SUMMARY OF BACKGROUND PAPER 4

AFRICA INFRASTRUCTURE COUNTRY DIAGNOSTIC

Watermarks: Indicators of Irrigation Sector Performance in Sub-Saharan Africa

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About AICD

This study is part of the Africa Infrastructure Country Diagnostic (AICD), a project designed to expand the world's knowledge of physical infrastructure in Africa. AICD will provide a baseline against which future improvements in infrastructure services can be measured, making it possible to monitor the results achieved from donor support. It should also provide a more solid empirical foundation for prioritizing investments and designing policy reforms in the infrastructure sectors in Africa.

AICD will produce a series of reports (such as this one) that provide an overview of the status of public expenditure, investment needs, and sector performance in each of the main infrastructure sectors, including energy, information and communication technologies, irrigation, transport, and water and sanitation. The World Bank will publish a summary of AICD's findings in spring 2008. The underlying data will be made available to the public through an interactive Web site allowing users to download customized data reports and perform simple simulation exercises.

The first phase of AICD focuses on 24 countries that together account for 85 percent of the gross domestic product, population, and infrastructure aid flows of Sub-Saharan Africa. The countries are: Benin, Burkina Faso, Cabo Verde, Cameroon, Chad, Congo (Democratic Republic of Congo), Côte d'Ivoire, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mali, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, South Africa, Sudan, Tanzania, Uganda, and Zambia. Under a second phase of the project, coverage will be expanded to include additional countries.

AICD is being implemented by the World Bank on behalf of a steering committee that represents the African Union, the New Partnership for Africa's Development (NEPAD), Africa's regional economic communities, the African Development Bank, and major infrastructure donors. Financing for AICD is provided by a multi-donor trust fund to which the main contributors are the Department for International Development (United Kingdom), the Public Private Infrastructure Advisory Facility, Agence Française de Développement, and the European Commission.. A group of distinguished peer reviewers from policy making and academic circles in Africa and beyond reviews all of the major outputs of the study, with a view to assuring the technical quality of the work.

This and other papers analyzing key infrastructure topics, as well as the underlying data sources described above, will be available for download from www.infrastructureafrica.org. Free-standing summaries are available in English and French.

Inquiries concerning the availability of datasets should be directed to vfoster@worldbank.org.

Indicators of Irrigation Sector Performance in Sub-Saharan Africa

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The paradoxes and contrasts of Sub-Saharan Africa are fully apparent in the irrigation sector, where plentiful resources are only spottily exploited, leaving harvests vulnerable to the vicissitudes of climate and millions on the continent uncertain about their food supply. Failure to exploit fully the productivity-enhancing and value-adding power of irrigation has also been a missed opportunity for economic growth.

The continent's water resources, ample overall, are spread unevenly over a wide range of agro-ecological zones in which access to water can vary starkly and suddenly. Efforts to manage water and to make it available where it is most needed are hampered by long-term underinvestment in irrigation and the water sector, by the undeveloped state of institutions for irrigation and water-resource management, and by the prevalence of subsistence farming. Ample groundwater resources in much of the continent remain largely untapped, except in southern Africa.

Irrigation is rare except in a handful of countries, even though the volume of food imports is increasing and irrigation clearly has the power to raise agricultural productivity, as demonstrated in successful schemes that use irrigation to produce high-value export products. Only a small share of agricultural land is equipped for irrigation, and the rate of expansion has been slowing in recent years. In a seeming paradox, a relatively high share of irrigation-equipped land is fitted with high-tech systems that permit efficient pressurized irrigation. The disproportionate contribution to agricultural production of Sub-Saharan Africa's small irrigated area suggests that returns to additional investment in irrigation would be high, in terms of agricultural income generation and poverty alleviation, greater food security for the continent, and greater production of export-quality agricultural goods.

The World Bank and other donors have called for significant investment in irrigation in coming years in response to the call by Commission for Africa to double irrigation funding between 2005 and 2015. Greater investment is indeed needed to close the gap in agricultural productivity between Sub-Saharan Africa and other world regions and, by closing that gap, to improve food and nutritional security in Sub-Saharan Africa, reduce rural poverty, and widen opportunities for economic growth. Greater capital investment is also needed in fertilizers, advanced seed delivery systems, postharvest processing facilities, access to markets, and other facets of rural infrastructure. But irrigation stands out strongly among these because of its role in stabilizing yields in the face of increasing climatic variability, reduced rainfall, higher temperatures, and other effects of climate change.

Study objectives and context

The objectives of this study were to survey the irrigation sector in 24 Sub-Saharan countries included in the Africa Infrastructure Country Diagnostic (hereinafter "the sample countries"), to identify indicators that would make it possible to analyze the future performance of the irrigation sector on the continent, and to establish baseline values for those indicators that will allow future comparisons to be made.

The 24 sample countries make up a large subset of Sub-Saharan Africa, comprising 70 percent of its area and 85 percent of its population. In most respects, the sample countries are similar to Sub-Saharan Africa. Like the subcontinent as a whole, the sample countries diverge starkly from the world norm in how they use their water resources. For example, Sub-Saharan Africa withdraws only about a quarter as much water per inhabitant as does the world as a whole (163 m^3/year compared with 599 m^3/year), with a much higher share of withdrawals going for agricultural use. The low rate of withdrawal reflects the scanty use of irrigation in theregion: the Sub-Saharan countries irrigate only about 4 percent of their collective cropland, compared with a world average of about 18 percent.

Only a few of the sample countries have developed more than a small share of their "irrigation potential," that is, the area in which it would be beneficial and feasible to irrigate. By this measure, the standouts are South Africa (which has developed 100 percent of its irrigation potential by irrigating about a tenth of its cultivated land area), Cape Verde (89 percent), Madagascar (72 percent), and Sudan (67 percent). The other countries in the sample have developed no more than a third of their potential to benefit from irrigation (table 1).

Table 1 Realization of irrigation potential in sample countries

Country	Irrigation-equipped area as % of cultivated area	% of irrigation potential realized
Benin	0.4	4
Burkina Faso	0.6	15
Cameroon	0.4	9
Cape Verde	6.2	89
Chad	0.8	9
Congo, Dem. Rep.	0.1	15
Côte d'Ivoire	1.1	0
Ethiopia	2.7	11
Ghana	0.5	2
Kenya	2.0	29
Lesotho	0.8	21
Madagascar	30.6	72
Malawi	2.3	35
Mozambique	2.7	4
Namibia	0.9	16
Niger	1.6	27
Nigeria	0.9	13
Rwanda	0.6	5
Senegal	4.8	29
South Africa	9.5	100
Sudan	11.2	67
Tanzania	3.6	9
Uganda	0.1	10
Zambia	2.9	30

Source: FAO.

We studied the performance of the irrigation sector in five broad areas: (a) the institutional framework surrounding irrigation; (b) water resource utilization; (c) irrigated area and irrigation technology; (d) agricultural productivity; and (e) poverty and food security.

The impact indicators and baseline values we developed were selected to provide comprehensive coverage of important aspects of the water resource system and irrigation performance. The indicators are variables that are likely to change in response to expected increases in irrigation investment.

Most of the indicators were drawn from the global databases of the United Nations Food and Agriculture Organization (FAO); data were also drawn from data sets maintained by the World Bank and the International Food Policy Research Institute (IFPRI), although the IFPRI data were used only where it was not possible to construct useful thematically related indicators from the global databases.

Because it was deemed important to cover the 24 countries in the study consistently, the subset of indicators was restricted to those that could be obtained for comparison across all or nearly all of the 24 countries.

The FAO's subregional classifications describe the various agro-ecological environments found on the continent (table 2). In this summary we use these classifications to present data on irrigation potential and performance in Sub-Saharan Africa.

Table 2 Agro-ecological zones of Sub-Saharan Africa

Zone	Sample countries in region	Characteristics
Sudano-Sahelian	Burkina Faso, Cape Verde, Chad, Niger, Senegal, Sudan (29% of total area of zone)	Dry; low population density. Large-scale use of irrigation limited to Sudan. Some successful use of irrigation elsewhere for food and cash crops.
Eastern	Ethiopia, Kenya, Tanzania, Uganda, Rwanda	37% of arable area under production. Large arid zones unsuitable for crops. Other large areas of fragile agro-ecology. Irrigation has boosted cash crops in Ethiopia and Kenya.
Gulf of Guinea	Benin, Côte d'Ivoire, Ghana, Nigeria (44% of total area of zone)	Great variation in climate, including precipitation. Varied scope for irrigation.
Central	Cameroon, Dem. Rep. of Congo (56% of population of zone)	Generally well-supplied with water, but imbalance in distribution of groundwater resources. Low population density; much rough terrain.
Southern	Lesotho, Malawi, Mozambique, Namibia, South Africa, Zambia	Oceans temper climate in coastal areas. Wide variation in precipitation, water availability, and agro-ecological conditions: some tropical (Mozambique), some dryland (South Africa).
Indian Ocean Islands	Madagascar (99% of area of zone)	Conditions vary from semi-arid to tropical humid.

Irrigation institutions: dammed up

Despite their importance in managing and sharing water over areas of great agro-ecological and hydrological diversity, in a region where a large proportion of the population works in subsistence agriculture and lives at the whim of increasingly variable climates, Sub-Saharan Africa's framework of irrigation-related institutions is relatively undeveloped.

What is an "ideal" institutional framework for irrigation? Certain principles of good water resource development and management are widely accepted. Beyond these general values, however, the optimal institutional configuration in a particular country, and the correct pathway to reach it, are country and time specific. Therefore, it is very difficult to define a set of regionwide indicators that can be used to measure "progress" in institutional change resulting from an irrigation investment program. For example, it is hard to say with confidence how large irrigation management units should be, which system of water rights is best, how much regulation should be imposed on irrigation service providers, how much decision-making authority should be lodged at a given level, or whether a river basin management organization with command and control authority is always necessary.

Nevertheless, the presence or absence of several specific features in a country's water institutional environment suggests an interim set of indicators for improvements in the institutional framework. The indicators are these:

- Does a specialized agency exist to handle basin-level management?

- Is infrastructure development institutionally separate from agricultural management?
- Do water-user associations have adequate power and authority?
- Does the country have an irrigation strategy?
- Does it have an irrigation action plan?

Some of these institutional features are more common than others in the sample countries. Water-user associations are empowered in 17 of the 24 countries. A national irrigation strategy is found in half of the sample countries, but an irrigation action plan is found in just nine. Nine of the countries have a specialized agency for basin-level management. In only four is infrastructure development institutionally separate from agricultural management.

Madagascar, Tanzania, and Nigeria each have four of the five institutional features described, perhaps indicating a higher level of institutional development than elsewhere. Most of the sample countries have one to three of the features. Cape Verde, Democratic Republic of Congo, and Rwanda have none.

Water resources: underused

As already noted, the countries of Sub-Saharan Africa make less use of their relatively abundant water resources than do other regions of the world. The extent of that use—for irrigation and other purposes—can be considered (and measured) in terms of total water withdrawals, agricultural water withdrawals, the capacity to store surface water, and the extent to which use is made of groundwater.

Table 3 Indicators and baseline values of water resource use in the sample countries, Africa, and the world

Percent

Region	Indicators			
	Total water withdrawals as share of total renewable water resources	Agricultural water withdrawals as share of total renewable water resources	Dam capacity as share of total available surface water	Groundwater pumped as a percentage of total renewable groundwater
Africa	3.8	3.3	14.6	—
Sub-Saharan Africa	1.5	1.3	11.2	—
24 sample countries	3.0	2.6	14.9	8.4
Sudano-Sahelian	28.3	27.3	9.8	3.3
Eastern	5.7	4.9	5.5	3.1
Gulf of Guinea	2.2	1.5	61.7	0.0
Central	0.1	0.1	0.9	0.0
Southern	9.1	5.8	47.8	21.0
Indian Ocean Islands	4.4	4.2	0.1	8.7
Asia	19.4	15.8	12.0	—
World	7.4	5.2	7.6	—

Sources: FAO Aquastat database; Global Groundwater Information System.
— = data not available.

Total water withdrawals across the region are very low, averaging just 3 percent of available supply (table 3). South Africa with its large commercial irrigation sector, urban conglomerations, and well-developed industrial base, and Sudan with its vast Gezira scheme, dwarf other countries in this regard. By contrast, total withdrawals in Asia comprise almost one-fifth of available water (19.4 percent). The world average (7.4 percent) is more than double the level for

the sample countries. The generally low values of this indicator suggest ample scope for additional withdrawals to support rural livelihoods, food security, and economic growth.

The picture for *agricultural withdrawals* is similar to that for total withdrawals, with South Africa and Sudan again standing out dramatically from a low overall average. Low agricultural withdrawals in the humid Central African region are understandable given the wider scope in the region for rain-fed agriculture. The Asian value of this indicator is six times that of the sample countries; the world value is double that of the 24 countries considered here.

The average *storage capacity* in the sample countries is about 15 percent of average annual discharge, with much higher rates in the Gulf of Guinea and Southern agro-ecological zones that reflect large projects in Côte d'Ivoire, Ghana, Lesotho, South Africa, and Zambia. Although Africa's dam capacity relative to the size of its rivers exceeds that of Asia and the world as a whole, the potential for additional development is significant.

In Zambia, Lesotho, and elsewhere, dammed storage is used largely for hydropower generation, as shown by the relatively small fraction of water withdrawn for agriculture in these countries. The lack of storage in the Central African region, which has considerable hydropower potential, results from the relative abundance of water, relatively low population density, and densely forested and difficult terrain.

Data on *groundwater abstraction* are sparse, with only 13 of the 24 sample countries reporting values. With the exception of South Africa, all the available values are very small, suggesting the potential for much greater development. Shallow groundwater aquifers are good water sources for individual and small community irrigation systems. Like surface water reservoirs, groundwater aquifers may also serve to buffer fluctuations in the supply of irrigation water.

Irrigation area: scant coverage

Compared with the rest of the world, a very small portion of Africa's territory is equipped for irrigation. And since 2000 the expansion of that area has slowed to a crawl.

Just 6 percent of the cultivated area in Africa is equipped for irrigation (3.9 percent in the 24 sample countries), compared with 33.6 percent in Asia and 17.7 percent for the world as a whole (table 4). Of the sample countries, only Sudan and Madagascar rise to double digits. The share of the area equipped for irrigation that is actually irrigated ranges widely, from less than half in Benin, Malawi, Mozambique, and Sudan to more than 90 percent in Burkina Faso, Côte d'Ivoire, Ghana, Kenya, and Madagascar. Lower values reflect facilities that have deteriorated since construction and are no longer usable, areas in which water supply is insufficient to irrigate the entire area, and areas in which deficient management keeps available water from reaching the entire area. The average utilization rate is 69.4 percent in the sample countries, comparable to the Asian average, but well below the global average.

Irrigated area can be classified by the size of the scheme—small, medium, and large. In general, large-scale schemes account for the majority of irrigated area in most countries, the exceptions being Madagascar and Senegal. But because the definitions of small and large differ widely across countries, precise comparisons are impossible.

In addition to areas of classically equipped irrigation, many African countries also contain cultivated areas with more basic water control facilities or no permanent facilities at all. These include areas of flood recession agriculture, spate irrigation, and cultivated wetlands. In spate irrigation, floodwaters originating from mountain catchments are diverted from riverbeds and spread over extensive areas. Because of their less reliable water supply and limited control, these areas are generally less productive than those equipped for classical irrigation. Locally, however, they may be very important, and offer opportunities for upgrading to improve productivity.

Table 4 Indicators and baseline values of irrigation area in the sample countries, Africa, and the world

Percent

Region	Indicators				
	Irrigation-equipped area as share of cultivated area	Area actually irrigated as share of irrigation-equipped area	Water-managed area as share of cultivated area	Average annual expansion of irrigated area	
				1973–2003	2000–03
Africa	5.8	81.6	6.7	—	—
Sub-Saharan Africa	3.5	71.0	4.5	—	—
24 sample countries	3.9	69.4	4.4	1.4	0.5
Asia	33.6	66.9	34.3	—	—
World	17.7	92.4	17.6	—	—

Source: FAO Aquastat and ResourceStat databases.
— = data not available.

If the less formal ways of managing water are counted, the share of cultivated area in which water is managed rises from 3.9 percent (the irrigation-equipped area) to 4.4 percent for the sample countries, with more dramatic changes in Chad, Malawi, Nigeria, Rwanda, Uganda, and Zambia.

The average annual rate of expansion of irrigated area over the past 30 years was 1.4 percent in the sample countries, though many countries showed more rapid expansion. The overall rate would appear quite slow, given that Africa's use of irrigation falls far below that of Asia and the rest of the world, and far below the continent's irrigation potential. Moreover, the rate of expansion has slowed significantly since 2000. Between 2000 and 2003, the rate of expansion in irrigation was only about a third of the longer-term rate (0.5 percent), suggesting a slowing of irrigation development. Seventeen of the 24 sample countries showed a zero rate of recent expansion. Only a handful of countries (Kenya, Nigeria, Senegal, and Zambia) showed recent growth rates of greater than 3 percent per year.

Irrigation technology: the pressure is on

On-farm pressurized irrigation technologies—sprinkler and micro-irrigation—can reduce water use while increasing productivity and, for horticultural crops, improving product quality. On this score, Africa rates very well. On average, 21.3 percent of formally equipped irrigation area in the 24 sample countries (17.7 percent in Africa as a whole) is equipped with pressurized irrigation equipment, compared with just 2.4 percent in Asia, and 11.7 percent in the world at large. The great bulk of this advanced equipment is found in South Africa, with smaller presences in Kenya and Zambia.

Other important indicators for irrigation technology include the shares of localized, sprinkler, and surface irrigation in total irrigation-equipped area, and irrigation-equipped and actually irrigated area as a share of total water-managed area. More advanced and water-saving pressurized systems are much more likely to be found in Africa than in Asia, and somewhat more likely than in the world as a whole.

Agricultural productivity: untapped potential

Africa makes far less use of irrigation than do other areas of the world, yet, in most of its agro-ecological zones, its rainfall is no more reliable. It is clear, therefore, that Africa's agricultural productivity, and thus its food security and the welfare of its people, stand to benefit from more extensive use of irrigation. How much benefit can be expected?

Two measures of the impact of irrigation on productivity are the value of crops derived from irrigated agriculture (as a share of total agricultural output) and the per hectare value of irrigated agricultural output compared with the value of an average hectare of rain-fed output.

Table 5 Agricultural productivity in agro-economic zones of Sub-Saharan Africa

	Indicators		
Region	Value of irrigated output as share of total agricultural output	Water-managed area as share of total cultivated area	Value of irrigated output as multiple of value of rain-fed output
Sudano-Sahelian	45.5	6.8	4.99
Eastern	17.0	2.8	1.03
Gulf of Guinea	2.0	2.1	0.30
Central	19.8	0.2	1.20
Southern	36.9	5.0	2.25
Indian Ocean Islands	—	30.9	—
Average, 24 sample countries	19.9	4.4	1.36

Source: FAO (2003), Buinsma (2003), IMPACT (2000)
— = data not available.

In the 24 countries of our sample, irrigated agriculture accounted for nearly one-fifth of the value of all agricultural output. That is just half of the ratio found in the world as a whole. But when one considers that that share was produced on just 4.4 percent of the cultivated land in the sample countries (a multiple of almost 5 to 1), one begins to understand the potential of irrigation to improve livelihoods in Africa.

The picture is complicated, however, by a lower-than-expected ratio of the value of irrigated output as multiple of the value of rain-fed output unit productivity. In the sample countries, that ratio is 1.36, whereas it is between 1.5 and 3 in other areas of the world. This lower-than-expected value is obviously at odds with the very strong impact of irrigation shown by the previous indicator. We need to examine more carefully the data underlying these indicators to reach a firm conclusion about the current state of irrigation productivity in Sub-Saharan Africa.

Poverty and food security: water control is the answer

Given that more than half of the economically active population of Africa is engaged in agriculture, compared with just over one-fifth of the population of the world as a whole (table 6), and that irrigation has already demonstrated its power to increase agricultural productivity, investments in irrigation clearly have the potential to generate benefits for a region where poverty is high and the food supply can rarely be taken for granted.

The share of Sub-Saharan Africa's population with incomes falling below the national poverty line is significantly higher than the rate in Asia and the world at large. In general, the 24 countries of our sample are somewhat poorer.

Caloric intake per capita in Africa is well below the values for Asia and the world, providing ample room for targeting improvement.

Conclusion: the last drop

Table 6 Indicators and baseline values of poverty and food security in the sample countries, Africa, and the world

Percent, except as otherwise noted

	Indicators			
Region	Poverty headcount ratio at national poverty line	Rural poverty headcount ratio at rural poverty line	Agricultural workers as % of economically active population	Caloric intake per capita
Africa	35.7	—	56	2,524
Sub-Saharan Africa	41.1	—	—	2,290
24 sample countries	44.8	37.6	54	2,274
Asia	32.7	—	47	2,799
World	32.7	—	21	2,899

The study developed indicators in five categories—institutional framework, water resource use, irrigation area and technology, agricultural productivity, and poverty and food security. In all cases, indicators were selected that could reasonably be expected to respond in some way to increased irrigation sector investment, allowing the impacts of the investment program to be monitored and assessed.

Institutional framework. Additional effort is needed to arrive at a set of indicators capable of measuring the progress of water-related institutions. Even after consensus is achieved about which indicators might be most useful, the absence of cross-country information on the institutional context for irrigation (and water resource management in general) will complicate the effort to measure progress. It would be useful to develop a comprehensive set of indicators—covering policies, laws, documents, and other information—that would enable us to assess change in this area in response to increased investment.

Water resource use. Total water withdrawals and agricultural withdrawals in Africa, which are about half of those in the world as a whole, have ample room to rise as investments in irrigation are ramped up.

Storage capacity. Relative surface-water storage capacity in Africa is well above the global average, but storage is very unevenly distributed, and much of it is used solely for hydropower generation. Average groundwater utilization in the region is less than 10 percent of renewable supplies. Groundwater is a resource particularly well suited for small-scale irrigation and for multiple-use systems. Both dammed storage and groundwater could be more extensively used to increase agricultural productivity.

Irrigation area and technology. The share of cultivated area equipped for irrigation in Africa is about a third of the world average and just one-sixth of the value for Asia. The low coverage of irrigated area and the slow rate of growth in coverage clearly represent a lost opportunity for a hungry continent. On the positive side, a remarkably high share of irrigated land in Sub-Saharan Africa (with the share even higher in the sample countries) is equipped with efficient pressurized water application, suggesting a promising direction for future investment.

Agricultural productivity. The sample countries produce one-fifth of their crops (by value) from the 5 percent of their cultivated land on which water is managed, which again suggests that additional investment in irrigation would pay large benefits.