



COUNTRY REPORT

Sudan's Infrastructure: A Continental Perspective

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Africa's Infrastructure | *A Time for Transformation*

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About AICD and its country reports

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

The AICD is based on an unprecedented effort to collect detailed economic and technical data on African infrastructure. The project has produced a series of original reports on public expenditure, spending needs, and sector performance in each of the main infrastructure sectors, including energy, information and communication technologies, irrigation, transport, and water and sanitation. *Africa's Infrastructure—A Time for Transformation*, published by the World Bank and the Agence Française de Développement in November 2009, synthesized the most significant findings of those reports.

The focus of the AICD country reports is on benchmarking sector performance and quantifying the main financing and efficiency gaps at the country level. These reports are particularly relevant to national policy makers and development partners working on specific countries.

The AICD was commissioned by the Infrastructure Consortium for Africa following the 2005 G8 (Group of Eight) summit at Gleneagles, Scotland, which flagged the importance of scaling up donor finance for infrastructure in support of Africa's development.

The AICD's first phase focused 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, Côte d'Ivoire, the Democratic Republic of Congo, Ethiopia, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, South Africa, Sudan, Tanzania, Uganda, and Zambia. Under a second phase of the project, coverage was expanded to include as many of the remaining African countries as possible.

Consistent with the genesis of the project, the main focus is on the 48 countries south of the Sahara that face the most severe infrastructure challenges. Some components of the study also cover North African countries so as to provide a broader point of reference. Unless otherwise stated, therefore, the term "Africa" is used throughout this report as a shorthand for "Sub-Saharan Africa."

The World Bank has implemented the AICD with the guidance 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 (AfDB), the Development Bank of Southern Africa (DBSA), and major infrastructure donors.

Financing for the AICD is provided by a multidonor trust fund to which the main contributors are the United Kingdom's Department for International Development (DFID), the Public Private Infrastructure Advisory Facility (PPIAF), Agence Française de Développement (AFD), the European Commission, and Germany's Entwicklungsbank (KfW). A group of distinguished peer reviewers from policy-making and academic circles in Africa and beyond reviewed all of the major outputs of the study to ensure the technical quality of the work. The Sub-Saharan Africa Transport Policy Program and the Water and Sanitation Program provided technical support on data collection and analysis pertaining to their respective sectors.

The data underlying the AICD's reports, as well as the reports themselves, are available to the public through an interactive Web site, www.infrastructureafrica.org, that allows users to download customized data reports and perform various simulations. Many AICD outputs will appear in the World Bank's Policy Research Working Papers series.

Inquiries concerning the availability of data sets should be directed to the volume editors at the World Bank in Washington, DC.



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Synopsis

Improvements in infrastructure in all parts of Sudan in recent years have had a strong impact on per capita growth, contributing 1.7 percentage points. Consistent with trends in other countries, the information and communication (ICT) revolution that swept Africa contributed the most to Sudan. Raising the infrastructure endowment of all parts of Sudan to that of the region's best performer, Mauritius, could boost annual growth by about 3.5 percentage points.

Sudan has invested heavily in infrastructure in recent years, with some notable achievements. Power generation capacity tripled in just a few years, rising from around 800 megawatts (MW) in 2005 to 2,687 MW in 2007, with a shift toward hydropower. Nevertheless, service reliability remains an issue. In ICT, Sudan has made enormous strides in liberalizing the sector and as a result has attracted significant private capital. Mobile penetration soared from less than 1 percent in 2000 to 33 percent in 2009. Recent connectivity to an undersea fiber-optic cable has led to expansions in access, improvements in quality, and reduction in prices.

Looking ahead, Sudan's most pressing infrastructure challenges lie in the water and transport sectors.

Most of Sudan lacks access to safe sources of water. Access to sanitation is bimodal, where 40 percent of the population uses improved sanitation technologies and around 40 percent defecates in the open. Access challenges have been compounded by large inefficiencies at the water utilities. Inadequate collection of revenues, large distributional losses, and to some extent inability to recover costs have diverted over \$120 million in revenues each year.

In the transport sector, even though the road network almost doubled in length to 6,200 kilometers (km) between 2000 and 2008, a sizable share of the country lacks roads. There are a few well-developed internal corridors, but rural connectivity is almost nonexistent. Road density is exceedingly low and traffic along most roads is sparse. Poor-quality roads drastically undermine the efficiency of transport services. Further, the large volumes of unpaved roads make movement impossible during the rainy season.

Sudan's infrastructure development has so far had a national focus, and there is much that remains to be done to achieve greater regional integration. While internal road corridors are developed, connectivity with neighbors is largely absent. Sudan has a natural gateway to the sea through Port Sudan but the port's performance is severely hindered by long dwell times, high costs, and capacity constraints. Looking further ahead, Sudan has the potential to be a major hydropower exporter if additional capacity could be developed and transmission links with neighboring Nile Basin countries strengthened.

Addressing Sudan's infrastructure challenges will require sustained expenditure of almost \$4.2 billion per year over the next decade, mainly for capital investments. In terms of the size of the economy that level of infrastructure needs is equivalent to just over 20 percent of gross domestic product (GDP). Not unthinkable of, as it is comparable to the 15 percent of GDP China has been investing in recent years on infrastructure. Yet, it is an ambitious target for Sudan as it would represent almost tripling the recently observed annual average of infrastructure spending (about 7 percent of GDP). Water and transport account for 80 percent of the spending needs.

Sudan already spends approximately \$1.5 billion per year on infrastructure, equivalent to about 6 percent of its GDP. Two-thirds of Sudan's spending consists of investment, with Chinese funds accounting for 40 percent of investment finance. Private investment in Sudanese infrastructure is also significant, at 23 percent of the total, while official development assistance (ODA) is negligible. In contrast to its peers, Sudan's capital spending on infrastructure is strongly skewed toward the power sector.

A further \$580 million a year (equivalent to 2.7 percent of GDP) is wasted due to inefficiencies, largely due to mispricing of power. Over 80 percent of these inefficiencies derive from the power sector. Electricity is currently priced at 50 percent of its cost-recovery threshold, leading to losses worth \$378 million annually. The mispricing of power results in inefficiencies on the order of \$380 million for the utility, while distribution losses are worth \$106 million annually.

Sudan's annual infrastructure funding gap is \$2.9 billion per year, equivalent to almost 14 percent of its GDP. Most of the funding gap is associated with the water and transport sectors, each of which is more than \$1 billion short of resources. But these gaps could each be reduced by half by judicious choice of lower-cost technologies for water and sanitation services and road surfacing. No funding gap is found for power, due to the relatively high level of spending in recent years and the magnitude of inefficiencies that could be captured to bolster sector finances.

To bridge the funding gap, Sudan could build on its existing success in capturing infrastructure finance both from China and the private sector. Sudan has done quite well in attracting about 1 percent of GDP in private investment for infrastructure; but a number of other African peers have done even better, capturing two to three times as much in proportional terms. Nevertheless, the largest funding gaps in transport and water may be less amenable to private finance. One option would be for Sudan to draw increasingly on its Chinese and Arab partners to support transport and water investments, and allow the private sector to play a larger role in the power sector, where it has not been active to date. Nevertheless, the funding gap remains substantial relative to the Sudanese economy.

The continental perspective

The Africa Infrastructure Country Diagnostic (AICD) has gathered and analyzed extensive data on infrastructure in more than 40 Sub-Saharan countries, including Sudan. The results have been presented in reports covering different areas of infrastructure—ICT, irrigation, power, transport, and water and sanitation—and different policy areas, including investment needs, fiscal costs, and sector performance.

This report presents the key AICD findings for Sudan, allowing the country's infrastructure situation to be benchmarked against that of its African peers. Sudan is a relatively well-off low-income state richly endowed with oil; therefore, both low-income and resource-rich benchmarks will be used to evaluate its performance. Detailed comparisons will also be made with immediate regional neighbors in the East African Community (EAC) and with countries in North Africa in some cases.

Several methodological issues should be borne in mind. First, because of the cross-country nature of data collection, a time lag is inevitable. The period covered by the AICD runs from 2001 to 2006. Most technical data presented are for 2006–07 (or the most recent year available), while financial data are

typically averaged over the available period to smooth out the effect of short-term fluctuations. Second, to make comparisons across countries, the indicators and analysis were standardized so that everything was done on a consistent basis. This means that some of the indicators presented here may be slightly different from those that are routinely reported and discussed at the country level. Third, in terms of nomenclature, *all parts of Sudan* refers to Sudan prior to the split of the country, *Sudan* refers to the northern part of Sudan, and *South Sudan* is the newly independent country. Fourth, data for Sudan and South Sudan were originally collected and processed for the country as a whole, that is, all parts of Sudan. But given recent geopolitical events, including the seceding of South Sudan from the rest of the country, and the vast differences between Sudan and South Sudan in terms of topography, infrastructure, and financial resources, this report presents analyses and results that reflect the situation in Sudan as much as possible. In a few cases, this involves relying on imperfect data and using proxy variables to attribute otherwise global estimates.

Why infrastructure matters

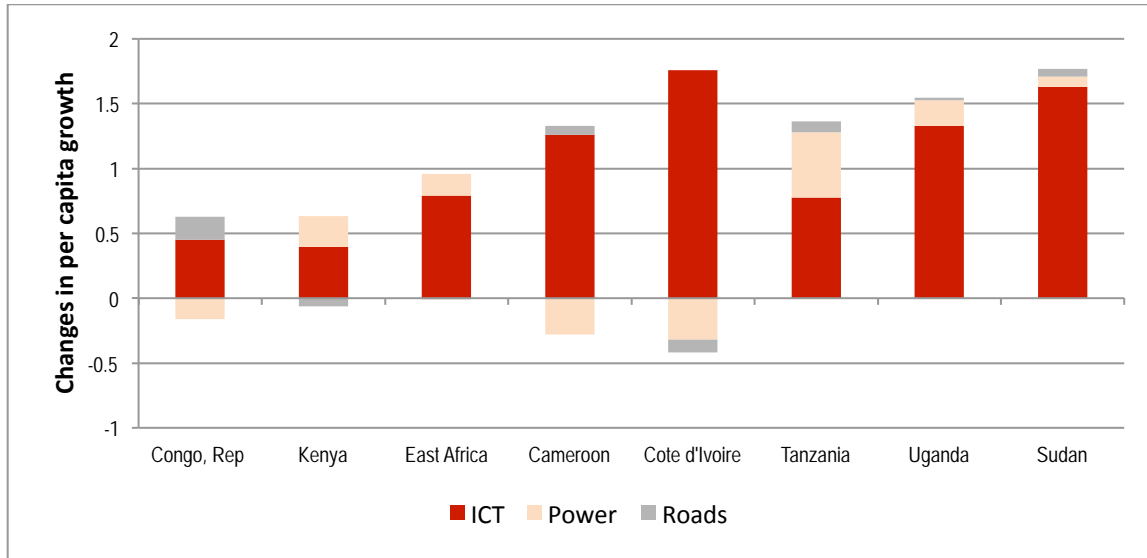
The recent schism of *all parts of Sudan* into Sudan and South Sudan will have massive impacts on the Sudanese economy. For one, the splitting of oil assets that are mostly in South Sudan will impact Sudan's overall resource revenues in the coming years.

The economy for all parts of Sudan grew at the rate of 6 percent per capita between 2003 and 2007. Its growth was more robust than that of several of its East African peers, who grew at 4 percent per capita during the same period.¹ The advent of an oil-based economy in Sudan was the harbinger of robust growth between 2000 and 2008. Oil constituted around 90 percent of Sudanese exports and was driven by oil production in South Sudan. Oil resources enabled the government to roll out new physical and social infrastructure, focused primarily on the northern part of the country. There was an increase in the volume of transportation between Khartoum, where economic activity has been concentrated, and Port Sudan, the coastal gateway for imports and exports.

Empirical evidence linking infrastructure to recent economic growth patterns documents how the allocation of oil wealth to infrastructure development has impacted the economy. Between the 1990s and early 2000s, all parts of Sudan reaped large growth benefits in infrastructure development. Infrastructure contributed over 1.75 percentage points to all parts of Sudan's per capita growth (figure 1a). The ICT sector made the strongest impact on growth. The road and power sectors made modest contributions in contrast to other countries, where inadequate power infrastructure had a negative effect on growth. Since most of the improvements in the ICT sector were recorded in Sudan and very little in South Sudan, it is reasonable to expect that the largest gains in growth came through contributions from the ICT sector in Sudan.

¹ The growth represented is based on GDP per capita (constant 2000\$). The East African peers are Burundi, Ethiopia, Djibouti, Kenya, Rwanda, Tanzania, and Uganda.

Figure 1a. Infrastructure's historic contribution to economic growth, 1990–95 vs 2000–05

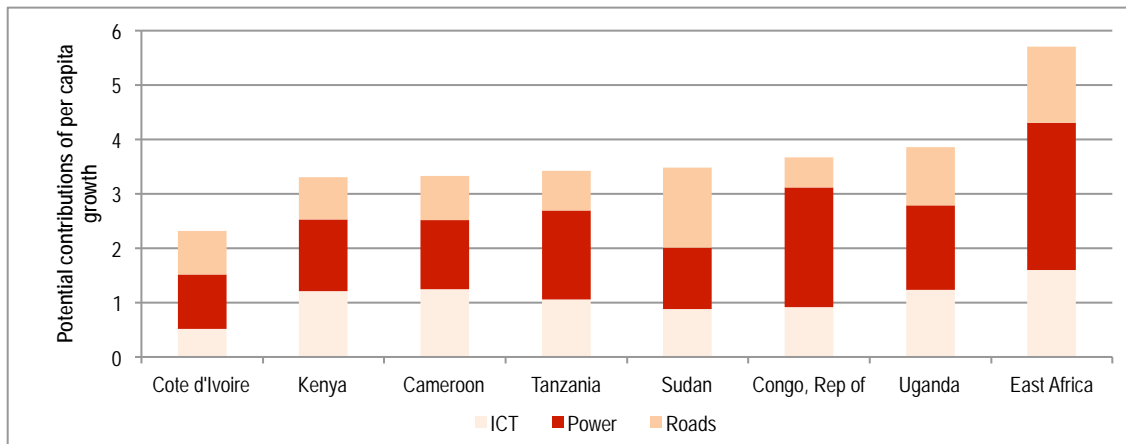


Source: Calderón 2009.

Note: ICT = information and communication technology.

Infrastructure could contribute more to all parts of Sudan's infrastructure in the future than it has in the past (figure 1b). Simulations suggest that if Sudan's infrastructure were to be upgraded to the level of the best-performing country in Africa (Mauritius), the impact on per capita economic growth would be on the order of 3.5 percentage points. While all areas of infrastructure—ICT, power, and transport—need to be upgraded, improvements in roads can impact growth the most—by around 1.5 percent. Improvements in power infrastructure will add another 1 percent to per capita growth. Infrastructure's immediate potential contribution to growth is less than it is in several other East African countries.

Figure 1b. Infrastructure's potential future contribution to economic growth



Source: Calderón 2009.

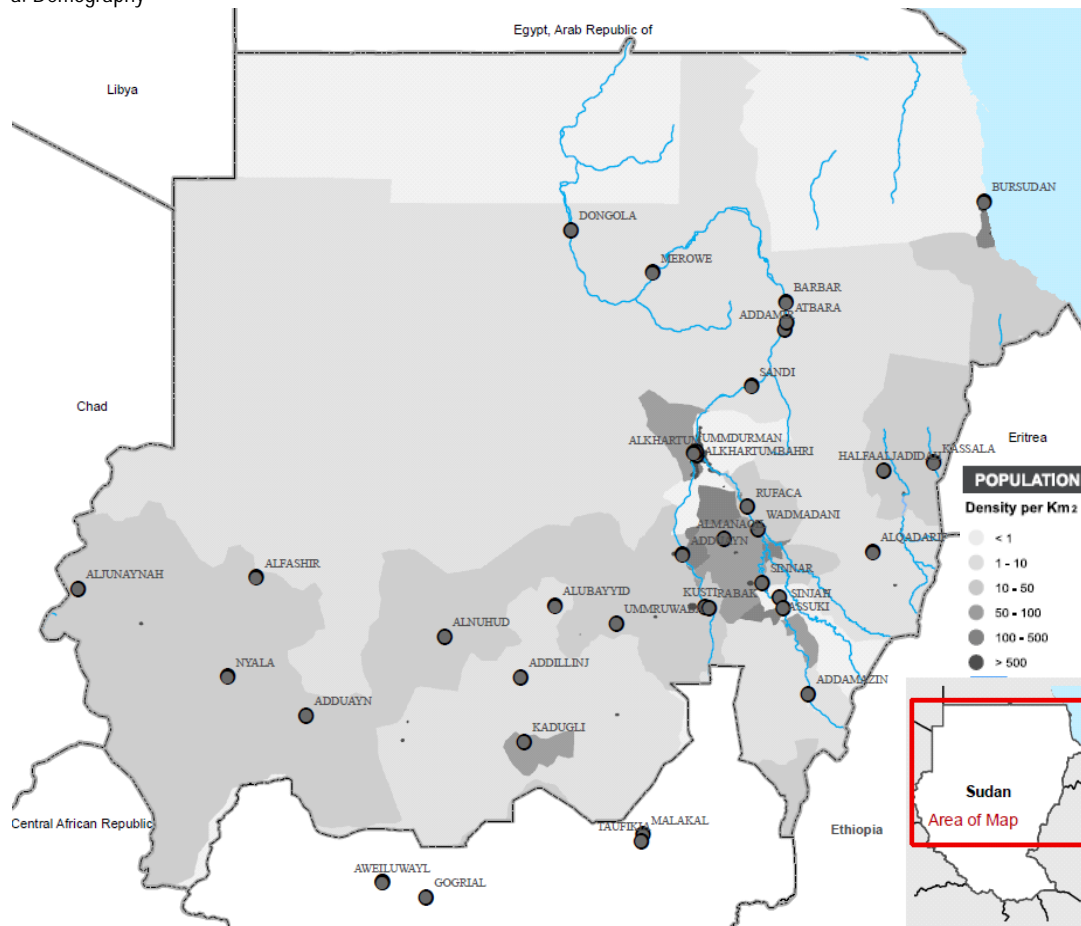
Note: ICT = information and communication technology.

The state of Sudan's infrastructure

The spatial distribution of Sudan's economy shows a sparse population with pockets of economic activity around a few urban centers. There is a heavier concentration of activity and population along the Nile (figure 2a). The topography of Sudan is divided into three regions—the deserts, the semi-arid Sahel region, and the wetlands and rain forests. The deserts in the north—the Nubian Desert to the east of the Nile, the Libyan Desert, and the rugged uplands to the northwest of the Nile—comprise around 30 percent of the area of Sudan. Central Sudan is characterized by the semi-arid Sahel region of steppes and low mountains. Southern Sudan has vast wetlands in the upper Nile region that are among the largest in the world. The Nile spans a vast length of Sudan's territory. The tributaries of the Nile—the White Nile and Blue Nile—meet in Khartoum in the north. The White Nile crosses South Sudan from the Ugandan border, while the Blue Nile flows through east and central Sudan, irrigating a large part of the Sudanese land (figure 2b). Sudan is endowed with significant natural resource wealth in the form of metals and oil. There is one oilfield along the Red Sea in the north and another closer to the border of South Sudan (figure 2c).

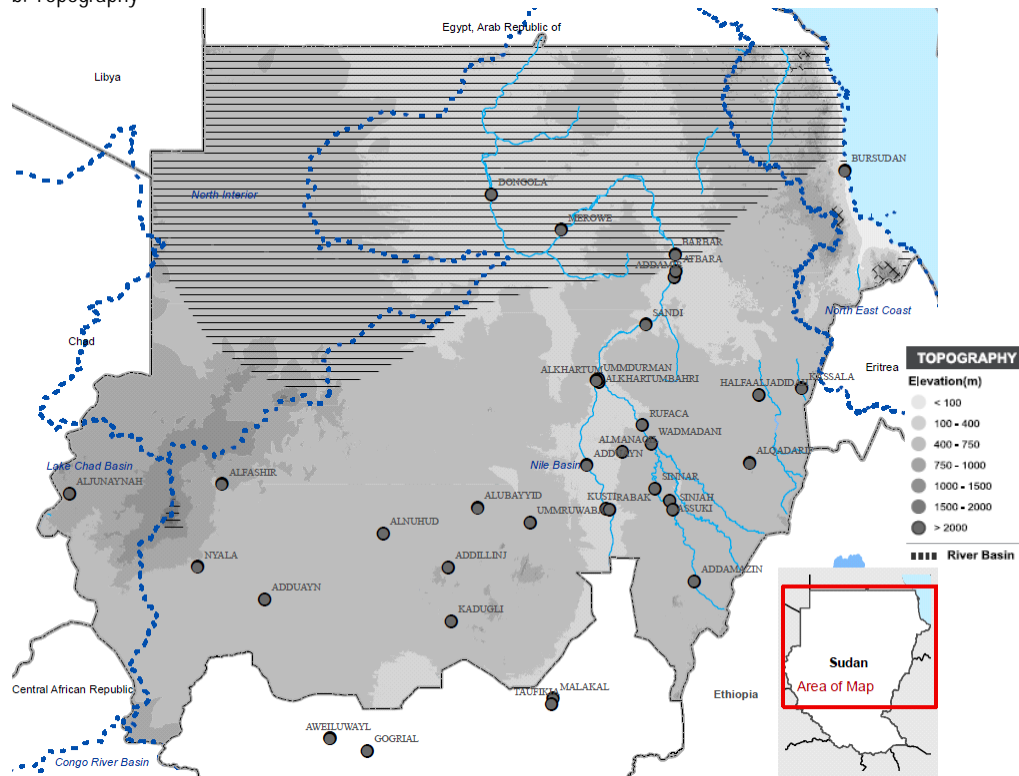
Figure 2. The demography, topography, and natural resources of all parts of Sudan

a. Demography

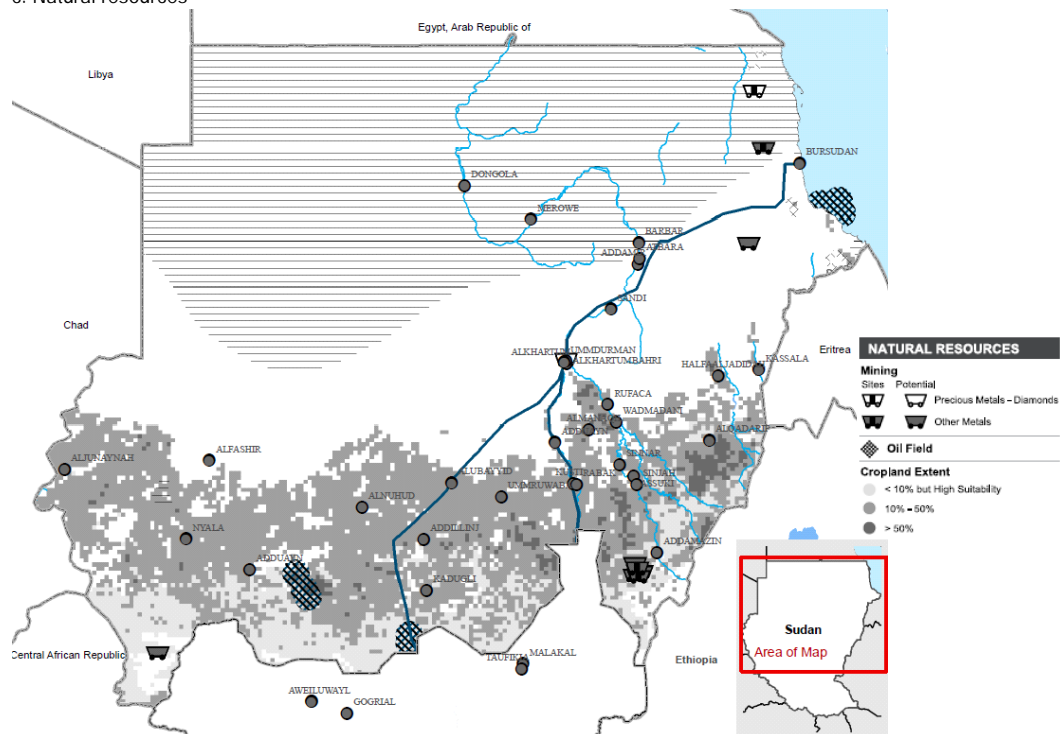


SUDAN'S INFRASTRUCTURE: A CONTINENTAL PERSPECTIVE

b. Topography



c. Natural resources



Source: AICD.

Note: The topography information is derived from www.imcg.net/gpd/africa/sudan.pdf.

Road density in Sudan is among the lowest in Africa and the world. The existing road arteries are centered on Khartoum as the hub. One artery connects Khartoum with the coastal gateway of Port Sudan, a second connects Sudan with Egypt and North Africa, a third connects Khartoum with the Eritrean border, and a fourth leads to Ethiopia. Connections to South Sudan are fragmented; there is little traffic overall. In fact, along most of the networks, except between the Red Sea and Khartoum, traffic is sparse and road conditions patchy at best.

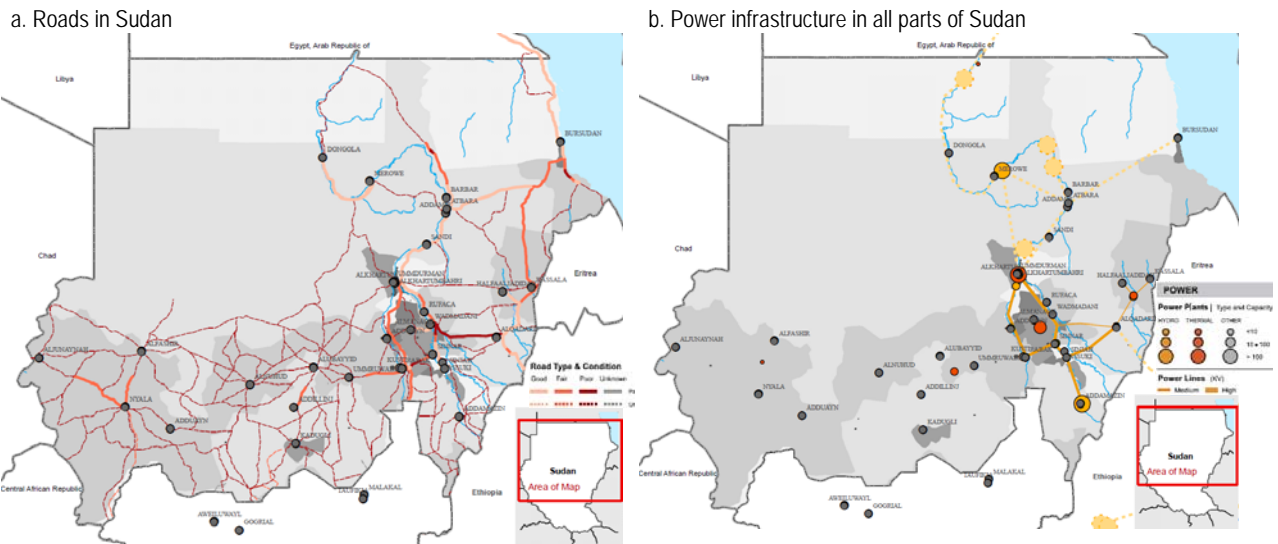
Power infrastructure is developed only around select urban centers. A national grid is nonexistent, and there are no cross-border interconnectors. Power infrastructure is primarily focused on hydropower, with some thermal generation capacity. In recent years Sudan has benefitted from an increase in capacity, but there is an even greater hydropower potential that can be exploited (figure 3b).

Sudan is naturally endowed to be a large producer and exporter of agricultural products. It is a riparian country, its fertile soil centered on the Nile, and areas of high suitability can be better exploited (figure 3c).

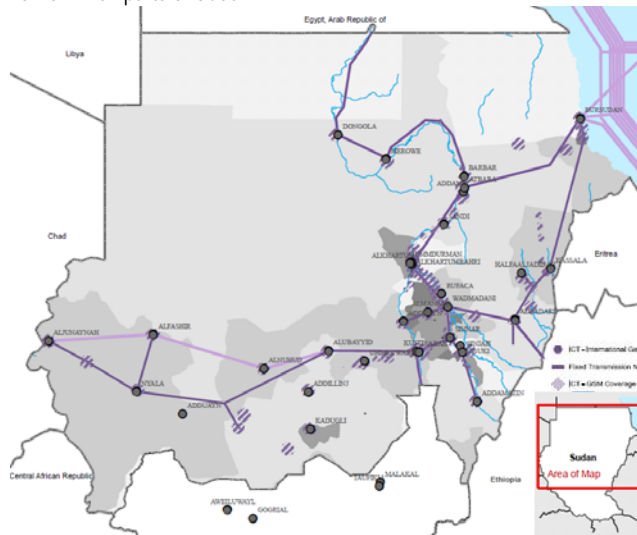
The bright spot of Sudan's infrastructure is the ICT sector. ICT growth has accelerated and is comparable to regional averages. Mobile subscriptions have grown exponentially, and Sudan boasts of one of the most liberalized ICT markets in Africa, with a strong multinational presence. It is also relatively well endowed with fiber-optic connectivity to several undersea cables (figure 3d).

This report begins by reviewing the main achievements and challenges of each of Sudan's major infrastructure sectors (table 1). Thereafter, attention will turn to the problem of how to finance the outstanding infrastructure needs.

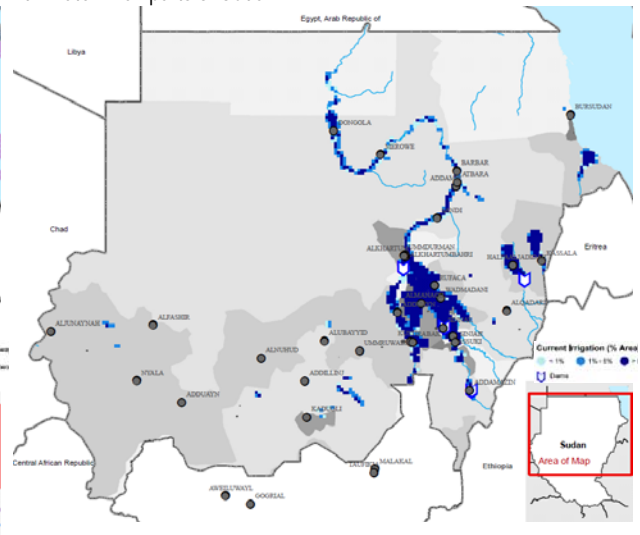
Figure 3. Development of the regional infrastructure backbone and national backbones in Sudan



c. ICT in all parts of Sudan



d. Water in all parts of Sudan



Source: AICD.

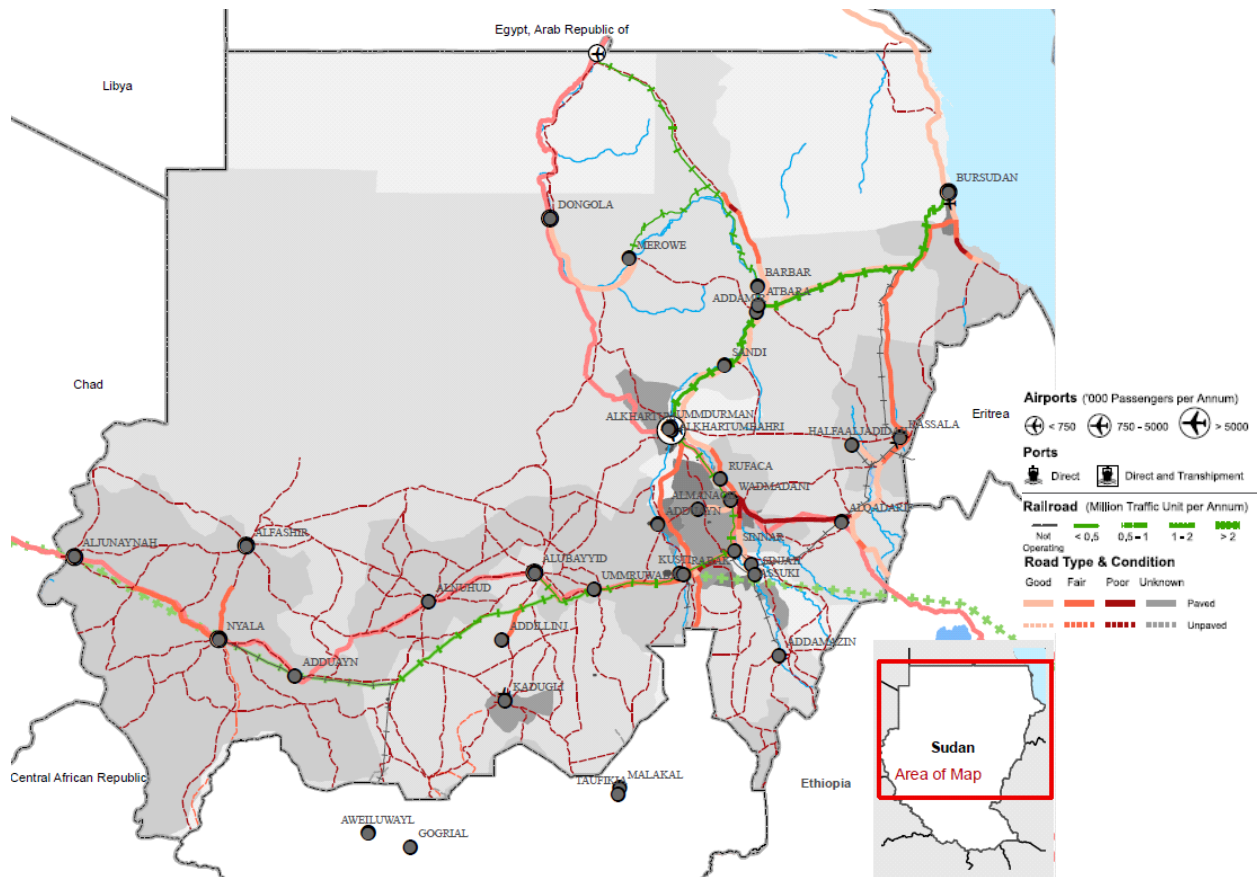
Table 1. Achievements and challenges in Sudan's infrastructure sectors

Sector	Achievements	Challenges
Air transport	Strong international gateway in Sudan, with increasing traffic between Sudan and South Sudan. Per capita seats are higher than neighbors. Good connectivity with the Middle East, Europe, and Ethiopia.	Raising air safety standards; increasing government oversight in air transport.
Energy	Strong increase in installed capacity in Sudan between 2005 and 2009. Increasing reliance on hydropower. High reliance on modern fuels for cooking. Moderate tariffs for power. Strong record in collection of bills.	Increasing the volume, reliability, and quality of electricity supply; tackling underpricing of services in the power utility to achieve cost recovery; reducing large system losses.
Information and communication technology (ICT)	Impressive increase in mobile penetration across the country. Tariffs compare favorably with African peers. Sudan has among the most liberalized telecom markets in Africa. Established regional infrastructure backbone for ICT with connection to undersea fiber-optic cables.	Expanding the Internet bandwidth from existing low levels; increasing the limited landline penetration.
Ports	Increase in traffic in Port Sudan. Port authority has generated significant revenues and has used these funds for port infrastructure upgrades. Port Sudan becoming a feeder port.	Reducing the long dwell times and truck cycle times at Port Sudan; tackling high handling charges at Port Sudan; minimizing port-congestion-related delays and challenges.
Roads	Increase in kilometers of road in the period 2000–08. Some good-quality roads connect major urban centers.	Improving quality of roads; connecting rural areas with national road network; enhancing efficiency of transport services; raising institutional capacity in road sector.
Surface transport	Lower freight tariffs charges compared to several African peers because of a competitive trucking industry and lower petroleum prices. Internal corridors are relatively well developed.	Enhancing road connectivity with neighbors; lowering high costs and long transit times associated with moving freight in and out of Sudan.
Water and sanitation		Boosting access to improved water and sanitation sources; reducing open defecation and reliance on surface water; attaining cost recovery for the water utility; tackling large distributional losses for utilities and improving collection of bills.

Source: Summary based on analysis presented in this report.

Transport

Figure 4. National and regional transport network in all parts of Sudan

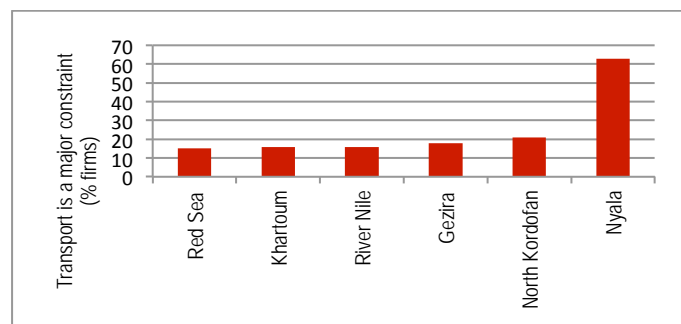


Source: AICD.

Multimodal transport

Sudan's transport infrastructure is unevenly developed. Despite a few road corridors, a large share of Sudan is unconnected or lacks paved roads. The networks consist of nearly 2,500 miles of single-track railroad with a feeder line (supplemented with limited river steamers) of about 1,200 miles of paved and gravel road—primarily in greater Khartoum and Port Sudan. In addition some roads in the north-south direction have been built, as well as an oil pipeline that is 840 miles long and runs from the oilfields in the Nuba Mountains and Khartoum to Port Sudan on the Red Sea

Figure 5. Transport poses an obstacle to business in some areas of Sudan



Source: World Bank 2009b.

Around 22 percent of firms indicated that transport is a major obstacle to business activity, with challenges more acute in some areas than others. A sizable share of establishments in Sudan used their own transport facilities. The average share of own-transport use ranged from 35 percent of the total value of production-related transport activities within the country in Khartoum to 17 percent in North Kordofan. Nyala Red Sea (with 26 percent) and Gezira (with 25 percent) also registered a high rate of own-transport use. Transport in Nyala (Darfur region), meanwhile, was cited as a constraint on doing business by around 60 percent of the firms based there.

The main internal corridors in Sudan are well developed and generally in good condition but do not extend to provide cross-border connectivity with neighbors (see figure 4). The trading artery in Sudan is the route that connects Kosti to Port Sudan via Khartoum. This road records the greatest traffic volumes in Sudan and boasts overall good-quality roads, particularly from Khartoum to Port Sudan. Another corridor connects Sudan to the Djibouti Corridor offering connectivity to the Port of Djibouti and Addis Ababa. While systematic data on these routes are not available, traffic volumes from Sudan along this corridor are expected to be very low, and the quality of roads range from fair to poor. Connectivity with South Sudan is practically nonexistent and was never a strategic priority. The regional corridor connecting to South Sudan is in bad condition and records very low traffic volumes. During the rainy season (April/May to October/November), a majority of the roads particularly in South Sudan are impenetrable.

Sudan records average performance by African standards but poor performance when compared to global standards. Along some of the internal transport routes, surface transport moves at a pace that ranges from 8.5 kilometers per hour (kmph)² to over 13 kmph,³ comparable to East Africa; in the parts less travelled and with poorer-quality roads, velocity is consistent with central African countries (table 2). Overall, freight in Sudan moves at the pace of a horse and buggy.

Table 2. Benchmarking Sudan's national network against African aggregates for regional corridors

Corridor	Road in good condition (%)	Implicit velocity (km per hour)	Freight tariff (US cents per tonne-km)
Western	72	6	8
Central	49	6.1	13
Eastern	82	8.1	7
Southern	100	11.6	5
Sudan	26	8.5–13.5	8–10
South Sudan	0	6.4	20

Source: Teravaninthorn and Raballand 2009; Nathan 2010; UNLJC and FAO 2005; Yoshino 2010; World Bank staff estimates

Note: Estimates for Sudan based on routes from Khartoum to Kosti and Khartoum to Port Sudan. For South Sudan, costs are based on varying estimates for travel between Juba to Nimule. Implicit velocity is the total distance divided by the total time taken to make the trip, including time spent stationary at ports, border crossings, and other stops.

Table 3. Time and costs associated with transport within Sudan

Route	Mode of transport	Time (days)	Implicit velocity
Khartoum–Malakal	Road and river	7	4.7
	Road	5	6.7
Khartoum–Juba	Road and river	13.5	6.3
	Road	7.5	11.4

Source: AICD calculations based on data from Yoshino and others (2009), UNLJC and FAO (2005), and Keer- MISC (2007).

² This is the estimated velocity of traffic between Khartoum to Kosti.

³ This is the estimated velocity of traffic between Khartoum and Port Sudan.

Poor road transport connectivity between Sudan and South Sudan requires the use of multimodal transport during half the year and is associated with lengthy transit times. Roads, particularly during the rainy season, are often unavailable. Relying on other forms of transport does not solve the problem: river transport services are not well developed, ports are inadequate, and commercial vessels are old. Freight that has to move via river takes six days longer than if it were to travel only by road (table 3). Services are limited between Juba and Kosti, and are used mainly for transporting goods arriving by train in Port Sudan.

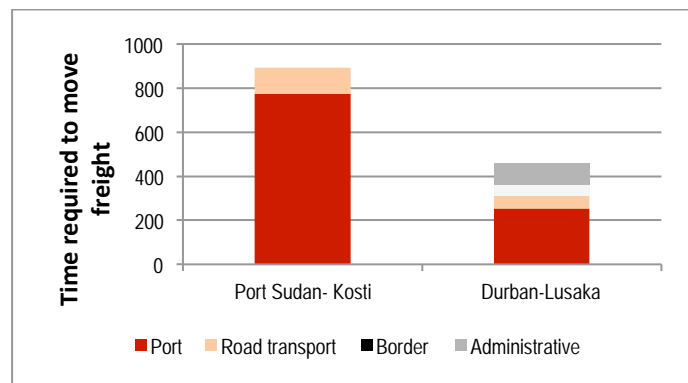
The cost of moving freight in Sudan is almost twice what it is on other continents, though it compares with the average for Africa. The average freight tariff between Khartoum and Port Sudan is about \$0.08 per tonne-kilometer (tonne-km), and between Khartoum and Kosti is slightly higher, an average of \$0.10 per tonne-km. These prices are comparable to that of East Africa but much higher than the global standard of around \$0.04 per tonne-km.

The middle-of-the-range costs of moving freight—relative to the African average—are driven by the competitiveness of the trucking industry and access to lower-priced petroleum. In Sudan the trucking industry appears competitive, with few barriers to entry. Growth in the trucking fleet was steady during 2004–06: 10 percent annually for lorries, 20 percent for tank trucks, and over 40 percent for dry-cargo heavy trucks. Additionally, the trucking sector is not cartelized as it is in West and Central Africa. Absence of cartels keeps profit margins reasonable without significant markups. Further, the low cost of petroleum, oil, and lubricants in Sudan—50 percent lower than the regional aggregate—helps maintain reasonable prices.

Trucks travelling to South Sudan, however, may encounter various transport bottlenecks that increase costs. For example, one truck transporting sacks of onions from Kassala to Malakal was subject to taxes and fee payments at about 20 different locations, totaling 2,000 SDG (\$800) (Yoshino 2009). Similar payments have not been reported while travelling within Sudan.

Moving freight in Sudan is constrained by inadequate infrastructure and high costs. Comparing the competitiveness of Sudan’s main trading artery (Port Sudan to Kosti) with Africa’s best-performing corridor (the North-South corridor) reveals that there are significantly more costs and longer delays associated with moving along Sudan’s arteries (figures 6 and 7). Moving freight within Sudan takes longer than moving imports from Durban to Lusaka—a route across three countries that is 800 km longer.

Figure 6. Moving freight within Sudan vs. moving imports from Durban to Lusaka



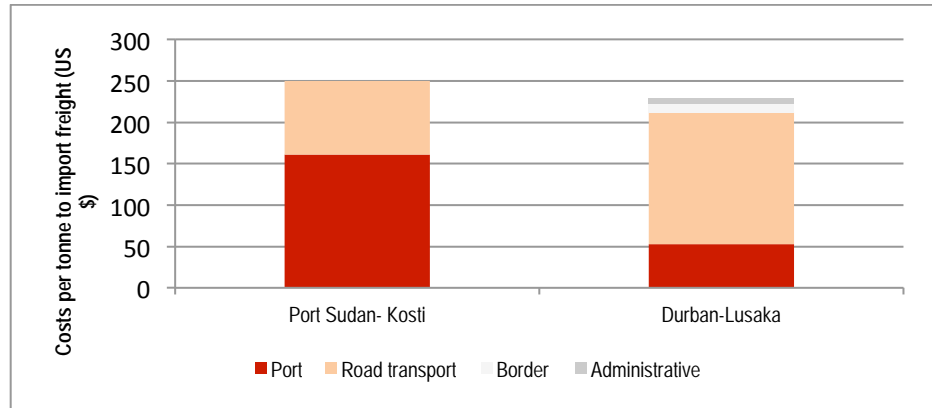
Source: AICD calculations based on Nathan (2010); UNLJC and FAO (2005), and Yoshino (2010).

Transit times can be broken down into four components: the travel times of moving goods, that is, the time of travel based on the effective velocity along each corridor; administrative time spent importing

goods to a country; port time, that is, the time taken to clear goods at ports; and border time, that is, the delays incurred in crossing borders. Transport costs are based on unit costs of moving freight along specific corridors, whereas administrative costs are based on costs involved in transporting imports into a country. Port and border delays were quantified into costs based on the assumption that delays cost \$5 per day per tonne of imports.

Port-related delays are the primary reason why it takes 18 days longer to move freight from Port Sudan to Kosti than from Durban to Lusaka, a route that is 800 km longer and spans three countries. The time required to move freight within Sudan does not include border-related delays

Figure 7. Expense of moving freight within Sudan and across southern Africa



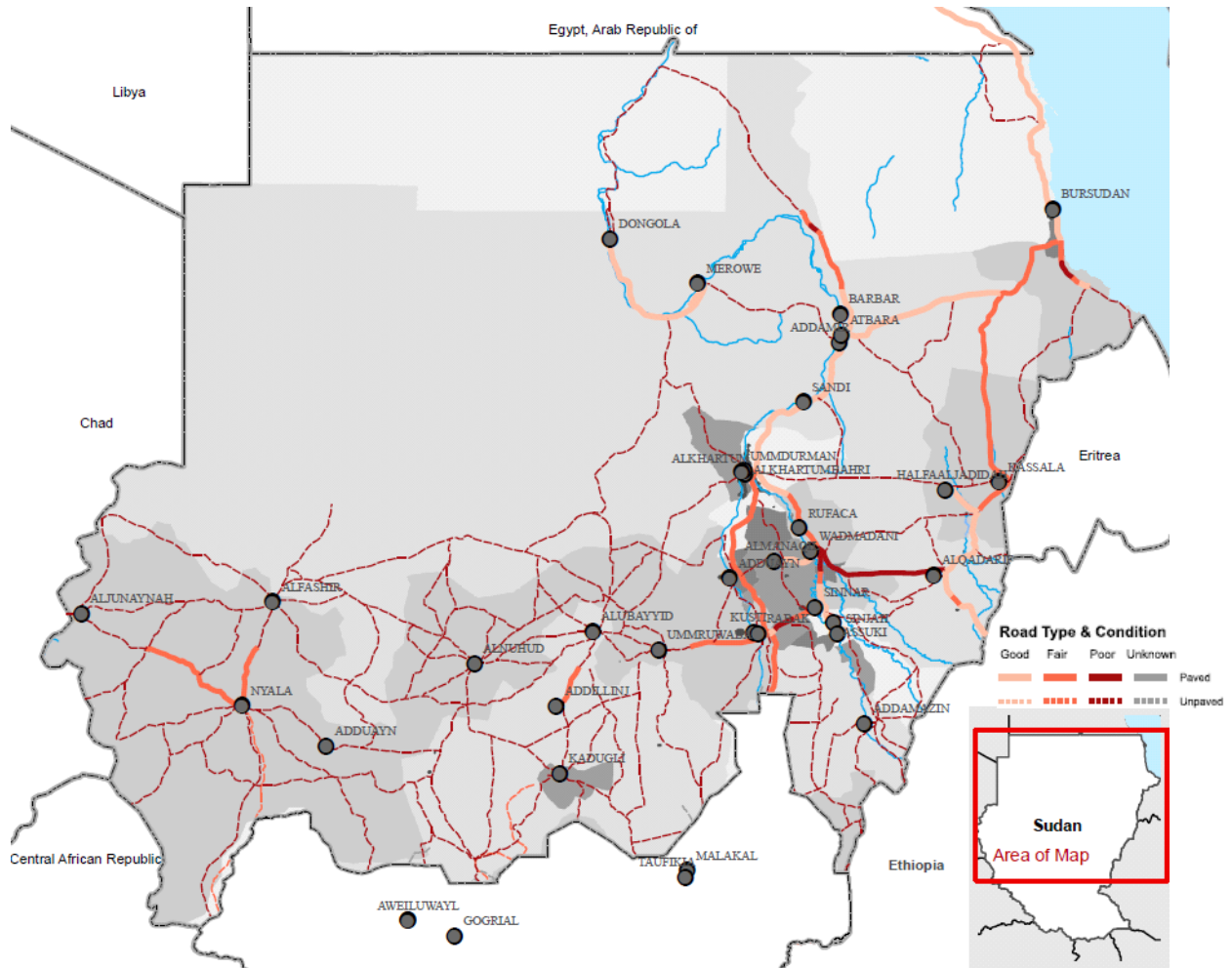
Source: AICD calculations based on Nathan (2010); UNLJC and FAO (2005), and Yoshino (2010).

or customs clearance processes that imports or exports to another country would require. The main cause of the delays within Sudan are the extremely long wait times by vessels for a berth and long dwell times in Port Sudan. Durban, one of the most efficient ports in Africa, records far fewer delays.

In addition to the long delays, it costs more to move freight from Port Sudan to Kosti than it does to import freight to Lusaka from Durban. The extremely high costs posed by Port Sudan are reflected in the total cost required to move freight. Moving freight within Sudan is also much more difficult than across southern Africa (table 2). It is striking that even though imported freight to Zambia is subject to various customs fees and border delays, it is still cheaper overall.

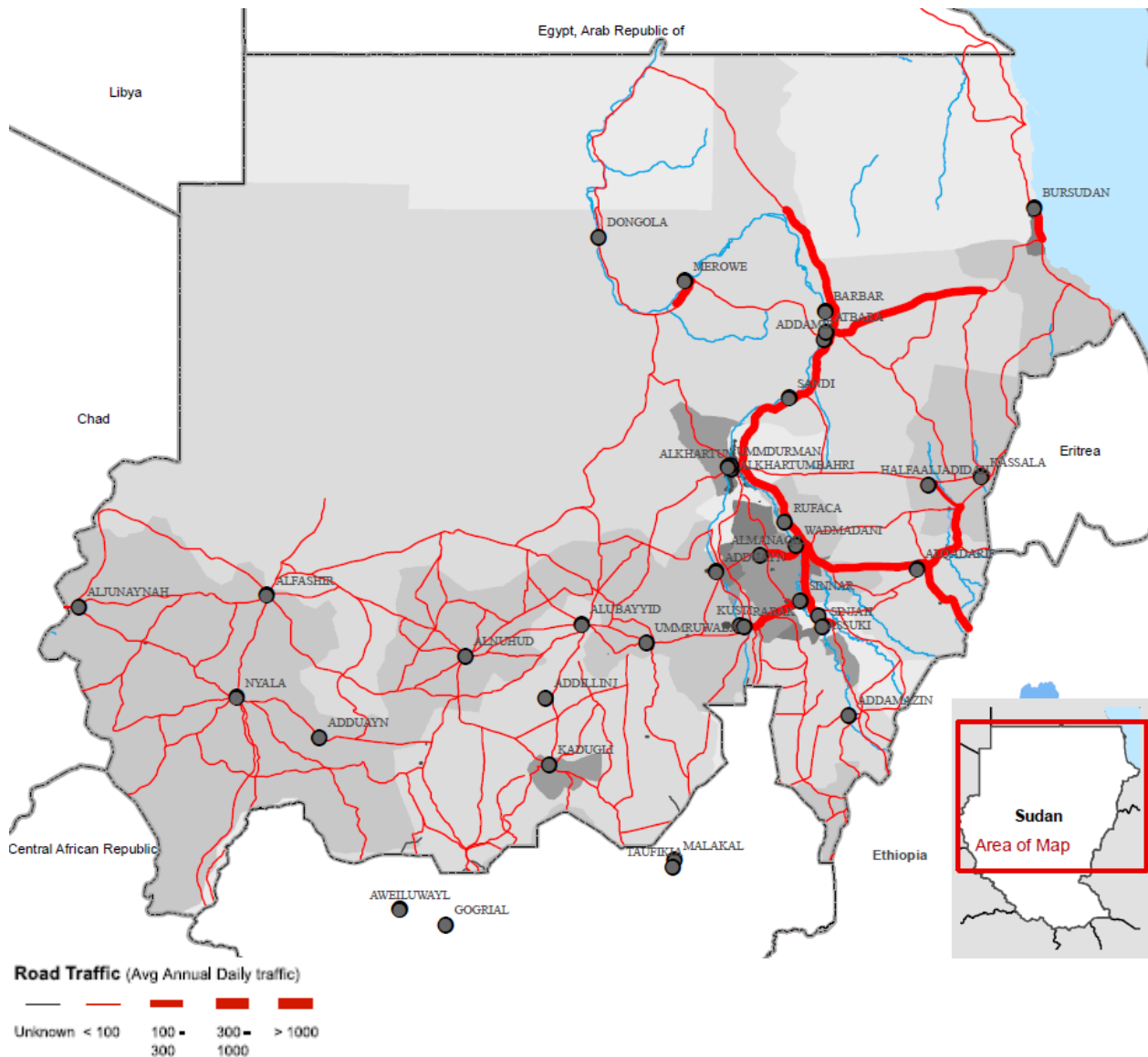
Roads

Figure 8. Road quality in Sudan



Source: AICD

Figure 9. Road traffic in Sudan



Source: AICD.

Despite the road network's expansion since the advent of the oil industry, Sudan's performance in the road sector lags regional aggregates. Between 2000 and 2008, the length of roads almost doubled from 3,400 km to over 6,200 km. The network expansion involved major arterial routes that connect Khartoum with Port Sudan and onward to Egypt (Berger Group and Doshi Borgan & Partners 2010). While these north-south links are developed and in relatively good condition, east-west connectivity lags behind (see figure 8). Sudan has extremely low road densities and poor paving rates; a significant segment of the road network is in poor condition. The classified road network in Sudan is around 30 percent the size of what is prevalent in low-income countries and resource-rich countries, and traffic volumes are extremely low. Figure 9 indicates that a bulk of the traffic is concentrated in the northeastern part of the country, mainly from Khartoum to Port Sudan and Khartoum to the Red Sea. These low traffic volumes raise questions about the extent to which roads in Sudan meet traffic thresholds that justify paving.

Table 4. Benchmarking the performance of Sudan's roads

Indicator	Unit	Sudan	Low-income countries	East Africa	Middle-income countries	Resource rich
Classified road density	km/1,000 km ² of arable land area	37	88	101	278	57
Paving ratio	% of primary network paved	47	71.6		32	82.1
Paved road traffic	AADT (vehicles per day)	369	1,341	1,549	3,798	1,408
Unpaved road traffic	AADT (vehicles per day)	13	39	47	75	54
Classified network condition	Percentage in good or fair condition	26	86	59		80
Paved network condition	% of paved roads in good or fair condition	24	86	79	82	68
Unpaved network condition	% of unpaved roads in good or fair condition	0	56		58	61

Source: Derived from AICD calculations.

Note: The paving ratio for Sudan is calculated based on the classified road network that is paved. The paved network condition in Sudan is based on regional and national roads in Sudan. The paved road network for Sudan does not include roads of fair quality because the length of roads with fair quality is unknown. AADT = average annual daily traffic.

Table 5a. Land area in Sudan with high agricultural suitability

Percent contribution to aggregate agriculture value	South Sudan	Sudan	All parts of Sudan
< 10% but high suitability	4,381	1,438	5,819
10%–50%	2,279	4,793	7,072
> 50%	54	265	319
Total area of high agricultural suitability	6,714	6,496	13,210

Table 5b. Distribution of agricultural value within Sudan

Percent contribution to aggregate agriculture value	South Sudan	Sudan	All parts of Sudan
< 10% but high suitability	65	22	44
10%–50%	34	74	54
> 50%	1	4	2
Total area of high agricultural suitability	100	100	100

Source: AICD calculations.

The poor quality of roads in Sudan significantly lowers the efficiency of transport services. The poor maintenance and need for overlay in Sudan are due to inadequate funding for road maintenance and the lack of cost recovery along existing roads. The net result is a rapid deterioration of the quality of existing roads. The revenue collected by the National Highway Authority from tolls covers only 100 km of overlay and rehabilitation per year. In addition, a backlog of preventive maintenance needs has accumulated, to the extent that between 400 and 500 km of rehabilitation and overlay per year would now be required. Inadequate enforcement of restrictions on axle loads is further accelerating road deterioration (World Bank 2009a).

Agricultural land is very lightly used in Sudan, in part due to inadequate roads. Sizable parts of economically productive areas in Sudan are isolated from the markets. Development of roads is a necessary precondition to exploiting the agricultural potential of Sudan. Sudan has roughly 650,000 square kilometers (km²) of land (table 5a) with high agricultural potential, but 75 percent of it is farmed at only 10 to 50 percent of its capacity. Around a quarter of the land that has high suitability is farmed at only 10 percent of its capacity (tables 5a and 5b).

Transport spending needs can be estimated based on the assumption that key economic nodes need to be connected. It is estimated that Sudan needs 2,900 km of road to meet regional connectivity standards (linking Khartoum to international frontiers); 5,300 km to meet national connectivity standards (linking all provincial capitals to the regional network); and a further 34,201 km to meet rural connectivity standards (linking land responsible for 80 percent of existing agricultural production value to the national network as well as linking land with the capability of producing 50 percent of the nonrealized agricultural value). In addition, the urban connectivity standard assumes an extension of the paved road network to within 500 meters of the population.

Two scenarios are considered. In the base scenario, all infrastructure is maintained in good condition, and higher-end surfacing options are used (asphalt for all regional, national, and urban roads and single-surface treatment for rural roads). In the pragmatic scenario, half the infrastructure is maintained in good condition and half in fair condition, and lower-cost surfacing options are used (single-surface treatment for national and urban roads and gravel for rural roads).

An initial estimation of the connectivity needs suggests that sizable spending requirements—\$750 million to \$1 billion—are needed to reach the goals outlined in either scenario. The largest components of this total are attributed to improving conditions of existing roads and expansion of capacity. Once basic connectivity goals have been reached, an ongoing road sector maintenance budget of at least \$400 million per year would be required to expand the network, and an additional \$390 million would be required to sustain the network. In the pragmatic scenario, while the standards for new developments and upgrading are relaxed, emphasis on maintenance is sustained.

Table 6. Sudan's spending needs for regional, national, rural, and urban connectivity

Mode	Road length in good condition (km)		Spending needs (\$ million per year over a 10-year period)					As share of GDP (%)
	Actual	Required	Expand capacity	Upgrade category	Improve condition	Maintenance	Total	
Basic scenario								
National	874	5,372	0	213	23	123	360	1.7
Regional	2,010	2,893	189	84	38	129	440	2.1
UAI	50	4,226	222	20	5	15	262	1.2
RAI	—	34,201	0	310	33	122	466	2.2
Total	2934	46,692	411	627	99	390	1,528	7.2
Pragmatic scenario								
National	874	5,372	0	160	3	119	282	1.3
Regional	2,010	2,893	113	33	4	117	268	1.3
UAI	50	1,839	63	17	5	15	100	0.5
RAI	—	34,201	0	116	2	258	376	1.8
Total	2,934	44,305	176	326	13	509	1,025	4.8

Source: Adapted from Carruthers, Krishnamani, and Murray (2009).

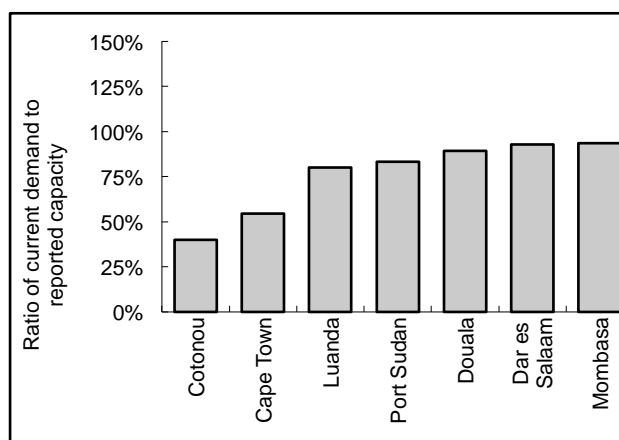
Note: RAI = Rural Accessibility Index ; UAI = Urban Accessibility Index

Ports

Achievements

The Sudanese Port Authority (SPC) has used its large revenues to invest in infrastructure improvements at Port Sudan. The SPC revenue per ton of throughput increased by 47 percent in dollar terms between 2000 and 2005. A combination of a higher realization per tonne handled and large increases in throughput has led to the generation of substantial surpluses. Information from the mid-2000s suggests that the SPC invested around \$187 million in development projects. This resulted in the main areas being in good condition with a number of new berths added and infrastructure projects commissioned. The SPC enjoys a monopoly in its role as the country's main node for maritime trade, and its revenues appear high relative to the number of ships using the port and the volume of cargo it handles (World Bank 2008).

Figure 10. Port Sudan faces serious congestion problems



Source: AICD ports database.

Challenges

Port Sudan remains one of the most inefficient ports in Africa. Compared to regional benchmarks, container dwell time at Port Sudan is over four times that of global best practices and among the worst in Sub-Saharan Africa. Truck cycle times for receipt and delivery of cargo at Port Sudan are 24 times higher than global benchmarks, and crane productivity is less than a third of what is observed in several parts of Africa. The handling charges at Port Sudan are at the lower end of what is charged in other African ports, but the inefficiencies present a huge deterrent to increased usage of the port (table 7).

Table 7. Benchmarking Port Sudan's performance

	Port Sudan	Mombasa	Dar es Salaam	Southern Africa	West Africa	Global best practice
Performance						
Container dwell time (days)	28	5	7	4–8	11–30	<7
Truck processing time (hours)	24	4.5	5	2–12	6–24	1
Crane productivity (containers per hour)	8	10	20	8–22	7–20	20–30
Crane productivity (tonnes per hour)	8	21	23	10–25	7–15	>30
Charges						
Container handling (\$ per TEU)	150	67.5	275	110–243	100–320	80–150
General-cargo handling (\$ per tonne)	10	6.5	13.5	11–15	8–15	7–9
Container handling (\$ per TEU)	-130	-54.5	-248	110–244	100–321	80–151

Source: AICD ports database.

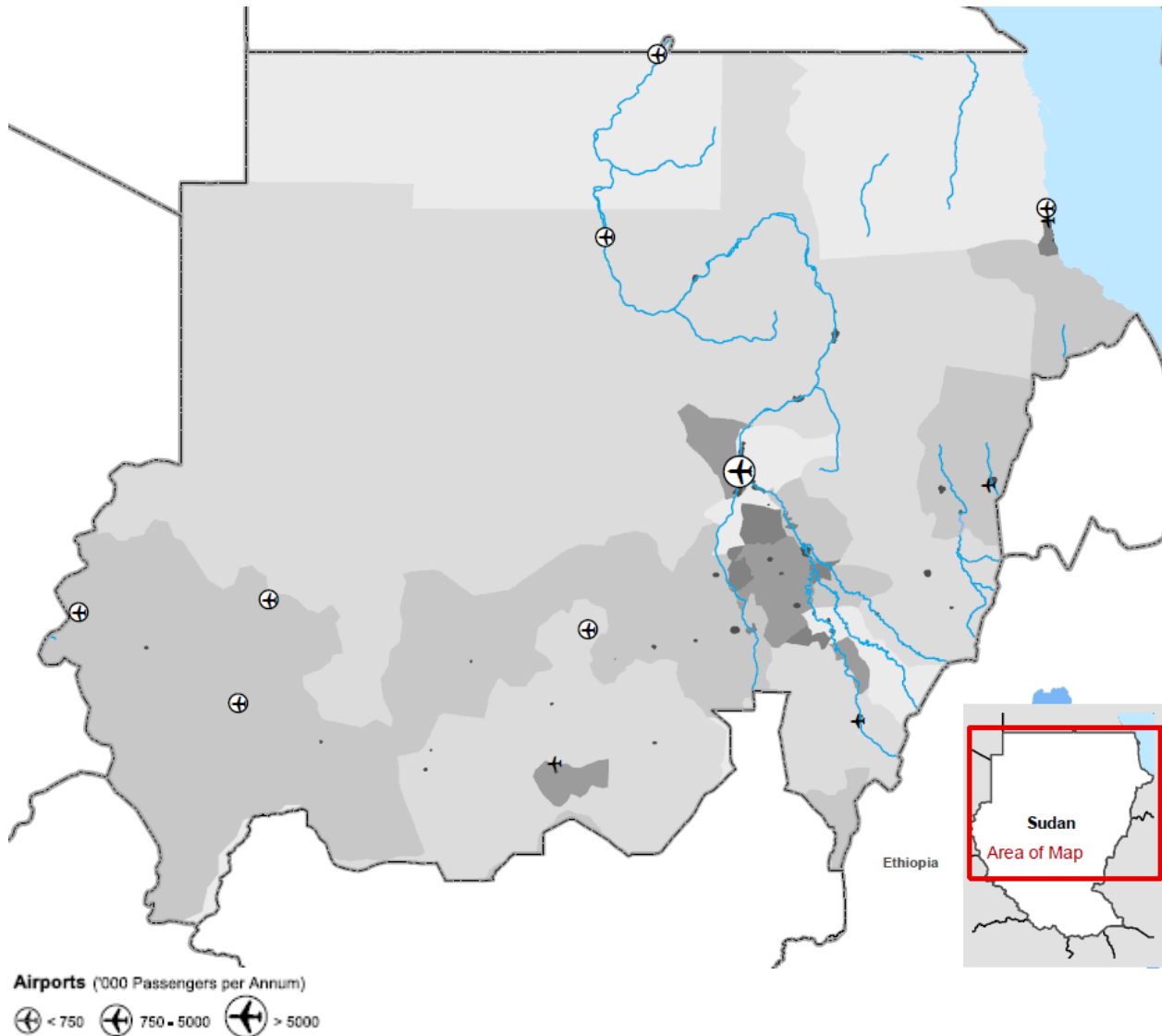
Note: TEU = 20-foot equivalent unit.

A steady increase in containers handled at Port Sudan has created serious port congestion problems, adding significant delays to the movement of freight. Several of the region's ports are beginning to experience serious capacity constraints (figure 10) due to burgeoning demand associated with increases in container traffic and dry-bulk cargo. Port Sudan in particular is already operating at 80 percent capacity at least, a level of intensity that creates problems in terms of congestion. There is some scope for easing capacity constraints by improving the efficiency of port performance, although ultimately new investments will be needed (see figure 10).

Labor requirements at the port lead to overstaffing, poor productivity, and higher costs. In the North Port, the equivalent of a dock labor board exists and there is a legal requirement to use labor from a pool of 25,000 workers. In the container terminal, the SPC provides the labor and acknowledges that it is overstaffed by 7,300 workers (World Bank 2008).

Air transport

Figure 11. Khartoum is the main airport in Sudan



Source: AICD.

Achievements

Sudan's per capita airline seat capacity is higher than that of most of its neighbors, excluding Kenya and Egypt (which have their own exceptionally strong national carriers). Sudan has developed a strong international gateway for air transport in Khartoum. Overall traffic in Sudan has risen, largely driven by intercontinental traffic. Consistent with the rest of Africa, the overall size of the aircraft flown has decreased from wide-body to single-aisle jets.

Growth in seats for travel between Sudan and South Sudan tripled between 2001 and 2007. The Diio SRS shows that in 2007, while there were 219,741 seats for travel within Sudan, there were only 696 seats advertised for South Sudan (table 8) These figures may mask the fact that traffic between the two regions has actually grown rather significantly—from 24,452 seats in 2001 to 87,191 in 2007. How much of that traffic is hub traffic through Khartoum traveling between points in South Sudan is not known.

Table 8. Benchmarking air transport indicators for Sudan and select other countries⁴

Country	Sudan	Ethiopia	Chad	CAR	Kenya	Egypt
Traffic (2007)						
Domestic travel ('000 seats per year, excluding south)	218	729	n.a.	n.a.	2,093	5,959
International travel within Africa ('000 seats per year)	302	1,837	110	21	3,145	1,886
Intercontinental travel ('000 seats per year)	2,052	2,005	89	24	2,755	15,793
Seats available per 100 people	9.8	5.8	1.8	1	21	27.5
Herfindahl-Hirschmann Index—air transport market (%)	15.29	70.61	36.35	50.26	39.47	24
Quality						
Percent of seat-km in newer aircraft	71.9	98.5	99.5	100	80.2	90.7
Percent of seat-km in medium or smaller aircraft	72	39.7	93.6	23.5	20.8	51.2
Percent of carriers passing IATA/IOSA audit	0	100	0	0	11.1	50
FAA/IASA audit status	No audit	Passed	No audit	0	0	Passed

Source: Bofinger 2009.

Note: The Herfindahl-Hirschmann Index (HHI) is a commonly accepted measure of market concentration. It is calculated by squaring the market share of each firm competing in the market and then summing the resulting numbers. A HHI of 100 indicates the market is a monopoly; the lower the HHI, the more diluted the market power exerted by one company/agent.

FAA = U.S. Federal Aviation Administration; IASA = International Aviation Safety Assessment; IATA = International Air Transport Association; IOSA = IATA International Safety Audit; CAR = Central African Republic.

n.a. = Not applicable.

Challenges

Existing air connectivity in Sudan is largely oriented toward the Middle East and Egypt. Addis Ababa (Ethiopia) is used as the main connecting point to transit to the rest of Africa, while Sudan has, for example, no direct flights from Khartoum to Kampala (table 9).

There is a lack of regulatory oversight in the air transport sector. A number of small, domestic carriers, registered generally as charter airlines, are operational. These operators may act as scheduled carriers, but do not report information to a booking or ticket sales agency. Often such operators in countries with poor oversight pose an air safety problem as they operate aircraft maintained on minimal budgets, with maintenance crew and pilots whose skills may not be consistent with international standards. The percentage of seats in Sudan flown on newer aircraft is smaller than its neighbors, creating additional safety risks.

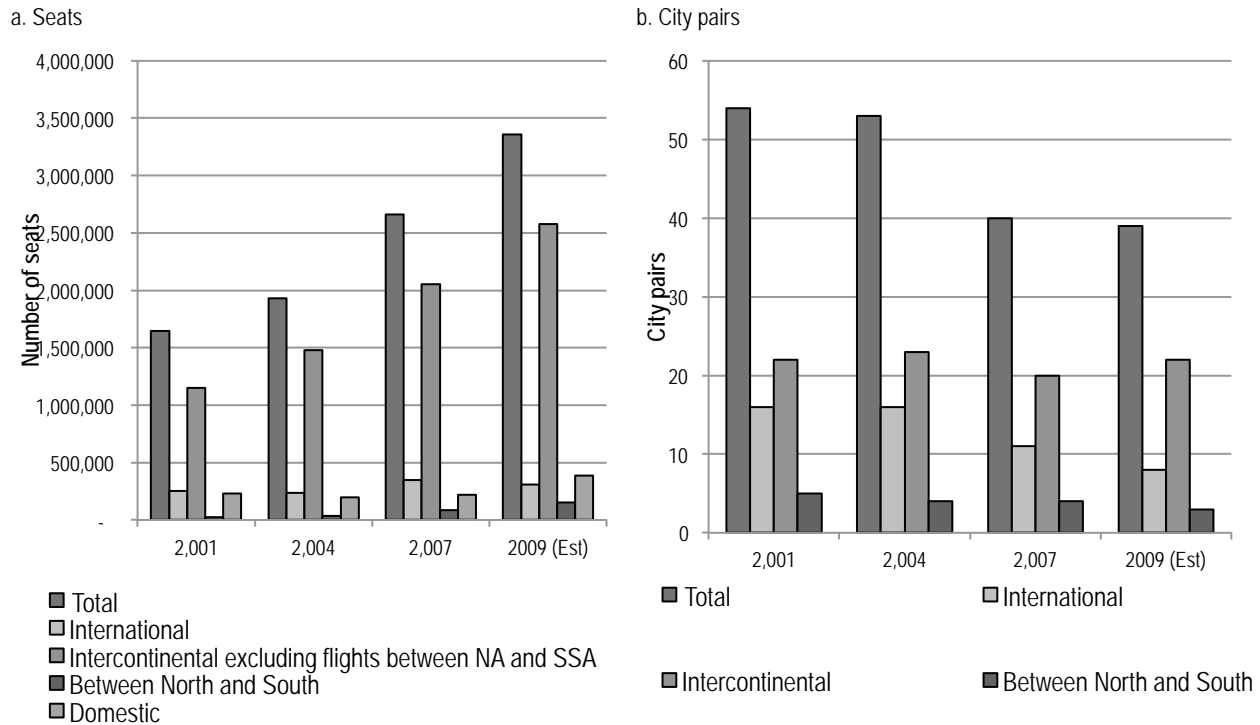
⁴ All data are as of 2007 based on estimations and computations of scheduled advertised seats, as published by the Diio SRS Analyzer. This captures 98 percent of worldwide traffic, but a percentage of African traffic is not captured by these data.

Table 9. Origin destination matrix—Sudan

	Bahrain	Egypt	Eritrea	Ethiopia	Germany	Jordan	Kenya	Lebanon	Libya	Netherlands	Sudan	Qatar	Saudi Arabia	Syrian Arab Republic	Turkey	United Arab Emirates	United Kingdom	Yemen
Bahrain											10							
Egypt											38							
Eritrea											1							
Ethiopia											10							
Germany											4							
Jordan											6							
Kenya											14							
Lebanon											3							
Libya											2							
Netherlands											3							
Sudan	10	38	1	10	4	6	13	3	2	3		15	17	2	7	29	3	2
Qatar											14							
Saudi Arabia											17							
Syrian Arab Republic											4							
Turkey											7							
United Arab Emirates											29							
United Kingdom											3							
Yemen											2							

Source: Bofinger 2009.

Figure 12. Evolution of seats and city pairs in Sudan



Source: Bofinger 2009. Derived from AICD national database (www.infrastructureafrica.org/aicd/tools/data).

Note: As reported to international reservation systems.

NA = North Africa; SSA = Sub-Saharan Africa.

Water supply and sanitation

Challenges

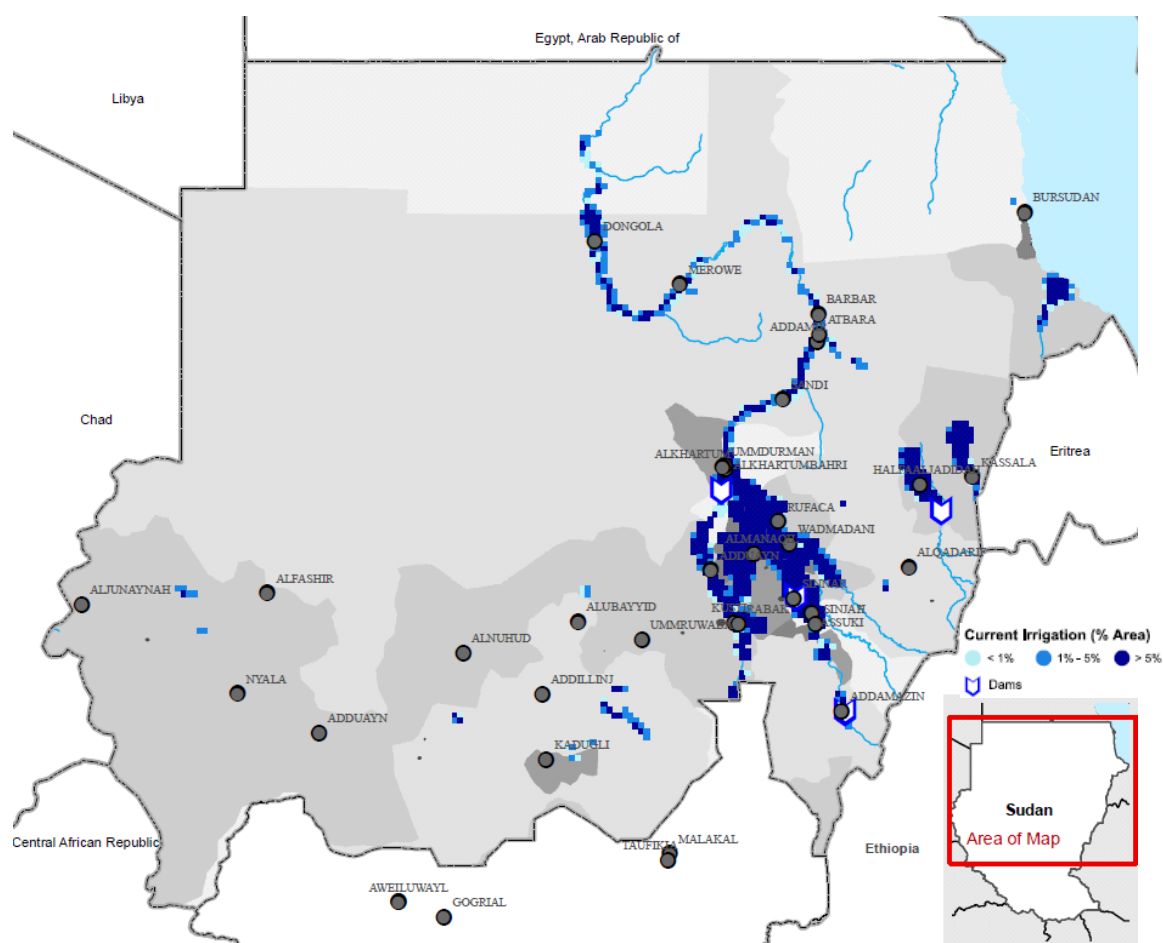
Around 85 percent of Sudan's populace lacks access to safe sources of water (figure 13). Over 25 percent of the population relies on surface water and almost 60 percent relies on wells and boreholes. Sudan's reliance on wells and boreholes for water supply is higher than for any other country in its peer groups and is becoming a challenge for the country. Fewer than half the wells and boreholes in Africa provide safe water (table 10).

Sanitation access in Sudan is bimodal. On the one hand, 40 percent of the population has access to improved latrines; on the other, 40 percent continues to practice open defecation. Both ratios are substantially higher than for the relevant resource-rich and low-income African peer groups. In contrast to these peers, reliance on flush toilets and traditional latrines is much more limited.

A very small share of the population—15 percent—has access to utility water, well below all other African benchmarks. Available information suggests that there is almost no access to piped water, and stand posts are the only form of utility water that is accessed. Census data for all parts of Sudan indicate that in 1993 about 60 percent of the population had access to utility water but there has been a steep decline in access rates—down to 35 percent—in the 2000s. Since access to utility water is negligible in South Sudan, the access data for all parts of Sudan reported in the census relates primarily to Sudan itself.

The precarious decline in access has been attributed to a lack of maintenance of water supply assets that has led to their gradual dilapidation.

Figure 13. Water resources in Sudan



Source: AICD

Table 10. Benchmarking water and sanitation indicators in Sudan⁵

	Unit	Sudan 2009	Resource-rich countries Mid-2000s	Low-income countries Mid-2000s	Middle-income countries Mid-2000s
Access to piped water	% pop	—	13	9.3	61
Access to stand posts	% pop	15	12	17.1	22
Access to wells/boreholes	% pop	58	47	39.3	5
Access to surface water	% pop	27	27	34.2	11
Access to flush toilets/septic tanks	% pop	5	13	4.7	48
Access to improved latrines	% pop	41	37	18.3	34
Access to traditional latrines	% pop	11	22	38.5	7

⁵ The AICD used the March 2010 Joint Monitoring Data (JMP) coverage statistics as the main source of access data on water supply and sanitation, and processed it under a standardized methodology to allow cross-country comparisons. The AICD calculations might differ from the access rates reported by governments.

	Unit	Sudan	Resource-rich countries	Low-income countries	Middle-income countries
		2009	Mid-2000s	Mid-2000s	Mid-2000s
Open defecation	% pop	43	28	38.3	11
		2005	Mid-2000s	Mid-2000s	Mid-2000s
Domestic water consumption	liter/capita/day	53	115	50.9	196
Revenue collection	% sales	64	60	94.1	99
Distribution losses	% production	40	40	34.8	29
Cost recovery	% total costs	62	67	89.5	86
Operating-cost recovery	% operating costs	86	94	125.2	121
Labor productivity	connections per employee	93	96	175.9	203
Total hidden costs	% of revenue	121	194		67

		Scarce water resources	Sudan	Other developing regions
Average effective tariff	U.S. cents per m3	60	57	3–60

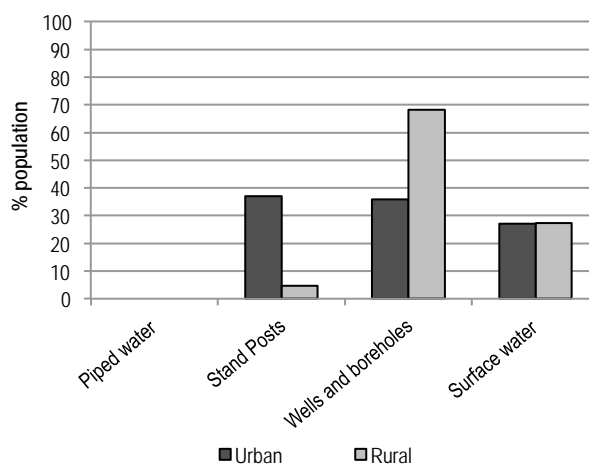
Source: Demographic and Health Survey (DHS) and AICD water and sanitation utilities database (www.infrastructureafrica.org/aicd/tools/data). Note: Access figures calculated by the AICD based on the 2000 and 2006 DHS figures published by the Joint Monitoring Program (WHO 2010).
 — = Not available.

Only 40 percent of urban dwellers rely on advanced water technologies for their water supply. Close to 40 percent of the population has access to utility water—mainly stand posts—in urban areas, and around 5 percent in rural areas. Almost 70 percent of rural Sudanese rely on wells and boreholes, 30 percent higher than in urban areas. It is very striking that there is little difference in the reliance on surface water—around 25 percent of both rural and urban Sudanese obtain their water from open sources.

There is significantly greater usage of improved sanitation technology types in urban areas (figure 14). Urban areas have twice the level of access to flush toilets or improved latrines compared to rural areas. In the case of flush toilets, the access rate in urban areas is 14 percent compared to 1 percent in rural areas. Sixty percent of the urban population relies on improved latrines compared to 32 percent of the population in rural areas (figure 15). Some 68 percent of the rural population defecate in the open compared to 12 percent of urban dwellers.

Deep boreholes and hand pumps are the predominant technology used for water supply in the poorer households, and water filters (improved sources of water) are the water supply modalities in wealthier households. Around 41 percent of the poorest quintile of households derive their water from wells and

Figure 14. Limited access to advanced water technologies in urban Sudan



Source: Access figures calculated by AICD using data 2009 DHS data.

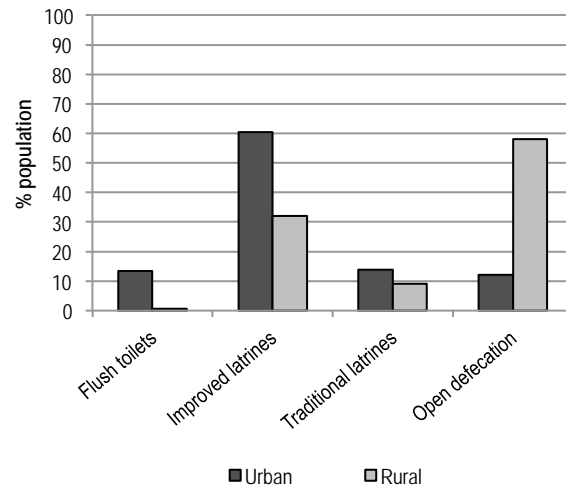
boreholes, while 12 percent of the wealthiest quintile of households rely on water from wells and boreholes.

Lower-income Sudanese use lower-end sanitation technologies. Around 54 percent of the poorest quintile of the population defecates in the open compared to 13 percent of the richest quintile. While none of the poorest quintile of the population uses flush toilets, almost 20 percent of the richest quintile do so. The most dominant sanitation technology across the board is pit toilets. Disparities are less glaring in the use of pit toilets—around 42 percent of the poorest quintile of the population and 56 percent of the richest quintile of the population use them.

The KWC's poor performance, particularly due to inadequate collection of bills and network losses, also holds back service expansion. The KWC fares poorly when its performance is compared to regional benchmarks. Nonrevenue water, at 40 percent of production, is twice that of a well-performing utility. At 90 connections per employee, labor productivity is less than half the average productivity of a utility in middle-income countries, which is 200 connections per employee. On average, Sudan's water utilities recover only 62 percent of the total billing, which is comparable to the revenue collection of utilities in resource-rich countries, but is a very poor track record in absolute terms. Finally, cost-recovery tariffs are not in place, creating a constant financial drain.

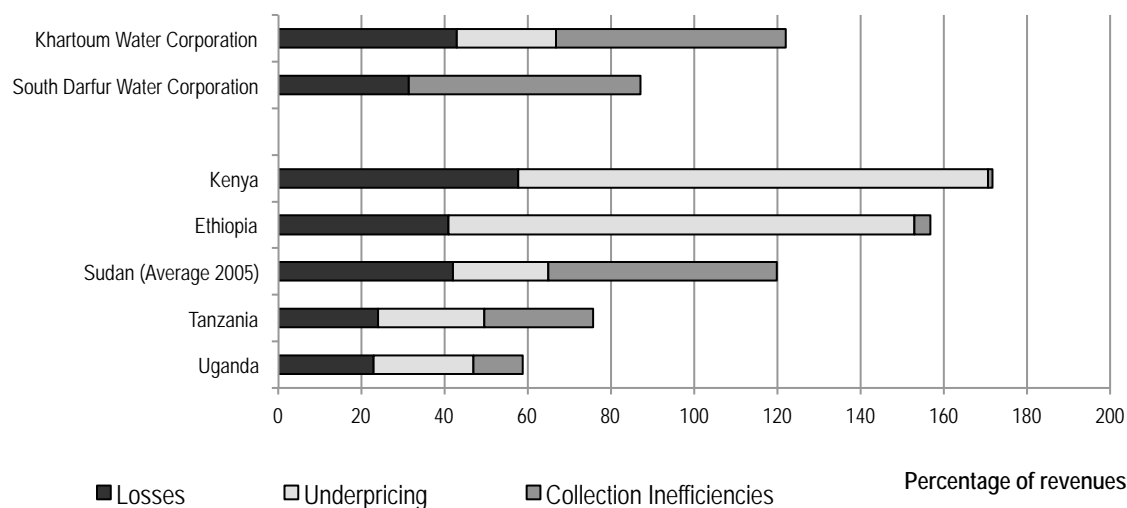
The poor performance can be quantified as a percentage of revenue, giving a sense of the hidden costs attached to such inefficiencies. Sufficient data were available to quantify these hidden costs for the KWC as well for one other provincial utility in Sudan: the South Darfur Water Corporation. The KWC emerges at the more inefficient of the two. Overall, the utilities lose between 80 and 120 percent of their revenues. The main drivers of these losses are collection inefficiencies, followed by distributional losses. The inefficiencies in Sudan's utilities are slightly lower than several East African countries (Kenya and Ethiopia) that lose up to 150 percent of their revenues due to hidden costs (figure 16), but are still very high in absolute terms, amounting to \$73 million a year.

Figure 15. Sanitation access is largely bimodal



Source: Access figures calculated by AICD using data 2009 DHS data.

Figure 16. Hidden costs of selected water utilities, as percentage of revenue



Source: Derived from Briceño-Garmendia, Smits, and Foster (2009).

The valuation of these hidden costs helps identify the individual challenges faced by Sudanese utilities. Collection inefficiencies are leading concerns for the South Darfur Water Corporation and the Khartoum Water Corporation. The underlying observable performance indicators are presented in table 11.

Table 11. Operational indicators for water utilities in Sudan, 2005

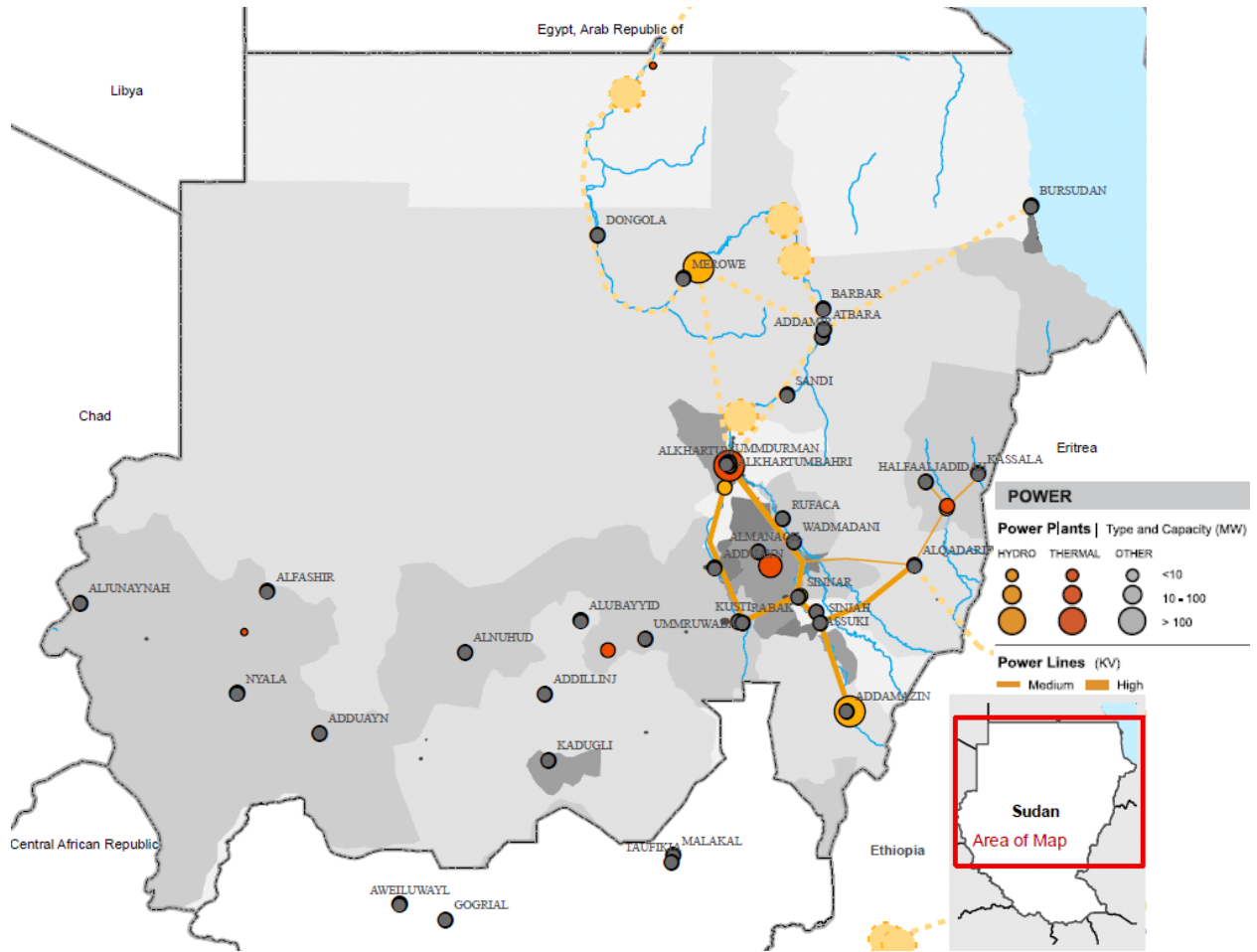
Utility	Water delivered (million m ³ /year)	System losses (%)	Collection ratio (%)	Average total cost (\$/m ³)	Average effective tariff (\$/m ³)	Total hidden costs (\$ million/year)	Total hidden costs (% revenues)
Khartoum Water Corp	250	40	62	0.68	0.59	73	122
South Darfur Water Corp	7	49	49	0.89	1.13	3	87

Source: Derived from Briceño-Garmendia, Smits, and Foster (2009).

Note: For Sudan water delivered (million m³/year) and total hidden costs (\$/year) are reported as the sum of the utilities; the other indicators are calculated as weighted averages. Average total cost per cubic meter was calculated assuming a unit capital cost of 40 cents.

Energy

Figure 17. Power infrastructure in Sudan



Source: AICD.

Achievements

Installed electricity generation capacity in Sudan tripled between 2005 and 2007. Sudan's installed capacity increased from 801 MW (AICD 2005) in 2005 to around 2,687 MW in 2009 (Platts 2009).⁶ Compared to its African peers, Sudan's installed capacity far exceeds what low-income countries have put in place but lags behind that of resource-rich countries. In 2005 around 70 percent of the electricity was generated via thermal generation and around 20 percent using hydropower resources. But the composition mix seems to have changed since 2005; with the construction of new hydropower plants, the generation mix has now shifted to 55 percent hydropower and 45 percent thermal.

The National Energy Corporation (NEC) enjoys healthy bill collection. The utility reports that all of the billings are routinely collected by the utility. These rates are higher than all other African peer groups (table 13).

Sudan boasts a relatively high use of modern fuels (gas and electricity) for cooking relative to its African peers. Around 36 percent of Sudan's population uses modern fuels for cooking compared to 1 percent of resource-rich Nigeria's population. Over 65 percent of Sudan's richest quintile use modern fuels for cooking relative to 6 percent in Nigeria and 16 percent in Kenya (see table 12). Even 8 percent of the poorest quintile of the population used modern fuels.

Challenges

Electricity access rates, at around 37 percent of the population, are still low relative to most of Sudan's resource-rich peers. The figure is more or less comparable to that of African low-income countries, however. Over 52 percent of urban areas have access to electricity compared to 28 percent of rural areas. Rural electrification is broadly comparable with other parts of Africa, but urban electrification lags significantly. There is a difference of over 25 percentage points between access to power in urban areas in Sudan and in other resource-rich countries in Africa.

Inadequate power access retards business activity, with the challenge being more acute in some areas than others. Though firms reporting that power is not widely available varied from 25 to 60 percent, state to state, across all states firms identified power to be a major problem. This challenge is particularly acute in the Nyala region, where around 60 percent of firms say inadequate power constrains business activity (figure 18a). Power outages in Sudan, at 19 days per year, greatly impact productive activity and exceed those found among the country's resource-rich and low-income peers.

Table 12. Relatively high usage of modern fuels for cooking in Sudan

Usage of modern fuels	Usage of modern fuels	
	All households	Richest households
Sudan (2009)	36.10	64.90
Kenya (2003)	3.45	16.52
Nigeria (2003)	1.19	5.51
Uganda (2001)	0.87	4.34
Ethiopia (2005)	0.31	1.48
South Sudan (2009)	0.30	0.80
Tanzania (2005)	0.24	1.22

Source: World Bank 2010b and c DHS various years.

⁶ Based on the estimate that around 97 percent of all parts of Sudan's power is in Sudan.

Table 13. Benchmarking power indicators in Sudan

Indicators	Units	Sudan	Low-income, nonfragile countries	Middle-income countries	Resource-rich countries
Access to electricity (national)	% of population	36.5	33	50	46
Access to electricity (urban)	% of population	52	86	72.8	79.4
Access to electricity (rural)	% of population	28	12.7	26.3	28
Installed generation capacity	MW	2,712	651	36,971	4,105
Installed generation capacity per million population	MW per million population	80	20	799	43
Power outages	Days/year		10.4	5.9	14.5
Firms that find power a constraint for business	% of firms		52	31	56
Firms with own generator	% of firms	41	41	18	63
Collection rate	% billing	100	92	91	70
Revenue per unit	US cents/ kWh	9	14	13	13
System losses	% of generation	22	24	20	52
Effective power tariff		Sudan	Predominantly hydro	Other countries	
Residential at 100 kWh	US cents/kWh	0.09		10.27	
Commercial at 100 kWh	US cents/kWh			11.73	5.0–10.0
Industrial at 50,000 kWh	US cents/kWh			11.39	
Average effective tariff	US cents/kWh	9	8	15	12.6

Source: All data unless specified are for 2005 and based on AICD calculations; data for access to electricity for Sudan are from 2009 and were obtained from the US Energy Information Administration (EIA); data for South Sudan access to electricity are from 2010 and were obtained from World Bank (2011); data for installed capacity for Sudan are from 2009 and were obtained from Platts (2009); data for power outages are derived from Vennemo and Rosnes (2009); data for Emergency Generation from Eberhard and others (2008); data for firms that find power to be a constraint and firms with own generators are from 2007 and were obtained from World Bank (2009b); data on Sudan collection rate, revenue per unit, and system losses are for 2004 and were taken from World Bank (2007); data for average effective tariff for Sudan are for 2004 and taken from World Bank (2007); data for average effective tariff for South Sudan are taken from World Bank (2011). For the thermal benchmark, data represent primarily residential users.

Note: Access to electricity data for Sudan are estimates based on calculations from the AICD economic model for power investment needs. Installed capacity per million population was calculated based on Platts (2009) estimates for installed capacity.

* The aggregate is based on manufacturing firms.

Excessive reliance on generators to cope with erratic and unreliable power supply increases production costs and reduces competitiveness. A significant share of manufacturing enterprises (from 36 percent in North Kordofan to 96 percent in Red Sea) share or own generators. The share of electricity consumption produced by generators in these states was 66 percent and 72 percent, respectively. Apart from increasing costs and reducing competitiveness, investment in these generators also holds up a significant amount of resources that could have been used for other fixed assets or to lower working capital constraints of most of the businesses (World Bank 2009b). Given erratic supply and high reliance on backup generators, industrial and commercial consumers account for only around 30 percent of electric utility consumption (figure 19). Consumption of power for agricultural uses is around 5 percent, and the rest of the consumption is primarily by domestic consumers. In contrast, billing patterns (as a proxy for consumption) in South Africa suggest that industrial and commercial consumers account for 92 percent of all billings, and residential consumers for only 8 percent.

Figure 18a. Electricity is the largest obstacle to doing business in Sudan

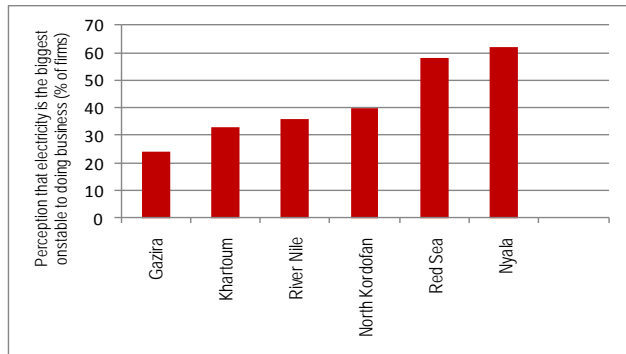
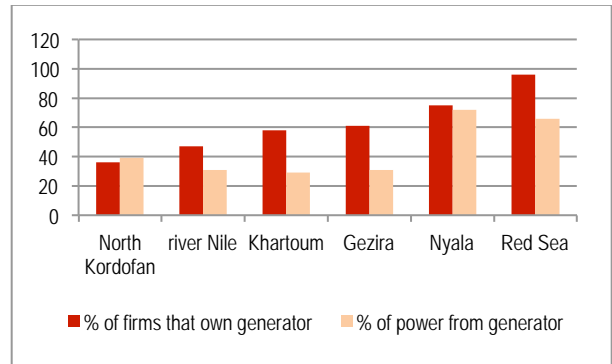
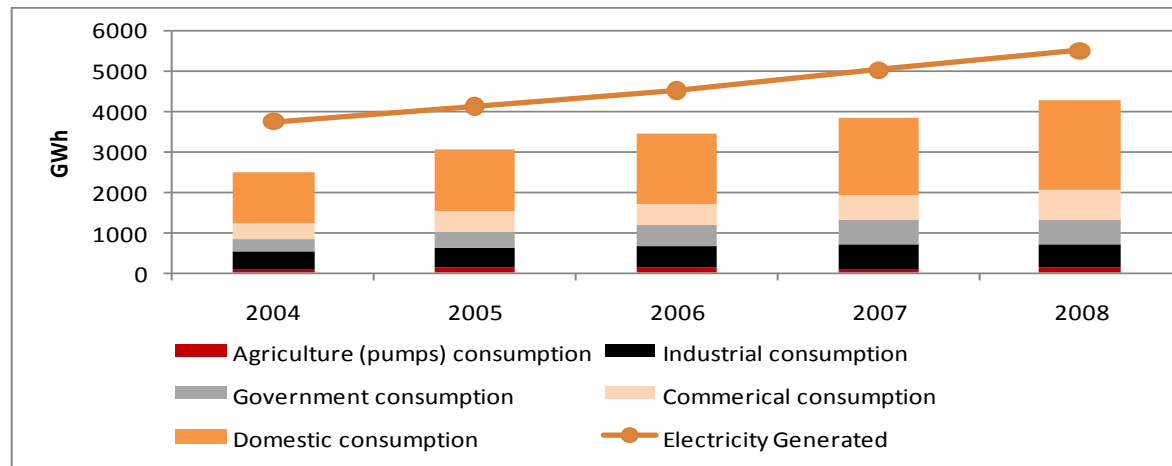


Figure 18b. High reliance on generators for power



Source: Derived from World Bank (2009b).

Figure 19. A small share of Sudan's power consumption is for industrial activities

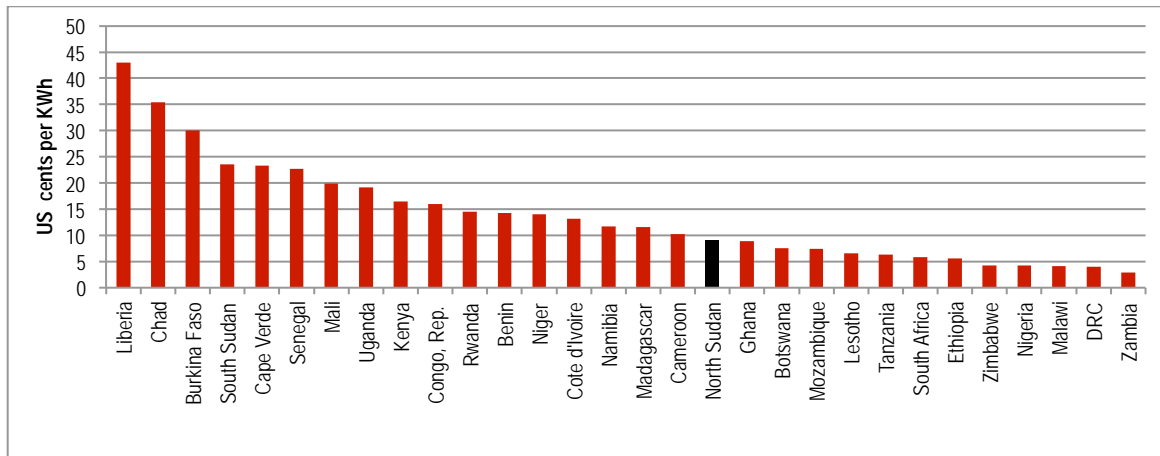


Source: Based on statistical handbooks produced by the Central Bureau of Statistics and on data reported by the NEC, which are assumed to reflect the situation in Sudan.

Power prices are toward the lower-middle end of the range observed in Sub-Saharan Africa. At \$0.09 per kilowatt-hour (kWh), the price is close to the average of countries predominantly reliant on hydropower. Nevertheless, given that thermal power has been dominant until quite recently and continues to play a significant role, tariffs look low relative to historic costs of around \$0.19/kWh (figure 20).

The costs of producing power are marginally higher than the average cost of power production in Africa. The average power production cost in Sudan, at \$0.19/kWh, is slightly more than that of Sub-Saharan Africa's, which is around \$0.18/kWh (figure 21). The costs are partially offset by generous government subsidies to the power utility. In 2003 and 2004 the government of Sudan provided subsidies valued at around \$60 million. While there are no data available for later years, it is believed that the power utility continues to receive these subsidies from the government. The end user ultimately pays less than half of what it costs to produce the power.

Figure 20. Moderate power tariffs in Sudan

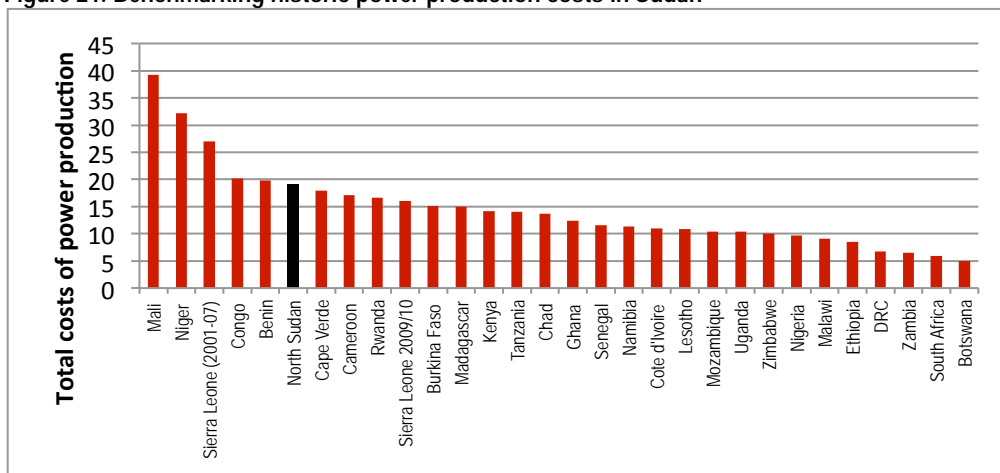


Source: Briceño-Garmendia and Shkaratan 2009; World Bank 2007; World Bank 2011.

Note: South Sudan's price is the median of its price range of 18–29 cents.

DRC = Democratic Republic of Congo.

Figure 21. Benchmarking historic power production costs in Sudan



Source: Briceño-Garmendia and Shkaratan 2009; World Bank 2007; World Bank 2011.

Note: DRC = Democratic Republic of Congo.

In spite of the generous subsidies received from the government, the NEC reported large financial losses. The utility lost \$12 million each year in 2003 and 2004, \$0.02–\$0.03 per unit of electricity sold. Even the 10 percent increase in power sales from the previous year did not stabilize the financial performance of the NEC.

Hidden costs diverted significant resources from the utility, causing economic losses of almost \$500 million (\$484 million) in 2008. Underpricing is one major problem—the \$0.09 per kilowatt-hour tariff recovers only 50 percent of the \$0.18 required to produce a kilowatt-hour. Despite subsidization, this underpricing added almost \$380 million to the NEC’s 2008 losses.

Network losses were around 22 percent in 2008. Though generally consistent with what most African utilities encounter, losses of this magnitude are double international best-practice standards. Network losses contributed \$106 million to the NEC’s 2008 financial losses (table 14).

Table 14. Operational indicators for the NEC

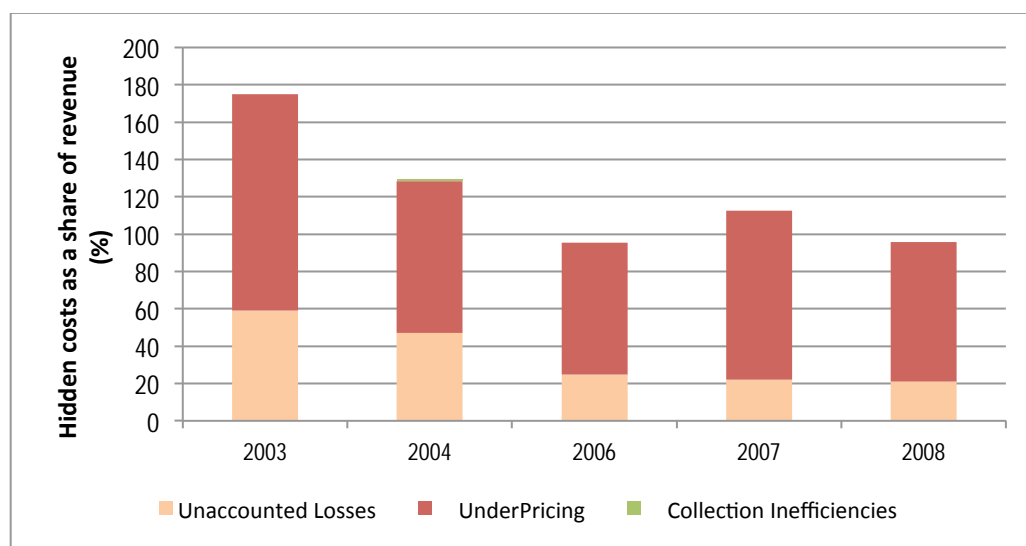
	Net generation (GWh/year)	System losses (%)	Implicit collection ratio (%)	Average total cost (\$/kWh)	Average effective tariff (\$/kWh)	Total hidden costs (\$ million/year)	Total hidden costs (% revenues)
2003	3,560	34.8	100	0.16	0.08	306	175
2004	3,749	33.4	100	0.16	0.09	293	129
2005	4,124	26	100	—	—	—	—
2006	4,521	24	100	0.16	0.092	340	96
2007	5,021	22	100	0.20	0.092	528	113
2008	5,506	22	100	0.19	0.098	484	96

Source: AICD analysis based on World Bank (2007) and Sudan Central Bureau of Statistical Handbooks.

— = Not available.

Some progress has been made, however. Hidden costs as a share of utility revenue fell substantially from 175 percent of NEC's revenues in 2003 to 96 percent in 2008 (figure 22). This is largely attributable to significant reduction in network losses, which were as high as 35 percent in 2003 but were reduced to 22 percent by 2008. While tariffs have risen slightly, they have not kept pace with the rising costs of production. Nevertheless, a 60 percent expansion of power production all sold at a loss, has inflated absolute hidden costs from \$306 million in 2003 to \$484 million in 2008. Expressed in terms of the size of the economy, these hidden costs shaved off 2.2 percent of GDP in 2003, falling to 1.5 percent of GDP in 2008.

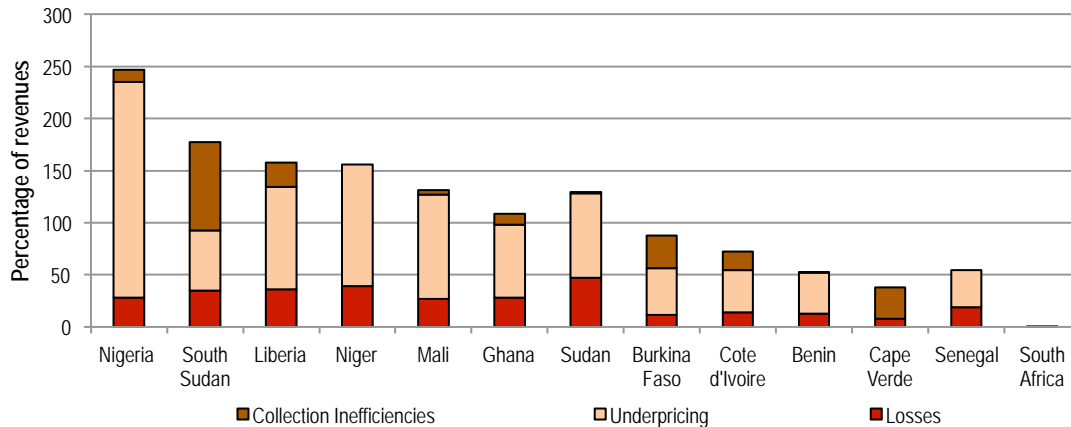
Figure 22. Large hidden costs at the NEC due to underpricing and unaccounted losses



Source: Derived from Briceño-Garmendia, Smits, and Foster (2009) using data from World Bank (2007) and Sudan Central Bureau of Statistics handbooks.

The NEC's hidden costs look high when compared to that of other African utilities (figure 23). They represent about 100 percent of the NEC's revenues and are double that of the top-performing countries such as Senegal, Côte d'Ivoire, and Benin. Nevertheless, they are far from being the worst in Africa.

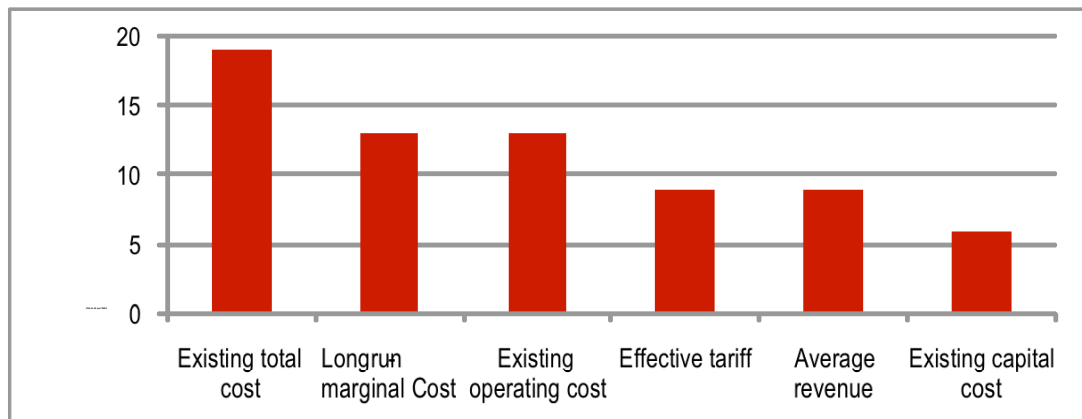
Figure 23. Hidden costs are high in Sudan relative to other African countries



Source: Derived from Briceño-Garmendia, Smits, and Foster (2009); Sudan Central Bureau of Statistics handbooks.

In the long run, Sudan’s power cost-recovery situation looks a little more promising, particularly if the nation’s hydropower potential is developed. Using a model that simulates optimal (least-cost) strategies for generating, transmitting, and distributing electricity in response to demand increases, it is estimated that the long-run marginal costs of producing power in Sudan would be about \$0.13/kWh when all cost-effective power strategies are fully developed. Although this is well below the historic cost of around \$0.19/kWh, it is still significantly above the current tariff of \$0.09/kWh. Thus, there is a need to continue raising the tariff toward these long-term equilibrium levels (figure 24).

Figure 24. Existing tariffs for power are insufficient to recover huge operating costs and long-run marginal costs



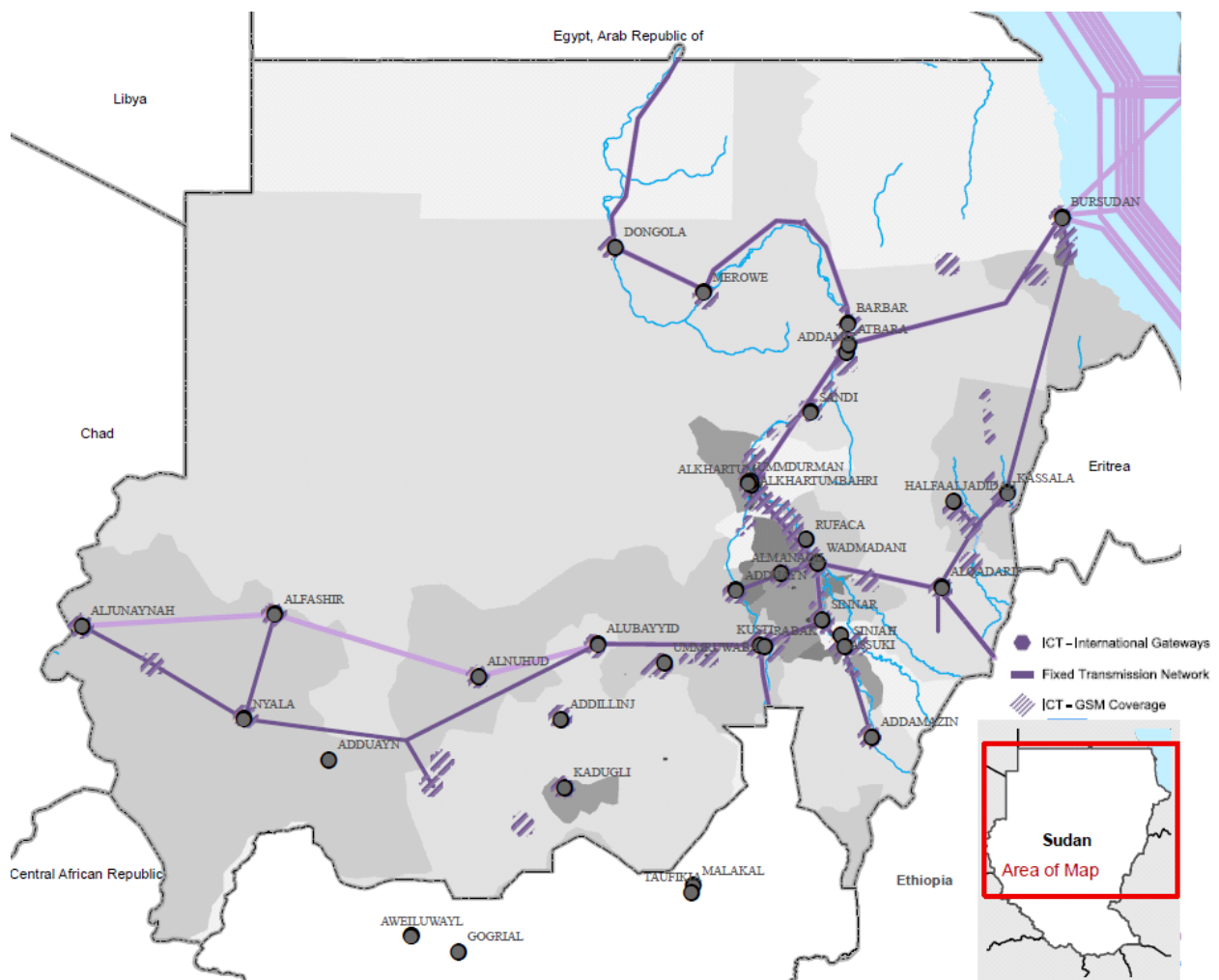
Source: AICD calculations.

Sudan’s rich endowment of hydropower resources could make it a significant exporter of hydropower in the Nile Basin region. To meet its potential, Sudan would need to develop more than 3,100 MW of hydropower capacity beyond its domestic needs, which would represent a doubling of capacity. The nation would also need to develop around 13,500 MW of interconnector capacity, the largest of any country in the region.

Deepening power trade would save the Eastern Africa Power Pool–Nile Basin (EAPP-NB) around \$1 billion in energy costs. Even though Sudan and Ethiopia have to make the lion’s share of the investments, these will offset the high costs of thermal generation, which is currently the main source of generation in the EAPP. Expanding capacity and investing in interconnectors will allow Sudan to gain a substantial 12 percent per year return on the investment. Moreover, by increasing the share of hydropower in the regional generation portfolio, the region could save several million tonnes of carbon emissions a year. Under trade expansion, Sudan’s weight of hydropower increased from 73 to 87 percent, making the generation of power less carbon intensive.

Information and communication technology

Figure 25. Sudan’s ICT backbone infrastructure as of the mid-2000s



Source: AICD.

Note: The figure captures the situation in Sudan in the mid-2000s, when the mobile signal coverage was not as high. Today, this situation has significantly improved.

Achievements

All parts of Sudan have made impressive progress in the ICT sector since the early 2000s, placing access and service penetration rates on par with African peers. In the early 2000s, only around 60 percent of the population was covered by a GSM⁷ signal. As of 2010, over 80 percent of the population is covered by a GSM signal. Mobile subscription rates have risen from less than 1 percent in 2000 to 33 percent in 2009. Growth in mobile telephony has been impressive and Sudan's is among the most rapidly growing in Africa. Until recently, most of the development in the sector was in the northern part of Sudan. Only a few other countries in East Africa—Kenya, Tanzania, and Uganda—have achieved mobile penetration of around 20 percent or more. Internet penetration has also grown significantly but slightly lags behind resource-rich and middle-income African countries. International bandwidth in all parts of Sudan has grown exponentially and exceeds all benchmarks except middle-income countries. The landline sector has not demonstrated much growth, meanwhile, in part because of an overwhelming preference for mobile phones. This trend is broadly consistent across Africa as a whole.

Table 15. All parts of Sudan compare favorably to the average African country in terms of ICT access and prices

Indicator	Unit	All parts of Sudan		Resource-rich countries	Low-income countries	Middle-income countries	Sub-Saharan Africa
		2000	2008	2008	2008	2008	2008
Access							
GSM coverage	% population under signal	60	80	78	63	96	72
International bandwidth	Bits/person	0.06	35	18	25	209	39
Internet	Users/100 people	0.1	5.9	9	3.5	7	5.5
Landline	Subscribers/100 people	1.2	1.09	0.9	0.8	9.2	1.4
Mobile phone	Subscribers/100 people	0.05	33	38.2	24.4	95.3	33.1
Prices		2008	2009	2008	2008	2008	2008
Price of monthly mobile basket	US \$	4.8	3	17.07	11	9.24	12.06
Price of monthly fixed-line basket	US \$	4.4	5.3	15.12	10.43	11.41	12.38
Price of monthly fixed broadband	US \$	47	25	231.98	286.72	57.42	208.71
Price of a call to the United States per minute	US \$		0.42	0.92	0.69	0.56	0.7
Price of an inter-Africa call per minute	US \$		0.42	1.16	0.94	1.06	0.99

Source: Adapted from Minges and others 2009 using data from the Central Bureau of Statistics, Sudatel, Zain, and World Bank ICT At-a-Glance.

Source: Data for landline subscribers is for 2005 taken from the Central Bureau of Statistics, South Sudan; Mobile phone subscriptions based on World Bank staff estimates for 2011; *Note:* Landline and mobile subscriber data are based on information from Sudan; the others are based on Sudan aggregates. These are representative of Sudan because until recently South Sudan did not have access to adequate ICT services. Most of the ICT connectivity existed only in Sudan.

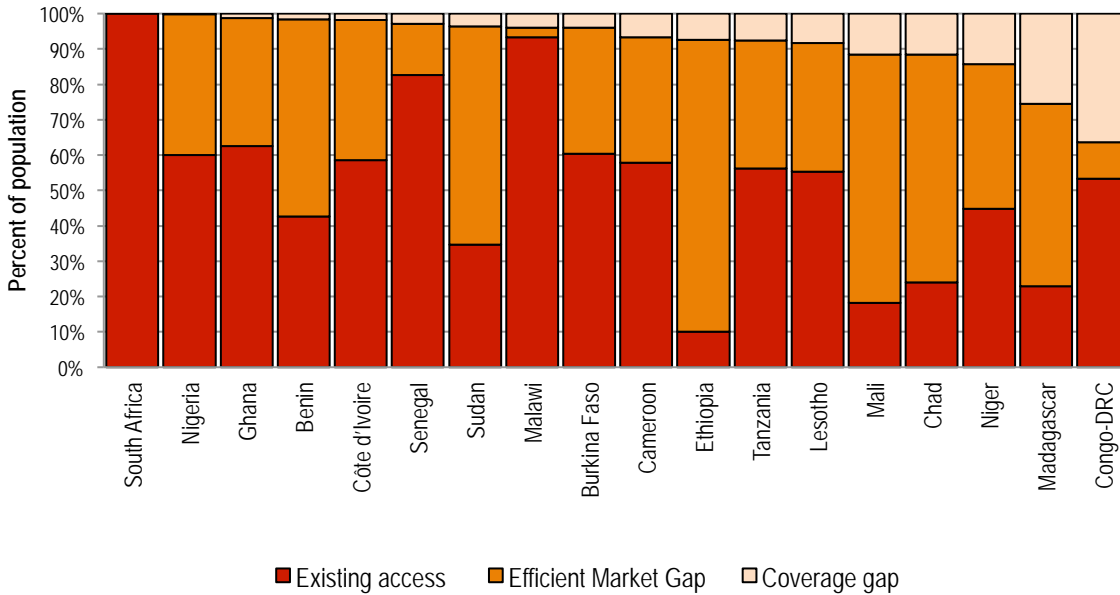
Analysis of 2006 data for all parts of Sudan suggests that almost 98 percent of the population could access mobile telephony on a commercially viable basis (figure 26). This result is based on the assumption that 4 percent of local income in each area could be captured as revenue for voice telephony

⁷ Global system for mobile communications.

services. The gap in universal access to telephony can be closed relatively easily for Sudan on a commercial basis. A small subsidy could aid in reaching the uncovered 2 percent of the population.

For broadband infrastructure, simulations present an optimistic picture. Around 96 percent of all parts of Sudan’s population could gain access to limited performance WIMAX⁸ broadband infrastructure on a commercially viable basis. A gap of 3 to 4 percent exists in the northwest region of all parts of Sudan—primarily a desert—and in the south (figure 27)

Figure 26. A small subsidy could have closed the mobile telephony coverage gap in all parts of Sudan



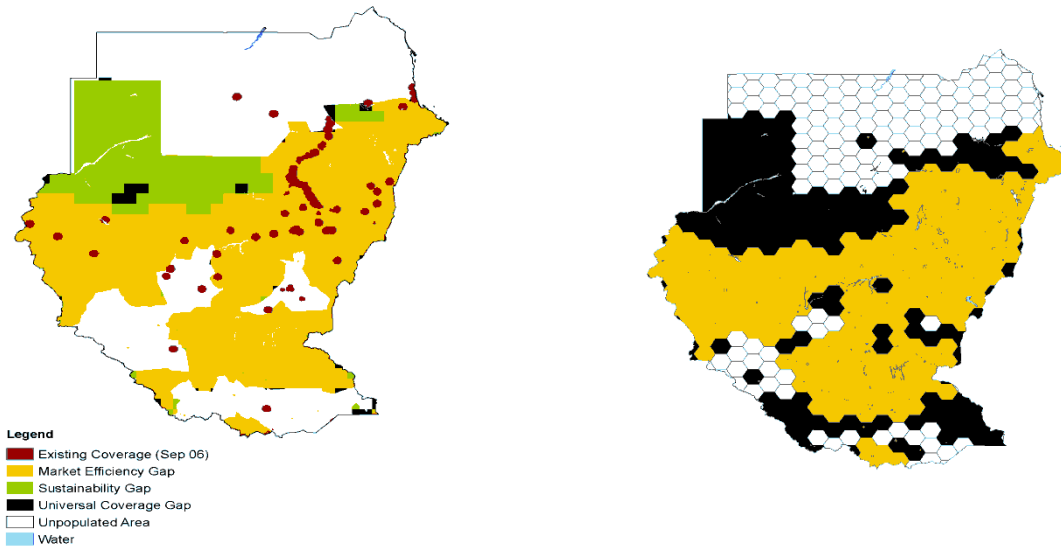
Source: Mayer and others 2009.

The advent of undersea fiber-optic cables has enabled Sudan to develop a strong ICT infrastructure backbone (figure 26). Three undersea cable systems land in Port Sudan: SAS-1 (providing a direct link to Saudi Arabia), Flag Falcon, and, most recently, the Eastern Africa Submarine Cable System (EASSy). In addition, there are terrestrial links to Egypt and Ethiopia and a 10,000 km domestic fiber backbone (Sudatel 2009). The EASSy has established a landing station in Sudan. Significant private investment has facilitated Sudan’s fiber-optic connectivity. Sudan needs to establish overland connections to the cable to complete the national ICT backbone

The emergence of competition in gateways as a result of connectivity to the undersea cable has facilitated very attractive prices for ICT services in Sudan—among the most attractive in Sub-Saharan Africa. Sudan pays a third of what resource-rich countries pay and a fourth of what low-income countries pay for the mobile basket. Landline telephony, which has not experienced any growth, has also seen its prices slashed. But prices for fixed broadband are the most striking. In 2005 all parts of Sudan paid 10 percent of what resource-rich countries paid for their ICT services and 8 percent of what low-income countries paid (table 15).

⁸ Worldwide interoperability for microwave access.

Figure 27. The voice telephony gap could easily have been filled in Sudan



Source: Mayer and others 2009.

Evidence from Sub-Saharan Africa suggests that access to the submarine cable has generally reduced costs of ICT services when international gateways are present (table 16). Sudan has established competition in its international data gateways and partial competition in its international long-distance gateway. The pricing of ICT services, particularly Internet-access prices, reflects the emergence of competitive gateways (table 15). Prices to call within the region are consistent with those of other countries that have established competition in international long distance, and are half what resource-rich and low-income countries pay in general. Prices to call the United States are half what low-income and resource-rich countries pay on average (table 15), but are double those of countries that have established competitive gateways (table 16).

Table 16. Prices of Internet and phone calls in Sub-Saharan Africa, with and without access to submarine cables

\$	Call within region	Call to the United States	Internet dial-up	Internet ADSL
Without submarine cable	1.34	0.86	68	283
With submarine cable	0.57	0.48	47	111
Monopoly on international gateway	0.70	0.72	37	120
Competitive international gateway	0.48	0.23	37	98

Source: AICD calculations.

Note: ADSL = asymmetric digital subscriber line.

Sudan has made impressive strides in liberalizing its ICT markets and now boasts one of the most liberalized markets in Africa. The original National Telecommunication Authority has been dissected into two core competencies. The National Telecommunication Corporation (NTC), the industry regulator, was established in 2001 and took on the function of regulation and supervision. The provision of ICT services was licensed to private operators. One operator, Sudatel, was established in 1994 as a public company and subsequently floated on the regional stock market. The government owns around 21 percent of the

company and the rest is owned by other private entities. Shares in Sudatel have been available to the public since 1997 and are traded on several Middle Eastern stock markets. Sudatel is also a strategic investor in its own right, with operations in Mauritania and Senegal as well as Ghana and Nigeria. Now there are two fixed-line operators (Sudatel and Canar) and three nationwide GSM mobile operators (Sudatel, MTN, and Zain), which also operate in South Sudan.

By establishing a universal service fund, Sudan is garnering funds to expand service coverage to economically unviable rural areas. Effective from 2009, mobile network operators pay 2 percent of their gross revenues into a universal access fund, plus \$0.87 per customer per year. Proceeds from the fund are expected to be used to subsidize rollouts in otherwise economically unfeasible rural areas (Lange 2010).

Financing Sudan's infrastructure

To meet its most pressing needs, Sudan has to significantly improve infrastructure in key areas. For the purpose of this report, illustrative targets have been set using standardized criteria and assuming a time horizon of 10 years to meet the targets. For example, it is reasonable to assume that the water and sanitation Millennium Development Goals (MDGs) can be attained using a mix of technological options. Similarly, targets for increasing electrification assume, at least, doubling the current access rates, which in one case implies reaching 55 percent of the population on average. In the case of transport, national connectivity involves connecting centers with populations larger than 25,000 people. This translates into a need for 5,372 km of road in good condition in the north (table 17).

Table 17. Illustrative investment targets for infrastructure in Sudan

Sector	Economic targets	Social targets
ICT	Install fiber-optic links to neighboring capitals and submarine cable. Add 26,900 base stations for urban and 41,204 base stations for rural.	Provide universal access to GSM signal and public broadband facilities.
Power	Assuming trade stagnation, estimate optimal (least-cost) investment strategies for generating, transmitting, and distributing electricity in response to demand increases. Achieve exogenously determined electrification rates. Develop 440 MW of new generation capacity (no trade scenario). This scenario could be replaced under trade expansion with 2,200 MW of generation capacity and the needed megawatts in interconnectors.	Raise electrification from 37 to 55 percent of population (100 percent urban, 30 percent rural).
Transport	Achieve regional (national) connectivity across Sudan with good-quality 2-lane (1-lane) paved road. Provide rural road access to 100 percent of the highest-value agricultural land based on current production, plus providing rural road access to 50 percent of the nonproductive agricultural land with highest potential. Add or rehabilitate roads to have the following number of kilometers in good condition: 5,372 km for national connectivity, 2,893 km for regional connectivity, 4,226 km in urban areas, and 34,200 km in rural areas.	Provide urban road access within 500 square meters.
Water	Increase population with access to improved water to 72 percent of the population and access to improved sanitation to 76 percent of the population. Target technology mix for improved water: Piped water (23% urban, 0% rural), standposts (52% urban, 12% rural), safe wells (25% urban, 88% rural).	Achieve Millennium Development Goals by preserving the current mix of sanitation technological options and clearing the sector rehabilitation backlog.

Source: Mayer and others 2009; Rosnes and Vennemo 2009; Carruthers, Krishnamani, and Murray 2009; You and others 2009.

Sudan would need to spend \$4.2 billion a year—or 20 percent of its GDP—over the next decade to meet infrastructure targets (table 18). After South Africa and Nigeria, these are the largest infrastructure spending needs for any Sub-Saharan African country. They are broadly comparable to the needs faced by the Democratic Republic of Congo and Ethiopia. As explained earlier, the massive needs are driven by the initial starting conditions and are based on reasonable assumptions regarding what outputs are attainable. The estimates are conspicuously large (i) because the land area of the country is massive, with large pockets of uninhabited terrain, and (ii) because of the low starting point, particularly in the water and transport sectors.

Table 18. Indicative infrastructure spending needs in Sudan, 2006–15

US\$ million per year				
Sector	Capital expenditure	Operations and maintenance	Total needs	Total needs as share of GDP
ICT	267	43	310	1.45
Irrigation	—	—	—	—
Power (nontrade)	320	104	424	1.98
Transport	1,295	490	1,785	8.35
Water supply and sanitation	1,422	280	1,701	7.97
Total	3,303	917	4,220	19.8

Source: Mayer and others 2008; Rosnes and Vennemo 2009; Carruthers, Krishnamani, and Murray 2009; You and others, AICD 2009. Derived from models available online at www.infrastructureafrica.org/aicd/tools/models.

Note: ICT = information and communication technology.

— = Not available

The transport and the water and sanitation sectors have the highest financing needs. About \$1.8 billion would be needed to provide minimum surface connectivity and around \$1.7 billion would be needed each year to meet the MDGs for water and sanitation. Particularly in the water network, decades of war have created an enormous rehabilitation backlog. For example, 40 percent of rural water assets and 42 percent of urban water assets need rehabilitation for Sudan as a whole. Transport needs are largely driven by the need to maintain regional corridors and upgrade existing rural tracks to make them usable.

A distant second are the needs for power, at \$424 million. The spending needs estimates assume that only the power infrastructure needed to meet domestic demand is developed. The estimates would be substantially higher if the development of power export potential were also considered—that is, if Sudan were also to fully develop its 3,000 MW of hydropower export potential, a further \$1.1 billion would be needed annually to develop additional capacity and interconnectors.

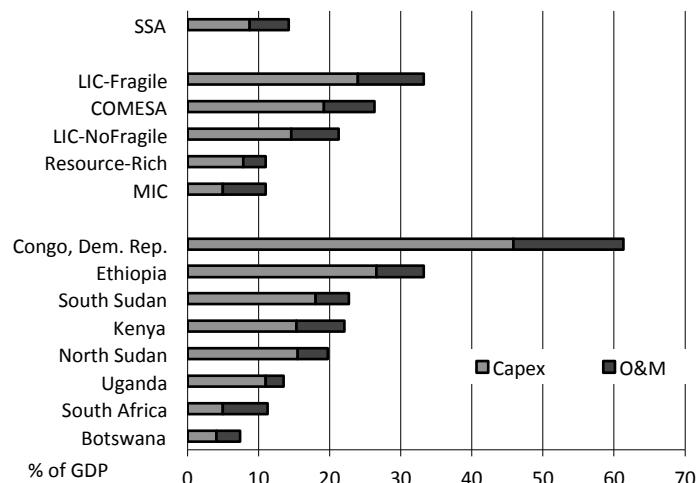
Needs estimates for ICT, at \$310 million a year, are the lowest among the sectors. This is because of the recent ICT boom, which has largely been financed by the private sector. While an undersea cable is accessible via Port Sudan, overland connections to the cable need to be financed to complete the national ICT backbone.

At 20 percent of GDP, Sudan's needs are twice as high as other resource-rich economies in Africa and broadly comparable to those of low-income countries such as Kenya, Senegal, and Madagascar (figure 28). These needs in terms of the economy's size are strikingly high given the recent oil influx and revamping of infrastructure investments. New investments account for over three-quarters of total needs

and are around 15 percent of GDP—roughly equivalent to what China has been investing on its own domestic infrastructure development in recent years.

Figure 28. Sudan's infrastructure spending needs in the regional context, as share of GDP

Estimated infrastructure spending needed to meet targets, as percentage of GDP



Source: Foster and Briceño-Garmendia 2009.

Note: Values excludes irrigation.

LIC = low-income country; MIC = middle-income country; COMESA = Common Market for Eastern and Southern Africa; SSA = Sub-Saharan Africa; GDP = gross domestic product; O&M = operations and maintenance; CAPEX = capital expenditure.

Sudan already spends a sizable amount—\$1.5 billion per year, or 7 percent of GDP—to meet its infrastructure needs (table 19). In terms of the economy's size, the aggregates are comparable to what middle-income countries spend and perhaps slightly higher than what other resource-rich countries spend (figure 29). About 60 percent of the total infrastructure spending is allocated to capital expenses and 40 percent to operating expenditures. Operating expenditure is entirely covered from budgetary resources and payments by infrastructure users. The composition of financiers indicates that Sudan has been able to capitalize on the interest of non-Organisation for Economic Co-operation and Development (OECD) investors and the private sector.

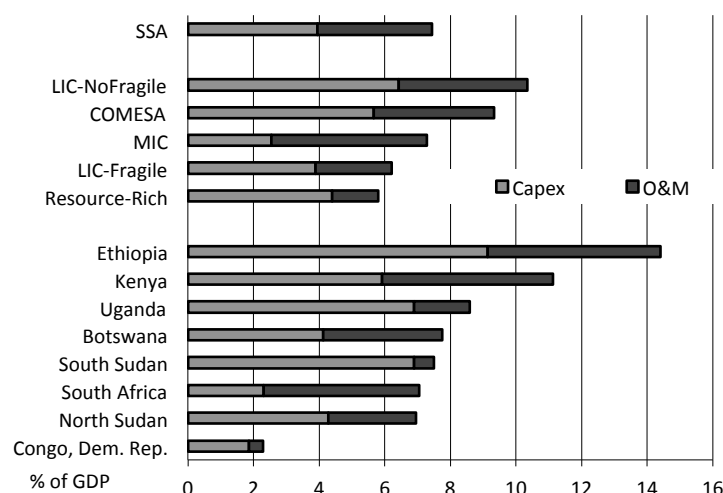
Table 19. Financial flows to Sudan's infrastructure, average 2001 to 2005

\$ millions per year	O&M		Capital expenditure				Total spending	Total spending as share of GDP
	Public sector	Public sector	ODA	Non-OECD financiers	PPI	Total CAPEX		
ICT	4	5	0	35	209	249	253	1.18
Power	281.9	104	0	304	0	409	690	3.23
Transport	282.0	183	22	22	0	227	509	2.38
WSS	2	6	12	5	7	31	32	0.15
Total	570	298	35	366	215	915	1,485	6.95

Source: Derived from Foster and Briceño-Garmendia (2009).

Note: O&M = operations and maintenance; ODA = official development assistance; PPI = private participation in infrastructure; CAPEX = capital expenditure; OECD = Organisation for Economic Co-operation and Development; WSS = water supply and sanitation; ICT = information and communication technology; GDP = gross domestic product.

Figure 29. Sudan's current infrastructure spending is average by African standards



Source: Foster and Briceño-Garmendia 2009.

Note: Values excludes irrigation.

LIC = low-income country; MIC = middle-income country; COMESA = Common Market for Eastern and Southern Africa; SSA = Sub-Saharan Africa; GDP = gross domestic product; O&M = operations and maintenance; CAPEX = capital expenditure.

The largest single financier of infrastructure investment is China, followed by Indian and Arab investors. Together they account for 40 percent of total annual investments, almost entirely allocated to the power sector. China's partnership with Sudan in infrastructure development dates back to 2001, with cumulative total financing commitments on the order of \$2 billion in 2010. Sudan benefits from a \$3 billion framework agreement signed in December 2007, one of the largest to have been accorded to any African country to date. Chinese projects are providing some 2,200 MW of new thermal power generation, and the country is responsible for the now-completed 1,250 MW Merowe Dam and associated 1,800 km transmission line. China has also been involved in the reconstruction of some 1,500 km of roads (table 20).

Sudanese federal and state governments and state-owned enterprises (SOEs) account for an additional third of Sudan infrastructure investments, and have focused on transport and to some extent power. The remaining capital funding comes from the private sector, which, as in most of the rest of Africa, supports the ICT boom. ODA flows have played a very small role in capital infrastructure financing.

Capital investments in Sudan are heavily skewed toward the power sector, much of this funded by China. Investment levels in ICT and transport are comparable

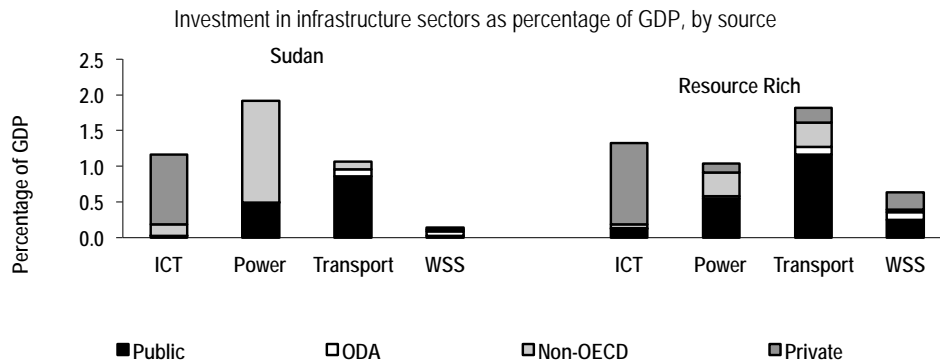
Table 20. Identified infrastructure projects financed by non-OECD financiers

US\$ million	Project costs
China	949
Construction of 300 MW gas-fired power plant in Al-Fulah	518
Construction of the El-Gaili Combined Cycle Power Plant, Phase 1	150
NEC transition line	81
White Nile electricity network	200
China and Arab countries	1,200
Construction of the Merowe hydroelectric dam (1,250 MW)	1,200
India	475
Setting up 4x125 MW Kosti Combined Cycle Power Plant	475
Total	2,624

Source: Foster, etc (2009). Calculations based on World Bank-PPIAF Chinese project database. (<http://ppi.worldbank.org>), in current \$ millions .

in magnitude, with the former sourced largely from the private sector and the latter from the public sector. Investments in water and sanitation are absent.

Figure 30. Sudan's pattern of capital investment in infrastructure and that of comparator countries



Source: Derived from Briceño-Garmendia, Smits, and Foster (2009).

Note: Private investment includes self-financing by households. ODA = official development assistance; OECD = Organisation for Economic Co-operation and Development; ICT = information and communication technology; GDP = gross domestic product; WSS = water supply and sanitation; LIC = low-income country.

How much more can be done within the existing resource envelope?

Even without increasing spending, additional resources could be directed toward infrastructure by eliminating inefficiencies. This report quantifies some operational inefficiencies based on measurable and observable performance indicators. The first type relates to operators and/or infrastructure providers, including utilities, SOEs, and special funds. For this type of estimate, providers within Sudan will be compared against well-functioning utilities in Africa and/or engineering norms. These comparisons will cover (i) underrecovery of costs: comparing effective tariffs and user fees against actual unit costs of providing the service; (ii) overstaffing: assessing the difference between average labor cost per connection of the utility evaluated against a well-functioning utility; (iii) distribution losses: assessing the difference between distribution of losses of the evaluated system against engineering norms for a system of similar age and characteristics; and (iv) undercollection: assessing the ability of the operator to collect bills within the year against a standard of full revenue collection. In addition, the analysis measures the ability of governmental agencies to execute their budget allocations for capital projects within the fiscal year.

The analysis suggests that Sudan can recover \$584 million each year by reducing inefficiencies in the system (table 21). Most of the efficiency gains are associated with aligning tariffs to cost-recovery levels and reducing distribution losses in both the water and power systems. Increasing tariffs to cost-recovery levels could save \$378 million in power and \$15 million in water sectors annually. Distributional losses in power cost \$106 million per year, and another \$27 million in the water sector. Undercollection of bills for water services could save a significant \$35 million. Finally, budget underexecution is a significant issue in the transport sector, leading to underspending of about \$20 million of available funds annually.

Table 21. Sudan's potential gains from greater operational efficiency

US\$ million	ICT	Irrigation	Power	Transport	WSS	Total	Total as share of GDP
Underrecovery of costs	—	n.a.	378	n.a.	15	393	1.84
Overstaffing	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Distribution losses	—	n.a.	106	—	27	133	0.62
Undercollection	—	n.a.	0	n.a.	35	35	0.17
Low budget execution	0	n.a.	0	20	2	22	0.10
Total	0	n.a.	484	20	79	584	2.73

Source: Derived from Foster and Briceño-Garmendia (2009).

Note: WSS = water supply and sanitation; ICT = information and communication technology; GDP = gross domestic product.

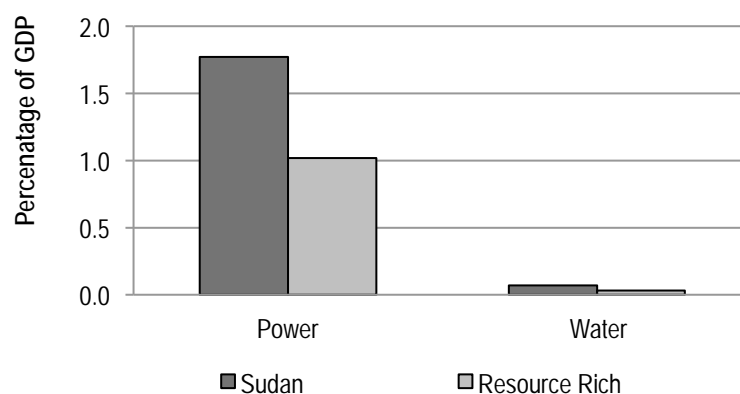
— = Not available.

n.a. = Not applicable.

The power sector offers the largest potential savings—up to \$584 million per year—if the operational inefficiencies of its utility were tackled. Undercharging for power costs Sudan about \$380 million each year, or around 1.8 percent of the country's GDP. If compared with the rest of Africa, where underpricing of power is commonplace, the National Power Corporation of Sudan (NEC) is doing better than utilities in other resource-rich countries on average, but is nevertheless a poor performer (figure 31).

Figure 31. Underpricing of power and water in Sudan

Financial burden of underpricing, as percentage of GDP



Source: Derived from Briceño-Garmendia, Smits, and Foster (2009).

The NEC's 2004 distributional losses of 33.4 percent are three times the best-practice 10 percent benchmark, resulting in a staggering \$106 million cost of inefficiencies.

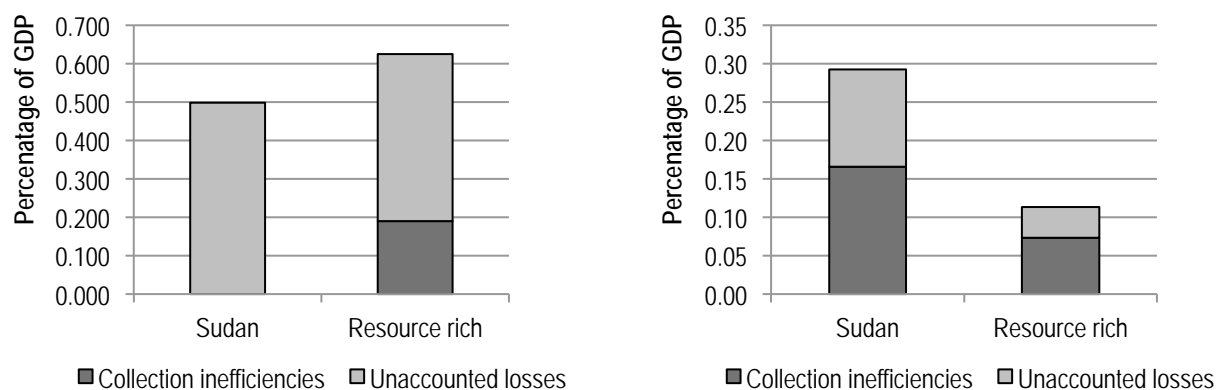
In the water sector, average tariffs stand at \$0.6 per cubic meter versus an estimated \$0.69 per cubic meter average cost-recovery tariff. The macroeconomic burden of 0.007 percent of GDP is much lower than that for power, but is comparatively higher than that of other resource-rich countries.

Operational inefficiencies are also plaguing the water sector, and cost Sudan about \$62 million a year, equivalent to 0.3 percent of GDP. This cost could be avoided by increasing the collection efficiency for

water services and reducing nonrevenue water. In the water sector, the burden of operational utility inefficiencies is considerably higher than for the benchmark countries (figure 32).

Figure 32. The burden of inefficiency in Sudan's power and water utilities

- a. Uncollected bills and unaccounted losses in the power sector, as a percentage of GDP
- b. Uncollected bills and unaccounted losses in the water sector, as a percentage of GDP



Source: Derived from Briceño-Garmendia, Smits, and Foster (2009).

Annual funding gap

Sudan's annual infrastructure funding gap amounts to \$2.9 billion per year, or roughly 14 percent of GDP (table 22). The largest funding gap is in the water and sanitation sector, followed closely by transport. Given strong private investment, only a small funding gap remains in ICT. In the case of power, existing spending is sufficient. But if power tariffs could be raised to cost-recovery levels, much more of this expenditure could be funded internally, freeing up external finance for other critically needed areas.

Table 22. Funding gaps by sector

US\$ million	ICT	Irrigation	Power	Transport	WSS	Total	Total as share of GDP
Spending needs	(310)	—	(424)	(1,785)	(1,701)	(4,220)	(19.8)
Existing spending*	253		424	509	32	1,218	5.7
Reallocation potential within sectors	0		0	0	0	0	
Efficiency gains	0		484	20	79	584	2.7
Funding gap	(57)		—	(1,255)	(1,590)	(2,902)	(13.6)
Reallocation potential across sectors	0		267	0	0	267	1.2

Source: Derived from Foster and Briceño-Garmendia (2009).

Note: Estimates use the base scenario of spending needs. Potential overspending across sectors is not included in the calculation of the funding gap, because it cannot be assumed that it would be applied toward other infrastructure sectors.

WSS = water supply and sanitation; ICT = information and communication technology; GDP = gross domestic product.

*traced to needs

**Assuming complete fungibility across sectors

— = Not available.

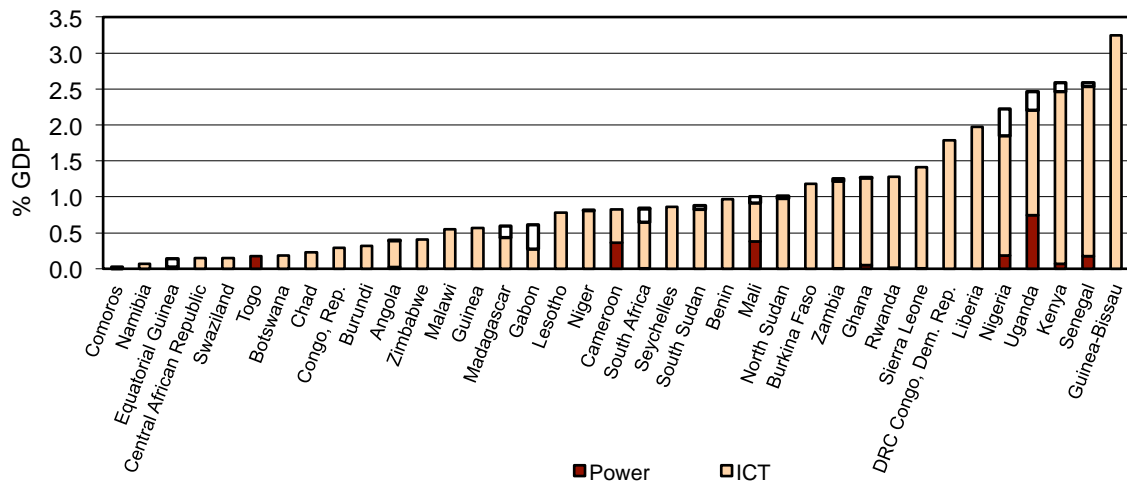
What else can be done?

Sudan’s funding gap is large relative to the size of its economy, and enormous with respect to its current level of spending. Nevertheless, there are a number of options that could make it more manageable, including raising additional finance, taking additional cost-cutting measures, and lengthening the period of time allotted for meeting the illustrative infrastructure targets. In any case, given the magnitude of the gap, difficult decisions will have to be taken regarding the prioritization of the different investments.

There are realistic prospects for increasing the flow of resources to infrastructure. Although not all components of the required infrastructure platform are suitable for private finance (particularly roads, water, and sanitation), other components may be (for example, ICT, power generation, and ports). Challenges for attracting private investors are conspicuous particularly due to the country risks linked to the instability of the country, repeated violations of the rule of law, and the very poor ranking of Sudan’s governance compared to its peers in Africa.

Sudan has captured private investment commitments worth around 1 percent of its GDP, predominantly in the ICT sector. Many other African countries have done significantly better in this area (figure 33). Countries such as the Democratic Republic of Congo, Liberia, Nigeria, Uganda, Kenya, and Senegal have all captured between 1.8 and 2.5 percent of GDP, while the most successful country in this regard—Guinea-Bissau—has captured in excess of 3.0 percent of GDP.

Figure 33. Many African countries capture more private investment than Sudan



Source: PPI Project Database. (<http://ppi.worldbank.org>), in current \$ millions.

Adopting lower-cost technologies could substantially reduce the cost of meeting the posited infrastructure targets, and help make the funding gap manageable. Meeting the MDGs for water supply and sanitation with lower-cost technologies than previously used (such as stand posts, boreholes, and improved latrines), could reduce the associated price tag from \$1,701 million to \$889 million each year. Similarly, meeting transport connectivity standards using lower-cost road-surfacing technologies (such as single-surface treatment) together with a rural policy that narrows its focus exclusively to provide 100 percent accessibility currently active (as opposed to potential) agricultural land postponing, could reduce

the associated price tag from \$1,785 million to \$771 million. The overall savings from these measures would amount to \$2 billion for Sudan (table 23).

If Sudan were unable to raise additional financing or reduce infrastructure costs, the only way to meet the targets identified here would be to take longer than ten years to do so. If the

Table 23. Savings from innovation

\$ millions	Before innovation	After innovation	Savings	Savings as % of sector funding gap
WSS appropriate technology	1,701	889	812	51
Roads appropriate technology	1,785	1,124	660	53
Total	3,486	2,014	1,472	51

Source: Derived from Foster and Briceño-Garmendia, AICD Flagship Report, 2009
Note: WSS = water supply and sanitation.

country were able to instantly realize all potential efficiency gains while holding spending at current levels, it could meet the identified infrastructure targets within 30 years. These simulations underscore the importance of making progress on the efficiency agenda, which could propel the country forward toward meeting its infrastructure targets.

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This country report draws upon a wide range of papers, databases, models, and maps that were created as part of the Africa Infrastructure Country Diagnostic. All of these can be downloaded from the project Web site: www.infrastructureafrica.org. For papers go to the document page (www.infrastructureafrica.org/aicd/documents), for databases to the data page (www.infrastructureafrica.org/aicd/tools/data), for models go to the models page (www.infrastructureafrica.org/aicd/tools/models), and for maps to the map page (www.infrastructureafrica.org/aicd/tools/maps). The references for the papers that were used to compile this country report are provided in the table below.

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