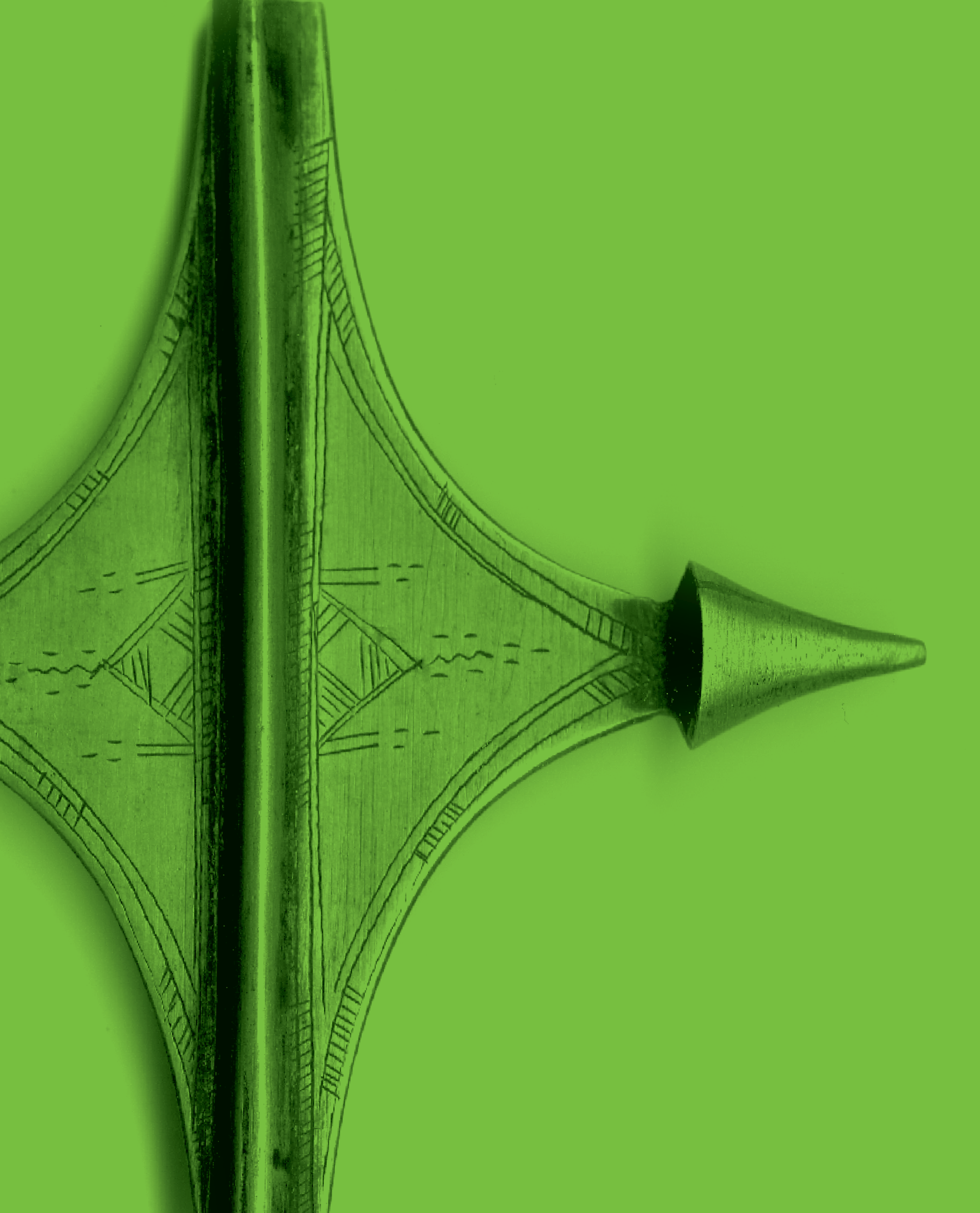


# INTERVENTIONS IN WATER TO IMPROVE LIVELIHOODS IN RURAL AREAS

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## EDITORIAL NOTES

This is a reproduction of Chapter 4 of "Water and the rural poor: Interventions for improving livelihoods in sub-Saharan Africa", published by the Food and Agriculture Organization of the United Nations (FAO) in 2008. The editors are grateful for permission to reproduce the material. The figures, tables and boxes in this chapter have been renumbered accordingly.

## INTRODUCTION

While water control is often not the only limiting factor in crop production in sub-Saharan Africa (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 described in Annex 1, 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".

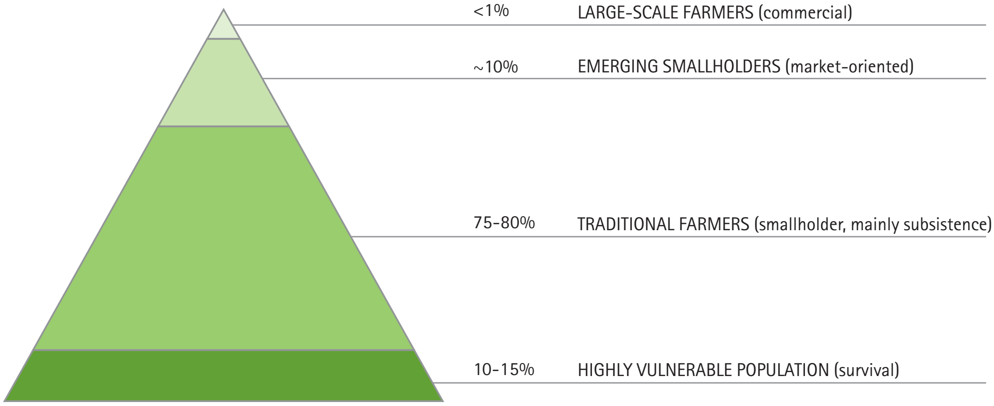
Notwithstanding the differences that are relevant, a key observation is that successful efforts to improve crop yields and farm incomes in SSA will require concerted efforts to intensify crop production on small-scale farms (Abalu and Hassan, 1998). In most cases, when dealing with such farms, investments 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 1). 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

FIGURE 1

*A typology of farming populations in sub-Saharan Africa*




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 2. 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.

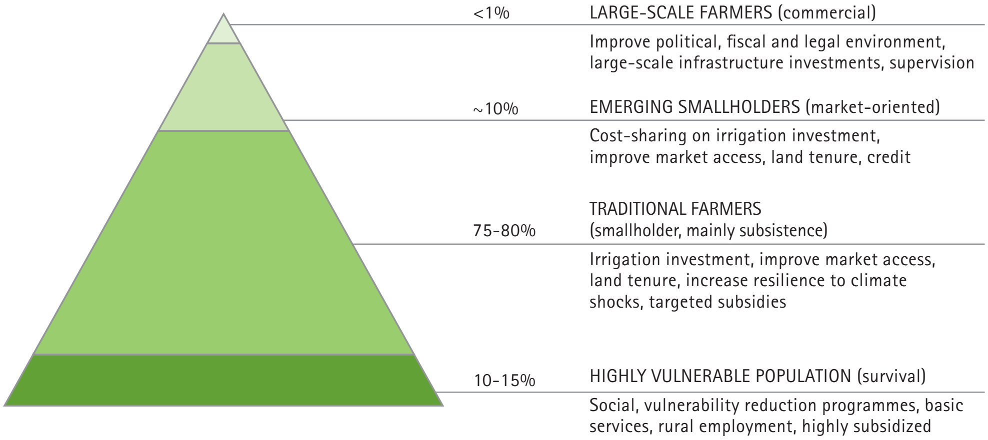
The smallholder farmers in rural SSA require investments in rainfed water management and supplementary irrigation where feasible. They need secure land tenure that is stable and reliable, guaranteed access to water, support to the empowerment of local communities, in particular water users associations (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, 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.

FIGURE 2

*Adapting agricultural support strategies to different farmers groups*




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 when 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 distinguish 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, 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 1).

## BOX 1
## 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.

*Source*: FAO (forthcoming)

## 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 3 presents a typology of some of the most widespread agricultural water management options.

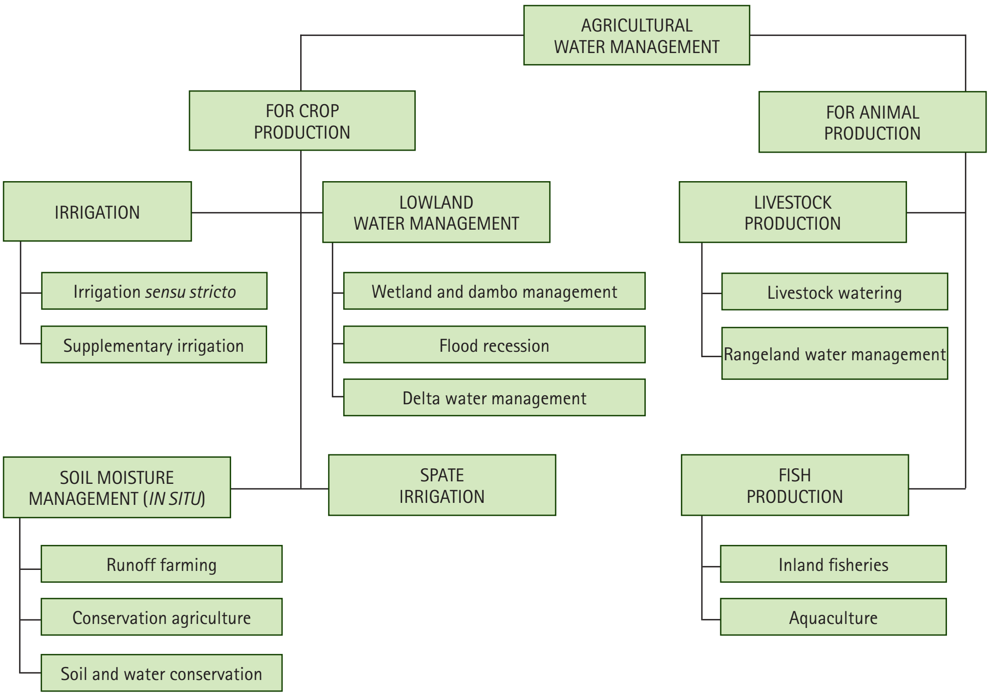
Based on the above typology, it is possible to establish a list of water-related interventions. Table 1 is adapted from a matrix developed in the framework of FAO's Special Programme of Food Security (FAO, 1998), and shows options for water control by type of use and available technologies, organized 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 1 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.

FIGURE 3

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




*Source*: Adapted from FAO-AQUASTAT (2008)

TABLE 1

*Indicative list of water control and water use technologies*

<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 rowspan="2">Domestic water use (safe drinking-water for cooking, bathing, laundry, cleaning)</td><td>Shallow tubewells:<br>dug wells<br>drilled wells<br>Spring diversion<br>Deep tubewells</td><td></td><td rowspan="2">Human powered pumps:<br>hand pulleys and buckets<br>hand pumps<br>Solar pumps<br>Motorpumps</td><td rowspan="2">Water purification methods:<br>filters (e.g. sand filters)<br>boilers for drinking-water<br>chlorination</td></tr>
<tr><td colspan="2">Recharge enhancement system:<br>recharge wells<br>Underground water harvesting system:<br>cistern or other underground water storage structure fed by a catchment area<br>Above ground rainwater harvesting system:<br>rooftop tank or jar</td></tr>
<tr><td rowspan="2">Irrigated crops (including urban and small plot cropping)</td><td>Shallow tubewells:<br>dug wells<br>drilled wells<br>Spring diversion<br>Deep tubewells</td><td>Elevated tanks/drums</td><td rowspan="2">Human-powered pumps:<br>hand pulleys and buckets<br>hand pumps<br>treadle pumps<br>Animal-powered pumps:<br>mohte<br>Persian wheel<br>Motorpumps:<br>petrol<br>diesel</td><td rowspan="2">Aboveground:<br>shallow trenches or ditches<br>family/drum drip irrigation kit<br>low cost hose irrigation system<br>Belowground:<br>porous ceramic jars<br>porous and sectioned pipe</td></tr>
<tr><td colspan="2">Water harvesting systems, composed of:<br>catchment area and a water storage structure aboveground (e.g. excavated pond, impounded reservoir)<br>catchment area and a water storage structure belowground (e.g. cistern)</td></tr>
<tr><td rowspan="2">Supplementary irrigation</td><td>Shallow tubewells:<br>dug wells<br>drilled wells<br>Deep tubewells</td><td>Small dams/reservoirs</td><td rowspan="2">Human-powered pumps:<br>hand pulleys and buckets<br>hand pumps<br>treadle pumps<br>Animal-powered pumps:<br>mohte<br>Persian wheel<br>Motorpumps:<br>petrol<br>diesel</td><td rowspan="2"></td></tr>
<tr><td colspan="2">Run off the river diversion<br>Water harvesting systems composed of:<br>catchment area and a water storage structure above ground (e.g. excavated pond, impounded reservoir)<br>catchment area and a water storage structure below ground (e.g. cistern)</td></tr>
<tr><td>Enhanced water management for rainfed</td><td colspan="2">Soil and water conservation and management (runoff farming):<br>stone bunds, ridges, broad beds, furrows<br>no-tillage<br>infiltration pits<br>contour bunds (semi-circular, triangular)<br>vegetative bunds<br>terraces (eyebrow, Negarim)<br>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<br>Integrated paddy and fish production</td><td></td><td>Basins<br>Ponds<br>Water-level control in small streams</td></tr>
</table>

<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 rowspan="3">Livestock watering</td><td>Shallow tubewells:<br>dug wells<br>drilled wells<br>Spring diversion</td><td></td><td rowspan="3">Human-powered pumps:<br>treadle pumps<br>Animal-powered pumps:<br>mohte<br>Persian wheel<br>Motorpumps:<br>petrol<br>diesel</td><td rowspan="3">Watering facilities:<br>watering troughs</td></tr>
<tr><td colspan="2">Water harvesting systems composed of:<br>catchment area and a water storage structure above ground (e.g. excavated pond, impounded reservoir)<br>catchment area and a water storage structure below ground (e.g. cistern)</td></tr>
<tr><td colspan="2">Micro-catchment water harvesting systems for rainwater runoff:<br>contour bunds (semi-circular, triangular)</td></tr>
</table>

*Source*: Adapted from FAO (1998)

## 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 2.

TABLE 2

*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)

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 combining 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 2 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 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 3).

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.

## BOX 2
## 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 3
## 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.

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 socio-economic 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 $m^3$ 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 4 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 different 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.

### BOX 4
### 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).

## 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 5 and 6). 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.

## BOX 5
## 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)

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.*, 2007), 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.

## BOX 6
## 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.

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 practiced on another 960 000 ha (FAO, 2006b). 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 control of soil moisture and nutrient conditions (Dalton and Guei, 2003; Kijima, Sserunkuuma and Otsuka, 2006). Higher rice yields have the potential to improve farm incomes, to increase the aggregate supply of rice in the region, and to limit rice imports at regional level. It is as a result of exploiting these advantages that rice 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- 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 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 7).

## BOX 7
## 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).

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 8) to others in Cape Verde and the Democratic Republic of Congo.

### BOX 8
### 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.

## 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 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 become 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, 2006c), 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 9). 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).

## BOX 9
## 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.

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 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, 2006d). 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 3 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.

TABLE 3

*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)

## Securing access to markets

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

- 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. Infrastructure 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 re-allocation 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 10). 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.

## BOX 10
## 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.

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 4). 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.

TABLE 4

*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 | Rwanda | 77 |
| | | Nigeria | 57 | Equatorial Guinea | 83 |
| | | Eritrea | 58 | Somalia | 88 |
| | | Ghana | 58 | | |

*Source*: Henao and Baanante (2006)

## 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 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 11).

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 4 shows how different social groups require specific financial support.

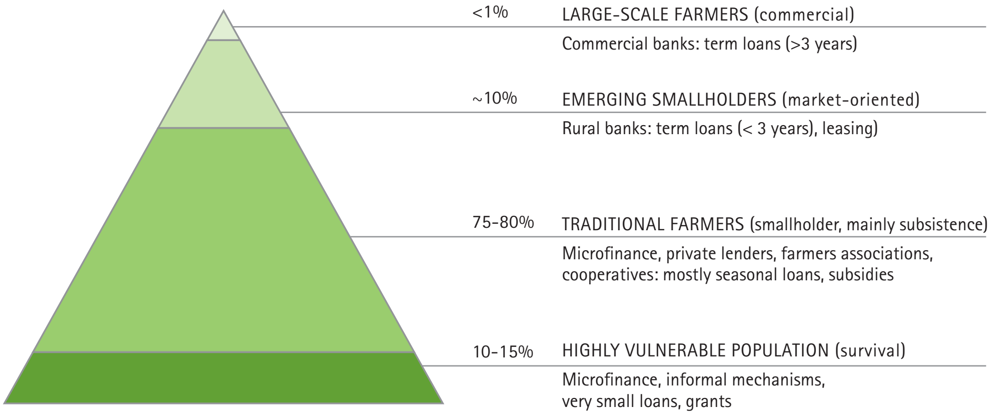
## BOX 11
## RECORD MAIZE HARVEST IN MALAWI

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 4

*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 5 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 5 also confirms the results showing the potential for water intervention by livelihood zone, with particular emphasis on cereal-based and agropastoral zones.

TABLE 5

*Relevance of intervention by livelihood zone*

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

*Source*: Compilation of information based on FAO and International Fund for Agricultural Development (IFAD) projects

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 finds 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 following three criteria: prevalence of poverty; water as a limiting factor for rural livelihoods; and potential for water intervention (Annex 2 provides details of the methodology). The assessment at regional level consisted of the following steps:

- 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;
- Water as a limiting factor: application of a coefficient taking into account the importance of water as a limiting factor for each livelihood zone;
- 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 6–8. Table 6 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 6

*Potential for water-related interventions by livelihood zone*

| Livelihood zone | Manage soil moisture in rainfed areas | Invest in small-scale water harvesting infrastructure | Promote small-scale community-based irrigation | Improve existing irrigation systems | Improve water control for peri-urban producers | Invest in water for livestock production | Facilitate multiple use of water |
|---|---|---|---|---|---|---|---|
| | ha | $Mm^3$ | ha | ha | ha | head | 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 7 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 7

*Number of people reached by intervention and livelihood zone*

| Livelihood zone | Manage soil moisture in rainfed areas | Invest in small-scale water harvesting infrastructure | Promote small-scale community-based irrigation | Improve existing irrigation systems | Improve water control for peri-urban producers | Invest in water for livestock production | Facilitate multiple use of water | Total | Total in % of rural population |
|---|---|---|---|---|---|---|---|---|---|
| | no. people | no. people | no. people | no. people | no. people | no. people | no. people | no. people | % |
| 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 586093** | **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 8

*Investment costs by intervention and livelihood zone*

| Livelihood zone | Manage soil moisture in rainfed areas | Invest in small scale water harvesting infrastructure | Promote small-scale community-based irrigation | Improve existing irrigation systems | Improve water control for peri-urban producers | Invest in water for livestock production | Facilitate multiple use of water | Total | Total per beneficiary | Total per ha of cultivated land (*) |
|---|---|---|---|---|---|---|---|---|---|---|
| | USD million | USD million | USD million | USD million | USD million | USD million | USD million | USD million | USD/pers. | USD/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

Table 8 expresses these potential interventions in terms of capital investment costs. In total, these investments could amount to about USD86 000 million, which would represent USD350 per beneficiary. For land-related interventions, the average investment would be about USD330/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.

## CONCLUSION

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.

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# ANNEX 1
# DESCRIPTION OF THE LIVELIHOOD ZONES USED

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's 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 $km^3$/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 followed in order to generate the assessment are described below.

## 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 investment 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 USD1/$m^3$ 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.

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, USD/unit*

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

## 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 m3/ha (unit: million m3).
- 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).

TABLE A2.3

*Absolute potential*

| Livelihood zone | Manage soil moisture in rainfed areas | Invest in small-scale water harvesting infrastructure | Promote small-scale community-based irrigation | Improve existing irrigation systems | Improve water control for peri-urban producers | Invest in water for livestock production | Facilitate multiple use of water |
|---|---|---|---|---|---|---|---|
| | ha | $Mm^3$ | ha | ha | ha | head | 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** |

## 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 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 $m^3$ 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.

TABLE A2.4

*Number of people reached per unit*

| Livelihood zone | Manage soil moisture in rainfed areas | Invest in small-scale water harvesting infrastructure | Promote small-scale community-based irrigation | Improve existing irrigation systems | Improve water control for peri-urban producers | Invest in water for livestock production | Facilitate multiple use of water |
|---|---|---|---|---|---|---|---|
| | **pers./ha** | **Mm3** | **ha** | **ha** | **ha** | **head** | **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 |