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Infrastructure: achievements, challenges, and opportunities

Infrastructure services—including power, transport, telecommunications, provision of water and sanitation, and safe disposal of wastes—are central to the activities of households and to economic production. This reality becomes painfully evident when natural disasters or civil disturbances destroy or disable power stations, roads and bridges, telephone lines, canals, and water mains. Major infrastructure failures quickly and radically reduce communities' quality of life and productivity. Conversely, improving infrastructure services enhances welfare and fosters economic growth.

Providing infrastructure services to meet the demands of businesses, households, and other users is one of the major challenges of economic development. The availability of infrastructure has increased significantly in developing countries over the past several decades. In many cases, however, the full benefits of past investments are not being realized, resulting in a serious waste of resources and lost economic opportunities. This outcome is frequently caused by inadequate incentives embodied in the institutional arrangements for providing infrastructure services. While the special technical and economic characteristics of infrastructure give government an essential role in its provision, dominant and pervasive intervention by governments has in many cases failed to promote efficient or responsive delivery of services. Recent changes in thinking and technology have revealed increased scope for commercial principles in infrastructure provision. These offer new ways to harness market forces even where typical competition would fail, and they bring the infrastructure user's perspective to the forefront.

This Report focuses on economic infrastructure: the long-lived engineered structures, equipment,

and facilities, and the services they provide that are used in economic production and by households. This infrastructure includes public utilities (power, piped gas, telecommunications, water supply, sanitation and sewerage, solid waste collection and disposal), public works (major dam and canal works for irrigation, and roads), and other transport sectors (railways, urban transport, ports and waterways, and airports). Social infrastructure, often encompassing education and health care, represents an equally important although very different set of issues that are not analyzed in this Report (see *World Development Report 1993: Investing in Health*).

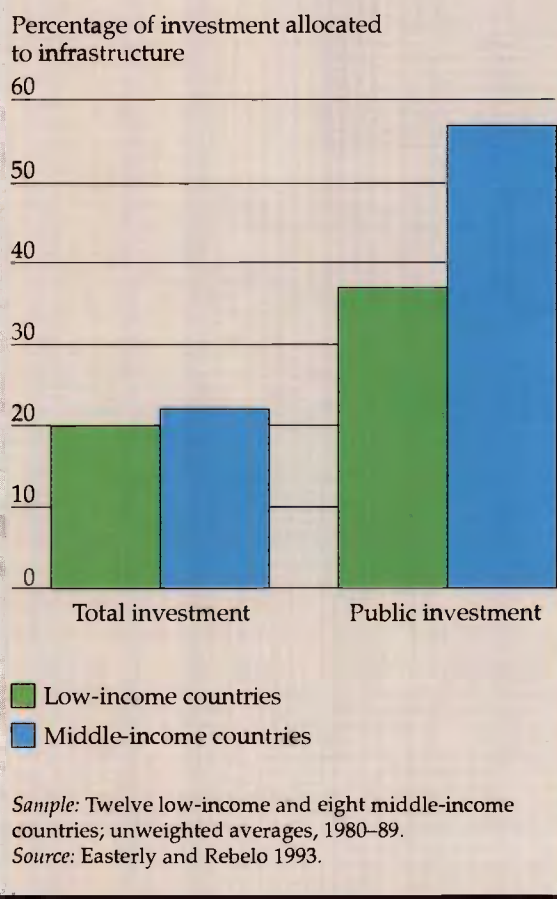
As defined here, infrastructure covers a complex of distinct sectors that, by any measure, represent a large share of an economy. Taken together, the services associated with the use of infrastructure (measured in terms of value added) account for roughly 7 to 11 percent of GDP (Table 1.1), with transport being the largest sector. Transport alone commonly absorbs 5 to 8 percent of total paid employment. A sample of developing countries shows that infra-

Table 1.1 Value added of infrastructure services by country group
(percentage of GDP)

Sector	Low-income countries	Middle-income countries	High-income countries
Transport, storage, and communications	5.34 (9)	6.78 (26)	9.46 (3)
Gas, electricity, and water	1.29 (22)	2.24 (36)	1.87 (5)

Note: At market prices. At factor cost (for which fewer observations are available), the values are slightly higher. Figures in parentheses are number of observations. Data are for 1990 or latest available year.
Source: World Bank national accounts data.

Figure 1.1 Public infrastructure investment is a large fraction of both total and public investment in developing countries.



structure typically represents about 20 percent of total investment and 40 to 60 percent of public investment (Figure 1.1). In round figures, public infrastructure investment ranges from 2 to 8 percent (and averages 4 percent) of GDP. Even these shares understate the social and economic importance of infrastructure, which has strong links to growth, poverty reduction, and environmental sustainability.

Infrastructure's impact on development

Links to economic growth

Infrastructure represents, if not the engine, then the "wheels" of economic activity. Input-output tables show that in the economies of Japan and the United States, for example, telecommunications, electricity, and water are used in the production process of

nearly every sector, and transport is an input for every commodity. Users demand infrastructure services not only for direct consumption but also for raising their productivity by, for instance, reducing the time and effort needed to secure safe water, to bring crops to market, or to commute to work.

Much research in recent years has been devoted to estimating the productivity of infrastructure investments (Box 1.1). Many studies attempting to link aggregate infrastructure spending to growth of GDP show very high returns in a time-series analysis. Some cross-national studies of economic growth and infrastructure—notably, one using public investments in transport and communications and another using capital stocks in roads, railways, and telephones—also show that infrastructure variables are positively and significantly correlated with growth in developing countries. In both types of studies, however, whether infrastructure investment causes growth or growth causes infrastructure investment is not fully established. Moreover, there may be other factors driving the growth of both GDP and infrastructure that are not fully accounted for. Neither the time-series nor the cross-sectional studies satisfactorily explain the mechanisms through which infrastructure may affect growth.

Sectoral studies focusing on rural infrastructure's effect on the local economy in certain developing countries have revealed more about the nature of the apparent benefits. Studying data over time from eighty-five districts in thirteen Indian states, researchers found that lower transport costs increased farmers' access to markets and led to considerable agricultural expansion and that modern irrigation methods brought higher yields. At the same time, because improved communications (through roads) lowered banks' costs of doing business, banks expanded lending to farmers, and farmers used the funds to buy fertilizer, further increasing yields. According to a household- and village-level survey conducted in Bangladesh, villages classified as "most developed" in terms of access to transport infrastructure were significantly better off than the "less developed" villages—in terms of agricultural production, incomes and labor demand, and health. (It is difficult, however, to verify whether the Bangladesh study took into account all possible intervening factors, such as unobserved differences among the communities in natural endowments.)

What is evident is that a strong association exists between the availability of certain infrastructure—telecommunications (in particular), power, paved roads, and access to safe water—and per capita GDP (Figure 1.2). An analysis of the value of infra-

Box 1.1 Returns on infrastructure investment—too good to be true?

Recent studies in the United States suggest that the impact of infrastructure investments on economic growth represents startlingly high rates of return (up to 60 percent). Too good to be true? Possibly. The results presented in Box table 1.1 may overestimate the productivity of infrastructure for two reasons. First, there may be a common factor that causes growth in both output and infrastructure that is not included in the study. Second, it may be that growth leads to infrastructure investment, and not that investment produces growth. A number of studies have found that causation runs in both directions. Yet more sophisticated estimates that address these issues either have concluded that the positive results were not much affected by different econometric methods or have found no noticeable impact of infrastructure on growth. Neither finding—of an extremely high impact or of a negligible impact—is entirely credible, and research efforts continue in an attempt to refine the methodology.

An alternative approach estimates the impact of in-

frastructure on production costs. Studies (summarized in Aschauer 1993) found that infrastructure significantly reduces production costs in manufacturing in Germany, Japan, Mexico, Sweden, the United Kingdom, and the United States. One estimate suggests that three-quarters of U.S. federal investment in highways in the 1950s and 1960s can be justified on the basis of reductions in trucking costs alone.

While there is still no consensus on the magnitude or on the exact nature of the impact of infrastructure on growth, many studies on the topic have concluded that the role of infrastructure in growth is substantial, significant, and frequently greater than that of investment in other forms of capital. Although the indications to date are suggestive, there is still a need to explain why the findings vary so much from study to study. Until this problem is resolved, results are neither specific nor solid enough to serve as the basis for designing policies for infrastructure investment.

Box table 1.1 Results from studies of infrastructure productivity

<i>Sample</i>	<i>Elasticity^a</i>	<i>Implied rate of return^b</i>	<i>Author/year</i>	<i>Infrastructure measure</i>
United States	0.39	60	Aschauer 1989	Nonmilitary public capital
United States	0.34	60	Munnell 1990	Nonmilitary public capital
48 states, United States	0	0	Holtz-Eakin 1992	Public capital
5 metro areas, United States	0.08	—	Duffy-Deno and Eberts 1991	Public capital
Regions, Japan	0.20	96	Mera 1973	Industrial infrastructure
Regions, France	0.08	12	Prud'homme 1993	Public capital
Taiwan, China	0.24	77	Uchimura and Gao 1993	Transportation, water, and communication
Korea	0.19	51	Uchimura and Gao 1993	Transportation, water, and communication
Israel	0.31–0.44	54–70	Bregman and Marom 1993	Transportation, power, water, and sanitation
Mexico	0.05	5–7	Shah 1988, 1992	Power, communication, and transportation
Multicountry, OECD	0.07	19	Canning and Fay 1993	Transportation
Multicountry, developing	0.07	95	Canning and Fay 1993	Transportation
Multicountry, OECD and developing	0.01–0.16	—	Baffes and Shah 1993	Infrastructure capital stocks
Multicountry, developing	0.16	63	Easterly and Rebelo 1993	Transportation and communication

a. Percentage changes in output with respect to a 1 percent change in the level of infrastructure.

b. Ratio of discounted value of increase in dependent variable to discounted value of investment in infrastructure.

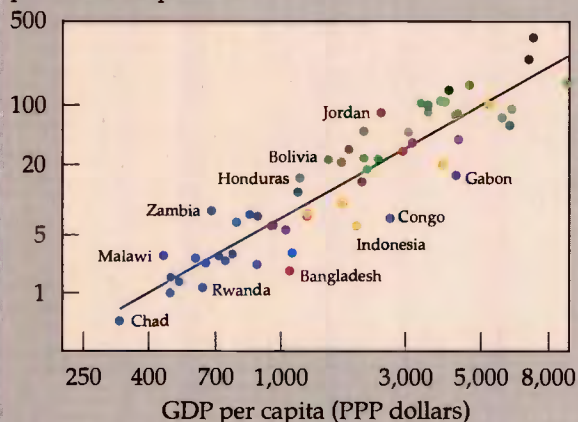
structure stocks indicates that their composition changes significantly as incomes rise. For low-income countries, more basic infrastructure is important—such as water, irrigation, and (to a lesser extent) transport. As economies mature into the middle-income stage, most of the basic consumption demands for water are met, the share of agriculture in the economy shrinks, and more transport infrastructure is provided. The share of power and telecommunications in investment and infrastruc-

ture stocks becomes even greater in high-income countries. Data for 1990 indicate that, while total infrastructure stocks increase by 1 percent with each 1 percent increment in per capita GDP, household access to safe water increases by 0.3 percent, paved roads increase by 0.8 percent, power by 1.5 percent, and telecommunications by 1.7 percent.

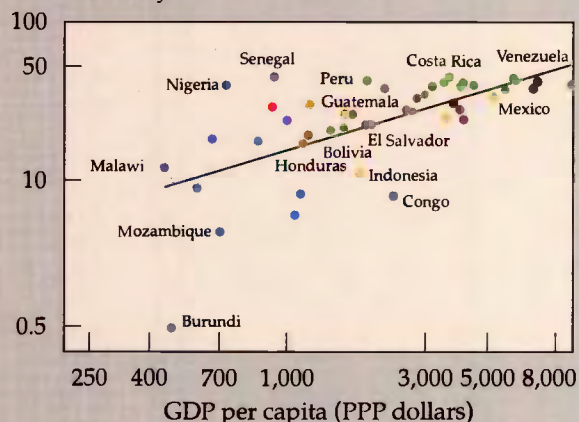
These relationships suggest that infrastructure has a high potential payoff in terms of economic growth, yet they do not provide a basis for prescrib-

Figure 1.2 Per capita availability of major infrastructure is closely related to income levels.

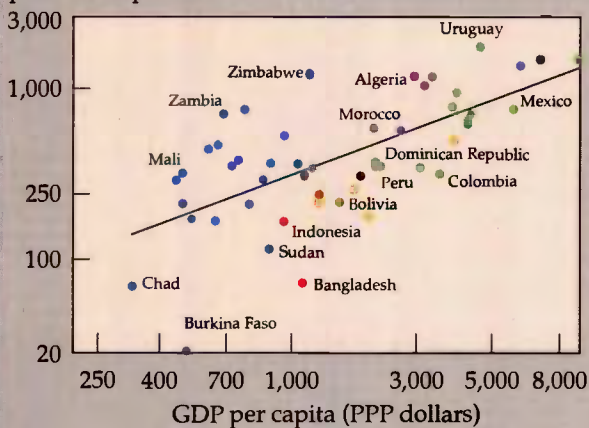
Telephone main lines per thousand persons



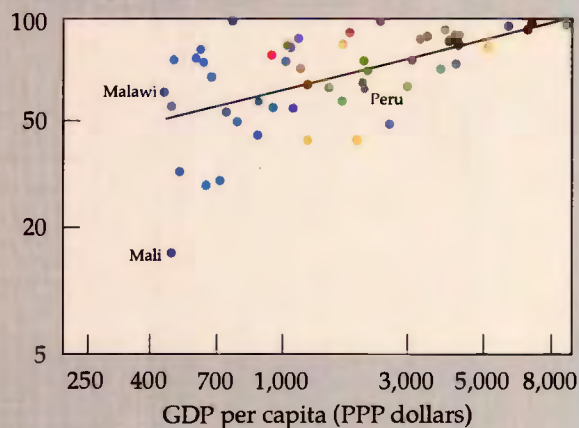
Percentage of households with electricity



Kilometers of paved roads per million persons



Percentage of population with access to safe water



- Middle East and North Africa
- Latin America and the Caribbean
- East Asia and Pacific

- Sub-Saharan Africa
- South Asia
- Europe and Central Asia

Note: Axes are logarithmic; infrastructure quantities and GDP are for 1990; purchasing power parity (PPP) dollars are valued in Summers and Heston 1985 international prices.

Source: WDI table 32; Summers and Heston 1991.

ing appropriate levels, or sectoral allocations, for infrastructure investment. Other evidence confirms that investment in infrastructure alone does not guarantee growth. Many studies reveal much smaller returns for infrastructure than those suggested in Box 1.1—closer, in fact, to the return on private investments. These disparities may be due to

differences in the efficiency of investment across countries and over time. For example, a study of the economic returns to individual World Bank projects shows that, when overall economic policy conditions are poor, the returns to infrastructure investment decline. Returns are lower by 50 percent or more in countries with restrictive trade policies than

in countries where conditions are more favorable. Infrastructure spending cannot, therefore, overcome a weak climate for economic activity. Nearly twenty-five years ago, the Brookings Transport Research Project evaluated the impact of transport projects in several developing countries and concluded similarly that, although the investments generally had reasonable rates of return, success depended largely on economic policy.

Another approach to assessing the economic returns from infrastructure investment is to examine the rates of return in a large sample of completed World Bank projects. The average economic return on infrastructure projects, reestimated after loan disbursement (completion of project construction), has been 16 percent over the past decade—just above the World Bank project average of 15 percent (Table 1.2). Returns have been lowest (and declining) for irrigation and drainage, airports (for a very small sample), railways, power, water supply, and sewerage. Why should this be so, given the expected benefits of such investments in developing countries?

Some of the causes relate to implementation problems (discussed below under “The record of performance”) and others to project identification and design. A common pattern discovered in project completion reviews of water, railway, and power projects is the tendency at the time of appraisal to overestimate the rate of growth in demand for new production capacity and, therefore, of revenues. For the power projects in the sample, demand was overestimated by 20 percent on average over a ten-year operating period. In water projects, overestimation of rates of new connections and per capita consumption also averaged about 20 percent. In the case of railways, until recent years projects often assumed recovery in demand even where railways were continually losing traffic to roads offering better service. In twenty-nine of thirty-one cases, freight traffic failed to reach its projected level, and in one-third, traffic actually declined.

One important explanation for the misjudgments during appraisal is inadequate procedures for assessing demand (including the effects of tariff increases). Oversizing and inappropriate design of investments then occur, resulting in financial burdens on the project entities concerned. Although Bank projects may not be entirely representative, they are subject to more careful evaluation than many infrastructure investments in developing countries and so may have achieved better performance than average public investments in these sectors.

Infrastructure is a necessary, although not sufficient, precondition for growth—adequate comple-

Table 1.2 Average economic rates of return on World Bank-supported projects, 1974–92 (percent)

<i>Sector</i>	1974–82	1983–92
Irrigation and drainage	17	13
Telecommunications	20	19
Transport	18	21
Airports	17	13
Highways	20	29
Ports	19	20
Railways	16	12
Power	12	11
Urban development	..	23
Water and sanitation ^a	7	9
Water supply ^a	8	6
Sewerage ^a	12	8
Infrastructure projects	18	16
All Bank operations	17	15

.. Not available.

a. Rates are financial, not economic, rates of return.

Source: World Bank data.

ments of other resources must be present as well. The growth impact of infrastructure investments also depends on the timing and location of additions to capacity, and on the existing imbalance between supply and demand. Because much infrastructure consists of networks, relieving bottlenecks at certain points of the system can produce very high returns. Box 1.2 illustrates the repercussions in China’s economy from critical constraints in the transport of coal needed for power generation.

Adequate quantity and reliability of infrastructure are key factors in the ability of countries to compete in international trade, even in traditional commodities. In part because of infrastructure problems, shipping costs from Africa to Europe are 30 percent higher for plywood (and 70 percent higher for tuna) than those from Asia to Europe. These costs have to be borne by exporters.

The competition for new export markets is especially dependent on high-quality infrastructure. During the past two decades, increased globalization of world trade has arisen not only from the liberalization of trade policies in many countries but also from major advances in communications, transport, and storage technologies. These advances center on the management of logistics (the combination of purchasing, production, and marketing functions) to achieve cost savings in inventory and working capital and to respond more rapidly to customer demand. About two-thirds of production and sales in the OECD countries are processed directly

Box 1.2 The importance of infrastructure to economic development: an example from China

The fact that infrastructure provides critical support to the growth of an economy can be clearly seen when bottlenecks arise. One of the most striking examples is that of China's intercity transport system, with its links to the supply of raw materials, coal, and electricity.

The coverage of China's intercity transport networks is one of the thinnest in the world: the total route length per capita or per unit of arable land—for highways or railways—is similar to, or lower than, that in Brazil, India, and Russia. This has resulted mainly from chronic underinvestment in China's transport infrastructure. China's transport investments amounted to only 1.3 percent of GNP annually during 1981–90, a period of rapid growth in transport demand.

Since the onset of China's open door policy in 1979, economic growth averaging 9 percent a year has resulted in an unprecedented expansion in intercity traffic—with growth averaging 8 percent a year for freight and 12 percent a year for passengers. This traffic growth has imposed tremendous strains on the transport infrastruc-

ture, as manifested by the growth of bottlenecks in the railway network, the severe rationing of transport capacity on railway lines, and the poor quality of service experienced by shippers and passengers.

Transport shortages have adversely affected the supply of coal in particular. Coal is the source of some 73 percent of China's commercial energy and represents about 43 percent of the total tonnage of freight handled by the railways. The shortage of coal has in turn adversely affected supplies of electricity, about 76 percent of which is generated by thermal plants. In 1989, China was experiencing a shortfall in available power of about 20 percent of industrial electricity requirements. Central and local authorities established quotas for allocating electricity and rationed new connections, but power cuts have nevertheless been frequent.

A conservative estimate is that the annual economic costs of not having adequate transport infrastructure in China during the past several years amount to about 1 percent of China's GNP.

to order, and "just-in-time" delivery of products has become the norm in many sectors. Because about 60 percent of their exports are directed to OECD markets, developing countries must meet these standards. Virtually all the improved practices designed to reduce logistics costs, including those in transport, have been based on information technologies using telecommunications infrastructure. Cost reductions and the increased speed of freight movements over the past few decades have also been increasingly based on multimodal transport involving containerization, which requires intensive coordination by shippers across rail, port, air, and road freight modes.

For developing countries wishing to compete in global markets, or to participate in "global sourcing" (the linking of businesses in several countries producing different components for a final product), not just any kind of transport and telecommunications infrastructure will do. Manufacturing assembly operations in Mexico and horticultural exports from Kenya are examples of the diversification of trade permitted by appropriate logistical support and multimodal facilities. During the 1980s, the proportion of garments, shoes, and handicraft exports shipped by air from northern India quintupled because land and ocean transport systems were no longer able to meet demanding delivery requirements. Because India's ports have been slow to

adapt to containerization and are subject to regulatory delays, freight transport to the United States is one-third more expensive from Indian ports than from Bangkok or Singapore.

The availability of infrastructure services valued by users is also critical for the modernization and diversification of production. The growth of electronic data exchange involving telecommunications—informatics—is central to efficient operations in manufacturing, services, the financial sector, and government. Availability of power allows substantial improvements in workers' productivity (for example, in the transition from foot-powered to electrically powered sewing), while international telecommunications, facsimile services, and rapid transport of goods permit the artisan to produce to order for a computerized global market. A higher quality of water and sanitation is required to shift from production of raw agricultural commodities to processed foods. Surveys of prospective foreign investors over a wide range of countries show that the quality of infrastructure is an important factor in ranking potential sites for location of direct investment.

The nature of an economy's infrastructure is central to its ability to respond to changes in demand and prices or to take advantage of other resources. The formerly socialist countries (particularly those in Central and Eastern Europe and the former So-

viet Union) provide a clear illustration of how the patterns of supply and demand imposed by central planning affect infrastructure development. These countries showed an extremely high transport and energy intensity (owing to noneconomic decisions on location of production units, underpricing and inefficient use of energy, and an emphasis on heavy industry and raw materials production). They also showed a greater reliance on rail than on road transport than did countries with similar conditions, and on long- over short-haul public transport facilities. With market reforms, the location and composition of demand will alter, giving a greater role in these economies to light industry, to services such as domestic distribution, and to the diversification of external trade. Small enterprises and consumers will become a more important source of demand. These trends require corresponding modifications in infrastructure, with greater attention to the quality and variety of services.

Public spending on infrastructure construction and maintenance can be a valuable policy tool to provide economic stimulus during recessions. As long as quality and cost-effectiveness are not compromised, labor-based approaches to infrastructure development can also be an important instrument for employment-intensive economic growth. In deciding on public spending for infrastructure, policymakers have frequently not looked sufficiently beyond the near-term impacts, and many governments have been attracted to the political benefits of the highly visible structures created. When public spending on infrastructure is not wisely deployed, it can crowd out more productive investment in other sectors. At the same time, short-term fiscal constraints have often led to disproportionate cutbacks in infrastructure, thereby sacrificing an important impetus to renewed growth following adjustment (Box 1.3).

Sometimes the least-cost approach to improving the supply of infrastructure services would require interregional (cross-country) integration of infrastructure networks, for example, power grids. Such an agreement would call for not only coordination of investments but, equally important, cooperation to maintain efficient policies governing the trade in services. Most countries, however, resist depending on others for a supply of services deemed to be of strategic importance; therefore, importing power to meet the base load demand is less acceptable than acquiring only peak load from abroad. International agreements have been more common for cross-border transport, which is a particularly important issue for landlocked countries. Often, the quality of

Box 1.3 Throwing infrastructure overboard

When times are hard, capital spending on infrastructure is the first item to go, and operations and maintenance are often close behind. Despite the long-term economic costs of slashing infrastructure spending, governments find it less politically costly than reducing public employment or wages. Studies of fiscal adjustment and expenditure reduction find that capital expenditures are cut more than current expenditures, with infrastructure capital spending often taking the biggest reduction. Moreover, within current expenditures, nonwage expenditures (which include operations and maintenance) are cut by more than the wage bill.

The decline in investment, at least in the initial phases, is not altogether undesirable as it often induces a rationalization and strengthening of countries' project portfolios. Cutbacks in operations and maintenance expenditure, however, are worrisome. A World Bank review of countries' adjustment experience found that reductions in nonwage operations and maintenance and a marked deterioration in infrastructure services were common. For instance, in Costa Rica during the 1980s current nonwage expenditures (principally operations and maintenance) fell from 1.6 percent of GDP to a mere 0.3 percent, and the share of the national and cantonal road network in poor to very poor condition rose to 70 percent.

transport infrastructure on an international corridor is less of a problem than are institutional constraints. For example, one-third of the time required to ship freight between landlocked Mali and neighboring ports in Lomé (Togo) and Abidjan (Côte d'Ivoire) is due to delays in customs clearance. Removing inefficient regulation of road transport and privatizing transport operations, and deregulating power generation and distribution (as discussed in later chapters), may facilitate some international exchange of services in these sectors.

To summarize, infrastructure investment is not sufficient on its own to generate sustained increases in economic growth. The demand for infrastructure services is itself sensitive to economic growth, which is notoriously difficult to predict. The economic impact of infrastructure investment varies not only by sector but also by its design, location, and timeliness. The effectiveness of infrastructure investment—whether it provides the kind of services valued by users (responding to “effective demand”)—depends on characteristics such as quality

and reliability, as well as on quantity. Matching supply to what is demanded is essential. Finally, the efficiency with which infrastructure services are provided is also a key to realizing potential returns.

Links to poverty

Infrastructure is important for ensuring that growth is consistent with poverty reduction, a topic covered extensively in *World Development Report 1990: Poverty*. Access to at least minimal infrastructure services is one of the essential criteria for defining welfare. To a great extent, the poor can be identified as those who are unable to consume a basic quantity of clean water and who are subject to unsanitary surroundings, with extremely limited mobility or communications beyond their immediate settlement. As a result they have more health problems and fewer employment opportunities. The burgeoning squatter communities surrounding most cities in developing countries typically lack formal infrastructure facilities, a condition arising from their nonpermanence of tenure. In India the proportion of the urban population living in slum areas grew during 1981–91, while the share of the population living in poverty (estimated using traditional poverty measures based on income and food consumption) declined. The lack of access to infrastructure is a real welfare issue.

Different infrastructure sectors have different effects on improving the quality of life and reducing poverty. Access to clean water and sanitation has the most obvious and direct consumption benefits in reducing mortality and morbidity. It also increases the productive capacity of the poor and can affect men and women differently. For example, the poor—women in particular—must commit large shares of their income or time to obtaining water and fuelwood, as well as to carrying crops to market. This time could otherwise be devoted to high-priority domestic duties, such as childcare, or to income-earning activities. Such gender-specific effects need to be considered in the evaluation of proposed projects.

Access to transport and irrigation can contribute to higher and more stable incomes, enabling the poor to manage risks. Both transport and irrigation infrastructure have been found to expand the opportunities for nonfarm employment in rural areas, often in indirect ways (Box 1.4). A seeming development dilemma is that while rural poverty reduction requires higher incomes, raising farmgate food prices could make urban poverty worse. By raising the productivity of farms and of rural transport,

both an increase in the incomes of rural workers and a reduction in food prices for the urban poor can be achieved. The green revolution (with irrigation playing a central role) demonstrated that the wages of, and demand for, low-skilled agricultural laborers rise in step with more intensive cultivation and increased yields. Over twenty years, one closely observed Indian village saw yields increase almost threefold and agricultural laborers' wages rise from 2.25 to 5 kilograms of wheat a day. Improved rural transport can also ease the introduction of improved farming practices by lowering the costs of modern inputs such as fertilizer. An adequate transport network reduces regional variations in food prices and the risk of famine by facilitating the movement of food from surplus to deficit areas.

The benefits of transport and communications include the access they provide to other goods and services, especially in cities. Where the poor are concentrated on the periphery of urban areas, as in many developing countries, the costs and availability of public transport become key factors in their ability to obtain employment. Access to secure and reliable public transport has been identified in household surveys in Ecuador as influential in determining the ability of low-income girls and women to participate in evening training classes.

The construction and maintenance of some infrastructure—especially roads and waterworks—can contribute to poverty reduction by providing direct employment. Civil works programs (as carried out in Botswana, Cape Verde, and India), which often involve the provision of infrastructure, have also been important in strengthening famine prevention and providing income.

Links to the environment

Infrastructure provision results from the efforts of individuals and communities to modify their physical surroundings or habitat in order to improve their comfort, productivity, and protection from the elements and to conquer distance. Each sector—water, power, transport, sanitation, irrigation—raises issues concerning the interaction between man-made structures (and the activities they generate) and the natural environment. Environment-friendly infrastructure services are essential for improving living standards and offering public health protection. With sufficient care, providing the infrastructure necessary for growth and poverty reduction can be consistent with concern for natural resources and the global environment (the "green" agenda). At the same time, well-designed and -managed infrastruc-

Box 1.4 Infrastructure's direct and indirect effects in rural India

A study of two villages in rural Karnataka state, southern India, offers a glimpse of the full impact that infrastructure can have on rural living standards. The researcher, who studied the Wangala and Dalena villages in the 1950s and 1970s, described how the two villages had been similarly poor and backward until a large-scale irrigation project brought Wangala into a canal network while Dalena's high elevation left it unirrigated.

Although canal irrigation directly promoted rapid intensification of cultivation in Wangala, institutions and the villagers' way of life were relatively unaffected otherwise. In contrast, Dalena did not benefit directly from the canal. Its villagers were compelled to adjust their way of life significantly in order to capture the indirect economic benefits from the irrigation project. The villagers purchased land outside Dalena, sought positions in the Public Works Department and a nearby sugar mill, and became involved in the transport of irrigated vil-

lages' sugarcane to the mill. Dalena quickly established itself as a service center in the region, and its residents integrated themselves into a much wider economic sphere than did those in Wangala.

The research emphasized how many Dalena villagers traveled daily between their homes in the village and their places of work in nearby towns. This observation, echoed in other studies, suggests that the development process need not entail migration from rural areas to urban centers. In the Uttar Pradesh village of Palanpur, per capita living standards rose between 1957 and 1993 in the face of population growth, in part because of expanding nonfarm employment. Residents of Palanpur commute daily to the towns of Chandausi and Moradabad, largely by rail. This type of rural commuting more commonly occurs along roads by foot, bicycle, motorcycle, bus, or car.

ture can promote the environmental sustainability of human settlements (the "brown" agenda). *World Development Report 1992* focuses on environmental issues, including those of infrastructure sectors, in detail.

The relationship between each infrastructure sector and the environment is complex. The most positive impacts of infrastructure on the environment concern the removal and disposal of liquid and solid wastes. But much depends on how disposal facilities are planned and executed. Underinvestment in municipal sewerage relative to water supply in densely populated cities such as Jakarta has been found to lead to harmful contamination of water reserves, to exacerbate flooding, and to reduce the health benefits from water investments. Provision of sewerage without wastewater treatment can lead to severe downstream pollution and public health problems where receiving waters are used for drinking-water supply or for recreation, irrigation, and fisheries—as illustrated by the cholera outbreaks in Peru and neighboring countries in recent years. Poor management of solid waste complicates urban street drainage and has been linked with the proliferation of disease-bearing mosquitos in standing water. The growing problem of hazardous and toxic wastes as countries industrialize poses particular concerns about safe disposal. For example, uncontrolled dumping has led to soil contamination in the Upper Silesian industrial region of Poland and to subsequent food crop contamination.

Power plant and vehicle emissions are important contributors to air pollution, so their air quality impacts deserve careful analysis when facilities are expanded. In developing countries, almost one-third of commercial energy is devoted to electricity generation, which is the fastest-growing component of the energy sector. By the year 2000 Asia may well surpass all of Europe in sulfur dioxide emissions, and by 2005 it may surpass Europe and the United States combined in power plant emissions. Vehicles are a significant source of airborne toxic pollutants, accounting for up to 95 percent of lead contamination. In Central and Eastern Europe, road transport is estimated to account for 30 to 40 percent of total emitted nitrogen oxides and hydrocarbons. Although OECD countries account for three-quarters of the world stock of motor vehicles, a rapid increase in vehicle use is expected in parts of Central and Eastern Europe, East Asia, and South America. In large and growing developing country cities, such as Bangkok and Jakarta, vehicle congestion already gives rise to considerable environmental and economic costs. For Bangkok, it is estimated that if reduced traffic congestion permitted a 5 percent increase in peak-hour vehicle speeds, the value of travel time saved would amount to more than \$400 million a year. A 20 percent improvement in air quality in Bangkok, as a result of a reduction in pollutants related to vehicle or power plant emissions, would produce annual health benefits valued at between \$100 and \$400 per capita for Bangkok's 6 million residents.

Expansion of transport infrastructure can reduce total pollution loads as congestion falls, average vehicle speeds rise, and routes are shortened. But road improvements can also encourage vehicle use and increase emissions. Therefore, additions to infrastructure capacity are only part of the solution. Improved management of traffic and land use and promotion of nonmotorized modes, cleaner fuels, and public transport are also needed (see Chapter 4). Integrated urban planning and transport policy can lead to more efficient use of both land and transport capacity, with favorable environmental results. In the city of Curitiba, Brazil, an emphasis on encouraging enterprises and residential developments to locate around carefully designed public transport routes has contributed to low gasoline consumption, low transport costs relative to household incomes, and very low rates of traffic accidents—despite one of the highest rates of private vehicle ownership in the country.

Beyond urban areas, overuse of water for irrigation (which accounts for about 90 percent of water withdrawals in most low-income countries) damages soils and severely restricts water availability for industry and households, which often have a higher willingness to pay for the quantities of water they use. The inefficient burning of biomass fuel (plant and animal waste) for household energy contributes to deforestation and thus to erosion and loss of soil nutrients, as well as to indoor air pollution. Some infrastructure investments, especially road construction, can put unspoiled natural resources at risk and threaten indigenous communities. Reservoirs associated with hydroelectric projects, flood control, or irrigation can give rise to environmental problems, both upstream (inundation of land) and downstream (sedimentation).

Origins of the public sector role in infrastructure

Infrastructure's large and varied potential impacts on development derive from certain technological and economic characteristics that distinguish it from most other goods and services. These characteristics make infrastructure subject to special policy attention.

Production characteristics

Historically, society's needs for water supply, irrigation and flood control, and transport have led to the construction of engineered physical works—many of them quite large, elaborately designed, and enduring. Today's distinctively modern infrastructure

sectors are the result of a technology-driven "infrastructure revolution" that has changed the way in which age-old demands for water, lighting, communications, and waste disposal are met.

Not until the invention of cast-iron pipes and steam-driven pumps did extensive water infrastructure spread, beginning with a piped water network in London in the 1850s. This lowered costs (especially in urban areas) and dramatically increased use. Before the development of gas networks at the start of the 1800s, infrastructure for lighting was rare. The invention of alternating-current transmission near the end of the century lowered costs of electricity and led to new and expanded uses of electric power, especially in urban transport.

The history of other infrastructure sectors is similar. The public telegraph and telephones replaced hand-carried messages, and piped sewerage replaced individual disposal of wastes in many communities. Irrigation and transport have for centuries utilized networks of irrigation canals and roads, although development of alternative modes of transport (including inland canals and railroads) has proceeded since the early 1800s.

The most general economic characteristic of modern infrastructure is the supply of services through a networked delivery system designed to serve a multitude of users, particularly for public utilities such as piped water, electric power, gas, telecommunications, sewerage, and rail services. The delivery system is in most cases dedicated, that is, it carries only one good. Investments in the delivery system (such as underground water pipes or electric wires) are mostly irrecoverable because they cannot be converted to other uses or moved elsewhere—unlike the investment in a vehicle, for example. Once paid, these costs are said to be "sunk." Because the delivery system is networked, coordination of service flows (traffic, electricity, communications signals) along the system is critical to its efficiency. This interconnectedness also means that the benefits from investment at one point in the network can depend significantly on service flows and capacities at other points.

The scope for competitive supply of infrastructure varies greatly across sectors, within sectors, and between technologies. Where the unit costs of serving an additional user decline over a wide range of output, economies of scale are created—an important source of "natural monopoly." This is a common term, although one best used cautiously because many infrastructure monopolies are in fact unnatural, driven by policy and not technology. But sectors differ greatly in the range of declining costs.

For example, the optimal dimensions of a high-voltage transmission grid may well be national, but the volume-related unit cost savings for water can be realized at the municipal or submunicipal level. Even within sectors, different production stages have different characteristics. In power, size savings for generation are often exhausted at a capacity that is small relative to the size of a well-developed market. Activities also differ in the importance of sunk costs, another potential source of natural monopoly. In railways and ports, for example, sunk costs are less significant for investments in rolling stock or freight-handling equipment than for the fixed facilities. It is easier for firms to enter and exit activities with a relative absence of sunk costs and thereby challenge one another's potential market power. Such activities are said to be "contestable." Technological and economic differences in production create the possibility of "unbundling" the components of a sector that involve natural monopoly from those that can be provided more competitively.

Many infrastructure services can be produced by very different technologies. Sanitation based on improved latrines or septic tanks provides the same underlying service as does sewerage—disposal of wastes, but without networked investments. Small-scale irrigation—particularly irrigation based on wells or boreholes—and small-scale renewable-energy-based power generation (such as micro-hydro schemes) also need not involve interconnections with large networks but can provide service highly responsive to users. Telephone services can be provided over wire-based networks or through radio-based systems.

Consumption characteristics

As seen earlier, the demand for infrastructure services derives from the activities of both industries and individuals. Ensuring a flow of services of at least minimum quality and quantity is often considered by governments to be of strategic importance, since any interruption or restriction of supply would be seen as a threat to society. However, because infrastructure investments are often "lumpy" (new capacity must be created in large increments), it is difficult for planners to match the availability of supply with demand at all times. Costly episodes of over- or undercapacity often result.

Beyond consuming an "essential minimum" of certain infrastructure services, users have very diverse demands—although the output of large-scale, monopoly providers is often not sufficiently differentiated to meet these demands. For example, a

steel mill and a residential community may both derive water from the same supplier, but each user group values the quality of the water in quite different ways. Yet, because many infrastructure facilities are locationally fixed and their products are non-tradable, users cannot readily obtain substitute services that better suit their needs. Moreover, it is often difficult for users to obtain information about service alternatives or characteristics. They cannot, therefore, "shop around" for the best source of supply and are vulnerable to any abuse of monopoly power. With many infrastructure activities, however, supply can be better tailored to differences in demand once suppliers understand them—for example, transport can be offered at varying service and fare levels—and provided that consumers have adequate information to declare their choices. Service markets can also be opened to alternative suppliers and technologies in order to provide a differentiated product (such as cellular and enhanced services in telecommunications).

Many infrastructure services are almost (although not perfectly) private goods. Private goods can be defined as those that are both "rival" (consumption by one user reduces the supply available to other users) and "excludable" (a user can be prevented from consuming them). In contrast, "public goods" are neither rival in consumption nor excludable. Markets work best in providing pure private goods or services. Most of the services that the infrastructure sectors produce are excludable in a specific sense—their use depends on gaining access to a facility or network, for example by connection to the piped water, gas, or sewer system, and service use may be metered and charged for. In the case of railways, ports, and airports, access to the entire infrastructure can be restricted. However, once a user is connected to the network utility or gains access to the transport facility, the degree of rivalry with other users depends on the costs (including congestion) imposed on existing users or on the service supplier when an additional service unit is consumed.

It has been common in many countries not to charge users for the volume of some utility services consumed because the marginal supply cost was considered negligible, congestion was absent, or technological constraints (such as the absence of water meters) prevented volume pricing. However, recent developments, such as the increased scarcity (and supply cost) of water, growing congestion as network capacity becomes fully utilized, and technical innovations in metering consumption, have made it possible and desirable to price these services like other private goods.

Roads are not private goods, although for reasons that differ with the type of road. Rural roads (a typical public good) and uncongested interurban roads are not completely rival because an additional driver does not reduce the value of anyone else's use of the road. Access to some interurban roads can be prevented by making them toll roads (a classic "club" good, i.e., a good that is excludable but nonrival). By contrast, urban roads are congested during peak periods, but until recently it has been difficult to exclude users from urban roads or to charge users different amounts during peak and off-peak periods. New electronic techniques of monitoring road use may eventually make it technically feasible to treat many urban roads almost as private goods.

Water outside of piped networks is often—in practice and in principle—a "common property" resource. While water consumption is rival between users, monitoring the use of groundwater from underground aquifers or from other natural sources is difficult and costly, and therefore groundwater use is rarely excludable. By the same token, controlling the consumption of common property resources is also difficult. How much the extraction of water (from aquifers or natural flows) affects other potential users depends on location-specific hydrological features that are important in water policy.

Although most infrastructure goods are private, they produce spillovers or external effects—many of which (as shown earlier) affect the environment. Ignoring the important negative externality of emissions from fossil fuel power generation could lead to excess power being produced with the wrong mix of fuels. By contrast, some cities have neglected to develop a well-designed public transport system, even though such a system can have positive environmental effects and also promote social equity. To ensure that society obtains positive benefits—such as public health benefits from water and sanitation—the private goods must also be delivered effectively.

Thus, although infrastructure services differ from other goods, they also differ among themselves (Figure 1.3). The characteristics of various infrastructure activities have important implications for how services should be provided. To the extent that specific infrastructure activities entail natural monopoly or depend on a network characterized by natural monopoly, they will not be provided efficiently by an unfettered market. The network component can, however, be separated (unbundled) from the more competitive activities of the sector, with regulation to ensure fair access to the network.

Infrastructure activities that create externalities or produce essential services to captive users may also warrant some regulation, but this can be narrowly focused on these market imperfections while permitting wide scope for competition in other components of the sector.

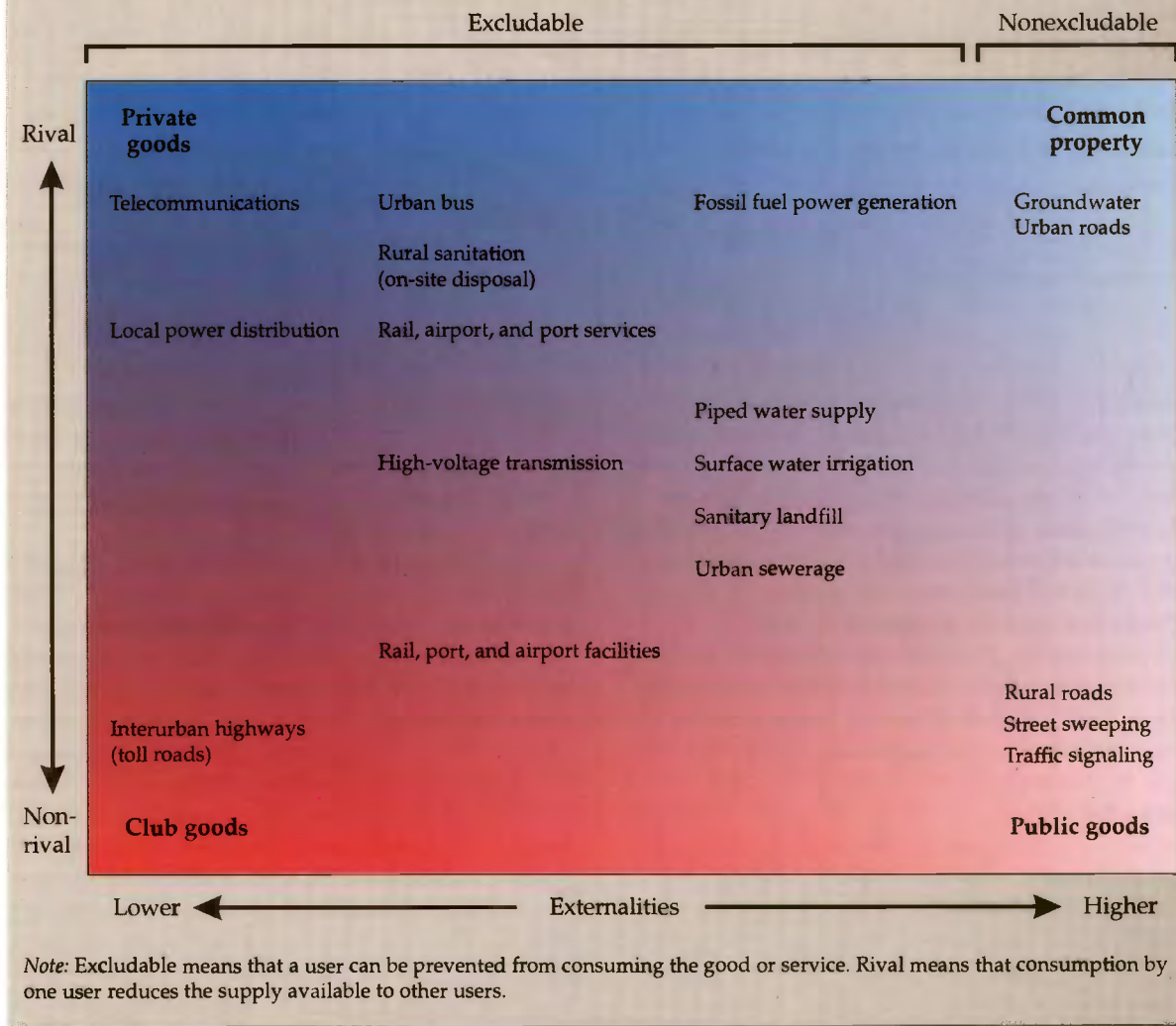
Certain characteristics of infrastructure also create challenges in financing. Where a minimum level of consumption of a particular service (such as water, heating, or power) can be identified as a "lifeline" for some users, society may judge that they should not be excluded if they cannot afford to pay. Financing strategies also have to be designed to take account of the risk that arises because many infrastructure investments are large and long-lived, while the revenue stream is often slow to develop. Such characteristics can justify some public financing of infrastructure from general revenues, but to supplement—not entirely substitute for—the revenues obtained from users and commercial sources of finance.

Public sector dominance in infrastructure

Infrastructure clearly represents a strong public interest, and so merits the attention of governments. However, the special characteristics of infrastructure do not explain or justify the fact that governments and public sector agencies have dominated almost all aspects of this sector in developing countries in recent decades. Private participation was important in the nineteenth century and the first half of the twentieth century in many countries—and some pockets of private provision still remain—but the overwhelming trend until the early 1980s was government or parastatal provision, largely through vertically integrated, monolithic entities. By then, only a small percentage of the power sector was in private hands. Virtually no private telecommunications firms existed, and most early private railways had disappeared with nationalization. Although toll roads played a part in the early history of many countries, they also became rare, and road construction (and especially maintenance) was executed largely by government employees, or force account. Other services—water, sewerage, waste disposal—also tended to be both owned and operated by governments at either the national or the local level.

The dominant public sector role in infrastructure has arisen for a number of reasons: recognition of infrastructure's economic and political importance; a belief that problems with the supply technology required a highly activist response by governments;

Figure 1.3 Infrastructure services differ substantially in their economic characteristics across sectors, within sectors, and between technologies.



and a faith that governments could succeed where markets appeared to fail. Many countries made impressive strides in infrastructure expansion under the earlier stages of this public leadership. But more recent experience has revealed serious and widespread misallocation of resources, as well as a failure to respond to demand. Moreover, the blunt instruments of public ownership, financing, and operation have not demonstrated any advantage in achieving poverty reduction goals or environmental sustainability. These deficiencies in performance are not happenstance—they are embedded in the prevailing system of institutional incentives for the supply of infrastructure.

The record of performance

Achievements

Although the data are spotty, impressive expansion in infrastructure has been achieved in recent decades, as measured by stocks and production of services (Table 1.3). In low-income economies, telecommunications, sanitation, and water supply registered the highest rates of increase in availability between 1975 and 1990, starting from a very low base in each sector. In middle-income economies, growth in this period was concentrated mainly in the power and telecommunications sectors, where

Table 1.3 Expansion of infrastructure coverage in low-, middle-, and high-income economies, recent decades

Sector	Low-income economies			Middle-income economies			High-income economies: coverage, 1990
	Coverage		Annual percentage increase	Coverage		Annual percentage increase	
	1975	1990		1975	1990		
Power-generating capacity (thousand kilowatts per million persons)	41	53	1.6	175	373	4.7	2,100
Telecommunications (main lines per thousand persons)	3	6	3.2	33	81	5.6	442
Sanitation (percentage of population with access)	23	42	3.8	44	68	2.7	95+
Paved roads (kilometers per million persons)	308	396	1.6	1,150	1,335	0.9	10,106
Water (percentage of population with access)	40	62	2.7	54	74	2.0	95+

Note: Percentage increases are compound growth rates.

Source: Appendix tables A.1 and A.2.

capacity more than doubled between 1975 and 1990. Even in middle-income economies, however, access to water and sanitation is still lacking for significant shares of the population—for water, one-quarter of the population in this group remains unserved, and for sanitation, one-third. The most dramatic expansions in paved roads occurred during 1960–75 for both groups, after which growth slowed.

Infrastructure coverage has increased in both rural and urban areas. Urban populations are significantly better served than rural populations in access to drinking water, sanitation, and power. The gaps in coverage for water and power have been narrowing (Figure 1.4). Rural and urban areas do not have the same effective demand for infrastructure services and thus may require different rates of infrastructure coverage to achieve desired development benefits. There is an economic case for providing relatively more power and telecommunications connections, and more extensive transport networks, in locations with a higher density of population and industry.

Urbanization in itself is an important factor stimulating demand for infrastructure. When infrastructure capacity in water supply, sanitation, power, telecommunications, roads, and public transport is inadequate in expanding urban areas, serious constraints on (environmentally sustainable) economic growth and on poverty reduction result. In the rapidly growing periurban (and, in many cases, unauthorized) settlements that ring many cities, conventional delivery of formal services is often prevented by legal, topographical, or economic constraints. Projected growth in urbanization in coming decades—especially in Africa and South and East Asia—will inevitably increase pressures for greater access to infrastructure. However, some rural-to-

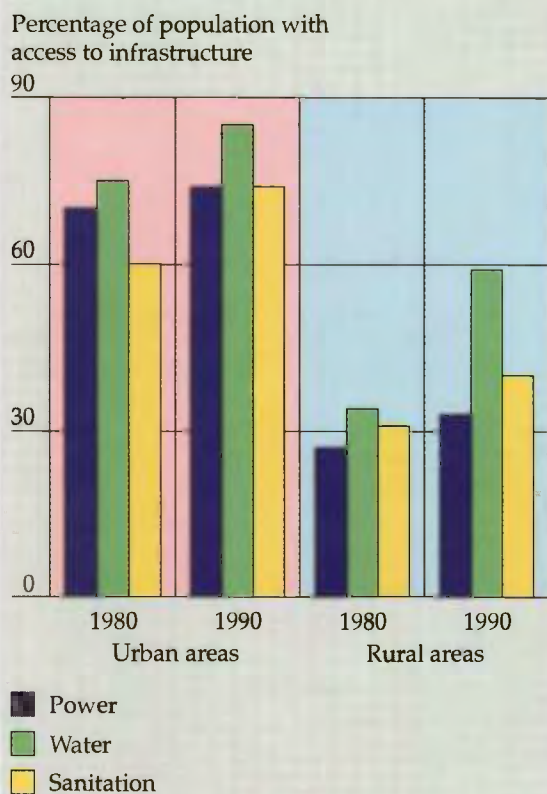
urban migration may be forestalled through policies that provide appropriate infrastructure in rural areas and that prevent the degradation of natural resources (especially soils, forests, and water supplies).

An analysis of how countries measure up on infrastructure coverage compared with other measures of performance is revealing. Although coverage tends to be correlated with GDP, efficiency and effectiveness of infrastructure provision are not. Plots of coverage against performance in water, power, telecommunications, roads, and railways show little relationship across a wide sample of low- and middle-income countries (summarized in Figure 1.5). Moreover, there is no close correlation between a country's efficiency of provision in one sector and its performance in another. These findings indicate that efficiency and effectiveness of infrastructure provision derive not from general conditions of economic growth and development but from the institutional environment, which often varies across sectors in individual countries. This suggests that changes in the institutional environment can lead to improved performance, even when incomes are low, because in each sector some low-income countries perform well. As a corollary, a recent OECD review of infrastructure noted that even many high-income countries encounter the performance issues described below.

Challenges

To determine future demand for infrastructure, it is necessary to consider the efficiency with which existing capacity is being used and how well the services generated are responding to users. Although each sector has special problems, there are com-

Figure 1.4 The rural-urban gap in access to power and water in developing countries narrowed over the past decade.



Source: Israel 1992; WHO 1980, 1990.

mon patterns—operational inefficiencies, inadequate maintenance, excessive dependence on fiscal resources, lack of responsiveness to users' needs, limited benefits to the poor, and insufficient environmental responsibility.

INEFFICIENCY OF OPERATIONS. The broadest indicator of inefficient performance by an infrastructure system is the extent of output lost in delivery. Unaccounted-for water (that portion of supply for which consumption is not recorded, largely because of technical and managerial failures) is typically two to three times higher in developing country systems than in countries that achieve the industry standards. In 1987 one-quarter of the power utilities in developing countries had losses of electricity in the transmission and distribution network that were twice those in efficiently operated systems. In some

African countries, spending \$1 million to reduce line losses could save \$12 million in generating capacity. Irrigation efficiency (the proportion of water delivered to the field) in developing country projects is typically 25 to 30 percent, compared with 40 to 45 percent under best practice.

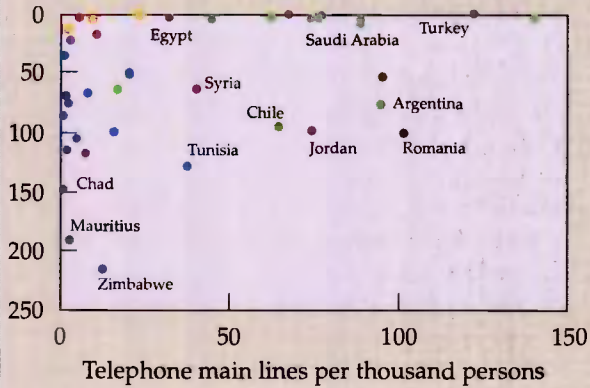
Inefficient use of labor is especially common and costly in infrastructure. At various periods, two-thirds of the labor in railways in Tanzania and Zaire, 80 percent of port staff in Argentina (before recent privatizations), and one-quarter of highway department staff in Brazil have been estimated to be redundant. The combination of overstaffing and underpricing of railway services produced a wage bill almost as large as (and sometimes larger than) total railway revenues in Argentina (before recent reforms) and in Colombia, Egypt, Nigeria, Turkey, and Uruguay. Overstaffing is also common in water, power, and telecommunications. At the same time, in the production of public works and rural infrastructure, developing countries often use equipment-based methods of construction and maintenance rather than employment-intensive approaches that can produce high-quality results, while being more consistent with relative capital and labor costs.

INADEQUATE MAINTENANCE. Closely related to operating inefficiencies is lack of maintenance: roads deteriorate, irrigation canals leak, water pumps break down, sanitation systems overflow, installed phone lines fail, and power generators are not available when needed. Capacity is then lost, output declines, and substantial additional investment is needed simply to sustain existing levels of service.

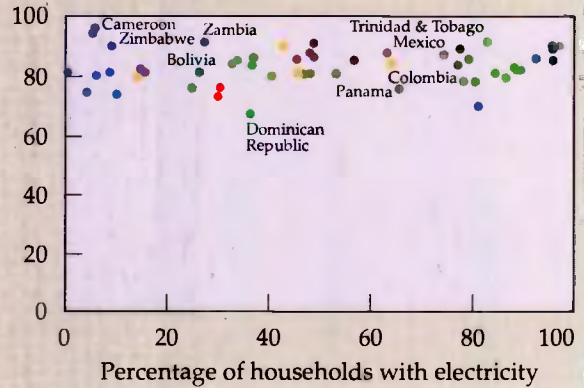
In the road sector, inadequate maintenance imposes large recurrent and capital costs. The engineering and physical properties of paved roads are such that, as a road begins to deteriorate, lack of regular routine maintenance will hasten deterioration. Neglect of (relatively inexpensive) routine maintenance can compound problems so much that the entire surface of a road has to be replaced. Examination of completed Bank highway projects shows that, on average, estimated returns on projects involving primarily maintenance are almost twice as high as those on projects involving mainly new construction. Yet, in Sub-Saharan Africa, almost \$13 billion worth of roads—one-third of those built in the past twenty years—have eroded because of lack of maintenance. In Latin America, for every dollar not spent on maintenance, \$3 to \$4 are estimated to be required for premature reconstruction. Maintenance expenditures often are not allocated by economic

Figure 1.5 Efficient and effective delivery of infrastructure services does not always accompany increased availability.

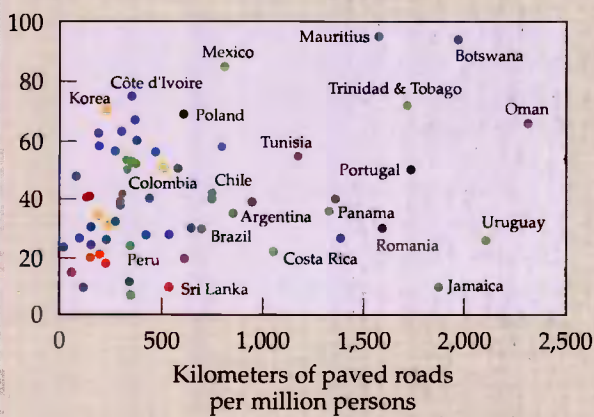
Faults per 100 main lines



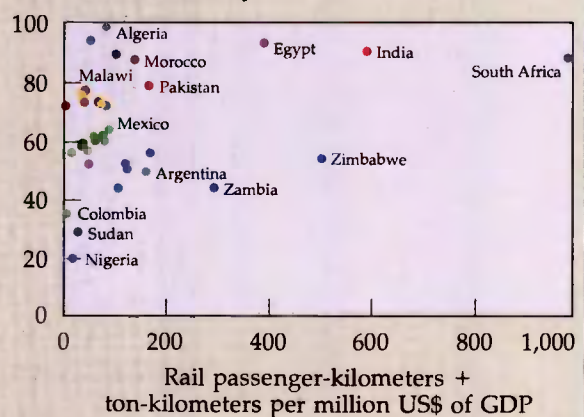
Percentage of power delivered



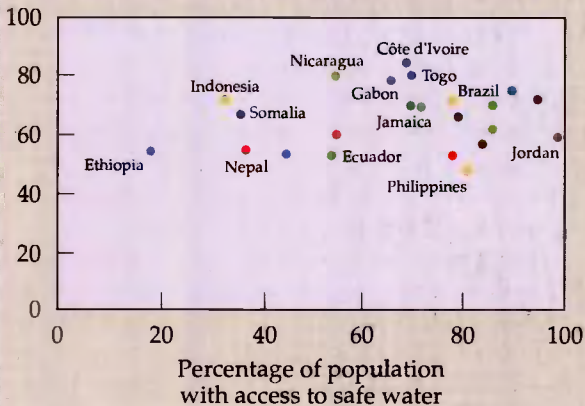
Percentage of paved roads in good condition



Percentage of diesel locomotive availability



Percentage of accounted-for water



- Middle East and North Africa
- Latin America and the Caribbean
- East Asia and Pacific
- Sub-Saharan Africa
- South Asia
- Europe and Central Asia

Source: WDI table 32.

priorities. For example, Cameroon, which still has a predominantly rural population, has neglected its 30,000-kilometer unpaved road network over the past ten years in favor of investment in and maintenance of 3,700 kilometers of intercity paved roads. The result is that some 80 percent of the unpaved network requires either complete reconstruction or heavy reshaping and compaction.

In railways, inadequate maintenance (as well as other operating deficiencies) is evident in the small share of locomotives available for service. In 1991 only 60 percent of all locomotives were available for service in Latin America and 70 percent in the Middle East and North Africa region, compared with 90 percent in North America. Such deficiencies cause some railways to turn away freight traffic, which in turn compounds the sector's financial difficulties.

In irrigation, too, poor maintenance is costly and results in distribution channels filling with silt and weeds, canal linings cracking at an increasing rate, and outlets breaking or being bypassed. Drainage also fails, causing salt buildup in the soil. In China almost 1 million irrigated hectares have been taken out of production since 1980, and in the former Soviet Union, even with continuing investment in irrigation, almost 3 million hectares were lost between 1971 and 1985—one-quarter of the new irrigated area. Worldwide, works covering 60 percent of the irrigated area require upgrading to remain in good working condition.

In both rural and urban water supply and in the power sector, inadequate maintenance is a common problem. A study of water and sewerage in Bogotá found that the costs of unaccounted-for water—arising in part from poor maintenance of the distribution system—were 42 percent of the supplier's total operating income. Poor maintenance practices account for some of the low availability of power-generating capacity, which averages less than 60 percent for thermal plants in many developing countries, compared with more than 80 percent in systems operated at best-practice standards.

Sometimes problems of operation and maintenance are rooted in the initial design or construction of infrastructure. For example, a recent review of completed World Bank irrigation projects found that basic design flaws (such as inappropriate transfer of desert technologies to tropical monsoon climates) were widespread. Operations and maintenance can be made more difficult by inappropriate design standards that increase the requirements for skills in short supply or involve heavy dependence on imported spare parts where foreign exchange is scarce. Poor construction and design of power and

water treatment plants, or inappropriate location, make it difficult to carry out operations and maintenance and to meet environmental objectives. There are also many examples of investments that were economically nonviable to begin with and that should never have been made—such as over-designed or "gilt-edged" roads and power plants.

Procurement problems are often a factor in weak operational performance. Systematic delays in purchasing by sector entities and inadequate supervision of contracts are estimated to increase costs of imported materials to some African countries by 20 to 30 percent. Contracting and bidding procedures may also favor large-scale enterprises, which tend to use more equipment-based methods of construction and maintenance than is appropriate given relative factor costs. The lack of standardization of equipment, such as water pumps obtained from diverse foreign donors, creates delays in repair and increases the costs of replacement parts. There is need for donors to standardize their procurement rules to ease the administrative burdens on recipient countries. Donor aid that excludes finance for local costs can also bias the choice of technology for public works in favor of capital-intensive methods that are unsustainable for the recipient country.

FINANCIAL INEFFICIENCY AND FISCAL DRAIN. Poor infrastructure policies and inefficient provision absorb scarce fiscal resources and damage macroeconomic stability. Because prices are often held well below costs, the subsidies flowing into public infrastructure enterprises and agencies have been enormous in many countries. In Bangladesh, India, Indonesia, Pakistan, and the Philippines, irrigation receipts have been well below the costs of operations and maintenance. During the 1980s power tariffs in developing countries were on average about one-half the costs of new supply and were much lower than in OECD countries. (The record on pricing is discussed further in Chapter 2.) In recent years, 60 percent of Ghana Railway revenues consisted of government subsidies—a not-uncommon performance for this sector—and recurrent subsidies to railways have amounted to as much as 1 percent of GDP in a number of countries. In Zambia the total cash shortfall in transport absorbed 12 percent of the government's current revenue in fiscal 1991. Telecommunications tends to be an exception to the generally poor cost recovery elsewhere in infrastructure, although its revenues are often siphoned off by government for other uses, leaving the sector underfunded. Inadequate tariffs are often compounded by poor financial management. In a sam-

ple of Latin American water utilities, collection of accounts receivable took almost four months on average, compared with good-practice standards of four to six weeks. In addition to creating an added burden on taxpayers, poor financial performance by many infrastructure providers means a loss of creditworthiness for the entity concerned. It also results in a low reliance on internal revenues to finance investment—and therefore an inability (and lack of incentive) to expand or improve service.

UNRESPONSIVENESS TO USER DEMAND. The result of inefficiency and poor maintenance is low-quality, unreliable service, which alienates users. Reliability is a critical aspect of user satisfaction that is often ignored. Even where users have telephones, high call failure rates (more than 50 percent in many cases) and high fault rates drastically diminish the value of the service. Unreliable quantity or quality of water leads to enormous investments in alternative sources that are especially costly to those who can least af-

Box 1.5 Households' responses to unreliability of water supply

In 1991, micro-level research on household responses to deficient water supply by public utilities was undertaken in Faisalabad (Pakistan), Istanbul (Turkey), and Jamshedpur (India). These surveys revealed that nearly all households in the three cities are dependent on multiple sources of water, including house taps, wells, tubewells, public taps, rivers, and street vendors. Not all alternatives are available to all households. Because access to a source increases with income, poorer households bear a disproportionate share of the burden of deficient infrastructure. The private expenditures incurred for water supply indicate consumers' willingness to pay for reliable water.

In Istanbul, the poorest households surveyed spend a larger share of their income (about 5 percent) to supplement inadequate water supply than do wealthier ones (which spend about 1 percent). These expenditures on informal sources of water, including self-provision from wells or storage facilities, are in addition to the user charges for publicly supplied water, which amount to 1 to 2 percent of annual income.

In Jamshedpur, the connection charges for piped water vary between \$1.66 and \$16.66. The residents of the periurban areas, served by the local municipal authorities, incur capital costs of \$50 to \$65 in installing tubewells and \$150 to \$300 in digging wells to avoid dependence on the (unreliable) public water supply. Despite the existence of a piped water system, at least 17 percent of the population meets 90 percent of its water needs from wells and handpumps. Over and above the monetary costs that consumers bear, households in Jamshedpur spend, on average, two hours a day fetching and storing water. The burden of these activities falls in nearly all cases on women.

The pattern of private augmentation of the public water supply at substantial private costs to consumers is observed also in Faisalabad, Pakistan. Less than 20 percent of the households with piped water use this source exclusively; 70 percent have motor pumps and 14 percent have handpumps.

Box 1.6 Public failures raise private costs

According to a 1988 study of Nigerian manufacturers, 92 percent of the 179 firms surveyed owned electricity generators. In the face of chronically unreliable public services, many had also acquired radio equipment for communications, vehicles to transport personnel and freight, and boreholes to assure their own private water supply. For firms with fifty or more employees that could practice economies of scale, these extra costs amounted to some 10 percent of the total machinery and equipment budget. For small firms, the burden could be as high as 25 percent. Yet because Nigerian regulations prevent firms from selling their excess power capacity, businesses both large and small were operating private generators and water systems on average at no more than 25 percent of capacity.

Of 306 Indonesian manufacturers recently polled, 64 percent had generators and 59 percent (compared with Nigeria's 44 percent) had boreholes for their own water

supply. Indonesia's largest companies invested as much as 18 percent of their capital in private infrastructure—almost twice Nigerian manufacturers' level of 10 percent—yet their generators, too, were underused and operating at about 50 percent of capacity.

Today in Indonesia, as in Nigeria, firms too small to afford private power or water are at the mercy of unreliable public utilities and subject to chronic and costly interruptions in service. Yet while the largest Indonesian firms pay \$0.07 per kilowatt-hour to produce electricity (not far above international norms), self-provided electricity costs the smallest firms \$1.68 per kilowatt-hour—twenty-four times as much.

Thailand—where public electric utilities are efficiently run—has been able to break this pattern. Of the 300 manufacturers polled, only 6 percent had private generators and 24 percent had private water supplies.

ford it (Box 1.5). In Indonesia and Nigeria, private businesses incur heavy costs in order to guarantee power supply: 92 percent of firms sampled in Nigeria and 64 percent in Indonesia had installed private generating capacity (Box 1.6); in Thailand, only 6 percent of companies needed generators. These large differences in self-provision reflect the performance of the formal suppliers. In Nigeria, only 43 percent of installed capacity was in service by 1990 (despite massive overinvestment in public power-generating capacity throughout the 1980s); in Thailand, the power utility is efficiently run.

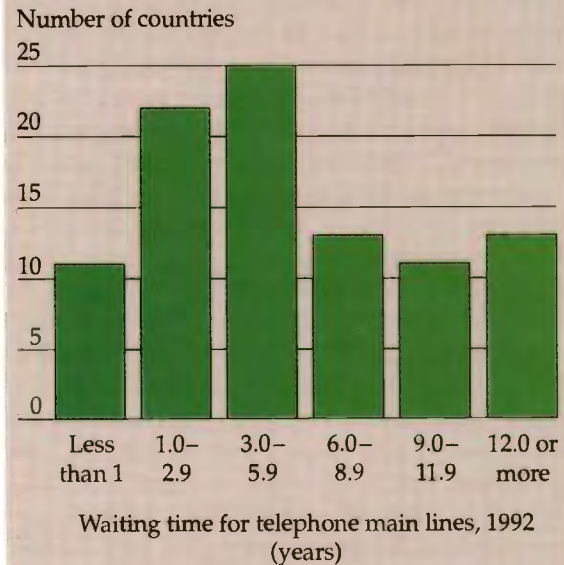
In telecommunications, unmet effective demand can be roughly measured, because in many countries users must apply for connection, which often involves paying a heavy initial fee. Of ninety-five developing countries, more than one-third were found to have a waiting period of six or more years for a connection, compared with less than a month in most industrial countries (Figure 1.6). Countries that can deliver service in less than a year include some with little current pressure on available capacity (such as Bolivia) as well as others in which investment is proceeding rapidly (Malaysia). In addition to the shortage of basic connections, in many countries providers fail to offer differentiated services matching types of use. For example, businesses increasingly require telecommunications facilities that accommodate high-speed data transmission as well as voice signals. A much higher priority could be given in many developing countries to the provision of pay phones to extend basic access to improved communications to a larger share of the population.

Excess demand for infrastructure, coupled with very low rates of compensation to infrastructure staff, breeds corruption in both service and investment decisions. Where connections are rare and service is poor, employees often demand side payments from users to install or repair connections—especially in telecommunications, irrigation, and water supply.

NEGLECT OF THE POOR. The poor typically use fewer infrastructure services than the nonpoor, but not only because of low incomes—they also have very low access. In Peru, for example, only 31 percent of the poorest fifth of households are connected to a public water network and 12 percent to a public sewer—compared with 82 percent of the top fifth for water and 70 percent for sewerage. The poor generally have less access than the rich in urban areas as well (Table 1.4).

Many countries have introduced subsidies through low tariffs with the aim of improving the

Figure 1.6 There is very high unmet demand for telephone connection.



Sample: 95 developing countries.
Source: ITU 1994.

poor's access to infrastructure services, but most of these subsidies have been captured by middle- and high-income households (as documented in Chapter 4). In addition, the providers often are not adequately compensated for the subsidies, so that overall expansion of service is constrained. The structure of tariffs can be an additional barrier. In Brazil, local telephone call rates are low, but connection charges are high. This prevents lower-income users from getting service. Flat-rate electricity charges in rural India have benefited mainly richer households, because the poor lack the income to purchase the pumps and consumer appliances that account for most electricity use.

While failure to reach the poor has often been associated with flawed infrastructure pricing policies, too little emphasis has been placed on providing the poor with suitable options for the kinds of services of most value to them (and for which they are willing to pay). For example, municipal sanitation agencies often promote technical designs for conventional sewerage that are unaffordable and even environmentally unsuitable in some low-income settlements. In large cities such as New Delhi, the reliance of the poor on foot travel is a serious con-

straint to their mobility (Figure 1.7) A study of transport options in Latin American cities found that in São Paulo, Brazil, personal travel by the poor had declined more sharply than for any other income group over a decade—partly because public transport services were ill designed for low-income users. The poorest residents on the periphery of Rio de Janeiro spent more of their income than the rich for transport, with longer waits, less frequent service, and more time spent in crowded vehicles.

Appropriate services for the poor are often lacking when decisions on investment and service are driven by assumptions about a “needs gap” rather than by an assessment of effective demand. In the Makete District in Tanzania, a survey of households undertaken to determine their transport needs in preparation for a proposed investment project revealed that improvement of the road network alone would benefit only a few residents and that complementary measures were needed—including support to transport services (the introduction of nonmotorized means of transport to replace head-loading), simple improvements to paths and tracks, and rehabilitation of grinding mills. A retrospective evaluation carried out after completion of the project found that these low-cost improvements were highly successful—and would likely have been left out of the project if no inquiry into the actual demand of the communities had been undertaken.

NEGLECT OF THE ENVIRONMENT. The impact of infrastructure on the environment has often been very negative (Box 1.7 recounts one of many examples, and one where regional cooperation is needed to develop a solution). The highly visible effects of certain large-scale facilities—such as dams and roads in sensitive ecological areas or where resettlement options are unsatisfactory to populations—have at-

tracted understandable public attention. Yet equally serious, and more pervasive, is the damage or loss of potential benefits to the environment because of failure to control unnecessary emissions and wasteful consumption of water. This is due in particular to the underpricing of power, vehicle fuels, and water for irrigation and municipal uses and to the neglect of maintenance. Inadequate maintenance practices leading to inefficient thermal power generation account for a large share of energy-related pollution. Neglect of sound environmental management practices in transport—including safe handling of hazardous cargos and appropriate disposal of waste from ships, port dredging, and vehicle maintenance—is a common failing. Unregulated, badly designed, or poorly managed municipal water and sanitation infrastructure has often been one of the biggest sources of urban environmental pollution. The focus of public spending on urban solid waste management often stops at collection—few developing country cities meet environmental standards for sanitary landfills.

Many of the problems in infrastructure performance are mutually reinforcing, creating serious economic and financial costs that make it more difficult for countries to achieve greater coverage and more modern services to better meet social and environmental goals. Systemic problems point to systemic causes—and solutions.

Diagnosis and directions for change

The conditions for improved performance: causes and cures

Where infrastructure is operated inefficiently and delivers poor service, the solution cannot be simply to tell suppliers to do more maintenance and to

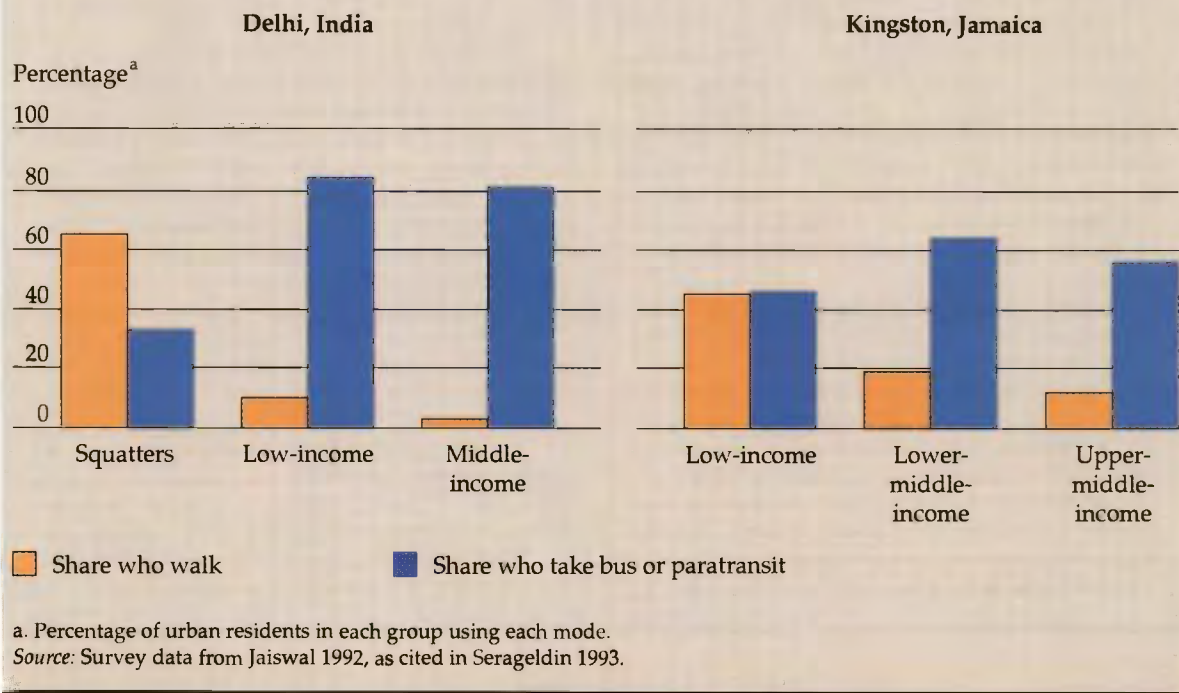
Table 1.4 Percentage of the poorest and richest population quintiles with access to infrastructure, various countries

Country/area	Access to public water supply		Access to sewers		Access to electricity	
	Poorest quintile	Richest quintile	Poorest quintile	Richest quintile	Poorest quintile	Richest quintile
<i>National areas</i>						
Côte d'Ivoire (1985)	2.4	62.1	3.4	57.0	13.2	74.8
Ghana (1987–88)	10.5	30.6	0.5	14.6	5.6	46.0
Guatemala (1989)	46.9	86.8	16.1	86.1
Mexico (1989)	50.2	95.0	14.2	83.2	66.2	99.0
Peru (1985–86)	31.0	82.0	12.3	70.0	22.8	82.5
<i>Urban areas</i>						
Bolivia (1989)	84.8	89.9	52.6	87.4
Paraguay (1990)	53.7	88.8	10.4	62.2	94.5	99.2

.. Not available.

Source: Glewwe 1987a, b; Glewwe and Twum-Baah 1991; World Bank 1993e.

Figure 1.7 Walking is a transport mode used frequently by the poor.



consult users. The weaknesses in infrastructure provision are inherent in the *incentives* built into current institutional and organizational arrangements, in which outputs and inputs are not closely measured, monitored, or managed, and suppliers do not depend on user satisfaction for reward. A proper set of incentives would make managers *accountable* to users and to others who own and finance infrastructure facilities. It would also give managers *autonomy* in making decisions—and responsibility for success or failure. This Report’s review of experience with infrastructure, in both the public and the private sectors, suggests that three elements are essential in creating the right incentives for efficient and responsive delivery of services. These are management based on commercial principles, competition, and involvement of users and other stakeholders.

COMMERCIAL PRINCIPLES. Infrastructure must be conceived of as a “service industry,” providing goods that meet customers’ demands. Such a commercial orientation contrasts sharply with the situation in most government departments and state-owned public utilities, which suffer from multiple and conflicting objectives and inadequate account-

ing for costs or financial risk, and which put little emphasis on revenues collected and the quality of service delivered. Managers have little motivation in such circumstances to satisfy customers or to achieve a reasonable return on assets through efficient operation and adequate maintenance. Typical providers of infrastructure are subject to pervasive interference by political authorities, which adversely affects operational decisions on investment, pricing, labor, and technological choices. It is common to view certain infrastructure services (such as power, water, ports, railways, airports, and telecommunications) as potentially “commercial” because these are the services for which it is easiest to recover the costs of provision through user charges or tariffs. In fact, almost all infrastructure (even roads and sanitation) can be operated with a business orientation. The basic conditions for this are limited and well-focused performance objectives, financial and managerial autonomy (with a hard budget constraint), and clear accountability both to customers and to providers of capital.

COMPETITION. Competition promotes efficiency and provides users with options that, in turn, make infrastructure providers more accountable. Govern-

Box 1.7 Infrastructure activities threaten the Black Sea environment

The Black Sea is fed by a basin of more than 2 million square kilometers, covering parts of seventeen countries in Central and Eastern Europe, the former Soviet Union, and Turkey. It receives the inflows of several major rivers, including the Danube, Don, Dnieper, and Dniester. As an almost fully enclosed water body, the Black Sea is especially vulnerable to changes in the quantity and quality of inflows from these rivers. The Don and Dnieper, in particular, have been highly developed for irrigation and other purposes through a chain of reservoirs.

Increasing pollutant loads from these rivers—especially the nutrients nitrogen and phosphorus—have led to algal blooms and the destruction of important nursery areas for fish. In addition, damming of the major rivers for navigation, flood control, water supply, and, above all, for irrigation, has considerably altered the seasonal flow patterns of these rivers. The damming has also decreased the total inflow to the Black Sea, resulting in an increase in salinity in critical coastal and estuarine areas, especially in the Sea of Azov, which creates further problems for fish breeding. The overall result is a 90 percent

decline in the once-productive Black Sea fishery over the last thirty years.

With assistance from the Global Environment Facility, the six Black Sea countries (Bulgaria, Georgia, Romania, Russia, Turkey, and Ukraine) have begun a regional program to analyze the causes of observed environmental degradation and to propose solutions. Actions in the basin to regulate fertilizer use and to control point sources of pollution are expected to result in reductions of nutrient inflows. Pilot projects are proposed to restore fish production under the new salinity conditions. Under the Bank-supported Environmental Management Project for Russia, a study of the Lower Don Basin will investigate ways to alter the operating rules for the major reservoirs to promote greater fish regeneration downstream.

Given the size of the problem and the importance of these reservoirs in the agricultural economies of Ukraine and Russia, it would be unrealistic to expect dramatic changes. Nevertheless, recognition of the problem and the development of mechanisms for regional cooperation now make progress much more likely.

ments in most countries have not taken advantage of the potential for competition, even in activities where a natural monopoly does not exist, such as road freight transport or solid waste collection. Today competition can be used directly in more infrastructure activities because of technological changes. In telecommunications, satellite, microwave, and cellular radio transmission of telephone signals is revolutionizing the industry, making the economies of scale with cable-based transmission less important. In power generation, combined-cycle gas turbines operate efficiently at lower output levels than other generation technologies. While open competition for users in the market is still not feasible in many infrastructure areas, there are other ways of obtaining the benefits of competition. For activities with high sunk costs, competing for the right to operate a monopoly can capture many of these benefits. Even where the number of operators is necessarily limited, regulation can compel them to compete against performance benchmarks (“yardstick” competition).

INVOLVEMENT OF USERS AND OTHER STAKEHOLDERS. In many infrastructure activities, market signals cannot be relied on to provide information about demand or to gauge performance. Where users are locked into a delivery network, they cannot express their preferences or dissatisfaction through choice.

In such circumstances, other means of making suppliers accountable to users are needed. Through various mechanisms designed to broaden participation in decisionmaking and to provide wide access to information on infrastructure provision, users and other key stakeholders can be represented in (and sometimes take responsibility for) the planning, financing, and delivery of services.

Opportunity knocks

Many of the above notions are not new, and some have been accepted in principle by policymakers if not yet put successfully into practice. Three factors—technological change, more pragmatic attitudes, and a greater sensitivity to infrastructure’s implications for poverty and environmental sustainability—have created a new climate for reform. Innovative techniques for drawing on private financing for investment create a further challenge to traditional ways of providing infrastructure. Many countries are now taking advantage of all these opportunities to test new ideas and approaches, discussed in later chapters of this Report.

TECHNOLOGY. Technological changes are creating a variety of new opportunities for changing the way infrastructure is provided in almost every sector—

in particular, by making the unbundling of diverse activities more feasible. Microelectronic monitoring devices and nondestructive testing techniques can facilitate the assessment of infrastructure facilities (at reduced cost), often permitting testing by an agent other than the operator—such as the owner or regulator. Remotely controlled devices for inspecting pipe networks and the shift from analog to digital telephone switching have greatly simplified and reduced maintenance costs. Electronic information systems, including geographic mapping, improve the planning and design of investments and the coordination of network operations. Technologies that are clearly more efficient, robust, and flexible than earlier methods enable developing countries to “leapfrog” sectoral transitions experienced earlier by high-income countries. For example, Brazil based its telecommunications expansion in the 1970s on emerging digital equipment and thereby facilitated the development of information-based industries. Policy-induced inefficiencies slowed the modernization of the sector in the 1980s, however.

NEW PRAGMATISM. A new attitude, stemming from an enhanced understanding of the relative strengths and weaknesses of governments and markets, is also creating opportunities for reform of infrastructure provision. In the 1980s, the efforts of many countries to reduce the size of their over-extended public sectors led to a better realization of what governments and markets can and cannot do. Worldwide liberalization of markets and experiments with different forms of private sector participation in many sectors have provided a new body of experience to reinforce this pragmatic attitude. Theoretical and institutional advances have also revealed when regulation is necessary and how to refine its application. All this leads to two main conclusions. First, there are fewer infrastructure activities requiring government intervention than once believed. Second, when required, government intervention can be exerted through less distorting instruments of public policy than those traditionally used.

RENEWED COMMITMENT TO SOCIAL AND ENVIRONMENTAL CONCERNS. Political developments—including the trend in many countries toward democratization, pluralism, and decentralization—have fueled a concern with finding more affordable and environmentally friendly solutions in infrastructure. This commitment has led to greater appreciation of the need to consult local communities, the poor, and groups affected by environmental factors. At the

same time, increased efforts are being made to devolve responsibility for infrastructure provision to local governments, to increase participation, and to foster self-help.

Awareness that the poor (and future generations) are constituencies that must be answered has stimulated a search for alternative ways of providing services or managing demands so as to broaden access while avoiding environmental problems. Relatively simple changes in design parameters for sewerage and improved design of latrines have made sanitation affordable to low-income communities while permitting private initiatives in financing, maintenance, and manufacture of parts. An increasing range of technical, economic, and institutional alternatives to conventional wastewater treatment can reduce the need for costly filtration plants. Countries are adopting alternatives to large-surface schemes in irrigation—such as drip, bubble, and sprinkler systems and low-level canals with low-lift pumps—that are highly responsive to farmers’ needs for water and are also environmentally sustainable. There is renewed interest in nonmotorized means of transport, including bicycles and hand carts, and simple road improvements that enhance mobility in both rural and urban areas. Recognition of the need to conserve scarce resources has led to efforts to avoid unnecessary infrastructure investments—for example, by promoting recycling and recovery of solid waste materials; reducing waste and effluents at the source; and managing demand for water, power, and transport (Chapter 4). Industrial and developing countries are learning from each other in these areas.

The way ahead: a road map of reform

Awareness of past mistakes, together with new opportunities, demands that a fresh look be taken at the roles that governments or other public agencies and the private sector should play in providing a more efficient and more responsive infrastructure. The challenge is to determine those areas in which competitive market conditions can work and those that require public action. Within these broad parameters, there is a menu of institutional options that allow governments, public sector agencies, and private groups (both for-profit and nonprofit) to assume responsibility for different aspects of service provision. The choices among the options will vary among countries, on the basis of their economic, institutional, and social characteristics. The spectrum of options is broad, but four main approaches can be identified:

- Option A: Public ownership and operation, through a public enterprise or government department
- Option B: Public ownership but with private responsibility for all operation (and for financial risk)
- Option C: Private ownership and operation
- Option D: Community and user provision.

The remainder of this Report discusses how more efficient and responsive provision of infrastructure can be achieved by improving incentives—through stronger mechanisms of accountability and autonomy. Chapter 2 discusses ways to create accountability in a public agency or government department (Option A) by establishing commercial principles and through organizational restructuring (corporatization). It also reviews contracting instruments to permit better monitoring and performance of operations, and appropriate mechanisms for achieving financial autonomy.

Commercial principles are often very difficult to instill permanently in the absence of effective competition. Chapter 3 discusses the scope and techniques for marshaling market forces to create accountability through competition and—where competition alone is insufficient—regulation. Chapter 3 also examines experiences with public ownership and private operation (Option B), in which competition for the market is used, as well as private ownership and operation (Option C). Both of

these arrangements require appropriate sectoral restructuring to maximize the opportunity for competition and to ease the regulatory burden.

Chapter 4 examines issues that neither commercialization nor competition alone can address—problems of externalities (particularly environmental), distributional equity, and the need for coordination of investments. It discusses approaches for assessing and creating accountability to social and environmental concerns, through decentralization of governmental responsibilities, participation by users and stakeholders (including through “self-help” schemes, Option D), and planning. Chapter 5 reviews how mechanisms of financing infrastructure can create incentives for efficiency by providing the disciplinary pressure of private financial markets. Because different aspects of infrastructure provision involve different kinds of risks, the chapter considers how a suitable packaging of finance using alternative sources and instruments (private and public) can lead to better risk management—in addition to mobilizing increased funds for infrastructure investment. Chapter 6 returns to the menu of options and shows how these can be applied in different infrastructure sectors and countries. The conditions for successful implementation of these options are also outlined. The chapter closes with a broad assessment of the economic and financial benefits that countries can gain by following the reform agenda presented in this Report.