SUMMARY OF BACKGROUND PAPER 3

AFRICA INFRASTRUCTURE COUNTRY DIAGNOSTIC

Costing the Needs for Investment in ICT Infrastructure in 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 July 2009. 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. AICD grew from an idea presented at the inaugural meeting of the Infrastructure Consortium for Africa, held in London in October 2005.

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.

Connecting the continent

Costing the needs for investment in ICT infrastructure in Africa

by Rebecca Mayer, Ken Figueredo, Mike Jensen, Tim Kelly, Richard Green, and Alvaro Federico Barra

Substantial investments in information and communications technology (ICT) and related infrastructure will be made through 2015 to meet market demand for telecommunications services in 24 countries of Sub-Saharan Africa. But those investments will not be enough to attain universal coverage of the same services. In this study, we identify the disparity between what private markets can be expected to finance and what will be left to the public sector. We call that disparity the public funding gap in ICT infrastructure investment requirements.

We provide answers to three questions:

- How much investment in voice and broadband infrastructure would be required to achieve universal population coverage by 2015?
- How much investment in voice and broadband infrastructure would be required to meet market-driven demand through 2015?
- How much investment is required to improve connectivity across Africa's regions?

The needed investments are expressed both in absolute dollar amounts and as percentages of gross domestic product (GDP). Readers should bear in mind that both expressions pertain only to the 24 countries studied—not to the whole of Africa.[1] On the other hand, because the 24 countries were selected to be representative of the situation in Sub-Saharan Africa, we believe that the GDP percentages provide a indication of the ICT investment needs of the region as a whole. Our results show that the social and economic benefits of widespread use of ICTs are well within Africa's reach.

The methodologies used to estimate investment needs are different for each of the three questions addressed in the study and for voice and broadband services. The universal coverage analysis uses a newly developed spatial methodology to identify uncovered areas and to assess the potential for full commercial viability at the level of individual cell sites. The market investment forecasts are based on the anticipated number of subscribers nationwide, with subscriber increases based on historical growth trends. Readers are encouraged to refer to the full study for explanations of the different methodologies.

[1] The 24 countries covered in our study, which we refer to as the AICD countries, are Benin, Burkina Faso, Cameroon, Cape Verde, Chad, the Democratic Republic of Congo, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, South Africa, Sudan, Tanzania, Uganda, and Zambia.

Toward universal coverage of voice and broadband telecommunications

In this study we use the term universal *coverage* rather than universal *access*. A mandate for universal access reflects a political decision to establish targets for public ICT facilities, service quality, and affordability. There is no single definition of these targets. Universal coverage, on the other hand, is a more infrastructure-oriented concept that is easier to quantify across countries. In this study a country will have attained universal coverage of voice telecommunications when more than 98 percent of the population lives within range of a mobile telephone signal. Universal broadband coverage is reached when a land connection for a public broadband facility (such as an Internet café) is available within close proximity of more than 98 percent of the population.

Universal coverage is a prerequisite to universal access and may fulfill the requirements of certain countries without further investment. Once coverage is achieved, fulfilling universal access to ICT services becomes a question of achieving a social consensus on what level of services constitutes a basic right, what skills the population needs to benefit from those services, and whether the political will exists to invest public funds to bring people and services together.

Voice services

Africa already has made great strides in widening access to telephone services. Of the total population in the 24 countries we analyzed, 56.7 percent (363 million people) lived within reach of a global system for mobile communications (GSM) network as of the third quarter of 2006, leaving 43.3 percent of the population (277 million inhabitants) without access to voice telecommunications. Fully 91 percent (172.5 million) of the urban population met our stated access condition, compared with just 42 percent (190.9 million) of the rural population.

To ensure universal voice connectivity in the 24 AICD countries, and to operate and maintain that infrastructure, would require an average annual investment equivalent to 0.09 percent of the combined GDP of the 24 countries. This equates to $646.7 million each year, or a total of $5.8 billion from 2007 through 2015.

To assess the public funding gap for universal coverage, total investment must be broken out into two major categories:

- Investment in areas where full coverage is commercially viable and is likely to be funded by the private sector, given efficient and competitive markets. This gap we refer to as the *efficient-market gap.*
- Investment in areas that lack the potential for full commercial coverage—the *coverage gap.*

The coverage gap breaks down further into two economic zones:

- Those areas with enough commercial viability to support the operating costs, but not the capital costs, of ICT infrastructure. This we call the *sustainable coverage gap.*
- Those areas that lack sufficient market viability to cover either capital or operating costs—the *universal coverage gap.*

Some 39 percent (249.6 million) of the population of the 24 countries is in the efficient-market gap—that is, they live in areas where voice telecommunications are likely to be commercially viable. The remaining 4.4 percent (27.9 million) is in the coverage gap, living in areas that do not demonstrate the potential for commercial viability at this time. Nearly two-thirds of the area in the coverage gap could generate revenues sufficient to meet operating costs. This sustainable coverage gap can be closed by subsidizing capital investment. Just 1.6 percent (10.8 million) of the population is in the universal coverage gap, which would require recurrent subsidies for operation.

To close the efficient-market gap in the commercially viable areas of the 24 AICD countries, investments equivalent to 0.057 percent of GDP would be needed (table 1). In absolute terms, for the 24 countries, the amount needed is $3.5 billion—$390 million each year from 2007 through 2015. To close the coverage gap, an additional 0.037 percent of GDP would be needed, translating into $2.3 billion, or $256.7 million annually, for the 24 countries.

Table 1 Investments needed to close gaps in voice coverage in 24 AICD countries, 2007–15

	Efficient-market gap	Sustainable coverage gap	Universal coverage gap
Investment (% of GDP)	0.057	0.037	0.024
Average annual investment ($ millions)	$390	$257	$167
Total investment ($ billions)	$3.51	$2.31	$1.50
Share of population affected (%)	39	3.2	1.6

The ratio of current service coverage to the efficient-market gap and the coverage gap varies greatly by country (figure 1). South Africa has already achieved universal coverage, with just 0.02 percent of the population in the efficient-market gap, compared with 85 percent in Ethiopia. South Africa, again, has the smallest coverage gap, at 0.04 percent of the population, while the Democratic Republic of Congo has the largest, at 22.4 percent. In 20 out of 24 countries, less than 5 percent of the population lives in the coverage gap.

According to the results of our analysis, therefore, policy makers in most countries can expect that voice infrastructure will cover 95 percent of their population by 2015—*provided they promote effective competition and mobilize private sector resources*.

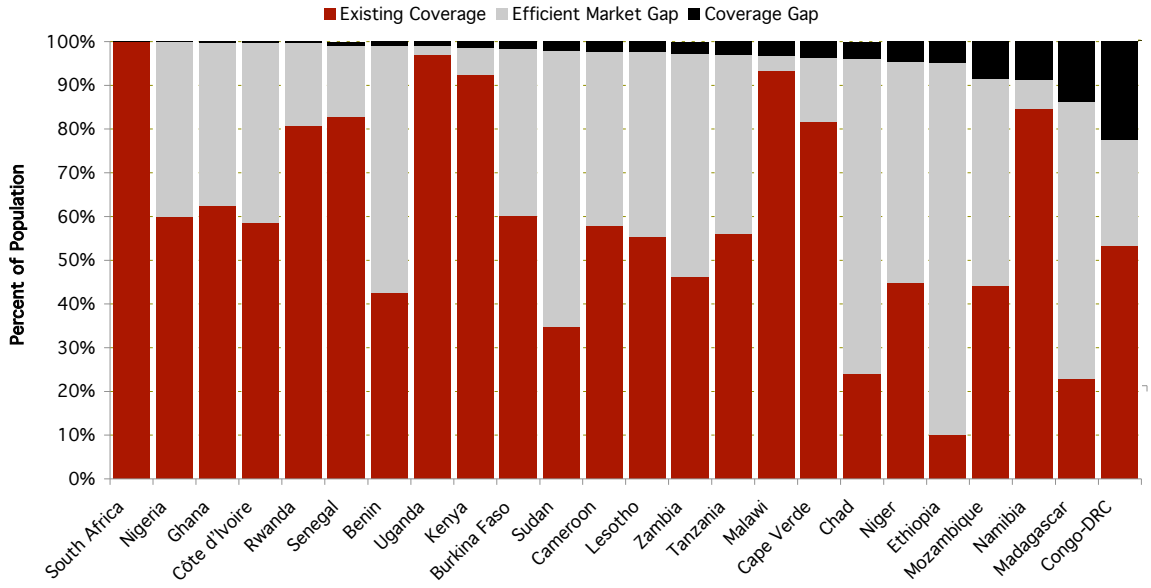
These estimates are premised on the existence of efficient and competitive markets, which cannot be taken for granted. To benefit fully from private investment in commercially viable areas, policy makers should do everything possible to enhance the efficiency and competitiveness of national and regional markets in telecommunications services. Furthermore, the infrastructure costs used to assess viability are based on rules of thumb regarding wireless network planning, and real costs may be quite different in specific locations that depart greatly from the average. These limitations of the methodology should be kept in mind. Our results are no more than *our best estimates* of the public funding gap in the 24 countries.

The spatial methodology that we used to reach these results pinpoints the areas most unlikely to be commercially viable because of their particular combination of population density (low), income (low), and terrain (steep). The most concentrated areas of nonviability are found in large,

poor countries such as the Democratic Republic of Congo, Madagascar, and Sudan (figure 2). Although the geographic areas representing the coverage gap may appear large, it is important to remember that they contain only 4.4 percent of the total population of the 24 countries studied.

Figure 1 Results of analysis of gap in voice infrastructure coverage in 24 AICD countries

Bar segments in **red** represent the percentage of the population currently covered by voice infrastructure.
Bar segments in **gray** represent the efficient-market gap— the percentage of the population for whom voice telecommunications services are commercially viable given efficient and competitive markets.
Bar segments in **black** represent the coverage gap—the percentage of the population for whom services are not viable without subsidy.



Source: Winrock International / Pyramid Research.

Note: Efficient-market gap = percentage of population living in areas where voice telecommunications services are commercially viable in efficient and competitive markets. Coverage gap = areas where services are not viable without subsidization of capital costs or capital and operating costs.

Sensitivity analyses performed on the model show that the study's main finding—that the vast majority of the uncovered population in the 24 AICD countries can be served through the operation of efficient markets—is robust. If the investment costs of voice infrastructure were three times higher than assumed in the model's baseline scenario, the coverage gap would grow from 4.4 percent to 12.7 percent of the population. More than 87 percent of the population could still be covered by the private sector in the context of efficient and competitive markets. However, the impact on the cost of serving nonviable areas would be more severe. If voice infrastructure costs tripled, the overall cost of closing the coverage gap would more than quintuple, to $12.4 billion, or 0.2 percent of GDP.

Some countries show much greater sensitivity to the model assumptions than others. This is partly because approximately one-fourth of the countries have already achieved a fairly high level of population coverage (greater than 80 percent), leaving little room for change when model parameters are varied. Population density is another factor that seems to influence sensitivity. Nigeria, with its high population density, shows very little sensitivity either to increases in

infrastructure costs or decreases in revenue assumptions. On the other hand, Mozambique, Chad, Zambia, and Madagascar all show relatively high sensitivity to changes in infrastructure costs, while the Democratic Republic of Congo and Madagascar are very sensitive to changes in revenue assumptions. In order to better inform policy debates, regulators and operators from countries that demonstrate high sensitivity to model assumptions are encouraged to produce refined estimates of this study's results by entering precise infrastructure costs and demand data into the model.

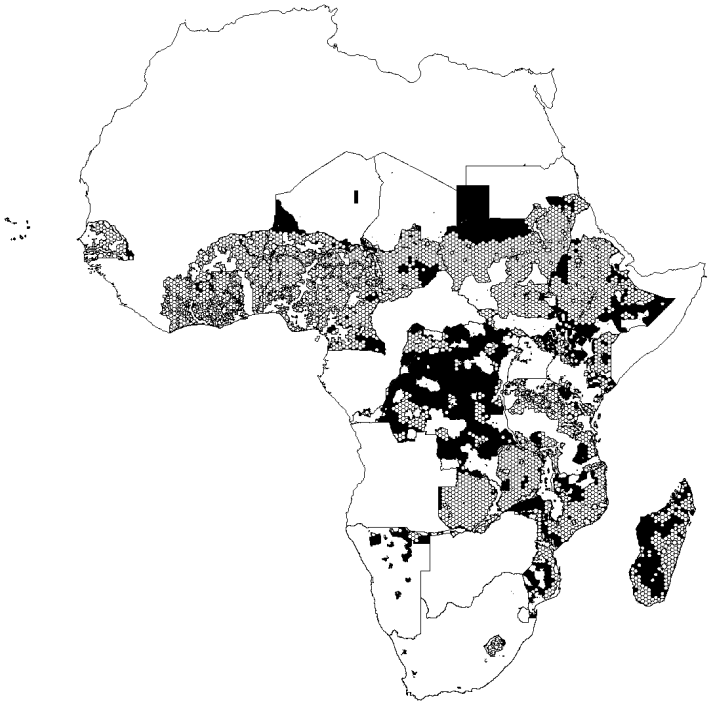
Broadband services

Mass access to nonvoice broadband services, particularly in rural areas, is largely unaffordable in most Sub-Saharan countries (at current infrastructure costs), in part because regulations do not allow broadband operators to provide voice services.

A privately funded approach to building broadband architecture that focused on businesses, wealthy households, and retail outlets for Internet services (Internet cafés and telecenters) could reach about 85 percent of the regional population. But these results vary widely by country. In the most extreme case, less than 30 percent of the population has the potential for commercial coverage (figure 3).

Figure 2 Gaps in voice infrastructure coverage caps in 24 countries of Sub-Saharan Africa

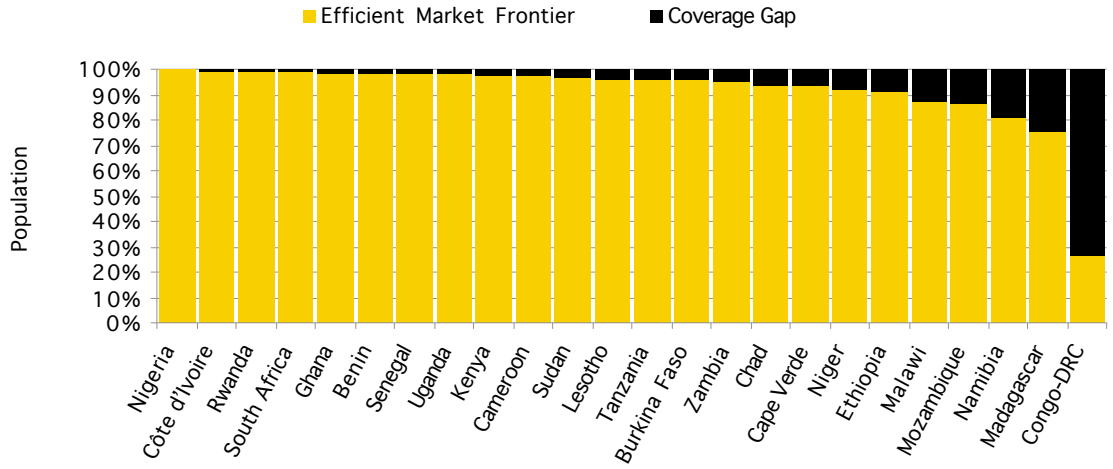
Areas in **gray** represent the efficient-market gap—voice telecommunications services are commercially viable given efficient and competitive markets.
Areas in **black** represent the coverage gap—services are not viable without subsidy.



Source: Winrock International / Pyramid Research.

Figure 3 Analysis of gaps in coverage of broadband services in 24 AICD countries

Bar segments in **gold** represent the efficient-market gap—the percentage of the population for whom voice telecommunications services are commercially viable given efficient and competitive markets.
Bar segments in **black** represent the coverage gap— the percentage of the population for whom services are not viable without subsidy.



Source: Winrock International / Pyramid Research.

To create the broadband infrastructure needed to provide universal coverage, an investment equivalent to 0.1 percent of GDP would be required through 2015—translating to $6.0 billion for the 24 countries, or an average of $752.4 million per year from 2008 through 2015. The level of investment needed to cover the efficient market—commercially viable areas only—would be about three-quarters of the universal-coverage level ($4.5 billion, or $564.5 annually, for the 24 countries). These estimates do not include the cost of computers, which could be significant, or the nonconnectivity expenses of operating Internet cafés.

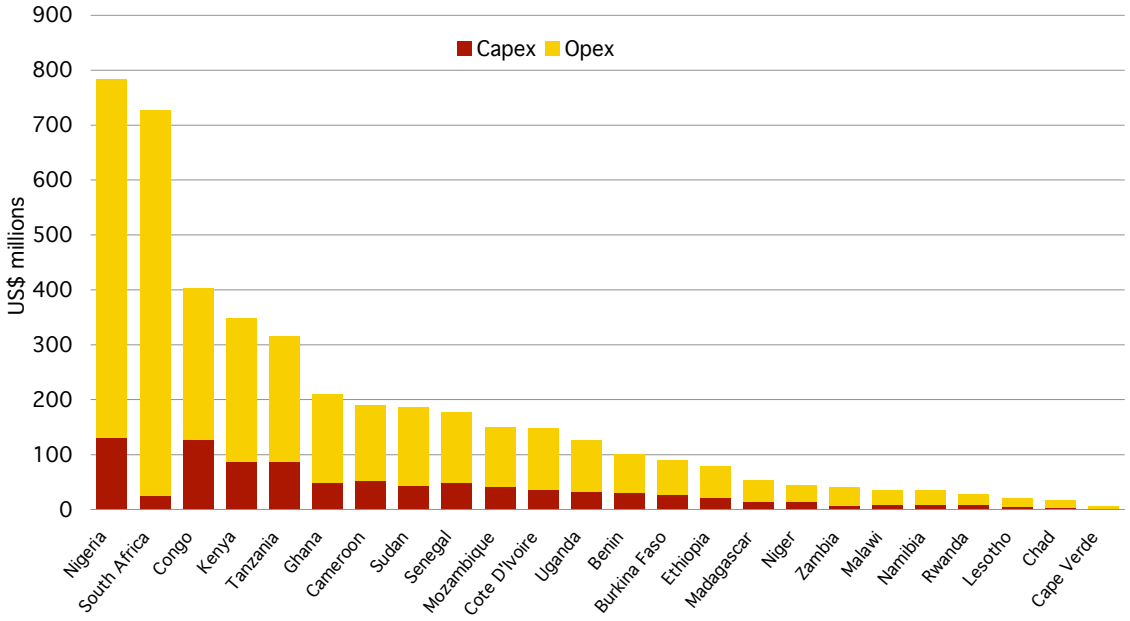
Therefore, to close the coverage gap and so extend broadband services to the 11.1 percent of the population living in areas that are not commercially viable would require public investment of $1.5 billion in the 24 countries, or $187.9 million per year from 2008 through 2015. The $1.5 billion includes $564.7 million in initial capital investment and $117.4 million in annual operating expenses. Again, these requirements exclude the cost of personal computers and the operating expenses of Internet cafés unrelated to connectivity.

Market-driven investment needs

In addition to coverage of unserved areas, significant investment is also needed to expand, maintain, operate, and upgrade the capacity of the installed infrastructure base, which presently serves more than half of the population in the 24 countries and includes most of the urban areas. Investment in urban infrastructure is largely driven by the need for increased capacity, rather than the need for wide coverage (which drives infrastructure deployment in sparsely populated areas).

Over the course of the forecast period, 2007–15, market-driven investment in voice infrastructure in the 24 countries is expected to reach $4.3 billion annually, for a total of $38.8 billion, or 0.6 percent of GDP. Of this, about one-quarter, or $909 million, will be required each year for capital expenses, with the remainder spent on operating expenses. A breakdown by country is provided in figure 4.

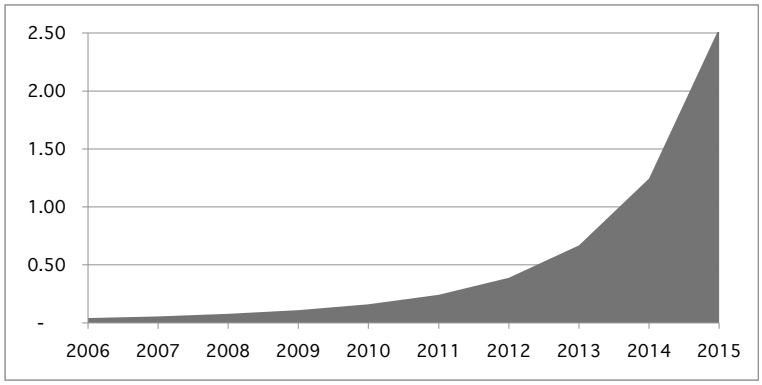
Figure 4 Average annual market-driven investment in voice infrastructure by country, 2007–15



Source: Winrock International / Pyramid Research.

Annual market-driven capital investment in broadband infrastructure in the 24 AICD countries is expected to be on the order of $314.8 million, for a total of $3.1 billion from 2006 through 2015 (or 0.05 percent of GDP). This figure is less than the one presented in the previous section mainly because it does not include operating costs, for which insufficient data are available.

Figure 5 Market-driven broadband penetration forecast for 24 countries, 2006–15



Source: Winrock International / Pyramid Research.

By the end of the forecast period, broadband penetration is expected to reach a regional level of 2.5 broadband lines per 100 inhabitants across the AICD countries—a 63-fold increase from the 2006 level of 0.04 lines per 100 inhabitants (figure 5).

The cost of regional connections

Grossly underresourced at the supranational level, Africa's communications infrastructure is sorely in need of investment—a key development challenge.

The problem reflects both poor intraregional connectivity and insufficient undersea cables connecting Africa to other areas of the world and to the rich information resources of the global Internet. The fundamental issue is to complete the network of submarine cables surrounding the continent to ensure that all coastal countries have access to the inter-continental network. At present, submarine cables exist for Western and Southern Africa although they do not yet provide full access to all countries. However, on the Eastern side of the continent, no submarine infrastructure is in place leading to exceptionally high costs of international communication. In addition, there is a need for intraregional backbones both to ensure that landlocked countries secure access to submarine infrastructure, and to facilitate communications within and across the main economic regions of Africa.

The investment requirements are relatively modest (table 2). Based on projects that have already been identified and are already underway to varying degrees, the completion of the inter-continental infrastructure would cost around US$1.8 billion, with the private sector playing a major role. Projects currently in the pipeline would probably also cover about half of the intra-regional connectivity requirements.

Table 2 Requirements for expansion in intercontinental and intraregional connectivity

	Intercontinental connectivity		Intraregional connectivity	
	Projects	Required investment (US$ millions)	Projects	Required investment (US$ millions)
East Africa	EASSy, TEAMS	260	Connect main hubs within and between subregions, and to submarine cables	51
Southern Africa	Infraco, SRII	510		117
Central Africa	Infinity, GLO-1, WAFS	1,010		75
West Africa				144
Total, Sub-Saharan Africa		1,780		387

Source: Africa Infrastructure Country Diagnostic, 2007 (preliminary findings)

For connectivity within Sub-Saharan Africa, we computed four different continental network configurations to illustrate both the range of the possible connectivity options and the associated costs. To attain a baseline throughput level of 10 gigabytes per second (Gbps), the cost envelope is 0.03 to 0.08 percent of GDP, or $229–$515 million for the 24 countries. These investment requirements are relatively modest, and most could be met by the operation of efficient markets.

At least 18 major cross-border fiber projects have been proposed throughout Sub-Saharan Africa. In the unlikely even that all of these projects were developed and put into operation, Africa would probably have the necessary infrastructure to absorb the future bandwidth demand.

But it would not ensure that Africa's carriers and the users of their services would get cheaper prices. Action—such as liberalization of international gateways—will be required to stimulate competition to avoid the shortage of affordable and high-quality services that are lacking in markets where transmission capacity is abundant but controlled by telecommunication monopolies, typically state-owned.

Without cooperation between governments (in Africa and elsewhere) and investors, however, the total cost could rise quite steeply, and the outcomes of any investment might be used inefficiently, if not wasted. Within each country, policy makers have an equally important role to play in promoting market entry through operator licensing and spectrum liberalization.

For Africa, a continent that missed out on some of the earlier rounds of infrastructure investment, it is critical not to miss out on the next round. In particular, Africa's future prosperity will depend on its level of integration with the global economy, and this will in turn depend on its connectivity. At the regional level too, as the postwar experience of Western Europe has shown, greater regional integration, promoted through trade, communication and migration, can promote economic and social development.