimbabwe, many household wells provide sufficient water to support domestic uses and small-scale farming, which improves income and reduces poverty (Lane, 2004).

Access to sufficient water is also essential for small agroprocessing, thus enhancing the value of agricultural production. This ranges from the simple washing of agricultural products to drying, packaging and canning. Health requirements for packed vegetables for export may also result in overall hygiene gains for the rural poor involved in such steps. Washing hands with soap leads to a significant reduction in intestinal diseases in families, and the packaged vegetables are not rejected by health inspectors.

In large irrigation schemes, people use water available in irrigation canals for multiple purposes. Canal water is often preferred to water from other sources for several reasons, including the volume available, accessibility, and practical considerations. Boelee, Laamrani and van der Hoek (2007) have identified five categories of water uses

Box 11 Multiple use of domestic water in South Africa

One study found a wide range of water-dependent productive activities in 13 communities in Bushbuckridge District, South Africa (Pérez de Mendiguren Castresana, 2003). Some of these activities provided goods and services to poor households, and they constituted an important element of the livelihoods of families. The main ones were: vegetable gardens, fruit trees, beer-brewing, brickmaking, hairdressing, livestock (cattle and goats), and ice-block making. Others included: grass-mat weaving; smearing and plastering of walls and floors; baking; poultry; and duck ponds.

that are observed in irrigated areas other than irrigation of the main crops:

- agriculture-related purposes, such as irrigating home gardens, watering livestock, washing agricultural equipment, and soaking fodder;
- domestic purposes, such as laundry, bathing, washing household utensils, soaking grains, cooking, drinking, house cleaning, and sanitation;
- commercial purposes, usually small-scale activities or home industries, such as brickmaking, butcher's or other shops, washing vehicles, pottery, and mat weaving;
- productive purposes, usually non-consumptive, such as fisheries and water mills;
- recreation.

The additional benefits made possible by providing water for household purposes can enhance the aggregate value of investments in irrigation. In some areas, the additional benefits might produce a positive benefit–cost ratio for a project that might otherwise not generate a positive return.

Households and small commercial firms in SSA might also benefit from the development of aquaculture in conjunction with existing or new irrigation systems. The concept of integrated irrigation aquaculture (IIA) is extensively documented for West Africa and other regions where fish is produced in irrigation reservoirs and canals, or in irrigated rice fields (FAO, 2006f). Fish production and harvesting have been conducted both formally and informally in irrigation systems, in flood recession schemes, swamps, bas-fonds and small ponds in Africa and elsewhere for many years, providing an additional source of food and revenue for many households. Further development of aquaculture production, particularly in extensive small-scale irrigation settings, might enhance rural livelihoods and reduce household vulnerability while also improving the aggregate productivity of water resources. A number of commonly available agricultural by-products represent a potential source of feed, and the protein efficiency of fish is usually higher than that of other animals (Molden, 2007). In addition, sediments from small aquaculture ponds can be used as fertilizer in agriculture.

The main challenge, other than the production-related ones, concerns the customary and/or formal governance of the water bodies. Different users, with different power positions, use freshwater resources for different purposes at different times of the year, and throughout the years – sometimes with large intermittent periods of absence. Such multiple-use/multiple-user scenarios are under even more stress and more vulnerable to conflicts when droughts and floods place additional burdens on access to assets and distribution of benefits.

Addressing multiple needs for water has a strong gender aspect. Women and men often have different priorities for water use in a water management scheme. While in most cases men use water for irrigating cash crops, women focus on growing staple/food crops and vegetables in home gardens, or use water for domestic purposes. The sustainability of a water management scheme for agricultural production may be at risk where other, sometimes conflicting, uses of water by women and men living in and close to the scheme are ignored (FAO, forthcoming).

If water management projects are to address concerns of both women and men, WUAs need to play an active role in localized water management for multiple use through recognizing the multiple uses of water in and around households for agriculture and for small-scale activities that allow both men and women to grow more crops and vegetables and to rear livestock.

Essential conditions for success

The likelihood of reducing poverty and improving food security in SSA through investments in the water sector depends on many supportive complementary investments in human, physical, financial, natural and social capital. The returns to major investments in new irrigation systems or investments that enhance rainfed production of staples or marketable crops will be small if farmers do not operate in a favourable environment. Markets, land tenure, property rights, water allocation procedures, and methods for resolving conflicts over land and water resources have substantial influence on the motivation, ability and success of smallholders in maximizing the value of investments in the water sector. Viable input and output markets, in which property rights are well defined and supported by the state, enable smallholders to obtain inputs and sell produce at competitive prices. Access to inputs and financial support, physical infrastructure, and investment in human capacities and technologies are also fundamental to the success of water development programmes. Discussed below are some of the key conditions for the success of water interventions in reducing poverty in rural SSA.

Ensuring enabling governance and policies

The policy environment must be supportive of smallholder production, consumption, and marketing of agricultural products. Policies at both macroeconomic and microeconomic level influence farm-level access to inputs and the ability to sell farm products at prices that provide sufficient revenue to sustain crop production. Macroeconomic policies must not create overvalued currency exchange rates that make exports more expensive, thereby reducing export opportunities for domestic farmers. Governments must also allow the importation of farm inputs and technological developments that might boost crop production at lower costs than is possible using only domestically produced inputs or existing production methods. Tariffs and quotas that restrict international trading of agricultural inputs and outputs must be considered carefully by public officials, as such limits can increase the cost of farming and reduce the revenues available to smallholders.

Policies regarding imports of food and fibre require particular attention. For many years, such imports, often arriving in the form of food aid from industrialized nations and international organizations, have increased the local supply in many countries of SSA. The increase in supply generally has had a downward impact on local prices, to the detriment of domestic farmers attempting to obtain market prices that cover their domestic costs of production. This impact discourages local farmers from investing in the quality or sustainability of soil and water resources, while also reducing labour opportunities in local economies.

The increases in urban populations that are occurring in many SSA countries and the global trends for rising agricultural food prices provide new opportunities for domestic farmers to increase production and receive attractive prices provided that the policy environment is supportive. Policies that promote investments in local agricultural production will generate greater long-term benefits than efforts to increase imports of lower-cost food products available on international markets.

Governance has implications at all levels in agricultural water management. Table 11 shows the different governance dimensions corresponding to different scales of intervention and the need to address governance issues in relation to water, land, infrastructure and market services.

Securing access to markets

The effective operation of markets for food and agricultural products requires:

4

- appropriate legal frameworks and efficient institutions to support market conduct, the enforcement of contracts, and property rights;
- institutional frameworks for monitoring and supporting the emergence of markets through activities such as providing market information and marketing extension;
- well-operated and well-maintained infrastructure to provide transport and communication networks, post-harvest handling and storage, and physical markets.

Agricultural input and output markets must be accessible to smallholders, and information regarding input and output prices must be available to all participants. Smallholders can use new developments in communication technology to obtain current information describing input and output prices across a range of possible buyers and sellers. Public investments in regional communication networks can be helpful in providing smallholders with the access they need in order to optimize their participation in local and regional markets.

Many farmers in SSA have limited experience with formal, freely-functioning markets for agricultural inputs and outputs. Such a situation constrains public efforts to reduce poverty and improve food security through investments in the water sector. Hence, there is a role for government in training farmers to understand market operations and to help farmers produce and prepare their crops in ways that will enhance the likelihood of obtaining good prices in market settings. Extension service personnel can assist farmers in implementing measures that will improve the quality of farm products. Affordable access to farm chemicals, refrigeration, and transport services will also be helpful in this effort. Over time, public agencies might also assist farmers in forming cooperative associations that might provide additional services to members, such as promoting market development, exploring export opportunities, and seeking ways to add value to farm products before selling them in domestic or international markets. Farmers cooperatives could be based on, or form the basis for creating, effective WUAs. Water planners often consider forming WUAs when designing new irrigation schemes. Such associations could expand over time to undertake a variety of activities that support farm production and marketing. The goals of expansion might include providing additional services that enhance farm-level revenues, and generating additional funds to sustain the WUAs.

Physical infrastructure

Despite substantial investments in infrastructure in the recent past, rural populations in many countries of SSA remain poorly served. Inadequate investment in physical infrastructure limits the pace of economic development in many areas of SSA. Water supply, sanitation, and reliable electricity services are available in too few villages and districts. Paved roads, railroad networks, and easily accessible market centres are rare. In many countries, there are fewer than 1 000 km of paved roads per 1 000 persons, a level of service that is an order of magnitude smaller than the amount of paved roads in many industrialized nations.

Inadequate availability of storage, processing, refrigeration and packaging facilities are partly responsible for post-harvest losses that continue to be excessive in many rural areas (up to 30 percent of harvested fruit and vegetables), and limit opportunities for adding value to agricultural products. In situations where there is a food deficit, it is unacceptable to have post-harvest losses that can be avoided.

In many areas of SSA, investments in infrastructure will enhance the returns to investments in water control. The infrastructure needs are substantial, but so are the potential direct and indirect returns to appropriate investments. Infra-

Table 11 Dimensions of governance and intervention

Level	Water	Land	Infrastructure	Market services
Farmer	Access to water: water rights; water markets	Access to land: land tenure; size of farm holdings	Access to affordable technology, including irrigation	Access to production inputs and markets
Farmer groups	Water rights; equity; water distribution; accountability	–	Management authority (irrigation schemes)	Farmer cooperatives, unions, meteorological forecasting
Irrigation service	Reliability, equity and flexibility of irrigation service delivery	Crop patterns and licensing	System management and maintenance; cost recovery; transparency; accountability	Farm roads maintenance and other scheme infrastructures
Local government	Water licensing (nepotism); conflict resolution	Land-use planning	Decentralization; development of new infrastructure (including markets)	Market infrastructure and transport; access to finance; market information
Basin authority	Sectoral water allocation; water quality management; water conservation (financial incentives)	Soil conservation; watershed protection	Main hydraulic infrastructure planning; development and management (corruption)	–
National government	Water policy and legislation; institutional arrangements	Land-use policy and legislation; cadastre; land-use planning	Policies and legislations on: decentralization; infrastructure development planning; cost recovery; financing mechanisms for infrastructure; access to finance for local stakeholders	Policies and legislation on: food security; agriculture (subsidies); rural development; trade (tariffs, subsidies); food self-sufficiency; rural finance
Regional	Transboundary water; security of supply	–	Transboundary water shared infrastructure	Regional trade agreements
Global level	International security and solidarity	–	–	Agricultural subsidies and tariffs

Source: WWAP (2006).

structure development is needed at all levels of investment:

- At the macrolevel, efforts should be made to ensure basic transport and communication infrastructure. Improved access and density of roads can reduce transaction costs for both inputs and outputs. Improvements in transportation, in particular when coupled with rural electrification, often lead to an increase in the cultivation of improved varieties of plants, increased fertilizer use, and expansion of areas under irrigation and water management. Transport and telecommunication services enable communication and information flow between rural and urban centres. This links farmers to markets and also facilitates the flow of information to and from extension specialists. The secondary and synergistic impacts of investments in roads, electricity and other forms of communication can be substantial, particularly in the least developed areas. The introduction of mobile phones has considerably increased information on markets for previously remote farmers and, thereby, increased their market opportunities. This changes the attractiveness of investment in various types of infrastructure.
- At the mesolevel, the development of safe and well-organized physical markets, both wholesale and retail, is important for facilitating the exchange of goods at regional level. In rural areas, markets not only provide a convenient location for farmers to meet with traders and consumers, they are also focal points for community activities. Some attempts to improve market infrastructure have been disappointing in the past, partly because of inadequate consultation with users. Better consultation might increase the likelihood of designing market centres that serve many purposes in ways that truly promote commerce and enhance the timely dissemination of market information.
- At the microlevel, investments in post-harvest handling, storage and processing facilities can also stimulate the non-farm sector and support the creation of small businesses. This can be a significant source of employment and, hence, income for poor people in rural areas.

The complementary nature of investments in irrigation and other forms of infrastructure, such as roads, schools, and health care facilities, is somewhat symmetric. As investments in roads and schools can improve the returns to investments in irrigation, so too can investments in irrigation improve the returns to investments in roads and schools (Ali and Pernia, 2003). It is reasonable to expect that the value of improving roads in a rural area will be greater if farmers have access to irrigation.

Land tenure and water rights

Farm-level efforts to improve and maintain productivity will be of limited value unless land tenure is secure for smallholders. Farmers must be able to count on the long-term benefits of near-term investments that reduce the rate of land degradation and maintain growth in productivity. In many areas of SSA, systems of land tenure and water-use rights have become dysfunctional and limit investment. Both land tenure and water rights issues must be addressed in a coordinated fashion in order to ensure optimal returns to public investments in irrigation and to motivate adequate investments at farm level.

Conflicts involving land and water resources often increase with population density and with increases in economic activity. In densely populated areas, the withdrawal of water for irrigation or other uses from the upper reaches of a river basin or watershed competes with the needs of people downstream. Effective river basin institutions are needed in such areas. Economic incentives might also be needed to achieve a socially optimal reallocation of water, in conjunction with defining water rights to shifts in water allocation.

More generally, the environmental sustainability of rural investment is inextricably linked to the economic and social development of the recipient communities. Genuine ownership on the part of communities is the most effective path to environmental sustainability. Without these, the overall economic, social and environmental sustainability of the water infrastructure investment is at risk.

Preventing soil degradation and restoring fertility

Investments in the water sector will not be successful unless smallholders have affordable access to complementary inputs, in particular fertilizers (Box 12). The average annual rate of growth in fertilizer use in SSA declined from almost 9 percent between 1962 and 1982 to less than 1 percent between 1982 and 2002, partly because of the removal of fertilizer subsidies in the 1980s and 1990s.

Government involvement in the provision of seed, fertilizer, and chemicals lost favour with international organizations in the 1980s and 1990s. Structural adjustment programmes required governments to discontinue subsidizing farm inputs. As a result, average productivity declined. Estimated soil nutrient losses exceeded 60 kg/ha in 21 countries in SSA in 2002–04 (Table 12). Declining soil productivity reduces crop yields and sets in motion a vicious cycle that might be described as inadequate soil fertility causing low crop yields, which produce limited farm revenue, such that farmers lack funds for purchasing mineral fertilizers. As this cycle is repeated over time, soil fertility and crop yields continue to decline. Input subsidies are needed in some areas in order to restore growth in agricultural productivity and ensure the success of new interventions in the water sector. Recently, governments that have restored an element of targeted fertilizer subsidy for the poor have seen gains in output and incomes in this group. This is discussed further below.

Providing targeted subsidies and adapted financial packages

Focusing on agriculture, the World Development Report 2008 (World Bank, 2007b) acknowledges the importance of well-targeted input subsidies as an element of poverty reduction strategies in rural areas. Several mechanisms are available to support farm-level purchases of key inputs, from providing selected inputs at no charge to farmers to low-interest-bearing seasonal or mid-term loans. The optimal combination of available methods will vary among countries and among production regions. The goal in all cases should

Box 12 The role of fertilizers in contract farming

Farmers in some areas of SSA have opportunities to produce cash crops that are purchased by trading firms in accordance with contracts that describe production goals and crop prices. Contract farming arrangements often provide financial credit to farmers at the start of a production season. Participating farmers can intensify crop production by applying more fertilizer and other inputs than would be possible without credit. In some cases, the credit enables farmers to increase their use of fertilizer on both their cash crops and their food crops. Jayne, Yamano and Nyoro (2004) observed this result in a panel survey involving crop production data for 1 540 households in Kenya in the period 1997–2000. Households engaged in marketing arrangements for selected cash crops applied substantially more fertilizer on those crops and on cereal crops than did households not engaged in marketing arrangements.

Table 12 Estimated soil nutrient losses in African countries, cropping seasons 2002–04

Low (less than 30 kg/ha/year) (kg/ha)		Medium (from 30 to 60 kg/ha/year) (kg/ha)		High (more than 60 kg/ha/year) (kg/ha)	
Egypt	9	Libyan Arab Jamahiriya	33	United Republic of Tanzania	61
Mauritius	15	Swaziland	37	Mauritania	63
South Africa	23	Senegal	41	Congo	64
Zambia	25	Tunisia	42	Guinea	64
Morocco	27	Burkina Faso	43	Lesotho	65
Algeria	28	Benin	44	Madagascar	65
		Cameroon	44	Liberia	66
		Sierra Leone	46	Uganda	66
		Botwana	47	Democratic Republic of the Congo	68
		Sudan	47	Kenya	68
		Togo	47	Central African Republic	69
		Côte d'Ivoire	48	Gabon	69
		Ethiopia	49	Angola	70
		Mali	49	Gambia	71
		Djibuti	50	Malawi	72
		Mozambique	51	Guinea Bissau	73
		Zimbabwe	53	Namibia	73
		Niger	56	Burundi	77
		Chad	57	Reanda	77
		Nigeria	57	Equatorial Guinea	83
		Eritrea	58	Somalia	88
		Ghana	58		

Source: Henao and Baanante (2006).

4

be to ensure affordable access to infrastructure, services and inputs, particularly for smallholders who are most vulnerable to shortfalls in agricultural production. Public assistance for purchasing key inputs will impose a cost on governments, while lowering the farm-level cost of producing crops and livestock products. The public cost can be justified by the non-market, public benefits of boosting agricultural production in a comprehensive effort to reduce poverty and improve food security (Box 13).

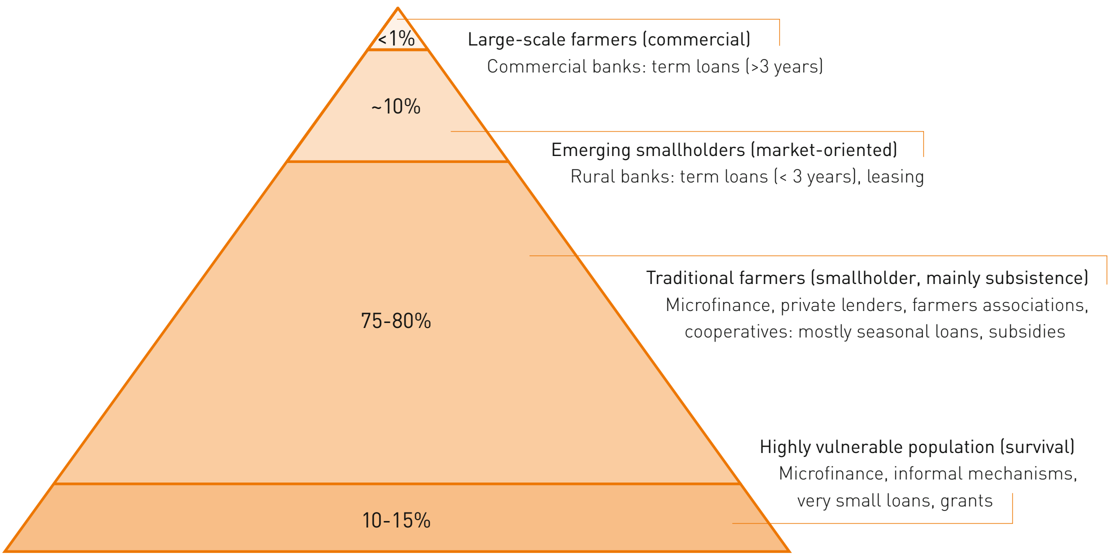
In addition to credit for purchasing the inputs needed at the start of each crop season, farmers must also have access to the financial credit needed to make investments that will generate benefits over time. Developers of financial tools and packages to support water investments in rural areas need to recognize the many different functions of water for agriculture and the spectrum of possible water interventions. The variety of functions and the range of possible interventions provide scope for designing innovative programmes that correspond to specific needs. For example, term finance needs to be promoted to support medium-term water-related investments. Figure 19 shows how different social groups require specific financial support.

Box 13 Record maize harvest in Malawi

Malawi has a chronic hunger problem, with more than one-fifth of the population unable to meet their daily food needs. One cause of the food shortage has been the poor crop harvests that the country has suffered for many years. In the last two years (2006 and 2007), the country has experienced bumper harvests, with a surplus of 1 million tonnes of maize in 2007. Behind these record results is the Government of Malawi's fertilizer and seed subsidy programme, introduced in 2005 and cofunded by the Department for International Development (DFID) of the United Kingdom. This programme, which allows Malawians to buy fertilizer and maize seed at better prices than in the past, has benefited some of the country's poorest people. In the future, the programme should help secure Malawi's food supplies in a sustainable way, while providing smallholder farmers with improved sources of livelihood.

Source: DFID (2007).

Figure 19 **Adapting financial services to the needs of different groups**



Investing in human capital

Complementary investments in education and training enhance the value of investments in irrigation and water control by providing farmers with appropriate knowledge and skills. Similarly, the returns to investments in education and training will be higher if farmers have opportunities to implement new production methods in irrigated settings.

Within this context, it is necessary to consider the important roles of women in irrigation, water harvesting, and other aspects of agricultural production in developing countries. The concerns of women must be taken into account in the conceptual phase of water investment projects. Excluding women from the design phase may have unexpected adverse effects in terms of poverty reduction and equity (FAO, forthcoming).

For example, an inappropriate design or location of tap-stands or wells may lead inadvertently to an increase in burdens or safety concerns for women and young girls charged with fetching the water. Similarly, a tight water rotation schedule is usually not suitable for women who must perform many different domestic tasks and do not have full control over their time. Therefore, capacity-building programmes in water management should be designed in ways that relieve women and girls from part of the heavy burden in conducting daily tasks.

Adapting interventions to local conditions

Not all intervention options have the same relevance and potential for poverty reduction in all settings. As stated throughout this report, agroclimatic conditions, prevailing livelihood zone types, and local socio-economic conditions all influence intervention programmes. Table 13 provides a summary of the relevance of the main intervention options described above in different livelihood contexts. While it can be further refined to take into account local conditions, it shows that, at regional level, substantial differences in patterns of investments can be observed in different regions. Table 13 also confirms the results of Table 7 showing the potential for water intervention by livelihood zone, with particular emphasis on cereal–based and agropastoral zones.

Soil moisture management, and in particular conservation agriculture practices, are most relevant in cereal – root crop zones and in highland temperate zones, where they can contribute to reducing the impact of dry spells in an otherwise favourable rainfall environment. Water harvesting, in particular for supplementary irrigation, is highly relevant in cereal–based zones, especially those dominated by maize. Small-scale community-based irrigation find its application in several settings, in particular those where rainfall alone cannot guarantee agricultural production. Investment in water control for livestock production is of most importance in arid and semi-arid environments.

Assessing investment potential

This section presents the results of an exercise to estimate the possible costs of a programme of investments in water in support of rural livelihoods. It is based on an assessment of the potential application of each of the seven water intervention options described above.

In line with the philosophy of this report, the proposed investments are expected to affect the livelihoods of rural people through increased water security and improved access to water for both domestic and productive purposes, increased resilience to climate shocks, and a consequent reduction in people's vulnerability. Such improvements in rural people's livelihoods will come from improved control of water for their main source of food and revenues, from reduced hardship in terms of working conditions and a consequent increase in labour productivity, and from improved hygiene and health conditions.

To this effect, the benefits to be expected from such investments can hardly be expressed solely in terms of increased production. They also need to account for reduced variability in production, gender empowerment, enhanced labour productivity, reduced burden of diseases, improved institutional capacities, etc. For this reason, the cost estimates of potential investments presented here are not accompanied with estimates of benefits.

In order to ensure consistency with the approach proposed in this report, the assessment used the three criteria described in Chapter 3 (Annex 2 provides details of the methodology). The assessment at regional level consisted of the following steps:

<table>
<caption>Table 13 Relevance of intervention by livelihood zone</caption>
<tr><th>Livelihood zone</th><th>Manage soil moisture in rainfed areas</th><th>Invest in small-scale water harvesting infrastructure</th><th>Promote small-scale community based irrigation</th><th>Improve existing irrigation systems</th><th>Improve water control for peri-urban producers</th><th>Invest in water for livestock production</th><th>Facilitate multiple use of water</th></tr>
<tr><td>Arid</td><td>low</td><td>moderate</td><td>low</td><td rowspan="13">High in irrigated schemes, n/a elsewhere</td><td rowspan="13">High around cities</td><td>low</td><td>low</td></tr>
<tr><td>Pastoral</td><td>low</td><td>low</td><td>low</td><td>high</td><td>high</td></tr>
<tr><td>Agropastoral</td><td>moderate</td><td>moderate</td><td>moderate</td><td>high</td><td>high</td></tr>
<tr><td>Cereal–based</td><td>high</td><td>high</td><td>high</td><td>moderate</td><td>moderate</td></tr>
<tr><td>Cereal–root crop</td><td>moderate</td><td>moderate</td><td>high</td><td>moderate</td><td>moderate</td></tr>
<tr><td>Root–crop–based</td><td>low</td><td>low</td><td>moderate</td><td>low</td><td>moderate</td></tr>
<tr><td>Highland Temperate</td><td>high</td><td>moderate</td><td>moderate</td><td>moderate</td><td>moderate</td></tr>
<tr><td>Highland Perennial</td><td>low</td><td>moderate</td><td>moderate</td><td>moderate</td><td>moderate</td></tr>
<tr><td>Tree crop</td><td>low</td><td>low</td><td>low</td><td>low</td><td>moderate</td></tr>
<tr><td>Forest–based</td><td>low</td><td>low</td><td>low</td><td>low</td><td>moderate</td></tr>
<tr><td>Large Commercial and Smallholder</td><td>moderate</td><td>moderate</td><td>moderate</td><td>moderate</td><td>moderate</td></tr>
<tr><td>Rice–tree crop</td><td>low</td><td>low</td><td>moderate</td><td>low</td><td>moderate</td></tr>
<tr><td>Coastal Artisanal Fishing</td><td>low</td><td>low</td><td>low</td><td>low</td><td>moderate</td></tr>
<tr><td colspan="8">Expected benefits (direct, by category of farmers)</td></tr>
<tr><td>Large-scale</td><td>low</td><td>low</td><td>low</td><td>medium</td><td>low</td><td>low</td><td>low</td></tr>
<tr><td>Emerging</td><td>low</td><td>medium</td><td>medium</td><td>medium</td><td>high</td><td>medium</td><td>low</td></tr>
<tr><td>Traditional</td><td>high</td><td>high</td><td>high</td><td>low</td><td>low</td><td>high</td><td>high</td></tr>
<tr><td>Highly vulnerable</td><td>low</td><td>low</td><td>low/medium</td><td>low</td><td>low</td><td>medium</td><td>high</td></tr>
</table>

1. Potential for water intervention: for each of the seven categories of interventions, and for each livelihood zone, assessment of the maximum possible extent of application of the intervention, taking into account the rural population, cultivated area, and available water resources, in modalities that vary from one type of intervention to another;
2. Water as a limiting factor: application of a coefficient taking into account the importance of water as a limiting factor for each livelihood zone;
3. Poverty incidence: application of a coefficient taking into account the importance and incidence of poverty for each livelihood zone.

Unit costs by type of intervention were estimated based on available information from investment projects used by FAO for similar regional assessments. These unit cost figures represent only rough averages. Substantial differences can be expected from one livelihood zone to another, and from one place to another within a given zone.

The results are presented in detail in Annex 2 and in summary form in Tables 14–16. Table 14 shows the potential for each type of intervention by livelihood zone. It is expressed in potential area of rainfed and irrigated land, required storage capacity, heads of livestock and number of households reached, according to the type of intervention.

Table 15 estimates the number of rural people who can be reached in each livelihood zone by the type of intervention – the assessment considered persons rather than households (therefore, that what benefits a smallholder farmer benefits the whole family). The interventions are not all mutually exclusive. Thus, it can be expected that a person may benefit from one or more of the proposed investments. In total, it is expected that about 58 percent of the rural population of SSA could benefit from some type of investment in water. The percentage varies from 96 percent in the cereal–based area, to a few percentage points in areas where such interventions are not economically or socially justified.

Table 16 expresses these potential interventions in terms of capital investment costs. In total, these investments could amount to about US$86 000 million, which would represent US$350 per beneficiary. For land-related interventions, the average investment would be about US$330/ha. The bulk of the costs (53 percent) would be for small-scale water harvesting infrastructures, in support of supplementary irrigation and other uses such as fish farming. This category of intervention is broad and ranges from very small check dams to small reservoirs and subsurface reservoirs. Soil moisture management in rainfed areas and small-scale community-based irrigation also represent substantial potential. Of lower value in terms of investment costs, but locally important, are interventions such as livestock watering and the development of multiple-use systems.

These figures should be taken as being only indicative and as an order of magnitude of the potential for investments in water in support of rural poverty reduction in SSA. Considerable uncertainties are associated with the estimation of "average" unit costs, and of the extent of the potential of each intervention. In particular, the range of options captured under the heading "small-scale water harvesting" and the range of costs associated with these interventions, together with the extent of possible application of such investments, are the single most important factor influencing the estimates of costs.

Table 14 Potential for water-related interventions by livelihood zone

Livelihood zone	Manage soil moisture in rainfed areas (ha)	Invest in small-scale water harvesting infrastructure (Mm^3)	Promote small-scale community y-based irrigation (ha)	Improve existing irrigation systems (ha)	Improve water control for peri-urban producers (ha)	Invest in water for livestock production (head)	Facilitate multiple use of water (household)
Arid	114 770	34	30 000	389 793	62 606	1 255 260	250 272
Pastoral	8 948 023	2 684	500 000	601 019	113 497	24 223 700	4 904 028
Agropastoral	41 547 366	12 464	600 000	458 437	234 625	35 174 400	6 917 706
Cereal–based	35 413 458	10 624	499 407	312 130	322 533	24 497 200	11 862 252
Cereal–root crop	51 176 547	15 353	358 122	223 826	249 844	38 576 100	12 229 596
Root–crop–based	2 146 486	644	11 192	93 267	111 223	1 218 008	730 676
Highland Temperate	7 576 418	2 273	104 128	86 774	123 970	9 283 125	4 054 523
Highland Perennial	1 756 652	527	10 772	26 930	80 667	1 563 705	1 637 755
Tree crop	305 265	92	2 087	57 965	94 816	94 189	133 312
Forest–based	818 626	246	5 491	45 758	73 991	249 578	437 555
Large Commercial and Smallholder	2 077 440	623	0	709 010	118 778	1 924 965	613 173
Rice–tree crop	150 575	45	6 501	346 763	15 261	86 510	120 785
Coastal Artisanal Fishing	73 299	22	6 724	186 787	103 205	44 258	70 011
Total	152 104 925	45 631	2 134 424	3 538 456	1 705 016	138 190 997	43 961 643

Table 15 Number of people reached by intervention and livelihood zone

Livelihood zone	Manage soil moisture in rainfed areas (no. people)	Invest in small-scale water harvesting infrastructure (no. people)	Promote small-scale community based irrigation (no. people)	Improve existing irrigation systems (no. people)	Improve water control for peri-urban producers (no. people)	Invest in water for livestock production (no. people)	Facilitate multiple use of water (no. people)	Total (no. people)	Total in % of rural population %
Arid	61 983	18 595	300 000	3 897 930	626 065	1 126 223	1 251 359	4 885 977	59
Pastoral	2 401 811	720 543	5 000 000	6 010 185	1 134 968	24 520 140	24 520 140	24 520 140	90
Agropastoral	18 800 948	5 640 284	6 000 000	4 584 370	2 346 248	30 745 360	34 588 530	34 588 530	90
Cereal–based	51 807 865	15 542 359	4 994 072	3 121 295	3 225 328	32 950 700	59 311 260	63 148 560	96
Cereal–root crop	53 882 439	16 164 732	3 581 216	2 238 260	2 498 440	33 971 100	61 147 980	62 200 355	92
Root–crop–based	2 903 776	871 133	111 920	932 665	1 112 228	1 461 351	3 653 378	5 060 589	10
Highland Temperate	17 715 750	5 314 725	1 041 282	867 735	1 239 704	9 010 050	20 272 613	20 864 471	69
Highland Perennial	6 501 187	1 950 356	107 720	269 300	806 670	3 275 510	8 188 775	8 188 775	25
Tree crop	528 729	158 619	20 867	579 645	948 156	266 623	666 558	2 077 397	7
Forest–based	1 518 707	455 612	54 909	457 575	739 912	875 109	2 187 773	2 771 103	9
Large Commercial and Smallholder	1 946 780	584 034	0	7 090 095	1 187 784	1 532 933	3 065 865	10 224 659	50
Rice–tree crop	359 095	107 729	65 015	3 467 630	152 606	241 571	603 926	4 044 346	50
Coastal Artisanal Fishing	157 022	47 107	67 243	1 867 870	1 032 052	140 023	350 057	3 124 188	20
Total	158 586 093	47 575 828	21 344 244	35 384 555	17 050 161	140 116 692	219 808 213	245 699 091	58

Note: Total per livelihood zone is lower that the total of single interventions because some people will benefit from several types of intervention

Table 16 Investment costs by intervention and livelihood zone

Livelihood zone	Manage soil moisture in rainfed areas (US$ million)	Invest in small-scale water harvesting infrastructure (US$ million)	Promote small-scale community based irrigation (US$ million)	Improve existing irrigation systems (US$ million)	Improve water control for peri-urban producers (US$ million)	Invest in water for livestock production (US$ million)	Facilitate multiple use of water (US$ million)	Total (US$ million)	Total per beneficiary US$/pers.	Total per ha of cultivated land (*) US$/ha
Arid	9	34	128	780	188	38	19	1 194	244	737
Pastoral	671	2 684	2 125	1 202	340	727	368	8 118	331	692
Agropastoral	3 116	12 464	2 550	917	704	1 055	519	21 325	617	465
Cereal-based	2 656	10 624	2 122	624	968	735	890	18 619	295	472
Cereal-root crop	3 838	15 353	1 522	448	750	1 157	917	23 985	386	424
Root-crop-based	161	644	48	187	334	37	55	1 464	289	48
Highland Temperate	568	2 273	443	174	372	278	304	4 412	211	373
Highland Perennial	132	527	46	54	242	47	123	1 170	143	141
Tree crop	23	92	9	116	284	3	10	537	258	38
Forest-based	61	246	23	92	222	7	33	684	247	58
Large Commercial and Smallholder	156	623	0	1 418	356	58	46	2 657	260	167
Rice-tree crop	11	45	28	694	46	3	9	835	206	305
Coastal Artisanal Fishing	5	22	29	374	310	1	5	746	239	204
Total	11 408	45 631	9 071	7 077	5 115	4 146	3 297	85 745	349	334
Total in percentage of total cost	13	53	11	8	6	5	4	100		

Note: *: The total per hectare of cultivated land refers to the first five interventions

Concluding note

This report carries two important messages. The first is that there is a large range of opportunities for interventions in water in support of the rural poor in SSA. The potential for such interventions in terms of people reached, water mobilized and land productivity enhancement is extremely large. In total, it is estimated that about 58 percent of the rural population of SSA could benefit from some type of investment in water. Water will remain a major factor affecting the livelihoods of rural people in the region, both in terms of basic services, and in terms of resilience building and vulnerability reduction. However, as advocated here, these water interventions are unlikely to generate poverty reduction effects if they are conducted in isolation, without also acting on the political, institutional, market, knowledge, and financial dimensions of the challenge.

The second message is that the variety of livelihood situations in which rural people operate in SSA calls for context-specific and targeted interventions, where rural people's constraints and opportunities are understood and addressed, and where they can take part in the decision-making processes in a way that is effective and ensures the greatest impact on their livelihoods. While all categories of rural people are expected to benefit directly or indirectly from such interventions, the traditional smallholders, farmers, fishers and herders offer the greatest potential for poverty reduction.

Rural communities are in transition, and the dynamics of this transition need to be understood and internalized in order to design effective poverty reduction programmes. As a basic human need, and as a major production factor in rural areas, water has a central role to play in helping rural communities to meet new challenges and to benefit from the associated opportunities.

References

Abalu, G. & Hassan, R. 1998. Agricultural productivity and natural resource use in southern Africa. *Food Pol.*, 23(6): 477–490.

Alexandratos, N. 2005. Countries with rapid population growth and resource constraints: issues of food, agriculture, and development. *Pop. Dev. Rev.*, 31(2): 237–258.

Ali, I. & Pernia, E.M. 2003. *Infrastructure and poverty reduction: what is the connection?* Economics and Research Department Policy Brief Series, No. 13. Manila, ADB.

Ashley, S.D., Holden, S.J & Bazeley, P.B.S. 1999. *Livestock in development 1999. Livestock in poverty focused development.* Crewkerne, UK.

Asian Development Bank (ADB). 2001. *Improving child nutrition in Asia.* Nutrition and Development Series No. 3. Manila.

Aw, D. & Diemer, G. 2005. *Making a large irrigation scheme work: a case study from Mali.* Washington, DC, World Bank.

Baïdu-Forson, J. 1999. Factors influencing adoption of land-enhancing technology in the Sahel: lessons from a case study in Niger. *Agric. Econ.*, 20(3): 231–239.

Boelee, E., Laamrani, H. & van der Hoek, W. 2007. Multiple use of irrigation water for improved health in dry regions of Africa and South Asia. *Irri. Drain.*, 56(1): 43–51.

Brown, C. & Lall, U. 2006. Water and economic development: the role of variability and a framework for resilience. *Nat. Res. For.*, 30(4): 306–317.

Center for International Earth Science Information Network (CIESIN). 2008. Child malnutrition dataset. (available online at http://www.ciesin.org).

Cleveringa, R., Huppert, W. & Cohen, A. (Eds.) (forthcoming) *InnoWat: Inn al Poverty*, Rome, IFAD.

Dalton, T.J. & Guei, R.G. 2003. Productivity gains from rice genetic enhancements in West Africa: countries and ecologies. *World Dev.*, 31(2): 359–374.

Demographic and Health Survey (DHS). 2008. Online database. (available at http://www.measuredhs.com/).

Department for International Development (DFID). 2007. *Record maize harvest in Malawi. Case studies* (available at http://www2.dfid.gov.uk)

Diao, X. & Pratt, A.N. 2007. Growth options and poverty reduction in Ethiopia: an economy-wide analysis. *Food Pol.*, 32(2): 205–228.

Diao, X., Hazell, P., Resnick, D. & Thurlow, J. 2007. *The role of agriculture in development: implications for sub-Saharan Africa.* Research Report 153. Washington, D.C., IFPRI.

Diemer, G. & Huibers, F.P., eds. 1996. Crops, people and irrigation: water allocation practices of farmers and engineers. London, IT Publications.

Drechsel, P. & Varma, S. 2007. *Recognizing informal irrigation in urban and peri-urban West Africa*. Water Policy Briefing, Issue 26. Colombo, IWMI. 8 pp.

Drechsel, P., Graefe, S., Sonou, M. & Cofie, O.O. 2006. *Informal irrigation in urban West Africa: an overview*. Research Report 102. Colombo, IWMI. 34 pp.

Easterling, W.E., Aggarwal, P.K., Batima, P., Brander, K.M., Erda, L., Howden, S.M., Kirilenko, A., Morton, J., Soussana, J.-F., Schmidhuber, J. & Tubiello, F.N. 2007. Food, fibre and forest products. In M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden & C.E. Hanson, eds. *Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, pp. 273–313. Cambridge, UK, Cambridge University Press.

Erenstein, O., Oswald, A. & Mahaman, M. 2006. Determinants of lowland use close to urban markets along an agro-ecological gradient in West Africa. *Agric. Ecosys. Env.*, 117(2–3): 205–217.

Eswaran, H., Almaraz, R., van den Berg, E. & Reich, P. 1997. An assessment of the soil resources of Africa in relation to productivity. *Geoderma*, 77(1): 1–18.

FAO. 1986. *Water for animals*, by P. Pallas. FAO Land and Water Miscellaneous. AGL/MISC/4/85. Rome.

FAO. 1994. *Water harvesting for improved agricultural production*. Proc. FAO Expert Consultation, 21–25 November 1993, Cairo. Water Report No. 3. Rome.

FAO. 1998. *Guidelines for the water control component of the Special Programme for Food Security*. Unpublished document.

FAO. 2001. *The economics of conservation agriculture*. FAO Land and Water Development Division. Rome.

FAO. 2002. Project integer Keita. Rapport terminal du projet. Project GCP/NER/032/ITA. Rome.

FAO. 2005. *Drought-resistant soils. Optimization of soil moisture for sustainable soil production*. FAO Land and Water Bulletin No. 11. Rome.

FAO. 2006a. *Demand for irrigated products in sub-Saharan Africa*. Water Report No. 31. Rome.

FAO. 2006b. *World agriculture towards 2030/2050: prospects for food, nutrition, agriculture and major commodity groups*. Rome.

FAO. 2006c. *Irrigation in Africa in figures*. Rome.

FAO. 2006d. *Mapping global urban and rural population distributions*. Environment and Natural Resource Working Paper 24. Rome.

FAO. 2006e. *Access to water, pastoral resource management and pastoralists' livelihoods*, by N. Gomes. FAO Livelihood Support Programme (LSP). Rome.

FAO. 2006f. *Integrated irrigation and aquaculture in West Africa: concepts, practices, and potential*, by M. Halwart & A.A. van Dam, A.A., eds.

FAO. 2007. Crop prospects and food situation. Global Information and Warning System on Food and Agriculture. No. 4. Rome.

FAO. forthcoming. *Pocket guide for gender mainstreaming in water management*.

FAO-AQUASTAT. 2008. Online database on water in agriculture (available at http://www.fao.org).

FAO-FGGD. 2008. Online food insecurity, poverty and environment global GIS database (FGGD). (available at http://tecproda01.fao.org).

FAOSTAT. 2008. FAO online database (available at http://faostat.fao.org).

FAO & World Bank. 2001. *Farming systems and poverty*, by J. Dixon, A. Gulliver & D. Gibbon. Rome and Washington, DC.

Fox, P. & Rockström, J. 2000. Water harvesting for supplemental irrigation of cereal crops to overcome intra-seasonal dry-spells in the Sahel. *Phys. Chem. Earth*, (B) 25(3): 289–296.

Gabre-Madhin, E.Z. & Haggblade, S. 2004. Successes in African agriculture: results of an expert survey. *World Dev.*, 32(5): 745–766.

Godswill, M., Kelemework, D. & Aredo, D. 2007. A comparative analysis of rainfed and irrigated agricultural production in Ethiopia. *J. Irri. Drain. Sys.* 21(1): 35–44.

Haefele, S.M., Wopereis, M.C.S., Donovan, C. & Maubuisson, J. 2001. Improving the productivity and profitability of irrigated rice production in Mauritania. *Eur. J. Agron.*, 14(3): 181–196.

Haefele, S.M., Johnson, D.E., Diallo, S., Wopereis, M.C.S. & Janin, I. 2000. Improved soil fertility and weed management is profitable for irrigated rice farmers in Sahelian West Africa. *Field Crops Res.* 66(2): 101–113.

Hayami, Y. 2001. Induced innovation and agricultural development in Asia. In A. Mason, ed. Population change and economic development in East Asia: challenges met, opportunities seized. Stanford, USA, Stanford University Press.

Henao, J. & Baanante, C. 2006. Agricultural production and soil nutrient mining in Africa: implications for resource conservation and policy development. Muscle Shoals, USA, IFDC.

Holmén, H. 2005a. Spurts in production – Africa's limping green revolution. In G. Djurfeldt, H. Holmén, M. Jirström & R. Larsson, eds. *The African food crisis: lessons from the Asian green revolution.* Wallingford, UK, CABI Publishing.

Holmén, H. 2005b. The state and agricultural intensification in sub-Saharan Africa. In G. Djurfeldt, H. Holmén, M. Jirström & R. Larsson, eds. *The African food crisis: lessons from the Asian green revolution.* Wallingford, UK, CABI Publishing.

Hussain, I. 2007a. Poverty-reducing impacts of irrigation: evidence and lessons. *Irri. Drain.*, 56(2–3): 147–164.

Hussain, I. 2007b. Pro-poor intervention strategies in irrigated agriculture in Asia: issues, lessons, options and guidelines. *Irri. Drain.*, 56(2–3): 119–126.

Hussain, I. & Hanjra, M.A. 2004. Irrigation and poverty alleviation: review of the empirical evidence. *Irri. Drain.*, 53(1): 1–15.

International Fund for Agricultural Development (IFAD). 2001. *Rural poverty report 2001. The challenge of ending poverty.* New York, USA, Oxford University Press.

International Fund for Agricultural Development (IFAD). 2005. *Agricultural water development for poverty reduction in Eastern and Southern Africa.* Draft report on component study for the AfDB, FAO, IFAD, IWMI, and the World Bank Collaborative Programme Investment in Agricultural Water for Poverty Reduction and Economic Growth in Sub-Saharan Africa. Rome.

International Fund for Agricultural Development (IFAD). forthcoming. *Water and poor rural livelihoods: a new reality. Strategic approach and guidance for IFAD's pro-poor rural water interventions*, by T. Rauch.

Inocencio, A., Kikuchi, M., Tonosaki, M. Maruyama, A., Merrey, D., Sally, H. & de Jong, I. 2007. *Costs and performance of irrigation projects: a comparison of sub-Saharan Africa and other developing regions*. IWMI Research Report 109. Colombo, IWMI. 71 pp.

International Institute for Applied Systems Analysis (IIASA) and FAO. 2000. *Global agro-ecological zones*, by G. Fischer, H.T. van Velthuizen, F.O. Nachtergaele & S. Medow. Laxenburg, Austria. CD–ROM (also available at http://www.iiasa.ac.at).

Jayne, T.S., Yamano, T. & Nyoro, J. 2004. Interlinked credit and farm intensification: evidence from Kenya. Agric. Econ., 31: 209–218.

Jayne, T.S., Yamano, T., Weber, M.T., Tschirley, D., Benfica, R., Chapoto, A. & Zulu, B. 2003. Smallholder income and land distribution in Africa: implications for poverty reduction strategies. *Food Pol.*, 28(3): 253–275.

Keller, J. & Roberts, M. 2004. Household-level irrigation for efficient water use and poverty alleviation. In V. Seng, E. Craswell, S. Fukai & K. Fisher, eds. *Water in agriculture.* ACIAR Proceedings No. 116. Canberra, ACIAR.

Kelly, V., Adesina, A.A. & Gordon, A. 2003. Expanding access to agricultural inputs in Africa: a review of recent market development experience. *Food Pol.*, 28(4): 379–404.

Kemper, K. & Sadoff, C. 2003. *The global water challenge*. World Bank Global Issues Seminar Series (available at http://siteresources.worldbank.org).

Kijima, Y., Sserunkuuma, D. & Otsuka, K. 2006. How revolutionary is the "NERICA Revolution?" Evidence from Uganda. *Dev. Econ.*, 44(2): 252–267.

Kulecho, I.K. & Weatherhead, K. 2006. Issues of irrigation of horticultural crops by smallholder farmers in Kenya. *Irri. Drain. Sys.*, 20: 259–266.

Lane, J. 2004. Positive experiences from Africa in water, sanitation and hygiene. *Water Pol.*, 6(2): 153–158.

Larsson, R. 2005. Crisis and potential in smallholder food production – evidence from micro level. *In* G. Djurfeldt, H. Holmén, M. Jirström & R. Larsson, eds. *The African food crisis: lessons from the Asian green revolution.* Wallingford, UK, CABI Publishing.

Lipton, M., Litchfield, J. & Faurès, J.M. 2003. The effects of irrigation on poverty: a framework for analysis. *Water Pol.*, 5: 413–427.

Magistro, J., Roberts, M., Haggblade, S., Kramer, F., Polak, P., Weight, E. & Yoder, R. 2007. A model for pro-poor wealth creation through small-plot irrigation and market linkages. *Irri. Drain.*, 56(2–3): 321–334.

Maredia, M.K., Byerlee, D. & Pee, P. 2000. Impacts of food crop improvement research and development: evidence from sub-Saharan Africa. *Food Pol.*, 25(5): 531–559.

Mellor, J.W. 1998. Food aid and agriculture-led development. *In* C.K. Eichers & J.M. Staatz, eds. *International agricultural development.* 3rd edition. Baltimore, USA, Johns Hopkins University Press.

Mellor, J.W. & Johnston, B.F. 1984. The world food equation: interrelations among development, employment, and food consumption. *J. Econ. Lit.*, 22(2): 531–574.

Molden, D. ed. 2007. *Water for food, water for life. A comprehensive assessment of water management in agriculture*. London, Earthscan, and Colombo, IWMI.

Morardet, S., Merrey, D.J., Seshoka, J. & Sally, H. 2005. *Improving irrigation project planning and implementation processes in Sub-Saharan Africa: diagnosis and recommendations*. Working Paper 99. Colombo, IWMI. 91 pp.

Mupangwa, W., Love, D. & Twomlow, S. 2006. Soil-water conservation and rainwater harvesting strategies in the semi-arid Mzingwane Catchment, Limpopo Basin, Zimbabwe. *Phys. Chem. Earth*, Parts A/B/C 31(15–16): 893–900.

Narayan, D., Chambers, R., Kaul Shah, M. & Petesch, P. 1999. *Global synthesis. Consultations with the poor.* Paper prepared for global synthesis workshop, 22–23 September 1999. Washington, DC, World Bank.

Otsuka, K. & Kalirajan, K.P. 2006. Rice green revolution in Asia and its transferability to Africa: an introduction. *Dev. Econ.*, 44(2): 107–122.

Oweis, T., Prinz, D. & Hachum, A. 2001. *Water harvesting: indigenous knowledge for the future of the drier environments*. Aleppo, Syrian Arab Republic, International Center for Agricultural Research in the Dry Areas.

Pender, J., Jagger, P., Nkonya, E. & Sserunkuuma, D. 2004. Development pathways and land management in Uganda. *World Dev.*, 32(5): 767–792.

Pérez de Mendiguren Castresana, J. C. 2003. *Productive uses of water at the household level: evidence from Bushbuckridge, South Africa*. International Symposium on Water, Poverty and Productive uses of Water at the Household Level, 21–23 January 2003, Muldersdrift, South Africa. (available at http://www.wca-infonet.org).

Poussin, J.C., Wopereis, M.C.S., Debouzie, D. & Maeght, J.L. 2003. Determinants of irrigated rice yield in the Senegal River valley. *Eur. J. Agron.*, 19(2): 341–356.

Renwick, M. 2007. *Multiple use water services for the poor: assessing the state of knowledge.* Arlington, USA, Winrock International.

Robb, C.M. 1999. *Directions in development: can the poor influence policy? Participatory poverty assessments in the developing world*. Washington, DC, World Bank.

Roberts, N. 1988. Dambos in development: management of a fragile ecological resource. *J. Biogeog.*, 15(1): 141–148.

Rockström, J. 2000. Water resources management in smallholder farms in Eastern and Southern Africa: an overview. *Phys. Chem. Earth,* (B) 25(3): 275–283.

Rockström, J., Hatibu, N., Oweis, T. & Wani, S. 2007. Managing water in rainfed agriculture. In D. Molden, D. ed. 2007. *Water for food, water for life. A comprehensive assessment of water management in agriculture.* London, Earthscan, and Colombo, IWMI.

Rossi, B. 2005. *Development brokers and translators: the ethnography of aid*. London, School of Oriental and African Studies, University of London

Sakurai, T. 2006. Intensification of rainfed lowland rice production in West Africa: present status and potential green revolution. *Dev Econ.*, 44(2): 232–251.

Sanchez, P.A. 2002. Soil fertility and hunger in Africa. *Science*, 295: 2019–2020.

Sanchez, P.A. & Swaminathan, M.S. 2005. Hunger in Africa: the link between unhealthy people and unhealthy soils. *Lancet,* 365(9457): 442–444.

Setboonsarng, S. 2005. *Child malnutrition as a poverty indicator: an evaluation in the context of different development interventions in Indonesia*. Discussion paper. ADBI.

Shah, M., Fisher, G. & van Velthuizen, H. 2008. *Rainfed agriculture, climate change and food security*, by M. Shah, G. Fisher & H. van Velthuizen, H. Report submitted at the FAO Expert Meeting on Climate Change, Water and Food Security, Rome, 26–28 February 2008.

Siebert, S., Doell, P., Hoogeveen, J., Faures, J.-M. Frenken, K. & Feick, S. 2005. Development and validation of the global map of irrigation areas. *Hydrol. Earth Sys. Sci.*, 9: 535–547.

Smith, L.E.D. 2004. Assessment of the contribution of irrigation to poverty reduction and sustainable livelihoods. *Int. J. Wat. Res. Dev.*, 20(2): 243–257.

United Nations Development Programme (UNDP). 2006. *Human development report 2006. Beyond scarcity: power, poverty and the global water crisis*. New York, USA.

United States Agency for International Development (USAID). 2008. *Famine and early warning system network* (available at http://www.fews.net).

Van der Hoek, W., Konradsen, F. & Jehangir, W.A. 1999. Domestic use of irrigation water: health hazard or opportunity? *Int. J. Wat. Res. Dev.*, 15(1–2): 107–119.

Vargas-Lundius, R. 2007. *Polishing the stone: a journey through the promotion of gender equity in development projects*. Rome, IFAD.

Wopereis-Pura, M.M., Watanabe, H., Moreira, J. & Wopereis, M.C.S. 2002. Effect of late nitrogen application on rice yield, grain quality and profitability in the Senegal River valley. *Eur. J. Agron.*, 17(3): 191–198.

World Bank. 2000. *World development report* 2000/2001. Washington, DC.

World Bank. 2007a. *Investment in agricultural water for poverty reduction and economic growth in sub-Saharan Africa.* Synthesis Report. A collaborative programme of AfDB, FAO, IFAD, IWMI and the World Bank.

World Bank. 2007b. *World development report 2008. Agriculture for development*. Washington, DC, World Bank.

World Water Assessment Programme (WWAP). 2006. *Water, a shared responsibility. The world water development report*. UNESCO-UN-Water.

World Water Assessment Programme (WWAP). 2006. *Water, a shared responsibility.* The United Nations World Water Development Report 2. World Water Assessment Programme. Paris, UNESCO, and New York, USA, Berghahn Books.

Annex 1
Description of the livelihood zones used in the report

The livelihood zones presented in this report are primarily based on the farming system zones described in FAO and World Bank (2001), which are, in turn, closely correlated with the main agro-climatic zones of the region.

This annex provides a description of the prevailing conditions and main farming activities that sustain rural livelihoods in 13 main zones, plus two locally relevant livelihood zones. In the text below, the term "region" refers to sub-Saharan Africa (SSA).

Arid zone

This zone is the largest (21 percent of the region) and corresponds to the deserts of the Sahara and southwestern Africa. It has marginal importance in terms of agriculture and population. The area under cultivation covers only 0.3 percent of the land area of the livelihood zones (mostly oases), while the rural population (8 million) represents only 2 percent of the regional total. In view of the high level of aridity, irrigated areas represent almost half the cultivated land. Rangeland and livestock are confined to marginal areas. Living conditions are extremely hard, and the rural population consists mainly of nomads, and a few sedentary people at the oases.

Pastoral zone

This zone is located mostly in the semi-arid zones extending across the Sahel from Mauritania to the northern parts of Mali, Niger, Chad, Sudan, Ethiopia and Eritrea. Some parts are also found in northern Kenya and Uganda, and in part of Namibia, Botswana and southern Angola. It occupies almost 2.7 million km^2, or 11 percent of the area of the region. The rural population is 27 million (7 percent), with 24 million head of livestock. Pastoral land is abundant (more than 190 million ha). This zone is characterized by nomadic pastoralists, who move to other zones during the driest period of the year, and exclusive pastoralists. The latter are livestock producers who grow no crops and simply depend on the sale or exchange of animals and their products to obtain foodstuffs. Such producers are most likely to be nomads, i.e. their movements are opportunistic and follow pasture resources in a pattern that varies from year to year. This type of nomadism reflects, almost directly, the availability of forage resources – the patchier these are, the more likely an individual herder is to move in an irregular pattern.

Pastoralists are highly vulnerable to climate variability and droughts. In particular, they are highly dependent on the availability of water points for their animals. Fragile balances exist between the availability of water and feed for animals. In periods of drought, excessive concentration of animals around watering points may lead to catastrophic losses of herds. Some of Africa' largest irrigated areas are located in the pastoral zones of the Nile and Niger Rivers, such as Gezira Scheme in the Sudan, where integration of irrigated agriculture and livestock play an important role in overall agricultural production.

Agropastoral zone

This zone covers 2.15 million km^2, or 9 percent of the land of the region. It is characterized by a semi-arid climate, with an average growing period of 95–100 days. It extends from Senegal to Niger in West Africa, and covers substantial areas of East and Southern Africa from Somalia and Ethiopia to South Africa. The rural population represents 9 percent of the region accounting for more than 38 million people, with a density of 18 inhabitants/km^2. Although the population density is limited, pressure on fragile land is high. Field crops and livestock are equally relevant in the household livelihoods of this zone. Cultivated land and livestock account for 40 million ha and 35 million head, respectively, i.e. 18 and 19 percent of the regional total. Pastoral areas are abundant (more than 148 million ha) and represent 14 percent of the regional total and 70 percent of the area of the zone. Rainfed sorghum and millet are the main sources of food, which are rarely sold on local markets, while sesame and pulses are sometimes marketed. Cultivation is frequent along riverbanks, particularly alongside the Niger and Nile Rivers. Livestock is used for subsistence, marketing (milk and milk products), offspring, transportation, land preparation, sale or exchange, savings, bridewealth, and insurance against crop failure. The region is characterized by extremely low soil fertility and chronic limitations in terms of organic matter.

Irrigation plays a relatively important role in this zone, with more than 900 000 ha of recorded irrigated areas, putting substantial pressure on the region's water resources (20 percent of total water resources of the zone are diverted for irrigation). Rainfed cultivation is often accompanied by water conservation practices in an attempt to enhance soil moisture retention (zai, half-moons, stone ridges, etc.). Nonetheless, vulnerability to drought remains high, with frequent crop failures and deprived livestock.

Cereal–based zone

This livelihood zone covers large parts of the region (2.45 million km^2) and it is the most important food production zone in East and Southern Africa. It extents mainly along the Rift Valley, across plateau and highland areas at altitudes of 800–1 500 m, from Kenya and the United Republic of Tanzania to Zambia, Malawi, Zimbabwe, South Africa, Swaziland and Lesotho. The climate ranges from dry subhumid to moist subhumid. The cultivated area covers 36 million ha and accounts for 15 percent of the regional total. The rural population is almost 66 million, 16 percent of the regional total. Most of the zone has monomodal rainfall, but some areas experience bimodal rainfall. Farmers are typically traditional or emerging smallholders, with farms of less than 2 ha. The main crops are maize (staple and cash crop), tobacco, coffee and cotton. Yields have fallen in recent decades owing to the shortages and high cost of inputs such as seeds, fertilizers and agrochemicals. Soil fertility has been declining, prompting smallholders to revert to more to extensive production practices. About 24.5 million ruminants are kept both for food and farm manure and ploughing, and savings. In spite of scattered settlement patterns, community institutions and market linkages in the maize belt are relatively more developed than in other livelihood zones.

Small-scale irrigation schemes and supplementary irrigation are scattered within the zone, and cover 620 000 ha, or 9 percent of the regional total, although the potential is much higher. In this zone, a combination of soil fertility restoration and supplementary irrigation has the potential to boost agricultural productivity substantially, in response to rapidly decreasing farm size.

Cereal–root crop zone

This livelihood zone extends from Guinea through northern Côte d'Ivoire to Ghana, Togo, Benin and the mid-belt states of Nigeria to northern Cameroon, and on to Central and Southern Africa. It covers 3.17 million km^2 (13 percent of the land area of the region) – mainly in the moist semi-arid zone with an average growing period of about 130 days. Some 51 million ha (22 percent of the regional total) are cultivated, sustaining a rural population of almost 68 million (16 percent of the regional total). Livestock (mostly ruminants) are abundant (42 million head). Pasture, with almost 195 million ha, accounts for 18 percent of the regional area. Compared with the cereal–based zone, this zone is characterized by lower altitude, higher temperatures, lower population density, abundant cultivated land, and higher livestock numbers per household. It also has poorer transport and communications infrastructure. Cereals such as maize, sorghum and millet are common in the area, rotated or intercropped with root crops such as yams, cassava and sweet potatoes. Although a range of agricultural products are marketed, most of the products are consumed within households, given the prevalence of subsistence agriculture and traditional farmers.

Irrigation is limited, it accounts for 6 percent of the regional total, with fewer than 422 000 ha, despite a relatively high potential, estimated at 7.7 million ha. A range of water intervention options have potential for poverty reduction, in particular soil moisture management practices, supplementary irrigation and community-level small-scale irrigation.

Root–crop–based zone

This livelihood zone corresponds mainly to a subhumid climate. It covers 2.8 million km^2 (about 11 percent of the land area of the region), has a cultivated area of 28 million ha, and is home to 48 million rural people. Precipitation patterns show a good seasonal distribution, and the risks of crop failure are limited. The zone contains about 16 million head of livestock. Farmers are mainly traditional smallholders, typically oriented towards staple crops and self-consumption, and root crops are indeed the main staple. Market prospects exist in places, in particular for export of oil-palm products, urban demand for root crops is growing, and linkages between agriculture and off-farm activities are relatively better than elsewhere.

Irrigation is marginal in the zone, owing mainly to the favourable climate conditions for rainfed and market opportunities. Water resources are abundant in most places. Therefore, possibilities for water-based interventions are relatively marginal.

Highland temperate zone

This zones covers 440 000 km^2 (2 percent of the area of the region). Ten million ha of cultivated land (4 percent of the regional total) support a rural population of 30 million (7 percent of the regional total). This zone is located mainly in the Ethiopian and Eritrean highlands at an altitude of 1 800–3 000 m, and the climate is predominantly subhumid or humid. Given the high altitude, this zone is typically monomodal, and presents one single and long growing season. Temperate cereals, such as wheat, teff (in Ethiopia) and barley, are the most common sources of livelihood, complemented with pulses and potatoes. Livestock are relatively abundant and an important source of cash. Some households have access to soldiers' salaries (Ethiopia and Eritrea) or remittances (Lesotho), but these mountain areas offer few local opportunities for off-farm employment.

The particular agroclimatic conditions of the zone have a twofold effect on its rural livelihood conditions. On the one hand, the population is highly vulnerable owing to the early and late frosts at high altitudes that can severely reduce yields, and crop failures are not uncommon in cold and wet years. On the other hand, there is a considerable potential for diversification into higher-value temperate crops. The potential exists for substantial increases in agricultural productivity through a combination of water and soil-fertility-related interventions, in particular through better soil moisture management and small-scale irrigation.

Highland perennial zone

This relatively small livelihood zone is located mainly in the highlands of East African, covering an area of about 320 000 km^2 (1 percent of the regional total). The climate is mostly subhumid or humid, with an average growing period of more than 250 days. The rural population is 32 million (8 percent of the regional total). This zone has the highest population density in the region (more than 1 inhabitant/ha). Therefore, the pressure on land is intense, and about 7 million ha of land are cultivated, mainly by smallholders. The average cultivated area per household is slightly less than 1 ha, but more than 50 percent of holdings are smaller than 0.5 ha. The livelihood base of this zone is characterized by perennial crops such as banana, plantain, enset, coffee and cassava, complemented by annual root crops, such as sweet potato and yam as well as pulses and cereals. Given the limited availability of pastures, livestock are a minor resource, amounting to about 6.2 million head. The main trends are diminishing farm size, declining soil fertility, and increasing poverty and hunger. People cope by working the land more intensively, but returns to labour are low.

Given the favourable conditions for rainfed agriculture, irrigation is a minor practice and accounts for only 52 000 ha (1 percent of the regional total). However, in conditions of heavy pressure on land resources, there is some scope for intensification through improved water control.

Tree crop zone

This zone is located in the Gulf of Guinea, with smaller pockets in the Democratic Republic of the Congo and Angola, largely in the humid zone. The zone occupies about 730 000 km^2 (3 percent of the regional total), accounts for 14 million ha of cultivated land (6 percent of the regional total), and is home to a rural population of almost 30 million (7 percent of the regional total). The production base of the zone is industrial tree crops, particularly cocoa, coffee, oil palm and rubber. Food crops are intercropped with tree crops and are grown mainly for self-consumption. Livestock are marginal (2 percent of the regional total). There are also commercial tree crop estates (particularly for oil palm and rubber), providing some employment opportunities for smallholder tree crop farmers through nucleus estate and outgrower schemes. As neither tree crop nor food crop failure is common, price fluctuations for industrial crops constitute the main source of vulnerability.

Given the favourable climate, irrigation is marginal in the region, and prospects for livelihood enhancement through water intervention are minor.

Forest–based zone

This zone occupies 2.6 million km^2 (11 percent of the total land in the region), accounts for 11 million ha of cultivated area (5 percent of the regional total), and is home to a rural population of 29 million (7 percent of the regional total). Most of the land lies in the humid forest zone of the Democratic Republic of the Congo. Farmers practise shifting cultivation, clearing new fields from the forest every year, cropping it for 2–5 years (cereals or groundnuts, followed by cassava) and then abandoning it to bush fallow for 7–20 years. Cassava is the main staple, complemented by maize, sorghum, beans and cocoyams. Sources of food and cash, in limited part, are also forest products and wild game. The livestock population is 3.2

million head (2 percent of the regional total), as pastoral land is limited, given the prevalence of forest vegetation. Rural infrastructures are poorly developed and access to markets is restricted. This implies agriculture of a largely subsistence nature.

While the irrigation potential (6.7 million ha) and the internal renewable water resources (1 460 km3/year) are the highest in the region, irrigation is marginal (87 000 ha) and represents 1 percent of the regional total. This zone offers little prospect for water-based interventions in support of poverty reduction in rural areas.

Large commercial and smallholder zone

This zone covers almost the whole of South Africa and the southern part of Namibia, Zambia and Zimbabwe. The climate is mostly semi-arid. The zone covers 1.23 million km^2 (5 percent of the regional total), with 15 million ha of cultivated land (7 percent of the regional total). It is home to 20 million rural people (5 percent of the regional total). It comprises two distinct types of farms: scattered smallholder farming in the homelands; and large-scale commercial farms. Both types are largely mixed cereal–livestock zones, with maize dominating in the north and east, and sorghum and millet in the west. Ruminants are abundant in this zone, but the level of crop–livestock integration is limited.

Irrigation is extensively used and has reached its full potential in many places, leading to competition for water between farmers and between sectors. Together with highly intense farming, irrigation is depriving soils, and the zone is becoming more drought-prone. In this zone, water-related interventions should concentrate on water productivity increases through improved management of agricultural water, and the development of water harvesting to support supplementary irrigation. Institutional issues, including issues of water rights, conflict resolution and river basin management, deserve particular attention.

Rice–tree crop zone

This zone is located exclusively in Madagascar – and benefits from a moist subhumid climate. It is the smallest zone of the region, accounting for less than 310 000 km^2 (1 percent of the regional total), of which 2.7 million ha are cultivated (1 percent of the regional total). The rural population is 8 million (2 percent of the regional total). Banana and coffee cultivation is complemented by rice, maize, cassava and legumes. Livestock are almost insignificant (about 1 million head).

Farms are small, and there is a significant amount of basin flood irrigation – equivalent to 10 percent of the total irrigated area of the region – used almost exclusively for paddy rice production, the main staple food in Madagascar. As irrigation is reaching its full potential in places, there is ample scope for increased productivity of irrigated agriculture through better water management.

Coastal artisanal fishing zone

This zone stretches all around the coastal areas of SSA. The zone covers 380 000 km^2 (2 percent of the regional total). It is home to accounts for 15.5 million rural people (4 percent of the regional total); most of the population of this zone live in urban areas (73 percent). People's livelihoods are based on artisanal fishing supplemented by crop production, sometimes in multistoried tree crop gardens with root crops under coconuts, fruit trees and cashews, plus some animal production. The cultivated land area of 3.6 million ha is only 2 percent of the regional total. Livestock numbers are small (fewer than 2 million head, or 1 percent of the regional total).

Irrigation is not very developed – 300 000 ha (4 percent of the regional total). However, as the coastal area has a high concentration of urban population, good prospects exist for the development of peri-urban agriculture, in which water control plays an important role. Therefore, in places, and according to market conditions, this zone offers prospects for further irrigation development.

Other relevant local zones

Peri–urban zone

Urban centres usually offer opportunities for rural people in terms of markets for farm products and labour. Agriculture areas around cities are characteristically focused on horticultural, livestock production, and off-farm work. Within the estimated total urban population of more than 200 million in the region, there is a significant number of farmers in cities and large towns. In some cities, it is estimated that 10 percent or more of the population are engaged in peri-urban agriculture. Overall, there are about 11 million agricultural producers in peri-urban areas. This livelihood zone is very heterogeneous, ranging from small-scale, capital-intensive, market-oriented vegetable-growing, dairy farming and livestock fattening, to part-time farming by the urban poor to cover part of their subsistence requirements. The level of crop–livestock integration is often low, and there are typically environmental and food quality concerns associated with peri-urban farming. The potential for poverty reduction is relatively low, mainly because the absolute number of poor is low. Agricultural growth is likely to take place spontaneously, in response to urban market demand for fresh produce, even in the absence of public-sector support. Unless curbed by concerns over negative environmental effects, rapid adoption of improved technologies can be expected. Overall, this is a dynamic livelihood zone with considerable growth potential.

Irrigated zone

Irrigated areas are scattered across the region, and they provide a broad range of food and cash crops, including rice, vegetables, cotton, and sugar cane. Irrigation constitutes a special case in relation to the heterogeneity of livelihood zones. Where irrigation-based production is the principal source of livelihood in an area, as in the case of large-scale irrigation schemes, the entire area can be considered an irrigation-based livelihood zone. Water control may be full or partial. Irrigated holdings vary considerably in size. Water shortages, deterioration of infrastructure, and reduced margins for main irrigated products are among the main problems facing farmers in irrigated areas. Many state-run schemes are currently in financial crisis, but if institutional and market problems can be solved, prospects for future agricultural growth are good. The incidence of poverty is lower than in other livelihood zones, and the absolute numbers of poor are small.

Annex 2
Method for assessing investment potential

This annex describes the method used to assess the potential for investments in SSA. It also shows the potential outcomes, in table form, by livelihood zone and type of intervention. In order to determine priority for action in the different livelihoods zones, the method utilized the following three criteria:

- prevalence of poverty;
- water as a limiting factor for rural livelihoods;
- potential for water intervention.

The steps used in order to generate the assessment are described as follows.

Step 1: quantifying priorities according to the three criteria

This entailed a quantification of the three priority levels (low, moderate and high) for the criteria used in the analysis (above). Coefficients were applied to represent these three levels as a percentage of possible interventions for the criteria related to water as a limiting factor and poverty incidence: 100, 50 and 15 percent. The criterion relating to potential for intervention was based on population, land and water data (Table A2.1).

Step 2: assessing unit costs by type of intervention

Costs have been assessed on the basis of data available at FAO from a large number of invest-

Table A2.1 Weighting factor for priority for action by livelihood zone

Livelihood zone	Poverty incidence	Water as limiting factor	Potential for water interventions
Arid	15	100	Based on population, land and water data
Pastoral	100	100	
Agropastoral	100	100	
Cereal-based	100	100	
Cereal-root crop	100	100	
Root-crop-based	50	15	
Highland Temperate	100	75	
Highland Perennial	50	50	
Tree crop	15	15	
Forest-based	50	15	
Large Commercial and Smallholder	15	100	
Rice-tree crop	50	15	
Coastal Artisanal Fishing	15	15	

Table A2.2 Unit costs (US$/unit)						
Manage soil moisture in rainfed areas (ha)	Invest in small-scale water harvesting infrastructure (Mm^3)	Promote small-scale community-based irrigation (ha)	Improve existing irrigation systems (ha)	Improve water control for peri-urban producers (ha)	Invest in water for livestock production (head)	Facilitate multiple use of water (household)
75	1 000 000	4 250	2 000	3 000	30	75

ment projects in the region. In view of the wide range of possible interventions and associated costs, such an assessment can only be viewed as a very rough estimate of such a potential for action and associated costs. Unit costs related to irrigation and land improvement are relatively well known. Costs of multiple-use systems have been assessed on the basis of a recent study (Renwick *et al*., 2007), considering one system per household. The two types of interventions for which unit cost estimates are most difficult are those related to livestock watering and small-scale water harvesting infrastructures. For water harvesting, the costs associated with the range of possible technical options makes any assessment of an "average" cost very difficult. In order to be able to compare the different technologies, water harvesting interventions were expressed per unit of volume stored. A value of US$1/$m^3$ was chosen. Table A2.2 shows the unit costs selected for this assessment. In view of the uncertainty associated with these costs, no attempt was made to differentiate between the livelihoods zones.

Step 3: assessment of the "absolute" potential for interventions by livelihood zone

The absolute potential for each intervention by livelihood zone represents the maximum possible extent of each type of intervention in each zone, irrespective of the role of water as a limiting factor and of the incidence of poverty in the area. The results are presented in Table A2.3. The potential was assessed on the basis of demographic and natural resources as follows:

- Manage soil moisture in rainfed areas: Extent of rainfed cultivated land in the zone (unit: ha).
- Small-scale water harvesting: the lower of the following two: (i) 80 percent of local runoff (considering a 20 percent "environmental" flow); or (ii) 30 percent of the rainfed cultivated land multiplied by 1 000 m^3/ha (unit: million m^3).
- Small-scale community-based irrigation: the lower of the following two: (i) current extent of small-scale irrigation (i.e. this would correspond to a doubling of existing small-scale irrigation infrastructure); or (ii) the difference between potential irrigation and actual irrigation (unit: ha).
- Improve existing irrigation systems: 50 percent of existing irrigation.
- Water control for peri-urban producers: 0.008 ha per inhabitant in urban areas, based on assessment made in Ghana (unit: ha).
- Water for livestock production: number of livestock (cattle) in the livelihood zone (unit: head).
- Multiple use of water: number of rural households in the zone, with an estimated 5 persons per household (unit: household).

Step 4: assessment of the intervention potential

The intervention potential was calculated by applying the coefficients of Table A2.1 to each combination of intervention and livelihood zone. The coefficients were modified for poverty incidence in three cases. In the cases of irrigation improvement and peri-urban producers, no

Table A2.3 Absolute potential

Livelihood zone	Manage soil moisture in rainfed areas (ha)	Invest in small-scale water harvesting infrastructure (Mm^3)	Promote small-scale community-based irrigation (ha)	Improve existing irrigation systems (ha)	Improve water control for peri-urban producers (ha)	Invest in water for livestock production (head)	Facilitate multiple use of water (household)
Arid	765 135	230	200 000	389 793	62 606	8 368 400	1 668 478
Pastoral	8 948 023	2 684	500 000	601 019	113 497	24 223 700	5 448 920
Agropastoral	41 547 366	12 464	600 000	458 437	234 625	35 174 400	7 686 340
Cereal–based	35 413 458	10 624	499 407	312 130	322 533	24 497 200	13 180 280
Cereal–root crop	51 176 547	15 353	358 122	223 826	249 844	38 576 100	13 588 440
Root–crop–based	28 619 812	8 586	149 226	93 267	222 446	16 240 100	9 742 340
Highland Temperate	10 101 891	3 031	138 838	86 774	123 970	12 377 500	6 006 700
Highland Perennial	7 026 607	2 108	43 088	26 930	107 556	6 254 820	6 551 020
Tree crop	13 567 324	4 070	92 743	57 965	189 631	4 186 170	5 924 960
Forest–based	10 915 013	3 275	73 212	45 758	147 982	3 327 710	5 834 060
Large Commercial and Smallholder	13 849 601	4 155	0	709 010	118 778	12 833 100	4 087 820
Rice–tree crop	2 007 666	602	86 686	346 763	30 521	1 153 460	1 610 470
Coastal Artisanal Fishing	3 257 752	977	298 859	186 787	206 410	1 967 010	3 111 620
Total	227 196 195	68 159	3 040 181	3 538 456	2 130 401	189 179 670	84 441 448

Table A2.4 Number of people reached per unit

Livelihood zone	Manage soil moisture in rainfed areas (person/ha)	Invest in small-scale water harvesting infrastructure (Mm^3)	Promote small-scale community-based irrigation (ha)	Improve existing irrigation systems (ha)	Improve water control for peri-urban producers (ha)	Invest in water for livestock production (head)	Facilitate multiple use of water (household)
Arid	0.54	540	10	10	10	0.90	5
Pastoral	0.27	268	10	10	10	1.01	5
Agropastoral	0.45	452	10	10	10	0.87	5
Cereal-based	1.46	1462	10	10	10	1.35	5
Cereal-root crop	1.05	1052	10	10	10	0.88	5
Root-crop-based	1.35	1352	10	10	10	1.20	5
Highland Temperate	2.34	2338	10	10	10	0.97	5
Highland Perennial	3.70	3700	10	10	10	2.09	5
Tree crop	1.73	1732	10	10	10	2.83	5
Forest-based	1.86	1855	10	10	10	3.51	5
Large Commercial and Smallholder	0.94	937	10	10	10	0.80	5
Rice-tree crop	2.38	2384	10	10	10	2.79	5
Coastal Artisanal Fishing	2.14	2142	10	10	10	3.16	5

reduction coefficient was applied. In the case of multiple-use systems, it was estimated that the need for multiple-use systems could never be more than 90 percent of the households.

Step 5: assessing the number of people reached for each intervention

For soil moisture management and small-scale water harvesting, the number of persons per hectare and per 1 000 m3 of water respectively was estimated by multiplying the number of rural people in the zone by a coefficient representing the number of crop farmers, and dividing by the rainfed cultivated area in the zone. For small-scale irrigation, improvement in irrigated systems and peri-urban producers, the area was multiplied by the average number of farmers per hectare (estimated at 10 farmers per hectare). Livestock was calculated by dividing the number of head by the rural population, and multiplying by a coefficient representing the percentage of households having animals. Multiple-use systems were calculated considering 5 persons per household. These figures are summarized in Table A2.4.

Step 6: calculating investment costs

The investment costs were calculated by multiplying the relevant intervention figures of the livelihood zones by the unit costs of Table A2.2.

Glossary

Agricultural water management: Planned development, distribution and use of water resources in accordance with predetermined agriculture-related objectives.

Agro-ecological zones: Zones defined by FAO on the basis of the average annual length or growing period for crops, which depends mainly on precipitation and temperature. They are: humid (> 270 days); moist subhumid (180–269 days); dry subhumid (120–179 days); semi-arid (60–119 days); and arid (0–59 days).

Commercial farmers: Farmers that produce agricultural products intended for the market to be delivered, sold or stored at commercial structures and/or sold to end consumers (feedlots, poultry farms, dairies, etc.), fellow farmers and direct exports. They generally use high levels of inputs.

Cropping system: The cropping patterns used on a farm and their interaction with farm resources, other farm enterprises, and available technologies that determine their cultivation. The cropping system is a subsystem of a farming system.

Cropland, cultivated land: Cropland is defined as a land cover type by the Global Agro-Ecological Zones (GAEZs) and is used in this report to represent cultivated land. Cultivated land is defined as the sum of arable land and land under permanent crops. Arable land is defined as land under temporary crops, temporary meadows for mowing or pasture, land under market and kitchen gardens, and land temporarily fallow (less than five years).

Drought: A phenomenon that exists where precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems.

Dry spell: Short period of water stress during critical crop growth stages and which can occur with high frequency but with minor impacts compared with droughts.

Emerging smallholders: Smallholder farmers with a higher level of technical knowledge and better receptivity to improved technology than traditional smallholders. They tend to specialize in specific crops, relying on irrigation and other types of water control, and tend to market their production surplus.

Farming system: A population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate. Depending on the scale of analysis, a farming system can encompass a few dozen or many millions of households.

Household: All the persons, kin and non-kin, who live in the same dwelling and share income, expenses and daily subsistence tasks.

Infrastructure: Facilities, structures, and associated equipment and services that facilitate the flows of goods and services between individuals, enterprises and governments. It includes:

public utilities (electric power, telecommunications, water supply, sanitation and sewerage, and waste disposal); public works (irrigation systems, schools, housing and hospitals); transport services (roads, railways, ports, waterways and airports); and research and development facilities.

Intervention (water and complementary): Interventions are a set of actions that can include a combination of infrastructure investments (hard), policy reforms, institutional and financial support, capacity building, extension services, etc. (soft).

Investment: Outlays made by individuals, enterprises and governments to add to their capital. From the viewpoint of individual economic agents, buying property rights for existing capital is also an investment. However, from the viewpoint of an economy as a whole, only the creation of new capital is counted as an investment.

Irrigation: Irrigation refers to water artificially applied to soil, and confined in time and space for the purpose of crop production. They are different type of irrigation systems depending of the level of control, institutional setting, farm size, etc. The equipment may be for permanent or supplementary irrigation.

Irrigation potential: Total possible area to be brought under irrigation in a given river basin, region or country, based on available water and land resources.

Land tenure: The relationship, whether legally or customarily defined, between people, as individuals or groups, with respect to land and associated natural resources (water, trees, minerals, wildlife, etc.).

Livelihood: A livelihood comprises people, their capabilities and their means of living, including food, income and assets. Tangible assets are resources and stores, and intangible assets are claims and access. A livelihood is environmentally sustainable where it maintains or enhances the local and global assets on which livelihoods depend, and has net beneficial effects on other livelihoods. A livelihood is socially sustainable where it can cope with and recover from stresses and shocks, and provide for future generations.

Livelihood assets (capitals): A key component in the sustainable livelihoods approach, they are the assets on which livelihoods are built. They can be divided into five core categories (or types of capital): human capital, natural capital, financial capital, social capital, and physical capital.

Livelihood zone: A livelihood zone is a geographical area within which people broadly share the same livelihood patterns, including access to food, income, and markets.

Malnutrition: Failure to achieve nutrient requirements, which can impair physical and/or mental health. It may result from consuming too little food, or a shortage of or imbalance in key nutrients (e.g. micronutrient deficiencies, or excess consumption of refined sugar and fat).

Multiple use of water: Where water is used for domestic, agricultural or other purposes, reflecting the realities of rural people's multifaceted water use.

Peri-urban agriculture: Agricultural system developed around cities to take advantage of local markets for high value crops (fruits, vegetables, dairy products, etc.).

Rainfed agriculture: Agricultural practice relying exclusively on rainfall as its source of water.

Resilience: The ability of a system (people or ecosystem) to recover quickly from a shock.

Renewable water resources: Average annual flow of rivers and recharge of groundwater generated from precipitation. Internal renewable water resources refer to the average annual flow of rivers and recharge of groundwater generated from endogenous precipitation.

Rural population: Rural people usually live in a farmstead or in groups of houses containing 5 000–10 000 persons, separated by farmland, pasture, trees or scrubland. Most rural people spend the majority of their working time on farms.

Smallholder farmers: The definition of smallholders differs between countries and between agro-ecological zones. In favourable areas of SSA with high population densities, they often cultivate less than 1 ha of land, whereas they may cultivate 10 ha or more in semi-arid areas, or manage 10 head of livestock. Often, no sharp distinction between smallholders and other larger farms is necessary. Within the smallholder category, this study distinguishes two typologies: traditional and emerging.

Soil moisture management (in situ): Process of preventing runoff and inducing water infiltration in the soil, and then minimizing evaporation to the extent feasible in the cropping area.

Subsistence farming: A form of agriculture where almost all production is consumed by the household, often characterized by low-input use, generally provided by the farm.

Supplementary irrigation: The process of providing additional water to stabilize or increase yields under site conditions where a crop can normally be grown under direct rainfall, the additional water being insufficient to produce a crop.

Traditional smallholders: Smallholder farmers based on traditional subsistence agriculture. Farming is generally rainfed, and production is mainly based on staple crops with low yields. Their main target is self-consumption.

Vulnerability: The characteristics of a person, group or an ecosystem that influence their capacity to anticipate, cope with, resist and recover from the impact of a hazard.

Water access: The degree to which a household can obtain the water it needs from any source in a reliable way for agriculture or other purposes.

Water control: The physical control of water from a source to the location at which the water is applied.

Water harvesting: The process of collecting and concentrating rainfall as runoff from a catchment area to be used in a smaller area, either for agriculture or other purposes.

Water productivity: An efficiency term quantified as a ratio of product output (goods and services) to water input.

Water rights: A legal system for allocating water to a user.

Water scarcity: The point at which the aggregate impact of all users impinges on the supply or quality of water under prevailing institutional arrangements to the extent that the demand by all sectors, including the environment, cannot be satisfied fully.

Water users association (WUA): Association of persons usually sharing the same source of water. A WUA can combine both governance and management functions.

Water withdrawal: The gross volume of water extracted from any source, either permanently or temporarily, for a given use. Agricultural water withdrawal refers to the annual volume of freshwater withdrawn for agricultural purposes.

Insecure access to water for consumption and productive uses is a major constraint on poverty reduction in rural areas. For millions of smallholder farmers, fishers and herders in sub-Saharan Africa, water is one of the most important production assets, and securing access to and control and management of water is key to enhancing their livelihoods. This report argues that the potential exists for well-targeted, local interventions in water that contribute to rapid improvement in the livelihoods of the rural poor and help attain the Millennium Development Goal of eradicating extreme poverty and hunger. It discusses conditions for success and proposes water-based, context-specific, and livelihood-centred approaches to poverty reduction in rural areas.

ISBN 978-92-5-105982-1

9 789251 059821

TC/M/I0132E/2/01.09/1000