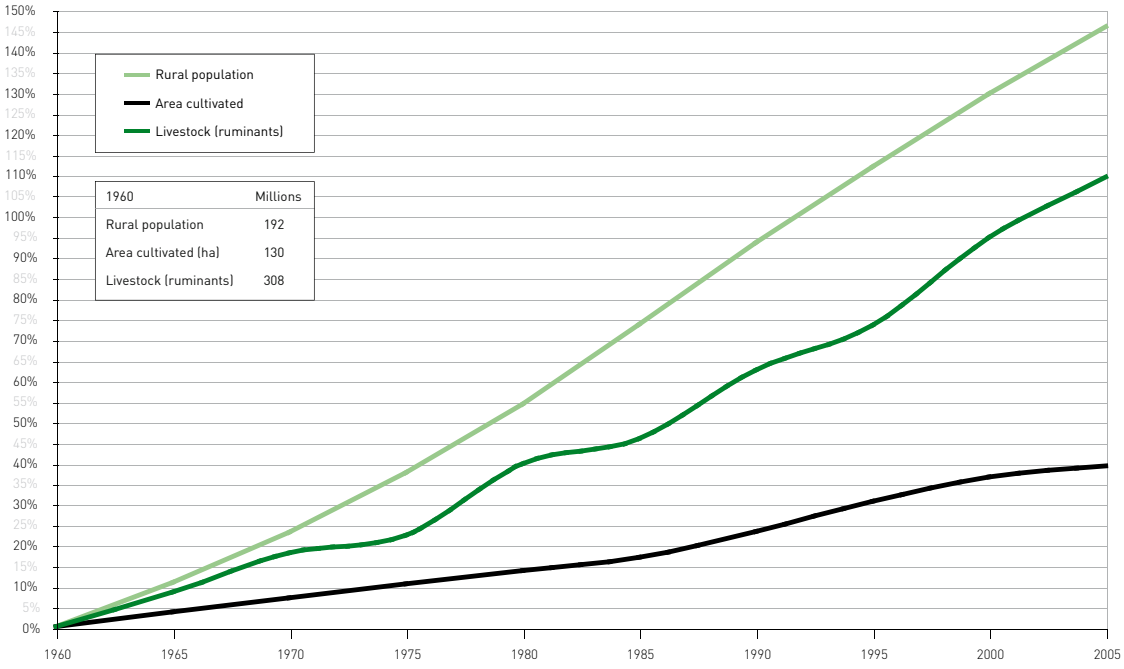
Mapping poverty, water and agriculture in sub-Saharan Africa

Population, natural resources and agriculture

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

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

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



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

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

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

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

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

Overview of agricultural water management in the region

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

Annual internal renewable water resources for SSA amount to more than 3 880 km^3. Madagascar is the richest country in terms of water resources (5 740 m^3/ha/year). Gulf of Guinea and Central Africa are also well endowed subregions, with 4 490 and 3 520 m^3/ha/year, respectively. They account for 49 and 24 percent of SSA's water

resources, respectively. The Sudano-Sahelian subregion is the most deprived with only 186 m^3/ha/year, with Mauritania having only 0.4 km^3/year (3.9 m^3/ha/year). Considering the availability of resources per capita, at country level, the most disadvantaged countries are Mauritania (130 m^3/inhabitant/year in 2005) and Niger (272 m^3/inhabitant/year in 2005), while Gabon, Congo and Equatorial Guinea enjoyed almost 120 000, 57 000 and 50 000 m^3/inhabitant/year, respectively, in 2005.

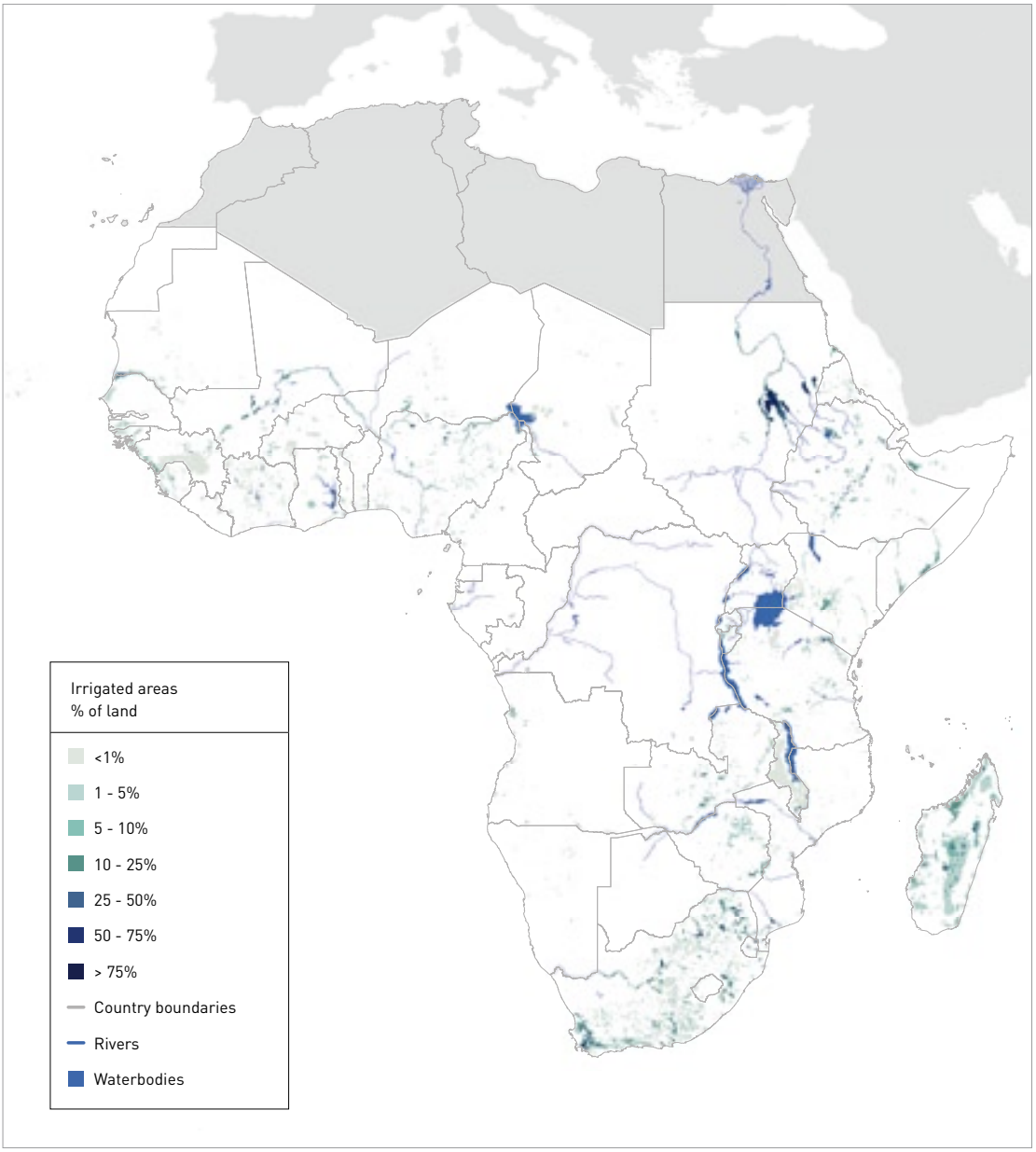
There has been a decrease in internal renewable water resources per inhabitant since 1960. From 1960 to 2005, owing to population growth, the average decreased from more than 16 500 to 5 500 m^3/inhabitant, with an average decrease of

Table 2 Water and agriculture in sub-Saharan Africa

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

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

Figure 3 **Irrigated areas in sub-Saharan Africa**



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

In regard to water use, total annual withdrawal of water from rivers, lakes and aquifers was about 121 km^3/year in 2004, about 170 m^3/year per capita. Agriculture is by far the main water user in comparison with domestic and industrial sectors, accounting for 87 percent of the total withdrawal, against 10 and 3 percent, respectively, for the other sectors. The average annual withdrawal

from irrigated areas is about 15 000 m^3 per hectare of irrigation. Out of about 105 km^3/year from the agriculture sector, 48 percent is withdrawn in the Sudano-Sahelian subregion, which accounts for only 15 percent of domestic withdrawals. On the other hand, the Southern area accounts for only 15 percent of agricultural withdrawals but 42 percent of domestic ones. In the last 20 years, water withdrawal has increased considerably in the entire region as population and irrigated agriculture have expanded. Agricultural withdrawals have risen by more than 90 percent on average in the entire region, apart from the Southern subregion (which has almost reached the total irrigation potential and where the increase has been only 9 percent). Table 2 gives the basic agriculture and water-related data for the region and for the world, and Figure 3 shows the distribution of irrigation in SSA.

Mapping rural poverty in sub-Saharan Africa

Context

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

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

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

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

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

Box 2 The multiple dimensions of poverty

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

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

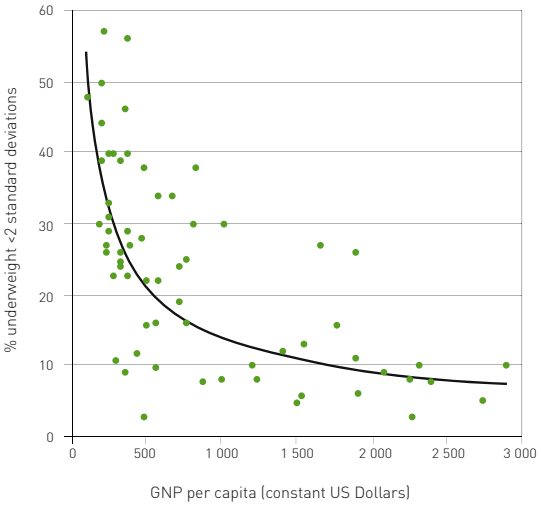
It is necessary to be able to measure poverty consistently in order to make comparisons. Measuring poverty helps policy-makers to target resources to reduce poverty and helps them, and others, to assess progress in reducing poverty. Poverty can be measured in three ways: (i) a scalar approach using a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

Child malnutrition as an indicator of poverty

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

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

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



Source: World Bank (2000).

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

Measuring and mapping rural poverty

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

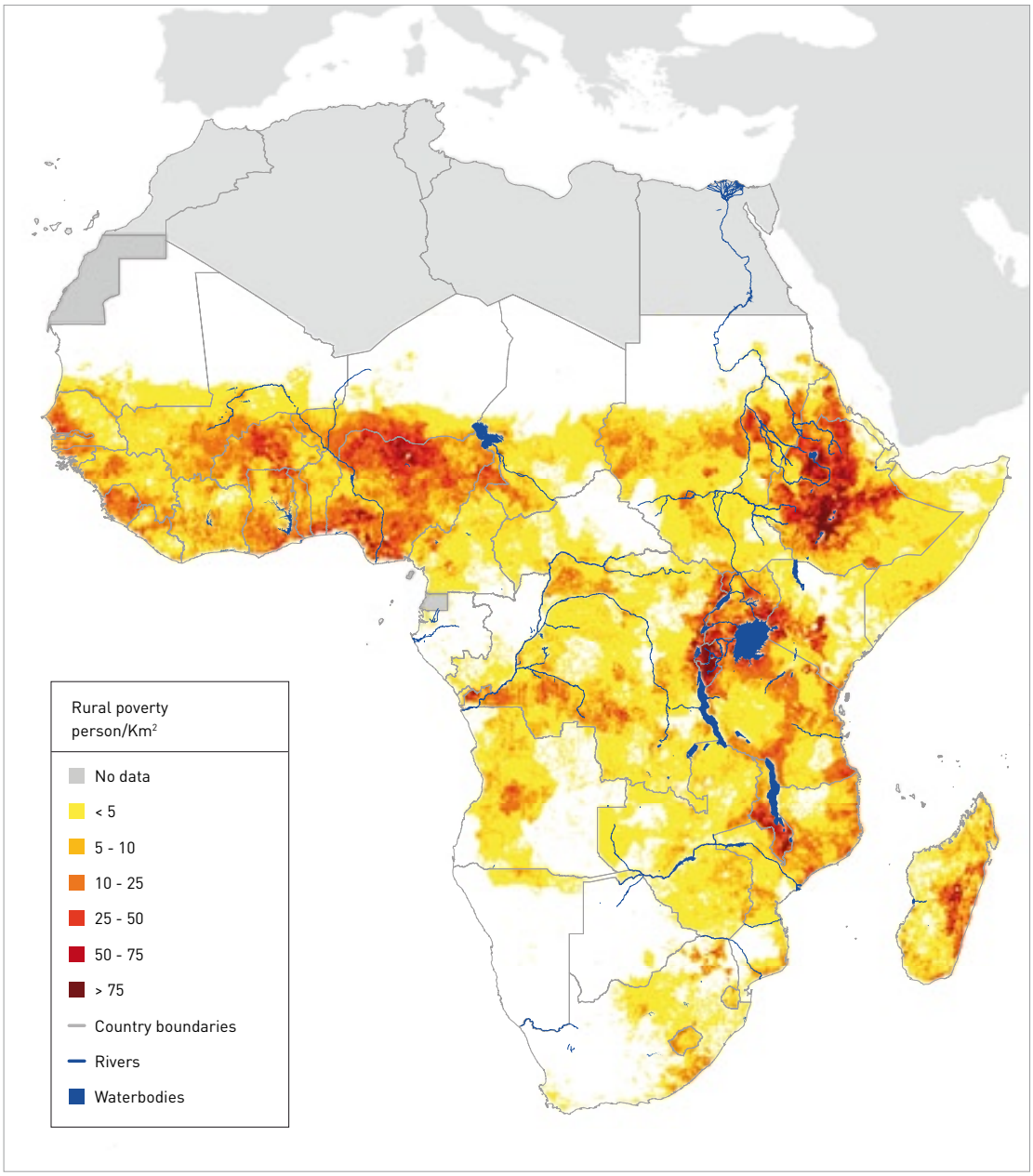
- As part of the Poverty Mapping Project, FAO prepared a Food Insecurity, Poverty and Environment Global GIS Database (FAO-FGGD, 2008) for global analysis of food insecurity and poverty in relation to environment. One of the maps in the database is the FGGD high-resolution rural population density map.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

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

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

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

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



expressed as persons per square kilometres, on a grid with a resolution of 30 arc seconds, about 0.85 km^2. The results are presented in Figure 5, which shows how rural poverty is distributed in SSA. It is spread all around the region with a particular concentration in the Eastern African highlands of Ethiopia and the Lake Victoria basin as well as in Madagascar and in the Gulf of Guinea, with particular emphasis in Nigeria, given the high density of rural population. This measure of

poverty incidence is represented by the number of rural poor, i.e. malnourished children, but it does not show the degree and depth of rural poverty – i.e. how "deep" their poverty is in terms of how far below the poverty line a group of individuals lies.

Mapping livelihoods in rural areas

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

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

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

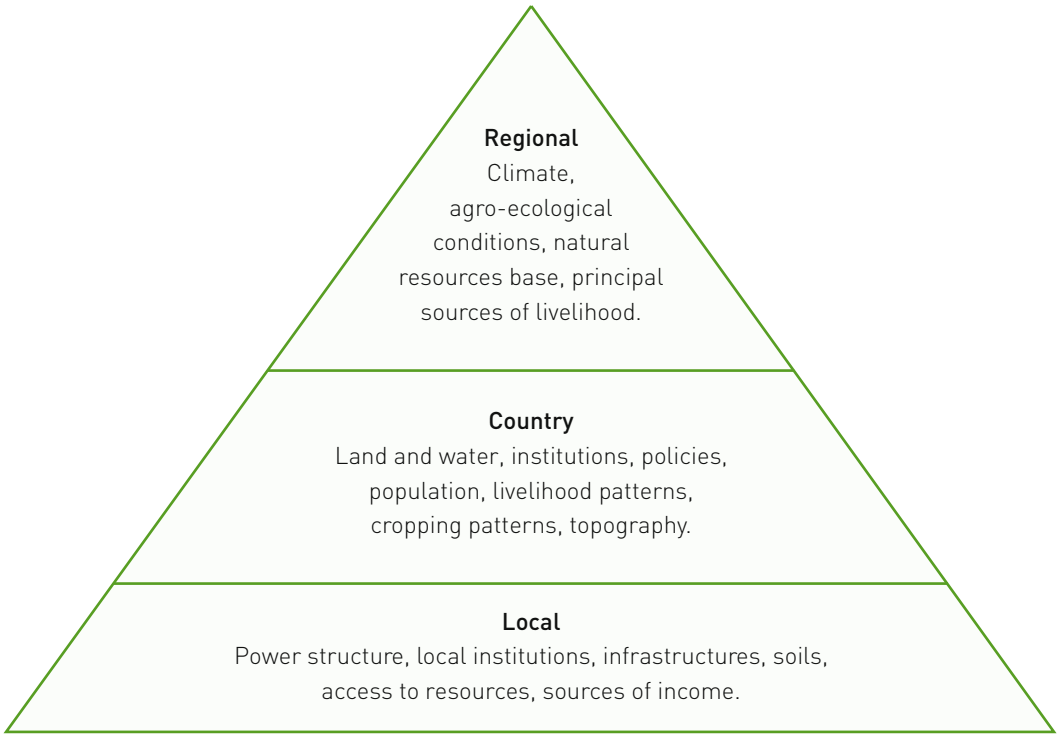


Table 3 Main factors determining livelihood zones at different scales

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

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

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

From farming system mapping to livelihood zoning

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

social, economic and institutional context. Moreover, farms within rural context are strongly linked to the off-farm and labour economy as well as being interdependent on the urban economy. Off-farm activities make a considerable contribution to the livelihoods of many farms and households.

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

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

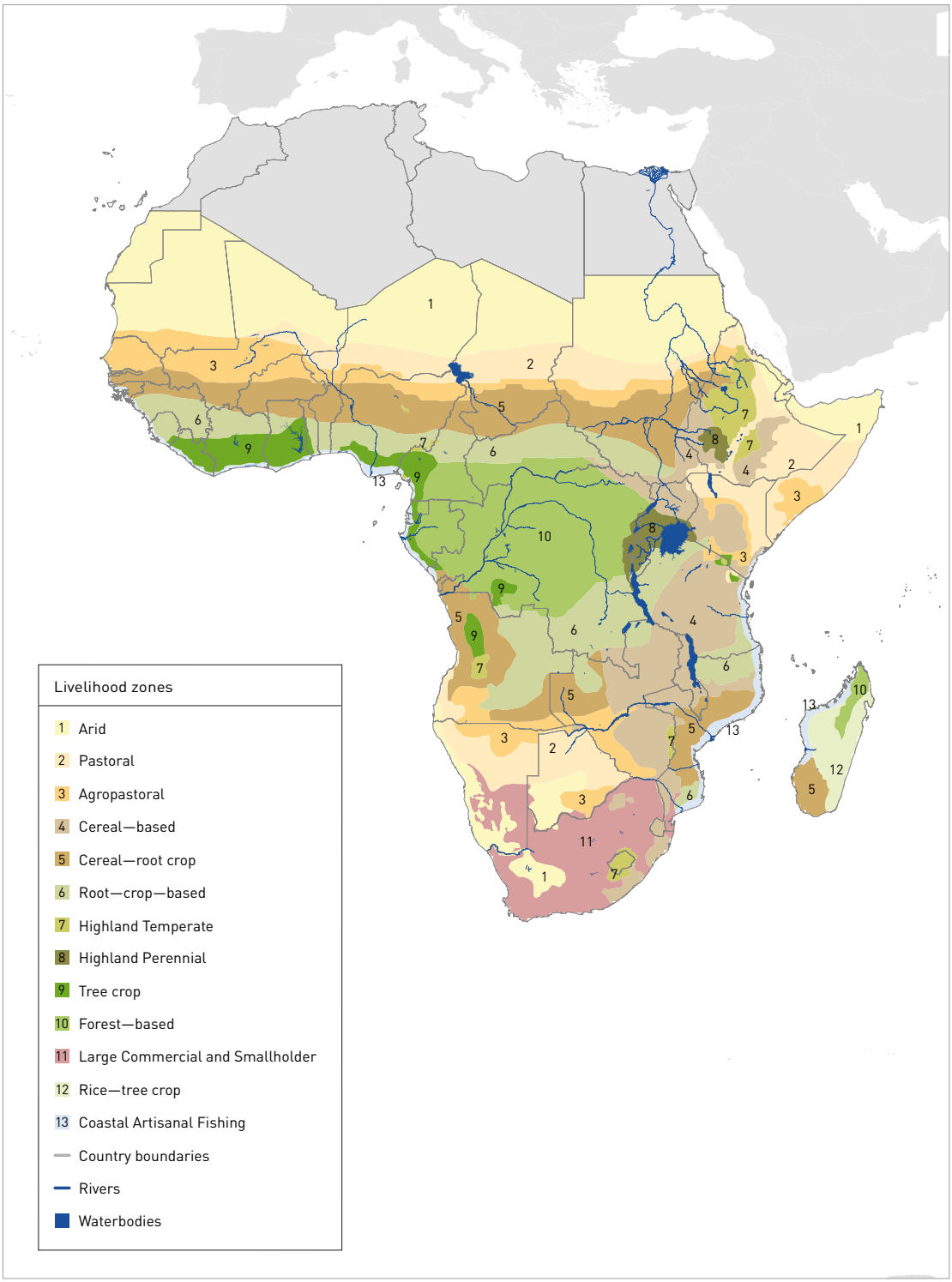
Main livelihood zones and their relation to water in sub-Saharan Africa

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

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

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

Figure 7 **Main livelihood zones in sub-Saharan Africa**



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

Analysing poverty, water and agriculture across livelihood zones

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

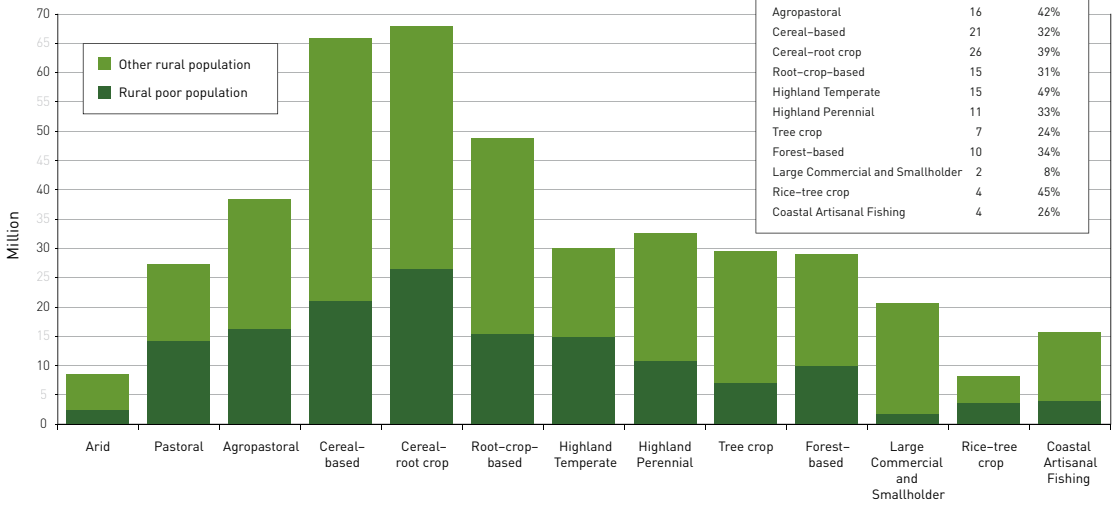
Rural poverty

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

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

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

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



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

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

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

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

Agriculture and water

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

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

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

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

Livelihood zone	Area (1 000 Km²)	Rural population (1 000)	Rural poor (1 000)	Area cultivated (1 000 ha)	Pasture (1 000 ha)	Livestock (1 000 ruminants)	Irrigated areas (1 000 ha)	Irrigation potential (1 000 ha)	Anthropogenic pressure on water resources*	Irrigated areas/ Irrigation potential
Arid	5 144	8 342	2 332	1 545	33 607	8 368	780	2 088	78.4%	37.3%
Pastoral	2 692	27 245	14 129	10 150	190 594	24 224	1 202	2 042	40.8%	58.9%
Agropastoral	2 132	38 432	16 208	42 464	148 440	35 174	917	2 300	8.1%	39.9%
Cereal-based	2 452	65 901	20 912	36 038	137 440	24 497	624	5 182	2%	12%
Cereal-root crop	3 174	67 942	26 434	51 624	194 555	38 576	448	7 759	1%	5.8%
Root-crop-based	2 810	48 712	15 227	28 806	128 651	16 240	187	8 640	0.2%	2.2%
Highland Temperate	439	30 034	14 816	10 275	27 509	12 378	174	1 768	2%	9.8%
Highland Perennial	320	32 755	10 795	7 080	9 883	6 255	54	833	0.8%	6.5%
Tree crop	732	29 625	7 035	13 683	23 944	4 186	116	2 512	0.4%	4.6%
Forest-based	2 624	29 170	9 991	11 007	58 514	3 328	92	6 722	0.1%	1.4%
Large Commercial and Smallholder	1 228	20 439	1 585	15 268	78 494	12 833	1 418	1 390	24.5%	100%
Rice-tree crop	309	8 052	3 654	2 701	20 803	1 153	694	780	4.7%	88.9%
Coastal Artisanal Fishing	387	15 558	4 035	3 631	13 921	1 967	374	1 113	1.7%	33.6%

*Agricultural water withdrawal / Total available runoff

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

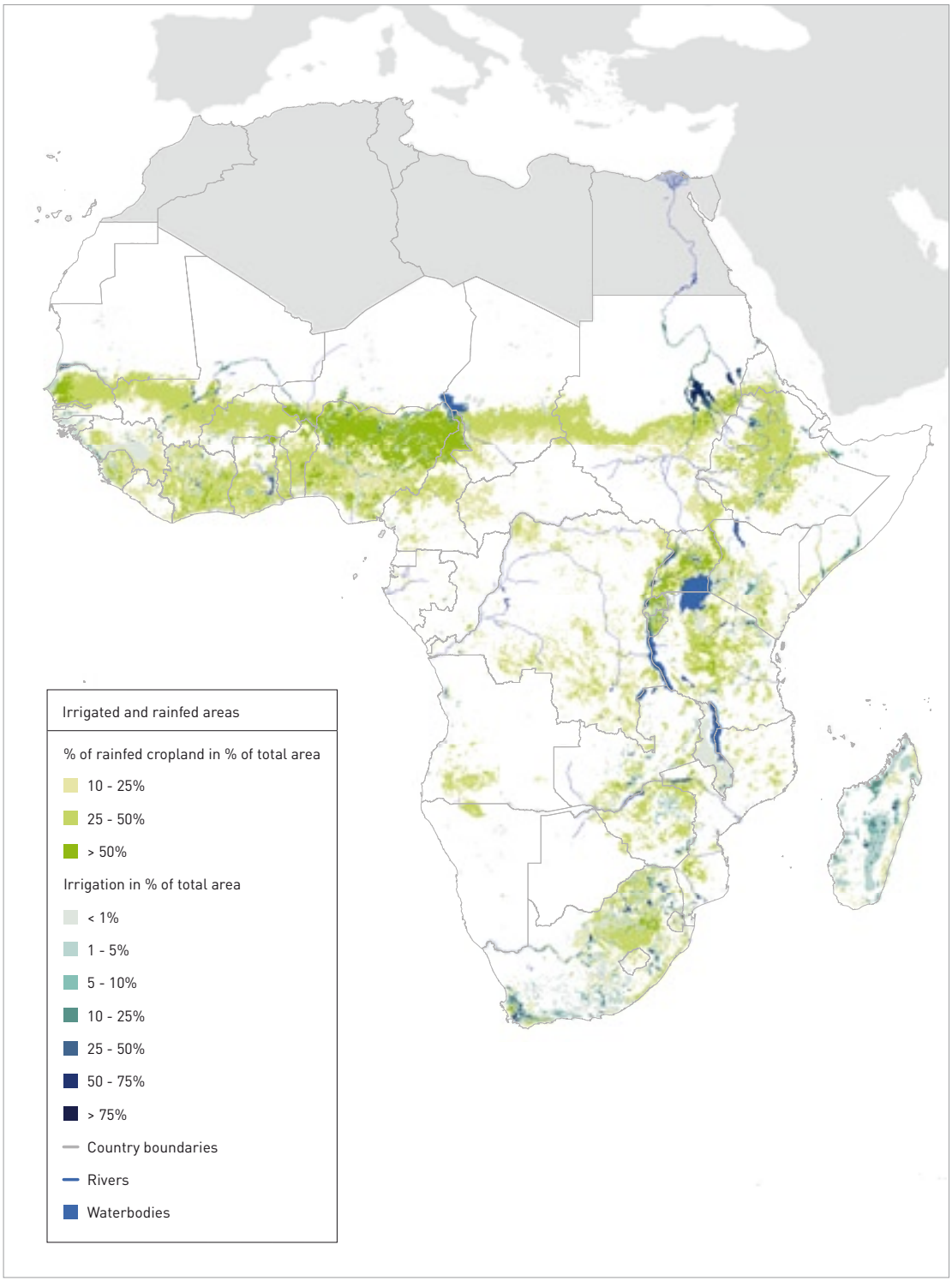
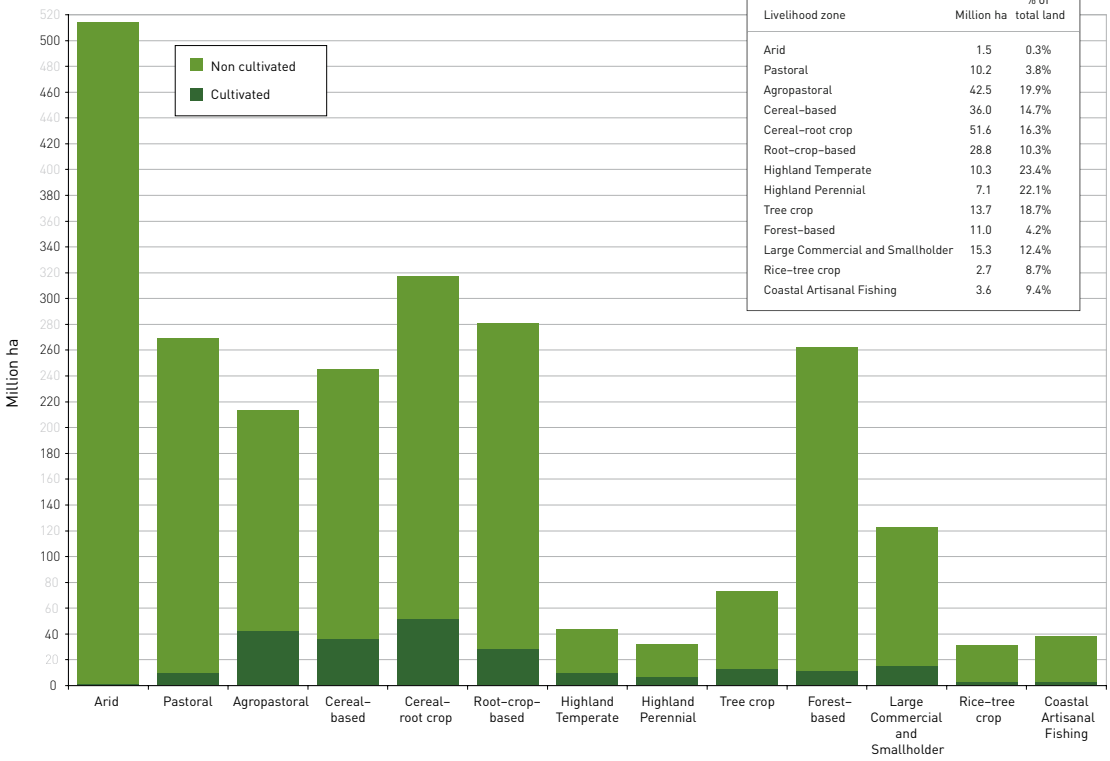


Figure 10 **Cultivated land in livelihood zones**



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

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

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

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

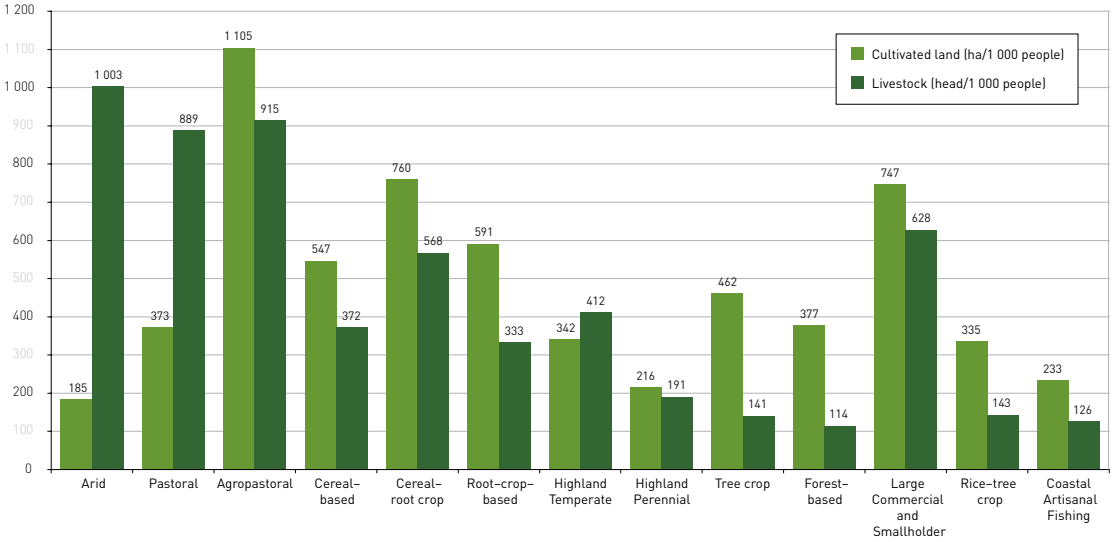
- a relatively low population density;
- abundant cultivated land;
- poor communications;
- lower altitude;
- higher temperatures;
- the presence of a tsetse challenge that limits livestock numbers and prevents the use of animal traction in much of the area (FAO and World Bank, 2001).

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

Irrigation and water resources

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

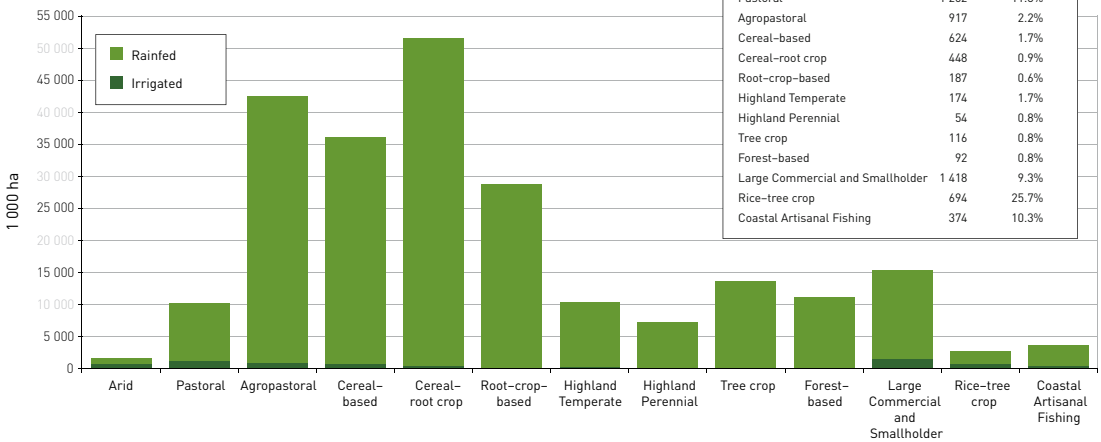
Figure 11 **Land and livestock resources available to rural people in livelihood zones**



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

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

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



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

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

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

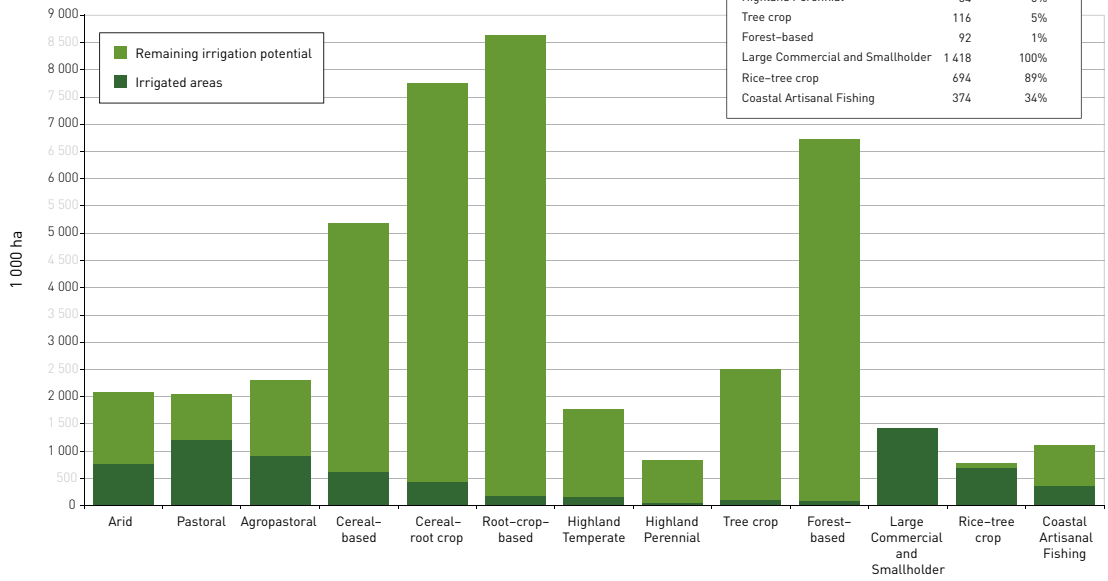
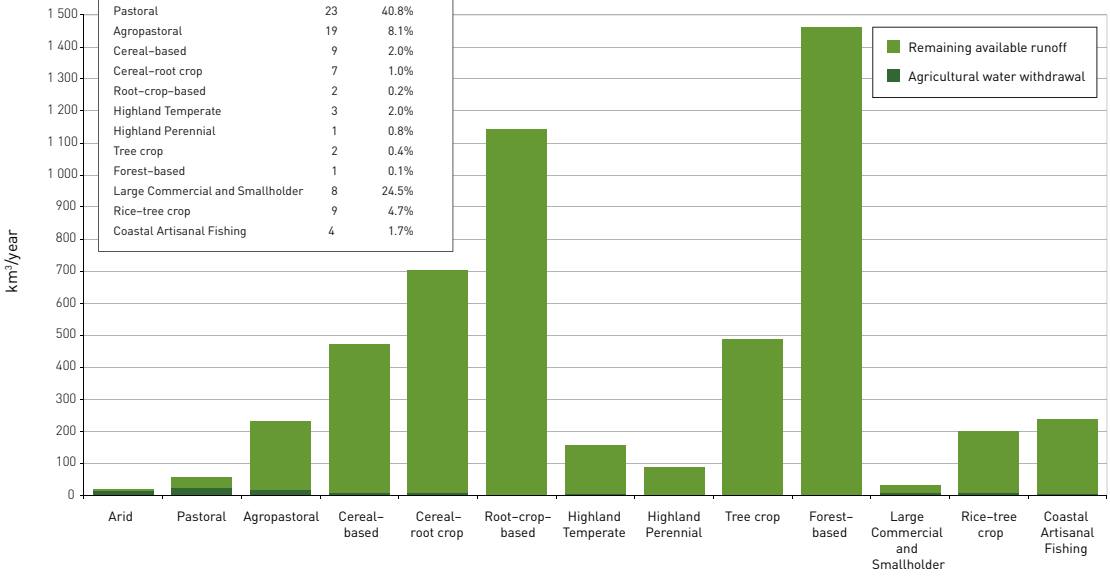


Figure 14
Agricultural pressure on water resources in SSA in livelihood zones

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



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

Assessing the potential for poverty reduction through water interventions

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

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

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

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

Prevalence of poverty

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

Water as a limiting factor for rural livelihoods

This criterion shows where water is the principal binding constraint, mainly for agricultural production but also taking account of other livelihood activities where lack of water may be a constraint. It illustrates how water can make the difference where it is the entry point for agriculture and other livelihood activities. This assessment is based mostly on field experience combined with information gathered from the literature, and on

information on the prevalence of droughts and dry spells (and the way they affect smallholders). In densely populated areas, the need for agricultural intensification has also been considered in determining these criteria. The classification is given in Table 6.

Table 5 Prevalence of poverty by livelihood zone

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

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

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

Potential for water intervention

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

Priority for action

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

Table 7 Potential for water intervention by livelihood zone

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

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

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

Priority level 1: high

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

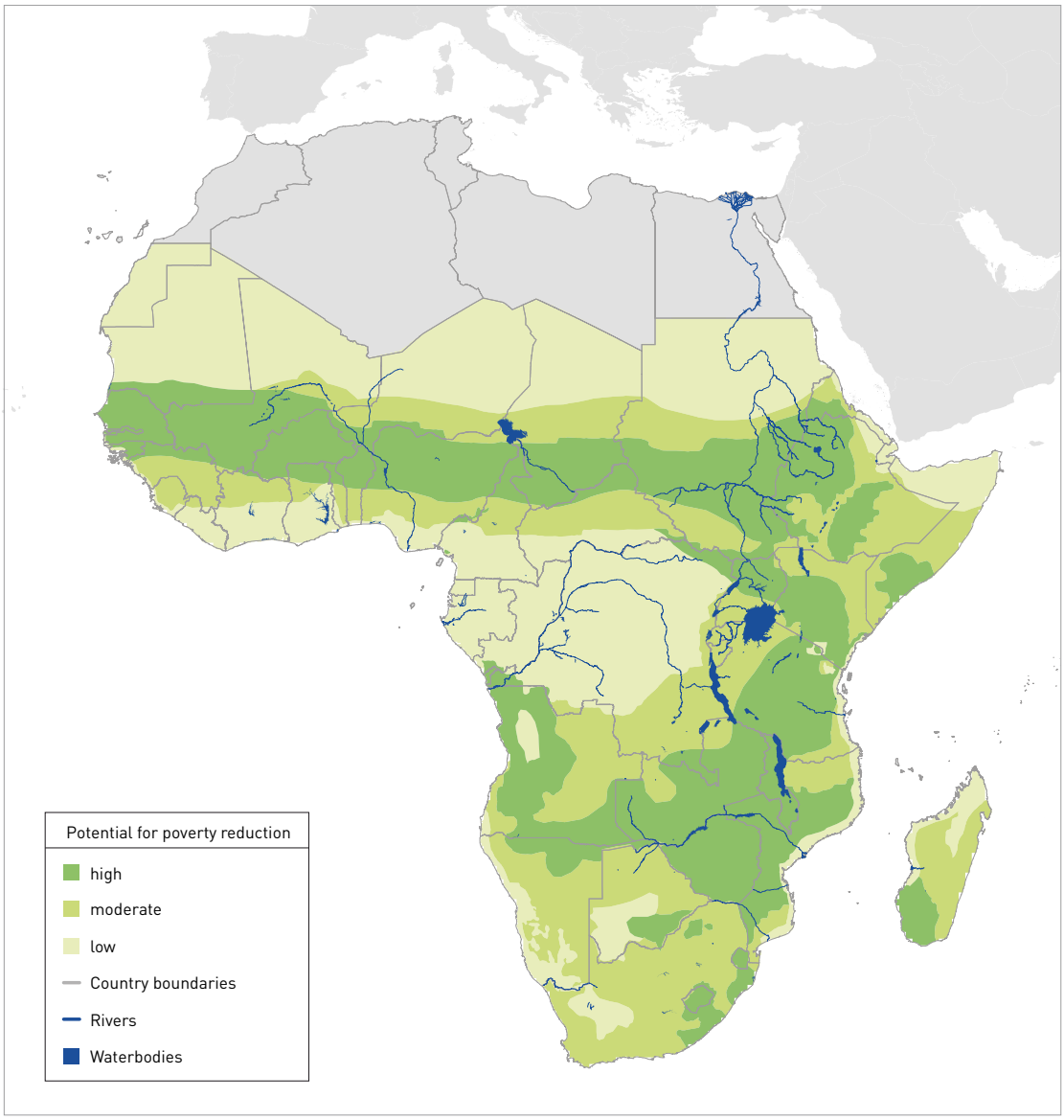
Because of their relatively important natural resource base, high-priority areas are those that offer broad opportunities for agricultural growth. Agriculture is particularly significant in these zones – most of the cereals that feed the region come from these areas. At present, water in these zones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

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

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

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

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



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

In selecting the right type of intervention, it is important to recognize that most agricultural production in SSA, now and in the future, will

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

Priority levels 2 and 3: moderate and low

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

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

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

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

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

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