SUMMARY TO BACKGROUND PAPER 7

AFRICA INFRASTRUCTURE COUNTRY DIAGNOSTIC

Improving Connectivity: Investing in Transport Infrastructure in Sub-Saharan Africa

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About AICD

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

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

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

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

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

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

Investment in transport infrastructure in Sub-Saharan Africa

by Robin Carruthers and Ranga Rajan Krishnamani, with Siobhan Murray

Roads, bridges, rail lines, ports, and airports deliver economic and social benefits by connecting firms to international and regional markets, and by enabling individuals to reach water, fuel, schools, clinics, jobs, and relatives. Without reliable and competitively priced freight transport over sturdy infrastructure, nations have little hope of trading their goods on the most advantageous terms. If they cannot transport their produce to market from isolated rural areas, farmers will be unable to break out of subsistence agriculture. If they cannot transport their children to schools and clinics, the next generation will fare no better. Transport makes markets work.[1]

When infrastructure is absent or degraded, it no longer fulfills its connective functions, and the economy suffers. As essential transactions and movements are delayed or disrupted, transport costs rise, individuals lose time in unremunerated commuting, and firms must fight harder to compete. To restore the connections, new infrastructure must sometimes be built, or—more frequently—old infrastructure restored or improved.

Transport infrastructure is not cheap. The huge investments required to build highways, railways, and ports must be well planned. If regularly maintained, transport infrastructure can be long-lived. But without maintenance, these valuable assets can disappear in a matter of a few years. Too often, the same roads end up being rebuilt over and over again, at a cost several times higher than if the appropriate maintenance measures had been taken on time.

An integrated model for costing investment needs

The model described here—constructed after an exhaustive review of national transport plans in Sub-Saharan Africa—is designed to facilitate the planning of transport investments by enabling planners, policy makers, and financiers to explore the costs of achieving a range of targets for a country's transport infrastructure and to estimate the full cost implications of achieving them. The effect of adjusting targets or altering the engineering standards used to reach those targets can be readily explored. At the same time, the model forces the user to go beyond a project-by-project view of the transport sector to examine the cost of developing an entire country network to a desired level of social and economic "connectivity." An online version of the model will allow users to run any number of other scenarios for themselves.

The model reflects a very detailed appreciation of the spatial configuration of each country based on extensive use of geographic information systems (GIS). As a result, investment needs are documented in

[1] This note summarizes recent and ongoing research on transport investment in 24 African countries performed at the World Bank under the aegis of the Africa Infrastructure Country Diagnostic. The full report, with detailed country annexes and technical notes, is available at http://www.infrastructureafrica.org.

a location-specific way. The platform includes geographical databases covering the following attributes of the African continent: spatial distribution of population, administrative boundaries, geographic and environmental features, and infrastructure facilities. The data on infrastructure facilities include the African road and rail map produced by the Digital Chart of the World, plus georeferenced information on the full set of ports and airports. That database was primarily used to calculate the distance (in transport network kilometers) between the geographic and demographic features of interest in each country.

Connecting people to economic centers

Our connectivity approach required us to identify the key geographic and demographic features of each country and then to quantify the transport infrastructure needed to connect those features using GIS to measure the necessary distances. The methodology distinguishes between four different types of connectivity: regional, national, rural, and urban.

Regional (or international) connectivity. Regional connectivity refers to the infrastructure needed to connect national capitals and all other large cities (those with a population of more than 250,000) to the main international border crossings and major deep sea ports . The infrastructure considered appropriate to achieve this regional connectivity includes interurban roads with at least two paved lanes and hard shoulders of at least 2 meters on each side; an international airport with a lighted paved runway at least 3,000 meters in length; a railway with a maximum axle load of at least 20 tons; and access to a container port by a two-lane paved road. In addition, the capacity of deep sea ports is adjusted so as to provide at least one 300-meter berth for each 0.5 million TEU (20-foot equivalent unit) of container freight.

National connectivity. National connectivity refers to the infrastructure needed to connect provincial capitals and other secondary cities (with a population of at least 25,000) to the regional network described above. The infrastructure considered appropriate to achieve this national connectivity consists of one-lane paved roads.

Rural connectivity. Rural connectivity is based on the World Bank's Rural Accessibility Index (RAI), which expresses the percentage of the rural population living within two kilometers of an all-season road. The existing values of the RAI for the countries in the study range from a low of 5 percent for Sudan to a high of 67 percent for Lesotho. Only 7 of the 24 countries have RAI values above 50 percent.[2] The average for the AICD countries (excluding Cape Verde) is 34 percent.

The model calculates the cost of meeting different target values of the RAI. Raising the value of the RAI initially involves upgrading the quality of the tertiary road network, then improving the network of unclassified roads (those below the tertiary level), and ultimately adding additional links to the unclassified network to reach the most isolated villages. Evidently, each successive increment in the RAI becomes increasingly costly, as more kilometers of road are needed to reach increasingly isolated segments of the population. In fact, moving from an RAI of 40 to 75 percent would involve doubling the length of the classified network in the countries concerned (figure A).

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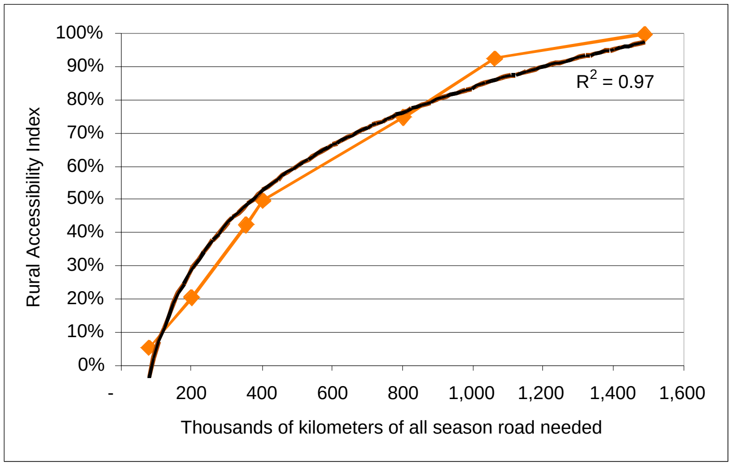
[2] For five of these seven countries, the values have been derived from a mathematical model for which we have been unable to find the specification. For one, the RAI value was obtained from a household survey. For another (Namibia), the results were derived by GIS methods.

Urban connectivity. Sub-Saharan Africa's cities have strikingly underdeveloped urban networks, reaching only about 128 meters of road per thousand residents compared to 700 meters per thousand in the low-income countries of the developing world. Urban connectivity is based on the concept of ready access to a one-lane paved road capable of supporting year-round access by a bus service or equivalent motorized vehicle, such as an ambulance or a fire engine.

Figure A Length of network needed to reach different levels of the Rural Accessibility Index



Knowing the population and area of each of about 140 cities in Sub-Saharan Africa, we were able to estimate the paved road length that would be necessary to ensure that no resident had to walk more than a specified distance to a paved road that could sustain a bus route, and achieve a minimum length of paved road per urban resident. We added to that distance a grid of roads of a higher standard that would serve as radial and principal roads. In doing so, we took into account projected growth in the urban population up to the year 2015.

Different levels of ambition

For each of these dimensions of connectivity, two levels of ambition are considered.

Base (or ideal) scenario. The base scenario assumes that all regional and national connectivity standards will be met using paved roads, of at least 2-lanes for regional and at least 1-lane for national connectivity. The RAI will be 75 percent, achieved through the use of single-surface-treatment roads. Urban connectivity aims for a target of 500 meters walking distance to an all-season road, met using asphalt roads and at least 300m of paved road per 1,000 urban residents.

Pragmatic scenario. In recognition that the base scenario may prove to be prohibitively costly for some countries, an alternative pragmatic scenario was also considered. The pragmatic scenario aims to meet a similar degree of regional and national connectivity at a lower cost, essentially by reducing the standards of infrastructure (for example, by substituting a single-surface-treatment road for an asphalt road) and by lowering the target condition (for example, maintaining infrastructure to at least fair condition rather than to good condition). The pragmatic scenario also reduces the level of ambition for rural and urban connectivity. The RAI target drops from 75 percent to 50 percent, and it may be met using all-weather gravel roads rather than single-surface-treatment roads. The urban accessibility target drops from 500 meters to 1,000 meters maximum walking distance to an all-season paved road capable of supporting a bus service, and at least 150 meters of paved road per 1,000 urban residents. Both these criteria would be met using an all weather gravel road rather than a paved road.

As much about quality as quantity

Achieving the specified connectivity standards is not simply, or even primarily, about creating new transport infrastructure. We found that, with a few important exceptions, Sub-Saharan Africa has almost as much transport infrastructure as it needs. The real issue is improving (and preserving) the quality of that infrastructure, which can mean both improving the condition of existing infrastructure or upgrading its category. In order to keep these distinctions clear, we report the estimated spending needs broken down by each of the following categories.

Improving condition. This refers to the costs of improving the condition of current transport infrastructure, so as to minimize ongoing maintenance costs. We obtained estimates of, or made informed assumptions about, the quantity of current infrastructure in each country that is in good, fair, and poor condition. To estimate the cost of bringing infrastructure in fair or poor condition up to fair or good condition, we multiplied the quantities of such infrastructure by the unit costs of improvement.

Upgrading category. This refers to the costs of upgrading the category of existing transport infrastructure to a level adequate to the demands made upon it. Examples include roads that need to be widened or have their surface upgraded from unpaved to paved, airport runways and port berths that need to be lengthened to meet current demands, and railways that need to be strengthened so as to bear heavier axle loads.

Extending networks. This refers to the costs of creating new infrastructure assets that did not previously exist. Examples include providing missing links of the road networks, providing new runways at unserved locations, and adding additional berths to increase port capacity. We used a combination of methods to estimate the optimal or desired extent of transport infrastructure networks or assets. The resulting target quantities were compared with present levels to determine the quantity of new infrastructure that needs to be provided.

Maintaining assets. This refers to the costs of maintaining the final network in its improved, upgraded, or expanded form. The poor condition of transport infrastructure in the region reflects insufficient attention to maintenance. The most common consequences of poor maintenance are lower operating speeds and higher costs of maintaining the vehicles that use the infrastructure. Unless more resources are allocated to maintenance, the benefits of improving the condition, upgrading the category, or expanding the quantity of transport infrastructure will be temporary.

The costs of better transport

Using the data described above, the model calculates the quantities of additional infrastructure required to meet the targets specified in the base and pragmatic scenarios, and then the associated cost of that infrastructure based on a detailed unit cost matrix reflecting recent experience in World Bank projects.

A call for more and better roads in rural areas and cities, and for upgrades in other modes

The targets for regional road connectivity set in both the base and pragmatic scenarios are nearly met by present infrastructure stocks, requiring only the building of the missing segments of the Trans-African

Highway (about 4,300 km). Greater challenges lie in meeting the *quality standards* set for regional roads (a surprising 27 percent of the regional network is not yet paved, and only 32 percent of the network is in good condition) and in achieving the regional-connectivity standards for air, rail, and sea transport.

Meeting the targets for national road connectivity would require adding some 7,700 km of roads under both scenarios, a relatively small amount. The national roads in the sample total approximately 111,750 km for the 23 countries, about 50 percent longer than the regional network. About 46 percent of that length already meets the one-lane paved standard for this class, with the remaining 54 percent having either a gravel or earth surface. On balance, the condition of national roads is not as good as that of the regional network, with only 28 percent being in good condition, 15 percent in fair condition, and more than half in bad condition.

Meeting the rural accessibility standard articulated in the base scenario (75 percent of the rural population living within two kilometers of an all-weather road) would require a road network of more than 1.1 million km. Only a fraction of that length is provided by the regional and national road networks. The first place to look to make up the difference is the remainder of the road networks of the countries. Eleven of the 23 countries (rising to 15 under the pragmatic scenarios) would not have to add any new roads to their present officially classified road network to reach the rural accessibility standard. What they *would* have to do to meet the standards stipulated in the scenarios is to maintain their roads in good condition. In the remaining 12 countries (or 8 under the pragmatic scenario), some or all of the unclassified road network would have to be upgraded to all-weather roads and maintained in good condition and some new roads built for the rural accessibility standard to be met.

As for urban roads, meeting the connectivity target specified in the base scenario for the projected urban population would require 83,800 km of paved roads, far more than the 28,000 now in place. The pragmatic scenario would require 44,500 km. None of the 23 countries now has a network of paved urban roads that is large enough to satisfy the base standard; only two (Lesotho and Namibia) rise to the pragmatic standard.

The scenarios' prescriptions for additional airport runways and terminals take into account projected growth in air passengers and air freight, while the numbers for port berths reflect projected increases in international trade and its changing composition (minerals and other primary products vs. manufactured products).

Maintenance absorbs the bulk of required expenditures

The investment cost of meeting the targets for transport infrastructure articulated in the base scenario for the sample of 23 AICD countries would average about 2.6 percent of GDP each year for the 10 years between 2006 and 2015 (table A). Based on the sample of countries considered here, that would put the cost for the whole of Sub-Saharan Africa at $209 billion and about 3% of GDP Almost half of the total (47 percent) would be needed for maintenance. The other three spending categories—improving the condition of present infrastructure, upgrading it to a higher category, and building new capacity—would absorb roughly equal shares of the remaining 53 percent.

Viewed by mode, rural roads would absorb more than 53 percent of the spending needed to meet the targets. A little more than half of that is associated with improvements to the existing classified road network, while the remainder would go for upgrades to the unclassified network. Regional and national roads, taken together, would soak up only about 20 percent of the total. This may seem a small share, given that these are the roads that attract most attention. But it is precisely that attention, with attendant funding, that has reduced the need for further investment. Moreover, the regional and national networks are only about a quarter as long as the networks of lesser roads. They have been the best maintained, and so require much less investment to bring their condition up to standard.

Table A Investment needs for 23 AICD countries under the base scenario

		Investment purpose						
		Improve condition	Upgrade category	Expand capacity	Maintain infrastructure	Total	As % of	
Infrastructure type		US$ million					GDP	Total investment
Regional roads		3,963	181	0	6,634	10,777	0.2	6.3
National roads		3,687	10,149	1,456	8,548	23,840	0.4	13.9
Rural roads	Rest of classified network	10,645	9,512	0	28,643	48,800	0.7	28.5
	Unclassified and RAI	2,520	891	16,054	23,663	43,128	0.7	25.2
Urban roads		2,711	6,996	6,031	4,922	20,660	0.3	12.1
Airports		536	145	3,449	4,736	8,865	0.1	5.2
Ports		2,955	315	747	1,274	5,291	0.1	3.1
Railways		4,516	1,839	1,000	2,708	10,063	0.2	5.9
Total		31,532	30,028	28,736	81,127	171,424	2.6	100.0
Estimated total for all SSA		*38,000*	*36,000*	*35,000*	*100,000*	*209,000*	*3.0*	
Annual average		3,153	3,003	2,874	8,113	17,142		
As % of GDP		0.5	0.5	0.4	1.2	2.6		
As % of total		18.4	17.5	16.8	47.3	100.0		

Source: Authors.

After rural roads, national and regional roads, the next largest share is for urban roads, at just over 12 percent of the total. The length of paved road needed to achieve the urban accessibility standard is much greater than the length of paved urban roads currently maintained by national or municipal governments.

The three other modes (railways, ports, and airports) as a group require just over 14 percent of the total projected spending, with railways needing the most (nearly 6 percent) and ports the least (about 3 percent).

The cost of meeting the lower standards of connectivity and transport quality contained in the pragmatic scenario would be lower than those just described, dropping to about 1.5 percent of GDP on average. Based on the sample of countries considered here, that would put the cost for the whole of Sub-Saharan Africa at $118 billion. Moreover, meeting the lower standards would also change the distribution of investment among modes of transport and spending categories, although, significantly, the share required for maintenance would be little changed—at about 42 percent of the total.

The most important distributional change in the move from the base to the pragmatic scenario is in the share now allocated to expanding infrastructure networks. Under the pragmatic scenario, that share would fall from about 17 percent of total spending to just over 12 percent. That reduction is matched by an increase in the share allocated to improving the condition of infrastructure, which would rise from 18 percent in the base scenario to 26 percent. But the absolute amount of investment of this type would still fall substantially.

Some countries face much larger burdens than others

Because three economies (Namibia, Nigeria, and South Africa) account for almost 50 percent of the projected GDP of the 23 AICD countries and less than 30 percent of the investment needed to meet the transport infrastructure standards of the two scenarios, it is helpful to consider the 23 countries individually in terms of the share of their GDP they would have to invest to meet the targets specified under the two scenarios (table B).

Four countries (Group 1) would have to invest more than 8 percent of their GDP to meet the targets of the base scenario, an indication that the standards are too high for them to achieve in the foreseeable future. Eight countries (Group 2) would need to invest less, but still more than 4 percent of their GDP, under the base scenario, much more than any country of Sub-Saharan Africa has ever invested, and more than most developed or rapidly developing countries have ever invested.

Another group of eight countries (Group 3) would need to invest between 2 percent and 4 percent of their GDP to achieve the accessibility standards. This may be feasible for the countries at the low end of the range. The others might have some difficulty reaching the needed level of investment. The fourth and final group of three countries could meet the standards of the base scenario by investing 2 percent or less of their GDP in transport, a level comparable with their current levels of investment and with those of many more-developed countries.

Table B Level of investment needed to meet transport targets of base and pragmatic scenarios, by country and country group

% of GDP

Base scenario			Pragmatic scenario		
Group	Country	% GDP	Group	Country	% GDP
1	Congo, Dem. Rep.	25.1	1	Congo, Dem. Rep.	12.6
	Niger	12.2	2	Niger	6.2
	Chad	11.1		Chad	5.5
	Mozambique	9.4		Mozambique	5.1
2	Zambia	7.5		Zambia	4.4
	Malawi	6.3	3	Malawi	3.9
	Namibia	5.6		Namibia	3.7
	Burkina Faso	5.1		Tanzania	3.0
	Ethiopia	5.0		Burkina Faso	2.8
	Tanzania	4.9		Ethiopia	2.7
	Madagascar	4.3		Benin	2.3
	Sudan	4.0		Ghana	2.2
3	Benin	3.8		Uganda	2.2
	Ghana	3.7		Sudan	2.1
	Uganda	3.6	4	Madagascar	2.0
	Senegal	3.5		Senegal	1.8
	Côte d'Ivoire	2.6		Côte d'Ivoire	1.8
	Cameroon	2.6		Rwanda	1.7
	Kenya	2.5		Kenya	1.5
	Rwanda	2.2		Cameroon	1.4
4	Nigeria	2.0		Nigeria	1.3
	Lesotho	1.5		Lesotho	1.3
	South Africa	0.6		South Africa	0.4

The pragmatic scenario was designed to respond to the situation confronting the countries that would have had to invest more than 4 percent of their GDP to meet the standards of the base scenario. As with that scenario, the average investment required to meet the standards of the pragmatic scenario, expressed as a share of collective GDP, conceals a wide variation among countries—but the range is much reduced.

Estimating investment needs using the targets and standards of the pragmatic scenario, Group 1 now consists of only one country, and this should be considered as a special case. The transport infrastructure of the Democratic Republic of Congo was never very extensive, the Congo River serving as a natural form of infrastructure that required almost no investment. Since independence, the country has invested less in transport infrastructure than any of the other countries in the survey group, and more of its transport infrastructure has been destroyed in the course of wars than in other countries. Group 2 now includes just four countries, while Group 3 has expanded to nine. Group 4 now also has nine members, rather than just three.

The foregoing exercise demonstrates our model’s utility in computing the cost of alternative targets for social and economic connectivity, and of alternative standards for meeting those targets. Conversely, it allows planners to work backwards, adjusting targets and standards to levels consistent with the resources available to a country at a particular time.

Emerging perspectives

The analysis offered here strongly suggests a reappraisal of the current allocation of public investment in transport infrastructure. To achieve shared connectivity targets—that is, to bring people closer to jobs, services, and markets—a much greater share of investment must be directed to rural and urban roads, and, to a lesser extent, to railways, airports, and seaports.

Moreover, knowing how much infrastructure is needed to achieve any particular social or economic target is meaningless if, once obtained, the infrastructure cannot be maintained. The proportion of transport investment allocated to maintenance has never come close to the 40 to 50 percent share shown here to be needed, despite the establishment of road maintenance funds in many of the countries included in this analysis. This persistent underinvestment in maintenance suggests that the road networks of some countries in the region may become unsustainable—unless a more judicious mix of investments can be found and followed.