SUMMARY OF BACKGROUND PAPER 9

AFRICA INFRASTRUCTURE COUNTRY DIAGNOSTIC

Irrigation Investment Needs 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, Cape 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. Freestanding summaries are available in English and French.

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

Summary

Irrigation plays a minor role in African agriculture. This is unfortunate, because wider use of the region's ample groundwater supplies would give a substantial boost to production of food staples and high-value export crops.

In Sub-Saharan Africa, rainfall is highly variable and, in many places, plainly insufficient. Drought is common. Although irrigation has the potential to boost agricultural yields by at least 50 percent, food production in the region is almost entirely rain-fed. The irrigated area, extending over 6 million hectares, makes up just 5 percent of the total cultivated area, compared to 37 percent in Asia and 14 percent in Latin America. Two-thirds of that area is in three countries: Madagascar, South Africa, and Sudan.

Almost half of the people of Sub-Saharan Africa live below the international poverty line. Because 65 percent of the region's population farm for a living, agricultural development clearly is the royal road to ending poverty. And in view of the strong links between irrigation and agricultural development, proposals to expand irrigation to increase productivity and reduce poverty in Sub-Saharan Africa have received a good deal of attention. Rightly so. But attention has yet to be translated into action.

The 2005 Commission for Africa report, for example, called for a doubling of the region's irrigated area by 2015. To achieve expansion on that scale, however, we must deepen our understanding of the locations that could benefit most—and of the technologies best suited to those locations. One purpose of this study of irrigation in 24 countries, undertaken as part of the Africa Infrastructure Country Diagnostic, is to identify agricultural areas where irrigation investments promise to yield significant returns. A related purpose is to estimate the amount and scope of investment needed to secure those returns.

We begin with a fundamental distinction. Water for irrigation can be collected in two ways: through large, dam-based schemes, or through small projects based on collection of run-off from rainfall. Both possibilities are considered here.

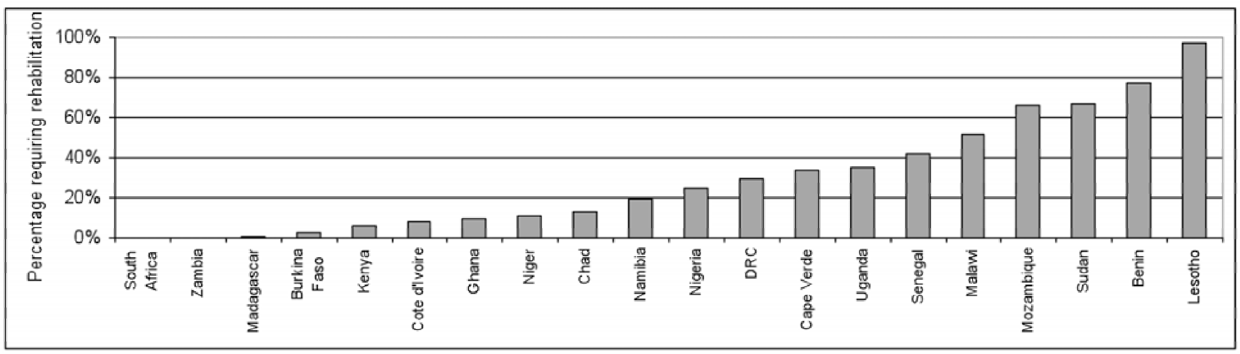
Large-scale schemes. Because of their cost and complexity, large dams are no longer built for one purpose alone. Any dam suitable for storing the large quantities of water required for large-scale irrigation will have to double as a hydroelectric power plant. Thus the reservoirs considered here for irrigation use are those identified by a companion AICD study on power sector investment needs as being economically viable for power system development within the next decade. Because these schemes are already deemed viable for hydropower generation alone, the irrigation component need not contribute to the capital cost of dam construction. In our analysis, therefore, the investment costs of large-scale irrigation development reflect only irrigation-specific infrastructure, such as distribution canals and on-farm systems. The irrigation potential of areas downstream from hydroelectric dams is evaluated according to a wide range of agro-ecological considerations.

Small-scale schemes. We examine rain-fed agricultural areas lying outside the reach of major dam projects for their suitability for small-scale irrigation projects involving soil-moisture management, supplementary irrigation, and rainwater harvesting, or small reservoirs. The potential for small-scale irrigation is assessed not only on the basis of agro-ecological conditions, but also in terms of market access, since irrigation is typically viable only if the increased yields can be readily marketed. We adopted a cut-off of five hours' travel time to select areas appropriate for the development of small-scale irrigation.

Fixing what's broken

Before considering the potential for further expansion of the region's irrigated area, however, it is important to acknowledge that rehabilitation of existing equipment is a significant issue. Of the 6 million hectares presently equipped for irrigation, approximately 1 million hectares are in need of rehabilitation. The share of irrigation-equipped area in need of rehabilitation varies dramatically across countries (figure A), from almost zero in South Africa and Madagascar to almost 100 percent in Lesotho. Of the three largest irrigating countries, Sudan is the worst off in this regard, with more than 60 percent of its 1.9 million hectares of irrigation-equipped land in need of rehabilitation.

Figure A Percentage of irrigation-equipped area requiring rehabilitation



Source: Adapted from FAO AQUASTAT.

At close to $1,900 per hectare, the cost of rehabilitation is significantly lower than the cost of developing new schemes if the costs of building a reservoir must be borne by the new scheme, but, if storage costs are already covered elsewhere (for example, by a hydroelectric project), the cost of rehabilitation is significantly greater than the incremental cost of putting new equipment in place. Final decisions on the relative costs and benefits of new versus rehabilitated systems must be made case by case. Usually, the decision will hinge on the reason why the present systems are not performing.

Large-scale schemes: lucrative but location-bound

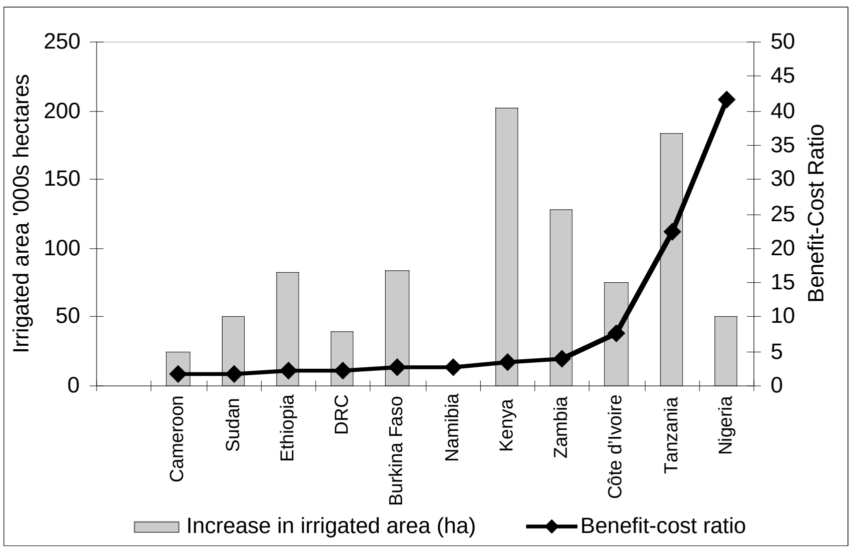
Of the 149 dams identified, irrigation development surrounding 49 existing dams and 57 planned dams would be profitable, with an increase in irrigated area of 2 million hectares, relative to the 6 million hectares that exist today. An on-farm investment cost of just $1.3 billion would generate a return of $6.8 billion (in net present value terms). Of the newly irrigated land, 0.9 million hectares would surround existing dams. The rest—1.1 million hectares—is associated with proposed reservoirs. The benefit-cost ratio of irrigation schemes linked to existing dams, at 8.9, is substantially higher than the corresponding ratio for potential dams, at 2.6.

Our baseline assumptions in making these computations include a discount rate of 12 percent, an investment cost of $1,000 per hectare, a canal-maintenance and water-delivery cost of $0.0025 per cubic meter, and on-farm annual operation and maintenance costs of $4 per hectare.

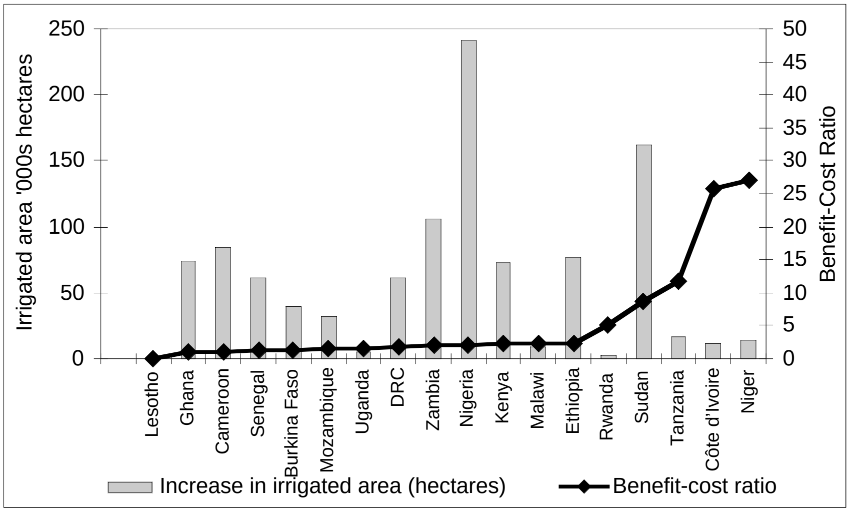
The countries with the greatest potential for large-scale irrigation based on existing dams are Kenya, Tanzania, and Zambia, with each offering between 100 and 200 thousand hectares of potential (figure B1). By far the greatest economic returns are to be found in Tanzania and Nigeria, where benefit–cost ratios are in the 20 to 40 range. Turning to schemes based on planned dams, the greatest potential in terms of surface area is found in Sudan and Nigeria, each representing between 150 and 250 thousand hectares of potential (figure B2). The highest economic returns from schemes surrounding proposed dams are seen in Côte d’Ivoire and Niger, with benefit–cost ratios are in excess of 20.

Figure B Scale and profitability of large-scale irrigation schemes surrounding existing and proposed dams

1. Existing dams



2. Planned dams



Source: Authors' calculations.

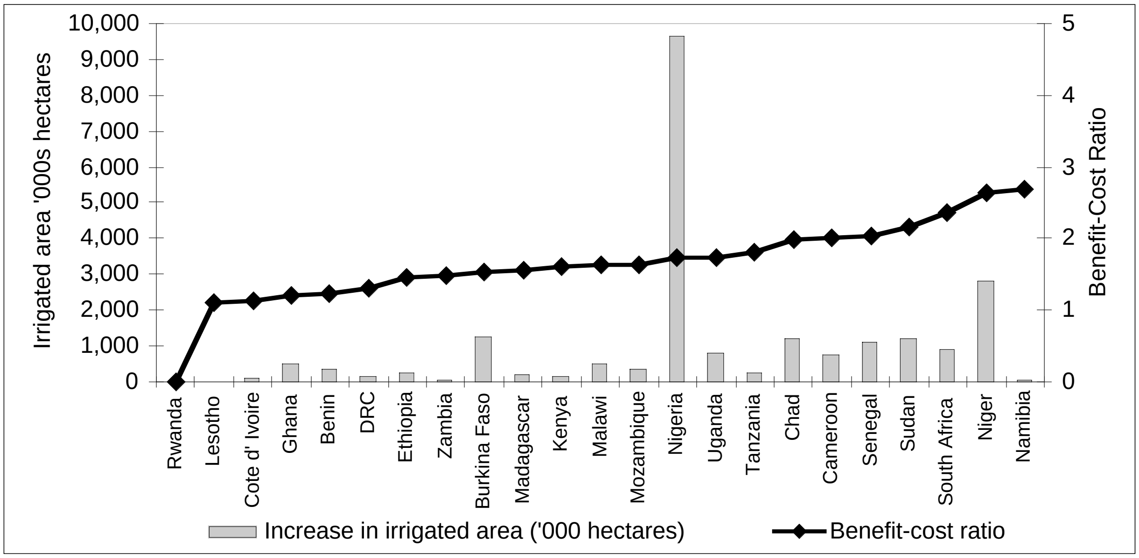
Small-scale schemes: ubiquitous but less remunerative

Some 23 million hectares of land lying within five hours' trucking time from a large city could be profitably irrigated under small-scale schemes. Almost half of that potential lies in Nigeria, with 11 million hectares (figure C). Niger comes next, with 7 million hectares, followed by a group comprising Burkina Faso, Cameroon, Chad, Senegal, South Africa, and Sudan each with 1 to 2 million hectares. The baseline assumptions underlying this conclusion include a discount rate of 12 percent, on-farm investment costs of $600 per hectare, and operations and annual maintenance costs of $25 per hectare.

The investment cost of achieving this four-fold increase over the surface area presently irrigated in the region is $35 billion, which represents an overall benefit–cost ratio of 1.9. There is relatively little variation in the ratio across countries, with the maximum being no more than 3 (far below the large multiples promised by some large-scale schemes). In all of the countries that have substantial potential for small-scale irrigation (except Burkina Faso and Nigeria), the benefit–cost ratio is just over 2.

Overall, more than 96 percent of the investments associated with viable expansion correspond to small scale rather than large scale schemes.

Figure C Scale and profitability of small-scale irrigation schemes



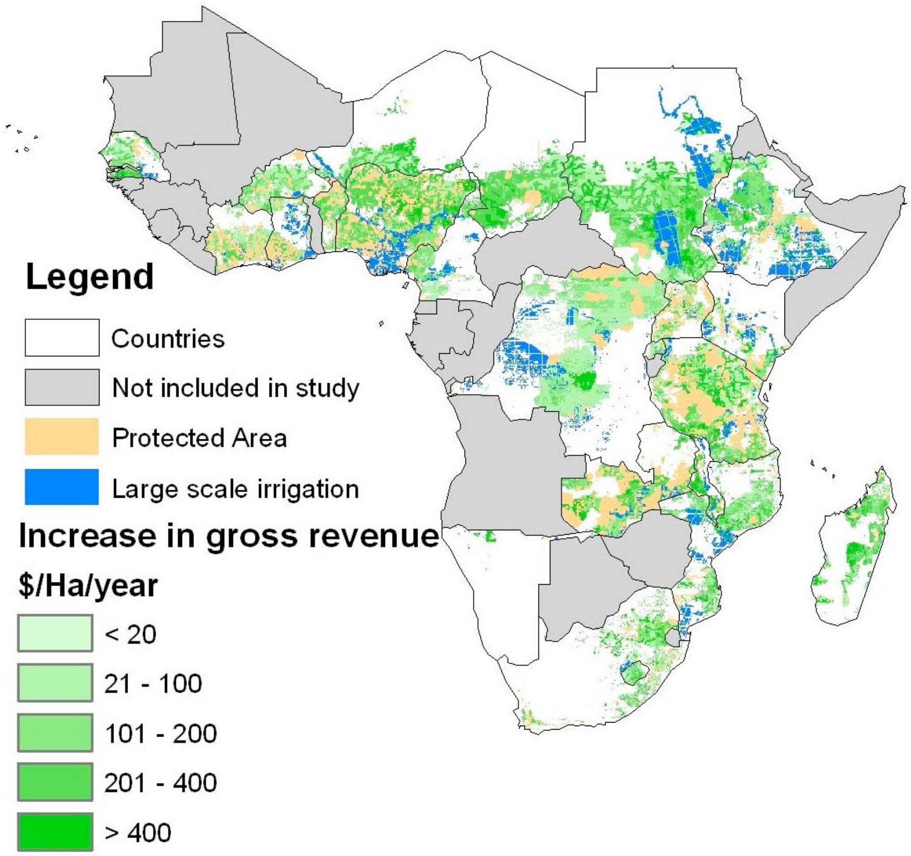
Source: Authors' calculations.

The results for large- and small-scale irrigation present a very striking contrast. On the one hand, the potential for profitable small-scale irrigation is about 10 times greater than that for large-scale irrigation, essentially because small schemes do not depend on the proximity of a large dam. On the other hand, large-scale schemes promise greater profitability. Recall that the benefit–cost ratio of large-scale schemes based on existing dams is 8.9; for large-scale schemes based on planned dams it is 2.6; and for small schemes it is just 1.9.

In terms of country potential, Nigeria stands out as having particularly great potential for both large- and small-scale schemes, particularly when planned dams are taken into account. Niger stands out as a particularly lucrative site for irrigation investments of all sizes. Otherwise, different sets of countries are attractive for large- and small-scale schemes, with East African countries such as Kenya, Tanzania, and Zambia showing significant potential for large-scale schemes and West African countries such as Burkina Faso, Chad, Cameroon, and Senegal showing significant potential for small-scale schemes.

In geographical terms, clear patterns emerge (figure D). Potential for large-scale schemes is concentrated in the Democratic Republic of Congo, Ethiopia, Nigeria, Sudan, and, to a lesser extent, in southeast Africa. Potential for small-scale schemes is particularly evident across the Sudano-Sahelian belt, and to a lesser extent in southeast Africa.

Figure D Potential increase in gross revenue per hectare from small-scale irrigation ($/ha)



Source: IFPRI, 2008.

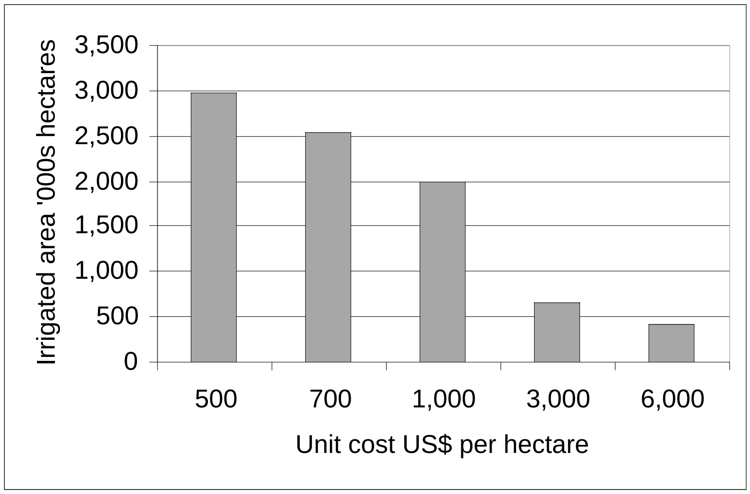
Keeping investment costs low to improve viability

The results just presented for large and small schemes alike, are sensitive to assumptions about the unit costs of their components. We conducted tests to determine the extent of that sensitivity.

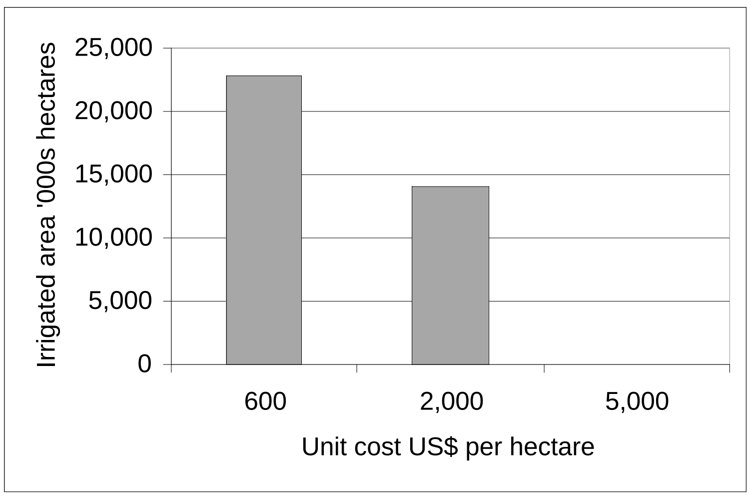
In the case of large-scale schemes, we analyzed the impact on our results of unit investment costs ranging from $500 to $6,000 per hectare. Broadly speaking, the lower values, up to and including the baseline assumption of $1,000, correspond to the incremental investment costs of developing a large-scale scheme when all or most of the costs of the dam are paid from some other source (typically hydropower revenues). The higher values, on the other hand, correspond to situations where some portion of the water-storage costs must be borne by the agricultural sector.

Figure E Sensitivity of profitable irrigated area to unit cost for irrigation investment

1. Large scale



2. Small scale



Source: Authors' calculations.

The results are dramatic (figure E1). When storage costs are excluded, the area in which irrigation would be profitable encompasses from 2 to 3 million hectares. However, if they are included, the viable area shrinks to just 500,000 hectares.

In the case of small-scale schemes, our range of possible development costs ranges from $600 to $5,000 per hectare. Once again, the lower end of the range corresponds to the simpler and more traditional forms of small-scale irrigation, whereas the higher end corresponds to more modern and capital-intensive techniques. Here the results are even more dramatic than for large scale schemes (figure E2). Whereas 23 million hectares are viable at a cost of $600 per hectare, this area shrinks to 14 million when costs rise to $2,000 per hectare. At the top of our range ($5,000 per hectare), the area that remains viable is just 2,000 hectares in South Africa.

The important conclusion is that only lower-cost technologies and approaches are viable on any significant scale in Sub-Saharan Africa.

We conducted other sensitivity tests, but none proved to be nearly as important as investment cost in determining the extent of potentially viable irrigated area.

It was not possible to perform a detailed climate-change analysis for this study, but we did test large-scale schemes for reductions in reservoir levels. Our results were consistent with those of other studies on the hydrological impact of climate change. According to our analysis, a small decrease in storage would have a modest effect on the potential for expansion of irrigated area associated with large dams. On the other hand, a 25 percent reduction in water availability would halve the size of the potential irrigable area for large-scale schemes from 2 to 1 million hectares.

From viability to affordability

So far the focus has been on measuring the area that is economically viable for irrigation. Summing the large- and small-scale expansion explored above, plus rehabilitation of existing systems, the total one-time investment need comes to more than $40 billion. That total is spread unevenly across countries, with as much as $15 billion needed Nigeria alone. In second place is Niger, with a total requirement of $4 billion. There follows a group of countries—Burkina Faso, Cameroon, Chad, Senegal, South Africa, Sudan and Uganda—whose need falls between $1 and $2 billion.

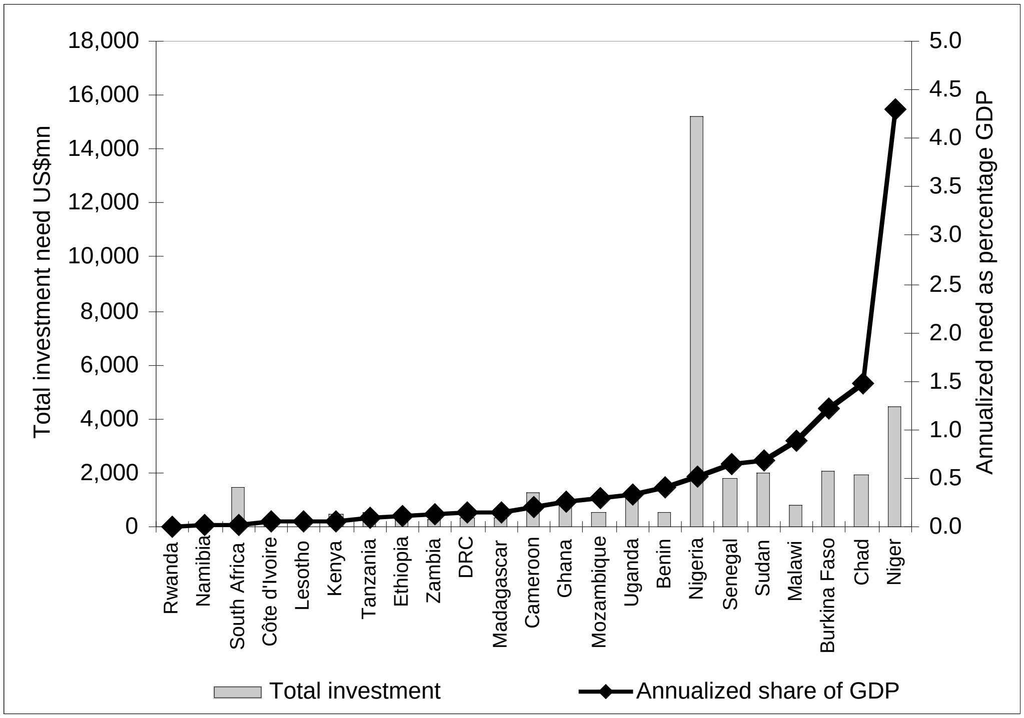
Viewed as a share of annual agricultural expenditures in the countries concerned, those amounts are substantial. With the cost of realizing countries' full irrigation potential representing from 100 to 2,200 percent of annual agricultural spending, it is unlikely that more than 10 percent of that potential will be realized for some time to come at present funding levels and patterns in the distribution of funding. On the other hand, if up to 50 percent of agricultural expenditures were diverted to agricultural water management—as in Asian countries in the 1970s and 1980s—then the region's full irrigation potential could realized over a 50-year time horizon, with two-thirds of the total achieved over the first 20 years.

By spreading investments over a 50-year horizon, however, they begin to look more affordable as a percentage of GDP. On this basis, it would be possible to keep the necessary investments below 0.4 percent of GDP in most countries (figure F). Nevertheless, Burkina Faso, Chad and Niger stand out as cases where investment needs would still exceed 1 percent of GDP even if paid in annual installments.

Another way of keeping the investments affordable would be for the donor community to provide sequenced financing reflecting certain priorities. This could be done in several ways. A purely economic approach would set priorities based on the highest benefit–cost ratios identified above, with the effort focusing on a handful of countries where the impact would be greatest. An approach driven by food security, by contrast, would target those countries that import more than half of their total cereal demand and lead to a focus on the Sudano-Sahelian region.

Boosting agricultural productivity is widely recognized as an important engine of socioeconomic development in Sub-Saharan Africa. Irrigation is an important vehicle for promoting increased productivity, provided investments in irrigation are properly targeted and accompanied by complementary improvements in other agricultural inputs. By taking a closer look at the agronomic, geographic, and economic characteristics of potential project sites with a high level of spatial disaggregation, we can gain a better understanding of the conditions under which irrigation investments will yield their full potential. The analysis presented here provides, in that sense, a first filter that helps to identify the areas of greatest potential. More detailed study of these areas is warranted to evaluate all of the other factors—institutional, agronomical, human, and environmental—that ultimately determine the success of irrigation projects at the country level.

Figure F Irrigation investment needs required to realize irrigation potential in Sub-Saharan Africa, by country



Source: Authors' calculations.