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DIRECTIONS IN DEVELOPMENT
Infrastructure

Rural Road Investment Efficiency

Lessons from Burkina Faso, Cameroon, and Uganda

Gaël Raballand, Patricia Macchi, and Carly Petracco

THE WORLD BANK

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Foreword

Development is a complex process—if it weren't, we'd be done by now—and so development practitioners frequently resort to rules-of-thumb to guide decision making. The alternative of undertaking a full-blown cost-benefit analysis of every investment or policy change would be impossible, given data and capacity constraints, let alone the need to take decisions in a timely manner. Often, these rules-of-thumb evolve implicitly as a result of the indicator chosen to measure progress. For example, when Gross Domestic Product (GDP) is considered an indicator of economic well-being, policy makers try to maximize its growth rate. When the poverty line is set at $1.25 a day, governments try to minimize the number of people below that line. While indicators and rules are clearly necessary, there is always the possibility that the particular indicator chosen is too simple, that it leaves out more than it captures, and that it may ultimately do more harm than good.

This book illustrates all of these ideas with the example of the Rural Access Index (RAI), which counts the percentage of the rural population that lives within two kilometers (approximately a 20-minute walk) of an all-season road. Originally intended as a measure of the social well-being of rural people, the RAI has become an economic indicator and, accordingly, a guide to investment decision making. Investments (including investments in rehabilitation) that increase the RAI are considered welfare-improving. As the authors point out, this indicator has led to a bias in favor of investing in rural roads at the expense of secondary and main roads. In some African countries, the World Bank invests almost exclusively in rural roads.

Using case studies from Burkina Faso, Cameroon and Uganda, the book shows how the creation and use of an index like the RAI can lead to a serious misallocation of resources. First, the notion of an "all-season road" refers to whether a four-wheeled vehicle like a truck or car can travel the road. But, as the book shows, in Central and West Africa, even passable roads have very few trucks on them—because population density is so low. Farmers transport their produce by foot or two-wheeled bicycles or motorcycles. In these circumstances, investing in improving the road may not be in the best interest of the rural population; the resources could benefit them more if used elsewhere.

Secondly, the focus on rural roads elicited by the RAI takes resources and political attention away from other potentially lucrative road investments, such as those in secondary and main roads. In particular, the authors describe the "missing middle" of secondary roads as being chronically neglected. There is a third problem, which the authors do not explicitly discuss, but is worth mentioning. It is no secret that road investments—around the world—are also politically motivated. Politicians like to build roads that benefit their constituencies. A rule of thumb that is based on the RAI gives considerable room for political criteria to dominate investment decision making, and poor people frequently lose out.

The book's authors propose a new set of criteria to guide decision making, criteria that take into account the economic justification for road investments. They are careful not to make their proposal so complicated that it will not be used. And the underlying message of the book is clear. To those of us who are constantly looking for simplifications or rules-of-thumb, and believe in the adage "what you measure gets done"—be careful what you wish for.

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Abbreviations

AEZ	agroecological zone
CPI	Consumer Price Index
GDP	gross domestic product
GIS	geographic information system
GLSS5	2005–06 Ghana Living Standards Survey
GPS	Global Positioning System
HDM-4	Highway Development Model-4
IMT	intermediate means of transport
ITC	Indian Tobacco Company
LC	local council
LUT	land utilization type
NRM	National Resistance Movement (Uganda)
RAI	Rural Access Index
SODECOTON	Société de Développement du Cotton (Cameroon)
SOWEDA	South West Development Authority (Cameroon)
UN	United Nations
VSAT	very small aperture terminal

CHAPTER 1

Introduction and Overview

This report is the second in a series of studies on transport and aid effectiveness in Sub-Saharan Africa. It follows a study on transport costs and prices along the main international trade corridors (Teravaninthorn and Raballand 2008). One of the principal findings of the research on international corridors in Africa was that trucking market structure and regulation differ widely among subregions in Sub-Saharan Africa; therefore, transport prices (but not necessarily transport costs)[1] differ greatly among subregions and corridors. The trucking environment and market structure in West and Central Africa are characterized by cartels offering low transport quality, whereas in East Africa, the trucking environment is more competitive and the market is more mature. Much of the transport price burden along African corridors seems to depend on the political economy of freight logistics.

The first study, however, did not broach the topic of local and national transport, which is equally important for market integration and poverty reduction. The same rationale for such research does exist, because since the 1970s, the World Bank has actively supported road investments in Africa, yet no clear effect on transport prices is evident. Why do end-users of road transport services not seem to fully benefit from lower transport costs? Although public spending on roads, education, and provision of utilities is generally thought to contribute to growth—by providing inputs that are complementary to more directly productive investments—Devarajan and colleagues demonstrate that seemingly productive expenditures, when used in excess, could become unproductive (Devarajan, Easterly, and Pack 2003; Devarajan, Swaroop, and Zou 1996).

The Rural Access Index

At a time when development partners are focusing on rural mobility in particular, trying to determine how to achieve better aid effectiveness in rural transport is a worthwhile effort. The Rural Access Index (RAI) is the proportion of rural people who live within 2 kilometers—a distance typically equivalent to a 20-minute walk—of an all-season road.[2] Despite major measurement problems, project teams must report the RAI every two years and assess the number of people covered at 2 kilometers in the project area. Because the RAI remains the main outcome indicator of road projects in Sub-Saharan Africa, it has started to bias investments in favor of rural roads compared to the main and secondary networks. In some countries, World Bank assistance now consists almost exclusively of support to rural roads.

Originally, however, the RAI was not intended as an economic indicator but as a social one to measure (even approximately) the social impact of road accessibility. Development partners have nevertheless adopted the RAI as the only outcome of World Bank–financed transport projects in Sub-Saharan Africa, thereby giving it a de facto economic significance.

This indicator selection is said to be a compromise between those who find any distance—even less than 1 kilometer—too great a struggle (for example, elderly people and those with disabilities) and those who are accustomed to walking great distances because of their remoteness from roads. It is aimed at measuring accessibility of rural populations to roads in a simple manner. However, Geurs and van Wee (2004) demonstrated that person-based measures, such as travel time between two locations, are a better measure of accessibility. The main caveat to such measures is data collection complexity. In the area of road accessibility, a trade-off seems to occur between a simple and measurable indicator that poorly captures accessibility and more complex indicators that better reflect accessibility but are difficult to collect. Thus, the RAI was designed as a simple indicator (with the underlying assumption that its capture of the level of road accessibility would be difficult). Hence, statistical support for the significance of the 2-kilometer measure was not studied in detail when the RAI was adopted.

The RAI poses several issues. For instance, problems arise in measuring the distance between the household and the road. Currently, household surveys are frequently used to obtain this measurement, creating accuracy problems.[3] Roberts, KC, and Rastogi (2006) cite household surveys from Albania and Tanzania showing that questions about *time* to roads are more accurate than questions about *distance* to roads. Nevertheless, the distance measure was selected for simplicity of the indicator. Moreover, the vital role that transport services play in connectivity has usually been neglected. Roberts, KC, and Rastogi (2006: 3) state that "the index reflects the importance of road transport for improving rural access for the great majority of rural people" and disregard the critical role of transport services.

Objectives of the Study

The main objectives of this study are twofold:

- Assess if the RAI, which prescribes achieving accessibility of all rural communities at 2 kilometers in Sub-Saharan Africa, is indeed economically justifiable and sustainable.
- Define a comprehensive methodology for linking economic density, road density, road level of service, and efficiency of transport services.

Indeed, as Van de Walle (2009) points out, one of the paradoxes of transport in Sub-Saharan Africa is that, despite a strong impetus for increased investments in the region, very few of the many aid-financed rural road projects in developing countries have been subject to evaluations. Estache (2009) explains that this paradox arises because implementing (quasi-) randomized evaluation techniques in transport is difficult and costly in Sub-Saharan Africa. Therefore, many investments in the region are built on the belief that infrastructure will ineluctably lead to poverty reduction and income generation.

The selected countries for this study represent three subregions of Sub-Saharan Africa:[4]

- West Africa—Burkina Faso
- Central Africa—Cameroon
- East Africa—Uganda

The study was carried out in two phases: the first phase included data collection, and the second involved a quantitative analysis of the data collection results. Data collection was based on more than 1,000 surveys (of household and transport service providers) and interviews of relevant stakeholders.[5] Four sets of villages were surveyed in each selected region: villages located closer than 2 kilometers to the secondary road, villages located from 2 to 6 kilometers, villages located more than 6 kilometers but less than 15 kilometers, and villages located more than 15 kilometers from the secondary road.

The study focuses on road planning as a means of achieving more efficient public spending in the road sector. It does not cover urban transport or the role of transport for internal labor movements and will touch only incidentally on the social dimension of secondary and rural roads.[6] Effects at the micro level in the availability of social services are not possible to explore in this framework because such an examination requires a different methodology and a considerable amount of resources.[7]

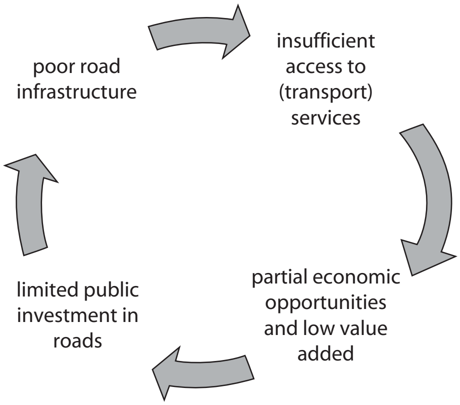
The Problem of Isolation: A Review of Current Literature

The cost of being isolated (relying on empirical evidence) is a growing field in economics. Rural road development enhances access to markets for both inputs and outputs through a reduction in transaction and trade costs (transport and logistics costs). The greater availability (both in terms of funding and physically speaking) of inputs increases their use by farmers. Consequently, agricultural productivity can increase. Rural roads also allow producers to achieve additional productive opportunities, leading to a rise in production that is highlighted by numerous studies. Stifel and Minten (2008) find, in the case of Madagascar, that isolation (defined as travel time during the dry season from the commune center to the nearest urban center) implies lower agricultural productivity, increased transport and transaction costs, and increased insecurity. They find a major jump in per capita consumption from the least remote quintile to the second quintile and, therefore, a negative relationship between isolation and poverty. For example, the distance from the plot to a passable road and the cost of transporting rice significantly decrease the use of fertilizer in rice production.[8] Controlling for soil fertility (and thus for nonrandom placement of roads), they demonstrate that crop yields for the three major staple items in Madagascar (rice, maize, and cassava) are lower in isolated areas than in areas that are not isolated. Sahn and Stifel (2003) also demonstrate that living standards in rural areas lag far behind those in urban areas. Dorosh, Wang, and You (2008) find, first, that in Sub-Saharan Africa, agricultural production and proximity to urban markets are highly correlated (even after taking into account the agroecological zone). They show that 40 percent of the population lives between 2.5 and 8.4 hours from a market and that the crop production of those same producers accounts for more than 60 percent of total production. Second, the authors conclude that the adoption of high-input technology is negatively correlated with travel time to urban centers. The study demonstrates that an inverted *U* shape exists between share of high-input, rainfed total crop production and travel time, reaching the highest point between three and four hours of travel time.

Greater sales opportunities or higher received prices for production create a rise in income for producers. Using household data in Ethiopia, Dercon and others (2008) find that the proximity of a road is a major factor in reducing poverty. Fan, Nyange, and Rao (2005) show that each kilometer reduction in the distance to a public transportation facility reduces the probability of a household being poor by 0.22 to 0.33 percent in Uganda.[9] Every million Ugandan shillings (U Sh) invested lifts 27 poor Ugandans out of poverty. In a study in Papua New Guinea, Gibson and Rozelle (2002) provide a simple correlation between access to roads and prices that farmers receive for their crops. Specifically, the rate of price decline is about 7 percent for each extra hour to the nearest transport facility. Thus, access to transport helps income generation. Deininger and Okidi (2002) show that distance to the municipality is a significant determinant of per capita income growth but not of consumption. The same kind of result appears in Escobal and Ponce (2002), whose methodology seems more reliable. Indeed, they assess the impact of road projects in Peru by propensity score matching techniques. Although rehabilitation entails an income increase, that is not the case for consumption. Apparently, this additional income serves saving purposes because it is considered as transitory. Figure 1.1 summarizes the current thinking in terms of empirical evidence.

However, the studies described here share a severe limitation that lies in the absence of treatment of the endogeneity bias in the poverty equation. In fact, road placement appears to be nonrandom (people do not randomly settle next to roads once they have been constructed). Therefore, roads may not necessarily increase agricultural productivity; rather, roads may be developed in the already more productive agricultural areas. Moreover, an omitted variable bias (such as geographic conditions) could be behind the road-poverty relationship.

Figure 1.1 The Transport Trap in Rural Areas



Source: Authors' representation.

Some studies attempt to deal with this potential endogeneity. Jalan and Ravallion (2002) show that road density (measured as kilometers of roads per capita) had a highly significant positive effect on consumption growth at the farm-household level in rural areas of southern China from 1985 to 1990. They ignore potential endogeneity, explaining that it is due to people choosing their locations because there was little or no geographic mobility of labor in rural China at the time. However, the endogeneity of road placement is ruled out without any explicit justification. The inclusion of regional dummies may be an implicit means to treat this simultaneity bias. The inclusion of many fixed-effect controls in the poverty analysis in Papua New Guinea by Gibson and Rozelle (2002) may have the same purpose. They find that a one-hour increase in traveling time to the nearest transport facility reduces real consumption by 10 percent. They conclude that poverty (a "welfare ratio") is associated with poor access to markets, services, and transportation. However, the combined traveling time to the nearest health center, high school, and government station has a nonsignificant effect on this welfare ratio.[10]

Jacoby and Minten (2009) attempt to overcome the problem of reverse causality. They estimate the willingness to pay for a reduction in transport costs on cross-sectional data collected in a small region of Madagascar. Because this region is relatively homogenous but faces great variation in transport costs to the same market, the problem of nonrandom placement of roads is solved. They find that "a road that essentially eliminated transport costs in the study area would boost the incomes of the remotest households—those facing transport costs of about USD75 per ton—by nearly half, mostly by raising nonfarm earnings" (Jacoby and Minten 2009: 28).

The transport requirement in rural areas has been increasingly investigated. Fan and colleagues reveal that what matters is to provide access to roads in line with the needs of the rural population (Fan and Chan-Kang 2004; Fan, Hazell, and Thorat 2000; Fan, Zhang, and Zhang 2002). Consequently, donors' investments should be directed to the construction and maintenance of secondary, rural, low-quality roads and not to roads for trucks, which are said to be irrelevant to cope with the issue of rural poverty. In a more recent analysis, Dercon and others (2008) find that increasing road quality to enable reasonable accessibility in the wet season has a major effect in stimulating higher consumption growth. In fact, the better the level of road quality, the higher the growth rate is.

Moreover, the issue of transport services is now at the core of discussions on mobility and income generation in rural areas: to take advantage of a transport infrastructure and, thus, to escape from poverty require affordable means and services of transport (Gannon and Liu 1997; Njenga and Davis 2003; Sieber 1999). A great deal of attention has been given to the means of transportation as a way of improving mobility and accessibility (see, for example, Dawson and Barwell 1993; Ellis 1997; Riverson and Carapetis 1991; Starkey and others 2002). Sieber (1999) demonstrates in Tanzania that adequate intermediate means of transport (IMT),[11] coupled with pathways, may have, in some cases, more economic impact than rehabilitating secondary roads alone. A wide diversity of transport modes, including both IMT and conventional vehicle types, has been observed in many Asian countries, but the range of choice in Africa is far more limited. The argument is that new forms of transport, such as IMT, could do a lot to relieve the transport burden of the rural population. It is sometimes argued that prices of transport services are often high in Africa, and without any measure to address the availability and prices of transport services, too much attention to roads is misplaced.

In contrast, *World Development Report 2009: Reshaping Economic Geography* (World Bank 2009c)[12] suggests that using a calibrated blend of policy instruments for integration—institutions, infrastructure, and incentives—can help countries achieve inclusive development although with "unbalanced growth." It identifies the most important market forces at each of three spatial scales: (a) at a local scale by analyzing the interactions between cities or towns and their neighboring areas, (b) at a national scale by examining the interactions between the lagging and leading areas in a country, and (c) at a regional scale by studying the relationships between neighboring countries. *World Development Report 2009* seeks to reframe the debates on urbanization, territorial development, and regional integration.

In *World Development Report 2009*, evidence is given of the threshold effect of investments in areas with low economic density. Countries are not homogenous entities but are composed of areas that are combinations of economic development and population. The term *low economic density area* refers to an area lacking economic development (that is, industries and services); usually such areas also have high poverty rates, and occasionally they have high population density. In response to these lagging areas, as they are called, governments have attempted to attract industry and disperse economic development more evenly across their country. For example, Brazil, India, Indonesia, and the Russian Federation have used a variety of methods—from state-planned location of industries, to relocation of people into lagging areas, to provision of incentives to private firms to locate in lagging areas. Unfortunately, such attempts seldom go as planned, and governments have recognized the existence of a threshold effect of investment in these areas.

World Development Report 2009 notes that only so much investment in these lagging areas is possible before they require greater integration with leading areas. By offering people and industry incentives to stay, governments are only isolating these lagging areas more, a problem that leads to confrontation with the investment threshold. Instead, countries should connect lagging and leading areas. By providing adequate—and passable—roads between leading and lagging areas, governments assist in uniting their country through a convergence in living standards.[13]

The Situation in Sub-Saharan Africa

Where does Sub-Saharan Africa stand in terms of population density and road density? Do we have the right picture? The average population density of the countries in the region is relatively close to that of countries in other World Bank regions but lower than in East Asia (table 1.1) and more broadly lower than the average population density of other low- and lower-middle-income countries in the world (Carruthers, Krishnamani, and Murray 2008). This analysis is especially important for transport investment, because in any country, a sparsely populated area still requires a basic minimum investment in roads; thus, the ratio of investments per capita may appear to be high, but it does create an additional financial burden. However, population density varies widely in Sub-Saharan Africa. Although some countries are densely populated (Ghana, Malawi, Rwanda, and Uganda), others have a sparse population spread over a relatively large geographic area (Burkina Faso, Cameroon, Sudan, and Zambia).

Nevertheless, the road density and access picture in Sub-Saharan Africa is not as bad as one may think. In terms of gross domestic product, road density is the highest of other comparator regions (see table 1.2). However, data on the extent of road networks are sometimes unreliable. Sub-Saharan Africa lags in the extent of its paved network; measured in terms of land area, the average road density for 23 Sub-Saharan African countries is 13.2 linear kilometers per square kilometer—10.7 kilometers for the low-income group alone. In contrast, the paved road density of the other low-income countries of

Table 1.1 Average Population Density, 2003–07

	People per square kilometer				
Region	*2003*	*2004*	*2005*	*2006*	*2007*
Sub-Saharan Africa	31	32	32	33	34
East Asia and the Pacific	117	118	119	120	121
Eastern Europe and Central Asia	19	19	19	19	19
Latin America and the Caribbean	27	27	27	28	28
Middle East and North Africa	34	34	35	36	36
Organisation for Economic Co-operation and Development	31	31	31	32	32

Source: World Bank Development Data Platform.

Table 1.2 Road Density

Region	*In terms of GDP (2001)*	*In terms of land area (2000)*
Sub-Saharan Africa	7.98	97
East Asia and the Pacific	7.03	115
Eastern Europe and Central Asia	5.05	52
Latin America and the Caribbean	2.81	34
Middle East and North Africa	2.11	42
Organisation for Economic Co-operation and Development	1.02	15

Source: Authors' calculations based on data from the World Bank's Development Data Platform and the International Road Federation.
Note: Road density in terms of GDP measures number of kilometers of road × 1,000,000/GDP; and road density in terms of land area measures number of kilometers of road per 100 square kilometers of land area.

the world is about 3 times greater, and that of the lower-middle-income countries is about 12 times greater (Carruthers, Krishnamani, and Murray 2008).

Continentwide, road access at less than 5 kilometers does exist for a large part of the population; 83 percent of the population is at least 5 kilometers from a regional or national road (see table 1.3). In the case of Sierra Leone, a postconflict country, only pockets of population remain uncovered at a 2-kilometer buffer (map 1.1). Map 1.2 represents the road coverage in Sub-Saharan Africa at the 10-kilometer buffer and demonstrates that over 90 percent of the population is located less than 10 kilometers from a main road.

It could be argued, however, that most roads are not passable. Therefore, from an economic perspective, this connectivity would not be real.

Hence, from a public policy perspective, does a Sub-Saharan African country require investments to increase the passability of the current roads and build new roads, or should it focus on enabling more affordable transport services? To address this question, one must examine some assumptions that are usually made in this area.

So far, most development partners and governments in Sub-Saharan Africa have relied on two overarching assumptions, which have led to massive road investments—sometimes without a sound analytical base:

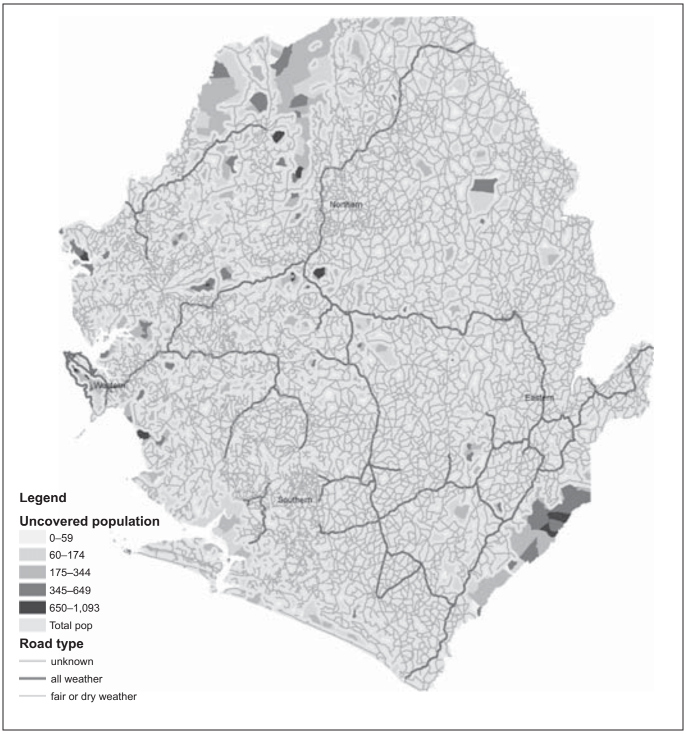
- Most households in rural areas in Africa are not connected to markets and, therefore, need a road passable by trucks (even more so because they are remote).
- Roads with a high level of service are crucial to achieving high economic outcomes.

Table 1.3 Sub-Saharan Africa Road Coverage, 2005

	Population covered (thousand)			*Percentage of population*			*Percentage of covered population*		
Buffer	*Urban*	*Rural*	*Total*	*Urban*	*Rural*	*Total*	*Urban*	*Rural*	*Total*
2 kilometers	103,063	30,106	133,169	59.5	17.2	38.2	77.4	22.6	100
5 kilometers	144,074	56,721	200,796	83.1	32.4	57.6	71.8	28.2	100
10 kilometers	160,836	90,004	250,840	92.8	51.4	72.0	64.1	35.9	100

Source: Regional data set created by Siobhan Murray, who conducted a connectivity analysis linking regional and national roads from the Digital Chart of the World dataset. In this analysis, regional roads = road networks connecting national capitals, cities with populations exceeding 500,000, and major ports; national roads = road networks connecting provincial capitals and cities with populations exceeding 25,000 that are not part of the primary network.

Map 1.1 Uncovered Population in Sierra Leone at 2-Kilometer Buffer, 2005

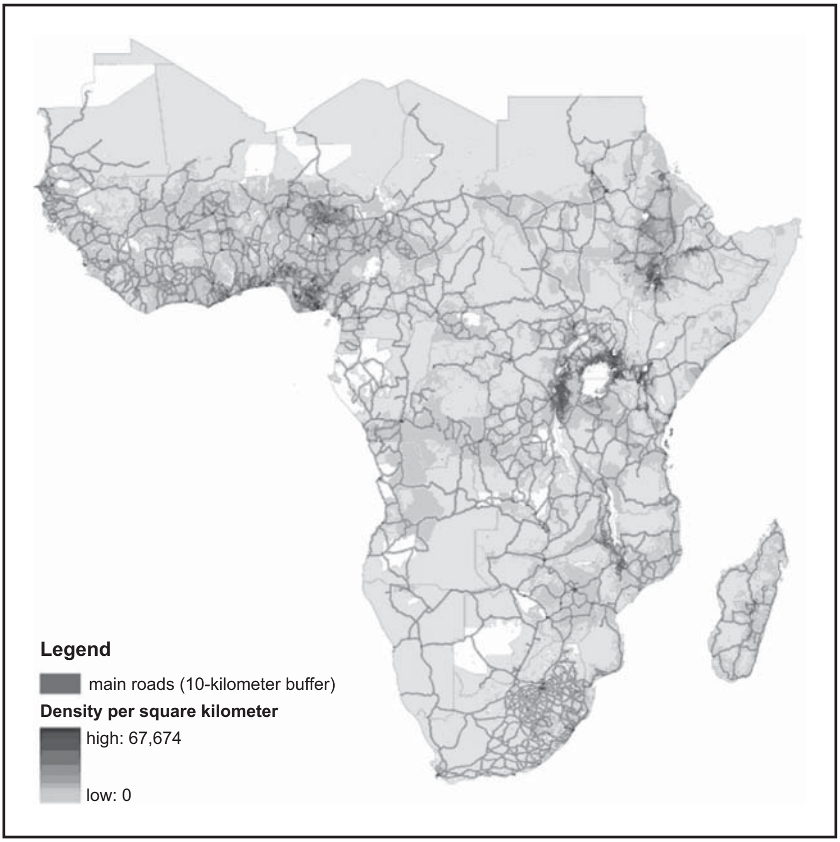


Source: Authors' representation based on government sources.

The accuracy of these two assumptions is increasingly being questioned. A continuum of integration to markets probably exists for most households in Africa. Although a road may not be passable for cars, a driver may, for instance, dismount a motorcycle, walk it around the trouble spot in the road, and then continue his or her trip. Therefore, from an economic perspective, most rural populations are *somehow* connected to markets; however, connectivity is usually understood as either 0 or 1.[14] Hence, from a public policy perspective, investments in roads could affect economic development less than expected, because transport connectivity is only one component of rural development—and sometimes not the most important one.[15] This continuum of integration may also explain why the major investments some countries have made in rural roads have failed to reduce poverty as much as expected.

Construction and rehabilitation of rural roads (so that they are suitable for trucks) have created major difficulties because (a) such roads are

Map 1.2 Population Density and Road Coverage in Sub-Saharan Africa at the 10-Kilometer Buffer, 2005



Sources: Roads: VMAP0 database, African Development Bank Trans-African Highways study estimates, Africa Infrastructure Country Diagnostic connectivity analysis, Digital Chart of the World (road types 1 and 2); population: Gridded Population of the World and Global Rural-Urban Mapping Project 2005 estimates, Center for International Earth Science Information Network.
Note: The black line represents the national or regional road and the 5 kilometers to each side of the road.

expensive to build relative to the economic development they make possible; (b) such roads are expensive to maintain, and in the absence of any sustainable framework for maintenance, roads disappear quite quickly; and (c) rural road infrastructure is usually underused. A study covering 50 villages in Burkina Faso demonstrated that of 47 rural access roads to villages, 19 had no motorized vehicle traffic at all, despite IMT traffic of up to 250 bicycles, 100 pedestrians, and 100 motorcycles a day (BDPA and Sahel Consult 2003).

The economics of transport services have usually been neglected under the assumption that a road investment that reduced the vehicle operating costs for a truck would automatically make transport affordable to farmers. However, policies that rely on this assumption fail to explore the fact that farmers may not be able to afford to use a truck because of a low agricultural surplus and that cost savings in vehicle operation may not be passed on to farmers or other users in lower transport tariffs because of cartelization of the trucking industry. A threshold effect may exist for roads in areas with low economic density; therefore, the possible effects of rural roads on economic development must be questioned. Using country data extracted from trucking surveys in Highway Development Model-4 (HDM-4),[16] Teravaninthorn and Raballand (2008) demonstrated that along roads with fewer than 150 trucks, which is the case almost everywhere in West and Central Africa, economic viability of these roads is problematic.

Note that the economic appraisal of main and secondary roads is currently carried out using road-planning models such as HDM-4. Such models are based on a partial equilibrium analysis in which investment, maintenance, and transport cost savings are believed to capture all the major costs and benefits of a project. Although some allowance is made for unpriced externalities such as road accidents and environmental effects, the principal assumption is of a fully employed economy in which prices reflect their true economic opportunity costs. The approach is broadly accepted, not because of a belief in validity of the assumptions, but because of the way that different costs and benefits can be identified and compared for different project designs (that is, the main strength of the approach is the way in which different projects can be easily compared and ranked).

The main predictive components of models like the HDM-4 are road deterioration and maintenance work effects, together with road-user costs. Major issues arise with predicting both road performance and user costs. More commonly, road-planning models such as HDM-4 and a simplified model, Road Economic Decision, for low-volume roads are used to measure changes in transport costs from road improvements. Such models estimate vehicle operating cost components (driver and passenger time savings, fuel consumption, depreciation, tire wear, and vehicle maintenance costs) from the road alignment, vehicle speed, and road roughness predictions. Although the model is able to predict some components relatively accurately, the validity of the prediction of vehicle maintenance costs, which currently represent a major part of the benefits of reduced road roughness resulting from improved running surfaces, is increasingly in doubt. Evidence indicates that HDM-4 considerably overpredicts vehicle maintenance costs (Cundill, Hine, and Greening 1997). Moreover, traffic generation, such as traffic growth and induced traffic, are usually assumed to "improve" the economic return of road projects.

For rural access or feeder roads, which may be specifically designed to help develop underdeveloped areas, the economic assumptions of partial equilibrium analysis are recognized as far less likely to be true. The importance of establishing accessibility for both social and economic reasons is seen as critical, and an analysis based on transport cost savings, particularly for existing traffic, is seen as less relevant. For this reason, planning procedures for low-trafficked roads often adopt a range of other procedures. These include the producers' surplus approach (Carnemark, Biderman, and Bovet 1976) and various ranking and screening procedures. The main difficulty with the former approach is that an empirical basis for forecasting a change in agricultural output following road investment is usually very difficult to find; hence, the procedure is open to abuse by practitioners.

The Findings of This Report

Taking into account current knowledge, this report tests the following hypotheses:

- *Hypothesis 1*. Farmers and rural households require a minimal transport service and infrastructure to be connected to markets, which means that opening new rural roads should not be an objective in most rural areas in Sub-Saharan Africa.
- *Hypothesis 2*. Better market integration of rural households depends on a differentiated mix between investment in infrastructure and support for the development of transport services. This mix depends mainly on economic density and climatic conditions.

Using data collected from various sources in the selected countries, the study demonstrates that from a cost-benefit perspective, the additional cost of extending an all-weather road 2 more kilometers to the farmer's door outweighs the benefits in most cases. For the selected 23 Sub-Saharan African countries, a recent study finds that reaching an RAI value of 50 percent would be beyond the financial resources of many countries (including all postconflict countries),[17] whereas the average value in other Bank regions is on the order of 65 percent already (Carruthers, Krishnamani, and Murray 2008; see also table 1.4).[18] Moreover, this approach may prove to be costly as well as unnecessary and ineffective (Riverson and Carapetis 1991; Starkey 2001).

This report shows that a one-size-fits-all approach is not effective in addressing the problems of all regions of African countries.[19] Governments and development partners probably need to adopt an approach that supplies the appropriate road for a rural area, realizing that a large main road may not be required, depending on the economic potential of the region. They must recognize that low production means no competition. Competition between truckers is virtually impossible to achieve at the lowest level of production because of high risk and low returns. When the production level is less than the minimum needed to cover the marginal cost, a trucker cannot cover its (marginal) costs; therefore, convincing several truck operators to sell their service is virtually impossible. For low-volume production, competition between truckers is wishful thinking, and virtually nothing can be done to ensure competition between truck operators (see chapter 3).

Policy recommendations of this report span various sectors and public policies. Chapter 6 describes key principles that policy makers should keep in mind when planning roads in Sub-Saharan Africa. However, there is a need to distinguish between policy recommendations for development partners and policy recommendations for country officials.

Policy Recommendations for Development Partners

The recommendations that follow are intended specifically for development partners.

Table 1.4 Rural Road Investment Needs for 23 Sub-Saharan African Countries under Base and Pragmatic Scenarios, 2008

	Base scenario		*Pragmatic scenario*	
	Investment needs/GDP	*Investment needs/total investment*	*Investment needs/GDP*	*Investment needs/total investment*
Rest of classified network	0.7	28.5	0.5	33.5
Unclassified and RAI	0.7	25.2	0.2	12.9

Source: Carruthers, Krishnamani, and Murray 2008.

Revise the RAI or Its Binding Power

Major investments in rural roads cost billions of dollars, yet they do not meet expectations. Transport is only one component to reducing poverty in rural areas. The 2-kilometer buffer is not an economic threshold. Moreover, because most rural households are located fewer than 5 kilometers from a (non-all-weather) road and because road passability is not a major consideration for small farmers (except in the case of bridges or tunnels), the last mile of public roads need not be suitable for small trucks—in most cases, infrastructure for motorcycles is sufficient. This report proposes revising the RAI to make it binding for a buffer zone of 5 kilometers from a road. Such a revision would ensure that most remote communities are not left behind but would prevent overinvestment or the generation of an unsustainable road network.

Better Tailor Interventions and Be More Innovative

Development partners should realize that a 7-meter main road is not required in most rural areas in Sub-Saharan Africa. Some pilots should be supported locally to potentially meet the demand for IMT (although any success may not be replicable in another region or country).

Monitor Allocation to Road Maintenance, Especially for Rural Roads

Serious efforts have been undertaken to rehabilitate and sometimes expand low-volume road networks. Nowadays, some governments are in a difficult position as far as maintenance is concerned. Incentives should be developed to force governments to allocate funds to maintain the existing road network instead of regularly financing road rehabilitation and network expansion (induced by the strategy to fulfill the RAI everywhere in Sub-Saharan Africa).[20]

Provide Assistance to Improve Investment Strategies in Rural Roads

Road investment strategies should be revised in many countries using new tools, such as spatial economics and satellite imaging, to increase the efficiency of such investments.

Focus More on the Missing Middle and Better Coordinate Interventions

The secondary network has long been forgotten and is vital to linking main (trunk) roads with rural roads. The last mile should not be a road for a truck, but the secondary network, which links secondary cities, should be in good condition (paved or unpaved) to enable truck fleet efficiency and competition. Donor coordination is critical. It can prevent, for example, the rehabilitation of rural roads that are not connected to passable secondary roads.[21]

Recognize the Role of More Sophisticated Load Consolidation Models

Without load consolidation and agglomeration at the local level, surplus for small farmers cannot increase significantly (with or without massive investments in roads). Load consolidation at the local level decreases the need for a road accessible by truck to every farm; it decreases investment needs and increases value added for farmers. From a cost-benefit analysis, consolidation (or agglomeration) is most effective, because it mainly reduces public investment in the secondary network and enables the decrease of transport costs because of increased predictability of volumes and strengthened competition between operators. Roads for trucks should be developed where local agglomeration occurs (mostly small towns or, less likely, large collection points). With increased volumes to transport, increased number of rotations because of more rapid turnover, and better road condition, competition may emerge between transport operators and affect transport prices positively.

Policy Recommendations for Country Officials

The recommendations that follow are intended specifically for country officials.

Review Investment Strategies Objectively

Road prioritization should be reviewed objectively in many Sub-Saharan African countries to better take into account economic potential. Probably more priority should be assigned to maintenance or rehabilitation than to network expansion. Moreover, in some cases, instead of investing in rural roads, public authorities should consider investing in schools, hospitals, or markets with a spatial perspective to create local agglomeration.

Better Coordinate Interventions and Focus More on the Missing Middle

The secondary network is vital to linking main roads with rural roads. In many countries in Sub-Saharan Africa, the definition of a *rural road* is based on network ownership and not the economic function of the road. Moreover, in several countries, rural road investments are the mandate of the ministry of agriculture or, in decentralized countries, local authorities, whereas the main and secondary networks are a mandate of the ministry of public works. Without coordination between public works officials and agricultural and local authorities, the effects of rural road rehabilitation may be severely limited because the ministry of public works may decide to allocate funding to other parts of the network in other regions (see box 1.1).

Adjust Strategies to Take into Account Agricultural Potential and Production

This last policy recommendation is especially important. Despite discourse, current strategies related to investment in rural roads do not take into account agricultural potential and current production. This study demonstrates that in some regions, the agricultural potential can

Box 1.1

An Example of Lack of Coordinated Interventions between Ministries

In the Meme division in the South-West region of Cameroon, the South West Development Authority (SOWEDA) is now implementing a project, the Rumpi Area Participatory Development Project, aimed at rural development. Of CFAF 8.5 billion (over US$17 million) scheduled for the project in the first year, more than half will be dedicated to the rehabilitation of rural roads. At the end of the project, more than 230 kilometers of rural roads should be rehabilitated. Two main problems remain. First, the national network (linked to the rural roads to be rehabilitated) is in the same condition as the rural roads and is subject to frequent road closings to vehicles. Nevertheless, the Ministry of Public Works, which is in charge of this network, does not allocate sufficient funds to keep it in good condition. Second, donor funds for SOWEDA cannot contribute to the rehabilitation of the national network in Meme division because the project was signed with the Ministry of Agriculture and Rural Development and its mandate is to rehabilitate only rural roads. The risk is that at the end of the project rural roads may be fully rehabilitated, yet frequent cuts may still exist in the secondary network. Hence, the increased agricultural production would not reach cities because of the poor condition of the secondary network.

Source: Guy Kemtsop's interview.

be 10 to 20 times lower than in other regions of the same country. Such low-potential regions should not benefit from the same road allocation. Chapter 6 includes a decision tree that takes into account the local context for potential investments. Applied to a country like Uganda, the decision tree is able to define some regions and strategies to increase the efficiency of the spending on roads. Although social criteria are important for road planning and will continue to play a major role, economic criteria should be given more weight to make investments in road networks more sustainable (see box 1.2).

Box 1.2

What Would a Revised Road-Planning Strategy Look Like Compared to the Current Situation?

Today, road allocation in secondary rural roads is usually based on three key principles:

- It is a function of the length of the regional network.
- It is a function of which needs are most urgent.
- It is a function of political goals, which partially explain why funding is usually dispersed and the most vocal or best-connected politicians get the highest allocation in their region.

Consequently, road planning is not strategic; departments in charge of rural roads act when an emergency occurs or when political pressure becomes excessive.

A revised road-planning strategy would be based on objective data on (a) regional potential and current agricultural value, and (b) georeferenced road networks with information on road condition and on critical points. Investment needs would be recomputed at the regional and local levels. Using this information, planners could prioritize some major investments in the most economically dense regions (mainly on the secondary and tertiary networks). Because of budget constraints, some parts of the network would not be maintained and network expansion would not be sought, except on an exceptional basis. The last mile would be the mandate of the ministry of agriculture or of local authorities and would be designed for IMT only. This approach was adopted in Finland with the definition of level-of-service targets and a classification of roads by order of priority, climatic conditions, and traffic levels. Some roads benefit from virtually zero allocation and others from massive investments because of their economic and strategic value (see Isotalo 1995 for more details, especially annex 5).

Source: Authors. Based upon Isotalo, 1995.

Notes

1. *Transport prices and tariffs* are the rates charged by a transport company or a freight forwarder to the shipper or importer. Transport prices usually are the result of negotiated rates between the shipper and the transport service provider. Transport prices normally cover transport costs and the operator's overhead and profit margin.

   Transport costs are the costs the transport operator incurs when transporting a cargo. In addition to vehicle operating cost, transport costs include indirect costs, such as license fees, roadblock payments, and the like.
2. An *all-season road* is a (gravel or bitumen-paved) road that is passable all year by the prevailing means of rural transport (often a pickup truck or a truck that does not have four-wheel drive). Predictable interruptions of short duration during inclement weather (such as heavy rainfall) are acceptable, particularly on low-volume roads.
3. To overcome potential problems, the authors of the report supporting the RAI recommend the use of pedometers; six pages of pedometer-user instructions are provided in the annex of the report (Roberts, KC, and Rastogi 2006). Alternate estimation methods are presented as well; by using a geographic information system (GIS) to match data on households' location and the location of the road system, one may obtain distance measurements. Several problems are associated with this approach. First, GIS is a relatively new tool with high costs of gathering the needed data. Second, GIS measures only the Euclidean distance (the flat distance between points, excluding mountains, valleys, and so forth). Using this method also prevents assessing the condition or the passability of the road.
4. These countries were also part of the sample of the previous study (Teravaninthorn and Raballand 2008).
5. The number of household surveys collected was 375 for Burkina Faso, 387 for Cameroon, and 197 for Uganda.
6. The definition of what constitutes a *rural road* is usually unclear: what are considered rural roads may be part of the secondary or tertiary road network. Low traffic usually characterizes this part of a network. Hence, such roads are sometimes called *low-volume roads*. Rural roads that are normally managed by local governments and communities include urban secondary roads managed by municipalities. Quite commonly, these roads represent 80 percent of the total road network length and carry only 20 percent of the total motorized traffic, but they provide access to a large share of the population in Sub-Saharan African countries. Traffic often consists of a majority of nonmotorized or intermediate means of transport and pedestrians. Furthermore, such roads are often not classified, and their extent and condition are usually unknown. For semantic reasons, *rural transport infrastructure* is used in this discussion to ensure that tracks, paths, and footbridges are included.

7. However, this study may lay the groundwork for further studies based on randomized experiments of improved transport services in rural areas.
8. In fact, the simple regression model they use to illustrate the correlates of transportation costs demonstrates that distance is a significant determinant of transporting 50 kilograms of rice to the nearest major city. A multicollinearity problem then arises and may bias results.
9. This finding could lead to biased estimates. To deal with this problem, several papers by Fan and colleagues study the impact of different types of public expenditures on growth and poverty reduction and provide a structural model of the poverty-road relationship (Fan and Chan-Kang 2004; Fan, Hazell, and Thorat 2000; Fan, Zhang, and Zhang 2002). They estimate simultaneous equation systems on panel data aggregated from household surveys and demonstrate that rural road investments rank high in terms of poverty reduction compared with other forms of government expenditure.
10. This finding may be due to a positive correlation between these two traveling times, because access to health and education facilities depends on access to transport.
11. IMT are diverse and encompass, among other things, bicycles, animal-drawn carts, and local taxis.
12. Appendix C summarizes *World Development Report*'s policy framework for the national dimension.
13. The threshold may occur when countries attempt fiscal transfers from leading to lagging areas. Such transfers may create fiscal dependency and may discourage independent development. Additionally, the restriction of the movement of goods and people may cause inefficient economic activity (that is, duplication of production and higher prices). Therefore, *World Development Report 2009* (World Bank 2009c) recommends that countries invest in the people in lagging areas while investing in the place in leading areas. This combination provides people in lagging areas with education to enhance their opportunities. Meanwhile, the improved infrastructure will allow mobility of people, goods, and information to and from the leading area.
14. If a path or trail can ensure limited connectivity, it is crucial in terms of public spending. The cost of a 2-meter-wide unpaved path or trail for bicycles was estimated at less than 10 percent of the cost of a 6-meter-wide all-weather rural road for motorized transport (Riverson and Carapetis 1991).
15. In the case of Burkina Faso, Ruijs, Schweigman, and Lutz (2004) find that the direct effect of transport cost reductions on the price of food, such as cereals, requires some nuance and tempered expectations, notably because of the organization of markets.
16. Highway Development Model-4 is the most widespread model used to justify the economic viability of road investments.

17. For example, Burkina Faso had an RAI value of 25 percent in 2003, and Cameroon had an RAI of 22 percent in 2002.
18. Improvements could include converting dry-season roads into all-season roads, spot treating potholes, or increasing the drainage on gravel roads.
19. Contrary to the study on transport costs and prices along international corridors (Teravaninthorn and Raballand 2008), this study found no specificities in terms of regulation of transport services per subregion; therefore, distinctions between subregions are not relevant. Differences in climatic conditions and in population density seem to have higher explanatory power on the impact of low-volume roads.
20. Road maintenance can be classified as follows:
    - *Routine maintenance* covers small-scale works conducted regularly. It aims to ensure the daily passability and safety of existing roads in the short run and to prevent premature deterioration of the roads (PIARC 1994).
    - Frequency of activities varies but is generally once or more a week or month. Typical activities include roadside verge clearing and grass cutting, cleaning of silted ditches and culverts, patching, and pothole repair. For gravel roads, it may include grading every six months.
    - *Periodic maintenance*, which covers activities on a section of road at regular and relatively long intervals, aims "to preserve the structural integrity of the road" (http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTTRANSPORT/EXTROADSHIGHWAYS/0,,contentMDK:20596514~menuPK:1476380~pagePK:148956~piPK:216618~theSitePK:338661,00.html). These operations tend to be large scale and require specialized equipment and skilled personnel. They cost more than routine maintenance works and require specific identification and planning for implementation and often design. Activities can be classified as preventive, resurfacing, overlay, and pavement reconstruction. Resealing and overlay works are generally undertaken in response to measured deterioration in road conditions. For a paved road, repaving is needed about every eight years; for a gravel road, regraveling is needed about every three years.
    - *Urgent maintenance* is undertaken for repairs that cannot be foreseen but that require immediate attention, such as collapsed culverts or landslides that block a road (Burningham and Stankevich 2005).
21. Moreover, the condition of the link between corridors and the secondary network should be investigated when decisions are made to upgrade or rehabilitate corridors.

CHAPTER 2

What Should the Objective Be to Significantly Reduce Isolation in Sub-Saharan Africa?

This chapter mainly assesses the impact of remoteness from roads on the agricultural income of smallholders. Using national and household surveys in the three selected countries, this chapter demonstrates that: (a) as people move farther away from markets, consumption has an overall downward trend (which is consistent with the literature); (b) the 2-kilometer distance from a road is not an economic threshold (that is, a distance beyond 2 kilometers from a road does not necessarily have a positive impact on household income); and (c) road passability does not have a major positive impact after a minimal level is reached.

The Low Impact on Agriculture from Living within the 2-Kilometer Buffer

An apparent paradox lies in the fact that increased rural road density has a positive impact on incomes but not in the 2-kilometer buffer.[1] Therefore, some minimal road access is needed to positively affect income generation, but an investment that places the rural population within the 2-kilometer buffer may be considered an overinvestment (in the selected districts studied in this book).[2] The 2-kilometer buffer has a minimal positive impact on agricultural income. Because of average limited plot size, better access to rural roads does not enable farmers to shift from intermediate means of transport to trucks (unless they consolidate their production with that of other small farmers), which is one of the most important factors leading to increased income generation. Moreover, sustainability of such investments is at stake; therefore, the road investment strategy should probably be better adjusted to farmers' transport requirements. These findings concur with those of Gräb and Grimm (2008), who decompose the sources of spatial disparities in incomes among households in Burkina Faso and show that spatial disparities are driven largely by disparities in community endowments. These findings also confirm research in Tanzania showing that rural poverty is weakly related to remoteness (Minot 2007).

Is Impassability More about Perception Than Reality?

Some households may view impassability of roads as the inability to use a road for whatever reason (usually related to weather-induced issues). Others may perceive impassability as having to navigate around the road to continue a journey. Differing interpretations of the word *passability* can result in stark differences in answers—differences that can appear between countries as well as within countries.

Table 2.1 presents descriptive statistics on the number days of impassability for the districts or regions of the three countries studied. Also included is the average yearly rainfall per district or region (which represents the potential for impassable roads because of washouts) and the government (unpaved) road infrastructure investment per kilometer (which is a proxy for road condition, given that in the rural areas in Sub-Saharan Africa, unpaved roads predominate).

Table 2.1 enables a comparison of perception and reality. On one hand, in the Meme district of Cameroon, the average rainfall is 2,800 millimeters per year—the highest of any of the areas studied—but the number of days of impassability is reported as zero (although investments have been minimal). Although a road may be impassable for cars and even motorcycles, a driver may, for instance, dismount the motorcycle, walk it around the trouble spot in the road, and then continue his or her trip.[3] On the other hand, the Centre-Nord region in Burkina Faso receives one of the lowest amounts of rain per year—on average, 664 millimeters. Even with the low incidence of rain, impassability was reported as high in three months of the year.

Table 2.1 Descriptive Statistics of Impassability, Rainfall, and Investments by District or Region, 2008–09

	Uganda (bicycle)			*Cameroon (motorcycle)*			*Burkina Faso (bicycle)*		
	Bushenyi	*Masindi*	*Tororo*	*Ngoketunja*	*Bamboutos*	*Meme*	*Boucle du Mouhoun*	*Centre-Nord*	*Sahel*
Mean	27	34	17	0	75	0	0	9	0
Median	0	30	5	0	60	0	0	0	0
Maximum	183	60	84	0	120	0	0	90	0
Minimum	0	3	0	0	60	0	0	0	0
Number of observations	32	11	32	14	6	5	27	69	21
Observations = 0	15	0	9	14	0	5	27	45	21
Annual rainfall (millimeters)	1,032	1,345	1,483	2,489	1,879	2,800	910	664	508
Public investment in unpaved roads (US$ per kilometer)	262	320	411	No data	No data	No data	696	1,192	304

Source: Authors' calculations.

Even comparisons within countries result in large differences, a finding that reinforces the assumption that different people perceive impassability differently. In the case of Tororo district in Uganda, 9 of the 32 observations reported zero days of impassability, whereas the maximum reported is 84 days. Moreover, the Rural Access Index (RAI) is extremely high in Tororo, and not a single village is more than 6 kilometers from a main road.

Therefore, what some people perceive as an impassable road is not so considered by others. From an economic perspective, this finding also demonstrates that road passability—especially in relation to transport by motorcycle—is much better than one usually expects, and many rural people are economically connected to markets in some manner.

Moreover, from a public policy perspective, because of the various perceptions of impassability, numerous perceptions exist of what should be the minimal level of passability. The RAI has attempted to assume away the issue of road condition by using "all-season" road in its definition, but concerns still exist. An *all-season road* is a gravel or bitumen-paved road that is passable all year by the prevailing means of rural transport (often a pickup truck or a truck that does not have four-wheel drive). Predictable interruptions of short duration during inclement weather (such as heavy rainfall) are acceptable, particularly on low-volume roads. However, reaching a consensus on "predictable interruptions of short duration" is sometimes difficult. Hence, properly defining and fully documenting road conditions is critical when one is calculating the RAI. Even more important from an economic perspective, however, is that although an all-season road may become unusable to trucks, bicycles and motorcycles may be able to maneuver around troubled areas.

When Does the Threshold of Road Access Limit the Impact of Isolation?

This section presents results of household survey analysis using two complementary approaches: for each selected country (when possible), it presents (a) results of the national household surveys to assess approximately how constraining transport access is on household consumption and (b) results of household surveys commissioned, which assess in detail how strong the transport constraint is on agricultural income.[4,5]

Case Study: Uganda

An analysis based on Ugandan national household surveys. By analyzing household surveys, one can demonstrate an overall downward trend of consumption as people move farther away from markets in both time and distance. Moreover, on average, consumption is the highest closer to the large cities and markets but sharply declines for those households more than 4.5 kilometers distant.

However, the picture is more complex than this finding. A distance–transport time ceiling appears to exist: income generation is marginally constrained beyond one day's walking distance from the markets. Moreover, the mode of transportation does not really have an impact on income, probably because transport is only one component of households' agricultural income.

Following is a summary of the results of the analysis conducted to determine the relationships between time and household consumption in Uganda.[6] The structure of the questionnaire limited the evaluation possible because transportation questions related to the market were not asked of those living with a market in their community.[7] One can observe the downward trend in mean consumption as households move farther from the nearest large city (population greater than 2,000 inhabitants; see table 2.2). Also present is the relative jump in mean consumption between the first quintile and the second quintile (up to 4.5 kilometers), which is the largest difference between any two quintiles (4.86). These findings are similar to those reported in Madagascar by Stifel and Minten (2008), who find evidence of a strong, positive relationship between isolation and poverty. They also note that the largest gap in per capita consumption and in the poverty

Table 2.2 Range of the Distance Quintiles and the Mean Consumption of the Quintiles in Uganda, 2005–06

Quintile of distance	*Range of distance by quintile (kilometers)*	*Mean of total consumption by quintile (U Sh thousand)*
1	0.115–4.509	28.152
2	4.512–12.903	23.293
3	12.904–19.898	20.186
4	19.899–30.883	19.707
5	30.902–75.103	20.214

Source: Ugandan National Household Survey 2005–06.

rate comes between the least isolated (first quintile) and the second quintile.

An analysis based on household surveys in three Ugandan districts. Table 2.3 presents some determinants of household income derived from sales of agricultural products. This section uses data collected in the three pilot districts selected (see box 2.1 for details on data collection).[8]

The apparent paradox lies in the fact that the 2-kilometer distance from a road is not an economic threshold because living farther than

Table 2.3 Transport Determinants of Income Derived from Agricultural Sales in Uganda, 2008–09

Dependent variable: cash income from agricultural sales (U Sh thousand)					
	Basic	*Controls*	*Density*	*Tororo district*	*Greater than 2 kilometers*
Sell direct	150.638***	144.447***	148.927***	124.201***	126.209***
	(39.679)	(40.170)	(39.805)	(39.235)	(39.326)
Crop type	122.013**	61.243	95.355	257.234***	249.087***
	(59.587)	(62.682)	(62.990)	(77.457)	(78.050)
Yield	0.176***	0.187***	0.207***	0.218***	0.219***
	(0.058)	(0.058)	(0.059)	(0.057)	(0.057)
Household size		1.636	2.951	3.239	2.869
		(3.625)	(3.658)	(3.543)	(3.570)
Secondary		16.303**	8.304	6.09	5.584
		(6.256)	(7.143)	(6.949)	(6.977)
Gender of head of household		61.288	39.307	18.331	11.391
		(42.884)	(43.044)	(42.145)	(42.890)
Number of bikes owned			27.646	22.141	21.175
			(22.737)	(22.081)	(22.123)
Passability of road			–0.604	0.001	–0.046
			(0.532)	(0.545)	(0.548)
Road density			440.951*	680.394***	693.383***
			(247.416)	(249.809)	(250.403)
Tororo				127.105***	123.665***
				(37.474)	(37.699)
Greater than 2 kilometers					22.574
					(25.407)
Constant	3.078	–74.553	–153.226**	–291.41***	–288.192***
	(24.811)	(51.275)	(65.691)	(75.549)	(75.686)
Number of observations	173	170	169	169	169
R^2	0.2209	0.2631	0.3021	0.3494	0.3527

Source: Authors' calculations.
Note: Significance: * = 10 percent, ** = 5 percent, *** = 1 percent. Standard deviations are in parentheses.

Box 2.1

Which Data Collection Methodology and Why?

A resource-consuming exercise was carried out because standard household surveys usually do not provide enough information to allow a detailed analysis of the impact of transport services and infrastructure on household production and income level. Indeed, transport services, infrastructure, and location characteristics are absent from standard household surveys.

Therefore, a questionnaire, derived from Sieber (1996) was designed to collect location characteristics (distance from roads, road density per type of road); road characteristics (level of passability); transport service characteristics (which mode of transport used for which trip, at which price); and agriculture data (plot size, price sold at different location, yields, types of crops, and so on), as well as control variables.[a] Thanks to the transport service module, vehicle operating costs were computed, and thanks to local supply chains, local agricultural data were collected to make the link between (a) roads or transport services and (b) agriculture at the local level.

a. The questionnaires are available from the authors on request.

2 kilometers from a road is never a significant determinant factor of agricultural income. However, increased rural road density has a positive effect on agricultural income. Thus, being close to a road obviously seems to create a higher likelihood of earning more from agriculture (all other things being equal). However, the distance beyond 2 kilometers does not seem to matter much, probably because transport accessibility is only one factor in explaining sales of agricultural products. Agricultural endowments and techniques are probably as or more important, as well as other factors, such as education.

Notably, road passability (measured by the number of impassable days) also does not seem to be a major determinant factor of agricultural sales. Two explanations are possible: (a) all farmers do not perceive road passability in the same way, thus the possible impact differs widely; (b) because passability is usually minimal for most smallholders, other factors play a more important role for agricultural sales. Moreover, bike ownership is also not statistically significant to explain agricultural sales, possibly because of the low value of time saved by bicycle rides.[9]

What seems to positively matter for increased income (consumption) are the following:

- Overall yield (of the household's land by crop)
- Crop type (which represents the level of market participation by the households through cash crops)
- Sale of products directly to markets (characterized by the total weight of all crops harvested that are sold directly at the market by the household and not through an intermediary)
- Increased rural road density (calculated as the kilometers of district roads in each district over the area of the district in square kilometers).

Therefore, one can probably conclude that some minimal road access is needed to affect income generation economically, but investing to ensure all rural population is less than 2 kilometers from a road may be considered as overinvestment (in this study's selected districts). In fact, this study demonstrates in the next two case studies that the 2-kilometer buffer has a minimal positive effect on income because of average low plot size, meaning increased road density does not create an expanded transport requirement for most farmers. Moreover, sustainability of such investments is at stake and, therefore, road investment strategy should probably be better adjusted to farmers' transport requirements.

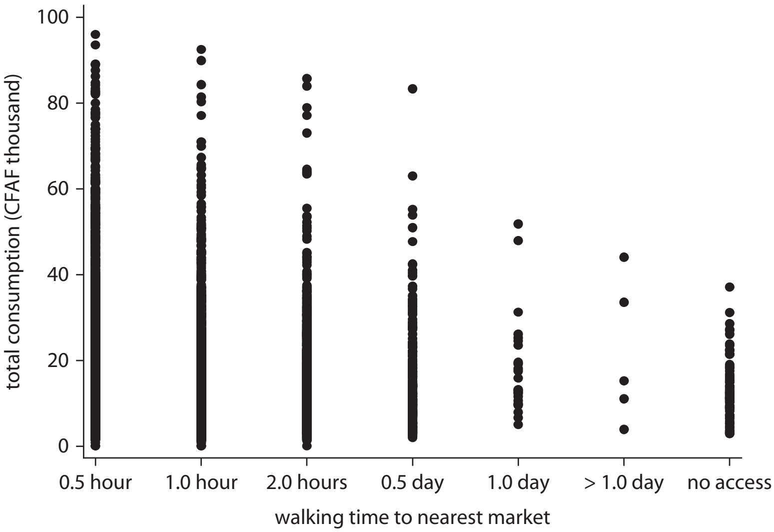
Case Study: Burkina Faso

As in the Ugandan case, this study uses the household survey analysis in Burkina Faso to show an overall downward trend of consumption as people move farther away from markets. However, the median consumption (as a proxy of income) among households within one day's walking distance to the markets ranges between CFAF 11,270 and CFAF 13,820. Thus, one day's walking distance is not a binding constraint, and therefore, the previously mentioned time ceiling has not yet been reached.

A limited analysis based on Burkina Faso national household surveys. Unfortunately, the 2003 national household survey in Burkina Faso is less meticulous than Uganda's. However, from the available data, one may observe the overall relationship between walking time to the nearest market and household consumption (see figure 2.1).[10]

Even though figure 2.1 seems to indicate that being far from the market is a disadvantage for consumption, the median income of a household less that 30 minutes' walk from the market was CFAF 13,800 while the

Figure 2.1 Total Household Food Consumption in Burkina Faso Compared to Walking Time to Nearest Market, 2003



Source: Burkina Faso Questionnaire des Indicateurs de Base du Bien-être 2003.
Note: The upper 5 percent of total consumption was dropped.

median income for a household between half-a-day and one-day distant was CFAF 13,150.[11]

Income determinants based on household surveys in three Burkina Faso districts. Table 2.4 replicates the approach to finding the determinants of cash income from agriculture sales in three districts in Burkina Faso.[12] Interestingly, the results are similar to those in Uganda. High-yield, high-value crops; selling direct to market; and road density are what matter. Also, from these results, one can conclude that living inside the 2-kilometer buffer has low impact on the household.[13]

Case Study: Cameroon

The lack of a national household survey in Cameroon prevents reproduction of previous analyses; however, one could predict that the conclusions reached for Uganda and Burkina Faso stand. Table 2.5 shows similar findings to the previous two tables for Uganda and Burkina Faso. High-yield, high-value crops; selling direct to market; and road density are significant determinants of household cash income, while the 2-kilometer threshold is not a crucial determinant.

Table 2.4 Transport Determinants of Income Derived from Agricultural Sales in Burkina Faso, 2008–09

Dependent variable: cash income from agricultural sales (CFAF thousand)					
	Basic	*Controls*	*Density*	*Sahel region*	*Greater than 2 kilometers*
Sell direct	35.198***	39.569***	34.441***	22.976***	25.423***
	(9.014)	(8.562)	(7.975)	(7.712)	(7.993)
Crop type	54.264***	46.471***	38.777***	50.458***	47.987***
	(8.940)	(8.535)	(8.067)	(7.805)	(8.120)
Yield	0.019***	0.021***	0.017***	0.009*	0.010**
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Household size		1.610***	0.977***	1.240***	1.234***
		(0.309)	(0.320)	(0.302)	(0.303)
Secondary		–9.181**	–8.534**	–9.227**	–9.749***
		(4.160)	(3.852)	(3.596)	(3.631)
Number of bikes owned			5.290***	3.948***	4.075***
			(1.330)	(1.263)	(1.269)
Passability			–0.085	0.046	0.078
			(0.180)	(0.170)	(0.172)
Road density			1,246.743**	4,037.454***	4,119.956***
			(485.929)	(670.255)	(673.606)
Sahel region				41.036***	41.868***
				(7.259)	(7.297)
Greater than 2 kilometers					4.546
					(3.817)
Constant	–21.24***	–38.16***	–50.69***	–94.59***	–99.88***
	(4.185)	(5.280)	(7.500)	(10.454)	(11.215)
Number of observations	217	217	217	217	216
R^2	0.5092	0.5699	0.6385	0.6868	0.6889

Source: Authors' calculations.
Note: Significance: * = 10 percent, ** = 5 percent, *** = 1 percent. Standard deviations are in parentheses. In the surveys in Burkina Faso, all heads of household were men; therefore, the variable "gender of head" was not included in the regression.

Also interesting is that when the dependent variable "cash income from agriculture sales" is replaced by "crop type," passability is almost statistically significant to explain the share of high-value product sales. However, greater distance from a road explains why high-value product sales increase. This finding confirms the preindustrial, nineteenth-century Von Thünen model, which states that farther from the city, only high-value products (and low-perishable goods) are economically viable (to a certain distance limit; see appendix G for details).

Table 2.5 Transport Determinants of Income Derived from Agricultural Sales in Cameroon, 2008–09

Dependent variable: cash income from agricultural sales (CFA Francs thousand)

	Basic	*Controls*	*Density*	*Meme*	*Greater than 2 kilometers*
Sell direct	380.551**	392.848**	301.809*	189.973	189.382
	(162.089)	(166.802)	(167.424)	(202.877)	(203.199)
Crop type	824.107***	822.275***	867.647***	888.216***	887.134***
	(73.031)	(74.285)	(75.436)	(78.328)	(78.796)
Yield	0.386***	0.388***	0.374***	0.379***	0.379***
	(0.049)	(0.050)	(0.050)	(0.050)	(0.050)
Household size		6.638	10.29	9.392	9.399
		(13.889)	(13.889)	(13.920)	(13.939)
Secondary		–3.622	–31.475	–35.206	–34.309
		(46.136)	(46.654)	(46.814)	(47.291)
Gender of head		129.594	75.485	101.521	102.747
		(246.862)	(246.202)	(247.658)	(248.146)
Number of motorbikes owned			303.364	294.062	297.211
			(219.686)	(219.907)	(221.297)
Passability			–2.71	–2.739	–2.726
			(2.658)	(2.659)	(2.664)
Road density			73.888***	63.628**	63.522**
			(26.551)	(28.557)	(28.606)
Meme district				–216.613	–219.392
				(221.895)	(223.040)
Greater than 2 kilometers					22.921
					(159.420)
Constant	–517.20***	–699.01***	–1035.34***	–875.40***	–893.06**
	(108.681)	(264.881)	(282.978)	(327.005)	(349.727)
Number of observations	371	367	367	367	367
R^2	0.3448	0.3460	0.3680	0.3697	0.3697

Source: Authors' calculations.
Note: Significance: * = 10 percent, ** = 5 percent, *** = 1 percent. Standard deviations are in parentheses.

Notes

1. The Rural Access Index measures household remoteness as more than 2 kilometers from an all-season road. The 2-kilometer bands to each side of the road comprise the 2-kilometer buffer.
2. This finding is consistent with research centered in Malawi (World Bank 2009b), which revealed that the optimal transport time for higher agricultural growth is 2.2 hours. Assuming one could walk or bicycle at 4 kilometers per hour, the research showed that the optimal transport distance for agricultural

production from a road would then be more than 8 kilometers (from an economic point of view).

3. This method of maneuvering around trouble spots was reported widely by field studies in Cameroon and in interviews of local people.
4. A type of transport module was developed to estimate the extent of the transport demand, the means of transport used, transport costs and prices for a household, and distances from various types of roads as well as their passability.
5. Because surveys were limited to three regions of three countries in Sub-Saharan Africa, coverage is obviously limited, which limits the possible extrapolation of results.
6. See appendix D for a methodological note. The study used the Uganda National Household Survey from 2005–06, which was performed by the Uganda Bureau of Statistics. It drew on two elements from this survey: the household socioeconomic portion, containing 7,426 households, and the community-level portion, administered in 706 communities. The first steps were to determine the proper measure of consumption and the markets to measure, because multiple options existed for each. Note that the study used consumption rather than income because income may be more difficult to accurately measure than consumption. Various consumption measures were available in this survey: food and beverage consumption over the past 7 days, consumption of nondurable goods and services over the past 30 days, consumption of semidurable goods over the past 365 days, and consumption expenditure per adult. Food and beverage consumption was used because it had the shortest recall period and was representative of overall household consumption.
7. In addition, the data contained inconsistencies, with some communities reporting time and distances that did not seem to make sense. For example, some communities reported being 0 kilometers from the markets but said they needed 1,000 minutes to arrive there. Some communities needed 200 minutes to walk 20 kilometers, while another community walked the same distance in 1,000 minutes. Although differing terrain is a possible explanation, other communities reported a travel time of 60,000 minutes, which is 1,000 hours, or a little more than 40 days. To combat some of these discrepancies, the analysis was conducted on a trimmed sample; the upper 5 percent of the time sample was dropped. Additionally, to make the data more manageable and more readable, the time to market was converted from minutes to hours and then to days.
8. For variable definitions for Ugandan household surveys, see appendix E. Appendix F provides a correlation table between variables.
9. This result is mainly because the median distance traveled is less than 5 kilometers, and the bicycle, when loaded, is pushed rather than ridden.

10. The 2003 Burkina Faso national household survey was conducted in 8,500 households. The survey asks for information on walking time to market and food consumption. The walking time to market question was answered in ranges, which is why the data points are not more scattered; the consumption question refers to the food consumption of the household over the previous 15 days.
11. A more detailed analysis could have been done if the national survey had asked for the common mode of transport and the time needed on that mode of transport to reach the closest market.
12. The three administrative regions studied in Burkina Faso are Boucle du Mouhoun, Centre-Nord, and Sahel.
13. In the results from the Burkina Faso regressions, the "between 6 and 15 kilometers" and the "greater than 15 kilometers" dummies are not significant, which could be explained by the country's flat terrain and easy road accessibility.

CHAPTER 3

What Is the Average Transport Demand from a Farmer and the Ideal Supply from a Trader?

The Agriculture Context

From a historical and global perspective, across countries, agriculture's importance to the overall economy tends to diminish over time, with a strong inverse correlation between agriculture's share of gross domestic product (GDP) and GDP per capita.[1] A second—and consistent—observation is that agriculture's share of GDP has declined in all countries, including those with a strong comparative advantage in agricultural activities. A third point is that the decline of the share of resources in agriculture has been larger for countries with lower incomes, which have more scope for improving agricultural productivity and for shifting resources into new nonfarm activities.[2] Whereas agriculture's share of GDP has fallen substantially for nearly all developing countries, the labor adjustment has been larger for middle-income countries than for lower-income countries. The reason would appear to be that while the share of GDP for nonagricultural activities is rising across countries, only in the middle-income countries have alternative employment possibilities become more widely available, allowing the transition of labor from semisubsistence farming to really get under way. Finally, the pace of adjustment is speeding up: in the countries of the Organisation for Economic Co-operation and Development, the fall of agriculture's share of GDP from 40 percent to 7 percent took a century, but middle-income countries have achieved these changes in three decades or less. This accelerating change is matched by a rapid release of labor from agriculture.

In Sub-Saharan Africa, agriculture remains predominant for rural populations (although increasingly, nonfarming incomes—rather than farming—have a major effect on poverty reduction[3]). Rapid urbanization has resulted in substantial demand growth in the urban markets of Africa. The higher value of horticultural crops relative to staple foods is a key factor. Horticultural products are also more perishable, which makes them more likely to be cultivated in urban and peri-urban areas in a context of poor transport or storage infrastructure. There is a general consensus that the horticultural subsector has strong production and trading potential, limited by the lack of infrastructure, such as storage facilities and rural roads. Gockowski and Ndoumbé (2004), for example, show that, driven by growth in urban market demand and high relative prices, horticulture provides a pathway for intensification among smallholders in southern Cameroon. However, not all farmers in Sub-Saharan Africa follow the same path and strategy: farmers' endowments and characteristics may differ widely (see box 3.1 and appendix H).

Nevertheless, rural Africa is usually characterized by semisubsistence, low-input, low-productivity systems. Lukanu, Green, and Worth (2007) give the example of Niassa province in southern Mozambique and explain that most smallholders give priority to cultivating food crops for consumption. What labor time is left over is used to cultivate cash crops.

Box 3.1

Various Types of Farmers in Sub-Saharan Africa

Peri-urban farmers enjoy higher prices during the postharvest period than do rural smallholders. They also enjoy lower prices during the preharvest "hungry" season than do rural smallholders.

Smallholders will switch between net seller and net buyer positions during the course of the agricultural year. Their preferences vary seasonally with food price distributions.

Rural, large commercial farmers are more likely to sell during the preharvest period peaks when smallholders become purchasers.

Source: Authors' classification.

Using data from the 2005–06 Ghana Living Standards Survey, Chamberlin (2008) finds that rural development strategies based on expanding existing market chains face challenges in connecting with the bulk of small producers, who are less well endowed than average statistics indicate and are by far the most numerous. Therefore, this chapter mainly deals with smallholders.

Arndt, Schiller, and Tarp (2001) show that to compensate credit impediment in rural zones, producers must sell at a lower price to cover either the high rural storage costs or the costs of transport to lower-cost storage sites. In the periods immediately following harvest, rural zones tend to rely on local stocks. As the marketing season progresses, the price increase in rural zones may push rural prices sufficiently high to cover costs of transport back from urban zones. Only then do rural households begin to enjoy the benefits of moderate price increases associated with urban storage. Consequently, rural consumers reap a relatively small share of the benefits.

The Role of Intermediate Means of Transport for Smallholders

As far as transport is concerned, transport by truck is, by far, the cheapest mode (per ton-kilometer) for agricultural products: it is almost 10 times cheaper than transport by bicycle and 8 times cheaper than transport by motorcycle (see table 3.1). However, the story is more complex, because per kilometer, transport by truck is more than 10 times more expensive than transport by bicycle or motorcycle, and in terms of cash need, transport by truck is much higher than transport by bicycle or motorcycle. Therefore, except in the case of large production (or consolidation of loads), transport with intermediate

Table 3.1 Transport Costs by Mode in Uganda

Mode	*U.S. cents per ton-kilometer*
Bicycle	105.9
Motorcycle	95.9
Truck	11.2

Sources: Surveys; for the value of time, DFID 2005.
Note: Mean loads are as follows: 60 kilograms for bicycles, 110 kilograms for motorcycles, and 10 tons for trucks. Value of time is included for bicycles and motorcycles; 1.0 hour is considered as the average transport time for bicycles (4 kilometers) and 1.5 hours for motorcycles (25 kilometers). See appendix I for more details on transport costs for Burkina Faso, Cameroon, and Uganda combined for various modes of transport.

means of transport (IMT) is economically adequate, which confirms some literature findings (Starkey 2001; Starkey and others 2002).

The Farmer's Perspective: The Last Mile Should Not Be a Road for a Truck

In most rural areas in Sub-Saharan Africa, most farmers produce cash crops of about 1 to 5 tons (annually) depending on commodities, soil fertility, inputs, and other factors.[4] In the case of most crops, taking into account the average cultivated area of about 1 hectare in most cases, not more than 100 to 200 kilograms weekly needs to be transported; therefore, except in special cases, a farmer requires transport only by bicycle or motorcycle, unless production is consolidated (see chapter 5). When the crop selling price is low, the current condition of production makes transport by walking or IMT and the sale of crops directly to local markets the most profitable option (a finding confirmed empirically by Fafchamps and Hill 2005).

Even in a case of significant increase of agricultural productivity—for example, a fivefold increase over current production levels[5]—with an average of 1 hectare per household, annual production would hardly reach 15 to 20 metric tons, which is equivalent to two truckloads per year. Therefore, in most cases, transport by truck is not the most appropriate answer (unless load consolidation is organized). In terms of infrastructure, a paved, all-weather road is not needed up to small farms; instead, IMT, with appropriate infrastructure, can bridge the last mile gap.

The distance from the farm to the consolidation point proves to be the area of concern. And at short distances, IMT can serve as the connection between farmers and markets, roads, and transporters.[6] Construction of an unpaved bicycle path, which costs a fraction of construction of an all-weather road, enables farmers to use IMT to transport their crops to markets (Riverson and Carapetis 1991). Moreover, from the farmers' standpoint, costs remain low when using IMT instead of motorized vehicles for smaller loads and shorter distances.

However, IMT do not solve all problems. Indeed, in most regions of Burkina Faso, men perform rural agricultural activities during the rainy season, and they usually do not have any other activity for seven to eight months of the year, which means that the decrease in transport time may not greatly affect labor productivity and low opportunity costs during this period (BDPA and Sahel Consult 2003).

In any case, data collection carried out in Burkina Faso, Cameroon, and Uganda confirms that only transport by bicycle, motorcycle, or both makes current production volumes and yields economically viable in most cases. Transport by truck can be economically viable only for high-value products over a relatively long distance (50 kilometers) with consolidated production. The data confirm some empirical evidence of "underused" rural roads. For instance, in a study covering 50 villages in Burkina Faso, which had good rural roads in good condition, of 47 rural access roads to villages, 19 had no motorized vehicle traffic at all, despite IMT traffic of up to 250 bicycles, 100 pedestrians, and 100 motorcycles a day (BDPA and Sahel Consult 2003).

Worth noting is that low transport demand does not necessarily mean that small farms are unproductive. For decades, empirical data from all over the world have consistently shown that large farms dependent on hired managers and workers are less productive and less profitable (per hectare) than small farms managed by families and operated primarily with family labor (World Bank 2009a). Hence, farm-level agricultural production (primary production) is normally subject to diseconomies of scale.

The transport constraint may not be as strong for high-value products. Using various selling prices (low, medium, and high), this study calculates the difference between sales and transport costs per mode of transport for different distances and tonnages. Unsurprisingly, for 1 metric ton transported 50 kilometers, the farmer's income is the highest when a truck is used (actually, the other modes of transport are not suitable); even more interesting is that for 60 and 110 kilograms, transport by bicycle is the most profitable (see table 3.2).

From a farmer's perspective, a key question is to know whether the usual economic return (profit) enables him or her to purchase a bicycle or motorcycle. Previously, surveys showed that with the current average production, farmers can afford to pay operating and depreciation costs for bicycles and motorcycles. Table 3.3 demonstrates that unless a farmer has financing possibilities or existing cash flow, a motorcycle in most cases is not affordable and a bicycle is affordable only if the crop selling price is not too low.[7]

The main implication for road planning and design is that, in most cases, infrastructure for bicycles and motorcycles in rural areas is sufficient to economically link farmers to the first market. Farmers opt for trader pickup when they cannot afford to carry or deliver their crop to market. In Uganda, only 15 percent of farmers carry their coffee to market; the

Table 3.2 Sales Price Differences for Agricultural Products (at the Local Price) and Transport Costs per Mode of Transport, Commodity Value, Distance, and Tonnage in Cameroon, 2008–09

	Sales price (US$)		
Mode of transport	*Low*	*Medium*	*High*
Difference for a cargo value of 60 kilograms over 10 kilometers			
Cart	3.6	29.6	91.9
Bicycle	4.3	30.4	92.6
Motorcycle	–2.8	23.2	85.5
Truck	–2.3	23.7	86.0
Difference for a cargo value of 110 kilograms over 10 kilometers			
Cart	9.6	57.2	171.4
Bicycle	10.3	58.0	172.1
Motorcycle	3.2	50.9	165.0
Truck	3.7	51.4	165.5
Difference for a cargo value of 1 metric ton over 50 kilometers			
Cart	n.a.	n.a.	n.a.
Bicycle	n.a.	n.a.	n.a.
Motorcycle	n.a.	n.a.	n.a.
Truck	109.9	543.3	1,581.0

Source: Authors' calculations.
Note: n.a. = not applicable. Low commodity selling price (cassava) is declared at CFAF 60 per kilogram, medium commodity selling price (beans) is declared at CFAF 278 per kilogram, high commodity selling price (cocoa) is declared at CFAF 800 per kilogram. These are the median prices. Transport costs include the value of time.

Table 3.3 Share of Initial Cost of a Bicycle or Motorcycle Compared to the Selling Price of 1 Metric Ton of Selected Commodities in Uganda, 2008–09

	Low-value commodity (%)	*Medium-value commodity (%)*	*High-value commodity (%)*
Bicycle	29	14	6
Motorcycle	655	302	131

Source: Authors' calculations.
Note: In Uganda, the average price is US$45 for a bicycle and US$1,000 for a motorcycle.

others simply sell their crop to itinerant traders. For a farmer producing low quantities and without cash to purchase a means of transport, bicycle transport is the cheapest mode of transportation. Farmers cannot fill a 5-ton truck and do not have the cash to pay US$30 per metric ton (which is more than 15 times more expensive than a bicycle and 10 times more than a motorcycle; see table 3.4). Therefore, cash scarcity and limited production scale contribute to explain why trucks are rarely seen on many rural roads.

However, transport by bicycle is sometimes impossible because of climate or terrain. In a wet climate, bicycles cannot be operated, and road

Table 3.4 Transport Price by Mode of Transport and Distance in Uganda, 2008–09

		Transport price (U Sh)			
Distance to Tororo market (kilometers)	*Commodities*	*Bicycle (60 kilograms per trip)*	*Motorcycle (110 kilograms per trip)*	*Pickup (1 metric ton per trip)*	*Truck (5–7 metric tons per trip)*
8	Groundnuts, fruits	3,000	5,000	15,000	50,000
5	Rice, maize	2,000	5,000	15,000	40,000
14	Onion, millet, tobacco	4,000	7,000	30,000	50,000
14	Onion	4,000	7,000	30,000	50,000
20	Pineapple, fruits, oranges, mangoes	5,000	7,000	40,000	80,000
23	Rice, pineapples, groundnuts	5,000	8,000	55,000	100,000

Source: Authors' calculations.

passability can become a serious problem; therefore, transport price is inflated because of greater recourse to cars, pickups, or trucks.

The Service Provider and Trader's Perspective: High Marketing Margins Are Needed to Compensate for a Lack of Economies of Scale

Although transport by bicycle is cheap, the margin between prices and costs is by far the highest, which explains why transport services (by bicycle and motorcycle) have flourished in many rural areas (see table 3.5). In a rural region, for a household with minimal cash, investing in a bicycle can be profitable (whereas a motorcycle necessitates more cash flow from farm activities). Margins of transport for a truck are comparable to those for a motorcycle and higher, which corroborates the finding that truckers and traders use their market power to set prices at levels with comfortable margins (more than US$3 per kilometer).

Also worth taking into account is that economic risk in rural areas is higher than on regular transport corridors because of the possibility of very low volumes and impassability. At the farmer's average production level, transport or marketing margins are high to compensate for a lack of economies of scale. Without 250 or 500 kilograms of cargo, running a truck more than 50 kilometers in rural areas is not profitable at all. Use of trucking services starts to be really profitable for the trader from 500 kilograms of load (see table 3.6). That is why consolidation of loads is so critical for a trader: without consolidation, the necessary discounted selling price is so

Table 3.5 Ratio between Transport Price and Costs in Selected Districts in Uganda, 2008–09

Transport mode	*Transport price-to-cost ratio*
Bicycle	7.5
Motorcycle	2.6
Truck	2.1

Source: Authors' calculations.
Note: Transport costs for bicycles and motorcycles include the opportunity cost of the driver.

Table 3.6 Selling Price Discount Needed to Compensate Operating Costs for a Truck for Various Quantities and Commodity Values in Uganda, 2008–09

	Selling price discount (%)				
Commodity value	*60 kilograms*	*110 kilograms*	*250 kilograms*	*500 kilograms*	*1,000 kilograms*
10 kilometers, old truck					
Low value	100	67	29	15	7
Medium value	57	31	14	7	3
High value	24	13	6	3	1
10 kilometers, new truck					
Low value	100	100	46	23	11
Medium value	88	48	21	11	5
High value	38	21	9	5	2
50 kilometers, old truck					
Low value	100	100	100	73	37
Medium value	100	100	68	34	17
High value	100	67	29	15	7
50 kilometers, new truck					
Low value	100	100	100	100	57
Medium value	100	100	100	53	26
High value	100	100	46	23	11

Source: Authors' calculations.

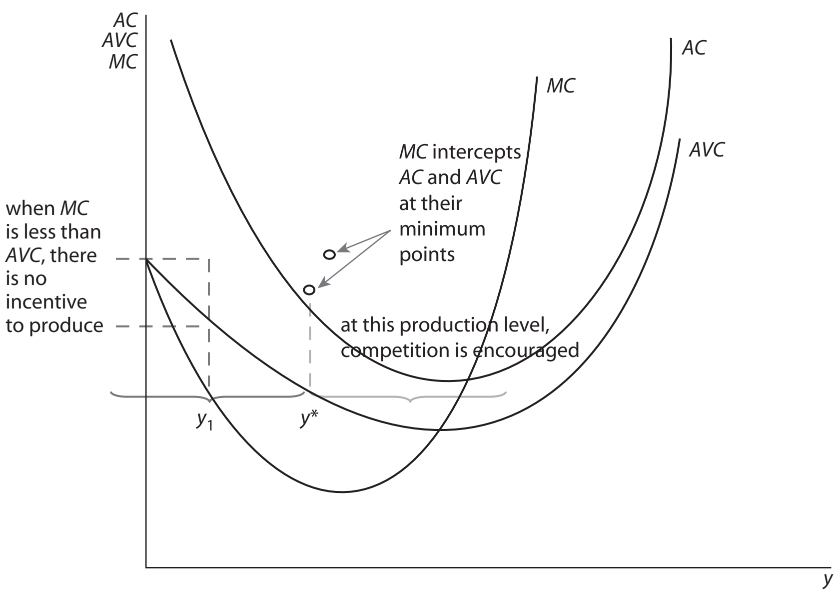
high that most farmers are not interested in selling their small quantities to traders (or their value added is considerably diminished).

This finding brings data to what Metschies (1998) has already pointed out: infrastructure and transport service requirements are correlated with agriculture type (commodity value and load; see appendix K). For small shareholders who depend on subsistence agriculture, agricultural surplus is so low that it cannot lead to transportation by truck (unless consolidation is organized); therefore, the infrastructure requirement should usually be limited to fulfilling IMT demand (for the last mile). In the case of larger plot sizes (and increased productivity) and, even better, mechanized agriculture, roads are needed for trucks.

Hence, low production means no competition. Competition between truckers is virtually impossible to achieve at the lowest level of production because of high risk and low returns. When the production level is less than the minimum to cover the marginal cost (y^*; see figure 3.1), a trucker cannot cover its (marginal) costs and, therefore, getting several truck operators to sell this service is virtually impossible. For low-volume production, competition between truckers is wishful thinking. Virtually nothing can be done to ensure competition between truck operators at this level.[8]

Moreover, significantly increasing agricultural yield would not justify transport by truck. In the case of significant increase of agricultural productivity, with an average of 1 hectare per household, annual production would be multiplied by barely seven times current production (see table 3.7). In terms of transport demand, this level of production is still equivalent to one or two full truckloads per year. Therefore, even though a growing season would last only a couple of months, the transport equivalent would be limited to less than a metric ton per week, which

Figure 3.1 Cost Curves Explain the Lack of Competition in Rural Areas



Source: Varian (1996), and authors' representation.
Note: *AC* = average cost curve; *AVC* = average variable cost curve; *MC* = marginal cost curve.

Table 3.7 Actual and Potential Yield per Household in Bushenyi, Uganda, 2008–09

	Yield (kilograms)		*Ratio of potential-to-actual production*
Crop	*Actual*	*Potential*	
Bananas	960	6,719	7.0
Beans	200	683	3.4

Source: Authors' calculations.
Note: Actual data extracted from household surveys; potential data derived from United Nations Food and Agriculture Organization model.

means that in terms of infrastructure, a paved, all-weather road would likely not be needed, and IMT, with appropriate infrastructure, could bridge the last mile gap.

Notes

1. For a review of these trends, see Cervantes-Godoy and Brooks (2008).
2. Some exceptions exist, such as Brazil and Chile, where the changes have been large in absolute terms but low relative to other countries at similar income levels.
3. See Barrett, Reardon, and Webb (2001) on this argument.
4. Production amounts can be higher for low-value crops, such as cassava, but the commercial value of those crops is not an incentive to dramatically increase production (all the more because the local demand is not infinite).
5. This factor is derived from agricultural potential models developed by the United Nations Food and Agriculture Organization. See appendix J for details.
6. IMT are of less interest for distances beyond 10 to 15 kilometers because, in terms of effort, transport by IMT is much more difficult than transport by truck, which may negatively affect labor productivity. Also, transport time is obviously much longer with IMT than with trucks.
7. Input costs, such as seeds, fertilizers, and pesticides (although the last are hardly used by most smallholders), have to be added to transport costs in making these calculations.
8. Competition is viable only if major traffic generation is assumed, which is usually the case in most economic analysis with Road Economic Decision or Highway Development Model-4. However, in most cases, evaluations at the end of such projects do not confirm that level of traffic generation. This finding should be tested more rigorously and systematically in donor-funded projects in Sub-Saharan Africa. The same argument can be applied to traders to explain why traders usually exert monopoly power in rural areas in Sub-Saharan Africa.

CHAPTER 4

What Level of Investment in Roads Is Best to Stimulate Rural Growth?

Despite talk on the role of roads in enabling countries to fulfill their economic and agricultural potential, most Sub-Saharan African governments do not, in reality, seem to follow any economic strategy when assigning funds to construct, rehabilitate, or maintain their road network, especially rural roads. Governments disperse funds throughout the country usually without any clear connection between (a) allocation to rural, district, and secondary roads and (b) road condition and economic agricultural potential.

Governments see road building as an important tool in maintaining the political unity of the country. As a result, road-building funds are usually not allocated on the basis of any systematic prioritization arrived at through a modeling process. Rather, roads are used as political tools. Ayogu (2002) describes this situation in the case of Nigeria, for example, where the interaction of interest group struggles and the politics of center-state grants involve difficult trade-offs. Bates and Block (2009) demonstrate how regions producing agricultural exports have been discriminated against compared to those where small farming predominates (except if the country's president was from this region or if the country is rich in resources). There are strong incentives for central and local governments to favor local residents (and possibly collect funding) by investing in rural roads.

Moreover, as the Kenya Anti-corruption Commission (2007) points out, risks of inefficient investments in the road sector are not negligible.

In Kenya, weak strategy; poor planning (lacking feasibility studies, traffic data, and data on road condition); and procurement problems sometimes lead to costly investments with very limited benefit for the local population.

How possible is it to limit the disconnect between agricultural and economic potential and road investments? The following section outlines a short methodology with this objective.

Current Low Efficiency of Spending on Low-Volume Roads: The Ugandan Case

As in many Sub-Saharan African countries, because of the current investment strategy in rural roads where increased allocation mainly depends on the road network's length, local authorities in Uganda deemed expanding their network preferable to maintaining it. This may explain why local authorities now strive to upgrade many community roads to district roads.

Road condition plays almost no role when maintenance funds are allocated. Based on reliable and extensive data by district, table 4.1 highlights that road condition (or even poverty rate) does not explain why some districts benefit from higher funding than others. Taking into account the extremely high correlation between network length and allocation for road maintenance, one could assume that a formula exists that is based on network length to define the allocation per district.[1]

This assumption was confirmed by government reports indicating that the district road maintenance funds in Uganda are allocated mainly by the length of the district road network in addition to a minimum standard amount for network operating cost (Ministry of Works and Transport 2008).

This study then computes the correlation between the actual and the "optimal" road maintenance fund allocation under different scenarios (defined arbitrarily). The optimal allocation by district is a function of agricultural potential, district population, district area, and length and condition of the district road network, weighted as follows:[2]

$$Optimal_i = \alpha * \left(\frac{Agr\ pot_i}{\sum_i Agr\ pot_i} \right) + \beta * \left(\frac{Pop_i}{\sum_i Pop_i} \right) + \delta * \left(\frac{Area_i}{\sum_i Area_i} \right) + \phi * \left(\frac{Length_i}{\sum_i Length_i} \right) + \eta * \left(\frac{Bad\ cond_i}{\sum_i Bad\ cond_i} \right),$$

where i represents each district.[3]

Table 4.1 Main Determinants of Spending for Rural Roads in Uganda, 2007

	Dependent variable: Released funds for feeder road maintenance (per capita)						
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Road condition	1.44	1.2	−5.08				2.93
	3.11	*3.14*	*5.18*				*3.44*
Network length per capita	4.71E+05**	4.74E+05**		4.85E+05**			4.81E+05**
	5.19E+04	*5.17E+04*		*4.71E+04*			*5.37E+04*
Number of constituents per capita	3.89E+06				1.86E+07**		5.38E+06
	4.29E+06				*6.37E+06*		*4.36E+06*
Number of National Resistance Movement constituents per capita		4.23E+06				2.00E+07**	
		5.19E+06				*7.88E+06*	
Area	0.01	0.01					0.01
	0.01	*0.01*					0.01
Poverty rate							2.07
							2.23
Constant	−3.25	5.46	738.64**	97.7	431.67**	488.78**	−127.08
	101.35	*99.79*	*97.04*	*62.46*	*92.12*	*83.47*	*174.94*
Number of observations	55	55	55	55	55	55	52
R^2	0.68	0.68	0.02	0.66	0.14	0.11	0.70

Source: Authors' calculations.
Note: Significance: ** = 5 percent. Standard error is in *italics*.

Table 4.2 presents the correlation coefficients between actual allocation to district road maintenance funds and alternative allocation methodologies that take into account agricultural potential, among other variables. The analysis indicates that when the function assigns more weight to agricultural potential, the correlation between the two allocations is lower, which again demonstrates that agricultural potential is not a major factor for defining allocation of road funds at this time.[4] For instance, the Kitgum district has the second-highest potential output for coffee production but receives less than the three districts with lowest agricultural potential, Mukono, Wakiso, and Tororo.[5]

Road Investments Do Not Necessarily Close the Agricultural Income Gap between Regions

Empirical evidence suggests that regional disparities in incomes are often very high and that these disparities do not necessarily decrease as economies grow. If road budget allocation does not consider agricultural potential, the country may miss some lucrative opportunities. In the districts selected for this study, average agricultural income varies from a ratio from 1 to 8 depending on climatic conditions[6] and which cash crop is grown (figure 4.1).[7] Differences in agricultural potential per district are even wider.

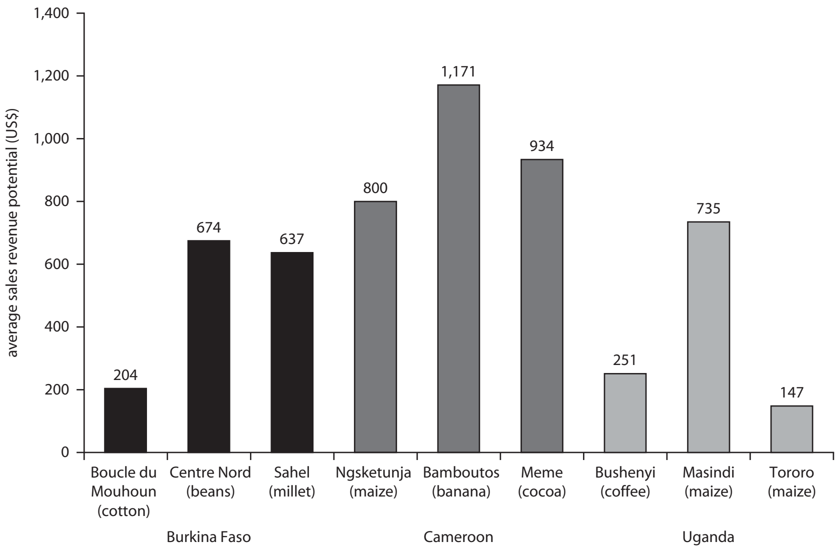
In the case of Uganda, potential export values were computed by district; the crop with the highest potential value was selected and then

Table 4.2 Correlation between Rural Road Investment Strategies and Current District Road Allocation Maintenance in Uganda, 2007

Parameters (weights)					*Correlation between actual and optimal district road maintenance funding*
Agriculture potential (α)	*Population (β)*	*Area (δ)*	*Network length (φ)*	*Network in bad condition (η)*	
0.00	0.0000	0.0000	1.0000	0.0000	0.78
0.20	0.2000	0.2000	0.2000	0.2000	0.65
0.50	0.1250	0.1250	0.1250	0.1250	0.35
0.75	0.0625	0.0625	0.0625	0.0625	0.20
1.00	0.0000	0.0000	0.0000	0.0000	0.11

Source: Authors' calculations.

Figure 4.1 Average Agricultural Sales Revenue Potential per Hectare of Main Crop in the Three Selected Districts in Burkina Faso, Cameroon, and Uganda, 2008–09



Source: Authors' calculations.
Note: Crop selection is based on the most lucrative cash crops by region or district using simulations of the United Nations Food and Agriculture Organization model.

compared to road maintenance allocation.[8] If a district has the financial means to improve its road network, then that district has a greater opportunity to sell its agricultural output. For example, if the district of Masindi decided to reach its coffee potential of 107,700,000 kilograms, then with an improved road system it could export that coffee for a total of US$174 million. Or if the Pader district in north Uganda chose to grow its potential cotton output of 70,400,000 kilograms, an improved road system would allow it to export US$85 million in cotton.

Table 4.3 demonstrates that the agricultural potential varies tremendously between districts in Uganda. Districts in the north of the country, such as Yumbe, Moroto, and Kitgum, seem to have a much higher potential than districts in the southwest, such as Kisoro, or in the southeast, such as Bugiri. Agricultural potential per hectare could differ by a factor of 1 to 400, whereas road maintenance allocation varies by a factor of 1 to 10 (from US$30,000 to US$320,000).[9]

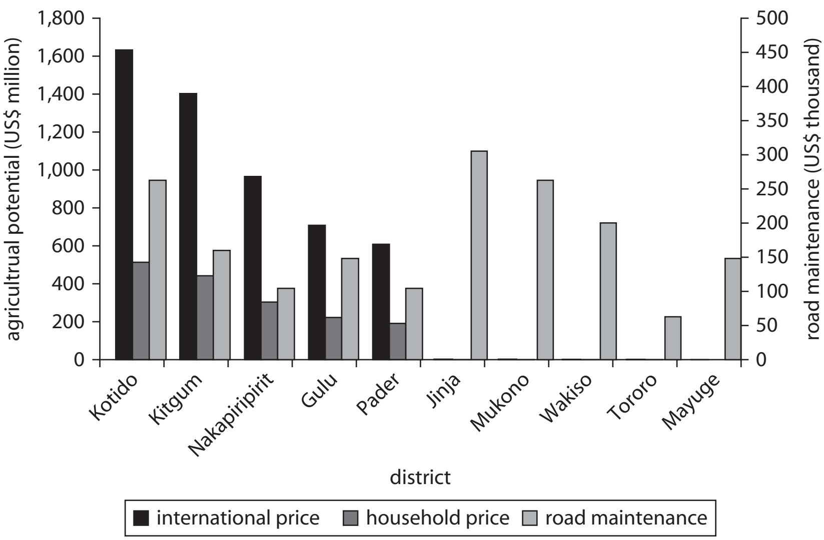
In figure 4.2, the potential value of these crops is compared to the road maintenance allocation per district in Uganda. Potential output in

Table 4.3 Agricultural Potential per Square Kilometer by District in Uganda, 2007

District	*Agricultural potential (US$)*
Yumbe	4,393
Moroto	4,393
Nakapiripirit	4,289
Kitgum	3,688
Adjumani	3,404
Mukono	89
Bugiri	80
Mayuge	77
Kisoro	74

Source: Authors' calculations.
Note: Computed as the agricultural potential divided by the district area.

Figure 4.2 Coffee Potential at International and Local Prices Compared to Road Maintenance Grants in Selected Districts in Uganda



Source: Authors' calculations based on data provided by the Ugandan Ministry of Finance, Planning, and Economic Development.
Note: Data for local and international prices are for 2007, and data for road maintenance grants are for 2008.

international and local prices is presented on the left vertical axis, and the amount of the road maintenance grant is shown on the right vertical axis.[10] Only a subsample is provided, including the five districts with the largest and smallest potential for production. The Nakapiripirit district has the potential to generate almost US$1 billion from coffee at international prices but receives less than half the road allocation that Jinja—a district that has little potential to produce one of Uganda's largest exports—receives.

How Can the Sustainability of the Current Investment Strategy Be Assessed? The Ugandan Case

Using the current size of the road network (in the selected Ugandan districts), one can assess the yearly maintenance needs and then compare them to the current maintenance funding allocation. Table 4.4 highlights that the present allocation covers only routine maintenance needs (for district roads).[11] In the most favorable district, Tororo, periodic maintenance can be ensured for about 10 percent of the current network (on top of routine maintenance). In any case, in Bushenyi, the present allocation does not cover routine maintenance for the whole district network, which means that even without further expansion of the *district* road network,[12] sustainability may be questionable. This type of computation is especially important when there are massive plans to further expand the current network of rural roads (to reach a Rural Access Index of 100 percent).

Finally, one could argue that the spending allocation for road maintenance should be increased to reach the full agricultural potential of the regions. However, reaching this potential mainly depends on the value added of the current production of the selected districts. Table 4.5 demonstrates that if periodic maintenance is completely covered, between 8 and 19 percent of the district agricultural value added would

Table 4.4 Share of Maintenance and Rehabilitation Needs (for District Roads) Covered by the Current Maintenance Allocation in Uganda, 2007

	District		
	Bushenyi	*Masindi*	*Tororo*
Routine maintenance	88	108	138
Routine maintenance + periodic maintenance (every 6 years)	29	36	46
Rehabilitation	3	4	5

Source: Ugandan Ministry of Finance, Planning, and Economic Development for maintenance allocation per district; Ugandan Ministry of Works for road unit costs.
Note: Needs are computed from road unit costs and network size. Per kilometer road unit costs are as follows: for routine maintenance, US$319; for routine maintenance + periodic maintenance (every 6 years), US$1,278; for periodic maintenance, US$3,836; for rehabilitation, US$9,204; for low-cost sealing, US$17,297.

Table 4.5 Share of Potential Spending on Periodic Maintenance Covered by Agricultural Sales in Uganda, 2007

	Periodic maintenance need (US$ per square kilometer)	*Percentage of spending on periodic maintenance covered by agricultural sales (per square kilometer)*
Tororo		
District roads	357	12
District roads + community roads	444	15
Bushenyi		
District roads	241	8
District roads + community roads	575	19

Source: Authors' calculations.
Note: Agricultural sales are computed on the basis of production of the three main traded products, multiplied by median selling prices, and divided by district area: US$3,049 per square kilometer in Tororo and US$3,014 in Bushenyi.

be dedicated to road maintenance and could then very rapidly reach an unsustainable point.

What Could Be a More Effective Road Allocation Maintenance? A Proposed Methodology

Obviously, several criteria should be taken into account in allocating funds for roads, such as population density, road condition, climatic conditions, and size of the existing network. Promoting a better match of allocating road investments to areas with agricultural potential does not necessarily mean that subsistence agriculture should not be supported. For this reason, population (or even the size of current subsistence production) could also be taken into account.

Nevertheless, to increase efficiency of spending on rural roads, the decision on how to allocate funding for roads requires analysis of agricultural potential data (possibly coupled with current production data), an estimation of maintenance needs, and an assessment of whether network expansion is desirable. The main steps are then the following:

1. Computing agricultural potential at the district level (or a combined measure of agricultural potential and current production; see box 4.1)[13]

Box 4.1

How Is Agricultural Potential Computed?

Computation of agricultural potential is possible thanks to the agroecological zone (AEZ) model developed by the United Nations Food and Agriculture Organization. It consists of two main steps. First, AEZ provides a standardized framework for the characterization of climate, soil, and terrain conditions relevant to agricultural production. Second, AEZ matching procedures are used to identify crop-specific limitations of prevailing climate, soil, and terrain resources under assumed levels of inputs and management conditions. This part of the AEZ methodology provides maximum potential and agronomically attainable crop yields of basic land resource units (grid-cells).

Finally, agricultural potential values are computed by multiplying the output of the best-suited crop in ideal conditions (in terms of inputs) by the crop value.

Source: United Nations Food and Agriculture Organization.

2. Estimating maintenance needs by multiplying network length by unit costs of various interventions (routine or periodic maintenance or rehabilitation)
3. Assigning a share of the potential dedicated to roads[14]
4. Comparing the assigned share of potential with maintenance needs and current maintenance allocation
5. Adjusting, if necessary, the road maintenance or construction strategy by privileging roads at the highest level with the lowest passability

This approach requires computation of agroecological zone data at a disaggregated level on top of simpler data, such as road network length and condition and current road allocation per district. Applied to Uganda, the approach demonstrates that several districts in the country have the potential to produce extra agricultural income, taking into account the current size and condition of the network, whereas in several districts of the southwest, the central government could decide to subsidize some of the districts if it funded these districts using the same rules as in the other regions. In the case of the north of the country, some expansion or upgrading of the network could be envisaged (see table 4.6).

Table 4.6 Difference between Total Agricultural Potential and Road Maintenance Needs in Districts in Uganda, 2007

District	*U.S. dollars*
Moroto	37,128,108
Kotido	36,724,816
Kitgum	34,927,546
Gulu	25,699,983
Nakapiripiriti	24,669,255
Bugiri	–25,666
Kalangala	–93,900
Ntungamo	–110,066
Kisoro	–264,947
Kabale	–477,288

Source: Authors' calculations.
Note: Computed as the difference between a share of agricultural potential (5 percent) and maintenance needs (computed as the current network length multiplied by a unit cost of periodic maintenance per kilometer). Agricultural potential data can be coupled with real production data, such as in the Spatial Production Allocation Model developed by You, Wood, and Wood-Sichra (2009), to take more account of current production constraints.

As demonstrated earlier, however, investment in infrastructure is economically justifiable only as long as consolidated production enables reasonable agglomeration to justify transportation by truck.

Notes

1. Also worth noting is that this allocation is probably adjusted in accordance to some political factors; indeed, the number of constituents in parliament seems to affect the amount allocated for road maintenance.
2. Sources and definitions for each variable are as follows.
   - *Actual district road maintenance fund (2006)*. Funds released by the Ugandan government for district, feeder, and secondary road maintenance by district (vote 501–577, program 7). Data are in Ugandan shillings, and 2006 data refer to fiscal year 2006–07. Source: Draft estimates of revenue and expenditure for fiscal year 2006–07, Ministry of Finance, Planning, and Economic Development 2007.
   - *Agricultural potential*. Total potential cash crop area multiplied by the total potential production of the winner cash crop. *Winner cash crop* refers to the crop with higher potential yield (in Ugandan shillings). Cash crop prices are the prices at which farmers sell direct to the market. Cash crops are coffee, maize, bananas, groundnuts, and cotton. Sources: Global

Agro-ecological Zones database (for potential data) and household surveys (for cash crop prices).

- *Area*. Total district area in square kilometers. Source: Uganda Bureau of Statistics.
- *Road network length*. Number of kilometers of district, feeder, and secondary roads by district. Source: Ministry of Works and Transport 2008.

3. During the past decade, Uganda has been increasing the number of districts by dividing the original districts that existed in 2002. Therefore, the values of the divided districts were aggregated to match the 2002 sample (56 districts).
4. It would have been interesting to carry out the same exercise with current agricultural production value, but reliable data for all districts could not be found.
5. A simple correlation test was run with the agricultural potential data (for various crops) using the 2006 figures of the amount of money released to the districts under the heading of Road Maintenance Conditional Grants. The results show no correlation between the agricultural output of a district and the amount of road grants received: 0.05 for the correlation coefficient between coffee potential and road grants, –0.02 for the correlation coefficient between cotton potential and road grants, 0.02 for the correlation coefficient between maize potential and road grants; and –0.04 for the correlation coefficient between soybean potential and road grants.
6. Increased resource use associated with agricultural intensification is not always accompanied by an increase in production efficiency. Although agricultural intensification based on high external input strategies yields higher marginal returns in the Northern Guinea savanna, a similar strategy is not critical to success in the Sudan savanna, given current use levels and the biophysical endowments of the latter ecological zone (Okike and others 2004).
7. Because agricultural produce is primarily used for food purposes, achieving the full agricultural potential could be problematic for food independence. Therefore, data on agricultural potential should probably be used with real production data to reduce the food concern that may arise with monoculture.
8. The possibility always exists that households are consuming some of the output and that not all of the potential output is going to market.
9. These figures should be taken with caution because the model is based on "ideal" conditions, and some potential areas may not be cultivated for various reasons.
10. Agricultural potential is in millions of U.S. dollars, whereas road maintenance is in thousands of U.S. dollars.
11. The selected districts are not among the lowest in terms of road maintenance allocation.

12. Community roads are excluded from this discussion, assuming that they have a second priority order.
13. This computation can be undertaken at a higher or more disaggregated level.
14. Obviously, this methodology does not resolve the issue of private or public funding of roads. Indeed, even though agricultural potential may be higher in one district or another, investments in roads will remain essentially public, whereas agricultural value added is shared between private companies and farmers.

CHAPTER 5

How Can Load Consolidation Be Fostered?

From a historical perspective, Bosker, Buringh, and van Zanden (2008) use a large (new) dataset of cities in Europe, North Africa, and the Middle East between 800 and 1800 to explain why the world's urban center of gravity moved from Iraq to Western Europe and then to the shores of the Atlantic (during the 17th and 18th centuries). The underlying story is that urbanization largely explains economic take-off: the number of cities with population exceeding 10,000—54 in the year 800—grew continually to 615 cities in 1800.

If urbanization and agglomeration seem so important in explaining economic development, secondary towns and local agglomeration should probably be sought today in Sub-Saharan Africa. In many rural regions of Sub-Saharan Africa and Asia, population density is precipitating thresholds for collective facilities and services on the one hand but also squeezing the provision of land for living on the other (Qadeer 2000). As countries develop, they undergo a structural transformation from agriculture to manufacturing and services as well as a spatial transformation from rural to urban. This process has been far from uniform across countries, with some fostering rural diversification out of agriculture and others undergoing rapid agglomeration in megacities. Using cross-country panel data from developing countries spanning 1980–2004, Christiaensen and Todo (2009) find that migration out of agriculture into the missing middle (rural nonfarm economy and secondary towns) is strongly associated with poverty reduction, whereas expansion of megacities is not. Migration to the missing middle yields growth patterns that are more inclusive, whereas agglomeration in megacities widens income inequality.

At the local level, some countries, such as Ethiopia, have many small farms that are too small to provide a subsistence living, even in years with good conditions (Hazell 2005). In Nigeria, poor infrastructure and low purchasing prices for farm output have led some small farmers to abandon their land and work as wage laborers in the city or for large farms (Bah and others 2003). At some point, forces appear to begin to push land size back from division and instead toward consolidation.

From a transport perspective, Smart (2008: 341) describes what is a relatively well-known phenomenon:

> When all origin–destination freight flows are large compared to the capacity of a standard vehicle, then the optimal routing is point-to-point because all standard vehicles are likely to achieve high load factors, and the point to-point routing minimizes travel distance. However, when the capacity of the most efficient vehicle is large compared to the average origin–destination freight flow, *then consolidation and deconsolidation of freight at hubs becomes optimal*.

In rural transport, this fact is forgotten in most cases.

In this chapter, the minimal thresholds required to create sustainable trucking transport are computed, and models of consolidation that allow small farmers to remain independent but capitalize on the power of consolidation are described. This consolidation can occur at different levels: among the farmers themselves (for example, the producer groups in Poland described in a later section) or at a higher level in the chain where the farmers' output is consolidated at a single point by an outsider (for example, the e-*Choupal* model or contract farmer–outgrower schemes described in a later section).

Strong Incentives Not to Consolidate

Coordination problems are rooted in game theory. Whether or not authors explicitly note the ties to game theory, it is present. Game theory is applicable to agricultural economics because of its ability to model interactions between individuals—specifically the farmer-seller and the trader-buyer.

The interaction of these two individuals is represented by a coordination game (also known as the "prisoners' dilemma"), whose features include two choices for both individuals, with two equilibriums (Grabowski 1999). The presence of multiple equilibriums is where the problem exists; there is a high equilibrium and a low equilibrium. As presented in table 5.1, both the buyer and the seller have two choices, option I or option II. These two options represent either investing (option I), which gives a greater return, or not investing (option II), which results in a lower return. Two equilibriums are present in this situation: when both choose option I or both choose option II. If both select option I, their return is 5, but if the buyer cheats and selects option II instead, the buyer receives 8 and the seller receives nothing. To remove the risk of receiving nothing, the players will choose option II, the low equilibrium, from which they have little incentive to move (Grabowski 1999).

The situation now becomes a low-level equilibrium trap that is caused by a fear of coordination risk, the risk of investment failure caused by the lack of complementary investment by the other player (Kydd and Dorward 2004; Smart 2008). This risk deters farmers from investing more in their land and crops for fear of not finding a buyer. For example, a farmer may improve his soil condition, resulting in a better-quality product, but the buyer-trader is not willing to pay more for this quality improvement. Examples of this fear are present all over; producers often cite the lack of a buyer as a marketing problem (Kindness and Gordon 2001). Conversely, a trader may decide to invest in a better or larger mode of transport only to find that the farmers he purchases from do not have enough produce to make the larger mode of transport economically viable. Kydd and Dorward (2004) identify the existence of a threshold level of investment that extends through the entire supply chain. Below this threshold, the players face no incentive to invest, but above the threshold, returns from investment will continue to spur growth and more investment. Unfortunately, poor rural farmers have disproportionately higher rates of risk than other groups in developing countries, making

Table 5.1 Farmer-Trader Dilemma

	Seller	
Buyer	*Option I*	*Option II*
Option I	5, 5	0, 8
Option II	8, 0	2, 2

Source: Grabowski 1999.

the rise above the threshold difficult (Anderson 2003; Barrett 1996). Nonetheless, there are opportunities to break the coordination problem.

One Option: Selling Directly to Markets

For a small farmer with a plot size of 1 hectare, selling his or her product directly to the first local market by walking or by bicycle is the most economical option, which seriously limits the transport infrastructure requirement for the last mile for most villages. However, Fafchamps and Hill (2005) find that selling to the market is more likely when the quantity sold is large and the market is nearby.[1]

Some of the literature suggests that intermediate means of transport (IMT) may provide a more direct connection for rural farmers. With rural areas difficult to access, the few traders who do come have little competition and are at an advantage in the transaction compared to the farmer (Porter 2002). Instead of incurring the financial burden of a motorized vehicle, producers who travel short distances with small loads can substitute IMT (Porter 2007; Sieber 1999).

Nevertheless, IMT are still just the connector, because consolidation must occur at some point for these rural farmers, especially when farmers are far from urban centers. Instead, IMT could be used as a mode of transportation that moves produce to a collection point, where larger vehicles can consolidate several small loads into one large load (Sieber 1999).

The Usual Option: Market Intermediaries without Storage

Different approaches can overcome the coordination trap that characterizes the current situation faced by small farmers. One approach is the use of market intermediaries to facilitate the transaction between the buyer and seller. Market intermediaries become the link and can take different forms—from the *ddebe* boys in Uganda to the *delala* grain brokers in Ethiopia to the subcollectors and wholesalers in Madagascar.

The option for a household is either (a) to sell postharvest and become a net grain buyer in the "hungry" season or (b) simply to store and consume on location, thus avoiding transport costs and cash disbursements. Benirschka and Binkley (1995) studied optimal storage. In a geographically dispersed market, the opportunity cost of holding stocks declines as distance to the market increases. Benirschka and Binkley have shown that in an effective market, longer-term storage, such as grain reserves and carryover stocks, will be located far from markets because of the decrease in opportunity cost. However, according to Arndt, Schiller, and Tarp (2001), high storage costs in rural zones force farmers to sell immediately postharvest and repurchase late in the marketing season to benefit from more efficient storage elsewhere (in urban zones). The regularity and the rapidity of seasonal grain price increases in Mozambique indicate both a constrained ability on the part of smallholders to hold stocks and a strong desire for cash (to finance consumption).

Market intermediaries offer themselves as a possible solution to obtain cash rapidly, but they can quickly turn into middlemen exploiting farmers for their own gain. The study conducted by Fafchamps and Hill (2008) in Uganda shows that increases in international prices of coffee are not followed by increases in local price. Instead, the price increase signals the entrance of another level of middlemen, called *ddebe* boys—traders who travel from farm to farm purchasing coffee from farmers and then selling to wholesalers. From *ddebe boys* up, prices rise with the international price; only the farmers are left out, mainly because of their lack of knowledge of international demand and prices (Fafchamps and Hill 2008).

Subcollectors in Madagascar serve as the bridge between farmers and wholesalers. Subcollectors usually live in the village where they work. Their purpose is to purchase crops from individual farmers and consolidate the crops into one load (Barrett 1997).

Other examples of intermediaries exist around Sub-Saharan Africa and are typified by the high margins between the price at which traders purchase crops from the farmers and the price at which traders sell the crop to the wholesaler or consumer. In Malawi, the selling price is 49 percent higher than the purchase price (Fafchamps, Gabre-Madhin, and Minten 2005). However, even though local storage is available and accessible, the farmers will face the same coordination problem to access better prices and pay low transport costs for filling a truck.

At Which Yield or Farm Size Is Consolidation a Must?

Assuming that competition in the trucking industry requires at least five trucks on the same route, one can compute the catchment area needed to make transportation by these trucks economically viable. At the current production level (of approximately 1 metric ton of cash crop per year per hectare), trucks would need to consolidate the production of at least 600 farmers), which would mean that a truck could probably serve only one of every three villages in the production area. The unserved villages would have to transport their production by IMT to the served village. Obviously, for the equivalent of 10 trucks, the number of unserved villages would increase tremendously (table 5.2).

This phenomenon is noteworthy because a trade-off occurs between individual traffic (for roads and trucks) and catchment area, usually neglected on the assumption that traffic will grow coupled with a smaller catchment area. In reality and in the short and medium terms, increase in individual traffic (for a road) can come only at the expense of a larger catchment area, which explains why investments in large infrastructure and services in rural areas should be prioritized carefully. In any case, serving all settlements with roads designed for trucks should not be an objective.

For many African countries, secondary roads, as the "missing middle," arguably have often been ignored in prioritizing road investments. Central government road agencies tend to take trunk roads as a priority while community-driven development (that is, agriculture and social groups operating within donor agencies) has been more interested in supporting the feeder and tertiary road network. As a result, secondary roads are often in far worse physical state than are the feeder roads that connect to them, even though secondary roads may take a hundred times the traffic of the connecting feeder roads.

How to Break Out of the Coordination Trap

Multiple options exist for farmers to break out of the coordination trap, including producer groups, the e-*Choupal* model, and contract farming schemes.

Table 5.2 Catchment Area (in Numbers of Farmers and Villages) for the Equivalent of 5 and 10 Trucks' Traffic

Catchment area	*Need for 5 truck-equivalent traffic (3 times a week)*	*Need for 10 truck-equivalent traffic (3 times a week)*
Case 1: 1 metric ton per hectare		
Number of farmers	600	1,200
Number of villages	3.0	6.0
Case 2: 5 metric tons per hectare		
Number of farmers	120	240
Number of villages	0.6	1.2

Source: Authors' calculations.
Note: Computations are made for a 5-ton truck that transports goods over 30 kilometers, has a return load and fixed costs of US$4,000, and charges US$1.20 per kilometer.

Producer Groups

After the end of Communist rule in Poland in 1990, many farmers were lost without the direction and reliable purchasing of the former government. In the free market economy, many farmers suffered, especially because of their small landholding and their inability to comply with quality standards. In response, the Polish farmers organized producer groups. In producer groups, all farmers retain control over their land, and the group exists only to act as a market intermediary that coordinates sellers and buyers in the hope of obtaining higher prices for farmers' output (Banaszak 2007). The benefits from the group stem from diminished transaction costs to the sellers; instead, the group manager searches, negotiates, communicates, contracts, and monitors the transaction. By consolidating their output, the producer groups could organize pickup and transportation of their crops to buyers and use their consolidated size to negotiate better prices (Adamowicz and Lemanowicz 2006). The producer group acts as a point of consolidation of agricultural output, where the large size of the output creates marketing strength. In fact, on average, group members received a premium of 6.2 percent on their products, with some groups reporting premiums as high as 39 percent. Though all of the successful groups participated in joint sale, 57 percent of successful and 27 percent of partially successful groups participated in joint transportation. Thus, the strength comes not only from the large quantity that can be sold but also from the ability to take advantage of economies of scale and transport that large output by large trucks, without having to pick up small quantities from several farmers.

An ordinal probit model was run to pinpoint the elements of success, with the level of success as the dependent variable. The results include positive and significant coefficients on the preexistence of business relations between members, a selection process for members, the leader's strength, and the number of members (Banaszak 2007). The lesson learned from the experience of producer groups in Poland is the need for groups to be developed by those directly involved in production—farmers who already have business ties. The producer groups should also establish a selection process for members and seek legal recognition of the group. Increasing market share and bargaining power with purchasers also requires recruiting more members.

*Consolidation through ITC: The e-*Choupal *Model*

The e-*Choupal* is the brainchild of the International Business Division of the Indian Tobacco Company (ITC). The idea came in response to the challenges of acquiring agricultural outputs in India—problems that included small and fragmented farms, multiple intermediaries, and poor infrastructure (Indian Planning Commission). To overcome these problems, ITC developed the e-*Choupal*, which means village meeting place in Hindi, as a way to connect directly with the farmers using Internet kiosks.

Before the e-*Choupal*, after harvesting their crop, farmers could either sell to a trader or bring their crops to *mandis*, regional markets established by the government. When farmers brought their crop to the *mandi*, potential buyers could visually inspect the product, followed by an open oral auction (Bowonder, Gupta, and Singh 2002). After the price was established and bids won, the farmers brought their produce to the weighing areas operated by the buying agent. At the weighing areas, the produce was put into sacks and weighed. With the calculation of the full weight of produce, the farmer collected his cash payment.

Although simple in design, the *mandi* system has numerous inefficiencies and problems. Most important is that the farmers do not have information about pricing beforehand, except what they may hear in the local village. Therefore, farmers may not have been selling their crop at the optimal time, which would have allowed them to maximize their income (Annamalai and Rao 2003). Other unsavory practices exploited the farmers, including underweighing of their produce, obliging the farmer to pay the costs of weighing and bagging, and not paying the farmer the full amount at the time of sale but requiring him to return to the *mandi* for the remaining amount owed (no interest was paid on this delayed payment). In addition, the *mandi* system caused problems for the companies at the end of the line, such as ITC. The multiple handling stages resulted in increased time and costs, inconsistent produce quality, and inflation of prices by the commission agents, both at the *mandi* and to the trading company (Annamalai and Rao 2003). With these issues in mind, ITC thought that dealing more directly with the farmers could eliminate a number of these problems. The e-*Choupal* was designed to facilitate this more direct connection.

The first step is identifying the location for the e-*Choupal*: the location acts as the hub with spokes reaching out to neighboring villages. On average, 600 farmers from 10 villages within 5 kilometers are served by one e-*Choupal*. When the village is identified, a *sanchalak* is selected. Also a farmer (Annamalai and Rao 2003), the *sanchalak* operates the e-*Choupal*. The computer is placed inside the home of the *sanchalak*, who acts as the intermediary between local farmers and the e-*Choupal*. The *sanchalak* is a vital part of the e-*Choupal*'s success: he must be willing to accept the responsibility and have the entrepreneurial spirit to undertake the project. To ensure commitment to the e-*Choupal*, the *sanchalak* must take a public oath to serve the farming community, thus garnering respect and prestige within the village (Bowonder, Gupta, and Singh 2002).

Once installed, the *sanchalak* accesses information from the e-*Choupal* regarding weather, new and best farming practices, and market prices, which is gathered from *mandis*. With this information, farmers are capable of making an informed decision; they can sell their produce either to ITC or at the *mandis*. The price offered by ITC is based on the *mandi*'s closing price of the previous day. This price is the highest possible price, and it is reduced depending on produce quality. If a farmer chooses to sell to ITC, he first brings a sample to the *sanchalak*, who conducts a quality assessment using a checklist (this provides transparency in pricing). The *sanchalak* then gives the farmer a tentative price quote; from there, the farmer proceeds to an ITC procurement hub with the produce. ITC's goal is to have a hub within 30 to 40 kilometers of every farmer. At the hub, another quality test is done, with price deductions resulting from the presence of foreign matter or moisture content, concepts that are well understood by the farmers (lab tests are not yet accepted by farmers). After inspection, the produce is weighed using an electronic scale, removing possible human errors or other shady practices that occurred at the *mandis*. With the price and weight known, the farmer then is paid in full at the hub payment counter. At that time, the farmer is also reimbursed for transporting the crop and receives a copy of the lab report and a receipt.

The e-*Choupal* system has been a win-win for farmers and ITC (box 5.1). With greater information and understanding of prices, farmers have become more aware of what they should or can receive for their crop. When farmers sell to ITC through the e-*Choupal*, prices are 2.5 percent higher on average then if sold at the *mandis* (Annamalai and Rao 2003). Even though ITC is paying more for the produce and compensating farmers for transport, ITC is paying less than before (Prahalad and Hammond 2002). Because ITC cut out the intermediaries, the markup it pays has decreased from 5.0 percent to 2.5 percent. ITC is not finished: currently, 6,500 e-*Choupals* serve 4 million farmers; the plan is for a total of 20,000 e-*Choupals*, serving 10 million farmers in the next five years.[2] In addition, ITC is starting to expand operations in the reverse direction, bringing goods to rural areas through structures called *Choupal Saagars*.

Load consolidation at the local level decreases the need for a road accessible by truck to every farm; it decreases investment needs and increases

Box 5.1

How Much? The Cost of Installing and Running the e-*Choupal* System

The cost of installing the e-*Choupal* is borne solely by ITC. The installation of the computer in the *sanchalak*'s home costs ITC between US$3,000 and US$6,000. The cost includes the computer and setup, though costs can vary from home to home. Setup includes ensuring a constant power supply, telecommunications connectivity, and bandwidth. If the power supply is unreliable, ITC may install solar panels to overcome that problem. As for the Internet, it is accessed either by the phones lines or by a very small aperture terminal (VSAT) connection. The VSAT connection is a satellite-based technology that allows the e-*Choupal* to avoid connectivity problems associated with dial-up. The VSAT system alone costs US$2,650 per installation.

Maintenance costs ITC about US$100 annually. It includes a 24-hour help desk for the *sanchalaks* to contact and twice-monthly visits by ITC engineers. These bimonthly visits are to ensure the integrity of the e-*Choupal* infrastructure. ITC currently retains a staff of about 15 engineers, with each engineer making one or two house calls a day at a cost of US$6.60 per visit.

After the e-*Choupal* is set up, the only expenditures incurred by the farmer are those that facilitate the use of the e-*Choupal*, including power and phone bills, which can run between US$60 and US$160 annually.

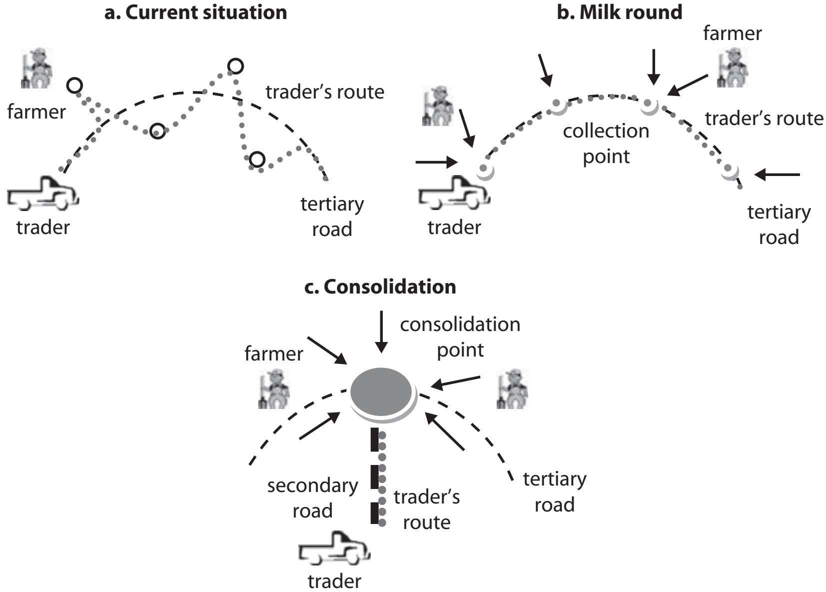
Source: Annamalai and Rao 2003.

value added for farmers. From a cost-benefit analysis, as illustrated in panel c of figure 5.1, the most effective form of consolidation is panel c because it mainly reduces road public investment to the secondary network and enables decrease of transport costs owing to increased predictability of volume and strengthened competition between operators.

Contract Farming and Outgrower Schemes

Contract farming and outgrower schemes are methods that firms use to take advantage of the existing assets of small rural farmers. Al-Hassan, Sarpong, and Mensah-Bonsu (2007: 8) define *contract farming* as "a vertical coordination between a central processing or exporting unit on the one hand, and growers of agricultural products." A contract between the central firm and the grower describes the terms of the purchase of the crop to be grown. In general, the firm provides inputs

Figure 5.1 Various Consolidation Models



Source: Authors' representation.

(seeds, fertilizer, pesticides) and extension services to the farm free or at a lower cost to the farmer, who in turn grows the crop and sells it to the firm at the previously agreed price (Kindness and Gordon 2001). Specific elements of the contract can vary, such as the extent of the firm's control over the farmer or an agreed amount of output. There is great potential for both good and bad to come of this contract. A study of small Zimbabwean farmers asked what the motivation was for entering a contract. The top responses were market uncertainty; indirect benefits (that is, knowledge); increased or more secure income; and intangible benefits (Masakure and Henson 2005). Consequently, even if the farming contract does not continue, farmers have gained greater knowledge about growing techniques, inputs, and the market. However, in any situation where a large firm interacts with smallholders, problems can arise that relate to the farmers' motivation for entering the contract.

The problem with contract farming is the unequal power relationship that develops between the farmer and the firm, with the firm exploiting the farmer. These contracts also exclude certain groups from the schemes, which places them at a greater disadvantage. These groups include the

Box 5.2

The Role of SODECOTON for IMT in Northern Cameroon

SODECOTON is a parastatal company operating in northern Cameroon with a mandate to promote cotton production. To increase cotton production, the company, apart from inputs (fertilizers and pesticides) and cereals provision, has started to promote IMT and mechanization with the objective of increasing yields and reducing transport costs. SODECOTON has promoted the use of animal- and hand-drawn carts and, to some extent, bicycles and motorbikes, which are provided through a loan system to cotton farmers. The loan is called *crédit court terme* (short-term loan) and extends for a duration of two years at an annual interest rate of 10 percent. So far, the loan recovery rate is about 99 percent. The technical quality and affordability of this equipment have contributed to its rapid spread in northern Cameroon and in the neighboring countries (Chad and the Central African Republic). From 15,300 in the 1996–97 agricultural campaign, the number of hand-drawn carts (produced locally) increased to 21,500 units in 2000–01 and reached 26,900 in 2006–07. The number of animal-drawn carts has followed the same curve: from 3,630 units in the 1996–97 agricultural campaign to 6,680 in 2000–01 and 10,200 in 2006–07.

Source: Provided by Guy Kemtsop.

landless poor, women whose labor is exploited by men, and children whose free labor is used by their parents (Porter and Phillips-Howard 1997). In addition, by not directly employing the farmers, firms are able to control crop production without incurring the costs of full-time employees. As time progresses, farmers may become more invested in growing the specified crop for the firm, which can result in limited alternatives and leave the farmer with no exit strategy and at the firm's mercy (Key and Runsten 1999; Porter and Phillips-Howard 1997). Food security presents additional concerns in areas that are highly invested in producing a cash crop for the contracting firm; a possible side effect may be less growing of food staples. Thus, local food prices begin to rise as food shortages strike local communities (Key and Runsten 1999; Porter and Phillips-Howard 1997; Warning and Key 2002).

Finally, vertically integrated companies sometimes contribute to the development of IMT, such as the Société de Développement du Cotton (SODECOTON) in Cameroon (see box 5.2).

Notes

1. Of note is that Fafchamps and Hill (2005) find the relationship between wealth and market sales to be nonlinear: poorer and wealthier farmers are more likely to sell to the market, while farmers of intermediate wealth usually sell at the farm gate.
2. ITC describes its plans on its Web site, http://www.itcportal.com/rural-development/echoupal.htm.

CHAPTER 6

Conclusions and Policy Recommendations

Conclusions

Generally, a one-size-fits-all approach is not effective in addressing the problems of all regions of all African countries.[1] Governments and development partners probably need to adopt an approach that supplies the appropriate road for a rural area, realizing that a large main road may not be required, taking into account the economic potential of the region.

Low volume creates low competition. Competition between traders and truckers is virtually impossible to achieve at the lowest level of volume because of high risk and unpredictable returns.

Policy Recommendations

Policy recommendations span various sectors and public policies, as pointed out in table 6.1. They may look simplistic, but they are key principles that should kept in mind for road planning in Sub-Saharan Africa. More specifically, differences in policy recommendations for development partners and policy recommendations for country officials need to be distinguished.

Table 6.1 Key Principles and Actions to Take in the Area of Rural Road Planning

Public policies	*Key principles and actions to take*
Macroeconomic/fiscal	• Estimate the ideal network size on the basis of the country's fiscal debt sustainability projections. • Prioritize allocation for road maintenance over network expansion.
Road planning	• Prioritize allocation to the secondary network over allocation to the rural road network (except in areas where agricultural potential or production is exceptionally high). • Better discriminate in making national and local road allocations instead of dispersing scarce resources. • Stop building roads fit for trucks for the last mile. • Develop and implement technological options, such as concrete pavement for critical points. • Better coordinate between ministries of public works and of agriculture (field-to-market "roads" should be the responsibility of the ministry of agriculture; the rest should be the responsibility of the ministry of public works).
Agriculture	• Estimate the approximate value of agricultural potential or production at the regional level. • Rehabilitate field-to-market roads to fit them for intermediate means of transport (a couple of meters wide). • Stop building rural roads and pass the mandate to the ministry of public works.

Source: Authors' representation.

Policy Recommendations for Development Partners

The following recommendations are addressed to development partners.

Revise the Rural Access Index or its binding power. Major investments in rural roads cost billions of dollars, yet they do not meet expectations. Transport is only one component to reducing poverty in rural areas. The 2-kilometer buffer is not an economic threshold. Moreover, because most rural households are located fewer than 5 kilometers from a non-all-weather road and because road passability is not a major consideration for small farmers (except in the case of bridges or tunnels), the last mile of public roads need not be suitable for small trucks—in most cases, infrastructure for motorcycles is sufficient. Because of its high opportunity costs, the Rural Access Index (RAI) should be revised to make it binding for a buffer zone of 5 kilometers from a road. Such a revision would ensure that most remote communities are not left behind but would prevent overinvestment or generation of an unsustainable road network.

Better tailor interventions and be more innovative. Development partners should realize that a 7-meter-wide main road is not required in most rural areas in Sub-Saharan Africa. Some pilot projects should be supported locally to meet the potential demand for intermediate means of transport (IMT), bearing in mind that any success may not be replicable in another region or country.

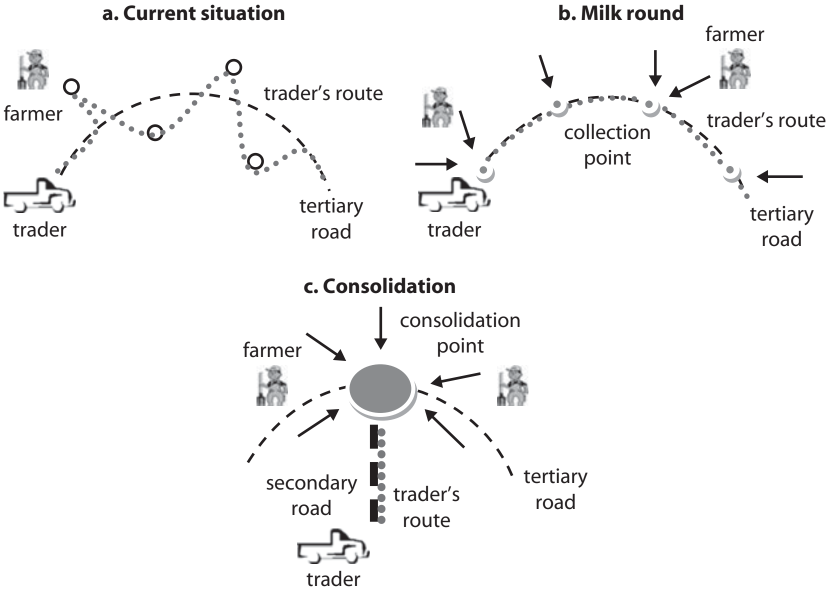
Monitor allocation to road maintenance, especially for rural roads. Serious efforts have been undertaken to rehabilitate and sometimes expand low-volume road networks. Nowadays, some governments are in a difficult position as far as maintenance is concerned. Incentives should be developed to force governments to allocate funds to maintain the existing road network instead of regularly financing road rehabilitation and network expansion (induced by the strategy to fulfill the RAI everywhere in Sub-Saharan Africa).

Provide assistance to improve investment strategies in rural roads. Road investment strategies should be revised in many countries using new tools, such as spatial economics and satellite imaging, to increase the efficiency of such investments.

Focus more on the missing middle and better coordinate interventions. The secondary network has long been forgotten and is vital to linking main (trunk) roads with rural roads. The last mile should not be a road for a truck, but the secondary network, which links secondary cities, should be in good condition (paved or unpaved) to enable truck fleet efficiency and competition. Donor coordination is critical. It can prevent, for example, the rehabilitation of rural roads that are not connected to passable secondary roads.[2]

Recognize the role of more sophisticated load consolidation models. Without load consolidation and agglomeration at the local level, surplus for small farmers cannot increase significantly (with or without massive investments in roads). Load consolidation at the local level decreases the need for a road accessible by truck to every farm; it decreases investment needs and increases value added for farmers. Cost-benefit analysis shows consolidation (or agglomeration) is the most effective model, because it mainly reduces road public investment in the secondary network and enables the decrease of transport costs because of increased predictability of volumes and strengthened competition between operators (see figure 6.1, panel c). Indeed, in panel c, less than 40 percent of the distance is run by a truck, compared with the current model (panel a), in which the roads are supposedly in better condition (see also table 6.2). Roads for trucks should be developed where local agglomeration occurs (mostly small towns or, less likely, large collection points). With increased volumes to transport, increased numbers of rotations because of more rapid turnover, and better road conditions, competition may emerge between transport operators and then affect transport prices positively.

Figure 6.1 Various Consolidation Models



Source: Authors' representation.

Table 6.2 Comparison of Transport Distance of the Various Consolidation Models

Model	*Transport distance (kilometers)*	*Percentage of current situation (in terms of distance)*
a. Current situation	104	100
b. Milk round	80	77
c. Consolidation	40	38

Source: Authors' calculations.
Note: The truck is assumed to run 20 kilometers to the first village (or consolidation point). In the current situation, four villages are all situated 3 kilometers from the road.

Policy Recommendations for Country Officials

The following recommendations are addressed to country officials.

Review investment strategies objectively. Road prioritization should be reviewed objectively in many Sub-Saharan African countries to better take into account economic potential. Probably more priority should be assigned to maintenance or rehabilitation than to network expansion. Moreover, in some cases, instead of investing in rural roads, public authorities should consider investing in schools, hospitals, or markets with a spatial perspective to create local agglomeration.

Better coordinate interventions and focus more on the missing middle. The secondary network is vital to linking main roads with rural roads. In many countries in Sub-Saharan Africa, the definition of a rural road is based on network ownership and not the economic function of the road. Moreover, in several countries, rural road investments are a mandate of the ministry of agriculture or, in decentralized countries, local authorities, whereas the main and secondary networks are a mandate of the ministry of public works. Without coordination between public works officials and agricultural and local authorities, the effects of rural road rehabilitation may be severely limited because the ministry of public works may decide to allocate funding to other parts of the network in other regions (see box 6.1 for an example in Cameroon).

Adjust strategies to take into account agricultural potential and production. Despite discussion on the subject, current strategies related to investment in rural roads do not take into account agricultural potential and current production. This study demonstrates that in some regions, the agricultural potential can be 10 to 20 times lower than in other regions of the same country. Such low-potential regions should not benefit from the same road allocation. Figure 6.2 provides a decision tree that takes into account the local context for potential investment. If applied to a country such as Uganda, the decision tree can be used to define some regions and strategies to increase the efficiency of the spending in roads. Although social criteria are important for road planning and will continue to play a major role, economic criteria should be given more weight to make investments in road networks more sustainable (see box 6.2 for an example of what a revised road-planning strategy would look like).

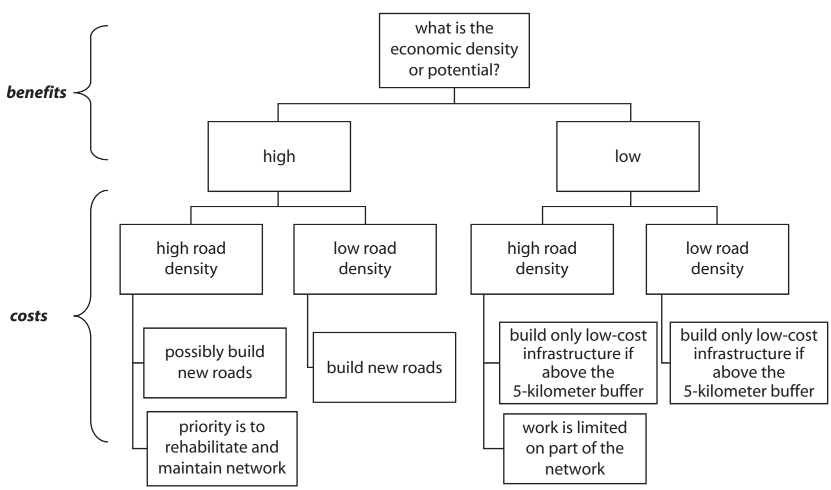
Box 6.1

An Example of Lack of Coordinated Interventions between Ministries

In the Meme division in the South-West region of Cameroon, the South West Development Authority (SOWEDA) is now implementing a project, the Rumpi Area Participatory Development Project, aimed at rural development. Of CFAF 8.5 billion (over US$17 million) scheduled for the project in the first year, more than half will be dedicated to the rehabilitation of rural roads. At the end of the project, more than 230 kilometers of rural roads should be rehabilitated. Two main problems remain. First, the national network (linked to the rural roads to be rehabilitated) is in the same condition as the rural roads and is subject to frequent road closings to vehicles. Nevertheless, the Ministry of Public Works, which is in charge of this network, does not allocate sufficient funds to keep it in good condition. Second, donor funds for SOWEDA cannot contribute to the rehabilitation of the national network in Meme division because the project was signed with the Ministry of Agriculture and Rural Development and its mandate is to rehabilitate only rural roads. The risk is that at the end of the project rural roads may be fully rehabilitated, yet frequent cuts may still exist in the secondary network. Hence, the increased agricultural production would not reach cities because of the poor condition of the secondary network.

Source: Guy Kemtsop's interview.

Figure 6.2 Decision Tree on Investment Strategies in Rural Roads



Source: Authors' representation.

Box 6.2

What Would a Revised Road-Planning Strategy Look Like Compared to the Current Situation?

Today, road allocation in secondary rural roads is usually based on three key principles:

- It is a function of the length of the regional network.
- It is a function of which needs are most urgent.
- It is a function of political goals, which partially explain why funding is usually dispersed and the most vocal or best-connected politicians get the highest allocation in their region.

Consequently, road planning is not strategic; departments in charge of rural roads act when an emergency occurs or when political pressure becomes excessive. A revised road-planning strategy would be based on objective data on (a) regional potential and current agricultural value, and (b) georeferenced road networks with information on road condition and on critical points. Investment needs would be recomputed at the regional and local levels. Using this information, planners could prioritize some major investments in the most economically dense regions (mainly on the secondary and tertiary networks). Because of budget constraints, some parts of the network would not be maintained and network expansion would not be sought, except on an exceptional basis. The last mile would be the mandate of the ministry of agriculture or of local authorities and would be designed for IMT only. This approach was adopted in Finland with the definition of level-of-service targets and a classification of roads by order of priority, climatic conditions, and traffic levels. Some roads benefit from virtually zero allocation and others from massive investments because of their economic and strategic value (see Isotalo 1995 for more details, especially annex 5).

Source: Authors based on Isotalo 1995.

Notes

1. Contrary to the study on transport costs and prices along international corridors (Teravaninthorn and Raballand 2008), this study found no specificities in terms of regulation of transport services per subregion; therefore, distinctions between subregions are not relevant. Differences in climatic conditions and in population density seem to explain more about the impact of low-volume roads.
2. Moreover, the condition of the link between corridors and the secondary network should be investigated when decisions are made to upgrade or rehabilitate corridors.

APPENDIX A

Methodology for Field Data Collection

Primary data collection was based mainly on surveys and interviews of relevant stakeholders. Three regions were surveyed in detail on the basis of the initial sampling and classification of regions defined. The first selected region had a relatively developed local road network and was relatively densely populated, and the second and third had a poorly developed local road network.

In each selected region, four sets of villages were surveyed: (a) 5 located less than 2 kilometers from the secondary road, (b) 5 located 2 to 6 kilometers from the secondary road, (c) 10 located 7 to 15 kilometers from the secondary road, and (d) 5 located more than 15 kilometers from the secondary road.

A questionnaire, based on Starkey's (2007) methodology, was used to collect data from villagers and traders about their transport demand, economic production, and availability of intermediate means of transport. A second questionnaire was used for truckers, and it assessed truckers' transport costs and prices at the local level (they were mainly interviewed in district capitals or local market towns). The sample also consisted of a control group without a developed local road network.

In addition to the transport providers, at least five farmers and traders in the selected villages were interviewed to obtain detailed information on the four areas defined:

- Economic density and agricultural potential
- Road density
- Road level of service
- Transport services

APPENDIX B

Data Collected in the Field

National Level

Interviews were conducted with the following:

- National transport authorities
- An importer of motorized transport
- An importer of bicycles

Regional Level (district capital)

Interviews were conducted with the following:

- Regional authorities
- Regional transport authorities
- Transport associations or truckers (trucking surveys)
- A trader or trucker operator (trader surveys)
- A seller of intermediate means of transport (IMT)

Interviews covered these areas:

- Road network, costs, and maintenance:
  - Road and pathway standards (that is, width and surface)

  - Road passability—that is, an estimate of passability using an index based on mode of transport (such as pedestrians; bikes and motorbikes; light IMT; regular light vehicles, up to the size of minibuses; four-wheel-drive vehicles; small trucks; heavy trucks) and periodicity (for example, all year long, some short interruptions, long interruptions, and dry season only)
  - Map of roads and pathways in the selected regions
  - Road unit costs per type of road or pathway (secondary, tertiary, and rural networks)
  - Public investment policy for types of roads per number of kilometers, including maintenance costs
  - Frequency of maintenance operations per type of road or pathway
  - Infrastructure requirements for the five transport services (trucks, taxis, animal-drawn carts, donkeys, bicycles)
- Vehicle operating costs of trucks (fixed costs, variable costs, and mileage)
- Agricultural supply chain for three products (based on trader-farmer surveys)

Village Level

Interviews were conducted with the following:

- Village authority
- Farmers (survey)
- Traders (survey)
- Employees working in the district capital

Interviews covered these areas:

- Characteristics and road accessibility for road users:
  - Village or settlement population
  - Distance from the first town or settlement with a population of 10,000
  - Distance from the first main marketplace
  - Time and distance to the closest secondary or tertiary road (paved)
  - Number of days the road or pathway is closed
  - Road and pathways standards (that is, width and surface) and length linking villages and small towns

- Satisfaction level of road users by transport mode
  - Accessibility to marketplaces for sale and purchase (distance and frequency of market days)
- Availability of transport services and traffic
  - Daily average traffic volume and composition (for example, trucks, taxis, animal-drawn carts, donkeys, or bicycles) per type of infrastructure
  - Availability of the five main transport services (depending on the region, these services could be trucks, taxis, animal-drawn carts, donkeys, bicycles, or others) with reference to load, usual distance, price, and type of goods per transport service
  - Transport price for the five main transport services
  - Truck vehicle operating costs
  - Cost of switching transport mode
- Economic density and agricultural potential
  - Surface of each road area of influence (in hectares) with maps
  - Agricultural production—that is, area, productivity (return) in export quantity/hectare, production costs (per hectare), price at farm gate, price sold at local markets, cattle headcount, average production surplus, and labor productivity[1]
  - Industrial production—that is, number of large companies, employment, and village distance to the factory
  - Small and medium enterprises and individual entrepreneurs—that is, number, type of production,[2] and employment level
  - Description of the existing transport chains in each area, including the organization of production and of farming practices
  - Geography of production; modal repartition between the various modes of transport; and their main constraints, with a focus on transport

Notes

1. The main agricultural products (export crops or food crops) sold (a) locally only (fewer than 10 kilometers) and (b) both locally/regionally (fewer than 50 kilometers) were selected.
2. According to a defined classification.

APPENDIX C

The *World Development Report 2009* Policy Framework for Lagging Regions

	Country type		
	Sparsely populated lagging areas	*Densely populated lagging areas in united countries*	*Densely populated lagging areas in divided countries*
What policies should facilitate	Labor mobility	Labor mobility and market integration	Labor mobility, market integration, and economic mass in lagging areas
Policy priorities			
Spatially "blind" institutions	Land market reforms, property rights, and education and health programs	Land market reforms, property rights; education and health programs; and basic public health services, including water supply, sanitation, and drainage	Land market reforms, property rights; land-use transformation; education and health programs; and basic public health services, including water supply, sanitation, and drainage

(continued)

	Country type		
	Sparsely populated lagging areas	*Densely populated lagging areas in united countries*	*Densely populated lagging areas in divided countries*
Spatially "connective" infrastructure		Interregional transport infrastructure and information and communication services	Interregional transport infrastructure, information and communication services, and local roads
Spatially "targeted" incentives			Agricultural incentives, irrigation systems, and work force training

Source: *World Development Report 2009* team.

APPENDIX D

Methodological Note on Ugandan Household Surveys

The designers of the Ugandan household surveys thought that if the proper distance could be calculated between the households and the markets they could get a better understanding of the relationship between consumption and remoteness. The survey provided Global Positioning System (GPS) coordinates for the households, the center of the community, and the common consumer market (see appendix E for more details). However, issues arose with respect to the GPS coordinates: not all of the coordinates were recorded in the same format or recorded properly, which required cleaning the household coordinates. Unfortunately, this activity was so time consuming that the same could not be done for the village or market coordinates. As a second-best approach, the households were connected to the nearest large city (more than 2,000 inhabitants, resulting in 68 cities across the country) and the Euclidean distance was calculated.[1] The reasoning behind this approach was that though other markets might be closer, a large city would have more types of markets and would allow consumers and farmers to purchase all of their needs at once.

The distance of each household to the city was then compared to the consumption of the household, providing a more accurate and precise measurement than before. To give an overall picture, the households were broken down by quintiles of distance to the city or market.

Note

1. Estimates of the distance to the markets and the road were given in the community survey, but as noted, the inconsistencies made these measurements unreliable.

APPENDIX E

Variable Definitions for Ugandan Household Surveys, National and Commissioned

Definitions for the Ugandan National Household Survey

Expenditure on foods, beverages, and tobacco: This part determines the household's total expenditures on food purchased at the marketplace and estimates the value of home-produced or homegrown food items consumed by the household as well as food received as gifts from relatives or friends or as payments in kind (that is, remuneration for work done on someone else's farm).

It refers to items consumed at home and away from home during the past seven days. *Home production* specifically refers to items produced or grown by the household that have been consumed by the household during the past seven days. The quantity and value of items that the household received in kind as gifts from relatives or friends or as payment in kind and consumed during the past seven days is measured.

All these categories were added to create a measure of total household consumption.

Tarmac roads: These main roads are maintained by the central government, and they normally connect one district to another. They are 6 meters or more in width.

All-season feeder roads: All-season feeder roads are major roads joining trunk roads that are accessible year round and maintained by district authorities (local governments).

Agricultural income: This income is the sum of the value of the total sales of each crop for one household. The measure is for one farming season and is in Ugandan shillings.

Limited consumer market or outlet: A limited consumer market or outlet will be either a cluster of shops and traders (market) or one or a few scattered shops with generally only a limited number of fast-selling commodities and services but with limited choice.

Agricultural input market: A general agricultural input market sells a variety of goods and services, including farm inputs. However, they do not specialize in farm inputs, and they sell such goods to a limited extent only.

Agricultural producer market: A general agricultural producer market sells a variety of goods related to markets and traders. Agricultural produce is sold or bought in bulk, in small quantities, or both. Such markets are not specialized farmers' markets—they sell such goods to a limited extent only.

Agricultural input or producers' market: The most common agricultural input or producers' market sells inputs and outputs (that is, crops). It is a specialized market where most of the needed farm inputs and outputs are available for sale.

Local council levels: The community questionnaire was administered at the local council (LC) 1 level in the selected enumeration areas. The LC system is a decentralized hierarchy of councils and committees, each governing an assigned area. There are three levels of LCs (1, 2, and 3), with LC 1 being the smallest level of aggregation.

Determinants of Household Income Derived from Agricultural Product Sales

Cash income: Income is the revenue generated from crop sales minus the cost of growing those crops:

$$Income = Revenue - Cost$$

Revenue: This variable refers to the sum of the weight of all the crops (i) sold, multiplied by their selling weight for each household (j):

$$Revenue_{ij} = \Sigma(Weight\ sold_{ij} \times Selling\ price_{ij})$$

Total cost: This variable refers to the sum of all costs, inputs, transport, and labor:

$$\textit{Total cost}_j = \textit{Input cost} + \textit{Transport cost} + \textit{Labor cost}$$

Input cost: For fertilizer, pesticides, and seeds, the cost was equal to the weight purchased multiplied by the selling price of input (*k*):

$$\textit{Input cost}_{kj} = \Sigma(\textit{Weight sold}_{kj} \times \textit{Selling price}_{kj})$$

Transport cost: This variable refers to the cost of transporting crops to the market for sale (if applicable) for each household (*j*):

$$\textit{Transport cost}_j = \Sigma(\textit{Transport cost to market})$$

Labor cost: This cost is calculated in addition to transport and input costs, using the daily rate for a casual farm worker in Uganda in 1998 (U Sh 429) (Agricultural Policy Committee). Using data on the Consumer Price Index (CPI) of Uganda from the World Bank Data Development Platform, one can convert the rate from 1998 shillings to 2007 shillings (U Sh 655), the most recent year for which the CPI is available. The preparation of the land to the harvesting of a crop lasts about six months; however, labor is not required for the entire period. Workers are assumed to work about three of those months and about 22 days in each month. The result is a seasonal rate that is then multiplied by the average number of workers a household uses on all its plots. The average of all the plots is used instead of the total to avoid running the risk of counting workers more than once who work on multiple plots:

$$\textit{Workers} = \Sigma(\textit{Workers on each plot})/\textit{Number of plots}$$
$$\textit{Rate} = (3 \text{ months} \times 22 \text{ days per month}) \times \text{U Sh } 655 \text{ per day}$$
$$\textit{Labor cost} = \textit{Average number of workers} \times \text{U Sh } 43{,}230$$

Note that the survey does not tell us whether the workers are family members. However, costs are associated with using family labor, such as additional room and board, so this wage rate is used for all workers.

Sell direct: This variable is the fraction of the total weight of all crops harvested that is sold directly at the market by the household, not through a trader:

$$\textit{Sell direct} = \textit{Weight sold to market}_j/\textit{Weight harvested}_j$$

Crop type: The type of crop is determined by a weighted average, by district, that represents the level of market participation by the households.

To calculate the weight, one must first calculate the revenue generated by crop (*i*) for each household (*j*) in that district (*p*):

$$Revenue_{ijp} = Weight\ sold_{ijp} \times Selling\ price_{ijp}$$

The revenue from each crop (*i*) is then summed to create the total agricultural revenue of the household (*j*) in that district (*p*):

$$Total\ revenue_{jp} = \Sigma(Weight\ sold_{ijp} \times Selling\ price_{ijp})$$

The total revenue of each household is summed to calculate the total return in each district (*p*):

$$Total\ return_{p} = \Sigma(Total\ revenue_{j})$$

The revenue produced by each household selling a specific crop is summed to give the total return earned per crop (*i*) in that district (*p*);

$$Total\ return_{ip} = \Sigma(Total\ revenue_{ijp})$$

The weight of each crop is equal to the total revenue of the crop (*i*) in that district (*p*) divided by the total return to the district (*p*):

$$Weight_{i} = Total\ return_{ip}/Total\ return_{p}$$

These different weights are then applied to the corresponding crop while taking an average of the percentage of crops that are sold to the market. The result is greater weight given to those crops for which a larger percentage of the total harvested is sold to markets. Therefore, a cash crop will have a greater weight than a subsistence crop.

For example, consider a household that grows cassava and maize. The household grows 100 kilograms of cassava and sells 40 kilograms (40 percent sold), and the household grows 50 kilograms of maize and sells 40 kilograms (80 percent sold). The average of the percentage of crops sold is (40 + 40)/(100 + 50) = 80/150 = 0.53. Thus, the household sells about 50 percent of its crops to the markets. However, this result does not accurately represent the facts. If one were to calculate the weights—say, for example, the weight of cassava is 0.2 and the weight of maize (a cash crop) is 0.8—the average percentage of crop grown would be $(0.2 \times 40) + (0.8 \times 40)/(0.2 \times 100) + (0.8 \times 50)] = 0.66$, resulting in a better representation of the household's involvement in the market through cash crops.

Yield: The yield represents the overall yield of the household's land by crop with each crop weighted. The weight is calculated districtwide; it is the sum of the total area a crop (i) covers in a district (p), divided by the total amount of land in the district (p). Greater weights go to those crops that cover more of the total land of the district:

$$Weight = \Sigma(Land_i)/\Sigma(Total\ land_p)$$

The weight of that crop (i) in that district (p) is then used to calculate the yield of the household, which is defined as the output of a crop per unit of land dedicated to that crop:

$$Yield = (Weight_p \times Weight\ harvested_i)/Land_i$$

Household size: This variable refers to the total number of people residing in the household as reported in the survey, where children are less than 16 years old, adults are between 16 and 45 years old, and elders are more than 45 years old.

$$\begin{aligned} Household\ size = {} & Male\ children + Female\ children + Male\ adults \\ & + Female\ adults + Male\ elders + Female\ elders \end{aligned}$$

Secondary education: This variable refers to the total number of household members with secondary school education. Other options for education were available, including the total number of household members with secondary education and a total education variable that was the sum of the primary and secondary variables. However, strong correlations existed between variables: household size and all education (0.9), household size and primary education (0.85), and all education and primary education (0.9). Therefore, secondary education was selected to represent the household educational status. The correlation between household size and secondary education was much weaker than that between the other variables (0.28).

Gender of the household head: The gender of the head of the household was 0 for female and 1 for male.

Number of bikes owned: This variable was the number of bicycles owned by the household. Note that motorcycles are not included, only 8.5 percent of the households surveyed owned a motorcycle, and all but one owned both a motorcycle and a bicycle.

Passability: This variable refers to the number of days per year that the household could not use the road or path to the center of the village by bicycle. A bicycle was chosen because of the prevalence of its ownership. Only 9.6 percent of the sample did not own a bicycle. For those without this information, the average number of days for that district was substituted.

Road density: This variable refers to the length of district roads (kilometers) in a district over the area of the district (square kilometers). Sources for this information were the Ministry of Works and Transport and the Ministry of Tourism, Trade, and Industry.

$$\textit{Road density} = \textit{Length of district roads}\ (\text{km})/\textit{Area of district}\ (\text{km}^2)$$

Tororo: This binary variable is 1 when the household is in the Tororo district and 0 otherwise. Tororo was chosen because of its differences from Masindi and Bushenyi: smaller size, location in the east, and border with Kenya.

Greater than 2 kilometers: This binary variable is 1 when the household is more than 2 kilometers from the market. Otherwise it is 0.

Note: Five observations were dropped as outliers, comprising less than 3 percent of the observations. Three were dropped as *income* outliers, with values greater than U Sh 80,000. The remaining two were dropped as outliers of the *yield* variable, with values over 2,000 kilograms.

Determinants of Feeder Road Maintenance Funds

Released funds for feeder road maintenance in 2006 (per capita): These funds were released by the Ugandan government for district, feeder, and secondary road maintenance (vote 501–577, program 7). Data are in Ugandan shillings. The 2006 data refer to fiscal year 2006/07. The sources of these data were draft estimates of revenue and expenditure for fiscal year 2006/07 from the Ministry of Finance, Planning, and Economic Development.

No major constraints: This variable is the percentage of district, feeder, and secondary roads per district that do not face major constraints when being used. The source for this information was gender-disaggregated data for road sector from the 2004 national service delivery survey, as provided by the Ministry of Finance, Planning, and Economic Development.

Network length per capita: The number of kilometers of district, feeder, and secondary roads by district was used. The source for the data was the Ministry of Works and Transport.

Number of constituents per capita: The number of representatives in the Ugandan parliament by district was used. The source for the data was the Ugandan parliament's Web site: http://www.parliament.go.ug/index.php?option=com_wrapper&Itemid=37.

Number of National Resistance Movement constituents per capita: The National Resistance Movement (NRM) is the official party. The number of representatives in the Ugandan parliament from the NRM by district was used. The source for the data was the Ugandan parliament's Web site: http://www.parliament.go.ug/index.php?option=com_wrapper&Itemid=37.

Area: Area is measured in square kilometers. The source for these figures was the Ugandan Bureau of Statistics.

Poverty rate: The poverty rate by district for 2005/06 was used. World Bank sources provided these data.

Rural consumption per capita: Rural consumption per capita by district for 2002 was used.

Source: Authors' compilation based on surveys.

APPENDIX F

Correlation Table between Variables for the Burkina Faso, Cameroon, and Ugandan Household Surveys

Burkina Faso

Variable	*Income*	*Crop type*	*Greater than 2 kilometers*	*Yield*	*Road density*
Income	1.0000				
Crop type	0.6728	1.0000			
Greater than 2 kilometers	–0.0311	0.0638	1.0000		
Yield	0.4281	0.4466	–0.0704	1.0000	
Road density	0.4859	0.3775	–0.0960	0.2982	1.0000

Cameroon

Variable	*Income*	*Crop type*	*Greater than 2 kilometers*	*Yield*	*Road density*
Income	1.0000				
Crop type	0.4729	1.0000			
Greater than 2 kilometers	0.0418	0.1530	1.0000		
Yield	0.3401	0.0138	–0.0335	1.0000	
Road density	0.0611	–0.2497	–0.1471	0.1153	1.0000

Uganda

Variable	*Income*	*Crop type*	*Greater than 2 kilometers*	*Yield*	*Road density*
Income	1.0000				
Crop type	0.1853	1.0000			
Greater than 2 kilometers	0.1740	0.1501	1.0000		
Yield	0.2918	0.5072	0.0639	1.0000	
Road density	–0.3347	–0.0676	–0.0262	–0.2842	1.0000

Source: Authors' calculations.

APPENDIX G

Determinant Variables of High-Value Crop Sales

	Burkina Faso		Cameroon		Uganda	
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Dependent variable: crop type						
Sell direct	0.614***	0.643***	–0.118	–0.107	–0.139**	–0.138**
	(0.054)	(0.052)	(0.117)	(0.117)	(0.058)	(0.058)
Yield	0.024***	0.024***	0.004	0.004	0.045***	0.045***
	(0.004)	(0.004)	(0.003)	(0.003)	(0.007)	(0.007)
Household size	0.004	0.003	–0.002	–0.001	0.006	0.005
	(0.003)	(0.003)	(0.010)	(0.010)	(0.005)	(0.005)
Secondary	–0.044	–0.058*	–0.022	–0.011	0.026***	0.025***
	(0.033)	(0.032)	(0.033)	(0.033)	(0.009)	(0.009)
Gender of head of household			0.346**	0.351**	0.105*	0.093*
			(0.172)	(0.170)	(0.054)	(0.055)
Number of bicycles owned	0.012	0.015	0.184	0.217	–0.026	–0.027
	(0.011)	(0.011)	(0.154)	(0.153)	(0.029)	(0.029)
Passability	0.003*	0.003**	–0.001	0.000	0.001*	0.001*
	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
Road density	7.305*	7.456*	–0.055***	–0.054***	–0.025	–0.003
	(4.136)	(3.971)	(0.018)	(0.018)	(0.312)	(0.312)
Greater than 2 kilometers		0.143***		0.256**		0.036
		(0.032)		(0.110)		(0.033)
Constant	–0.132**	–0.249***	0.593***	0.364*	0.114	0.114
	(0.064)	(0.067)	–0.196	–0.218	–0.083	–0.083
Observations	217	216	367	367	171	171
R^2	0.5663	0.6029	0.0818	0.0956	0.3579	0.3626
Correlation between income and crop type	0.6736		0.4729		0.1853	0.6736

Source: Authors' calculations.
Note: Significance: * = 10 percent, ** = 5 percent, *** = 1 percent. Standard deviations are in parentheses.

APPENDIX H

Comparison of Key Variables between the Top 5 Percent of Landowners in Each Country's Sample and the Country's Total Sample

	Total area owned (hectares)	*Agriculture income*	*Sell direct (%)*
Uganda			
Top 5%, mean	60	4,046	0.22
Total sample, mean	10	2,262	0.14
Top 5%, median	38	4	0.00
Total sample, median	6	1,453	0.00
Burkina Faso			
Top 5%, mean	20	91	0.52
Total sample, mean	5	18	0.30
Top 5%, median	18	50	0.48
Total sample, median	4	2	0.20
Cameroon			
Top 5%, mean	28	578	0.26
Total sample, mean	6	250	0.44
Top 5%, median	24	225	0.00
Total sample, median	6	23	0.40

Source: Authors' calculations.
Note: Income in Uganda is in U Sh (ten thousands), and agricultural income in Cameroon and Burkina Faso is in CFAF (ten thousands). In Cameroon, the percentage of output sold directly to the market is lower for the top 5 percent than for the total sample mainly because the largest landowners are cocoa farmers, and they do not sell directly to markets. In Uganda, the yield is lower for the top 5 percent of landowners, implying that they do not farm their land as intensively (or do not need to farm as intensively). In Uganda, the crop type is lower for the top 5 percent, implying that these farmers are not as involved in the market (either through selling directly or through production of cash crops) than the total sample.

APPENDIX I

Descriptive Statistics on Transport Costs per Mode

Mode	Distance (kilometers)	Variable costs (US¢ per kilometer)	Fixed costs (US¢ per kilometer)	Depreciation costs (US¢ per kilometer)	Financing costs (US¢ per kilometer)
Donkey					
Mean	2,102	1.53	1.82	0.99	7.36
Number of observations	218	175	150	209	54
Cart					
Mean	1,411	4.33	—	8.17	18.10
Number of observations	228	211	—	220	21
Bicycle					
Mean	3,568	1.39	—	0.89	1.48
Number of observations	461	451	—	442	63
Motorcycle					
Mean	7,370	16.19	10.97	14.99	22.53
Number of observations	197	194	52	7	14
Truck					
Mean	30,233	114.10	44.74	17.43	3.93
Number of observations	47	47	47	47	47

Source: Authors' calculations.
Note: — = not available. Data are aggregated for Burkina Faso, Cameroon, and Uganda. Donkey observations came only from Burkina Faso, and cart observations came only from Burkina Faso and Cameroon. The other three categories of transport are composed of observations from Burkina Faso, Cameroon, and Uganda. The mean values were calculated by averaging the responses from all three countries. Fixed costs include shelter (for the donkey), license and registration costs, and insurance paid per year. Variable costs consist of repairs, purchase of new wheels, fuel and oil costs, and veterinary expenses for the donkey per year. Depreciation is calculated by dividing the initial price by the expected lifetime of the vehicle.

APPENDIX J

Agroecological Zone Methodology

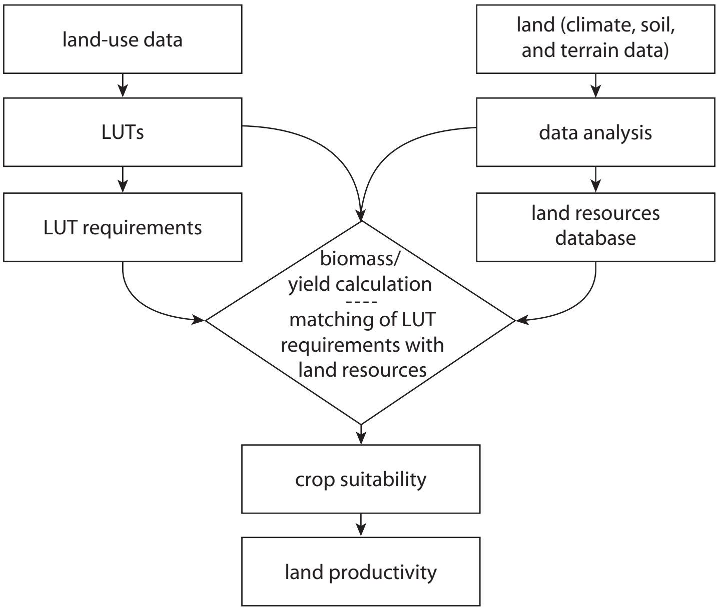
The agroecological zone (AEZ) framework contains three basic elements, as outlined in the figure J.1:

- Selected agricultural production systems with defined input and management relationships, and crop-specific environmental requirements and adaptability characteristics, which are termed *land utilization types* (LUTs)
- Georeferenced climate, soil, and terrain data, which are combined into a land resources database
- Procedures for calculating potential yields and for matching crop-LUT environmental requirements with the respective environmental characteristics captured in the land resources database, by land unit and grid-cell

Limitations of the Global AEZ Study

Although the datasets represent the most recent global data compilations, their quality and reliability are uneven across regions. The quality of the world soil map is especially reason for concern. It is based on a 1:5,000,000-scale map, and its reliability may vary considerably

Figure J.1 Conceptual Framework of AEZ Methodology



Source: International Institute for Applied Systems Analysis and the UN Food and Agriculture Organization. http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/agll/gaez/method/overview.htm.

between different areas. Moreover, the status of land degradation cannot be determined from the United Nations (UN) Food and Agriculture Organization Soil Map of the World. In addition, the agronomic data, such as the data on environmental requirements for some crops, contain generalizations necessary for global applications. In particular, assumptions on occurrence and severity of some agro-climate-related constraints to crop production would, no doubt, benefit from additional verification and data.

Socioeconomic needs of rapidly increasing and wealthier populations are the main driving force in the allocation of land resources to various kinds of uses, with food production as the primary land use. For rational planning of sustainable agricultural development, socioeconomic considerations are indeed crucial. So far, in global AEZ, the use of socioeconomic information is limited to the definition of modes of production and the quantification of "input-output packages." These are referred to as *LUTs*, taking into account, to some extent, the socioeconomic context of production decisions and conditions.

For the preceding reasons, the results obtained from this global AEZ study should be treated in a conservative manner at appropriate aggregation levels, which are commensurate with the resolution of basic data and the scale of the study. Although various modes have been pursued for "ground-truthing" and verifying results of the global AEZ suitability analysis, further validation of results and underlying databases is needed.

Sources: Based on material from the International Institute for Applied Systems Analysis and the UN Food and Agriculture Organization.

APPENDIX K

Link between Agriculture Type and Infrastructure Requirement

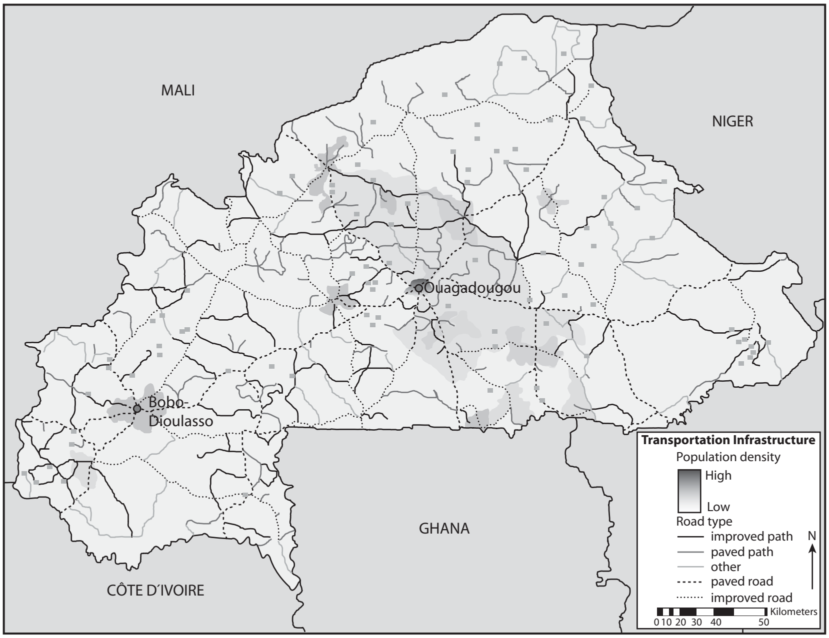
Agricultural level	*Required equipment*	*Agriculture type*	*Rural road and transport requirements*
Subsistence agriculture (fields of up to 1 hectare per family)	Hoes, wheelbarrows, and shovels	Harvesting small fields using hoes, shovels, and hand trailers	Shovels and earth distribution for cross-section of earth
Cash crop agriculture (up to twice the area of fields, 1–2 hectares, and 2–4 times the output of subsistence agriculture)	Oxen, bicycles, motorcycles, and motorcycle trailers (for most productive use)	Plowing by oxen	Transport to and from the field by bicycle trailers, transport to and from the markets by ox carts, motorcycles, or motorcycle trailers
Mechanized agriculture	Tractors, motorcycles, and motorcycle trailers	Plowing with hired tractors	Transport to and from the market with trucks, and to and from the field with tractors
Industrialized agriculture (on more than 30-hectare plots)	Heavy machinery and automation	Fully mechanized and partly automated harvesters	Roads for machinery and heavy trucks

Source: Adapted from Metschies 1998.

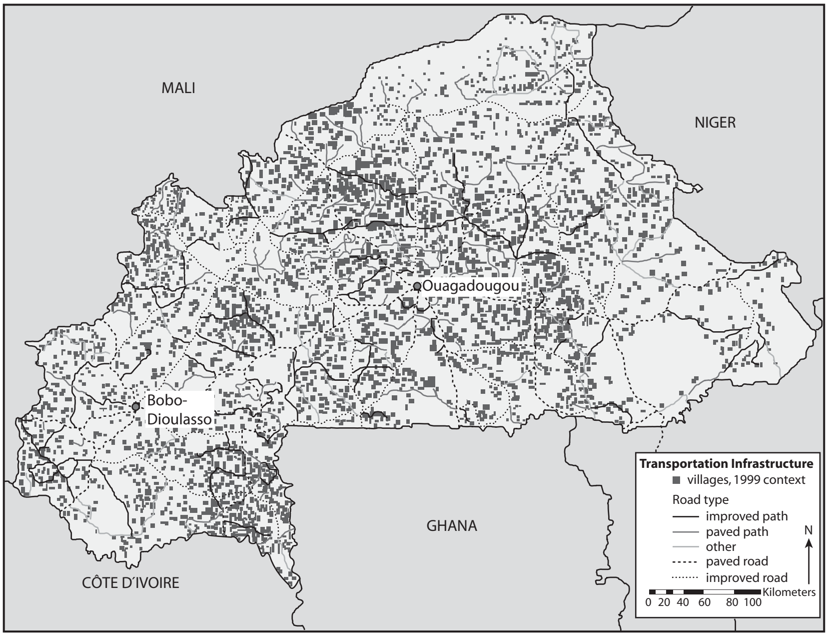
APPENDIX L

Maps of Burkina Faso

a. Population density



b. Poverty count

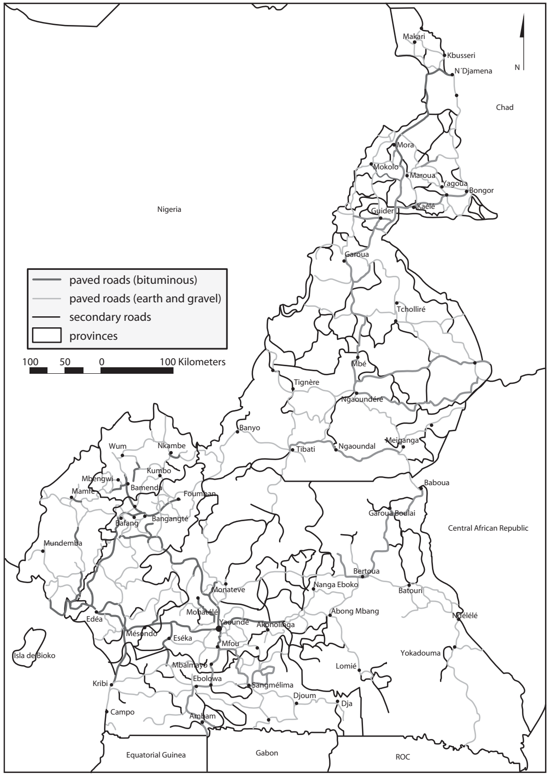


Source: Authors' representation based on government sources.

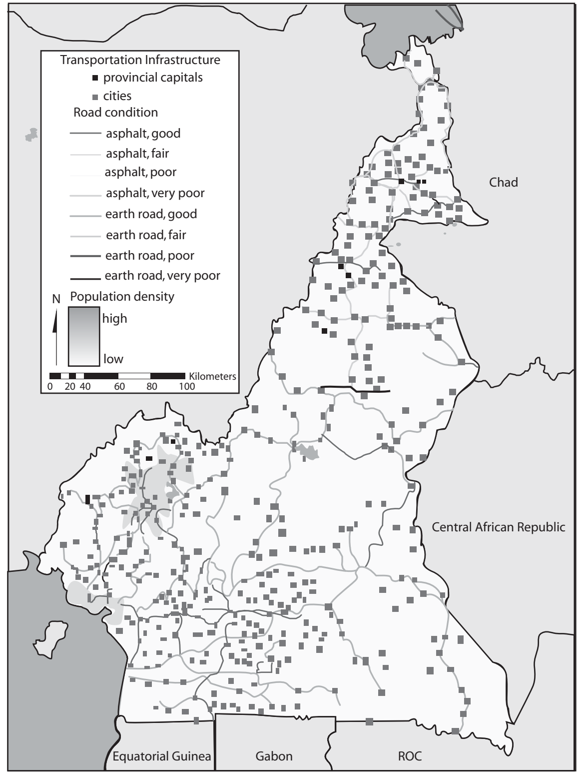
APPENDIX M

Maps of Cameroon

a. Road network



b. Road network condition and population density

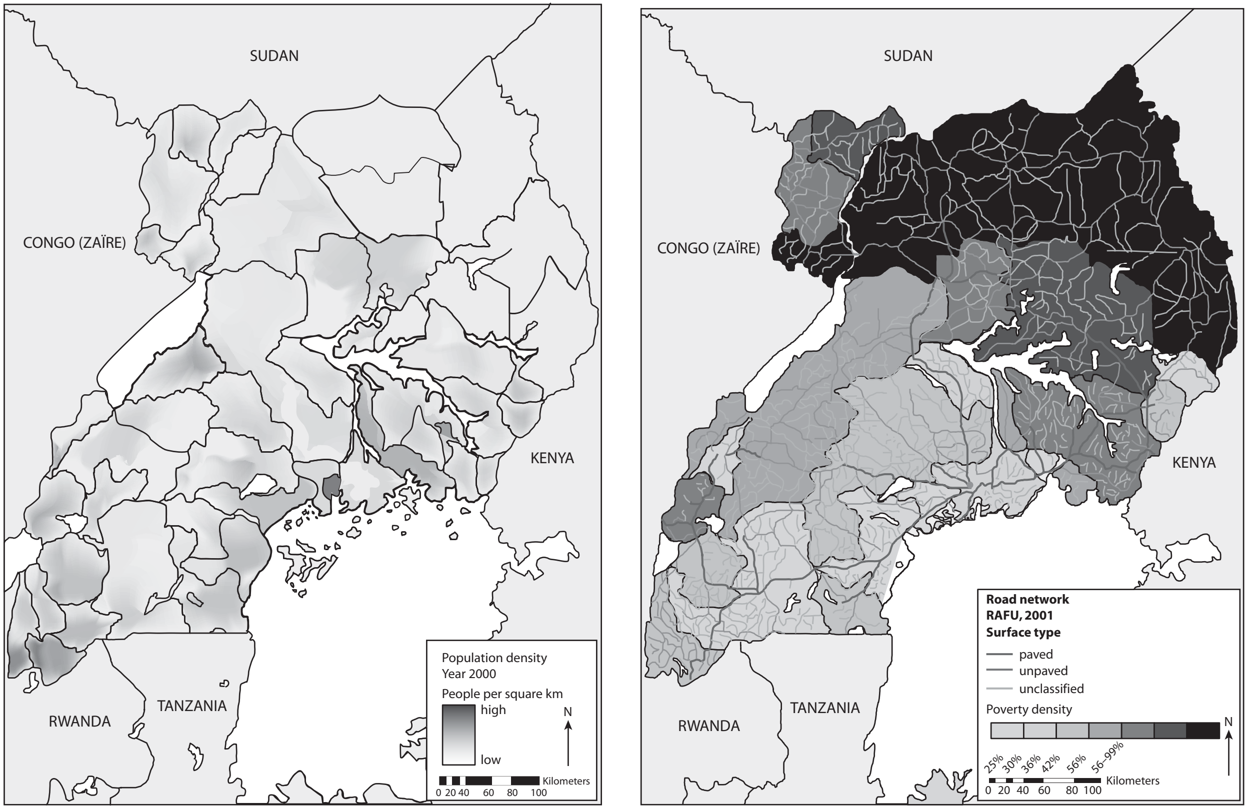


Source: Authors' representation based on government sources.

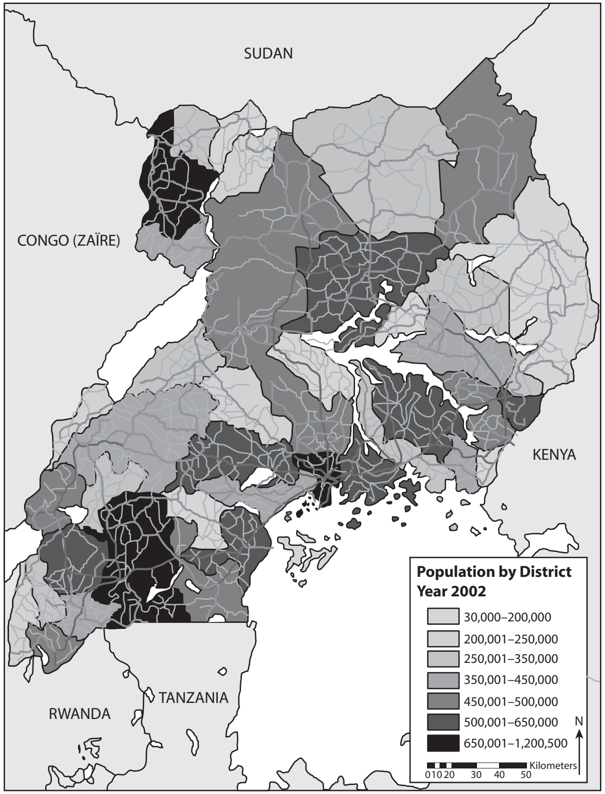
APPENDIX N

Maps of Uganda

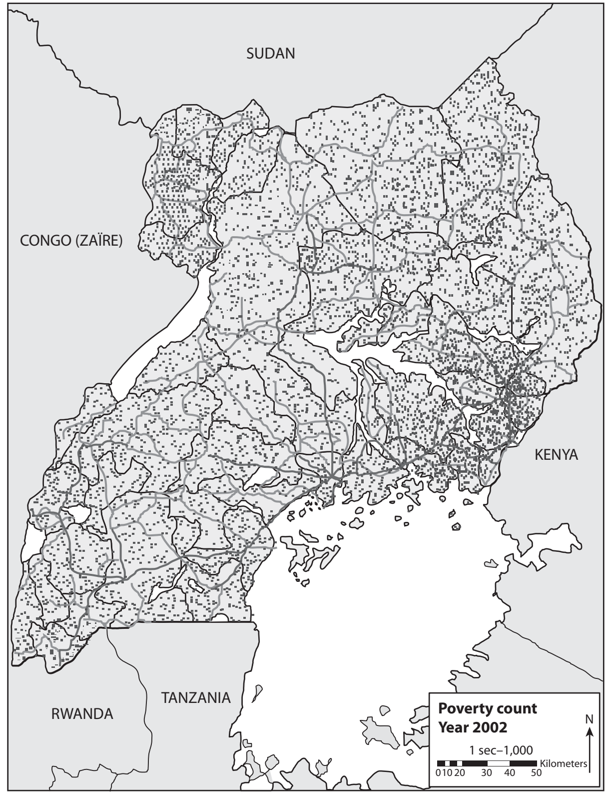
a. Population density **b. Poverty density**



c. Population by district



d. Poverty count



Source: Authors' representation based on government sources.

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The development aid community has placed a great deal of emphasis on the need for rural mobility in Sub-Saharan Africa (SSA). Thus far, most development partners and governments in SSA have relied on two overarching assumptions when dispensing transport aid—that most households in rural areas in Africa are not connected to markets and therefore need a road passable for a truck, and that roads with high levels of service are crucial in order to achieve high economic impact. Based on data collection from various sources in three SSA countries, *Rural Road Investment Efficiency* demonstrates that from a cost-benefit perspective, the additional cost of extending an all-weather road two more kilometers to the farmer's door outweigh the benefits in most cases.

Rural Road Investment Efficiency seeks to enhance the effectiveness of aid allocated for rural transport in SSA and calls into question the need for full implementation of all benchmarks set forth in the Rural Access Index (RAI) in SSA. This book will be an essential reference for government supervisory authorities and infrastructure experts throughout the region.

This book is a major contribution to a long overdue debate on the optimal design of a road transport strategy and on the planning of its implementation for any African country. It explains so well the implementation challenges. It also provides key insights on how to think analytically about the road sector as a regional integrator for Africa. In a nutshell, both the focus of the book and its timing are fantastically relevant to today's transport policy debates in Africa.

—Antonio Estache
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