CENTER FOR GLOBAL DEVELOPMENT **ESSAY**

People and Places: Can They Align to Bring Growth to Africa?

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ABSTRACT

Since the global financial crisis hit in 2008, talk of new infrastructure projects has abounded, principally because investment in infrastructure is seen as a potent way to provide a fiscal stimulus to economies in recession. Over the last decade, low- and middle-income countries, particularly in Latin America and sub-Saharan Africa, have recognized the importance of infrastructure for achieving rapid rates of economic growth.

The literature has largely focused on identifying the types of infrastructure that are the best means for achieving economic growth and on the modalities for financing such investments. This essay explores what is meant by infrastructure and the factors that affect investment choices, with a particular focus on demographics. Using demographic projections data, it discusses population trends that policymakers should consider as they make choices about infrastructure investment and how these weigh relative to other considerations. The main message is, simply, that demographics matter. Countries with growing populations must be prepared to provide a basic network of water, sanitation and social services and to respond to shifts in the population, particularly the rising number of individuals of working age.

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Preface

Demographics are of key importance to development, but this link is often ignored. Population—the study of people using the tool of demography—is slowly appearing across development discourse, with policy implications that reach far beyond family planning and reproductive health. In this paper, produced under the auspices of CGD's Demographics and Development Initiative, Professor Peter Heller examines the implications of demographics on infrastructure investments in developing countries, particularly in Africa, and its importance in achieving economic growth. Using demographic projections, Heller recommends how policymakers can consider population trends as they make choices about infrastructure investment. As demographic conditions continue to change, so too will infrastructure needs, and governments would do well to carefully monitor the connection between the two in order to achieve maximum benefits from their investments.

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What is Infrastructure?

Infrastructure is a category of investment that is generally, but not always, a public good. In general, investments in infrastructure either produce services directly for household consumption (water, sanitation, social services, telecommunications, electricity) or provide the critical inputs used by enterprises in the production process (transport, port facilities, electricity, and information and communications technology [ICT]). As with any form of investment, spending on infrastructure can take the form of new investment, but also may entail operations and maintenance (O&M) or the rehabilitation of existing infrastructure.[1]

As a public good, infrastructure is characterized for the most part by two features: it is mostly non-rivalrous (that is, if I use it, I do not limit your capacity to use it), and non-excludable (I cannot stop you from using it). Think paved roads or public parks. And the production function of infrastructure is often characterized by economies of scale or increasing returns, meaning that the more that the good is produced or supplied, the cheaper the marginal cost of producing or supplying it. In addition, some infrastructure projects provide benefits beyond the imagined direct benefit; for example, a road allows community members to travel more easily, which is what we might directly expect, but it may also increase tourism to the country because tourists can more easily travel, or may increase education consumption because children can now go to school more easily. For these reasons, the private sector usually undersupplies infrastructure because it cannot capture enough profit to cover the cost of supplying the good.

The World Bank's *World Development Report 2009* defines infrastructure according to three categories, which will be referred to throughout this essay:

- **Spatially universal** infrastructure, which includes things that are necessary anywhere people live, such as housing, water, sanitation, and basic social services (e.g., education and health).
- **Economically productive** infrastructure, such as energy, ICT, irrigation, ports, and transport (roads and railways), which can help to facilitate economic growth and employment.
- **Spatially connective** infrastructure, which can include transport modes that connect regions within a country or that facilitate international trade (either cross-border within a region or with global markets)

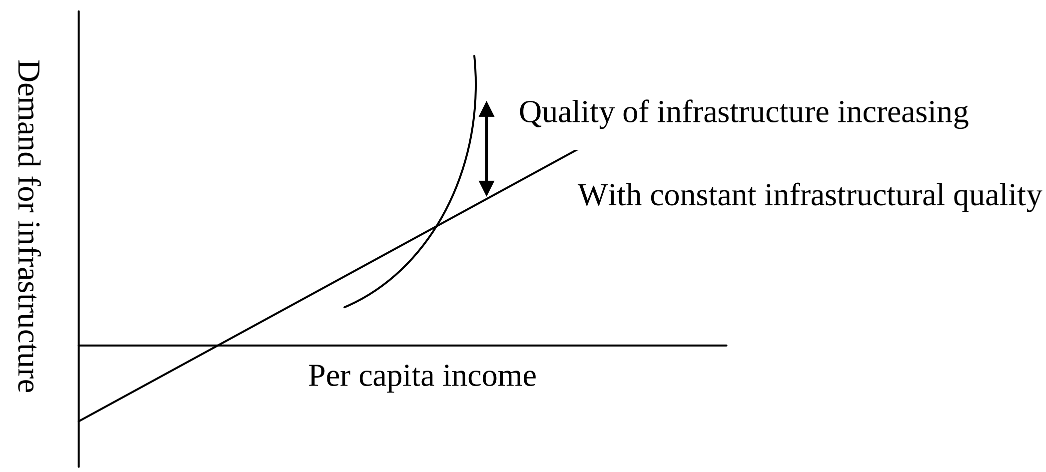
[1] These alternative ways of spending are substitutable to some extent: heavy initial investment outlays may reduce the amount of annual O&M required to service infrastructure or lengthen the periods over which rehabilitation outlays are required. Investment that has a limited life span may require more frequent O&M and rehabilitation outlays (see Heller, 1988).

What Drives Infrastructure Investment?

There are at least six broad factors that influence decisions about infrastructure investments. First, the provision of infrastructure may facilitate or stimulate **economic growth**, providing complementary capital inputs to the private sector. Conversely, the absence of high-quality infrastructure—in telecommunications, transport, power generation, water supply, and port facilities—is widely seen as a costly obstacle deterring foreign private investment. For example, erratic power generation substantially increases the cost of production and reduces productivity. A key policy issue confronting countries with low-quality infrastructure is to determine which investments are the most important prerequisites for growth. Is leapfrogging to the most advanced technology appropriate in the absence of the conjoining availability of human and private capital? Or is there a natural sequencing of infrastructural provision that is more appropriate for encouraging foreign direct investment?

While infrastructure can help to spur economic growth, the reverse causality also holds: growth and rising per capita income bring increased demand for more and better quality infrastructure. For example, the International Monetary Fund (IMF), in a recent World Economic Outlook (IMF, 2008a) notes that once a country's per capita income crosses a given threshold, there is a sharp increase in demand for car ownership. This, of course, intensifies the demand for associated infrastructure for urban and inter-urban transport. As people become richer, investments that upgrade existing infrastructure become increasingly profitable and politically urgent (Graph 1).

Graph 1. Increasing Income Elasticity for Spatially Universal Infrastructure



In short, income levels influence the demand for infrastructure. But when there is significant poverty, low-income groups may be unable to afford even the minimal payments required to cover the marginal cost of supply. Such demand-side constraints may make it difficult to recover costs for new infrastructural investments in low-income countries in the absence of significant subsidies. Hence, in low- and middle-income countries, quality differentials exist in infrastructure—whether water and sanitation, health, education, and transport—between urban and rural areas while such differentials typically do not exist in high-income countries.

Technology is another important factor that drives investments in infrastructure. This is most obvious for the ICT sector, where demand for cell phones and Internet requires satellites, satellite dishes, cell phone towers, and fiber optic cables, among other things. The private sector has been able to leapfrog the government and profitably provide this kind of infrastructure in a competitive market (unlike the largely monopolistic infrastructure associated with traditional communications technologies).

Technological innovations (for example, the development of renewable energy sources and ways to lower carbon emissions) will also create pressure for new infrastructure that can replace outmoded technologies.

But, even in the absence of new technologies, the demand for infrastructure may be shaped by innovative approaches to the *delivery* of infrastructural services. For example, some cities (notably Bogotá, Lagos, and Curitiba, Brazil) have pioneered the use of dedicated urban bus lanes in order to rationalize urban transport systems and encourage the use of public transport, thereby reducing the pressure of vehicular traffic and urban sprawl on existing infrastructure.[2]

A third factor influencing infrastructural investment in and for developing countries is the positive pressure of the internationally agreed-upon UN **Millennium Development Goals**. Target 7c seeks to reduce "by half the proportion of people without sustainable access to safe drinking water and basic sanitation." The specific indicators of achievement relate to the "proportion of population using an improved drinking water source," "the proportion of population using an improved sanitation facility," and to "achieving significant improvement in the lives of at least 100 million slum dwellers by 2020." To meet this target, particularly in the context of rapidly growing urban populations, governments will need to invest significant sums on infrastructure for water, sanitation, and housing. The UN Millennium Project estimates the global financial costs of meeting the MDG related to water supply alone would range from $51 to $102 billion; for sanitation, the equivalent figures are $24 billion to $42 billion.[3]

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[2] Similarly, in the area of sanitation, the UN Millennium Project notes the difference in costs and environmental impact associated with the use of pour-flush systems (as introduced in the Sulabh program in India) as opposed to flush toilets. The former reduces the quantity of water demanded and the quantity of wastewater produced. They also note the different options that exist for off-site sanitation systems, including wastewater conveyance (a simple sewer system), primary treatment systems (sludge drying beds and Imhoff tank), secondary treatment systems (trickling filters, sludge digesters, co-composting of sludge with garbage), and other alternative treatment options (constructed wetlands, in-stream wetlands, and waste-stabilization ponds).

[3] These UN Millennium Project estimates are for a minimum package of services in which low service levels are applied for rural populations and intermediate service levels are applied for urban populations, with the vast majority of need assumed to be in peri-urban areas and slums. The Millennium Project also estimates that for a sample of low-income countries (Bangladesh, Cambodia, Ghana, Tanzania, and Uganda), it would cost roughly $5–7 per capita annually to meet the MDGs relating to water and sanitation, $2–4 per capita annually to improve the lives of slum dwellers, $11–19 per capita annually to meet the energy needs related to the MDGs, and $21 per capita annually to meet the cost of roads.

Infrastructure investments are also related to **societal considerations,** which in turn relate both to poverty reduction and economic growth. In the absence of physical infrastructure, households are forced to adapt in significant ways. For example, without piped water or a village well, women and children may spend hours each day hauling water. Their energy (and associated nutritional requirements) essentially makes up for the absence of electricity, but the value of their "services" is rarely reflected in GDP estimates and is often ignored in considering the costs and benefits of infrastructure provision. The payoff to the provision of infrastructure may thus be understated.

Fiscal constraints have a significant impact on infrastructure investments. With few exceptions private provision of infrastructure has been relatively limited, confined mainly to such things as ICT, toll roads, and some forms of renewable energy.[4] Commercial profitability is hindered by the "free-rider" problem.[5] Thus, the public sector's ability to access financial resources often determines the level of overall investment. Fiscal constraints are most binding for aid-dependent low-income countries with low tax ratios, and limited capacity to borrow on global capital markets.

Many countries view public-private partnerships (PPPs) as a means of financing infrastructure. PPPs entail private financing of the construction and often operation and maintenance of an infrastructure project. Public guarantees are provided in relation to specified risks and usually with a commitment by the public sector to acquire the assets of the project at some time in the future. Although PPPs can alleviate the immediate liquidity constraints that limit a government's ability to invest in infrastructure, they may also entail contingent liabilities that potentially threaten a country's fiscal sustainability. Indeed, PPPs may imply as much sovereign risk as would direct public borrowing for a project (see IMF, 2004).

A final and crucial factor affecting investments in infrastructure, which will increasingly confront many governments in coming years, is **climate change**. Over the next several decades, climate change will result in both rising sea levels and more frequent and intense storms, with an associated higher level of storm surge.[6] Climate change may thus undercut the viability of some areas for settlement in the absence of coastal protection infrastructure. In some cities, it may affect the viability of existing housing infrastructure and settlements and lead to migration or resettlement, creating new demands for infrastructure. It may also lead to an increased risk of periodic flooding, requiring both emergency welfare outlays and infrastructural rehabilitation outlays.

For Africa, hydrological variability will exacerbate the challenge of providing infrastructure for water storage, where storage capacities (now at about 200 cubic meters per capita) are already far

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[4] In Africa there has been some commercial private involvement in infrastructure, principally in the area of telecommunications (especially in East Africa).

[5] In the area of water supply and power, the problem of leakage—of illicit connections—has challenged efforts by private sector firms to be profitable.

[6] Note that each inch of sea-level rise is associated with a five-inch rise in the level of the associated storm surge in heavy storms (see D. Wheeler, 2006).

below levels in Asia (which are on the order of 1,000 cubic meters per capita or higher). In Latin America, the melting of the Andean glaciers and decreased precipitation will force countries to seek alternative sources of energy generation to replace hydropower energy plants. In both Latin America and Africa, changes in precipitation patterns are expected to lead to a need to replace easily washed out gravel roads with more costly, though more durable, bitumen roads.

How Do Demographics Effect Infrastructure?

A number of demographic factors affect infrastructure at national, regional and metropolitan levels. Though it is difficult to separate the pressures of demographic changes from the developments that accompany such changes (such as subsidence, energy use, and socioeconomic developments), policymakers should consider demographics as they make choices about what kinds of infrastructure investments to make and when.

Population size is the most obvious demographic factor affecting infrastructure. The larger the population, the greater the need for a capacity to provide clean water and sanitation services, as well as medical care. Less obvious, but equally important, is the **number of households** in a population. In low-income populations, household size is typically large. As a population's per capita income and elderly population grow, the size of households may significantly shrink, but the number of households may increase, increasing the demand for hookups to essential services such as water, sanitation, power, and telecommunications.

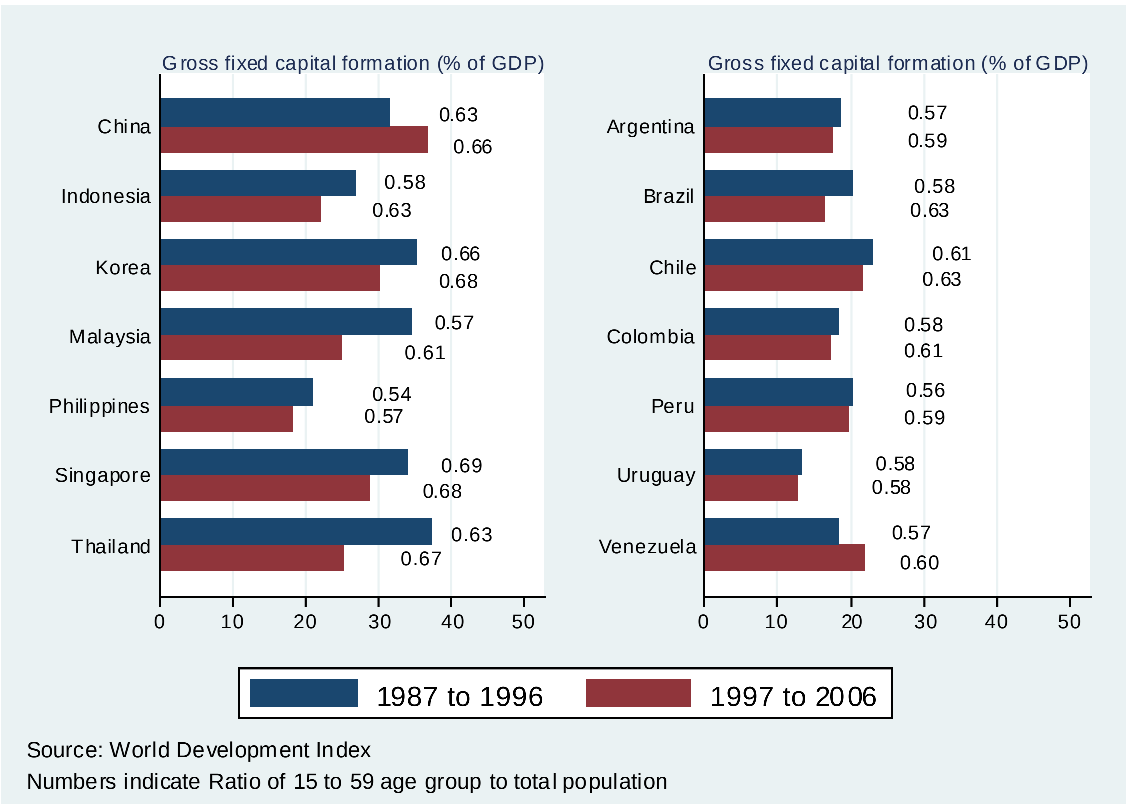
The **age structure of a population** also influences the demand for specific types of infrastructure. A young population implies, all other things equal, a greater demand for infrastructure related to the provision of education services. Conversely, the greater the share of the working age population, the greater the demands for infrastructure that can help to facilitate the creation of jobs, including infrastructure that complements and enhances the productivity of the private sector. Similarly, a large elderly population calls for infrastructure conducive to their needs, such as the availability of long-term care facilities, elderly-friendly transport, and housing structures.

The composition of infrastructure must change as population age structures evolve. High-fertility countries will feel tremendous popular pressure for new schools at all levels of the educational system, while also facing the prospect of continued growth in the number of potential entrants to the labor force, intensifying the pressure on governments to create a business-friendly environment for the private sector.

As a country moves through the demographic transition—as population growth slows and people age—the relative need for education facilities will drop and the need for infrastructure that facilitates job creation will increase. Similarly, in the later stages of the demographic transition, particularly for countries where the fertility rate has dropped significantly below replacement levels, an absolute decline in the population (particularly among the young) is typically accompanied by a sharp decline in the share of the population in rural areas and smaller urban centers (a development increasingly likely in Central and Eastern Europe). Existing infrastructure, particularly in the water and sanitation sectors, as well as education, can become inefficient in scale if the population drops below a certain level, a factor already evident in Germany and other European countries, as well as rural Japan.

It is worth noting that the demographic transition is usually conducive to higher savings and investment rates. The lower dependency rate associated with lower fertility can facilitate saving by households for retirement, medical expenses, housing, and children's education. This is what helped to facilitate the high investment and growth rate experienced among Asian countries during the 1980s and 1990s. Growth in the labor force can also attract foreign investors looking for low-cost labor in a world where many industrial and Asian countries are facing a population with a rising share of the elderly and a shrinking work force. But the potential for higher savings must still be realized in practice. Note how Asia's level of gross capital formation during its period of low dependency was considerably higher than that realized in Latin America during its period of relatively low dependency (Chart 1).

Chart 1. A Lower Dependency Rate is Not Necessarily Associated with a High Investment Rate



Another important demographic factor that shapes the demand for infrastructure is the extent and character of the **urbanization** process, particularly the **size of a city** and the **density of its settlement**. The larger the urban agglomeration, the greater the possibility for economies of scale in the provision of many kinds of infrastructure, which significantly reduces the unit cost of provision, particularly relative to rural areas. This applies to water, sanitation, power, transportation, and even social services. The density of an urban area further reinforces these technological possibilities. Higher (lower) densities significantly augment (constrain) the options for more efficient infrastructure networks that embody economies of scale, particularly for infrastructure of higher quality (see World Bank Group, 2010).

But five factors qualify these relationships. The first is that there is typically a demand for higher and more costly standards of infrastructure in urban areas, particularly in large or mega cities. This creates a number of challenges. Though urban densities may be sufficiently high to create a popular demand for higher quality infrastructure, they may not be high enough to allow significant economies of scale in their delivery.[7] Chart 2 (next page), adapted from a World Bank publication, starkly illustrates the wide variance in the capital cost per capita of standards of infrastructure provision by density. Essentially, in low-density areas, economies of scale may be difficult to achieve, and this is particularly the case in low-density "secondary urban areas."

Second, capital costs and salaries are likely to be higher in urban areas, raising the cost of infrastructure provision. Third, urbanization is often associated with a shift toward manufacturing and services production, which calls for greater provision of economically productive infrastructure in addition to universal services (such as ITC, transport links, electricity). Fourth, the fact of urbanization may not translate into increased infrastructure if fiscal constraints prove binding. Many of the world's larger cities in low-income and emerging market countries have dramatic differentials in the quality and quantity of infrastructure available. Many low- and even middle-income groups live in slums or low-income housing developments with far fewer (if any) and much lower-quality infrastructure services than those provided to upper-income groups. The "water wars" experienced in some Latin American and Asian cities in the last decade (e.g., Cochabamba, Manila) highlight this phenomenon. Indeed, differentials in the quality of the infrastructure available between rural areas and urban slums are often fairly minimal (see Montgomery et al. 2003). However, in net terms, there is likely to be an increased need for infrastructure with urbanization.

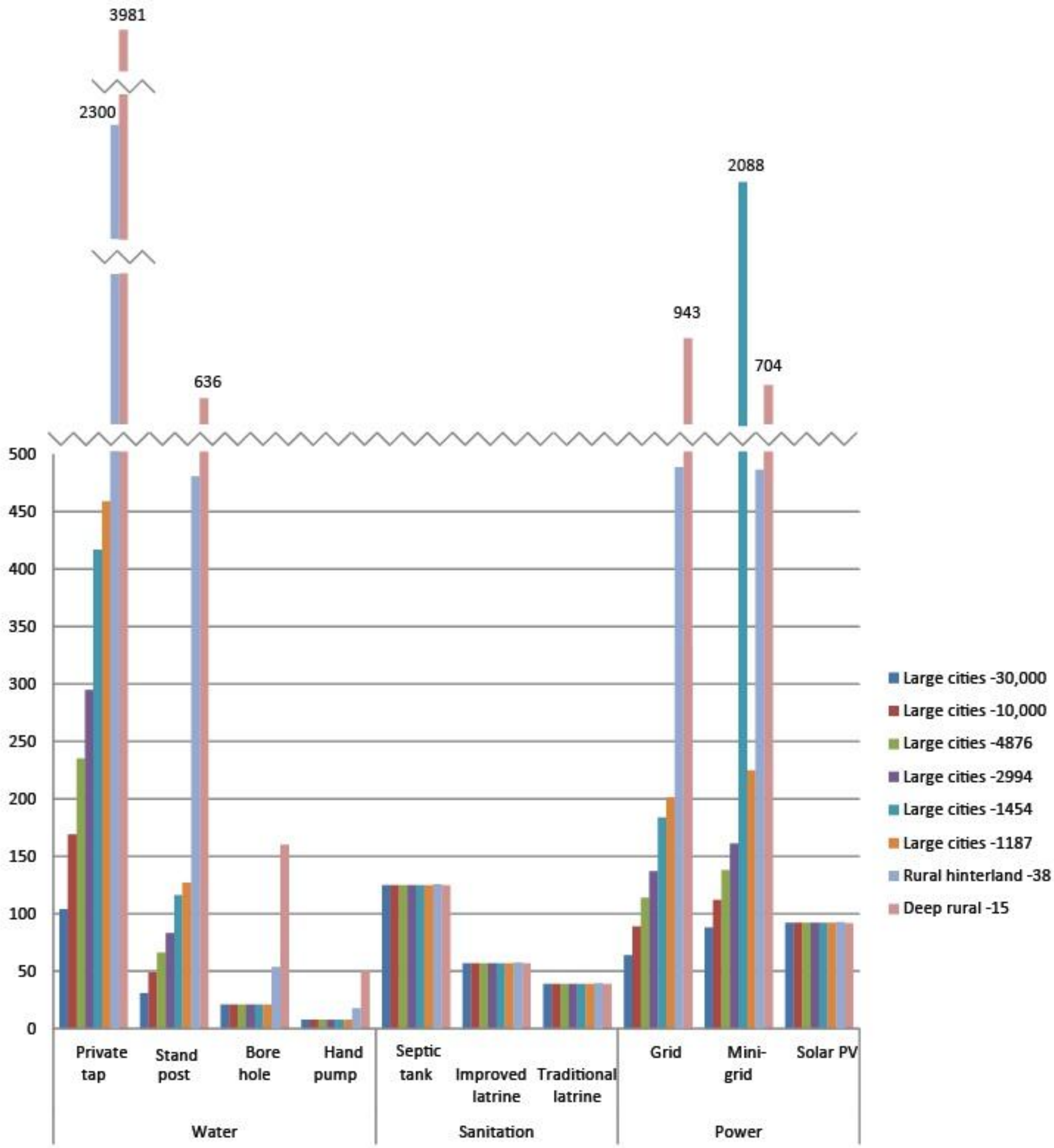
Finally, the pressures for infrastructure that urbanization creates do not determine by themselves the cost or nature of the infrastructure required. Significant differences in the quality of infrastructure exist. Water can be accessed with boreholes and hand pumps, stand-posts, or through private taps. In providing sanitation, traditional or improved latrines may be provided, or septic tanks, or sewage networks. Flexibility in the technology (and quality) decided upon for such basic services can significantly reduce the unit cost of infrastructure (Box 1).

There are several other ways in which urbanization and density affect the demand for infrastructure. Urban populations shift the consumption locus for both the domestic agricultural

[7] Foster and Briceño Garmendia, 2010.

sector and imports, spurring demand for storage, distribution, transport and port infrastructure associated with distant agricultural production.

Chart 2: US$ Investment in Infrastructure Type by Density of Urban Area People / km2



Source: World Bank Group, 2010. Units: US$ per capita.

Further, cities are rarely static. As a city grows, its existing infrastructure may become inadequate and require upgrading or replacement, creating the opportunity for investment in new approaches for water supply or sanitation or in the way in which the urban transport system is designed. Higher densities allow for the substitution of networked infrastructure, enabling both higher quality as well as lower unit costs.

Box 1. Urbanization Requires New Infrastructure, But Are There Alternative Approaches?

As urbanization occurs, there are many choices to make about how to invest in infrastructure, each with different costs. The Millennium Project considered two approaches to urban slum development. One involved the upgrading of existing slum areas, through upgraded housing, the retrofitting of infrastructure for water supply, and the provision of sanitation, transport and energy services. This approach requires a strong focus on *networked* technologies in the areas of sewers, piped water and electricity grids, storm drainage, and water storage.

The Millennium Project's second approach involved the development of new urban sites as an alternative to the formation of new slums. There are significant cost differences between these approaches. The Millennium Project suggests that slum upgrading requires an average investment per person over 15 years (including physical improvements to housing stock, and basic physical infrastructure, i.e., water, sanitation, drainage, road paving, and electricity) of about $42 per beneficiary per year. In contrast, providing new urban settlements can cost about $26 per beneficiary per annum, or one-third to one-half less than the cost of comprehensive upgrading.

In addition, with urbanization, there is a potential for an *unbundling of infrastructure services.* For example, in relation to sanitation services, for large urban areas, one might consider unbundling a service area into parallel independent service zones, each with its own sewerage network, leading to lower average diameter and average depth for the entire city. This can lead to lower capital costs, stretching funds, and easier management requirements. Bangkok is an example of a mega city where the unbundling of sewerage has been successfully applied.

And in many countries, urbanization occurs in coastal or deltaic regions. Particularly for mega cities, larger populations may put pressure on ground water levels as well as cause ground subsidence. Over time, the fall in ground water levels will engender the search for alternative sources of water and the construction of dams or reservoirs. Coastal urbanization also creates a demand for coastal protective infrastructure because of the population and property at risk from storm damage (even under current climatic conditions and ignoring, for the moment, the impact that future climate change might have on the intensity and frequency of hurricanes and typhoons). Ground subsidence from higher population settlement loads would of course be equivalent to a rise in sea level, and thus imply a higher risk from storm surges.

The last demographic factor to consider relates to **migration patterns**. This is not wholly unrelated to urbanization, since significant migration may derive from rural to urban movement. But substantial migration in or out of a country also influences population size, the number of households, and the age structure, and is thus a factor to consider (positively or negatively) when assessing the influence of demographic factors on the need for infrastructure. Policymakers should be sensitive to the precise nature of the rural-urban migration process. Does it largely reflect movements from rural to small cities, rather than simply a more direct migration to the capital city? The former may imply the need to provide new infrastructure for small cities, rather than to expand existing infrastructure networks.

The above heuristic discussion resonates with the empirical literature on infrastructure needs, where three demographic variables tend to be included in most studies—population size, density, and urbanization rate—and these generally prove statistically significant. Occasionally, population growth enters as well.

Does Infrastructure Influence Demographics?

There is one final dimension to the demography-infrastructure connection that is worth exploring, and this is whether the availability of infrastructure might be an independent factor influencing demographic developments. A number of relations might be posited. Does the availability of higher quality infrastructure influence migration decisions, say from rural to urban areas, or even from low-income to high-income countries? Some countries, notably China, have actively sought to develop cities, with the expectation that the availability of jobs would induce rural to urban migration. Indirectly, since fertility rates tend to be lower in urban areas, the availability of infrastructure may not only spur migration but ultimately lower fertility rates.

Along a similar dimension, the availability of certain types of infrastructure (e.g., separate toilets for girls in primary and secondary school) might set in motion decisions that then influence demographic factors, such as fertility. For example, there is compelling evidence that the provision of education to girls reduces fertility rates. But parents are often deterred from sending girls to school by the absence of separate sanitary facilities. Similarly, an adequate transport infrastructure, particularly in the rural areas, might facilitate access by isolated populations to both education and health facilities, which may increase the likelihood of child survival, a prerequisite for reduced fertility.

The issue can be posed from another angle. The absence of infrastructure—adequate roads, primary health clinics, primary schools and so forth—may be an important factor underlying higher morbidity and mortality rates or lower primary school enrollment rates. Such conditions might thus explain the slow pace of the demographic transition observed in many African countries and in rural areas.

Looking Ahead: What Do Demographic Trends Mean for Infrastructure through 2050?

What do demographic projections imply about the need for infrastructure investment in the coming decades? Drawing principally on the United Nations Population Division's (UNPD) 2008 population projections (using the medium and high variant assumptions), this section focuses on expected population growth; the size of the school-age, working-age, and elderly populations; and the urbanization rate (drawn from the UNPD's 2007 urbanization projections) in three categories of countries, with a special focus on Asia and Africa.[8] These categories represent the different stages of the demographic transition: the transformation of countries from high birth rates and high death rates to low birth rates and low death rates as part of the economic development of a country from a pre-industrial to an industrialized economy.

It is important to keep in mind two deficiencies in the UNPD projections. First, as noted above, the number of households may be more important than the total population size as a variable influencing the demand for infrastructure, and this variable is not included in the UNPD projections. Second, the UNPD's projections of urbanization use only the median variant population projections, rather than all the variants. They are also independent of any projections on economic growth during the projection time frame and do not allow for characterization of density levels. Yet the pace of economic growth influences urbanization rates.

Category 1: High Fertility (Mostly African) Countries

The first category of countries includes those experiencing relatively high rates of population growth. These countries are still in an early phase of the demographic transition (even if they have begun to observe some fall in their fertility rates). Among the countries characterized by the UNPD as having relatively fast rates of population growth are most African countries, including Afghanistan, Burkina Faso, Burundi, Chad, Democratic Republic of the Congo, Ethiopia, Guinea-Bissau, Kenya, Liberia, Mali, Niger, Nigeria, Somalia, Tanzania, Timor Leste, Uganda, and Yemen. Policymakers in these countries will experience an obvious demand for spatially universal infrastructure (housing, water, sanitation, and basic social services) through the next several decades.

Demographic need alone, however, does not mean that investment in such infrastructure will occur. Despite significant population growth over the last decade, infrastructure investment has lagged in sub-Saharan Africa (Table 1). This deficit is largest for traditional areas of infrastructure—power generation, telephone landline availability, electricity coverage, and paved

[8] The medium-variant scenarios assume a gradual reduction in fertility rates to close to two over the next 40 years in countries that have high fertility rates. For sub-Saharan African countries, such projections may be optimistic, assuming too rapid a fertility rate reduction. The high-variant assumptions assume fertility rates of at least 0.5 above the median-variant assumption. These are used in some of the projections provided below.

road density.[9] Power consumption in Africa is only 10 percent of that in other low-income countries (at 123 kwh per capita per year)—*and falling*. Since 1990, there has been little change in the share of the population with access to landline telephones, flush toilets, or piped water and only small improvements in the fraction of the population with access to electricity (increasing from only 22 percent to 28 percent). Rapid urban growth has left "infrastructure service providers severely stretched, [with the] … resulting gap [in water and sanitation] filled by lower cost alternatives such as boreholes and pit latrines" (Foster 2008, p. 3). Only for relatively new types of infrastructure, such as mobile phone and Internet density, are the gaps with other low-income countries smaller.

Table 1: Infrastructure Availability In sub-Saharan Africa and Other LICs

	Sub-Saharan Africa	Other LICs
Paved road density (km/km^2)	31	134
Total road density (km/km^2)	137	211
Mainline density (lines/1000 inhabitants)	10	78
Mobile density (lines/1000 inhabitants)	55	76
Internet density (lines/1000 inhabitants)	2	3
Power generation capacity ($MgWt/M^3$inhabitants)	27	326
Electricity coverage (percent of population)	16	41
Improved water (percent of population)	60	72
Improved sanitation (percent of population)	34	51

Source: Foster (2008), p. 2

In Africa, any kind of economic takeoff will require, at a minimum, filling existing infrastructure gaps, particularly in the power sector. Beyond that, there remains the challenge of providing infrastructure to meet the needs of a rapidly growing population. After 2025, while the increase in the size of the school age population is less than half that of the previous two decades, there will still be a significant absolute increase. And more crucially, there will be an enormous increase in the working age population—at least 433 million and most likely higher (under the high population variant). Absent the necessary complementary economic infrastructure, the private sector in Africa will face an enormous challenge to provide employment for this burgeoning work force.

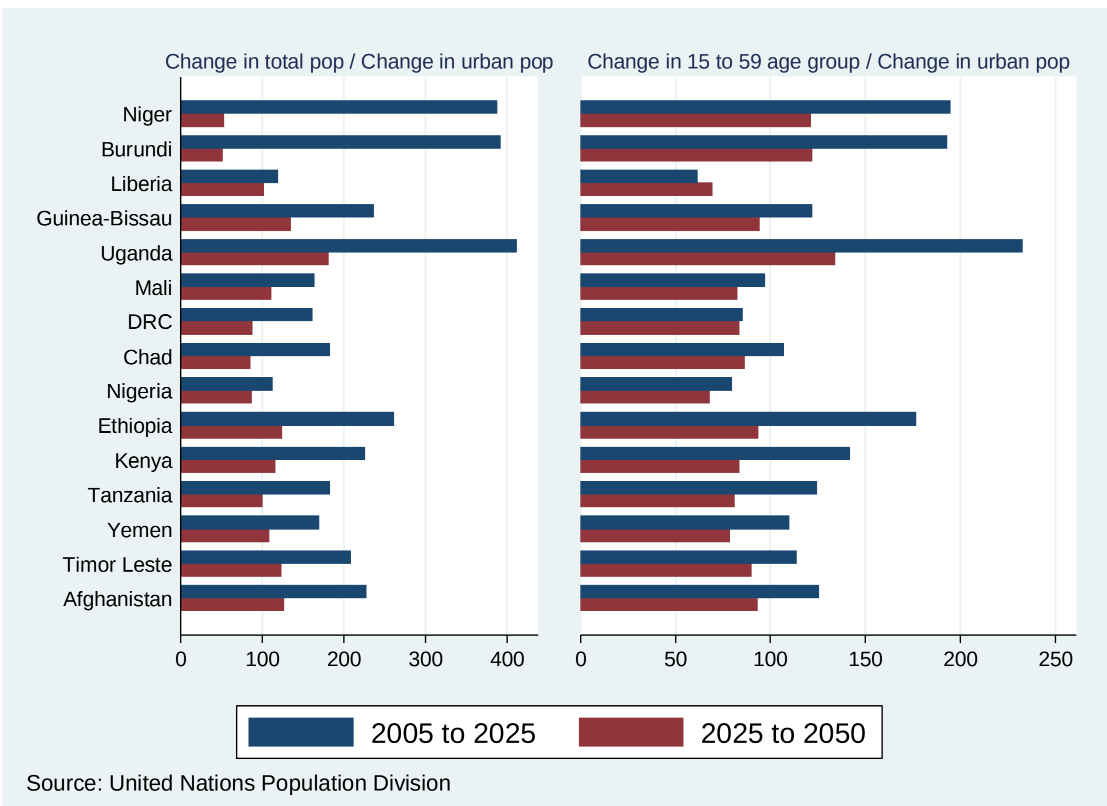
If fertility remains high in category one countries, policymakers will face the classic uphill battle associated with continuing growth in demand for spatially universal infrastructure services coupled with high dependency burdens that limit the availability of savings. In contrast, if

[9] See "Power and Roads for Africa: What the United States Can Do," *White House and the World* Policy Brief, Vijaya Ramachandran, Center for Global Development, 2008, http://www.cgdev.org/content/publications/detail/16557

fertility rates begin to fall, as the UNPD projects that they will, these countries will begin to observe, by 2025, a fall in dependency rates and a rising share of their populations in the working age group, with the implied shift in the character of the composition of infrastructure demand (Chart 3). The virtuous cycle of the demographic transition will then begin to be revealed, yielding at least the potential for higher savings and investment rates, and a higher economic growth rate associated with an increase in the labor force.

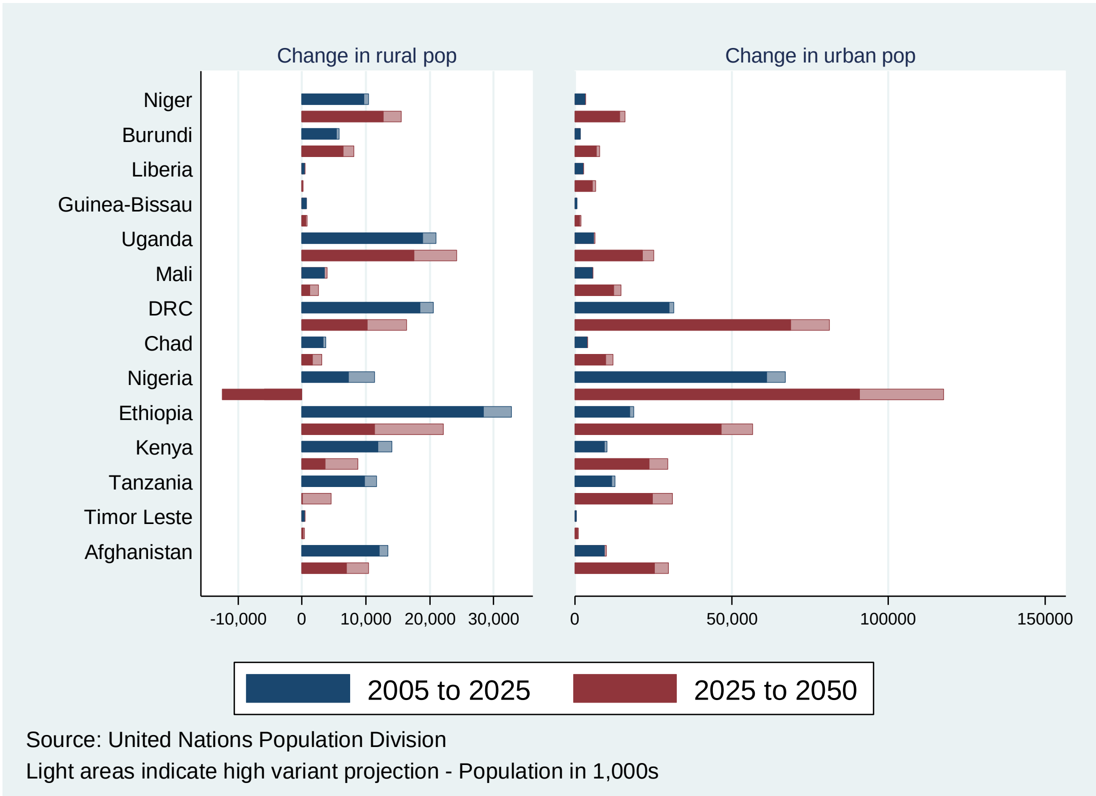
Also noteworthy, the UNPD projections suggest that this group of countries will begin to experience significant urbanization, particularly in the second quarter of this century (Chart 3), with the bulk of the urban population likely to be dominated by those of working age. This reinforces the importance of providing economic infrastructure—power, telecommunication, and transport— to facilitate increased private investments in services and manufacturing. Reflecting the low level of per capita income in these countries, the economic pressures for high-density settlements will be relatively small, implying limits on the ability of governments to install large-scale infrastructural service networks.

Chart 3: Rapid Urbanization Dominated by Working Age Population Groups



The UNPD also suggests that despite increasing urbanization in these countries, there will still be a growing number of persons living in rural areas, particularly over the next twenty years (Chart 4). Rural infrastructure will be needed both to address dramatic existing deficiencies and inequities, and to respond to the growth in the absolute size of the rural population. For rapidly growing countries—Burundi, Ethiopia, Guinea-Bissau, Kenya, Niger, Uganda, and to a lesser extent Tanzania, the Democratic Republic of the Congo, and Afghanistan—connective transport infrastructure will also be important, allowing rural areas to export their agricultural produce to urban centers at low cost.

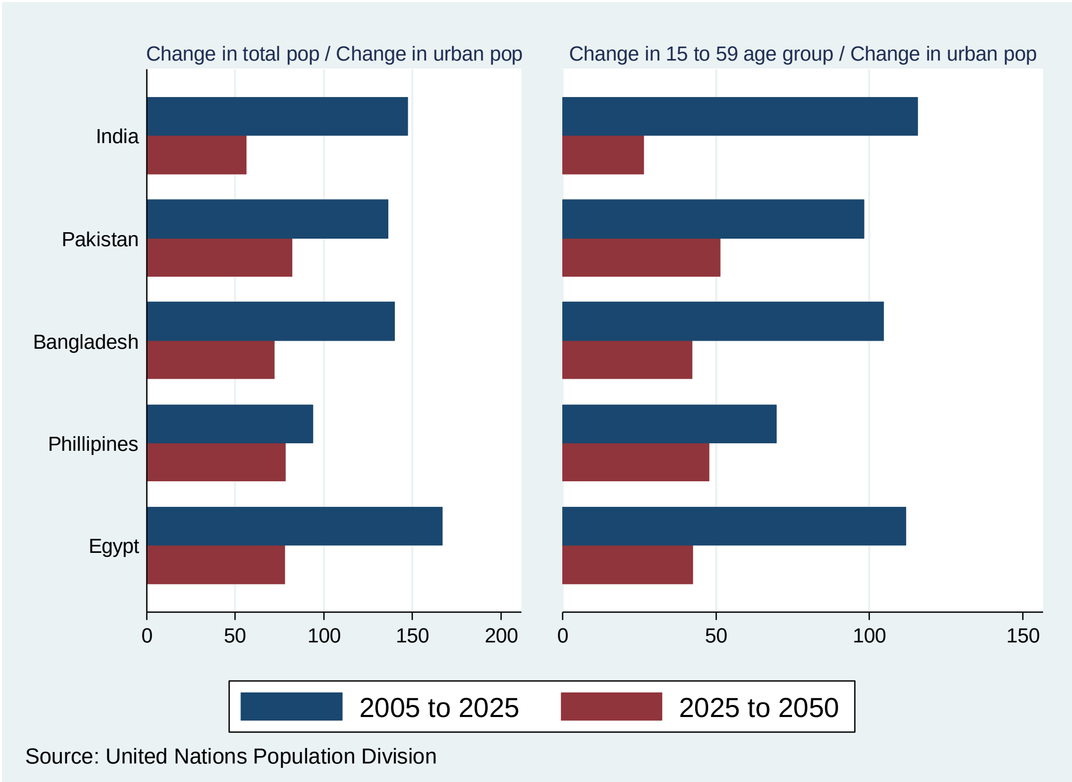
Chart 4: Countries in the Early Phase of the Demographic Transition: Rapid Urbanization But Rural Areas Still Important



Category 2: Countries (Mostly Asian) With Some Reduced Fertility

The second category of countries (which, with the exception of Egypt, are in South or Southeast Asia) includes those where population growth is still high but where there has already been a demonstrated reduction of fertility. These countries, which include, Bangladesh, Egypt, India, Pakistan, and the Philippines, will still experience significant absolute increases in population through 2050 due to momentum, but unlike category 1 countries, both the share of the working-age population and the dependency rate will remain unchanged. These countries will also begin to observe a significant shift in their population structures toward the elderly, away from the youngest age group. They will also begin to observe a dramatic shift, particularly after 2025, in the urbanization rate, with a sharp fall in their rural populations (Chart 5).

Chart 5: Countries Where Urbanization Will Begin to Deplete Rural Areas



There will still be substantial growth in these countries' rural populations through 2025, particularly in India, Pakistan, and Egypt, even though this rural population growth will be dwarfed by the growth in their urban populations. This will require universal services infrastructure as well as spatially connective transport infrastructure. However, the dramatic decline in the size of the rural sector after 2025 suggests that policymakers may wish to invest less in rural areas for the next decade or so. Otherwise, much of the infrastructure may prove costly and inefficient, given the shifting weight of the population towards urban areas.

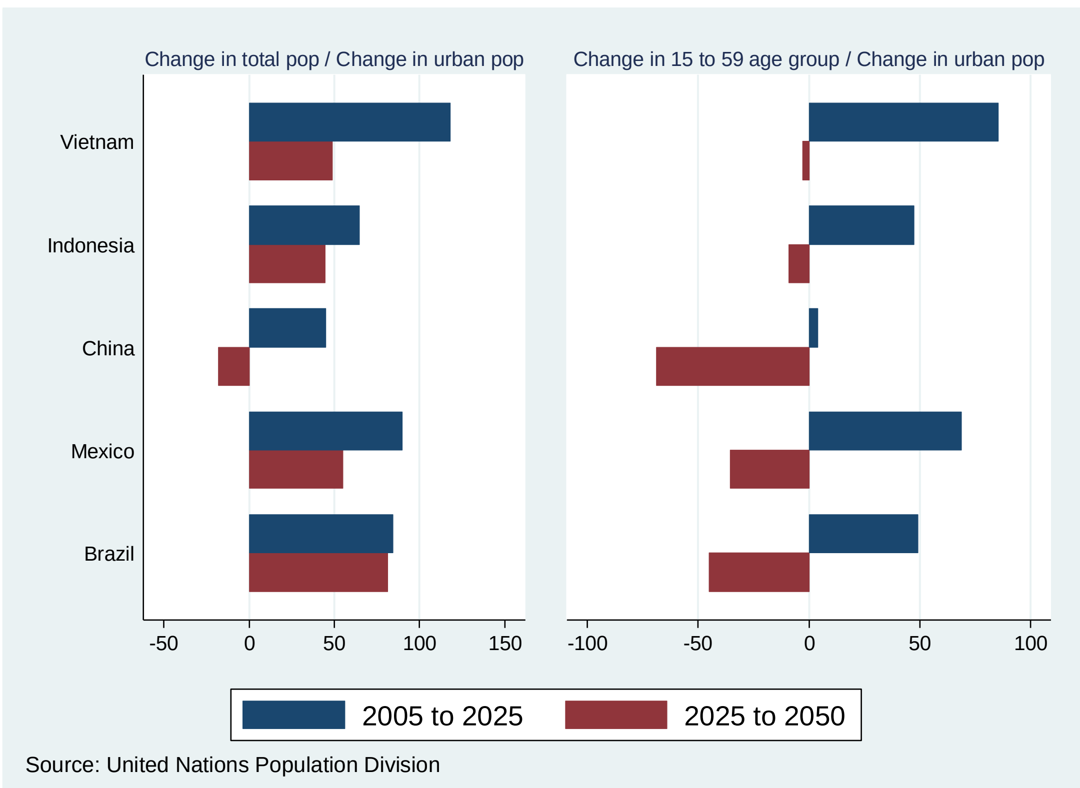
For Asia specifically, where infrastructure provision has been dynamic in recent decades, the demand for new infrastructure will principally center on strengthening transport routes and extending modern ICT infrastructure. Higher urbanization rates in these lower-middle and middle-income countries may imply higher per capita infrastructure costs, mostly reflecting the demand for higher-quality infrastructure, which may offset savings from the economies of scale associated with high-density settlements.

In terms of absolute population growth through 2025, Asia continues to dominate, with medium-variant population growth equaling 836 million persons (compared to 479 million in Africa). But after 2025, this dominance will likely reverse, with a significant slowing in Asia's population growth (with an increase by 459 million during this period relative to 599 million in Africa).

Thus, there will be a high need for spatially universal infrastructure in Asia, with high necessary levels of investment since these countries have higher per capita income levels and are more densely urbanized.

In Asia, the urban population is projected to grow by *more than double* the total population (1.05 billion versus 460 million), and the growth of the 60+ elderly population—at 540 million—will account for half of that growth (Chart 6). In contrast, in Africa, the growth in the urban population, at 575 million, is only somewhat higher than the growth in the working age population. Thus, in Asia, the challenge will be less to expand infrastructure to provide complementary capital for the work force and more to upgrade infrastructure associated with more highly valued additional jobs, as well as infrastructure to meet the needs of an elderly population (with presumably greater levels of household units per capita).

Chart 6: Advanced Demographic Transition: Rural Populations Wane while Urban Populations Shift toward Elderly



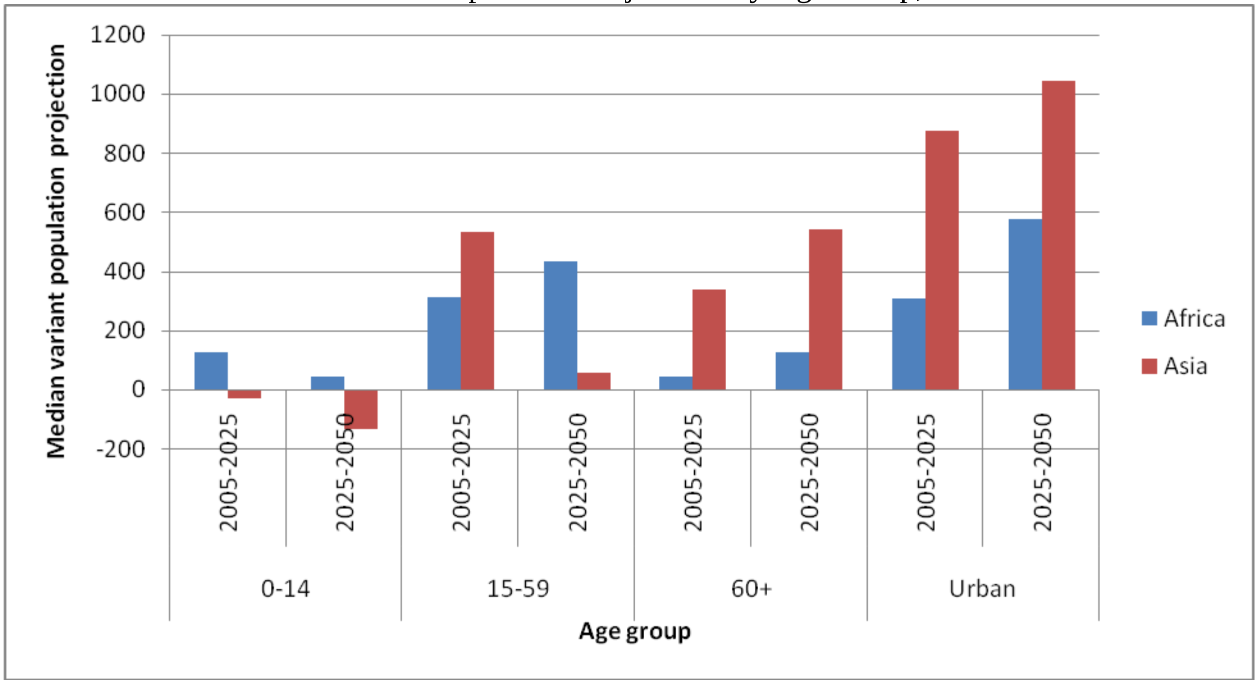
Also over the next 20 years, there will be a high demand for economic infrastructure in Asia, with an increase of 533 million in the population in the productive age group. Given the lower degree of risk associated with investments in Asia (due to the lower cost of doing business by any set of governance indicators), one might expect a far greater share of private capital flows to be drawn to investments in the Asian region, whether in terms of purchases of Asian sovereign debt instruments or in terms of participation in public-private partnerships (Table 2).

The only factor that will mitigate pressure for economic infrastructure spending in Asia relates to the demand for educational infrastructure. Asia is expected to witness an absolute decline in its 0-14 school-age population (compared to the still large growth of 125 million in Africa's school-age population). A need for secondary and tertiary educational infrastructure in Asia will presumably remain, but demand can be expected to slow. This suggests the need for a rationalization of the educational infrastructure rather than any new construction.

Table 2. Projected Annual Infrastructure Investment Needs: Africa and Asia, 2008–18
(As a percent of GDP per annum)

	Africa		Asia	
Annual required spending	New	O&M	New	O&M
Information and communication technologies	0.1	0.1	0.5	0.9
Irrigation	0.2	—	—	—
Power	4.2	2.4	2.0	1.0
Transport	1.7	1.5	0.9	0.5
Water and Sanitation Services	0.4	1.2	0.2	0.4
Total	6.9	5.2	3.6	2.8

Chart 7: Median-Variant UNPD Population Projections by Age Group, 2005–2050



Category 3: Low-Fertility Countries

Countries in the third category are well advanced in their demographic transition and have now experienced low fertility rates for a considerable period of time. They include, most notably, such prominent countries as Brazil, China, Indonesia, Mexico, and more recently, Vietnam (Chart 5). While the UNPD projects an increase in the overall population of these countries in the coming decades, a sharp decrease in the share of the younger age group and a substantial increase in the share of the elderly population are likely, implying an increase in the number of household units per capita. This will likely be matched by a large drop in the share of the working-age population, implying an increase in the overall dependency rate and signifying the end of the period when the demographic transition affords the dividend of a higher potential savings.

These countries will also experience a substantial increase in the urbanization rate—mostly of high density—and an absolute population decline in rural areas even in the next decade or so. Over time, a deceleration in demand for economic infrastructure and an increase in the demand for spatially universal infrastructure are likely, reflecting a high level of urbanization and an increasing number of household units. With rising incomes in these countries, one would also expect a demand for an upgraded quality of infrastructure in rural areas, reflecting the convergence in infrastructure standards that arise at higher income levels. A particularly interesting challenge for these countries (as well as the aging industrial world in general) is how to adapt certain elements of their urban infrastructure to accommodate an aging (and even shrinking) population (Box 2).

Box 2: Singapore: Approaches to the Adaptation of Infrastructure for an Aging Population

In many industrial and middle-income countries, the coming decades will see a large increase in both the absolute numbers and the share of the population of the elderly relative to other segments of the population. Many of the elderly will be retired; others will work part time. Increasingly, many will fall in the category of very elderly, particularly in industrial countries. Singapore is one of the few countries to have comprehensively assessed the implications of a substantial number of elderly on infrastructure.

In 2007, its *Committee on Ageing Issues: Report on the Ageing Population* provided guidelines on these issues. Among the recommendations:

- Prepare guidelines on providing accessibility and safety features in the homes for seniors.
- Make all new public buses low-floor, step-free, and wheelchair-accessible to allow everyone to use the public transport system.
- Expand and accelerate the upgrading and improvement of existing barrier-free measures on road facilities to enhance accessibility between destinations.
- Establish a new intermediate government residential care facility to address the current

service gap in intermediate residential care for seniors.
- Develop integrated models of day care and day rehabilitation centers, based on market driven needs, to provide more client-centric and efficient services.

How Should Policymakers Decide Where to Invest?

This essay was prompted by the question of how policymakers should take demographic factors into account in considering their infrastructure investment priorities. Understandably, demographic factors are not the only issues that do (or should) shape infrastructure decisions. Policymakers must weigh many considerations when deciding where to invest, including, as discussed earlier, economic growth, the demands of technology, sociological issues, fiscal issues, and climate change.

Money is perhaps the most binding constraint. Governments must consider whether fiscal resources will be adequate to finance infrastructure investments over the long term. Making such an estimate is not easy, since in principle, highly productive infrastructure investments can raise the potential growth rate and thus enhance the level of investment that might be fiscally sustainable (see Buiter, 2004, for an approach to estimating fiscal sustainability).

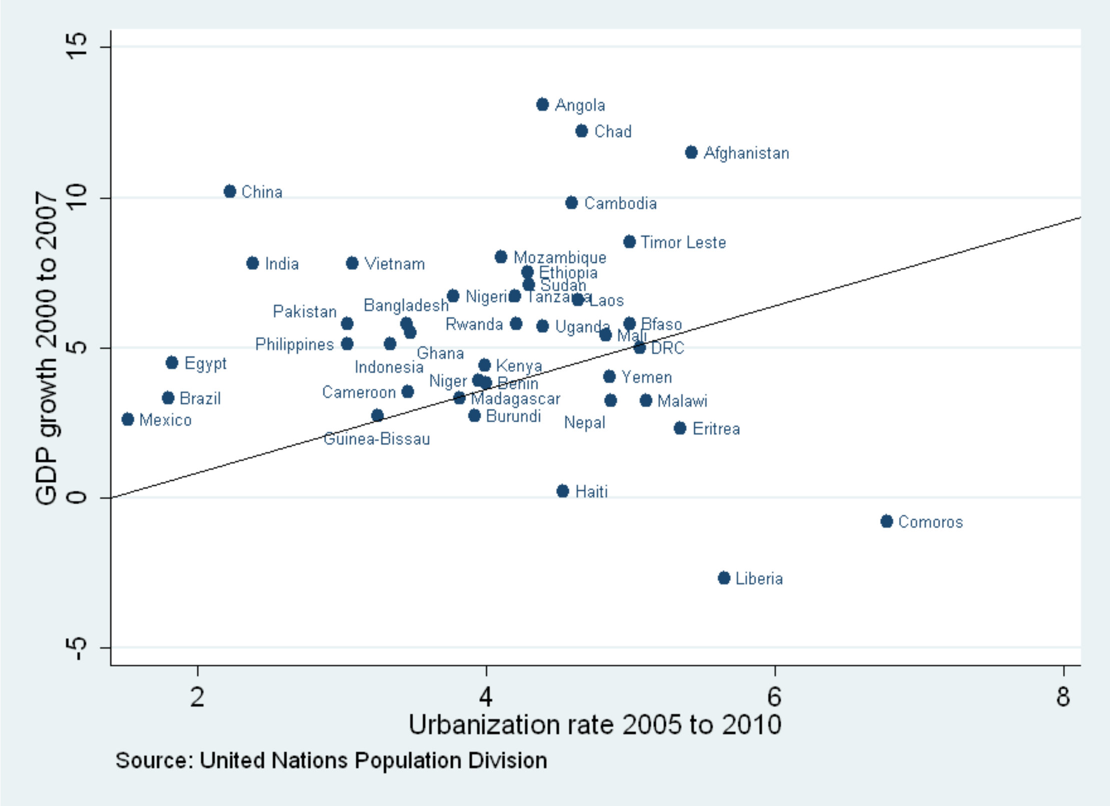
One approach to judging whether fiscal sustainability considerations might limit the potential for infrastructural investments is to compare the real growth of the economy with the rate of urbanization. For countries where urbanization growth rates are more rapid than that of real growth, one might question whether the increase in government revenue will be sufficient to finance the needed amount of infrastructure. This issue is particularly relevant in countries where the share of the urban population is relatively high.[10]

Graphs 2 and 3 provide a simple characterization of this issue, comparing real growth rates during the period 2000–07 with the projected annual growth of the urban population during the periods 2005–10 and 2025–30, respectively. The graphs are drawn such that countries above the line have higher real growth rates during 2000–07 than the projected urbanization rate for 2005–10 or 2025–30.

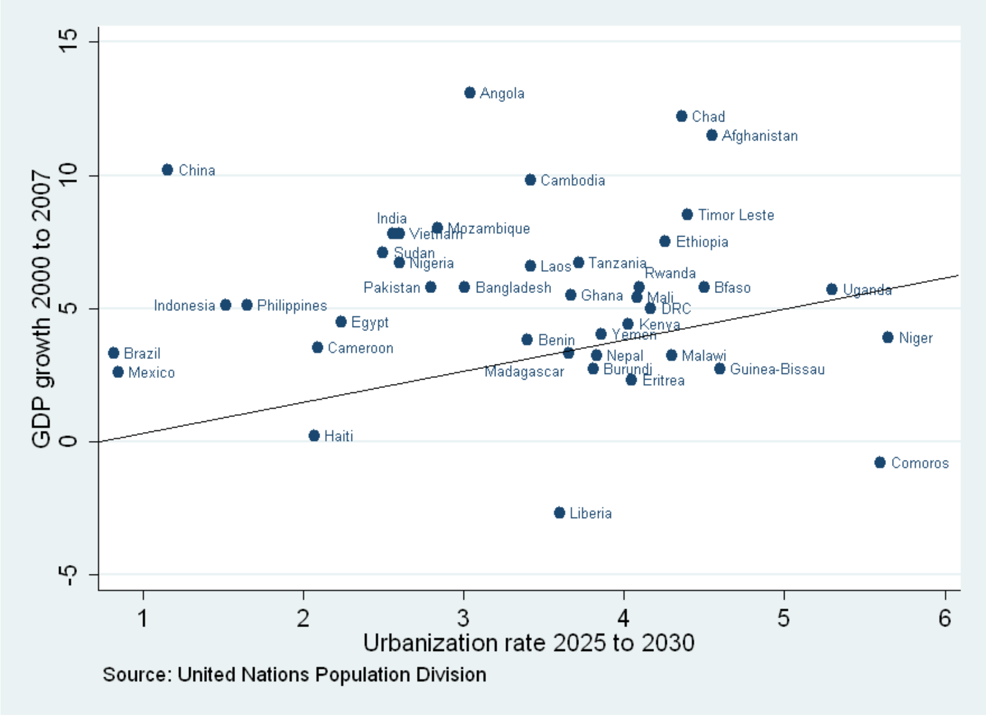
These graphs suggest that a number of countries—notably Burundi, Comoros, Eritrea, Haiti, Liberia, Madagascar, Malawi, Nepal, and Yemen—will evince current real economic growth rates less than their projected urbanization rates in the future. Several other countries—Benin, Cameroon, the Democratic Republic of the Congo, Guinea Bissau, Kenya, and Niger—will be able to realize current real growth rates roughly comparable to their projected annual urbanization rates. However, even these countries may be hard pressed not only to keep up with the infrastructure requirements associated with urbanization, but also to make up for the significant infrastructural backlog that they have allowed to develop over the last decade or so.

[10] For countries with only a small urban share, a high rate of urbanization in excess of the real growth rate would not necessarily imply that the growth in revenues was insufficient to finance the needed urban infrastructure.

Graph 2: Comparing Current Economic Growth Rates with Projected Urbanization: 2005–10



Graph 3: Comparing Current Economic Growth Rates with Projected Urbanization: 2025–30



Other factors that interact with demographic trends will also play an important role in influencing policymakers' infrastructure choices in coming decades, and the most important of these is climate change. Particularly for Asian countries, the effects of climate change, coupled with urbanization, will pose significant challenges to the viability of coastal cities and will require either coastal protection investments or revised settlement patterns. The combination of socioeconomic development, population growth, and the possibility of human-induced subsidence in these urban centers will dramatically increase the exposure of a number of cities—both in terms of population numbers and the value of assets—to the impact of flooding, storm surges, and wind damage, even in the absence of the higher sea level and increased storm intensity associated with climate change (Nichols et al. 2008).

The increase in population alone could result in a 150 percent increase in the number of persons exposed to the risk of a 100-year storm, even with no other factors involved (40 million in 2000 to 95 million in 2070). If one includes the impact of higher storm intensities, the rise in sea level, and the effects of human-induced subsidence, the population at risk increases to 140 million. Similarly, the value of urban assets at risk during this period will rise from $3 trillion to $35 trillion. Low-income countries in Asia and Africa will face the brunt of the exposure to such risks, due to their minimal existing flood/coastal protection infrastructure, the sharp increase in the size of their population centers, limited urban land-settlement programs, and the rapid projected socioeconomic development. Drawing from the study by Nichols et al. (2008), Map 1 shows the Asian, African, and Latin American coastal cities with maximum risk exposure in terms of the population at risk.

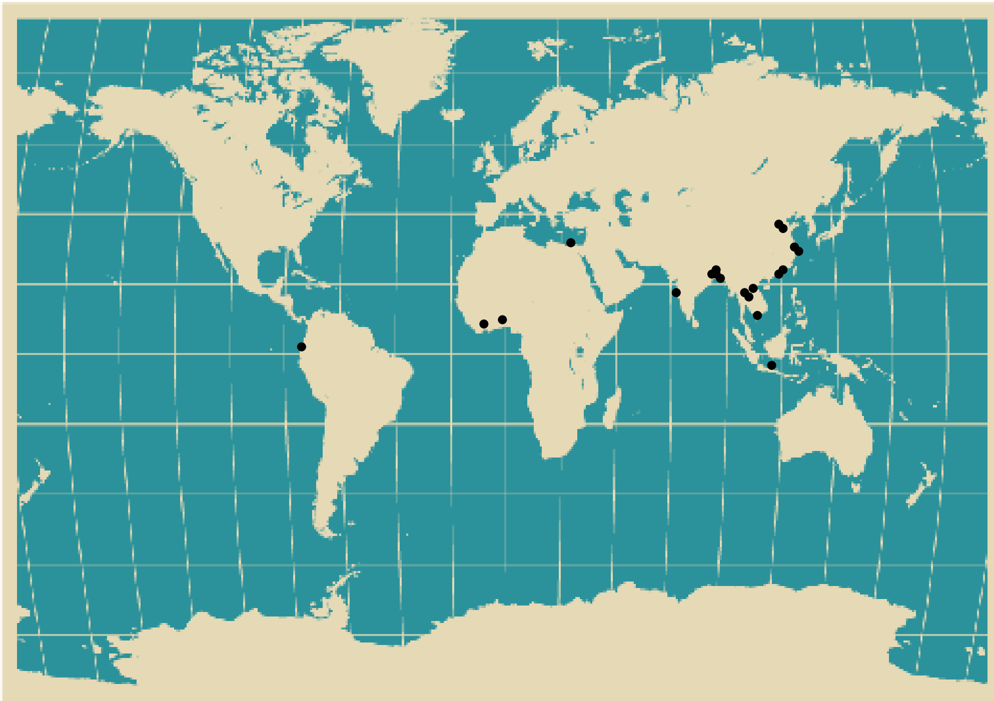
Map 2 shows the top 19 cities with the highest proportional increase in the value of the assets at risk by 2070 relative to the current situation. Among these cities, 17 are in Asia.

Policy Implications

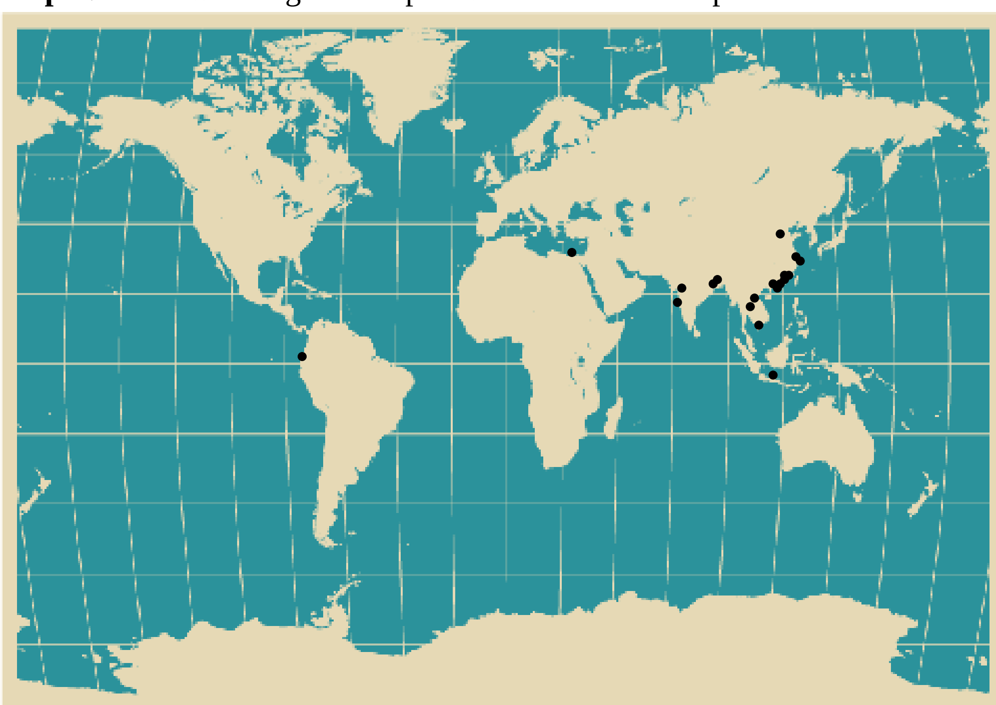
What, specifically, should individual countries do? What infrastructure is needed for a country to become competitive or to maintain competitiveness or attract FDI? What infrastructure is required to restructure modes of energy generation or to adjust to higher future carbon prices? How should water infrastructure needs be prioritized, particularly in view of the impact of climate change on general water availability? What policies are needed to render infrastructure both affordable and profitable in the context of still sizeable low-income populations?

The World Bank's World Development Report 2009, which focuses on spatial issues in development, suggests that efforts at leading the market are not often successful. Attempts to construct urban centers that lack an underlying economic rationale—with the expectation that such centers will attract both a labor force and private investment—have often proven

Map 1: Cities with Populations at Severe Risk to Sea -Level Rise and Climate Change



Map 2: Cities with Highest Proportional Increase in Exposed *Assets* at Risk by 2070[11]



[11] Source: Nichols et al (2008). Asia: Ningbo, Dhaka, Kolkhata, Fuzhou, Tianjin, Surat, Xiamen, Guangzhou, Mumbai, Hong Kong, Jakarta, Zhanjiang, Haiphong, Bangkok, Shanghai, Ho Chi Minh City, Shenzen. Latin America: Guayaquil. Africa: Alexandria.

unsuccessful as a strategy for development. And while the MDGs imply equal access to quality spatially universal infrastructure, if investment in economic infrastructure is neglected, the opportunity cost may be high in terms of forgone economic growth.

Jeffrey Sachs, in his UN Millennium Project report, argues that with scarce fiscal space, it is critical to achieve some “quick-wins”—providing access to electricity, water, sanitation, and the Internet for all hospitals, schools, and other social-service institutions. He suggests the use of off-grid diesel generators, solar panels, and other appropriate technologies (UN Millennium Project, 2005). He also argues for combining a growth focus with broader MDG objectives. For example, he notes that a green revolution in rural areas will require improved rural infrastructure services in the form of roads and other means of transport (the construction and rehabilitation of footpaths, feeder, district, and national roads), modern energy services, and communication technologies.

Box 3: Examples of Successful Urban Infrastructure: Mumbai and Shanghai

Mumbai: Three local associations formed an alliance to raise the political visibility of issues affecting the poor and to promote creative solutions, particularly with respect to land tenure, adequate housing, and access to electricity, transport, sanitation, and related services. Precedent-setting pilot projects were used to show feasible low-cost designs for affordable housing and sanitation.

Shanghai: This city took steps early to address the risks associated with sea-level rise, while also confronting its service and infrastructure challenges in an energetic and innovative fashion. The central government gave the city increased autonomy in revenue collection and expenditure, and the city established a foundation to mobilize funds for urban construction (the Shanghai Urban Construction Investment and Development Company), which displayed an “impressive record of achievement in infrastructure financing since its creation” (Montgomery, p. 366). Shanghai also employed a wide range of financing mechanisms through such state and non-state channels as international capital, bank loans and credits, construction bonds, the stock market, and service concessions. The city entered into concessions with profit-making enterprises to operate three bridges and a tunnel across the Huanpu River and established subordinate entities in charge of water supply. Though there are still severe housing backlogs for low-income groups, the delivery of urban services and urban infrastructure has improved dramatically. Perhaps the most spectacular outcome is the development of the Pudong New Area, a completely new district built in the old commercial center.

Source: Montgomery et al. 2003

Recent World Bank research on infrastructure in Africa (Foster, 2008; World Bank Group, 2010; Calderon and Servén, 2008) suggests a number of further considerations that may help policymakers respond to the pressures arising from demographic factors.

First, most studies on rates of returns to infrastructure investments suggest that the realized returns are greatest when investments remove critical bottlenecks in supply. For example, in the sphere of water storage, achieving water security for urban areas with high growth potential may need to be the highest priority. In urban areas, removing bottlenecks in the provision of basic services such as water, sanitation, and power, is especially important.

World Bank research also shows that the unit cost of infrastructure is highly sensitive to density. Policymakers will need to be flexible in terms of the quality and standards of infrastructure they choose in order to accommodate the needs of lower density settlements. This may imply investing in lower-quality (and lower-cost) infrastructure in areas that are not densely populated (see World Bank Group, 2010). Compromising on quality may facilitate more effective exploitation of the limited fiscal space available in order to achieve both the provision of universal services and the satisfy demands for job creation.

Policy reforms, particularly in pricing structures (usually involving cross subsidies) may be necessary to facilitate adequate cost recovery to support the provision of infrastructure related to water and energy. Indeed, one can argue that infrastructure investments, unaccompanied by good policies, are likely to be inefficient and prone to failure. Installing infrastructure without responding to user preferences or the capacity of users to pay for acquisition, operation, and maintenance operations, are unlikely to be successful.

World Bank research also suggests that higher spending levels on infrastructure are possible if greater efficiencies can be realized. They note the pressure of institutional bottlenecks, monopolistic practices raising costs, inadequate tendering processes, and weak operations and maintenance procedures, all of which force spending on new investments rather than on less costly maintenance. Infrastructure investment is also vulnerable to corruption: collusion between donors seeking export promotion favoring industrial interests, and politicians, seeking graft and associations with prestigious projects. The high value of contracts for infrastructure spending often leads to rent-seeking and the inappropriate absorption by the public sector of contingent fiscal risks in the negotiation of PPP contracts.

Investment in some types of infrastructure will be heavily influenced by both spatial and fiscal constraints. For example, in Africa, population densities are low and distances between urban agglomerations great. The high cost of realizing comprehensive road networks—both for investment and operations and maintenance—will make it difficult for countries to significantly upgrade or add to their existing networks. Low per capita income levels imply a relatively low value of time, undercutting the demand pressures for reducing the time involved in transport that often justify investments in higher quality roads.

Where infrastructural access is weak, policymakers will need to consider whether it reflects demand-side constraints (such as the low incomes of households and their inability to afford unsubsidized infrastructural services) or supply-side factors (such as the unavailability of infrastructure services or inappropriate infrastructure design) (Wodon et al, 2009).

Finally, considering the cost of providing basic infrastructural services, it would behoove policymakers to consider demographic factors, and in particular, the level of fertility, when making choices about where to invest. As long as fertility rates remain high, resources that could be used to spur economic growth will instead be required for the provision of basic infrastructure.

Conclusion

Demographics matter. In the 21st century, with the Millennium Development Goals enshrined as a minimum set of welfare targets, countries with growing populations must be prepared to provide a basic network of water, sanitation and social services. The projected rapid pace of urbanization also implies the need to accommodate this population movement and provide such services in places where they have hitherto not been provided. For many countries, this will also require investments to fill the outstanding backlog of infrastructure facilities.

This essay has also argued that beyond universal services infrastructure, the shifting age structure of the population, particularly the rising number of working-age people, will require countries to provide economic infrastructure that can attract private sector investments and facilitate the creation of jobs. And urbanization, which will require the creation of jobs in urban centers, will also necessitate the availability of infrastructure to exploit the production potential of rural areas in the agricultural and forestry sectors.

References

Agénor, Pierre-Richard and Blanca Moreno-Dodson, 2006, *Public Infrastructure and Growth: New Channels and Policy Implications* (World Bank Policy Research Working Paper No. 4064)

Asian Development Bank, *Connecting East Asia: A New Framework for Infrastructure* (2005)

Borcherding, Thomas and Robert T. Deacon, 1972? "The Demand for the Services of Non-Federal Governments," *American Economic Review*, 62(5), pp. 891-901)

Buiter, Willem, 2004, *Fiscal Sustainability* (Speech delivered to the Egyptian Center for Economic Studies) (available on the web).

Calderon, César, 2008, *Infrastructure and Growth in Africa* (AICD Working Paper, World Bank, Washington DC).

Calderon, César and Luis Servén, 2008 *Infrastructure and Economic Development in Sub-Saharan Africa*, Policy Research Working Paper 4712 (World Bank)

Canning, David and P. Petroni, 2004, *The Effect of Infrastructure on Long-Run Growth* (unpublished)

Chu, C.Y. Cyrus, "Population Density and Infrastructure Development," *Review of Development Economics*, 1(3), pp. 294-304, 1997

Dasgupta, Susmita, Benoit Laplante, Craig Meisner, David Wheeler, and Jianping Yan, 2007, *The impact of sea level rise on developing countries: a comparative analysis*, Policy Research Working Paper 4136 (World Bank)

Estache, Antonio, 2006, *Infrastructure: A survey of recent and upcoming issues*

Estache, Antonio, Biagio Speciale, and David Veredas, 2005, *How much does infrastructure matter to growth in Sub-Saharan Africa,*

Estache, A., B. Speciale, D. Veredas, 2005, *How Much does Infrastructure Matter to Economic Growth in Sub-Saharan Africa,* (unpublished, World Bank)

Fay, Marian and Tito Yepes, 2003, "Investing in Infrastructure: What is needed from 2000 to 2010," Policy *Research Working Paper No. 3102* (World Bank)

Foster, Vivian, 2008, *Overhauling the Engine of Growth: Infrastructure in Africa* (World Bank, September, 2008, unpublished)

Heller, Peter, *Operations and Maintenance Issues in Indonesia* (unpublished, 1989)

Hemming, Richard, M. Alier, B. Anderson, M. Cangiano, and M Petri, 2006, *Public-Private Partnerships, Government Guarantees, and Fiscal Risk* (IMF, Washington DC)

IMF, *World Economic Outlook* (April 2008)

IMF, *Public Investment Policy* (2004)

Mason, Andrew, 2001, *Population Change and Economic Development: What Have We Learned from the East Asia Experience* (East-West Center Working Paper No. 01-3)

Montgomery, Mark, Richard Stren, Barney Cohen, and Holly E Read, ed., 2003, *Cities Transformed: Demographic Change and Its Implications in the Developing World* (The Washington DC: National Academies Press,

Nichols, R, S. Hanson, C. Herweijer, N. Patmore, S. Hallegatte, J. Corfee-Morlot, J. Chateau, R. Muir-wood, 2008 "Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes," *Environmental Working Paper No. 1* (Paris: OECD)

Pinstrup-Andersen, Per and Satoru Shimokawa, 2006, *Rural Infrastructure and Agricultural Development* (paper prepared for Annual Bank Conference on Development Economics, Tokyo, 2006).

Ramachandran, Vijaya, Center for Global Development, 2008 "Power and Roads for Africa: What the United States Can Do," *White House and the World* Policy Brief, http://www.cgdev.org/content/publications/detail/16557

Seethpale, K., M. Bramati, and D. Veredas, 2008, "How Relevant is Infrastructure to Growth in East Asia," Policy Research Working Paper No. 4597(World Bank, Washington DC)

United Nations Population Division, Population Forecasts 2006, Urbanization Forecasts
World Bank, 2008a, *World Development Report 2009* (Washington DC: The World Bank)

UN Millennium Project, 2005, *Investing in Development: A Practical Plan to Achieve the Millennium Development Goals* (New York: United Nations Development Programme)

UN Millennium Project, Task Force on Improving the Lives of Slum Dwellers: *A Home in the City (*2005)

UN Millennium Project, Task Force on Water and Sanitation, *Health, dignity and development: What will it take?* (2005)

UN Millennium Project, *Energy Services for the Millennium Goals*, (2005) UN Population Division: *World Population Prospects: The 2008 Revision Population Database*

UN Population Division: *World Urbanization Prospects: the 2007 Revision*

Wodon, Q., S. Banerjee, A. Diallo, and V. Foster, 2009, "Is Low Coverage of Modern Infrastructure Services in African Cities due to Lack of Demand or Lack of Supply," *World Bank Policy Research Working Paper No. 4881*

World Bank, 1993,*World Development Report 1994: Infrastructure for Development*
World Bank, 2003, *World Development Report 2004: Drinking Water, Sanitation, and Electricity*

World Bank, 2004, *World Development Report 2005: Finance and Infrastructure*
World Bank, 2008 *World Development Report, 2009: Geography in Motion*

World Bank Group, 2010, *Africa's Infrastructure: A Time for Transformation*. Edited by V. Foster, and C. M. Briceño Garmendia, Washington, DC.

Yepes, T., Pierce, J. and Foster, V. 2009, Making Sense of Sub-Saharan Africa's Infrastructure Endowment: a benchmarking approach, *World Bank Policy Research Working Paper No. 4912*

Yepes, T, 2008, *Investment Needs for Infrastructure in Developing Countries 2008-15* (World Bank, unpublished draft).

Yepes, T., 2008, *Expenditure on Infrastructure in East Asia Region, 2006-2010* (World Bank).