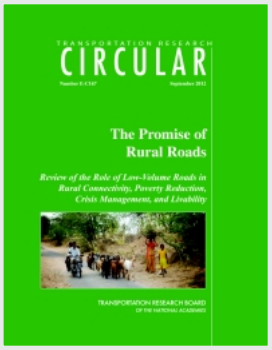

The Promise of Rural Roads

DETAILS

0 pages | 8.5 x 11 | PAPERBACK
ISBN 978-0-309-43487-4 | DOI 10.17226/22711

AUTHORS

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TRANSPORTATION RESEARCH
CIRCULAR
Number E-C167 September 2012

The Promise of Rural Roads

Review of the Role of Low-Volume Roads in Rural Connectivity, Poverty Reduction, Crisis Management, and Livability

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

Transportation Research Circular E-C167

The Promise of Rural Roads

Review of the Role of Low-Volume Roads in Rural Connectivity, Poverty Reduction, Crisis Management, and Livability

by
Asif Faiz

for the
TRB Low-Volume Roads Committee

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Washington, D.C.
www.TRB.org

TRANSPORTATION RESEARCH CIRCULAR E-C167
ISSN 0097-8515

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Javy Awan, Production Editor; Jennifer Correro, Proofreader; Jennifer J. Weeks, Formatting

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Cover photograph: Multiple road users on a rural road in Rajasthan, India.
(Credit: Michael Foley, World Bank)

Foreword

This circular was prepared by Asif Faiz, Emeritus Member of the TRB Committee on Low-Volume Roads. Faiz received his undergraduate degree in civil engineering from Peshawar University in Pakistan in 1968. He received his master's and doctoral degrees in transportation engineering from Purdue University in 1971 and 1975, respectively. He then joined the World Bank as an economist in the West Africa region. His international development experience of 37 years covers more than 40 developing countries in Sub-Saharan Africa, Latin America, South Asia, East Asia and the Pacific, and Eastern Europe. He was the World Bank's Highways Adviser from 1989 to 1992 and served in various advisory and management positions until his retirement in 2008. Since then, he has been working as a Consultant Adviser to the World Bank, AusAID, and the U.S. Institute for Peace. He has lectured internationally on the subject of low-volume roads. Faiz has actively participated in the work of TRB throughout his tenure at Purdue University and the World Bank. His profile was featured in *TR News*, No. 156 (September–October 1991). In 1999, he received TRB's Eldon Yoder Award for most outstanding paper on a topic related to low-volume roads.

Faiz was invited to deliver the keynote address at the TRB 10th International Conference on Low-Volume Roads held in Orlando, Florida, July 24–27, 2011. This address had a significant amount of material that is of great use to practitioners, owners, and researchers in the low-volume roads community worldwide. A survey of the Low-Volume Roads Committee members overwhelmingly supported the idea of inviting Faiz to prepare a document based on his presentation with additional information that would enhance its utility. An e-circular was considered the most appropriate medium to disseminate this information, as it would have the maximum outreach.

Low-volume roads are characterized not only by traffic volume, but also in terms of social and geographic context. Low-volume roads are a lower order of worldwide land transport. They begin where the animal track and walking trail end. They are at the beginning of world economy and are the lifelines for rural communities. Everything that sustains us—grown, mined, or drilled—begins on a low-volume road. Low-volume roads transcend language, culture, topography, and climate. Due to their basic necessity, they tend to drive innovation in design, material use, maintenance, and social development.

Nearly 30 million km of low-volume roads connect the world's population, yet, according to the World Bank, 31% of the world's population (1 billion people) still do not have adequate access to transport. Three-quarters of the population of 21 least-developed countries do not have access to all-weather roads, which are a key diagnostic measure of development.

The text of this circular received worldwide review from committee members and the friends of the committee.

—Michael T. Long
Chair, Low-Volume Roads Committee

Note: The contents of this e-circular are based on research and analysis undertaken by author Asif Faiz in his individual capacity. The conclusions and recommendations contained in this document are those of the author, and do not reflect the views of TRB or the National Academies.

The Promise of Rural Roads

Country roads, take me home
To the place I belong
West Virginia, mountain momma
Take me home, country roads
Take me home, now country roads
Take me home, now country roads

—Bill Danoff, Taffy Nivert, and John Denver

John Denver's memorable refrain captures the nostalgia of homecoming associated with country roads. This 1971 popular hit song immortalized country roads or low-volume roads (LVRs) as we have come to designate this essential component of rural infrastructure. In July 1972, TRB formed a Low-Volume Roads Task Force to research and document the characteristics and requirements for this class of roads. In the past four decades LVR lore has grown thanks to the work of TRB's Low-Volume Roads Committee and the 10 LVR conferences sponsored by TRB of the National Academies. Today there is a trove of solid technical knowledge and experience that covers all aspects of LVRs but the promise of rural roads has yet to be fully realized.

This Circular reviews the role of rural roads in improving rural connectivity, catalyzing economic growth and reducing poverty, managing natural disasters and manmade crises, sustaining rural livelihoods, and enhancing livability. In short, this Circular highlights the promise of rural roads as a harbinger of opportunity, progress, and prosperity and discusses what sustainability and its more practical subset, livability, mean in relation to rural roads and how the application of context-sensitive solutions (CSS) to rural roads could help achieve a better balance among the economic, social, and environmental dimensions of sustainability.

There is no universally accepted average annual daily traffic (AADT) threshold for defining a low-volume road. AASHTO in its *Geometric Design Guidelines for Very Low-Volume Local Roads* specifies an AADT of 400 or less. For purposes of geometric design standards, the working criterion for most researchers in the field is around 2,000 AADT for LVR and 400 for "very" LVR. The definition, however, varies widely across jurisdictions with the upper limit being as high as 5,000 AADT.

—Mike Long
Chair, TRB Low Volume Roads Committee

THE GLOBAL ROAD SYSTEM

About 33.8 million km of roads girdle the Earth's land mass of 148.9 million km^2 (an average 0.23 km/km^2 of land area); about 57% of it is paved (i.e., sealed with an engineered bituminous, concrete, or stone surfacing). Nearly all the unpaved roads (13 million km) and an estimated 85% of paved roads (17 million km) are LVRs with an average annual daily traffic (AADT) of 1,000 vehicles per day (vpd) or less.

In this review, an AADT threshold of 1,000 vpd is used for defining LVRs. This is a common traffic threshold considering worldwide practice, at which higher design speeds and related standards (wider lanes, paved shoulders, gentler curvature) kick in. In its report on U.S. Highway Statistics,

FHWA aggregates all rural arterials with an AADT of 1,000 or less in a single category. Irrespective of the AADT threshold (ranging from 400 to 1,000 vpd), LVRs account for about 80% to 85% of the global road network and very low-volume roads (VLVRs) account for about 70% to 75%. An AADT threshold of 5,000 would encompass nearly 98% of the world's roads.

These 30 million km of classified LVRs have a wide variety of geometric and paving standards ranging from barely motorable earth roads to modern high-speed two-lane paved highways. The global asset value (replacement cost) of these LVRs is conservatively estimated at about US$7.6 trillion (a lower-bound estimate), equivalent to about 50% of the estimated 2010 gross domestic product (GDP) of the United States. Beyond this classified system is another realm of designated trails, tracks, and paths as well as minor roads that serve enclave development (mines, industrial estates, agricultural plantations, irrigation schemes, tourism, forestry, etc.), and together number into millions of kilometers and also contribute to basic access and mobility.

Despite the huge public outlays on asset management and advances in geographic information systems (GISs), it is yet not possible to obtain an accurate assessment of the length and condition of rural roads globally, except in the more-advanced industrialized countries. Most countries have only a rudimentary inventory of their rural road system. As one would expect, the geographical distribution of roads is dominated by countries with large land masses or large populations; just eight countries (with United States in the lead) account for about 59% of the global road network (Table 1). The majority of these countries have a federal (decentralized) system of government, which poses its own peculiar governance challenges related to the funding and management of rural roads.

The global public road network increased by some 3.9 million km (a 13% increment) in the first decade of the new millennium (*1*–*3*). And there was a quantum increase in the quality of roads with 4.2 million km upgraded or constructed to paved standard.

Road Expansion and Modernization in China

Over the last decade, China has emerged as the global leader in rural road expansion and modernization with its road network crossing the 4 million km threshold in 2010 and the share of paved roads increasing from about 25% in 2000 to 44% in 2006 and 61% in 2010 (*4*, *5*). The expansion of the Chinese road system has been driven by a rapid increase in motorization over the past 20 years, similar to the advent of motorization in the United States at the turn of the 20th century. (Figure 1). Tracing the development of the U.S. highway system from 1900 to 2010 (Figure 2), the surge in road development in China during the first decade of the new millennium shows some similarity to the massive and unrivalled expansion of the U.S. road network between 1910 and 1920 (*6*). As shown in Figure 3, the annual growth rate in the road network over the respective decades is nearly identical (*7*).

There is, however, a subtle difference in the road building surge experienced by the two countries, almost a century apart. In 1919, a U.S. Army captain, Dwight D. Eisenhower, after participating in a cross-country convoy lasting 2 months to demonstrate the potential of motor transportation, was to remember the trip as "through darkest America with truck and tank," with the roads varying "from average to nonexistent" and heavy trucks breaking through the surface of the roads. That experience made him start thinking of "good, two-lane highways" and later as President of the United States he championed a vast system of Interstate highways (*8*).

TABLE 1 Growth in the Global Classified Public Road Network Between 1998 and 2008

	2008		1998	
	Length (million km)	**Percent Paved (%)**	**Length (million km)**	**Percent Paved (%)**
World	**33.839**	**57.4**	**29.912**	**50.8**
United States[a]	6.494	67.4	6.310	59.0
China[b]	3.730	53.5	2.210	18.0
India[c]	3.320	52.0	3.010	49.0
Brazil[d]	1.633	12.9	1.630	9.6
Japan	1.204	79.8	1.152	74.9
Canada	1.042	39.9	0.902	35.3
France	1.027	100.0	0.893	100.0
Russia[e]	0.982	79.0	0.948	67.2
Sub-Saharan Africa[f]	2.496	15.2	1.837	13.1
(of which, South Africa)	*(0.747)*	*(20.6)*	*(0.534)*	*(11.8)*

[a] The United States has the largest road system in the world (6.52 million km in 2009, with 67% paved), growing from about 3.71 million km in 1900 to 3.89 million km in 1910; 4.97million km in 1920; 5.30 million km in 1950; and 6.32 million km in 2000. About 26.4% of the system is classified as urban and about 84% of total network (63% of urban and 87% of rural) has an AADT of less than 1,000.

[b] According to the PRC Ministry of Transport, the total length of highways and roads in China crossed the 4 million km mark at the end of 2010; of these, nearly 3.7 million km comprises rural roads. The paved length in 2010 had reached 2.44 million km (61% of the network). By administration class, National Highways comprised 164,000 km, provincial 269,800 km, county 554,000 km, township 1,054,800 km, village 1,897,700 km, and dedicated roads 67,700 km. There was a sharp increase in the size of the classified network in 2006 due to the inclusion of village roads in the statistics. The official 1988 statistic of about 1.2 million km of roads has been adjusted in the table above by adding an estimated 1 million km of village roads, with the percent paved proportionately reduced from 22% to 18%.

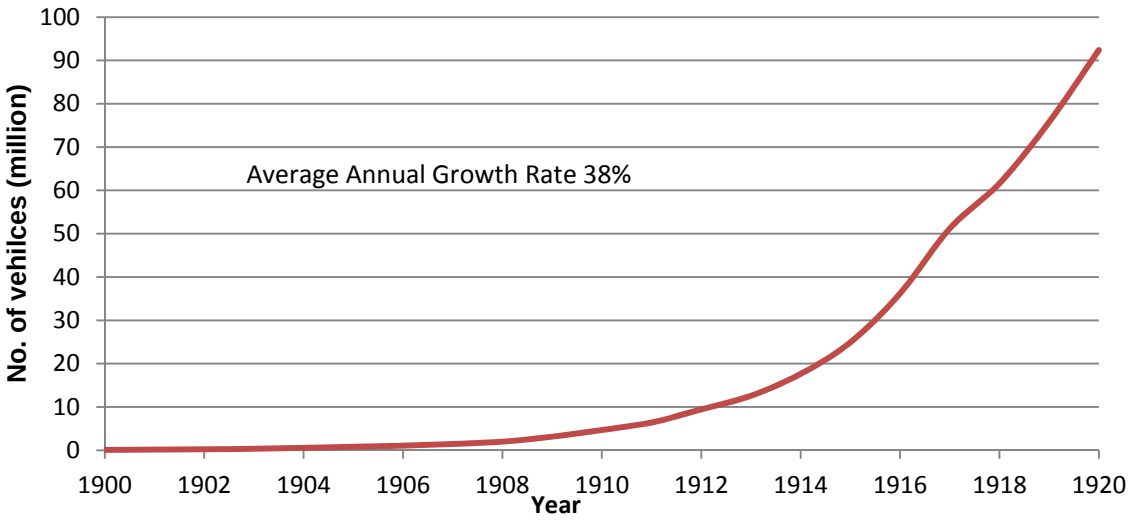
[c] Of the 3.3 million km of classified roads in India, 2.7 million km are rural roads including about 1 million km of motorable earth tracks constructed under various employment generation programs. Some 2 million km of roads and motorable tracks were added to the road system from 1980 to 2000.

[d] The Brazilian road system consists of approximately 1.63 million km of roads, of which 13% is paved (210,731 km). The road system is managed under three levels of jurisdiction: federal, states, and municipios *(*rural and urban). It is likely that the road system is significantly larger (CIA Factbook gives a figure of 1.752 million km) as road inventories at state and municipal levels may not be reliable or up to date.

[e] The nearly 1-million-km Russian road network in 2008 included about 50,000 km of federal roads and 502,000 km of regional roads. The Russian road classification defines gravel roads as hard-surfaced or paved roads. The percentage of paved roads, conventionally defined (i.e., excluding gravel roads) is estimated between 35% to 45% for 1998 and between 45% to 55% for 2008.

[f] The road network for Sub-Saharan Africa countries (49 countries including Djibouti, Mauritania, and Sudan, and the newest nation, South Sudan, which became independent on July 9, 2011) is included for comparative purposes. The Sub-Saharan African road network is dominated by South Africa's 746,978-km road system of which 20.6% was paved as of 2010. The increase in the Sub-Saharan road network between 1998 and 2008 does not imply new construction or upgrading of roads as some of the increase may have been due to incorporation of existing rural roads into the classified network.

SOURCES: *CIA World Factbook* (*1*, *2*) and *IRF World Road Statistics* (*4*) for data for Sub-Saharan Africa, Canada, France, and Japan. Data for United States, Brazil, Russia, India, China, and South Africa are derived from national statistics or World Bank sources. World totals derived from *CIA World Factbook* have been adjusted as necessary using national data. The years 1998 and 2008 were selected as benchmark years to allow the use of comparable global data sets over a 10-year period.



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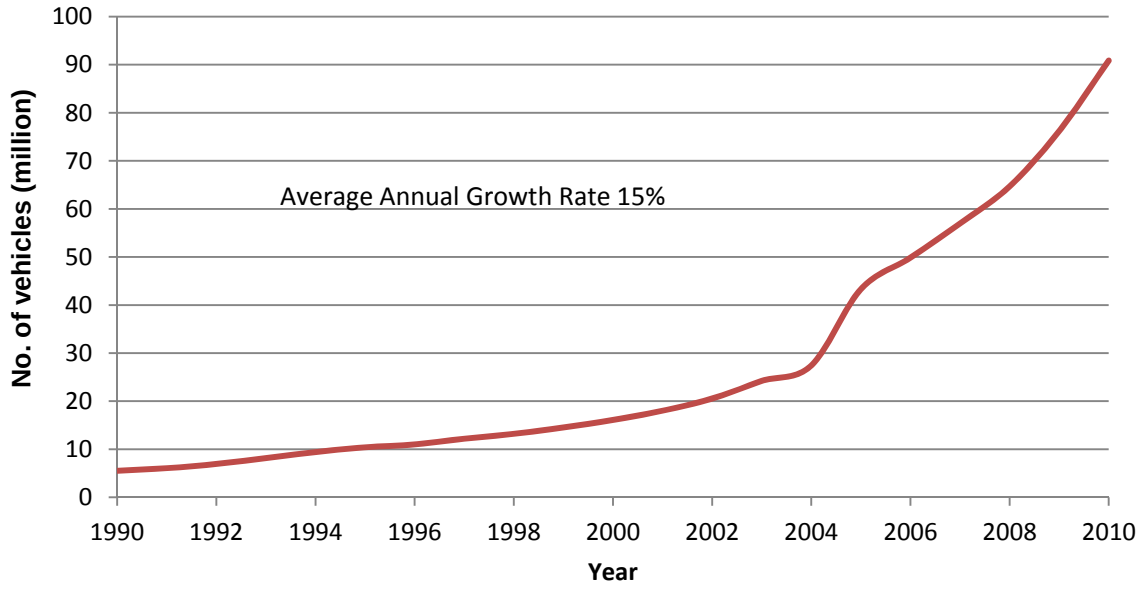
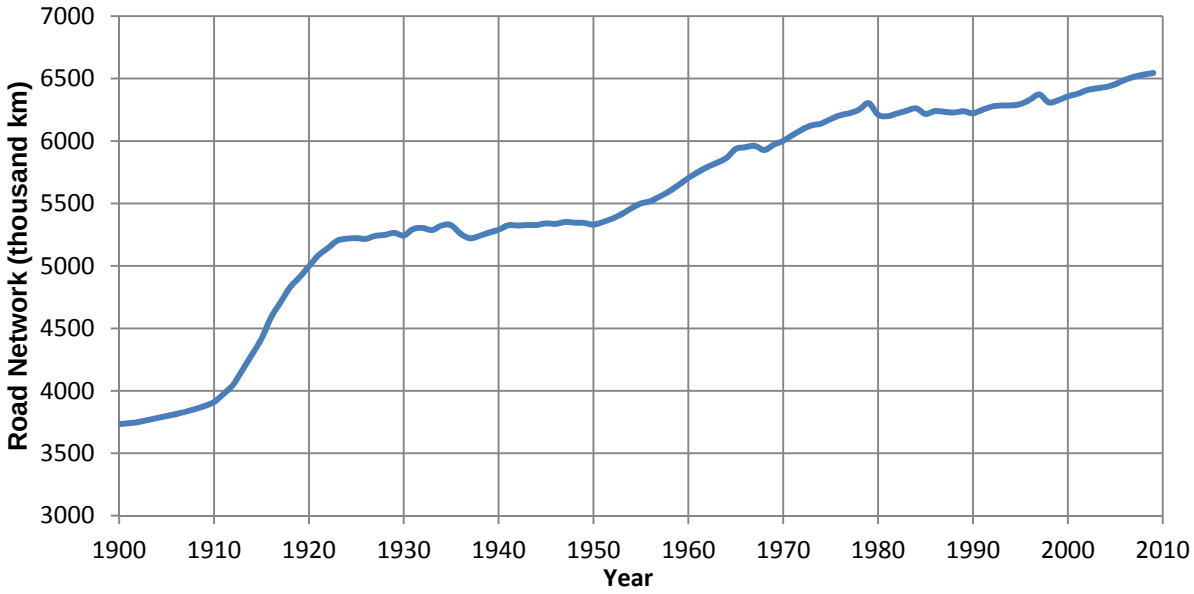


(b)

FIGURE 1 Rapid motorization: (*a*) U.S. vehicle fleet (1900–1920) and (*b*) China's vehicle fleet (1990–2010). [SOURCES: U.S. State Motor Vehicle Registrations (various years); FHWA, http://www.fhwa.dot.gov/ohim/summary95/mv200.pdf; *Statistical Yearbook of China* (*4*), and Wang (*7*).]



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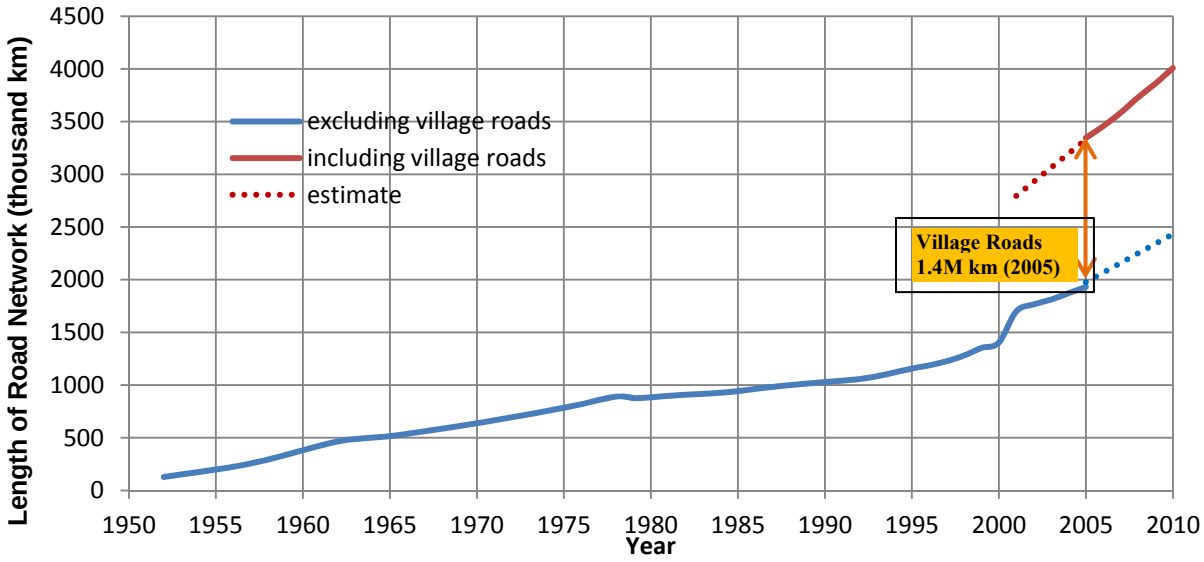

(b)

FIGURE 2 Growth in road networks: (*a*) United States, 1900–2010, and (*b*) China, 1952–2010. [SOURCES: United States Public Road Mileage Statistics, FHWA, http://www.fhwa.dot.gov/policyinformation/statistics/2009/vmt421.cfm; and Wang (*7*).]

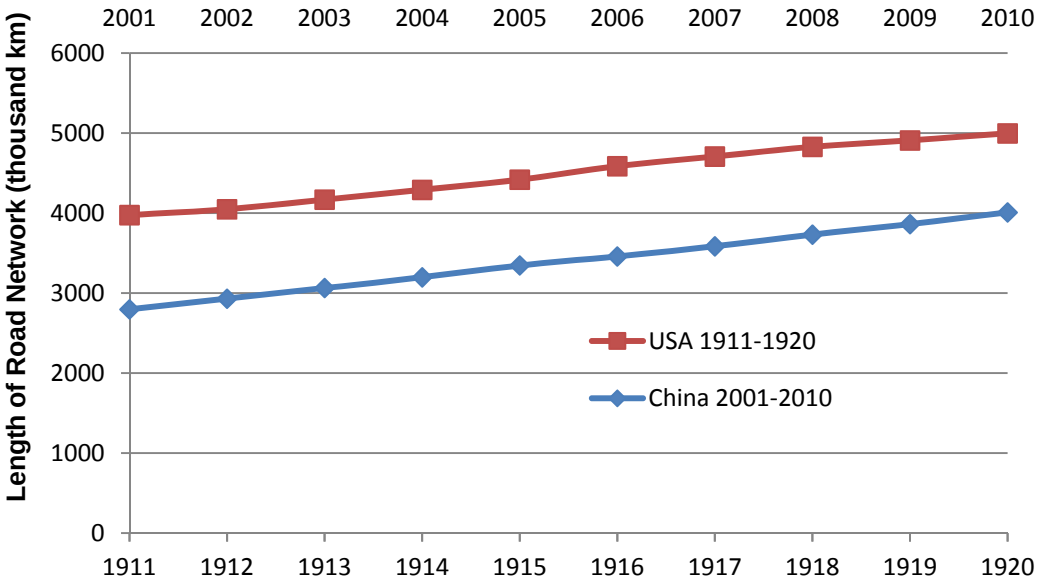

FIGURE 3 Comparative growth in road networks: United States (1911–1920) and China (2001–2010) (*7*).

China has focused on improving the road network quality and serviceability from the start, with a strong emphasis on building good two-lane, paved rural roads.

The importance and value of rural roads to economic growth and rural prosperity is not lost when one considers that China became the second largest global economy about the same time that its road system became the second largest in the world. While no causality is intended, neither is this just a mere coincidence. The impact of road expansion has had a profound impact on agricultural diversification and marketing in China (see Box 1).

Least Developed Road Networks in Sub-Saharan Africa

By all common statistical measures (Figures 4–7), Sub-Saharan Africa remains the region with the least developed road networks, with the possible exception of South Africa (which accounts for 30% of the region's roads) and a few small nations such as Gambia and Mauritius (*2*, *3*, *9*). Despite the progress achieved during the last 10 years (some 700,000 km were added to the classified network), the combined road network of the 49 Sub-Saharan countries is about 60% that of China and 75% that of India. In terms of quality, a mere 15% is paved; with South Africa accounting for 40% of all paved roads in the region (*2*, *9*). No other country exemplifies the road infrastructure deficit of Sub-Saharan Africa as poignantly as South Sudan. This youngest of all nations (it celebrated its independence on July 9, 2011) and roughly the size of France has less than 50 km of paved roads. With an area of about 620,000 km^2, drained by the White Nile and its tributaries and bordered by five countries, South Sudan has about 3,000 km of mine-free roads and seasonal motorable tracks. There is just one functional bridge on the White Nile over its entire sojourn through South Sudan from Nimule to Renk.

While work is proceeding on paving the 192 km Juba–Nimule Road, the country's main outlet to Uganda and the outside world, seven of the country's 10 state capitals have no all-weather road link with Juba, the country's capital. The isolation of South Sudan is replicated in Darfur (*10, 11*), the strife-torn western region of Sudan (see Box 1).

BOX 1 A Parable of Pears and Oranges


On a trip to the Golden Triangle in Northeast Thailand in 2002, I was surprised to find succulent pears in a local market near Chiang Rai. They were individually packaged in plastic netting in dainty wooden crates to prevent damage in transit. On closer examination, to my surprise I found that their provenance was in China. In texture and taste they reminded me of the pears sampled in Zhengzhou in Henan Province 20 years ago. Later on a trip to Burma (also known as Myanmar), I found Chinese pears in a fruit market in Mandalay. By 2004, the pears in their signature packing had arrived in Nepal, at the thriving border crossing at Kodari. And a few years later, I found the ubiquitous Chinese pear had the pride of place in the stalls of a local fruit market in Islamabad, Pakistan. It is quite probable that the phenomenal expansion of rural roads in China has contributed to the penetration of Chinese agricultural products into the South Asian markets. As agricultural produce moves from the farm to the regional and global markets, a critical link in the value chain is often the nondescript and inconsequential local rural road. Its importance is only felt when this critical piece of infrastructure is missing or it becomes unserviceable. While seldom recognized for its critical value, it is the local rural road that provides the first value-enhancing link, as a product moves up the value chain from the farm to the market.

In 2007, I found myself in strife-torn Darfur, one of the most geographically isolated and remote places on Earth. The region is virtually cut off from the rest of Sudan and the world for 3 to 4 months a year when the rains come. Air transport provides the only means of reliable access. As I sauntered through the local market in Nyala, the capital of South Darfur, I was struck by the quality of vegetables and fruits and soon I found some of the finest oranges I had seen in a long while. My first reaction was an implausible thought that these were imports from Turkey or Syria, as was the case in the capital city of Khartoum. But the fruit vendor explained that these were from the orchards of Jebel Marra, a well-watered high plateau with terraced fields and rolling hills that converge at a 3,088-m high extinct volcanic peak with its caldera lakes. Despite the destruction, insecurity, and lawlessness, vestiges of rural roads built many decades ago under an agricultural development project were still functional and permitted Marra's bounty of oranges and other fruits and vegetables to be transported by the occasional truck to the market in Nyala, the literal and symbolic end of the road. There were no reliable all-weather roads to take Marra's bounty further to the markets of the dusty, sprawling capital city of Khartoum, to substitute for the imported Turkish oranges. The Darfurian rebels enumerated the lack of roads, especially the incomplete Western El-Ingaz (Salvation) Highway, the vital all-weather, trans-Darfur road from El Obeid to El Geneina, which would have connected Darfur with the rest of Sudan, as a tipping point of their discontent. Vast empty spaces and lack of road connectivity remain the bane of development in Sub-Saharan Africa. Darfur is only a more extreme case, exacerbated by drought, war, and forced displacement.

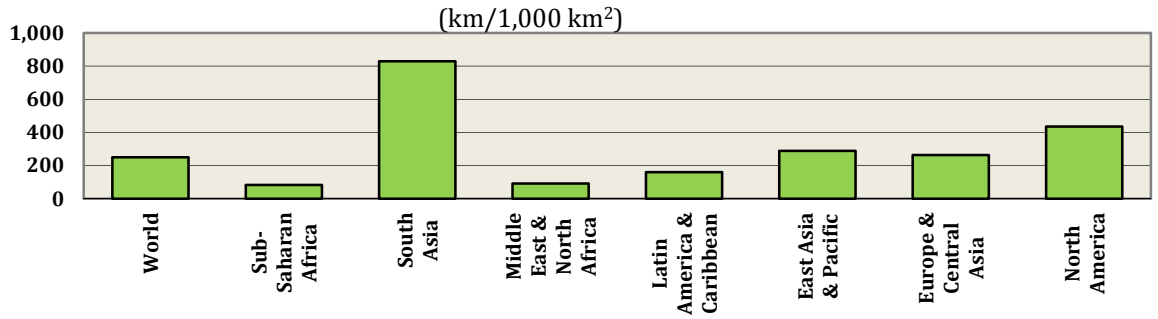

FIGURE 4 Area density of road networks by region, 2006. (Source: World Bank.)

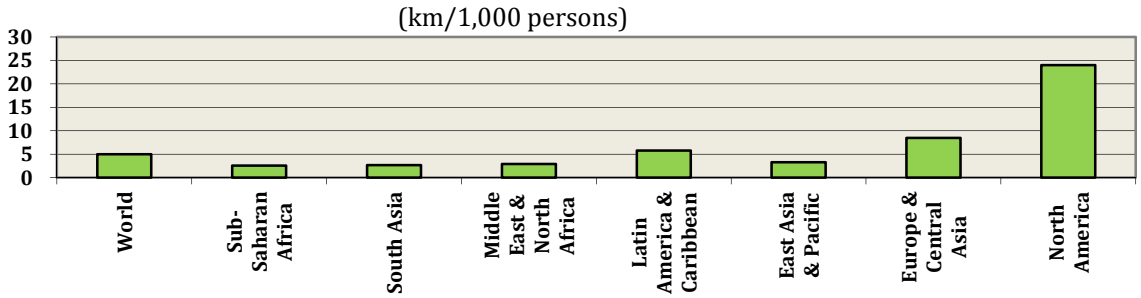

FIGURE 5 Population density of road networks by region, 2006. (Source**:** World Bank.)

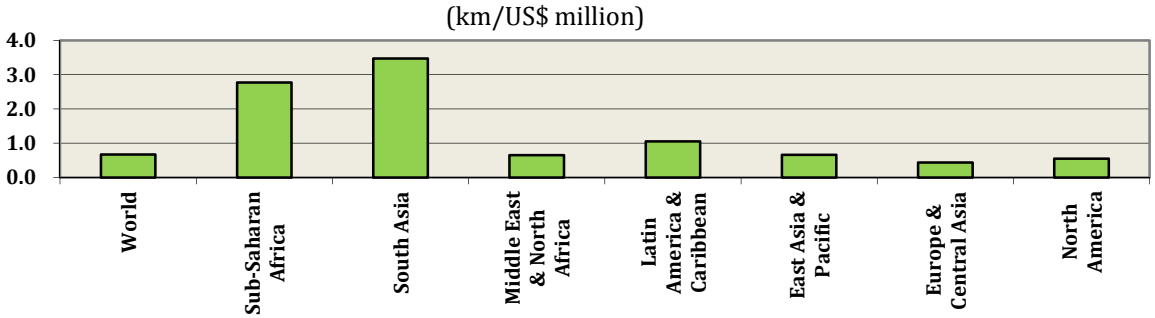

FIGURE 6 GDP density of road networks by region, 2006. (Source: World Bank.)

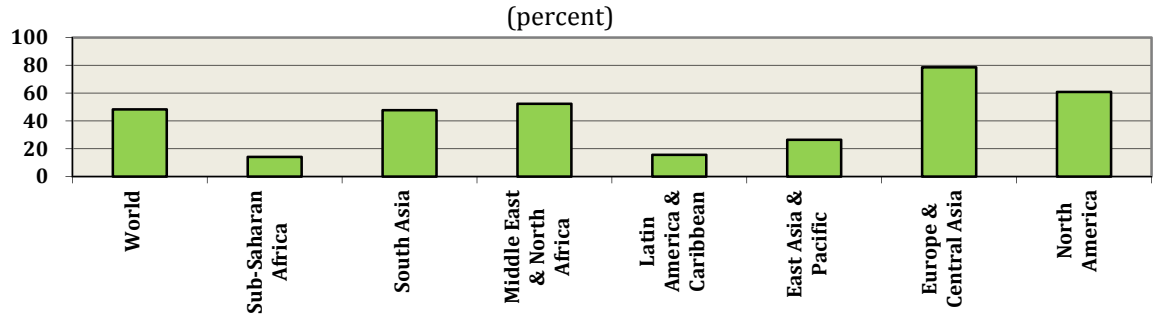

FIGURE 7 Percentage of paved roads by region, 2006. (Source: World Bank.)

ACCESSIBILITY: THE ESSENCE OF DEVELOPMENT

Accessibility, whether it is to markets, schools, health clinics, water points, places of worship, and community centers in rural areas or to the nearest town or city, is a precondition for the satisfaction of almost any economic or social need. Accessibility refers to the ability to make use of opportunities embodied in goods, services, activities, and destinations. For rural dwellers, access both defines and creates the opportunity to improve their social and economic well being. According to Litman (*12*), access is the ultimate goal of most transportation activities; even recreational travel has a destination, such as a hotel, a resort, a campsite, or a beach at the end of a trip. Chambers (*13*) has postulated that isolation or lack of accessibility is a key characteristic of poverty among the five core dimensions of poverty—the other four being lack of assets and income, physical debility, vulnerability to emergencies and disasters, and powerlessness. But the state of isolation does not signify remoteness, it means being cut off from supplies, services, facilities, and information. Isolation is not easy to recognize as it is often masked by the other dimensions of poverty. Improving access opens up the opportunity to relieve the constraints faced by rural communities and offers them the opportunity to improve their livelihoods. Thus improving access should be a major objective of rural development. This includes improving both mobility (reducing time and effort to gain access) and proximity to supplies, services, facilities, and information (bringing these closer to people) (*14*).

In the planning context, the terms accessibility and mobility are often used without a clear distinction. Mobility represents the potential for movement, while accessibility represents the potential for interaction (*15*). Accessibility measures include both an impedance factor related to the time or cost of reaching a destination and an attractiveness factor related to the characteristics of the destination. Mobility is primarily related to the impedance component of accessibility and is focused on means (the ease and speed of travel) while accessibility pertains to ends (the need or purpose of travel). Policies to improve rural mobility through provision of roads will generally increase accessibility but this may not always be the case (*16*).

Accessibility and Mobility in the South Asian Context

Bangladesh is well endowed with rural roads (a road density of 1.84 km/km^2 compared to an average of 0.84 km/km^2 for South Asia). But a rural infrastructure assessment found that districts with more roads (i.e., with longer and denser networks) had a lower percentage of good roads on account of inadequate maintenance while drainage gaps (insufficient or missing drainage structures) had rendered a large part of the feeder and rural road system unusable during the monsoons (*17*). In Sri Lanka, 81% of the road network is paved, a figure comparable to high-income European countries but a massive backlog of maintenance and rehabilitation has resulted in very rough roads with average speeds of 10 to 20 km/h. Transport providers are reluctant to operate on these roads and the frequency and affordability of rural transport services has diminished. In both instances, road investments aimed to increase rural mobility did not result in a sustained improvement in accessibility. It is also possible to have accessibility without "good" mobility (as characterized by motorable all-weather roads), as in Nepal's mountain districts where a system of engineered trails and suspension foot bridges, pioneered with Swiss assistance, has radically cut down on travel time and improved access to markets and services. Accessibility is not dependent on mobility, and neither is good mobility a sufficient or necessary condition for good accessibility (*16, 18*).

Mapping Rural Accessibility

The Rural Accessibility Index (RAI) developed by the World Bank represents an ambitious attempt to map rural accessibility at the global level. The RAI measures the proportion of rural inhabitants who live within 2 km (typically equivalent to a walk of 20 to 25 min) of an all-season road, which is defined as a road that is usable year round by motorized transport (typically by a pick-up or a heavier truck without four-wheel drive), except for occasional interruptions of brief duration on account of inclement weather. RAI measures accessibility of the target population to the road network rather than some attribute of the network size and distribution. On the basis of RAI values, it was estimated that 94% of rural people in the richer upper to middle income countries live within 2 km of an all-weather road, while only 37% live within this range in the 15 poorest Sub-Saharan countries. Globally, about 1 billion rural dwellers are estimated to lack access to an all-weather road (*19*).

Originally intended as a measure of social well-being of rural dwellers, loosely linked to Millennium Development Goals (MDGs), the RAI has become an economic indicator and a key measure of aid effectiveness in the transport sector, especially in Sub-Saharan Africa. Road investments that increase the RAI are deemed to improve economic welfare. But RAI's implicit use as a guide to investment decision making has created a bias in favor of rural roads at the expense of secondary and main roads. In some African countries, donor assistance is directed almost exclusively to rural roads with little consideration of networkwide needs. This can lead to a grave misallocation of public investment resources, because in large parts of the developing world there is neither the population density nor the scale of agricultural production to attract motor transport services without public subsidy. This is no better illustrated than in the Ethiopian highlands where farmers with their donkey-loads of farm surplus walk long distances to the nearest market, not only on newly constructed rural roads but along modern asphalted roads as well. In such circumstances, scarce public resources could be better spent for other development objectives, such as intermediate means of transport (IMT) to enhance rural mobility (*20*), or rural electrification to support, among other things, information and communications technology (ICT) penetration into rural areas. Moreover, the use of a rule of thumb, based on road density (e.g., kilometer per square kilometer of arable land) or RAI provides considerable leeway for political criteria to influence investment decision making, and poor people are often the losers (*21*). There are also some methodological issues with RAI pertaining to use of distance rather than time as a measure of accessibility, the differential travel time burdens on account of terrain and climate, and no consideration of availability, affordability, reliability and security (especially for women) of transports services in the assessment of accessibility (*22*).

As an aid to a better understanding of the spatial patterns of economic, physical, and social connectivity, Nelson (*23*) has developed a global map of accessibility which shows the travel time (from 0 h to 10 days) to the nearest city of 50,000 or more population in Year 2000 (Figure 8). Accessibility is defined as the travel time to a location of interest using land (road/off road) or water (navigable river, lake, and ocean) based travel, and is calculated using a cost-distance algorithm which computes the "cost" of traveling between two locations on a regular raster grid (friction surface), measured in units of time (*24*). This global map is essentially an overlay of several distance decay factors, including the road and rail networks, navigable rivers, shipping lanes and land cover, and may be considered as a proxy for global accessibility. The map shows the discriminatory effect of topography and transport infrastructure on the

distribution of human settlements and accessibility. The underlying GIS-based analysis shows that

- 95% of human population lives on 10% of the land and
- 60% of cultivated land is within 2 h of a city.

Only 15% of people are more than 1 h away from a large city in developed countries; in developing countries, it is 65%.

Defining Connectivity

Rural accessibility is also a function of appropriate placement, configuration and capacity of the transport infrastructure. All locations are not equal because some are physically more accessible than others; this implies an unequal and differentiated utility of place. The concept of accessibility may be disaggregated into two underlying parameters: *location*, which gives relativity of space in relation to the supporting transport infrastructure, and *distance*, which defines the connectivity between locations (*25*). Connectivity occurs when a given location is connected to other one or more locations through transport or ICT links, overcoming the friction of distance or space (usually measured in units of length, time, cost, or energy). A location that has the least friction relative to others is generally the most accessible. Keeping accessibility constant, an increase in transport density (relative to land area, population, or economic output) increases the availability of goods, services, and facilities, provides greater opportunities, and enhances the exercise of choice. A transport link (over the same distance) in a high-density setting will offer more opportunities than in a low-density setting (*26*).

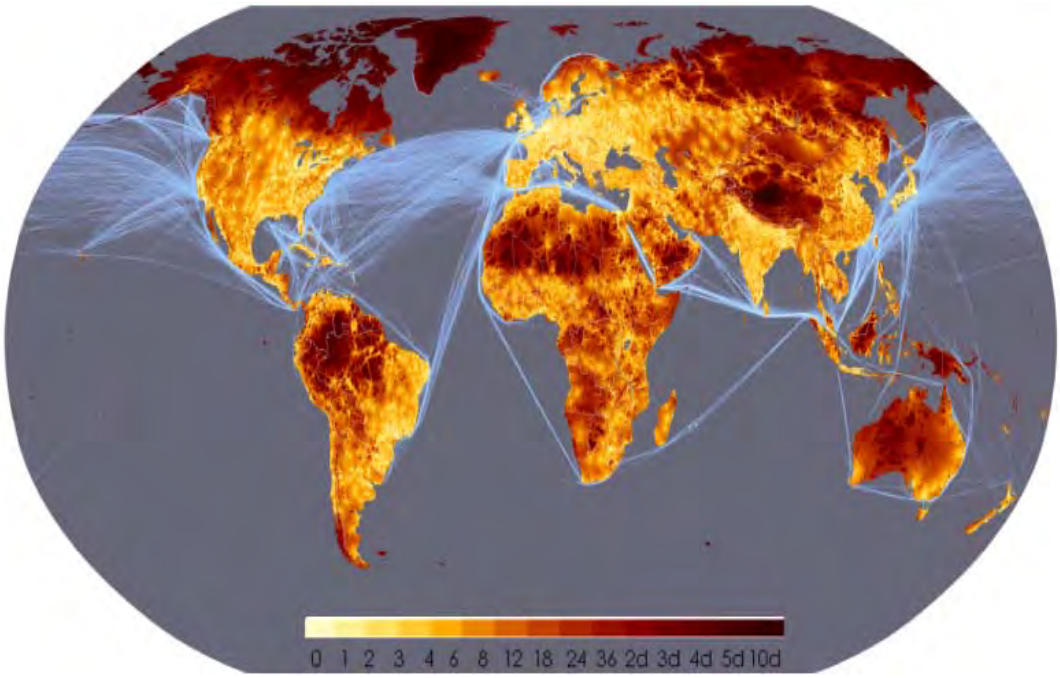

FIGURE 8 Global accessibility: travel time to a major city (population of 50,000 or more) (*23*, *24*).

Planning for Rural Accessibility

Road density (expressed in kilometer/square kilometer of land; km/1,000 population, or km/$1 million of GDP) has been used commonly as a proxy for rural accessibility and the percentage of paved road as a measure of the quality of rural access. For example, starting in 1943, India's road development plans established road density targets of 16 km/100 km^2, 32 km/ km^2 (further disaggregated at 44 km/100 km^2 for agriculturally developed, 19 km/km^2 for semi-developed, and 12 km/km^2 for underdeveloped regions) and 82 km/km^2, for each of the 20-year planning periods ending in 1961, 1981, and 2001, respectively. However, India's latest 20-year plan, the *Road Development Plan: Vision 2021*, has moved away from road density targets and lays stress on preparation of district level plans to improve village connectivity and to optimize the road network. Road density measures do not capture the connectivity dimension, the place utility, or access to opportunity provided by rural roads.

Wilfred Owen in his classic study of transport and communications in India—*Distance and Development* (*27*)—comments on the political hubris of local (rural) road programs designed to improve rural accessibility. In his view, the experience of getting the American farmers out of the mud in earlier years offered some interesting and relevant insights for India. Much of what he reported in 1968 continues to be relevant to developing countries today.

He noted that in 1949 "the U.S. had 2.5 million miles of local rural roads. Yet despite the high degree of mechanization and motorization of America's farms, more than half of this local (rural) road network was unsurfaced earth roads and 90 percent of the surfaced mileage was gravel. The most important functions of these rural roads were as routes for mail delivery (1.5 million miles), school buses (700,000 miles), and milk collection (500,000 miles)" (*27*). In 1945, 64% of all American farms were on an all-weather road and only 10% were less than a mile distant. The primary focus of road building was on grading and drainage and half the annual expenditure on rural roads (for the system as a whole) was for maintenance. But he went on to caution that a substantial percentage of local roads built in the United States up to 1950 rendered little or no service of any kind. According to an estimate by the U.S. Bureau of Public Roads (the forerunner of FHWA), about 400,000 mi of American local roads proved to be nonessential; the overbuilding of rural roads at the time, under the pressure of farm and political lobbies, cost U.S. taxpayer some $2.4 billion (in 1950 dollars). And the overbuilding of that era still casts a shadow on the ability of local governments in the United States to maintain and service this vast network of rural roads, further expanded, improved, and upgraded during the next 50 years.

Owen's explicit advice to the Indians was to focus on grading and drainage as the major task in improving road accessibility, with few roads requiring hard gravel or paved surface. The promise of rural roads is best fulfilled when connectivity to opportunity (economic and social) guides the planning, financing, and construction of this vital rural infrastructure instead of rules of thumb and broad guidelines vulnerable to political manipulation.

Connectivity Factor in Rural Road Planning in India and China

Connectivity of villages or habitations (of a minimum population size) to the road system serves both as a key metric for assessing rural accessibility and for programming rural road investments in India and China**.**

India

Roads are considered an essential public asset for administrative and strategic reasons and village accessibility has been a primary goal of rural road investments linked to minimum needs and basic minimum services programs. Between 1950 and 2005, the length of district and rural roads in India increased from 0.33 million to 3.1 million km, with an increment of nearly 2 million km of rural roads between1980 to 2000. The percentage of total villages (some 590,000) connected to an all-weather road increased from 20% in 1950 to 54% in 2000. Despite the massive investment in rural roads some 270,000 villages yet remained to be connected. Moreover, much of the emphasis of road building was on achieving the length targets and not necessarily on improved accessibility. In many instances, states were not able to provide adequate funding for maintenance and rehabilitation of existing roads and new road links lacked the required cross-drainage structures (*28*).

Regional imbalances in connectivity began to emerge with wide variations in road density; some villages had multiple road connections, others had none. A network approach to rural road planning was missing. In December 2000, a revamped Rural Roads Program known as Pradhan Mantri Gram Sadak Yojana (PMGSY) was launched to give a boost to rural connectivity while ensuring a balance between maintenance and upgrading of the existing network and investments in new connectivity. Uniform standards for pavements, drainage, and slope protection were instituted to ensure all-weather accessibility. To address issues of socioeconomic stratification within large villages with population clusters (habitations) separated by considerable distance, rural connectivity was redefined in terms of relatively homogenous habitations instead of villages.

When PMGSY was launched, it was estimated that about 347,000 habitations (40%) of a total of 825,000 habitations were without any all-weather access. At an estimated cost of US$28 billion, the program would require construction of about 370,000 km of new roads to link about137,000 eligible unconnected habitations and upgrading of 368,000 km of existing roads (along with mandatory budget allocations for maintenance of these assets) to ensure all-weather farm-to-market connectivity on a sustainable basis. By the end of 2008–2009, 38,800 habitations had been connected and work was in progress to connect a further 21,000 habitations, requiring new road construction of 97,500 km. In addition some 184,000 km of rural roads were upgraded (*29, 30*).

While PMGSY has given a major boost to rural road connectivity, a major challenge in the future will be the preservation and maintenance of the hard-won connectivity. This will require an inclusive asset management approach that integrates maintenance in the overall planning, and management of PMGSY. Rural road management in India is beset with many challenges including a functional classification of the rural road system, decentralization of maintenance functions and responsibilities to local governments, development of asset inventories and management systems, preparation of manuals for rural roads maintenance in regional languages, development of trained manpower, including small contractors and community-based maintenance cooperatives, and sustainable funding for maintenance (*31*).

China

Connectivity of villages to the road system is the primary indicator for planning and programming rural road investments in China. In 2010, about 94% of villages in China's eastern

and central regions were accessible by road, and the figure for villages in western regions was 98%. Bus service was available in 35,000 towns (98% of all towns) and 553,000 villages (88% of all villages). This reflects the massive investments in rural roads made during the last decade, with the total length of the rural road network reaching an estimated 3.7 million km in 2010. Under its *National Plan for the Development of Rural Roads,* China intends to link all towns and administrative villages with asphalt or cement concrete roads (*5*). The program also goes by other names, such as "Paved Access to Each Village" and "100 billion Yuan in 5 Years Initiative" for village roads. This is a fully government-financed program (mostly by national and provincial governments) and, unlike other rural infrastructure programs, no contribution in cash or kind is envisaged from the village beneficiaries.

To safeguard its massive investment in rural connectivity, China has established a comprehensive institutional and funding framework for rural road maintenance to guide and regulate operations at different administrative levels. All government departments follow this framework and are monitored by higher-level authorities. An estimated 90% of the rural road system is now under some form of regular maintenance. County-level government institutions assume most of the responsibility for rural road maintenance. China has also set up a diverse set of financial resources for rural road maintenance, with main contributions coming from budgetary allocations made at the national and provincial levels. In addition, a uniform bidding and contracting system of rural road maintenance guarantees effective implementation and quality of maintenance work (*32*).

Rural Road Connectivity: A Holistic Approach

Rural road (RR) connectivity in many aspects is analogous to information technology (IT) connectivity and the growing synergy between them offers new possibilities for enhancing rural accessibility and livelihoods through balanced and complementary investments in electric power, renewable energy, roads, ICT, IMT, and conventional transport services. In this context, it is important to integrate the vast realm of minor service roads (e.g., the miles of irrigation service roads that are constructed on canal embankments), motorable tracks (in desert environments), trails (such as the Appalachian Trail in the eastern United States and the Annapurna Circuit in Nepal), and paths suitable for pedestrians and IMT with the classified rural road system. This would help in improving rural connectivity with a seamless transition from pedestrian (and nonmotorized modes) to motorized locomotion. Use of engineered cableways on steep mountain slopes and ropeways and footbridges for crossing streams and deep ravines can provide basic access to remote communities in difficult terrain.

In Nepal, the Department of Local Infrastructure Development and Agricultural Roads (DOLIDAR) introduced a systematic approach to rural road inventory and classification in 1999, to include all types of district- and village-level roads, tracks, and trails as part of the local transportation system. DOLIDAR's functional classification system included district roads, village access roads, main trails, village trails, and ropeways. The inclusion of the lower-order rural transport infrastructure in the participatory planning and resource allocation process was of great importance to the rural population, given its critical role in providing basic access and connectivity, especially to the more remote rural settlements and communities (*33*).

India's *Rural Road Development Plan: Vision 2025* (*28*) makes access the primary objective of rural road planning, balancing connectivity requirements with cost-effective access solutions. This could include unsealed roads and engineered tracks and footbridges to provide

appropriate, low-cost access to the paved road network. For smaller habitations the definition of all-weather access may include a higher frequency and duration of interruptions on account of weather-related events. The vision for the new rural connectivity aimed to provide road access to all habitations with a population above 1,000 persons (500 in case of hill, desert, and coastal regions and tribal areas) by year 2010; and to all habitations with a population above 250 by year 2022. To turn this vision into reality, PMGSY introduced the concept of a core rural road network to provide at least one all-weather road between habitations with a population of above 500 persons (above 250 persons in case of hill states and desert and tribal areas) and a market center (*29*).

In Austria rural tracks and paths are maintained by the Austrian Alpine clubs. They often follow ancient connection paths between villages in the Alps and access paths to the "Almen" (where the cattle are placed during summertime). Connections to mountain tops were extended by enterprising mountaineers. These tracks have a route numbering system generalized all over Austria (main routes). There are in addition many local routes maintained and numbered by the local tourist boards. Paths with three (sometimes four) digits in the route number are maintained by the Alpine Clubs and the number is unique to a specific route within Austria and Germany. The total length of the signed mountain paths in Austria and Germany is 40,000 km. Most of these are in Austria, but both the Austrian and the German Alpine clubs look after their maintenance and upkeep. The local paths may have a single digit number that is not unique. In addition there are long-distance international tracks (e.g., from Scandinavia to Italy) with a common European numbering system and special signage (*34*).

Classifying and numbering trails and paths for pedestrians and IMT would give visibility and recognition to this important class of rural infrastructure in developing countries and eventually a claim on road user revenues for their maintenance and construction.

In short, the concept of accessibility has many dimensions and is not easily defined and measured. Handy (*16*) considers choice as an important element of accessibility, as more choices in both destinations and mode of travel mean greater accessibility. In the rural areas of the developing world, choice is intrinsically limited but can be expanded by integrating roads with paths and trails, and motorized transport with walking and other nonmotorized modes of travel that often depend on animal locomotion (*20*). All-terrain vehicles can also provide critical access and mobility to remote locations for provision of basic services when motorable roads are absent. The notion of connectivity (as a substitute for accessibility) is appealing, especially connectivity (measured in travel time irrespective of mode of travel) between a rural household, community or settlement, and the nearest market town or city as demonstrated by Nelson (*24*).

Rural roads play a critical role in enhancing economies of scale and agglomeration, thus expanding access to opportunity in all its multiple dimensions. Rural roads, however, are not a proxy for rural accessibility but have an essential role in facilitating and enabling development to happen. They are a means to an end and the end is connectivity to opportunity, information, and services.

CENTRAL ROLE OF RURAL ROADS IN POVERTY REDUCTION

In *Wasted Time: The Price of Poor Access*, Edmonds (*14*) provides a graphic description of the link between isolation and poverty. He contends that "isolation and access are the two sides of the same coin, with poor access as the defining characteristic of poverty. Lack of access has its impact at the most basic level of living: if there is poor access to health services, people will remain unhealthy; children will die; and any epidemic will be likely to have catastrophic results; if there is poor access

to clean water, again health will suffer; if there is poor access to basic information the household will be unaware of ideas and technology that might help them to lift their level of living; and if there is poor access to education, children will probably share in the future the limitations confronting their parents today." In his view, access is also related to poverty at a different level: "even if financial and physical access to the basic services is assured, this is actually only a starting point in the development process. If access to markets is difficult, farmers are hardly likely to diversify their production to include cash crops, or even to grow net surpluses of subsistence staples. And without such new ideas and opportunities poverty remains an endemic feature of rural life" (*14*).

The rural access deficit manifests itself in many ways and forms. Box 2 provides a glimpse of the symptoms of deprivation linked to lack of road access in rural India and, more generally, in South Asia. These symptoms are illustrative and by no means exhaustive, nor do they occur uniformly all over the country. They vary widely depending on the extent of road connectivity. While in some Indian states the level of connectivity is quite low, in some other states it is much better than average. Even in the same state, there are wide variations from district to district and within each district.

In a similar vein, the *World Bank's 2008 Transport Business Strategy* notes that in poor rural areas, isolation caused by poor transport is often the main impediment to economic progress and poverty reduction. Poor transport limits trading opportunities even within local markets, as the costs of production and distribution are increased, the profit margin from sale of tradable surplus is reduced, and production yields and output remain below their potential. The migration from subsistence to income-producing agriculture is retarded. The economic impacts of improved physical access to markets can be cumulative and far-reaching, making it worthwhile to modernize agriculture through mechanization, use of fertilizers, and planting of higher-yield varieties. This, in turn, increases demand for inputs as well as demand for and availability of credit. Rural transport also provides access to labor markets and therefore creates the opportunity to earn on-farm income. Moreover, the same road that provides transport access to product, service, and labor markets often provides the right-of-way for other utilities such as electricity, ICT, water supply, and sewerage (*35*).

An assessment of the impact of transport and energy infrastructure on poverty reduction by the Asian Development Bank showed that improvements in rural roads and transport services reduced transport costs for the poor, resulting in increased farm incomes and off-farm employment opportunities especially for landless poor households (especially for women as laborers, small contractors, social workers in local road construction and maintenance programs), improved access to health care, education services and common property resources, as well as improved personal security and participation in the community. A highly significant finding of this study is that time savings are of great importance to the poor, implicitly valued at more than the opportunity cost of labor. Time savings from road improvements expand the radius of off-farm employment opportunities accessible to the poor and reduce the time deprivation faced by poor rural women (*36*).

Rural Roads and Poverty Reduction: Empirical Evidence

Rural roads are a key component of rural development. Once adequately developed and maintained, rural roads enable and foster rural connectivity vital for improving rural incomes (on and off farm), creating productive jobs and promoting access to economic and social services.

BOX 2 Typical Symptoms of Deprivation Due to Lack of Access in Rural South Asia

- Several pregnant women die each day because they cannot reach the healthcare centers in time from their villages.
- Thousands of rural children cannot reach the schools during rainy season.
- Perishable agricultural produce cannot reach the markets in time leading to heavy losses to the farmers.
- A large number of cattle die in veterinary epidemics because help cannot reach them, especially during rainy season.
- Water tankers cannot reach several thousand drought-prone villages leading to migration of rural population in total despair.
- The public distribution system fails to penetrate to thousands of villages leading to malnutrition and infant mortality.
- Poor connectivity has a high correlation with high levels of illiteracy, unemployment, and poverty.
- Low levels of accessibility have deprived large number of villagers from equality of opportunity as compared to the urban population.

SOURCE: Report of National Rural Road Development Committee, Government of India, September 2000, referenced in NRRDA (*28*). PHOTO CREDITS: Asif Faiz, Kamran Akbar, and Michael Foley (World Bank).

There is a growing body of empirical evidence that relates rural road investment to the improved well-being of the poor. Research carried out over the past decade by the International Food Policy Research Institute (IFPRI), under the leadership of Shenggen Fan, shows a positive relationship between public spending on rural roads and poverty reduction. IFPRI case studies cover India, China, Vietnam, Thailand, and Uganda, countries that represent different stages of economic development. The research reported in these case studies uses an econometric model

that permits calculation of the number of poor people raised above the poverty line for each additional unit of public spending on different expenditure items. The model is also structured to enable identification of the different channels through which different types of government expenditures affect the poor, distinguishing between direct and indirect effects. The direct effects arise in the form of benefits the poor receive from employment programs directly targeted to the rural poor. The indirect effects arise when government investments in infrastructure (particularly rural roads), agricultural research, health, and education stimulate agricultural and non agricultural growth, leading to higher employment and income-earning opportunities for the poor and to cheaper food (*37*).

This work provides rigorous analytical evidence from India, China, Thailand, Uganda, and Tanzania that public spending on rural roads (especially in economically lagging areas) contributes significantly to lifting rural people out of poverty. In general, public expenditures with highest marginal return were on agriculture research, rural roads and education. The IFPRI researchers concluded that the importance of rural roads can scarcely be overemphasized in promoting economic growth and reducing poverty. Roads are literally the foundation of rural development in that good road networks lower the costs of everything else: rural electrification, irrigation, fertilizers, education and health services, agricultural extension services, financial services, output markets, and a whole host of other goods and services, all of which produce dynamic linkages to new opportunities for migration, investment, and trade. However, more specific attention should be focused on lagging regions, as well as on poverty at the community and household levels, in order to reduce the poverty and income inequalities that are often endemic in rural areas (*38*).

In India, government expenditure on roads has been found to have the largest impact on poverty reduction as well as a significant impact on productivity growth. It is a dominant "win-win" strategy. Investment in roads have contributed importantly to growth in Total Factor Productivity (TFP) in agriculture thus generating economic surplus for expenditure in other sectors—and, therefore, helping in all round socioeconomic development. The growth in TFP has helped to keep the consumer prices of food grains in check thus benefiting the poor. Non-agricultural employment opportunities have increased because of the stimulus to non-farm commercial activities, leading to higher wages. Of the total productivity effect on poverty, 75% arises from direct impact of roads in increasing incomes while 15% from lower agricultural prices and 10% from increased wages (*28*). The relationship between rural road connectivity and the incidence of poverty in Indian states is shown in Figure 9. The higher the accessibility, lower is the poverty. However, on closer examination, it seems that rural roads may have followed rather than led the growth in agricultural productivity and rural incomes (reverse causality) in the breadbasket of India (Punjab and Haryana).

As rural road investments are typically long term, observed benefits to households and communities tend to vary over time as short-term outcomes are overtaken by longer-term impacts. In Bangladesh, it was noted that short-term effects of rural roads on incomes, prices, schooling, and other social indicators attenuate over time. But these declining returns are offset by a sustained increase in rural non-farm employment and diversification away from core agricultural activities to off-farm activities. These results are heavily influenced by the baseline conditions pertaining to household and community characteristics as well as initial road quality. The very poor fail to sustain the short-term benefits of roads (*39*).

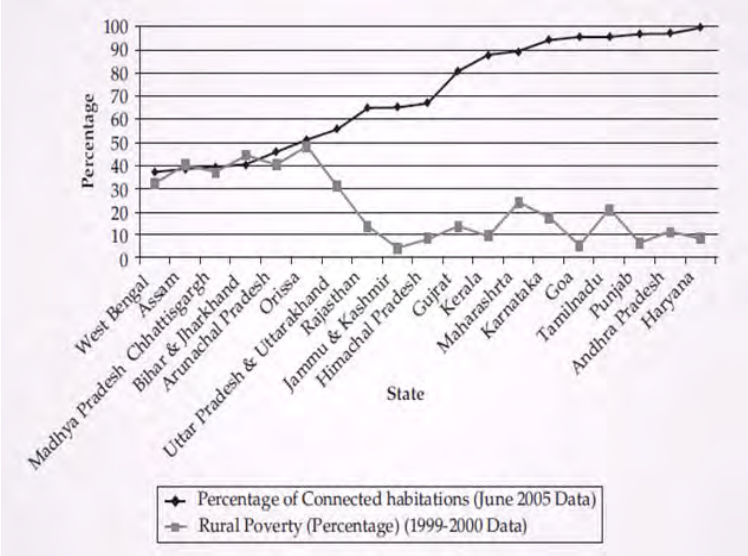

FIGURE 9 Road connectivity and poverty: Indian states (*29*).

The Rural Transport Trap

Raballand et al. (*21*) have further examined the relationship between rural road investment and agricultural productivity and rural incomes in Sub-Saharan Africa, drawing on lessons from case studies in Burkina Faso, Cameroon, and Uganda. They recommend abandoning the RAI based on a 2-km buffer zone as it is not an economic threshold. Based on empirical evidence, they postulate a rural transport trap (Figure 10) that explains the inadequacy of rural road infrastructure in low-income countries, particularly in Sub-Saharan Africa. They offer a set of

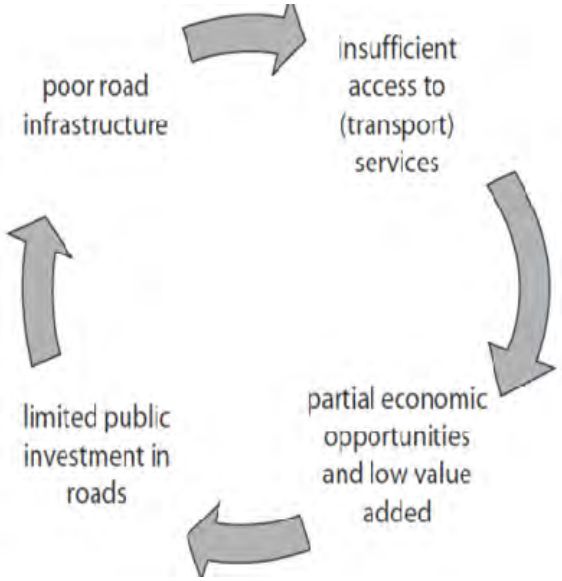

FIGURE 10 Transport trap in rural areas (*22*).

recommendations on how this circular trap could be transformed into a virtuous circle by providing connectivity to roads in line with the needs of the rural population. This will require a better balance between maintenance (including rehabilitation) and new construction in spending priorities, context-sensitive design standards that may be better suited for IMT, a road investment strategy that results in a balanced network of trunk, secondary and local access roads, and load consolidation at the local level to reduce the need for road access to every farm and habitation accessible by truck. They show that rural roads in Sub-Saharan Africa often fall way short of generating the anticipated truck traffic although they have a vibrant mix of motorcycles, bicycles, carts, pedestrians, and donkeys. In a survey of 47 rural access roads in Burkina Faso, 19 had no motorized traffic at all, despite IMT traffic of 250 bicycles, 100 motorcycles, and 100 pedestrians per day. What explains this is that the typical family farm or agricultural holding in Sub-Saharan Africa does not produce a truckload of agricultural surplus to make truck transport a financially viable proposition. The small surplus for the market can be easily transported on bicycle, cart, or pack animal or simply by head loading.

Motorized transport and nonmotorized transport (NMT)–IMT are the ying and yang of rural roads and this balance becomes even more pronounced in densely populated Asian countries.

Millennium Development Goals and Rural Roads

Since their advent in 2000, MDGs have been a key focus of the global development agenda aimed at freedom from extreme poverty and hunger, universal primary education, gender equality, reduced child mortality, improved maternal health, control of HIV and other communicable diseases, environmental sustainability, and global development partnership. Five of the eight MDGs seek health or education improvements. Basic mobility plays a critical role in delivering and providing access to health care and education. Most programs that directly target these goals (programs involving schools, health clinics, emergency services, nutrition programs, and social services) depend on road transport (motorized and nonmotorized) to underpin their delivery (*22, 28, 40*). The key linkages between MDGs and road transport infrastructure and services are outlined in Table 2. These linkages assume a critical significance in the Sub-Saharan context as elaborated in a seminal study by the African Union and the U.N. Economic Commission for Africa (*41*). Despite the pervasive influence of mobility and access issues on almost all aspects of development, the MDGs make no explicit reference to transport. The transport sector remains the missing link in the MDGs (*22, 40*).

Although rural roads (compared to direct investment in education, health, or social protection) may appear an indirect instrument for effecting socioeconomic change, they serve as the catalyst of social change, even in areas with few if any economic opportunities. In economically backward or lagging areas, roads perform a social, strategic, or administrative function. While they may carry little traffic, the ability for one vehicle a day or week to pass may be the difference between a community receiving and not receiving services critical to its well-being (*42*). Rural roads have essentially a facilitator–enabler role in poverty reduction by helping to create economic opportunity and jobs (on and off farm); promoting and sustaining agricultural growth; facilitating access to basic health and education facilities (for both service providers and recipients); enhancing democratic processes by bringing rural constituencies into national mainstream; and reducing vulnerability and insecurity(*28*). The provision of good rural roads often changes the characteristics of rural transport demand. People tend to travel more, vehicle ownership increases, and the cost of travel and transport comes down. Even agricultural tillers and tractors are modified for transport of goods and passengers and deployed on the road to enhance mobility (Box 3).

TABLE 2 Key Linkages Between MDGs and Road Transport Infrastructure and Services (*18*)

MDG	Final Outcomes	Intermediate Outcomes
MDG 1: Eradicate extreme poverty and hunger.	Increased access to assets, services and markets. More effective food marketing and distribution. National and local economy more active. More employment opportunities more widely available. Wider access to affordable basic goods and services. More reliable access to essential food supplies.	Target communities have improved affordable transport services to markets. Domestic transport more reliable and affordable international transport more competitive. Production, marketing, and distribution of food more effective.
MDG 2: Achieve universal primary education.	Improved school attendance and completion. More reliable staffing and equipping of rural schools.	Improved access leaves children more time to attend school. Children have quicker, safer routes to school. Better staff access and equipment supply for rural schools.
MDG 3: Promote gender equity and empower women.	Access needs of women and men are met effectively and equitably.	Transport services designed for the needs of women and girls.
MDG 4: Reduce child mortality.	Improved access for mothers and children to primary health care and emergency services. Reduced incidence of RAI in children under 5 due to improved access to cleaner fuels.	Rural families can have better transport to health care for babies and infants. Rural families have better access to cleaner fuels and improved stoves.
MDG 5: Improve maternal health.	More reliable staffing and equipping of rural health facilities. Better access for women to primary health care and emergency services.	More effective support of rural health facilities. Effective transport for women in perinatal crisis.
MDG 6: Reverse the spread of HIV/AIDS and other diseases.	Reduced spread of disease along main transport corridors. Reduced risk of disease from construction sites.	Workplace policies. Greater awareness and less risky behavior by vulnerable transport employees and those associated with them. Reduced delays at borders.
MDG 7: Ensure environmental sustainability.	Land use and transport patterns evolve in line with long-term strategic considerations including environmental sustainability.	Transport investments reflect full environmental costs. Transport strategy incorporates environmental and other long-term considerations.
MDG 8: Build global partnership for development (open trading; needs of landlocked countries).	Open, predictable, nondiscriminatory trading system established. Needs of landlocked countries and small island developing states met.	Practical, equitable systems established for security of and from transit shipments. Administrative costs of import/export minimized. Transport contribution to trade is optimized.

BOX 3 Tractor–Trolley: The King of the Rural Road in South Asia

For centuries, the bullock cart and its variants powered by the buffalo, donkey, and camel, have been the mainstay of rural transportation in the plains of South Asia. On improved roads with bituminous penetration macadam surfacing, the iron-rimmed wooden wheel gave way to the pneumatic tire but the ubiquitous bullock cart remained a fixture on South Asian rural roads—a swaying kerosene lamp signals its plodding road presence on moonless nights.

With farm mechanization, the agricultural tractor came on the scene and replaced the timeless animal-drawn plow. All that the ingenious South Asian farmer needed was to hook a trolley (trailer) to the tractor and he had at his disposal a veritable motorized vehicle to carry agricultural produce to the market place—the bulk of the sugar cane from the fields reaches the sugar mills in agricultural tractor–trolleys (*27*). This lumbering contraption is also used for private passenger transport especially on occasions such as *barats* (weddings), *melas* (fairs), *mandis* (markets) as well as religious festivals, public holidays, and voting days.

Although the agricultural tractor–trolley is a cumbersome and unwieldy road vehicle, and a safety hazard in the presence of faster moving buses, trucks, and cars, it is a convenient and affordable means of private transport, especially for the small farmer. As the tractor is used for farm work for about 100 days in a year, it is available for all and sundry purposes the rest of the time. It has a huge advantage in terms of rural mobility. It can go where no other vehicle dare to tread—bucking and rearing, it can negotiate rough tracks, pot-holed roads and even roads inundated with flood waters. The redoubtable tractor trolley is indeed the "King of the Rural Road" in South Asia. In East Asia, especially in China, the agricultural tiller–trailer, dubbed the "Iron Horse," has a similar eminence on rural roads.

PHOTO CREDIT: PMGSY, MORD, India

RURAL ROADS AND CRISIS MANAGEMENT

Economic shocks are powerful drivers of poverty and change in the human condition. Positive shocks are likely to reduce poverty and improve human development indicators, while adverse shocks have the opposite effect. The year 2008 was characterized by an unprecedented convergence of adverse shocks: the food crisis, the fuel crisis, and the global financial crisis (*43*). In addition the first decade of the new millennium was marked by monumental, and in some ways, unparalleled natural disasters affecting the developing world: notably earthquakes in Pakistan and Haiti; floods and landslides in Pakistan, Nepal, India, China, Brazil, and Haiti; the Indian Ocean tsunami affecting 10 countries; and persistent drought in the Southern Hemisphere extending from Argentina through eastern and southern Africa to Australia. Human strife and war resulted in mass internal displacement and dislocation of people primarily in South Asia (Nepal, Pakistan, and Sri Lanka) and Sub-Saharan Africa (Sudan, especially Darfur, Chad, Congo, Cote d'Ivoire, Sierra Leone, and Liberia), requiring massive international humanitarian relief and recovery efforts.

Role of Rural Roads in Emergency Crisis Response

There is ample evidence that rural roads can have an important role in responding to emergencies resulting from natural disasters, civil strife, and market vagaries of the type that triggered the triple food, fuel, and financial crises of 2008. In Ethiopia, the investment in rural roads has not only contributed to economic growth and poverty reduction but has also helped in drought proofing. These rural roads often located in drought-prone areas serve a dual purpose: they help to move agricultural surplus from farm to market in normal times and serve as a conduit for the delivery of food and other relief in periods of drought. Landlocked Malawi is among the world's poorest countries with 90% of its 15 million people living on the equivalent of less than $2 per day. One reason for the widespread chronic poverty is that more than 70% of Malawians live in rural areas. When natural disasters, such as a prolonged drought, strike, the delivery of emergency food aid to drought-stricken districts becomes an expensive proposition; the marginal cost of importing a ton of food-aid maize is US$400, versus US$200/ton to import it commercially, and only US$50 to source it domestically using fertilizers (*44*). The lack of rural roads and markets in Malawi is a major constraint in delivering affordable fertilizer to the farmers as well as the domestic sourcing of maize to supply to grain-deficit areas. Despite the massive public expenditure averaging over US$1 billion per year since 2005 on post-conflict stabilization and recovery in South Sudan (following 22 years of a devastating civil war), most of the food—even fresh vegetables, fruit, and eggs—consumed in the capital city of Juba continues to be imported from Uganda. The absence of rural roads is a major factor constraining agricultural production beyond subsistence levels, when the potentially rich agricultural landscape of South Sudan could deliver large marketable surpluses for domestic consumption and export.

The existence of well-engineered rural roads can facilitate the prompt and cost-effective delivery of relief in disaster-affected zones. Pakistan has an extensive system of canal roads (not part of the classified road network) located on canal embankments. Although the primary function of these roads is to provide access for maintenance and operation of the irrigation system, they served (along with other rural roads) as places of refuge and evacuation routes in the colossal flood of 2010. And in the immediate aftermath of the flood, they were used to

transport material, equipment, and labor to repair the canal breaches and other flood-damaged infrastructures, ensuring uninterrupted supply of irrigation water for the next crop season.

In the 2005 earthquake (measuring 7.6 on the Richter scale and centered in Azad Kashmir, i.e., Pakistani-administered Kashmir, close to the city of Muzaffarabad), it was easier for relief teams with pack animals to reach destroyed mountain villages with road access, despite the earthquake damage to the roads, as compared to remoter hamlets with no road access. Helicopters provided emergency assistance to the more remote locations but were often handicapped by inclement weather.

The early response to the 2010 flood emergency in Pakistan required daily search, rescue, and relief sorties involving some 60 to 90 helicopters, with 50% to 67% of the craft owned and operated by the Pakistani military and other agencies. The estimated national share of this early emergency response using choppers amounted to some $2 million per day. Getting food and other aid to 8 million or more people in urgent need was a logistical challenge. The relative cost of transporting food by truck, mules, and helicopter is given in Table 3. Trucks using all-weather rural roads were the most economical and common means of transporting food aid and other relief goods. Where damage caused to roads and bridges by the floods prevented vehicular access, mules and donkeys were used by the Pakistan army, the World Food Program, and other organizations, notably in Swat and Shangla districts in northern Pakistan, to reach marooned people. In flood-hit mountainous areas in the north (often with no all-weather rural roads or motorable tracks) or areas further south where roads had been completely submerged by flood waters, access to some 800,000 stranded people was only possible by helicopters (*45*).

The recent flood disasters around the world point to the need for climate resilient rural road design and construction with specific attention to drainage requirements (for both a higher frequency and a higher intensity flood regime) and slope protection, especially in geotechnically fragile areas. Greenstein (*46*) reflects on other planning, design, and construction considerations for low-cost road and bridge accessibility in postconflict or natural disaster areas in Sub-Saharan Africa and Latin America, with special reference to the natural disasters in Haiti.

Rural Roads and Workfare Programs

Rural roads have featured prominently in stimulus programs to confront the 1988 food–fuel–financial crises. These stimulus programs often utilize workfare and community-driven development (CDD) mechanisms to address job losses as part of counter-cyclical fiscal measures. Workfare, also referred to as cash for work, and public works are safety net programs that create employment targeted to the poor and commonly use labor-intensive technology.

TABLE 3 Reaching Flood Victims by Truck, Mule, and Helicopter in Pakistan: Estimated Cost of Transporting 100 tons of Food over 100 km

Mode	Capacity	No. of Units	Time Required	Total Cost (US$)	Cost/Ton Kilometers (US$)
Truck	10 tons/truck	10 trucks	3 h	1,200	0.12
Mule	38 kg/mule	2,632 mules	2 days	5,000	0.50
Helicopter	3.5 tons/sortie	30 sorties[a]	30 min	360,000	36.00

[a] Requiring eight helicopters.

SOURCE: IRIN, Aug. 28, 2010, based on data from World Food Program.

These crisis response programs serve a variety of objectives such as employment and income stabilization during times of crises. They create infrastructure assets for the rural poor and often evolve into longer-term anti-poverty interventions. Workfare programs were launched after the microeconomic crisis in East Asia in 1997 and Latin America in 2002 to mitigate the negative effects of shock on the most vulnerable populations. CDD mechanisms have also proven effective in constructing and maintaining rural roads utilizing labor-based methods and have been used successfully to create jobs in the aftermath of macroeconomic shocks (e.g., Mexico in 1995, Yemen in 1966, and Indonesia in 1997) (*47*).

Tuck et al. (*44*) estimated the potential effects on direct, indirect, and induced employment for different types of infrastructure projects in Latin America and the Caribbean region. They classify the short-term employment generation impact in three categories: primary impact related to those directly employed on site for project implementation; secondary impact related to those indirectly employed in the manufacture of materials and equipment needed for the project; and tertiary impact related to induced employment generated by the direct and indirect jobs created, including all of the jobs supported by consumer expenditures resulting from wages on account of primary and secondary impacts. Their analysis finds that the direct and indirect short-term employment generation potential of infrastructure projects may be considerable, averaging around 40,000 annual jobs per US$1 billion invested, depending upon such variables as the technologies deployed and local wage levels for skilled and unskilled labor. In comparison, rural road maintenance projects (albeit limited in scope and scale) may create 200,000 to 500,000 annualized direct jobs for every US$1 billion spent.

Such programs may invest up to 90% of the total project cost in labor activities, employing unskilled workers in rural areas paid at the minimum wage. Labor-intensive road maintenance projects generate significantly fewer indirect jobs because of less material and equipment inputs. But labor-intensive projects coupled with well-targeted social programs are generally a highly progressive intervention for reducing the impact of the crisis on poor communities. Such programs in a crisis environment, however, carry potential risks related to delayed implementation and impact, affordability, and corruption.

An informal assessment of job creation in the road construction sector in Georgia found that on average, it required an investment of US$4,400 to create a person month of employment (including management, skilled, and unskilled workers), but for road maintenance, the investment cost per man month dropped to US$980, a result that is consistent with the Latin American experience noted above (*48*).

The job creation potential of rural road programs depends significantly on the labor–equipment mix used in construction and maintenance activities. Labor-intensive construction, however, does not mean a substandard product, nor does it imply poor quality infrastructure for poor people. In this context, provision of adequate compaction equipment, proper location and sizing of drainage structures, and attention to the needs of pedestrians and NMT can go a long way to provide durable and people-friendly roads constructed with labor-intensive inputs and methods. But where time is of essence in restoring services after a natural disaster or providing critically needed infrastructure in unserved areas, the construction technology choice should be made in consultation with the affected people or beneficiary communities, as there may be a trade-off between job creation and speedy restoration or provision of critical infrastructure services such as reliable all-weather road access.

A typical distribution of material, equipment, and labor inputs in rural road construction in India utilizing equipment-intensive, labor-intensive, and intermediate construction

technologies is summarized in Table 4. Although material inputs are shown as constant across the three modes, this may not be strictly true as labor-intensive construction work in South Asia often involves manual stone crushing to produce aggregate for road construction and maintenance (a source of unskilled employment for women and youth). Using intermediate technology, it is estimated that an expenditure of INR10 million (about US$250,000) would create some 40,000 person days of direct minimum wage (at INR75 or US$1.70 per day) employment (*28*). This is roughly equivalent to 590,000 unskilled labor jobs per US$1 billion invested. But rural road construction generates more than a minimum wage, unskilled job. If all job categories (management, skilled, and unskilled) are taken into consideration, the number of jobs created would be about 170,000 per US$1 billion invested.

Labor-intensive construction programs aimed at job creation can also enhance environmental values and sustainability. Rural Green Roads, pioneered in Nepal in the 1990s, uses construction techniques that minimize disruption to existing vegetative soil cover and utilize all excavated material for road construction. The beneficiaries contribute through the sharing of indigenous knowledge about local geology and hydrology as well as participation in actual construction activities. This in turn requires social mobilization at the community level. Environment-friendly construction technology includes widening the road in stages (starting with a 1- to 1.5-m track) and using one monsoon season to consolidate and stabilize the roadbed. No rock blasting or the use of heavy equipment like excavators is permitted. The road takes longer to build, about two to three times longer than using conventional equipment-intensive methods. The average construction cost (in 1999 U.S. dollars) was about US$19,000 per km, with the following factor inputs: labor, 65%; construction materials, 15%; tools, equipment, and transport, 10%; and overhead (including construction supervision and social mobilization), 10%. Construction of 1 km of a green road required a labor input of 12,000 person days, equivalent to an average cost of US$1.60 per day per unskilled job (*49*).

Rapid-Response Stimulus Program for Creating Jobs and Improving Rural Roads

The 2008 world financial crisis had a major impact on the Republic of Armenia. The GDP fell by an estimated 14.4% in 2009. The construction subsector was particularly hard hit, with output declining by 42.3% and employment by some 40%. Exports declined by about 6% in 2008 and about 34% in 2009. Foreign Direct Investment dropped to 3% of GDP in 2009, down from 7.9% in 2008. Many migrant workers in Russia lost their jobs and returned home, further stressing local labor markets while depriving the rural poor of critical income in the form of remittances.

TABLE 4 Proportion of Labor, Materials, and Equipment in Rural Road Construction in India

Technology Option	Proportion of (percent)			
	Materials	Labor[a]	Equipment	Total
Labor intensive[b]	60	35 to 40	0 to 5	100
Intermediate (selective use of equipment)	60	25 to 30	10 to 15	100
Equipment intensive	60	5 to 10	30 to 35	100

[a] Skilled labor requirements (number and range) increase with increasing equipment intensity in construction.
[b] Applicable to tracks and uncompacted roads; materials include tools,such as picks, shovels, axes,etc.
SOURCE: NRRDA (*28*).

As a result, a significant portion of the labor force became unemployed. Poverty jumped by over five percentage points, increasing to 28%, and extreme poverty more than doubled, increasing to 6.9% of the population in 2009.

A rapid response was needed to help arrest the decline in output and the sharp rise in extreme poverty. The Government of Armenia acted swiftly to respond to this economic shock by launching a stimulus program involving "shovel ready" rural road investments which, in addition to addressing broader development challenges facing the country, would create jobs and mitigate the negative impact of the financial crisis. The rapid response stimulus package rehabilitated over 150 km of low-volume rural roads and generated about 15,000 person months of employment over an 8-month period from May to December 2009 (*50*).

The job creation impact of the program was in fact greater than suggested by the number of jobs created, since the project helped rehabilitate roads near factories and mines which had closed following the economic crisis, and provided a stimulus for their reopening. Moreover, this program helped local construction industries weather the crisis: nine of 23 contractors did not have any other contracts than those offered under the stimulus package and the rural roads contracts accounted for 22% to 27% of the gross revenue of all the contractors benefiting from the program. Accounting for primary and secondary impacts, the average cost of employment generation in Armenia was about US$2,000 per person month (equivalent to about 42,000 jobs per US$1 billion invested) (*51*).

Rural Roads and Peace Building

Besides crisis management, rural roads have a critical role in peace building and political integration of a country. The late Dr. John Garang, who led the struggle for the independence of South Sudan, now the newest 193rd member of the United Nations, envisioned development as a process of bringing the town to the country. The translation of this vision into reality has been impeded by the lack of rural road connectivity, critically needed to improve security and help bind South Sudan into a geographically integrated political entity. This, in turn, would help to ameliorate tribal and ethnic tensions that could rip this young nation apart. Rural roads help to diminish a sense of relative economic and social deprivation and provide the possibility to enhance democratic processes and bring people into the national mainstream. The link between roads and security is best summed up in the words of James Ladu, a development worker in Juba, South Sudan (*52*):

Where the legitimacy of the state is challenged through nondemocratic means, rural roads become a potent tool in counterinsurgency operations. The British built rural roads in Kenya to fight the Mau Mau insurgency (1952 to 1960) and earlier the communists in northern Malaya (1948 to 1960). More recently, nearly all peace-building operations in conflict-affected areas

> "Most of the insecurity happens because there are no roads and law enforcement officers cannot access the affected areas to impose law and order. For there to be investment, there must be security and for there to be security there must be roads. I think the government should focus on infrastructure, infrastructure, and infrastructure. Then the rest will all come."
>
> *—James Ladu*
> *A development worker in Juba*

(e.g., Afghanistan, Kosovo, Liberia, Nepal, Sierra Leone, South Sudan, and Timor Leste) have involved rural road programs. Afghanistan, in particular, has invested heavily in rural roads as a peace-building measure but many such roads also have a military purpose requiring higher technical standards than what is common for VLVRs. These roads have asphalt concrete pavements to allow passage of heavy trucks and armor and because mines and improvised explosive devices cannot easily be planted on such roads. The Soviet-era pavement standards for rural roads in Armenia and Georgia called for heavy-duty asphalt pavements for LVRs, presumably to make them capable of servicing military traffic (*50*).

Employment generation through rural road programs in conflict-affected areas helps to reduce poverty through large cash infusion into local communities while increasing the opportunity cost of resorting to violence. Road projects generally lead to higher employment of young males who in many cases have a higher propensity towards violence. In many settings, employment generation efforts are specifically aimed at engaging those groups that could potentially reignite violence. The idea is to increase the costs of returning to violence and to provide former fighters an incentive for maintaining peace. Targeting employment generation efforts towards these groups, however, carries some risks, giving preference to former fighters for jobs may be seen by the victims of conflict as unduly rewarding individuals for violence (*53*).

The LVR literature and engineering practice do not systematically address the role of rural roads in crisis management and disaster response. Interestingly it is the social scientists that have taken the lead in this area and are defining the code of practice. The focus tends to be on relief and recovery with urgent employment creation as a key objective. This may or may not result in rural road infrastructure that is economically and environmentally sustainable. There is an urgent need for the LVR community to provide the necessary technical and institutional underpinning (including guidelines, standards, and codes of practice) for rural road programs aimed at crises and disaster mitigation, to help ensure that public funds for such programs are spent wisely and yield sustainable outcomes.

SUSTAINABILITY AND LIVABILITY: CASE FOR CONTEXT-SENSITIVE RURAL ROADS

The idea of sustainability dates back to nearly 40 years and has its origin in the notion that it is possible to achieve economic growth and industrialization without damage to the environment. It was a major theme of the United Nations Conference on the Human Environment in Stockholm in 1972, and the United Nations Conference on Environment and Development in Rio de Janeiro in 1992. The United Nations 2005 World Summit (Outcome Document) reaffirmed the "interdependent and mutually reinforcing pillars" of sustainable development as economic development, social development, and environmental protection. Over the decades, thinking about sustainability has focused on the interaction among its three key dimensions: economic, environmental, and social The interlocking circles model of sustainability (Figure 11) points to the need to better integrate these three dimensions and to redress the balance between them in order to achieve desirable development outcomes.

From an operational standpoint, sustainable development has a wide range of interpretations. Adams (*54*) argues that sustainability as a concept is holistic, attractive, elastic but imprecise, and it is precisely this looseness that explains the widespread acceptance of the idea of sustainable development, as it can be used to cover very divergent views. The

sustainability model in Figure 11 assumes that trade-offs are always possible between the environmental, social, and economic dimensions. In practice, development decisions by governments, donors, and development agencies, while allowing for trade-offs, put greater emphasis on the economic dimension (and in that dimension, growth generally takes precedence over distribution). A distinction is often drawn between strong sustainability (where such trade-offs are not allowed or are restricted) and weak sustainability (where they are permissible).

There is, however, no agreed upon and universally accepted metric for defining the extent and level of sustainability achieved in development programs and projects. Sustainability and sustainable development tend to be ethical concepts to express the desirability of good environmental and social outcomes from economic decision-making. As Adams noted, "often sustainable development ends up being development as usual, with a brief embarrassed genuflection towards the desirability of sustainability. The important matter of principle therefore becomes a victim of the desire to set targets and measure progress" (*54*). Nowhere is this more apparent than in the rhetoric of green roads or in the standardized environmental and social safeguard policies of development institutions that aim to minimize environmental and social harm from development projects, when the objective of such policies should be affirmative action to enhance environmental and social values. As a working proposition, sustainability can be perceived as a condition in which economic, social and environmental factors are optimized, taking into account indirect and long-term impacts. Sustainable development is the process for making progress towards sustainability (*55, 56*).

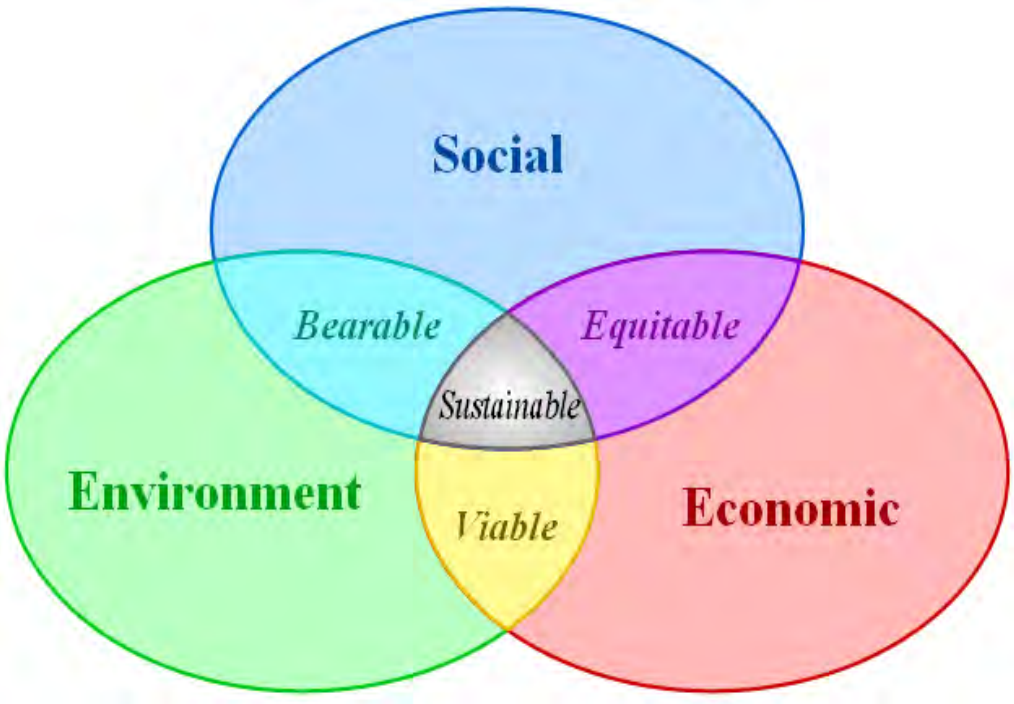

FIGURE 11 Interaction of the three fundamental dimensions of sustainability (*54*).

Rural Access and Sustainable Livelihoods

As discussed earlier, rural access is central to the alleviation of rural poverty, and has a close synergy with rural livelihood outcomes, such as increased incomes (e.g., tradable agricultural surplus, material goods, and cash), increased social well-being (e.g., non material goods, like self-esteem, health and nutrition status, access to education and other services, sense of inclusion), reduced vulnerability (e.g., better resilience through increase in asset status, access to emergency services), improved food security (e.g., from drought proofing, access to markets, and increased income to buy food) and a more sustainable use of natural resources (e.g., access to commercial energy, improved management of forests and wildlife resources) (*57*). By providing access to opportunity, rural roads contribute to making a livelihood sustainable, so that it is resilient in the face of external shocks and stresses, it is not dependent upon external support, it can maintain or enhance its capabilities and assets both now and in the future, it is able to maintain the long-term productivity of natural resources, and it does not undermine the livelihood opportunities of others (*55*, *58*, *59*).

The livelihoods approach is concerned first and foremost with people. So an accurate and realistic understanding of people's strengths (here called "assets" or "capital") is crucial to analyze how they endeavor to convert their assets into positive livelihood outcomes. People require a range of assets to achieve their self-defined goals, whereas no single capital endowment is sufficient to yield the desired outcomes on its own. This is particularly true for poor people whose access to any given category of assets tends to be very limited. As a result they have to seek ways of nurturing and combining what assets they do have in innovative ways to ensure survival (*55*).

The Asset (Capital) Polygon

There are six core asset categories or types of capital upon which rural livelihoods are built (Box 4); the "political" asset class (*60*) has been added to the five capitals originally defined by U.K. Department of International Development (*58, 61*) in the context of its sustainable livelihoods program, given the relevance of political capital to rural road programs. Although the term capital is used, not all the assets are capital stocks in the strict economic sense of the term (in which capital is the product of investment which yields a flow of benefits over time).

The six capitals shown in the Asset Polygon (Figure 12) are perhaps best thought of as livelihood building blocks; the term capital is used because this is the common designation in the literature (*55*). Some of these assets are not readily substitutable and their consumption might be irreversible (e.g., natural capital in the form of fragile ecosystems). Substitutability is also constrained by the multifunctionality of many natural resources. Forests, for example, not only provide the raw material for paper (which can be substituted easily), but they also maintain biodiversity, regulate water flow, and serve as a sink for carbon dioxide, the most abundant of the greenhouse gases (GHGs) (*57*). The depletion of natural and social capital is often irreversible (such as the loss in biodiversity or cultural diversity) and may have nonlinear consequences. Consumption of natural and social capital may have no observable impact until a critical threshold is reached and the loss is partially or wholly irreversible. There is, however, the potential for substitution between different capitals, for instance a replacement of a lack of financial capital through a better endowment with social capital (*59*).

BOX 4 Capital Assets for Rural Livelihoods (*59–61*)

1. Natural Capital: The natural resource stocks from which resource flows useful for livelihoods are derived (e.g., land, water, wildlife, biodiversity, environmental resources).
2. Social Capital: The social resources (networks, membership of groups, relationships of trust, access to wider institutions of society) upon which people draw in pursuit of livelihoods.
3. Human Capital: The skills, knowledge, ability to labor, and good health that is important to the ability to pursue different livelihood strategies.
4. Physical Capital: The basic infrastructure (transport, shelter, water, energy, and communications) and the production equipment and means that enable people to pursue their livelihoods.
5. Financial Capital: The financial resources that are available to people (whether savings, supplies or credit or regular remittances or pensions) and that provide them with different livelihood options.
6. Political Capital. This is the sum of political assets, strengths, and influence that may be combined with other forms of capital for purposive political action to improve livelihoods. It includes the interactions among the individual, the community, the civil society, and the state that may facilitate or hinder progress towards improvement in livelihoods. Political capital is linked to transparency, accountability, representation, and voice. Some analysts consider political capital as a subset of social capital.

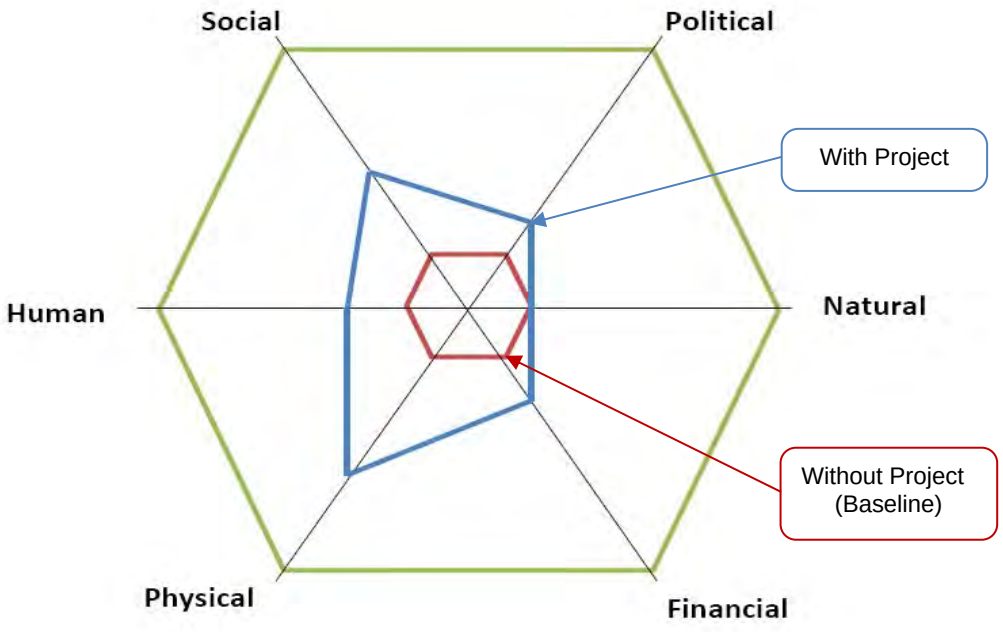

FIGURE 12 Asset polygon.
(SOURCE: Aysha Faiz)

Among the six categories of assets, financial capital is probably the most versatile as it can be converted into other types of capital or it can be used for achievement of livelihood outcomes (e.g., purchase of food to reduce food insecurity and construction of rural roads to improve access and mobility). However, it is an asset least available for the poor, and what makes other capitals important as substitutes (*59*).

Increasing access, which can take the form of ownership or the right to use, to these assets can effectively ameliorate poverty. Rural roads facilitate this access and also contribute to capital formation (primarily physical capital, but also human, social, and political capital). Conversely, rural roads can accelerate the depletion of natural capital (e.g., due to deforestation occasioned by easier access) and may also contribute to diminution of social (e.g., loss of cultural heritage and diversity or decline in social cohesion) and political capital (e.g., from corruption and misuse of public funds). The Asset Polygon depicted in Figure 12 can be used as a conceptual framework for assessing existing assets (different categories of capital) at the household, community, or project level and how an intervention such as a rural road can alter the asset balance (*55*).

Livability: A Framework for Balancing Economic, Environmental and Social Objectives

Despite its conceptual elegance, sustainability as a goal for achieving the right balance among economic, environmental, and social objectives remains somewhat elusive and subject to multiple interpretations. Livability refers to a subset of sustainability outcomes that directly affect people's lives (*56, 62*), such as access to jobs and economic opportunity; durable housing (resistant to natural disasters); provision of potable water, electricity, and ICT; quality schools; and reliable health services. In rural areas, roads can make many of these outcomes possible. At the community level, livability is concerned with environmental and social quality of an area as perceived by residents, employees, customers, and visitors. This includes safety and health (traffic safety, personal security, and public health), local environmental conditions (cleanliness, noise, dust, air quality, and water quality), the quality of social interactions (neighborliness, fairness, respect, community identity. and pride), opportunities for recreation and entertainment, aesthetics, and existence of unique cultural and environmental resources (e.g., historic structures, mature trees, and traditional architectural styles) (*63*). Through green, eco-friendly, and people-friendly rural roads, not only environmental concerns such as water quality, land conservation, and wildlife protection are addressed, but livability in rural neighborhoods is enhanced by traffic calming and

> By focusing on livability, we can help transform the way transportation serves the American people—and create safer, healthier communities that provide access to economic opportunities.
>
> *—Ray LaHood*
> *Secretary of Transportation*
> *U.S. Department of Transportation*

> Livability is defined as providing transportation choices that promote place-based transportation policies that are centered on people. A livable community is one in which people have multiple convenient transportation and housing options as well as destinations easily accessible to people travelling in and out of cars. Livability is about planning and designing transportation projects that preserve and enrich the unique character of rural, urban, and suburban communities.
>
> *—Victor Mendez*
> *Administrator*
> *Federal Highway Administration*

use of design standards to limit speeds, noise, and safety hazards (*55*, *64*).

Livability goals and objectives in transportation have drawn the interest and attention of transportation leaders across the United States, including the U.S. Secretary of Transportation and the FHWA Administrator (*62*, *65*).

Livability Principles

Livability is largely affected by physical location and condition of public facilities and also is influenced by public policy and planning decisions (*63*). Policy guidance on livability is encapsulated in a set of principles summarized in Box 5. Although these livability principles are applicable to U.S. conditions and focus more on urban needs, the values embodied in these principles are universal in their appeal and equally relevant to the developing world.

By incorporating livability principles into the planning and design of rural roads, communities can maximize the efficiency of rural infrastructure while providing better access and mobility. Livability approaches can also be a catalyst for revitalizing rural small towns. A transportation system that provides reliable, safe access to jobs, education, health care, and goods and services is every bit as important to rural communities as it is to urban areas. Rural communities present unique mobility challenges, and the types of transportation options (NMT–IMT) needed in rural areas, especially in developing countries should be different in order to ensure access for the poor, the elderly, and women and children to basic services and amenities. Linking rural road investments to productive sectors and provision of basic social services can

BOX 5 Livability Principles in the U.S. Context

- Provide more transportation choices. Develop safe, reliable, and economical transportation choices to decrease household transportation costs, reduce our nation's dependence on foreign oil, improve air quality, reduce GHG emissions, and promote public health.
- Promote equitable, affordable housing. Expand location-and energy-efficient housing choices for people of all ages, incomes, races, and ethnicities to increase mobility and lower the combined cost of housing and transportation.
- Enhance economic competitiveness. Improve economic competitiveness through reliable and timely access to employment centers, educational opportunities, services, and other basic needs by workers, as well as expanded business access to markets.
- Support existing communities. Target Federal funding toward existing communities—through strategies like transit oriented, mixed-use development, and land recycling—to increase community revitalization and the efficiency of public works investments and safeguard rural landscapes.
- Coordinate and leverage Federal policies and investment. Align Federal policies and funding to remove barriers to collaboration, leverage funding, and increase the accountability and effectiveness of all levels of government to plan for future growth, including making smart energy choices such as locally generated renewable energy.
- Value communities and neighborhoods. Enhance the unique characteristics of all communities by investing in healthy, safe, and walkable neighborhoods—rural, urban, or suburban.

SOURCE: FHWA, 2011. http://www.fhwa.dot.got.gov/livability/faq.

help reduce the pressure on natural and cultural resources, while better preparing communities to mitigate and adapt to the impacts of climate change. Ensuring that people in poor rural communities have a minimum level of mobility can have a profound impact on the quality of rural life (*57*). The key livability challenge in rural areas is the delicate balance between meeting mobility needs and preserving environmental and community values.

Context-Sensitive Solutions

Translating livability principles into practice is not an easy proposition and requires that human factors take precedence over motor vehicle factors in the provision of rural roads. The design vehicle speed must give way to the needs of NMT–IMT locomotion, and rural roads must hug and not blight natural landscapes. This requires a context-sensitive design (CSD) that is in sync with local community values and allows a better balance of economic, social, and environmental objectives in roadway design decisions. It allows narrower lanes, lower design speeds, sharper curvature, and special features (such as bus bays, foot and bike paths, and provisions to accommodate the needs of the elderly and the physically handicapped.). By minimizing cut and fill, and with appropriate provisioning for drainage and stable slopes, it can help to make transport infrastructure (particularly rural roads) more climate resilient. CSD aims to create a more balanced and efficient rural transport system that enhances accessibility, improves mobility, and is compatible with community values and needs (*67*).

The quality of a rural road is generally judged by the type and condition of the pavement surfacing. There is the perennial question of when to pave a gravel road but seldom is there a detailed inquiry into pavement surfacing alternatives. The answer is generally provided in terms of traffic (ADT) threshold above which paving is economically justified, and most LVR pavement manuals assume a minimum thickness of asphalt concrete or a bituminous surface treatment. An example of a context-sensitive assessment of pavement surfacing alternatives is given in Table 5. It is drawn from field research done under the African Community Access Program in Tanzania (*68*). The range of pavement surfacing is extended to some 14 alternatives and the advantage and disadvantage of each alternative is assessed under nine design and operational contexts. This is not an exhaustive list as other options like roller-compacted concrete, brick paving, and stabilization with a variety of binders could be added to the list. Nevertheless this is an uncommon approach to the selection of pavement surfacing; moreover, it allows the possibility of including environmental and social dimensions in the selection decision, such as job creation, use of local materials, labor-based construction and maintenance technologies, aesthetics, and provisioning for NMT–IMT. A more exhaustive catalog of roadway resurfacing alternatives (including some 50 resurfacing products illustrated in a photo album) is available from FHWA. This practical guide also provides a surfacing selection methodology to obtain context-sensitive paving solutions (*69*).

The selection of cost-effective and sustainable pavements for rural roads is also influenced by the reliability and quality of road maintenance and the associated funding arrangements. Because rural access roads are of low importance, their maintenance becomes the first casualty of constrained road budgets. In terms of life-cycle costs, it is often more economical to use stronger pavements initially, extending the pavement service life from the usual 10 to 15 years to 20 to 30 years or more. This option provides a safeguard against insufficient or poor maintenance while ensuring a more sustainable outcome for the road users.

TABLE 5 Alternative Context-Sensitive Pavement Surfacing for VLVRS in Tanzania (*68*)

Pavement Type	Local Materials	Flat Terrain	Steep Terrain	Populated Areas	Marshy Areas	Low Strength Sub-Grade	Small Contractor Suitability	Likely Cost Advantage	Maintenance Reduction
Gravel pavement	+	+	–	–	–	+	+	+	–
Unreinforced concrete	–	+	+	+	+	–	+	+	+
Reinforced concrete	–	+	+	+	+	+	+	+	+
Concrete geocells	–	+	+	+	+	+	+	+	+
Concrete strips	–	+	+	+	+	+	+	+	+
Concrete paving blocks	–	+	+	+	+	–	+	–	+
Hand-packed stone	+	+	+	–	+	+	+	+	–
Single Otta seal with a sand seal	–	+	–	+	+	–	+	–	+
Double Otta seal	–	+	+	+	+	–	+	–	+
Double Sand seal	–	+	–	+	–	–	+	–	+
Slurry seal	–	+	–	+	+	–	+	–	
Double surface dressing	–	+	+	+	+	–	+	–	+
Bitumen penetration macadam	–	+	+	+	+	–	+	–	+
Engineered natural surface	+	+	–	–	–	–	+	+	–

NOTES: Green (+) indicates a positive advantage; red (–) indicates a possible disadvantage.

Similar context-sensitive solutions (CSSs) could be developed and assessed for other dimensions of rural road design and operations. Keller and Sherar (*70*), Ketcheson and Keller (*71*), Clarkin et al. (*72*), and Stream Simulation Working Group (*73*) have prepared field guides that provide an extensive menu of context sensitive options to reduce storm damage risk and improve the environmental management of rural roads while making them more climate resilient. Douglas (*74*) presents the principles and techniques that underpin context-sensitive planning and design of forest and other natural resource access roads.

CSD, or more broadly termed as CSS, is the art of creating public works projects that meet the needs of the users, the neighboring communities, and the environment. It integrates projects into the context or setting in a sensitive manner through careful planning, consideration of different perspectives, and tailoring designs to particular project circumstances. FHWA and AASHTO define CSS as a collaborative, interdisciplinary approach that involves all stakeholders in providing a transportation facility that fits in its setting. It is an approach that leads to preserving and enhancing scenic, aesthetic, historic, community, and environmental resources while improving or maintaining safety, mobility, and infrastructure conditions. Furthermore, CSS requires an early and continuous commitment to public involvement, flexibility in exploring new solutions, and an openness to new ideas. Community members play an important role in identifying local and regional problems and solutions that may better meet and balance the needs of all stakeholders. Early public involvement can help reduce expensive and time-consuming rework later on and thus contributes to more efficient project development (*67, 75*).

TABLE 6 CSS for Transport: Goal, Core Strategies, and Operational Principles

Primary Goal		
Find a "best fit" transportation solution for the context that meets expectations of the transportation agency, stakeholders, and community.		
Core Strategies		
Establish a shared stakeholder vision to provide a basis for decisions.		
Demonstrate a comprehensive understanding of context.		
Foster continuing communication and collaboration to achieve mutual success.		
Exercise flexibility and creativity to shape transportation solutions		
Preserve and enhance community and natural environments.		
Operational Principles		
Use interdisciplinary teams.	Address alternatives and all modes.	Utilize full range of design choices.
Involve stakeholders.	Consider a safe facility for users and community.	Document project decisions.
Seek broad-based public involvement.	Maintain environmental harmony.	Track and meet all commitments.
Use full range of communication methods.	Address community and social issues.	Use agency resources effectively.
Achieve consensus on purpose and need.	Address aesthetic treatments and enhancements.	Create a lasting value for the community.
Information Sources		
University of Minnesota, Center for Transportation Studies. Context Sensitive Solutions. http://www.cts.umn.edu/contextsensitive/index.html		
Context-Sensitive Solutions, http://contextsensitivesolutions.org/content/gen/homepage/?		
Context Sensitive Solutions National Dialog, http://cssnationaldialog.org/schedule.asp		

SOURCE: *NCHRP Report 642*, 2009; VTPI, 2010.

CSD-CSS is guided by six key principles (*67*):

1. Balance safety, mobility, community, and environmental goals in all projects.
2. Involve the public and affected agencies early and continuously.
3. Use an interdisciplinary team tailored to project needs.
4. Address all modes of travel.
5. Apply flexibility in design standards.
6. Incorporate aesthetics as an integral part of good design.

A more detailed CSS taxonomy relative to goals, strategies, operational principles, and key sources of information is provided in Table 6 (*75*).

The preceding review of sustainability and livability suggests that a rural road must fulfill two conditions to be sustainable. First, it must contribute to and enhance rural livelihoods and livability and second, its planning and design (as well as construction and maintenance) must be context sensitive to ensure a balance among economic, social and environmental objectives, that is reflective of community values, aspirations, and needs.

THE WAY FORWARD

The world's population reached 6 billion in 2000 and is expected to increase to around 9 billion by 2050. Urban areas will account for a larger share of this growth, yet the rural population is estimated to grow by 1.2 to 1.5 billion people. A major part of the growth in the global rural population will be concentrated in Sub-Saharan Africa. If infrastructure and energy do not become a binding constraint, global passenger transport (measured in passenger kilometers) is estimated to increase three- or fourfold between 2000 and 2050, while freight transport (measured in ton-kilometers) is expected to grow by a factor of 2.5 to 3.5. Rising incomes will propel global mobility and motorization, especially in China and India. Growth will be much stronger in the developing world (outside the OECD region); even accounting for population growth, passenger mobility per capita in the developing countries is estimated by OECD to grow three- to fourfold between 2000 and 2050 (*76*).

Rural Road Prospects

It is expected that the next surge of rural road building, matching the United States and Chinese experiences a century apart, will occur in Sub-Saharan Africa well before 2050. South Sudan, Africa's newest country, will alone need some 20,000 to 30,000 km of new roads to bind this nation into a geographically connected and economically viable political entity. In other parts of the developing world, the focus will shift to improving road capacity and quality, with the proportion of paved roads increasing significantly from current levels. Rural connectivity goals in India and China aim to provide all-weather (mostly paved) road access to more than 100,000 habitations in India and some 75,000 administrative villages in China over the next 10 years. Based on the global trends in road expansion during the first decade of the new millennium, it is not improbable that, on average, between 1 and 2 million km of rural roads will be added every decade to the classified public road system between now and 2050.

The continued growth in rural roads is predicated by many factors, the foremost being the food requirements of a 9-billion global population by 2050. The required increase in food production will require massive improvements in the agricultural supply and marketing systems, with the rural road providing the first value-enhancing link, as agricultural produce moves up the value chain from the farm to the market and on to the consumer.

A vast majority of the world's chronically hungry live in rural areas, so enabling poor farmers to market their produce more efficiently is an effective means of reducing hunger and poverty. Rural roads help to lower input prices, increase agricultural production, and reduce the monopoly power of intermediaries (middlemen) in agrarian markets. Food security is enhanced with increased purchasing power from rising rural incomes and more diversified employment opportunities. Rural roads improve access to employment opportunities and can also help create jobs through labor-based construction and maintenance. Public spending on rural roads (especially in economically lagging areas) contributes significantly to lifting rural people out of poverty. Research shows that public expenditures to promote economic growth and reduce rural poverty have the highest marginal return for investments in agriculture research, rural roads, and education.

The eight MDGs ranging from halving extreme poverty to halting the spread of HIV–AIDS and providing universal primary education (all by the target date of 2015) depend on timely and affordable delivery of good quality public services, the facilitation of economic growth through national, regional, and international trade, the empowerment of vulnerable groups, and

establishment of links with the market economy and information society. An examination of each of the MDGs shows the catalytic role of transport in meeting the MDG targets, with five of the eight MDGs directly linked to the improved accessibility and mobility provided by rural roads.

The promise of rural roads extends beyond economic growth and poverty reduction. The natural and manmade disasters of the first decade of the 21st century (earthquakes, tsunamis, extreme droughts and floods, forced displacement of people due to war and civil strife, and the combined fuel–food–financial crisis of 2008) point to the critical role rural roads play in disaster management, emergency preparedness, and relief and early recovery operations. Rural road construction and maintenance has featured significantly in safety-net workfare (also referred to as cash-for-work and public works) programs, aimed at creating employment targeted to the poor. Job creation through rural road construction and maintenance is highly cost-effective in terms of the cost per job created as compared to other infrastructure interventions.

Agenda for Achieving the Full Promise of Rural Roads

For rural roads to achieve their full promise will require a change in how the LVR community responds to the emerging needs and opportunities.

1. There is a need to reexamine the concept of rural accessibility; it must embrace the vast network of enclave roads and rural trails, paths, and tracks as a viable and seamless extension of classified public rural roads, with NMT and IMT (including ICT options) fully integrated with motorized transport to improve rural mobility. This will require development of technical guidelines and standards and appropriate technology (including specifications) for engineered trails, bridges, and other structures suitable for NMT–IMT, including small all-terrain vehicles for ambulatory and other emergency services.
2. Rural road connectivity in many aspects is analogous to IT connectivity and should become the byword for rural accessibility planning. Rural roads are not a proxy for rural accessibility but have an essential role in facilitating and enabling development to happen. They are a means to an end and the end is connectivity to opportunity, information, and services. The purpose of rural roads is best fulfilled when connectivity to opportunity (economic and social) guides the planning, financing, and construction of this vital rural infrastructure instead of rules of thumb, indicators, and slogans vulnerable to political manipulation.
3. The critical role of rural roads in crisis management needs to be formally recognized, documented, and designated as a public service function with requisite budget appropriations. This would recognize rural roads as an asset for emergency preparedness and disaster management, similar to the designation of Interstate highways more than half a century ago as an asset for national defense. A core network of rural roads would require retrofitting to make it climate resilient in order to cope with storms of increasing intensity and flooding frequency associated with climate change. In addition, rural road design standards should require the preparation of run-off and drainage plans for the watersheds draining into the road alignment, with appropriate measures to control erosion and sedimentation.
4. There is an urgent need to further refine engineering and technical guidelines for the planning and execution of workfare (cash-for-work as well as food-for-work) programs involving road construction and maintenance, so that the infrastructure created under such programs is sustainable, context sensitive, and compliant with livability principles.

5. Sustainability in all its interacting dimensions should be the underlying premise for rural road programs. In this, the LVR community must become the champion of livability principles and seek and apply context sensitive solutions to all aspects of rural roads. Conventional roadway design standards define features such as minimum lane and roadway widths and a design speed that locks in place a road geometry that may be in conflict with environmental and social values and needs. The governing assumption is that bigger-and-faster-is-better, resulting in higher traffic speeds, increased costs and irreversible social and environmental damage. A research program to synthesize and document CSS for low volume roads would be a timely and useful endeavor.

The lyrics of an unforgettable Beatles song serve as a befitting reminder of the challenges and opportunities that lie ahead—the way forward is the long and winding LVR that leads to the door of sustainability.

The long and winding road
That leads to your door
Will never disappear
I've seen that road before
It always leads me here
Lead me to your door.

—"The Long and Winding Road"
Paul McCartney and John Lennon

AUTHOR'S ACKNOWLEDGMENTS

Thanks are due to the TRB Low-Volume Roads Committee for the invitation to prepare this circular, following my keynote presentation at the 10th International Conference on Low-Volume Roads in Orlando, Florida, July 2011. Special appreciation goes to Michael T. Long, G. P. Jayaprakash, Kumares Sinha, and Jolanda Prozzi for encouraging me to take on this assignment. I am most grateful to Winnie Wang, a Junior Professional Associate at the World Bank, who compiled and analyzed the statistical data related to motorization trends and the growth of road networks in United States and China, summarized in Figures 1–3.

This has been a labor of love and learning, with the able assistance of my daughters during their vacations. Maryam Faiz worked through reams of data and multiple statistical sources to compile the global road statistics reported in this paper. Aysha Faiz did background research for the paper and prepared all the tables and figures. She adapted the livelihoods asset polygon to show different forms of capital relevant to rural roads. To my wife, Surraya Faiz, very special thanks for her patience in putting up with my erratic working hours and sacrificing many weekend activities so that I could bring this work to a timely conclusion.

I remain indebted to my World Bank colleagues, Xiao Zhao, Elena Chesheva, Rodrigo Archondo, Anna Barbone, Manzoor-ur-Rehman, Eric Lancelot, Ashok Kumar, Fernanda Ruiz, Phuong Tran, and Chris Bennett, and to Jiangbo Ning at the Asian Development Bank and to Alex Visser at the University of Pretoria for promptly responding to my requests for information and reports.

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