

# Perspectives on Globalization of Infrastructure

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## BEGINNINGS OF INFRASTRUCTURE

Just north of the Dead Sea in the Jordan River's valley lies an archeological site popularly known as the city of Jericho. Excavations have revealed evidence of human settlement there that commenced some 11,000 years ago or earlier. The residents—by 8,000 BCE, perhaps 2,000 people living in mud-brick houses clustered in an area of four hectares (ten acres)—sustained themselves by farming, hunting, and possibly herding sheep. Around their town they built walls, five feet thick in places and today preserved to a height of about four meters (twelve feet), with a moat-like ditch beyond. Into the wall they built a great circular stone tower nine meters (30 feet) in diameter. This oldest of known human settlements had what we today would call civil infrastructure.<sup>1, 2</sup>

In his *Ten Books of Architecture*, written in about 15 BC, the Roman Marcus Vitruvius Pollio declares that “A city's public buildings serve three purposes: defense, religion, and convenience. To ward off hostile attack, we must defend the city with walls, towers, and gates. For the sake of religion, we plan shrines, and sacred temples to the immortal gods. For convenience, we arrange public sites for general use—harbors, open spaces, colonnades, theaters, promenades, baths, and all amenities for like purpose. “All,” he famously instructs, “must be carried out with strength, utility, grace.”<sup>3</sup> Infrastructure had clearly been recognized as an essential constituent of culture.

From such beginnings, our understanding of infrastructure has evolved. Nearly two millennia later, economist Adam Smith recognized provision of public infrastructure as an essential foundation for the wealth of nations and—in sharp contrast to his views on most areas of human economic activity—one of the three essential duties of government.<sup>4</sup>

As the Industrial Revolution progressed, so did our theories on infrastructure. The French engineer and economist Jules Dupuit in the mid-19<sup>th</sup> Century made important contributions to all aspects of infrastructure design and management, particularly with his ideas on ownership of the assets that infrastructure represents and how we should price their usage.<sup>5</sup>

Our recognition of the importance of pricing and its implications for how we finance infrastructure continued to grow as we came to understand the monopolistic power of government-based decision making and the implications for how scarce resources are allocated. American economist and statistician Harold Hotelling laid the groundwork for our understanding of how infrastructure influences regional patterns of economic activity and our treatment of such “exhaustible resources as energy supplies and environmental amenities.”<sup>6</sup>

Our concepts of infrastructure burst out of national boundaries with the founding of the World Bank in the aftermath of World War II's devastation. From its launch in 1945, the Bank was heavily involved in infrastructure development, including rehabilitation of India's railways, building power generation and transmission capacity in Brazil, Chile, and El Salvador, and similar activities around the world. The Bank's support for infrastructure was conceived as a critical means for building a foundation for long-term growth and social stability, and the discipline imposed by a focus on specific functions and facilities that infra-

structure represented appealed to John Maynard Keynes and the other architects of the Bretton Woods system that underlies our modern economy.

The international comparison of infrastructure and its role in social and economic development yielded new insights. On the one hand, we have gained greater understanding that demand for infrastructure is a “derived demand;” infrastructure is desired not for its own sake but rather because it facilitates other economic and social activity. In regions at all levels of development, we have observed a statistically significant relationship between overall development and infrastructure,<sup>7</sup> and we surmise the correlation stems from infrastructure’s real contributions to health, efficiency, and quality of life. On the other hand, as economist A. O. Hirschman concluded, the shortage that retards economic advance in most cases is management capability rather than physical facilities. Infrastructure is not a sufficient condition for development; it can be built later to “catch up” with demand derived from private industry’s growth, but it is a necessary condition for further economic growth as there is no economy that has been able to grow in a sustainable way without infrastructure.<sup>8</sup>

Another hard lesson was laid out most clearly in Garrett Hardin’s 1968 article in *Science*, “Tragedy of the Commons.” Hardin used the example of primitive herdsmen who, seeking their own self interest, will be driven inexorably to build their herds and overgraze the shared grassland, to expound the conflicts inherent in efforts to encourage development when environmental amenities such as clean air and water are considered, for the most part, “free goods.” While the concepts of public goods and externalities had been discussed among economists since early in the 20<sup>th</sup> Century,<sup>9</sup> Hardin’s discussion used game theory and an accessible style to provide powerful impetus for the growth of environmental concerns in infrastructure management.

## GLOBALIZATION EMERGES

The World Bank's founding, and Hirschman's and Hardin's contributions to the literature are key markers of the progression within infrastructure of the broad economic trend we have come to call "globalization."<sup>10</sup> While the facilities and services of infrastructure are still seen by public work managers and users as essentially local, the underlying demands for infrastructure and the means employed in its finance and development are increasingly global in scope. Business relationships and production increasingly are spread across national boundaries. Work proceeds "24/7." Most importantly for increasing numbers of those who concern ourselves with infrastructure development and management, the ways we think about infrastructure and make decisions are undergoing fundamental changes.<sup>11</sup>

Transport and communications costs have declined tremendously over time further contributing to the globalization and integration of economies. Between 1920 and 1990, the average cost of freight and port charges declined from \$95 per ton to \$30 per ton. The cost of a three minute phone call between London and New York declined from about \$250 in 1940 to less than \$1 in the 1990's. Computers cost about \$12,000 in 1960 and now cost a few hundred dollars.

Our current infrastructure technology relies substantially on large production facilities tied together by fixed distribution links. Generating plants and wires, treatment plants and pipelines, "edge cities" and highways, and the like together comprise geographically extensive networks; they entail large capital investments. Historians<sup>12</sup> have argued that the basic pattern is rooted in the 19<sup>th</sup> Century, but there have been remarkable advances in production and distribution capability—motorized vehicles, purified drinking water, electricity generation, to suggest only a few—that have greatly enhanced the services our infrastructure can provide. The networks themselves have shown a remarkable capability for expansion, enabling delivery of services to once-remote areas. Service availability has, in turn, spurred further growth and spreading out of demand.

One of the first major indicators of infrastructure's globalization was the creation of Federal Express, incorporated in 1971. This transportation company's business model was a radical re-invention of the messenger services that supported all commerce prior to the advent of telecommunications. Fred Smith, the firm's founder, built on the existing air transport infrastructure to create the long-distance overnight delivery that has now become commonplace and expected. The ideas of just-in-time inventory management and global manufacturers moving partially-finished goods from site to site, to take advantage of local economies, owe their success to the insights embodied in FedEx.

The still-emerging impact of global cellular wireless telecommunications similarly is traceable to the 1973 U. S. patent application Dr. Martin Cooper and Motorola filed for a "radio telephone system." Cellular telephones have made it possible not only for business travelers to keep in touch easily with their offices, from almost anywhere in the world, but also for remote villages to link more effectively into the marketplace. The ability to manage a stream

of global infrastructure services using local assets is hence enabled by global communication systems and the progress of infrastructure's globalization is further deepened by such technology.

Globalized infrastructure in turn influences globalized production. The low-cost digital watches that have become an immensely popular consumer product, often a fashion accessory, could not have been developed without global air transport and telecommunications. The 1976 introduction of the first US\$20 digital watch, by U. S. producer Texas Instruments highlighted the importance of labor costs in what had been a technology-based product. Prices dropped rapidly as production was moved out of North America. In less than a decade, only a single company (Timex) still assembled watches in the United States.

New global modes of infrastructure have emerged as well. The 1980 appearance of the CNN television network marked the arrival of a global information infrastructure that enabled dramatic change in how business is done. With global news and financial reporting delivered "real-time," all the time ("24/7") producers were brought closer than ever before to consumers and the sources of their factors of production. Arguably more significant has been the accelerated global commerce in ideas, exemplified (for the authors, at least) by the 1989 fall of the Berlin Wall and the images of the events that were immediately available to viewers worldwide. Socialism essentially collapsed as a plausible model for the economic organization of human activities, and even those nations that continue to espouse Marxist social ideals are today adopting capitalist market mechanisms in progressively larger segments of their economies.

More subtly, the concept that infrastructure can be privately owned and operated without compromising public well-being has gained increasing acceptance, as exemplified by the 1990's transformation of water utilities in the United Kingdom. The necessary policy and regulatory reforms that were needed to support privately provided infrastructure progressed more rapidly in the telecommunications sector, partly due to the speed by which telecommunications systems were being integrated globally, with the increased needs for standards and compatibility also driving the need for common policy and institutional settings to provide, manage, and operate these systems. The more global integration of telecommunications, communication, and information services therefore resulted in a speeding up of the global provision and management of these systems which still remained with important local infrastructures. In the water sector, where services remain to a large extent local, the progression of policy and institutional reform has also been much slower, as has been the penetration of globally managed water supply and sanitation systems. The water and telecommunications sector exemplify the acute factors that drive local versus global contrasts in infrastructure provision. Institutionally, the existence of regional integration attempts such as the European Union and Economic Commission of West African States (ECOWAS) illustrate further the need for common markets for infrastructure services such as transport, telecommunications, and energy that transcend the local nature of their assets.

With increasing private-sector participation has also come increasing internationalization of infrastructure management. The government approval in 1993 of an alliance between the Netherlands KLM and U. S. based Northwest Airlines was an early case. The "Wings" alli-

ance, granted immunity from antitrust laws, represented a new institutional structure that circumvented ownership restrictions of predominant bilateral aviation agreements, that prevent mergers and acquisitions in international air transport. The alliance—and others that soon followed, e.g., United, Lufthansa and SAS (Star) in 1997—also represented a consequence of the U. S. government’s Open Skies policy, which called for eliminating government restrictions on what routes airlines may fly, the number of flights they may schedule, and the fares they may charge. New Open Skies bilateral and multi-lateral treaties have created progressively larger free-trade zones in global air transport. The 1999 merger of France’s Générale des Eaux with U. S. Filter Corporation to create Vivendi Environment, a multi-national water company, represented a major extension of multinational management to water supplies.

The World Trade Organization’s (WTO) creation in 1995 institutionalized the goal of free trade and the ideal of collective action for the common good of all nations. Like the Berlin Wall, the WTO symbolizes a seismic change, particularly in establishing a binding dispute settlement system that is shaping our increasingly globalized infrastructure.

This progression of globalization has not been altogether smooth, of course. Infrastructure itself has become in more than a few cases an export industry, creating pockets of wealth held by the firms and employees who own and operate the infrastructure on which a widely dispersed and sometimes resentful consumer base relies for transport services, drinking water, energy, and waste disposal. Local communities also have shown increasing resentment and resistance to the presence of infrastructure facilities, even if those facilities could provide substantially improved services to the community. The English-language protest, “Not in my back yard,” has evolved into the internationally-used term “NIMBY.” Because infrastructure draws on financial markets that have become global in scope, what might once have been local liquidity problems spill over into international affairs. Such financial upheavals as Mexico’s “Tequila crisis” in the 1980s, Asia in the late 1990s, and more recently Turkey and Argentina, have forced development economists to re-think the once-promising role of private financing in infrastructure development and management. The September 11, 2001, terrorist attack on the United States has invigorated and added international dimensions to discussions of local vulnerability and security. Such concerns have given rise to rethinking of the relationships of private and public interests in infrastructure service provision and highlighted the challenges for infrastructure professionals implied in the precept, “Think globally, act locally.”<sup>13</sup>

## ACTING LOCALLY

The essential challenge facing infrastructure professionals today is embodied in that precept. How are we to resolve the inherent—and seemingly inevitable—conflicts between accommodating individual interests versus serving collective preferences, and between meeting immediate demands versus providing for future generations. The resolution is achievable, if at all, only at the level of individual projects and enterprises. We offer several examples.

### **Overton Park, USA**

Overton Park, a 342-acre city park located near the center of Memphis, Tennessee, in the United States, contains a zoo, a nine-hole municipal golf course, an outdoor theater, nature trails, an art academy, picnic areas, and 170 acres of forest. In 1956, local planners and the federal Bureau of Public Roads (now the Federal Highway Administration) proposed construction of a six-lane, high-speed, expressway cutting through the park, separating the zoo from the rest of the park and using some 26 acres of park land for the new right-of-way. The road was planned as a segment of Interstate Highway I-40, to provide a major east-west route through Memphis and easier access to downtown from the suburban areas on the city's eastern fringe. The design included primarily below-grade roadway running through open cuts, except for a segment crossing a stream. Government agencies acquired a right-of-way and announced final approval for the route and design in November 1969.

While the highway planners were at work, post World War II economic recovery and consequent middle-class prosperity in the United States was giving political strength to what we have come to call “environmental values.” The National Environmental Policy Act (NEPA), passed by Congress at the end of 1969 signed into law by President Nixon on January 1, 1970<sup>14</sup>, is arguably the most highly visible evidence of the changing balance of power, but there were other signs as well.

The Department of Transportation Act of 1966<sup>15</sup> included a crucial requirement in Section 4(f) prohibiting the Secretary of Transportation from authorizing the use of federal funds to finance the construction of highways through public parks if a “feasible and prudent” alternative route exists. Only if no such route is available may the federal funding be authorized, and then only if the highway incorporates “all possible planning to minimize harm” to the park.

Residents of Memphis, confronted with the prospect of the new highway, formed protest groups and (indulging a strong inclination with U. S. society) hired lawyers. Acting through grass-roots organizations, they took the case to court, eventually reaching the U. S. Supreme Court.<sup>16</sup> They contended that announcements approving the route and design of I-40 did not include formal statements of the Secretary of Transportation's findings that there were no feasible and prudent alternative routes or that design changes could not be made to reduce the harm to the park.

In their court arguments, the citizen groups pointed out that routes around Overton Park certainly could be found. In addition, they argued, the current route could be followed by constructing the highway in a tunnel beneath the park, thereby substantially reducing the lasting adverse impact of cutting the park in two.

The planners responded that construction of a tunnel would greatly increase the cost of the project, create safety hazards, and increase in air pollution that would not reduce harm to the park. Lower courts had ruled in favor of the government's arguments that formal findings by the Secretary were not necessary and that the Secretary's authority was sufficiently wide to support his authorization of the construction.

The Supreme Court ruled in favor of the citizens groups. In doing so, the justices wrote:

*It is obvious that in most cases considerations of cost, directness of route, and community disruption will indicate that parkland should be used for highway construction whenever possible. Although it may be necessary to transfer funds from one jurisdiction to another, there will always be a smaller outlay required from the public purse when parkland is used since the public already owns the land and there will be no need to pay for right-of-way. And since people do not live or work in parks, if a highway is built on parkland no one will have to leave his home or give up his business. Such factors are common to substantially all highway construction. Thus, if Congress intended these factors to be on an equal footing with preservation of parkland there would have been no need for the statutes.*

*Congress clearly did not intend that cost and disruption of the community were to be ignored by the Secretary. But the very existence of the statutes indicates that protection of parkland was to be given paramount importance. The few green havens that are public parks were not to be lost unless there were truly unusual factors present in a particular case or the cost or community disruption resulting from alternative routes reached extraordinary magnitudes.*

The substantially increased costs that any alternative route or design would entail made federal funding of the project essentially impossible. Because federal funds paid for 95 percent of the construction costs of highways on the Interstate system, eliminating federal funding effectively killed the project, and the highway was never built. The case was one of the earliest in which independent citizens groups had mobilized to oppose a government-sponsored project that had been planned according to established governmental procedures, and were successful. The case has been hugely influential, both as a citation in subsequent citizen actions to block other projects and as a force motivating the growth of broad public participation in the infrastructure investment process.

### **Chad-Cameroon Petroleum and Pipeline Development Project**

A recent example similar to Overton Park is the Chad-Cameroon pipeline, a project to develop the oil fields in Doba in southern Chad (at a cost of US\$ 1.5 billion) and construct a 1,070 km pipeline to offshore oil-loading facilities on Cameroon's Atlantic coast (US\$ 2.2 billion). The project is aimed to transform the economy of Chad, a country that is so poor at

present, it cannot afford the minimum public services necessary for a decent life. By 2004, the pipeline would increase Government revenues by 45-50% per year and allow it to use those resources for important investments, necessary to reduce poverty, such as in health, education, environment, infrastructure, and rural development. The sponsors of the project exemplify what a globalized provision of infrastructure entails. Investments come from a consortium consisting of ExxonMobil of the US (the operator, with 40% of the private equity), Petronas of Malaysia (35%), and ChevronTexaco of the U.S. (25%). The project could result in nearly US\$2 billion in revenues for Chad (averaging US\$80 million per year) and US\$500 million for Cameroon (averaging US\$20 million per year) over the 25-year production period.<sup>17</sup>

This project had extensive environmental and social consultation, both at the local level with communities in Chad and Cameroon, but also internationally with concerned interests in environmental and social protection. The project has been seen as one of the examples of how to manage the extraction benefits while preserving social and environmental heritage. In addition to detailed country specific work on environmental and social issues, this project also helped to launch cross-country work across the two countries. The two countries share a common vision for the project, they undertook similar analysis of alternatives, shared the same background work on biological studies and public health analysis, and followed the same approach to consultation and to dealing with oil spills.<sup>18</sup>

### **Jamuna Bridge, Bangladesh**

The Jamuna Bridge,<sup>19</sup> the 11th longest bridge in the world, provides the first fixed crossing of the Jamuna River (the main channel of the Brahmaputra River in Bangladesh), linking the eastern and northwestern parts of Bangladesh. While the concept of the bridge was discussed as early as 1964, construction work commenced in October 1994, and the bridge opened to traffic in 1998, festooned with signs reading “Yesterday a dream, today a reality.” With project costs of nearly U.S. \$1 billion over a 9-year-construction period, it was the most expensive and arguably the most challenging infrastructure investments ever undertaken in Bangladesh.<sup>20</sup> The 4.8 km-long bridge itself is designed to serve multiple purposes, carrying a 4-lane carriage way with shoulders and foundations adequate to carry a railway line, an electric power inter-connector, a gas pipeline, and telecommunications facilities. In addition, the project entailed dikes and other complex river regulation for flood protection. Because of the river’s braiding nature and concerns about the construction’s impact on the changing morphology, the approximate location of the bridge could only be decided in late 1992 and the location of the bridge access roads could not be fixed until late 1994. Nearly 3,000 hectares of land were acquired in a country where land is scarce, and some 100,000 people affected by the loss of agricultural land had to be helped.

The dream of the bridge had several aspects. Before the bridge, fruits and vegetables were trucked and ferried from the northwest region to Dhaka and other markets on the more populous eastern banks, sometimes waiting days to cross the river and often arriving damaged or spoiled. Press reports quoted a local trader from the northwest, “There is a changing mentality here [with the bridge]... now Dhaka seems like it is next door.” During devastating floods in 1998, the bridge played a critical role in preventing famine by enabling food and relief supplies to be transported quickly from one side of the country to the other. Govern-

ment plans enabled by the bridge include development of new export processing zones and private tourism complexes on both sides of the river, that are expected to create jobs and reverse the rural-to-urban migration that has placed growing pressure on big cities like Dhaka and Chittagong. As a crucial missing link in both the Asian Highway and the Trans-Asian Railway, the bridge is also opening new trade opportunities with neighboring countries. Traffic on the bridge has, for the most part, far exceeded expectation. (Table 1)

**Table 1: Usage of the Jamuna Multipurpose Bridge<sup>13</sup>**

	<b>Trucks</b>	<b>Buses</b>	<b>Light vehicles</b>	<b>Average/ Total</b>
AADT in opening year	920	799	575	2,294
Growth Rate (1993-1998)	3.6%	24.1%	32.7%	18.1%
Difference between appraisal and actual in AADT	-16.0%	135.0%	193.0%	41.0%

By reducing the river’s width at Kalihati, from 12km to 4.8km, construction substantially reduced erosion which periodically destroyed homes along the river. A recent study indicates that at least 70 percent of the land along the Jamuna was permanently saved from erosion by the bridge's channeling effect. In addition, the electricity and gas interconnectors that are part of the project should relieve acute energy shortages in the northwest where the only sources of fuel have been firewood, as well as slowing deforestation and spurring growth of industry.

The project was technically challenging, but the institutional arrangements were most noteworthy. Participants in decision making included local non-governmental organizations (NGOs) involved in aid and economic development work, the people living in areas that would feel the impact of construction and changes in the patterns of river flow, the international and domestic firms that formed a joint venture and entered into a 5-year contract to manage the operation of the toll bridge, the Inspection Panel appointed to assure that the project met standards established by the World Bank Group, the Asian Development Bank, and the United Nations Development Program. The Jamuna Bridge Authority (JMBA) was created by special legislation (the Jamuna Bridge Surcharge and Levy Ordinance), and given autonomous financial and managerial decision-making authority. Government agencies developed and put into effect an Environmental Management Action Plan, an Erosion and Flood Action Plan to mitigate impact, and a Resettlement Action Plan establishing legal rights to land and titles for fishing and families dependent on wildlife. Additional legislation facilitated land acquisition and prevented speculators from making fraudulent claims for the loss of houses or structures.

The process employed to make decisions during the construction phase was also complex. Eight Milestone Decision Meetings were held over the course of project implementation, involving the Jamuna Multipurpose Bridge Authority, project financiers, a panel of experts appointed to advise on complex engineering, social, and environmental aspects of the project, representatives of the Government of Bangladesh, consultants, contractors, and NGOs. There were also monthly meetings of the lenders to review progress.

The legislation, planning, and organization associated with the project represented a penetration of new ideas into a traditional and very-low-income society. The degree to which benefits are being realized by the Bangladeshis is being influenced, in turn, by how effectively these ideas have changed weak local governance or built on its existing strengths. Residents of the city of Tangail on the eastern end of the bridge seemingly have benefited more than the residents of Sirajganj on the west, for example, as measured by income increases. The fraction of people earning more than 5,000 taka per month in Tangail increased from 40 percent before the construction to 50 percent after, while in Sirajganj the fraction actually declined from 23 percent to 17 percent in the same period. Observers cite greater social cohesion in Tangail, support by local leadership for community development in surrounding villages, and lower incidence of conflict and fraud. In establishing land and property titles, the government registered title in both the husband's and wife's names, thereby enhancing the status of women.<sup>21</sup>

The Jamuna Bridge case shows how inclusion of different stakeholders in decision-making, commonly referred to as “empowerment”, combined with systemic linkages to decentralized institutions such as local and city governments, can introduce growth enhancing infrastructure in a sustainable way to support rural to urban trade and migration, but also global trade<sup>22</sup>. It was possible in the case of the Jamuna Bridge to see these results because of the length of time it took to get the project done and the complex consultations that were needed.

### **Deer Island Waste-Treatment Facility, Boston, USA**

In part as a culmination of trends illustrated in our preceding examples, and in part because of the NIMBY problem that pervades infrastructure management, one of the most important trends we have observed is the development of infrastructure to always provide multiple services. Consider, for example, Boston's new sewage treatment facilities.

Notable as one of North America's oldest settlements, the city of Boston now lies at the hub of a sprawling region of some 3.4 million people working and living in 129 politically distinct communities. Years of what some people viewed as total neglect of the region's wastewater problems had turned Boston Harbor, by the late 1970s, into one of the United States' most polluted coastal water bodies. Poorly maintained and undersized treatment plants poured millions of tons of raw sewage into the harbor, exposing neighboring communities to health hazards and foul odors. Funding that might have paid for improvements was a low priority for politically driven public officials. Motivated initially by a court suit filed by one of the coastal jurisdictions and encouraged by the federal Environmental Protection Agency (EPA), the state of Massachusetts in 1984 created a new institution, the Massachusetts Water Resource Authority (MWRA), to supply water and sewer services to 61 communities.

Almost immediately, the EPA filed suit against the MWRA for violations of the federal Clean Water Act's limits on pollution. The suit was motivated, according to staff members involved at the time, by concerns that no local constituencies had yet formed and there seemed to be no political leadership for action.<sup>23</sup> A court-ordered schedule of actions required to bring the MWRA into compliance with the Act included consolidation of waste treatment operations, construction of new primary and secondary waste-treatment facilities at the Authority's Deer Island plant, and construction of a 9.5-mile, 24-foot diameter tunnel

outfall to carry treated effluent beyond the harbor, into Massachusetts Bay. The decade-long construction project commenced in 1989. The Boston Harbor Project capital investment program as a whole will cost an estimated \$7.1 billion by the time it is completed in 2009.

The enormous cost of the project results in part from its expansive objectives. If the purpose were only to eliminate the pollution pouring into the water, a local engineering professor surmised, refitting every house in the region with a modern low-volume toilet and building a smaller treatment plant would have done as well and cost substantially less. The various community, local governments, and federal agencies sought to assure, among other objectives, that whales in Massachusetts Bay and beach-goers on the northern shore of Cape Cod would be unaffected by the project, at least in the long term.

The environmental and social resources thereby invested in the project—aquatic biota and recreational attractions—are secured by technology paid for by the region's municipal water consumers: 90 percent of project funds will be provided by local sources. The *Christian Science Monitor* reported that homeowners' water bills increased 329 percent between 1986 and 1999. Annual water charges per household were projected to reach \$1,002 by 2005. However, the treatment plant's location on Deer Island offers attractive views of Boston Harbor, the downtown skyline, and airplanes flying to and from Boston's Logan Airport. The MWRA has included walking trails and other amenities for the region's residents, that go beyond the project's immediate scope and boost the total return on investment.

### **Distributed Energy in Uganda and the Multi-Utilities**

Despite the democratizing influence that the Overton Park, Chad-Cameroon Pipeline, and the Jamuna Bridge projects had through their involvement of many voices not typically heard in the infrastructure decision-making process, all three projects were relatively traditional in their centralized concentration of resources and effort. A somewhat different perspective emerges if one considers the case of rural electrification in Uganda. New technologies for renewable energy sources—solar energy using photovoltaics and thermal conversion, biomass conversion, wind, and small-scale hydroelectric generation—have been coupled with institutional reforms to allow small-scale enterprises to provide power outside of the network grids. Also, a role for small communities to provide their own energy supplies has allowed two previously separate markets—undersupplied rural areas and off-grid industries and farms, and expanding peripheral neighborhoods in congested urban locations—to converge, to their mutual benefit.

Uganda has a population of 23 million people, nearly 5 million households, but only about 10 percent have access to electricity, most of them living in the capital city of Kampala. Rural and peri-urban Ugandans use several forms of energy to make up for lack of access to grid electricity, including kerosene, dry-cell batteries, lead-acid car batteries, and self-generating sets. (Table 2) Ugandans spend an estimated US\$ 100 million per year to power radios, cassette players, and flashlights, indicating that there is a potentially large market for low-cost alternative energy supplies. Recognition of that potential provided the incentive for the Government of Uganda to make regulatory and institutional changes.

**Table 2: Alternative Sources of Energy and their Costs for Ugandan Residents<sup>24</sup>**

Energy Source	Monthly Cost to the Household (USh)	Share of Households Using the Source	Cost (US\$/Kwh)
Kerosene	5,000	100%	
Dry-cell batteries	6,000	94%	400
Lead-acid car batteries	10,900	9%	3
Self-generating set	\$19 million/year, aggregate		0.19

Ush 1050 = US\$1 (as of September 1997)

Prior to these changes, all energy related business in the country was controlled by the Uganda Electricity Board, established in 1948 as a quasi independent, vertically integrated monopoly to generate, transmit, distribute and supply electricity within Uganda and to its neighboring countries. In 1999, the Electricity Act was passed which (a) removed the Uganda Electricity Board monopoly in the power sector; (b) unbundled generation, transmission, and distribution of electricity services into separate companies; and (c) established an independent sector regulator and created a legal and regulatory framework for private sector participation in the energy sector. This reform allowed the emergence of independent power producers to deliver services by accessing the main grid for supply of rural areas, developing independent grid systems, and using the potential of solar or other alternative supplies. The reform allowed fair competition of all suppliers and the use of regionally differentiated retail rates and tariffs as well as non-discriminatory wheeling and access tariffs to facilitate power transactions between distribution concessionaires and third party generators. Subsidy transfer and financing mechanisms were also instrumental.

The government put in place a system to support renewable supply development, using the World Bank executed Global Environmental Facility (GEF) to support stand-alone solar photovoltaics. The Bank's Prototype Carbon Fund was used to finance development of co-generation capacity at sugar mills and coffee husking facilities, small and mini hydro generation, the use of wind generation. The Fund was used also to offer financial support for private sector, commercially-oriented development of energy distribution services to rural and peri-urban areas.

The approach to distributed provision for energy in Uganda also allowed the development of other utility services in a distributed manner, offering opportunities for companies to offer multi-utility solutions. These included telephone services for accelerated rural access to basic telephone, the spread of internet services to district capitals, as well as the development of pilot telecenters. This experience is mirrored in the emergence, in several countries, of "multi-utilities," companies that offer a range of bundled utilities including electric power, natural gas, water and sewerage, and telephone service<sup>25</sup>.

Starpower in the metropolitan Washington area is an example of a company offering bundled services in telephone, cable, and internet.<sup>26</sup> In the UK, bundled gas and electricity services as well as electricity and water are common. Other countries with bundled utility services include Cape Verde, Colombia, Costa Rica, Morocco, and Argentina. In some countries, the bundling extends even beyond utility services. For example, in Hungary a single company offers both transport and telecommunications, while in Chile it is combination of gas and telecommunications services.

Regulatory reform that permits such integration of services is one key factor motivating these enterprises, but efficiencies gained by horizontal integration is another. These companies seek to take advantage of their existing networks of government and customer relations, financing capacity, administrative services, and use of buildings, equipment, and network rights of way. A multi-utility strategy can also be pursued as companies look for opportunities for vertical integration, such as bundling generation and distribution services in the power sector, or linking exports at a port with hinterland transport and then to a bundled port and rail service. P&O Company which has invested in the Port of Colombo in Sri Lanka as well as in other countries pursues such a strategy.

### DIMENSIONS OF INFRASTRUCTURE GLOBALIZATION

Such examples as these illustrate four broad dimensions of change characterizing the evolution of globalized infrastructure (Table 3), an evolution toward more effectively resolving conflicts between individual and collective interests, and between people's immediate demands and society's desire to provide for future generations.

**Table 3: Dimensions of Infrastructure Globalization**

Dimension	Manifestations of Change
Democratization of management	<ul style="list-style-type: none"> <li>• Citizen participation in infrastructure development</li> <li>• Distributed ownership of infrastructure and its returns</li> <li>• Environmental movement as force in infrastructure management</li> </ul>
Decentralization of service provision	<ul style="list-style-type: none"> <li>• High-occupancy vehicle (HOV) operating on roads as preferred alternative to rail transit</li> <li>• Wind power and small-scale power producers</li> <li>• Agency reform/restructuring</li> </ul>
Diffusion of innovation	<ul style="list-style-type: none"> <li>• Private provision of public services; BOO development, warranties and maintenance contracting</li> <li>• Cellular telephone standards</li> <li>• Water-system megacorps</li> <li>• City to City exchange of knowledge, services, and ideas</li> </ul>
Diversification of service scope	<ul style="list-style-type: none"> <li>• Debt-for-environment swaps</li> <li>• Investments for historic preservation, world cultural resources, and other "non-market" goods</li> <li>• "Green" accounting</li> </ul>

**Democratization.** When the environmentally-minded citizens of Memphis and the villagers and farmers along the Jamuna River became a part of the decision making that shaped a major infrastructure investment, they exemplified a broad trend of *democratization* in the decision-making process. Clever use of the political process, requirements imposed by delay-averse financiers, and pressures of world opinion have motivated inclusion of a wider range of "stakeholder" interests in infrastructure investment and operations. Viewed from the global perspective, we believe this trend is the consequence for infrastructure of general political movements toward more open societies.

**Decentralization.** The emergence of small-scale producers and a distributed supply system in Uganda's power sector illustrates a general trend toward *decentralization* we observe on the supply side of infrastructure worldwide. Infrastructure management is devolving toward less centralized control and smaller-scale production processes enabled by new technologies. The immense success of the automobile (and of motorcycles in those places where incomes

remain low) reflects an early instance of the trend now most apparent in energy supply, and perhaps telecommunications. We foresee advances in waste treatment and recycling that could spur similar changes in the water sector.

**Diffusion.** New, good ideas have always spread by *diffusion* from one user to others in different regions or fields of activity, but the speed and transnational scale of the transfers we are seeing in infrastructure mark a third important dimension of globalizing infrastructure. The rise of multi-national infrastructure providers willing and prepared to operate and perhaps even retain ownership shares as well as plan and build infrastructure in other countries represents a major shift from the historical willingness of investors to lend money across borders. In addition, the development of cadres of professionals in many places, educated at a relatively few world-class institutions, has both facilitated the spread of ideas and provided the intellectual resources needed to adapt those ideas to the specific conditions of site and situation. The ability to communicate easily using video-conferencing, email, and the internet, as well as the ease of international travel, are facilitating this diffusion; the World Bank Group, for example, has brought together in a virtual meeting mayors from cities and towns throughout Brazil and international experts, for a day of live discussions of new ideas on city management and development.<sup>27</sup>

**Diversification.** As we have already suggested, the trend toward *diversification*—expansion of the range of services expected of infrastructure—has been motivated in no small measure by the increased difficulty of putting new infrastructure into service. This increasing difficulty is in turn attributable, at least in part, to the trend toward democratization in decision making. However, it reflects also a shift in the values people judge to be important for making decisions; higher priority is now given to protection of wildlife habitat and social stability of communities, for example, than might have been the case several decades ago. We are broadening our concept of the “capital” invested in infrastructure, as well, now recognizing that pristine streams, close-knit neighborhoods, and historic structures have resource value that may not be fully reflected in current market prices. Gradually we are finding ways to measure these resources and make them more fungible, for example trading financial debt for protection of unique lands, or the exchanging pollution rights through the World Bank’s nascent Carbon Trading System.

## INSTITUTIONS FOR THE CONTINUING EVOLUTION

We are confident that the trends of infrastructure globalization will and should continue. We anticipate then that infrastructure professionals will more and more be called upon to think globally while acting locally, through more open decision making, less centralized control, use of internationally best and latest practices, and provision of diverse multiple services using fewer resources.

The traditional owners and developers of infrastructure, local governments and their consultants who must answer primarily to their local electorate, are not well prepared to deal with the challenges of globalized infrastructure. We foresee a growing need for institutions that can facilitate collective action in infrastructure development and management. Such institutions will supplement traditional government agencies, elected officials, and infrastructure professionals by enhancing decision-makers' sensitivity to the indicators of local communities' concerns, including communities at the fringe, and facilitating the balancing of different groups' interests, including those of future generations, and executing and implementing agreed decisions with commitment and accountability to all key stakeholders.

These institutions will have to operate at community, local, regional, national, and multinational levels, enabling coordination across boundaries, professions, and cultures. They will have to recognize and respect the hierarchy of interests that must be balanced in making globalized infrastructure management decisions. Individual preferences gain priority as democratization progresses, and these new institutions must provide the means for reaching consensus when many individuals and groups are influenced differently by infrastructure investment and operating decisions.

We see some emergent examples of what these new institutions might be. In addition to the such multilateral political bodies as the WTO, environmental organizations such as the Nature Conservancy increasingly are working in cooperation with local governments and businesses to protect environmental resources while satisfying demands for infrastructure services. However, institution building takes time and there are many barriers to coordination. The new institutions we foresee will necessarily operate differently from today's practices.

In particular, the new management institutions will have to mitigate the risks posed by rising expectations and diffuse preferences. If individuals and groups expect to be pleased with all aspects of an infrastructure decision, they will almost certainly be disappointed. If institutions of collective action serve only to express that disappointment rather than to facilitate the balance of interests that leads to consensus, decisions will be thwarted instead of implemented. We need to expand our working concepts of what is fair and just in managing infrastructure, and make those concepts an effective part of the decision making process.

As we do so, we will need to devise new ways of exercising management and regulatory control of infrastructure. We certainly can be more effective in the pricing of infrastructure services when markets exist, but we need also to continue developing tools to assist us when markets do not function.

Finally, and most fundamental, we need the motivation to keep working toward infrastructure supportive of sustainable long-term growth and improvement in our quality of life. As infrastructure professionals, we have a commitment to humanity's future prosperity and a belief in our capacity for improvement. At the same time, we recognize that people may disagree on the precise meanings of such terms—prosperity, improvement, and the like—and how they are to be achieved. Without question, infrastructure's globalization poses great and growing challenges for the people who work to manage that infrastructure, but for us the rewards to be gained by meeting those challenges make the effort well worth while.

## NOTES

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<sup>1</sup> The purposes of Jericho's infrastructure may not have been entirely military; see, for example, Bar-Yosef, O. "Walls of Jericho: An Alternative Interpretation" *Current Anthropology* v. 27, no. 2, 1986, p.157-162.

<sup>2</sup> There is not a universally accepted definition of "infrastructure," which some prefer to call "civil infrastructure," "public-works infrastructure," or simply "public works." To confuse matters further, the computer industry has in recent years adopted the word to refer to a variety of software and hardware that enable companies to keep track of their inventory, sales, personnel, and other business information. We confine ourselves to the more traditional usage, but take an inclusive view, that "infrastructure" encompasses facilities and services provided by government and the private sector. A committee of the U. S. National Research Council referred to "public works infrastructure" as including "...both specific functional modes-highways, streets, roads, and bridges; mass transit; airports and airways; water supply and water resources; wastewater management; solid-waste treatment and disposal; electric power generation and transmission; telecommunications; and hazardous waste management-and the combined system these modal elements comprise. A comprehension of infrastructure spans not only these public works facilities, but also the operating procedures, management practices, and development policies that interact together with societal demand and the physical world to facilitate the transport of people and goods, provision of water for drinking and a variety of other uses, safe disposal of society's waste products, provision of energy where it is needed, and transmission of information within and between communities." (*Infrastructure for the 21st Century*, National Research Council, Washington, DC: National Academy Press, 1987) The World Bank describes "infrastructure" as an "umbrella term for many activities referred to as 'social overhead capital'" by development economists, and concentrates on "economic infrastructure," meaning services from public utilities, public works, and other transport sectors. (*World Development Report 1994: Infrastructure for Development*, The World Bank, New York: Oxford University Press, 1994)

<sup>3</sup> While the text translation as "buildings" has made this quote a favorite of architects, Vitruvius' inclusion of walls, harbors, and open spaces makes clear the broader scope of his interest and the relevance of his advice for the professions of engineering and others that have in modern times become less comfortable with grace as a design value to be weighed against strength and utility.

<sup>4</sup> Smith writes in Book Five of *An Inquiry into the Nature and Causes of the Wealth of Nations*, published in 1776, "The third and last duty of the sovereign or commonwealth is that of erecting and maintaining those public institutions and those public works which, though they may be of the highest degree advantageous to a great society, are, however, of such a nature that the profit could never repay the expense to any individual or small number of individuals, and which it cannot be expected that any individual or small number of individuals should erect or maintain. The performance of this duty requires, too, very different degrees of expense in the different periods of society."

<sup>5</sup> Deputit's work earned him the Légion d'honneur in 1843; he published several significant contributions in the *Annales des Ponts et Chaussées*. See, for example, "On the Measurement of the Utility of Public Works," originally published in 1844, reproduced in translation in *International and Economic Papers*, Number 2, London: Macmillan, 1952, pp. 83-110.

<sup>6</sup> See, for example, Hotelling's 1929 "Stability in Competition," *Economic Journal* 39: 41-57, and his 1931 "The Economics of Exhaustible Resources," *Journal of Political Economy* 39(2): 137-175.

<sup>7</sup> Many researchers have looked at the relationship between infrastructure and economic growth using a number of measures of infrastructure. We have in mind here the type of work done by Canning and

Bennathan (2000), "The Social Rate of Return of Infrastructure Investments," and Charles Hulten (1997), "The Contribution of Infrastructure to Aggregate Output," both reviewed in Abstracts of Current research in Infrastructure produced by the World Bank's Development Economics Department. This work made very specific advances in the use of analytical and empirical models for quantifying the contribution of infrastructure to economic development.

<sup>8</sup> Hirschman's seminal book, *The Strategy of Economic Development*, New Haven: Yale University Press, 1958, was followed by *Development Projects Observed*, Washington, DC: Brookings Institution Press, 1967. The latter book motivated a rethinking on the World Bank's programs, and Hirschman's work generally encouraged aid organizations to focus on international exchange of students and technical services. See also Gillis, et al., *Economics of Development*, London: WW. Norton & Co., 5<sup>th</sup> edition, 2001.

<sup>9</sup> English economists Alfred Marshall and his student Arthur Pigou are most closely identified with the principles that underlie much of modern environmental economics.

<sup>10</sup> *New York Times* "Foreign Affairs" columnist Thomas L. Friedman is given much of the credit for popularizing the term and defining the forces and attitudes it entails, for example, in his best-selling book, *The Lexus and the Olive Tree: Understanding Globalization* (New York: Farrar, Straus and Giroux, 1999).

<sup>11</sup> Indeed, we argue that a new globalized infrastructure profession has emerged. *Infrastructure professionals* are concerned with the planning, design, finance, construction, management and operation of the public's fixed capital assets, without necessarily specializing in the workings of any single functional service area such as water supply, transport, or waste management. As with infrastructure itself, there is disagreement regarding whether there truly can be "infrastructure professionals," as we characterize ourselves, or only specialists who have wandered outside of their areas of competence.

<sup>12</sup> See, for example, Tarr, Joel A., and Gabriel Dupuy, eds. *Technology and the Rise of the Networked City in Europe and America*, Philadelphia : Temple University Press, 1988.

<sup>13</sup> This phrase has been widely adopted as a slogan for activism in many areas. Its origin lies, we believe, in economist E. F. Schumacher's seminal book, *Small Is Beautiful: Economics as if People Mattered* (London: Blond and Briggs, 1973).

<sup>14</sup> P. L. 91-190, as amended; 42 USC 4321-4347.

<sup>15</sup> P. L. 89-670, as amended; 49 USC 1653, Subtitle 1, Section 303(c).

<sup>16</sup> *Citizens To Preserve Overton Park, Inc., et al., v. John A. Volpe, Secretary, Department of Transportation, et al.*, 1971 (401 U.S. 402, 91 S.Ct. 814).

<sup>17</sup> More details about the Chad-Cameroon Project can be found in <http://www.worldbank.org/afr/ccproj>.

<sup>18</sup> Among the detailed analyses and studies done for this project are the Chad Environmental Management Plan, Compensation and Resettlement Plan, Regional Development Plan, Waste Management Plan, and Environmental Line List and Alignment Sheets. The Cameroon-specific volumes include the Environmental Management Plan, Compensation Plan, Environmental Foundation Plan which encompasses an indigenous peoples plan and the offsite environmental enhancement program, Waste Management Plan, and Environmental Line List and Alignment Sheets.

<sup>19</sup> The bridge has been officially named, by a decision of the Bangladeshi National Parliament, the Bangabandhu Jamuna Bridge, in honor of the first prime minister of the independent nation

<sup>20</sup> Implementation Completion Report for the Jamuna Bridge Project, June 19, 2000 (World Bank)

<sup>21</sup> However, the enhanced status of women also resulted in higher demands for dowry.

<sup>22</sup> The WDR 2003 on Sustainable Development refers to the kind of institutions needed to perform certain functions well: pick up signals and diagnose problems early and from the fringes—requiring feedback, information, and voice; balance interests—requiring transparency and open fora for discussion; and execute agreed decisions and implement them—requiring credible commitments and accountability. The Jamuna bridge case shows that these types of institutions can be created but they take time (60 years in the case of the Jamuna Bridge from concept to opening up for traffic) and are fragile.

<sup>23</sup> See *In Our Own Backyard: Principles for Effective Improvement of the Nation's Infrastructure*, 1993, A. A. Grant and A. C. Lemer, editors, Washington, DC: National Academy Press.

<sup>24</sup> Source: World Bank: Uganda Energy and Rural Transformation Project, PID 9031, 2001; *ESMAP, Uganda-Rural Electrification Strategy study, September 1999*

<sup>25</sup> While the Distributed Energy Project in Uganda is a good case for the multi-utility concept, it is not easy to generalize from it. At the time this case was written, the project had just become effective and little had been achieved in terms of intended development objectives.

<sup>26</sup> Starpower is a telecommunications company only, but it does indicate the manner in which companies are leveraging their customer interface and common rights of way to deliver an otherwise expensive infrastructure service. Such companies as Bechtel, Fluor, Lyonnaise des Eaux and Indosuez are have grown from their roots in construction to become multinational providers of infrastructure services.

<sup>27</sup> The virtual conference, in December 2002, was enabled by an investment by the Government of Brazil, corporations in Brazil such as Banco do Brasil, and the World Bank, in a Distance Learning Network commonly known as the Global Development Learning Network (GDLN).