

**ESTIMATION OF INFRASTRUCTURE INVESTMENT NEEDS IN THE SOUTH ASIA
REGION
EXECUTIVE SUMMARY**

Isabel Chatterton and Olga Susana Puerto ♦

A number of efforts have been made to provide bottom-up engineering estimates of the *one-time* cost of reaching specific infrastructure goals, such as for the water and sanitation sector¹. Yet, there have been no regional efforts to use a top-down approach to estimate *annual* investment needs based on macro-economic analysis. The information currently available on South Asia's infrastructure investment needs was derived by Fay & Yepes (2003). Therefore, following that approach, top-down estimates for South Asia are obtained based on historic relationships between national income, population and demand for infrastructure, combined with macro forecasts of economic and demographic growth. These estimates² suggest that a 7.5% GDP growth would result in increased demand for infrastructure services that in turn would require investment amounting to about 5% of GDP. In addition, a further 2% of GDP would be required for capital replacement³ amounting to over 7.5% of GDP in all (see Table 1). About two thirds of these expenditure requirements are associated with the roads and energy sectors alone.

**Table 1: Infrastructure Investment Needs to Meet 7.5% Growth
(% of GDP 2006-2010)**

	Electricity Generation Capacity	Telephone mainlines and mobiles	Paved Roads	Rail Routes	Improved Water	Improved Sanitation	Total
New Investment	1.8%	0.7%	2.0%	0.1%	0.3%	0.4%	5.4%
Capital Replacement	0.7%	0.4%	0.5%	0.1%	0.3%	0.3%	2.2%
Total	2.5%	1.1%	2.5%	0.2%	0.6%	0.7%	7.6%

The corresponding new annual investment requirement of US\$62 billion (2004 prices) implies more than trebling current investment levels. In addition, a further US\$25 billion would be needed for capital replacement of infrastructure, amounting to an overall expenditure requirement of US\$88 billion per year. This is as the investment needed to meet growing demand and maintain the existing capital stock. India amounts to nearly US\$70 billion per annum or 80 percent of the region's total investment. Comparing the estimated needs of US\$88 billion with recent estimated levels of actual investment in infrastructure of around US\$28 billion⁴, suggests an annual financing gap of about US\$60 billion.

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¹ World Bank, India- Water and Sanitation: Bridging the Gap between Infrastructure and Service, 2005

² This excludes irrigation, ports and airports.

³ Fay and Yepes (2003) called this operations and maintenance.

⁴ This is a guesstimate as there is no reliable data source on the level of public expenditure in the various infrastructure sectors. According to IMF Government Finance Statistics, expenditure by central government on infrastructure is less than half of this amount. However, given that a large proportion of infrastructure spending is undertaken by state-owned enterprises and sub-national governments as opposed to central government, these statistics give only a very partial view of the situation. A more approximate estimate of public investment is made by valuing the overall changes in infrastructure stocks over the period, and netting out the portion that was financed by the private sector. This leads to estimates of around US\$24.4 billion per year in public investment and US\$3.2 billion in private investment for a total of US\$27.6 billion.

ESTIMATION OF INFRASTRUCTURE INVESTMENT NEEDS IN THE SOUTH ASIA REGION

INTRODUCTION

Fay & Yepes (2003) estimated worldwide infrastructure investment requirements by region and income group from a set of 147 countries. Their technique gives an indication of the necessary investment to satisfy consumer and producer demand, based on some predicted rate of GDP growth. Subsequent research has been undertaken to refine Fay & Yepes's estimations for a specific region and has been presented in Yepes (2004) for East Asia and the Pacific, Fay & Morrison (2005) for Latin America, and Estache & Yepes (2004) for Sub Saharan Africa (see Table 1).

This document presents the refined estimations for the South Asia Region (SAR), based on Fay & Yepes, and as such, the estimations are comparable to the estimations obtained for other regions. In order to adapt the methodology to the characteristics of the region, some variations in the original model were undertaken as follows: (i) use of panel data comprising all countries in the region⁵; (ii) use of annual figures in most sectors – instead of quinquennial; (iii) refinement of investment stock mainly concerning paved roads in India and electricity generation capacity in Sri Lanka; and (iv) review unit costs for the region.

METHODOLOGY

Investment needs estimates can be derived from econometric models based on historic relationships between national income, population and demand for infrastructure, combined with macro forecasts of economic and demographic growth. In the methodology followed here, stocks of infrastructure are regressed against GDP, population density, size of urban population, agriculture and manufacture shares of GDP, and a lagged dependent variable. The regression models use cross-sectional time-series per sector (including power, roads, rails, telecommunication, and water and sanitation), with a fixed-effects estimator to control for omitted variables -such as prices- that differ between countries but are constant over time⁶. In addition, they assume no restrictions in the supply side. The models predict, as best as possible, infrastructure stocks per capita. This means that the results are those for which the highest explanatory power (R-squared) was obtained. As such, the results of the regressions do not reflect drivers or inhibitors of investment.

Total investment needs estimated are computed as the sum of annual new investment and annual stock replacement⁷. They reflect the investment needed to meet growing demand and maintain the existing capital stock. The annual change in forecasted infrastructure stocks are valued at best practice unit costs (see Table A1, Annex) to estimate new annual investment needs. The capital replacement needs estimated are derived as a percentage of the replacement cost of the capital

⁵ Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka. Due to lack of information, Maldives was excluded from some of the models.

⁶ It uses the changes in the variables over time to estimate the effects of the independent variables on the dependent variable, and is the main technique used for analysis of panel data. This estimator is equivalent to generating a dummy variable for each country.

⁷ New investment is computed as the difference between stock in t and stock in t-1. The average (or arithmetic mean) for five years correspond to the figures on new investment and replacement reported in this document. Cumulative five-year new investment and stock replacement are divided by cumulative five-year GDP to obtain the shares of new investments and stock replacement of GDP.

stock⁸. The results are ball park figures that are considered lower bound estimations of investment needs (as rehabilitation needs are excluded due to lack of data). Country-level estimations are indicative at best, as discussed by Fay & Yepes (2003).

Historic annual data series were obtained from the World Development Indicators (WDI) database for 1960-2003, and complemented whenever it was required by governments' databases, and regional sector experts' information⁹. Projections for GDP growth were obtained from the IMF's country statistics, and the governments' forecasts. As a result, 7.5% was assumed as the future GDP growth for the region to be included in the analysis. This rate is consistent with recent past growth trends. Table A2 in the Annex shows the models' outputs.

RESULTS

The results of this estimation suggest that a 7.5% GDP growth in South Asia would result in increased demand for infrastructure services that in turn would require investment amounting to about 5% of GDP plus a further 2% of GDP capital replacement. These rates are higher than originally estimated (see Table 1) due to the fact that the original models were adapted to the characteristics of the region, as follows: (i) use of panel data comprising all countries in the region¹⁰; (ii) use of annual figures in most sectors – instead of quinquennial; (iii) refinement of investment stock mainly concerning paved roads in India and electricity generation capacity in Sri Lanka; and (iv) review unit costs for the region..

Table 1. Estimation of Infrastructure Investment Needs as % of GDP, 2006-2010

Region	F&Y(2003)			Updates		
	Investment	Replacement	Total	Investment	Replacement	Total
EAP	3.67%	2.90%	6.57%	4.00%	2.20%	6.20%
LAC	1.62%	1.40%	3.02%	1.30%	1.10%	2.40%
SSA	2.84%	2.71%	5.55%	4.13%	3.87%	8.00%
ECA	2.76%	4.16%	6.92%			
MENA	2.37%	2.11%	4.48%			
SAR	3.06%	3.82%	6.88%	5.43%	2.22%	7.64%

Sources: Fay & Yepes (2003), EAP infrastructure flagship (2005), Fay & Morrison (2005) and Estache & Yepes (2004).

The corresponding new annual investment requirement of US\$62 billion (2004 prices) shown in Table 2 implies more than trebling current investment levels. In addition, a further US\$25 billion would be needed for capital replacement of infrastructure, amounting to an overall expenditure requirement of US\$88 billion per year. Comparing estimated needs of US\$88 billion with recent estimated levels in infrastructure of around US\$28 billion¹¹, suggests an annual financing gap of about US\$60 billion.

⁸ "These estimates are not meant to represent an optimum level of operation and maintenance expenditures but rather are to suggest the minimum annual average expenditure on capital replacement, below which the network's functionality will be threatened". Fay & Yepes (2003).

⁹ The dataset can be obtained from the authors upon request (ichatterton@worldbank.org).

¹⁰ Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka. Due to lack of information, Maldives was excluded from some of the models.

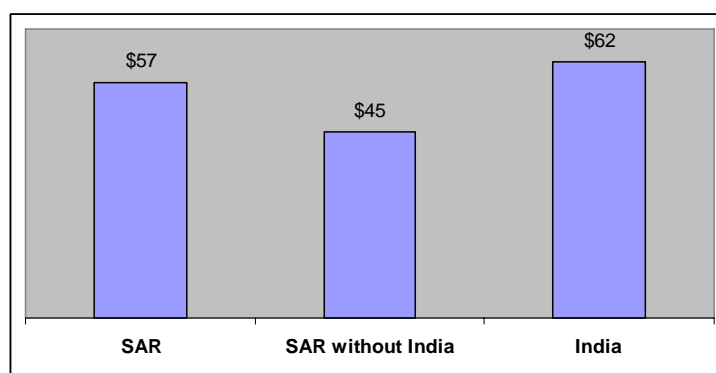
¹¹ There is no reliable data source on the level of public expenditure in the various infrastructure sectors. According to IMF Government Finance Statistics, expenditure by central government on infrastructure is less than half of this amount. However, given that a large proportion of infrastructure spending is undertaken by state-owned enterprises and sub-national governments, these statistics give only a partial view of the situation. A more approximate estimate of public investment is obtained by valuing the overall

Table 2. Expected Annual Expenditure Needs, 2006 – 2010

	Investment		Replacement		Total	
	US\$ Billion	%GDP	US\$ Billion	%GDP	US\$ Billion	%GDP
<i>SAR</i>	62.6	5.43%	25.5	2.22%	88.1	7.64%
<i>India</i>	49.5	5.52%	20.0	2.18%	69.5	7.70%

The estimated investments needs translate into annual per capita expenditures of US\$57 dollars between 2006 and 2010 (see Figure 1). As a comparison, current investment (i.e. US\$28 billion) corresponds to about US\$20 dollars per person. India's per capita investment needs of US\$62 are higher than for the region as a whole.

Figure 1. Expected annual expenditure needs per person, 2006 - 2010



About two thirds of these expenditure requirements are associated with the roads and energy sectors alone. Table 3 shows that electricity and roads will account for about 66 percent of the total investments needs in the region between 2006 and 2010. In addition, investment in mobile lines and in access to sanitation facilities will also account for a significant proportion of overall spending. This breakdown of needs by sector is similar to that observed for all developing countries (Fay & Yepes, 2003).

Table 3. Investment Needs by Infrastructure Sector, 2006 – 2010

Sectors	Share in Total Investment
Electricity	32.95%
Roads	33.11%
Rails	2.35%
Mainlines	6.11%
Mobiles	8.64%
Water	7.63%
Sanitation	9.21%
Total Sectors	100.00%

Table 4 and Table 5 show the breakdown of investment needs between new investment and capital replacement by infrastructure sector, for SAR and India respectively. According to the

changes in infrastructure stocks over the period, and netting out the portion that was financed by the private sector. This results in US\$24.4 billion and US\$3.2 billion in public and private investment respectively, for a total of US\$27.6 billion.

figures, the annual regional investment need for electricity generating capacity during 2006-2010 amounts to US\$29 billion, of which US\$25 billion are for generation in India. The estimates include generation from independent power providers but do not consider the possibility of captive capacity¹². The estimates also include Bhutan's large 1,020-megawatt Tala hydropower project that is expected to come on stream in 2006. Should the investment needs be fulfilled, an increase of around 40 percent in electricity generation capacity in the region would take place between 2005 and 2010 (see Table 6).

Table 4. SAR's expected annual expenditure needs per sector, 2006-2010

	Investment		Replacement		Total	
	US\$Bn	%GDP	US\$Bn	%GDP	US\$Bn	%GDP
Electricity Generation Capacity	21.5	1.86%	7.6	0.66%	29.0	2.52%
Paved Roads	23.8	2.06%	5.4	0.47%	29.2	2.53%
Rail Routes	1.2	0.10%	0.9	0.08%	2.1	0.18%
Telephone mainlines	3.0	0.26%	2.4	0.21%	5.4	0.47%
Mobile	5.3	0.46%	2.3	0.20%	7.6	0.66%
Improved Water	3.1	0.26%	3.7	0.32%	6.7	0.58%
Improved Sanitation	4.7	0.42%	3.2	0.28%	8.1	0.70%
Total	62.6	5.43%	25.5	2.22%	88.1	7.64%

Notes: US\$ are in 2004 prices. Totals may not add up due to rounding.

Table 5. India's expected annual expenditure needs per sector, 2006-2010

	Investment		Replacement		Total	
	US\$ Bn	%GDP	US\$ Bn	%GDP	US\$ Bn	%GDP
Electricity Generation Capacity	18.9	2.13%	6.4	0.73%	25.3	2.86%
Paved Roads	19.1	2.15%	4.2	0.47%	23.3	2.62%
Rail Routes	0.9	0.11%	0.7	0.07%	1.6	0.18%
Telephone mainlines	2.5	0.28%	2.0	0.23%	4.5	0.51%
Mobile	3.2	0.36%	1.7	0.19%	4.8	0.55%
Improved Water	1.8	0.18%	2.8	0.28%	4.6	0.46%
Improved Sanitation	3.1	0.31%	2.2	0.21%	5.3	0.52%
Total	49.5	5.52%	20.0	2.18%	69.5	7.70%

Notes: US\$ are in 2004 prices. Totals may not add up due to rounding.

Similarly, the tables show that the annual investment needs amount to about US\$29 billion for paved roads and US\$2 billion for rail lines. These later estimates for rail are comparable to the Government of India's estimates of about US\$1.4 billion per annum. The investments, if undertaken, would translate into a paved road network twice as large as it is today with 120 km per 100,000 habitants. Rail investments, however, would result in a slow but nevertheless positive increase in length per area¹³.

¹² Over the last decade there has been an increasing expansion of captive capacity of electricity in India. This additional capacity – estimated in 20 GW- is unaccounted by the sector and there is no detailed information about its. However a proxy exercise raising the stock level by 20 GW from 1990 suggests additional expenditures of nearly \$600 million for 2006-2010.

¹³ In recent years Indian Railways (IR) has invested significantly in fixed infrastructure, which unfortunately cannot be captured with the available information on routes length. IR has doubled –and even tripled- the track length, and has improved signaling and train

The region needs about US\$5.4 billion per annum worth of investment in fixed telecom lines and about US\$7.6 in mobile lines. This trend is consistent with the recent shift from fixed to wireless equipment in large growing economies such as Bangladesh and India. Indeed, the growth in mobile telephony will be so significant that about 100 wireless lines would be available per 1,000 people, which would represent five times the average coverage observed between 2001 and 2005. The investment needs for water and sanitation amount to about US\$15 billion and US\$10 billion per annum in the next five years respectively for the region and for India. Over one third of the investment is required for improved access to water and the rest for sanitation facilities. Should the investment needs above be fulfilled, 90 percent of the region's population would have access to an improved source of water, and 46 percent to sanitation by 2010. The estimates for India are higher than the US\$5.5 billion estimated by SASEI using bottom-up approaches for the period 2007-2012¹⁴.

Table 6. Estimates of Infrastructure Stock in SAR and India

Sector	SAR		India	
	2001-2005	2006-2010	2001-2005	2006-2010
Electricity Generation Capacity (<i>Million kilowatts</i>)	151.3	216.8	126.0	184.5
Paved Roads (<i>Km per 1000 Km²</i>)	231.9	361.6	274.7	438.1
Rail Routes (<i>Km per 1000 Km²</i>)	14.7	14.7	19.2	19.3
Mainlines (<i>lines per 1000 hab</i>)	37.5	59.4	44.1	68.9
Mobile (<i>lines per 1000 hab</i>)	21.1	100.4	22.0	92.8
Access to improved water (<i>% of population</i>)	86	90	88	90
Access to improved sanitation (<i>% of population</i>)	39	46	34	40

SUMMARY

Over the next decade South Asia will require substantial investment in infrastructure to meet the needs of the regional economy. The estimates suggest that a 7.5% GDP growth would result in increased demand for infrastructure services that in turn would require investment amounting to about 5% of GDP plus a further 2% of GDP for capital replacement. This results in an investment of US\$88 billion per annum in the next five-years. India has a considerable partaking in these figures, amounting to nearly US\$70 billion per annum or 80 percent of the region's total investment.

Among the infrastructure sectors, electricity and roads will demand the largest proportion of investment, followed by telecommunication and water and sanitation. In particular, electricity and roads will require investments equivalent to 2.52 percent and 2.53 percent of regional GDP respectively, while telecommunications, water and sanitation, and rails to 1.13 percent, 1.29 percent and 0.18 percent of GDP respectively. This breakdown of needs is similar to that expected for the East Asia Pacific region, according to Yepes (2005).

These figures do not include rehabilitation needs. As discussed by Fay & Yepes (2003), this type of approach offers reasonable estimates at regional levels but country level predictions must be regarded as indicative at best.

control systems. About \$2 billion have been recently invested in the Uni-gauge project to convert/change all the metre gauge railway lines and all the narrow gauge railway lines to broad gauge railway line.

¹⁴ Figure is in 2005 prices. Source: World Bank, India- Water and Sanitation: Bridging the Gap between Infrastructure and Service, 2005

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ANNEX

Table A1. Unit costs for infrastructure investment

Sector	Price	Unit
Electricity	US\$1,900	per kilowatt of generating capacity, including associated network cost.
Roads	US\$425,000	per kilometer of two lane paved road
Railway	US\$900,000	per kilometer of rail, including associated rolling stock
Mainlines	US\$400 (for 2000-2004), US\$280 (for 2005-2009), US\$261 (for 2010 onward)	per line
Mobile	US\$280 (for 2000-2004), US\$185 (for 2005-2010), US\$127 (for 2010 onward)	per subscriber
Sanitation	US\$700	per connected household
Water	US\$400	per connected household

Sources: Road Costs Knowledge System -ROCKS- for SAR, Fay & Yepes (2003), and Yepes (2005).

Table A2. Regression Results

	Electricity Generation Capacity	Kilometers of paved roads per 1000 habitants	Kilometers of rail routes per 1000 habitants	Number of main lines per 1000 habitants	Number of main lines and mobile subscribers per 1000 habitants	Percentage of population with access to improved water	Percentage of population with access to improved sanitation
Independent Variables							
Lag Dependent Variable	0.85 (24.02)***	0.92 (62.21)***	0.87 (25.03)***	0.95 (44.62)***	0.97 (46.74)***		
GDP per capita	0.34 (2.74)***	0.08 (2.59)**	0.03 (2.77)***	0.23 (3.74)***	0.11 (1.49)	0.50 (2.28)**	0.17 (1.77)*
Agriculture, share of GDP	0.20 (1.04)	0.15 (2.58)**		-0.04 (-0.4)	-0.08 (-0.83)	0.17 (0.63)	-0.66 (-0.53)
Manufacture, share of GDP	0.06 (0.62)		0.02 (1.98)**	0.03 (0.72)			
People per Squared Km		0.16 (3.67)***	-0.17 (-4.15)***	-0.02 (-0.36)	0.06 (0.94)	-0.30 (-1.13)	0.82 (0.67)
% of people in Urban Areas	0.07 (0.75)		0.01 (1.77)*	0.06 (1.31)	0.02 (0.47)	0.40 (2.46)**	0.53 (0.69)
Population Growth					-0.07 (-2.8)***		
Constant	-2.40 (-1.65)*	-1.84 (-4.39)***	0.25 (3.08)***	-1.13 (-1.62)	-0.49 (-0.69)	1.06 (0.57)	-1.27 (-0.15)
Observations	238	246	190	260	255	26	26
Groups	7	7	5	7	7	8	8
R-Squared	0.94	0.99	0.998	0.99	0.99	0.79	0.66
Model Type	Fixed- Effects	Fixed- Effects	Fixed- Effects	Fixed- Effects	Fixed- Effects	Fixed- Effects	Fixed- Effects
Sample	Annual	Annual	Annual	Annual	Annual	Quinquennial	Quinquennial

Absolute value of t statistics in parentheses. * significant at 10%, ** significant at 5%, *** significant at 1%.

REMARKS ON EACH SECTOR MODEL

Power Sector. The model uses electricity generating capacity measured in watts per person. Annual data was obtained from the US Energy Information Administration and the United Nations, Statistical Yearbook. The price per kilowatt, including associated network costs, is US\$1,900. This is the same price used by Fay & Yepes (2003) and Yepes (2005). The value of replacement needs is computed as 3 percent of the replacement cost of the capital stock for electricity generation¹⁵, implying an average stock life of 35 years. Other studies as Fay & Yepes (2003) and Yepes (2005) used 2 percent. Maldives was excluded from the model due to lack of data for the explanatory variables.

The independent variables in the model explain 94 percent of variance of electricity capacity within the sample. Density, measured by people per squared kilometer, was excluded from the set of explanatory variables due to its significance level in both, the model and the pair-wise correlation with the dependent variable.

Telecommunications. The model includes fixed and mobile lines. Annual data on the number of mainlines was obtained from WDI and Calderon and Serven (2005) database. Mainlines are defined as telephone lines connecting a customer's equipment to the public switched telephone network. Due to the fast technological change in the sector, the unit cost changes with time as follows: US\$900 from 1960 to 1994, US\$650 from 1995 to 1999, US\$400 from 2000 to 2004, US\$280 from 2005 to 2009, US\$261 from 2010, onward. This scaled change was also applied by Fay & Yepes (2003), following Ruzzier et al. (2000). Replacement is 8 percent of the replacement cost of the capital stock. The model for mainlines excludes Maldives due to lack of information on GDP.

Annual data on number of mobile subscribers was obtained from WDI. Mobile phone subscribers refer to users of portable telephones subscribing to an automatic public mobile telephone service using cellular technology that provides access to the public switched telephone network. The drastic expansion of the sector, especially in large economies such as India and Bangladesh, make the series hard to be modeled with the available independent variables. Hence, estimates for the mobile sector come from modeling the sum of mainlines and mobiles and then subtracting the predicted stocks of mainlines. This corrects the upward sloping trend in the forecasting period and was also applied by Yepes (2004). In terms of prices, the scaled change used is: US\$1500 for before 1995, US\$1100 between 1995 and 1999, US\$280 between 2000 and 2004, US\$185 from 2005 to 2009, and US\$127 from 2010 onward. Stock replacement corresponds to the 8 percent of the stock value. The model includes population growth.

Transport Sector. Separate models were developed for roads and railways. The lack of comparable data across countries led to the exclusion of ports, airports and canals.

The model for roads uses series of kilometers of paved roads surfaced with crushed stone (macadam) and hydrocarbon binder or bituminized agents, with concrete, or with cobblestones. The data sources are WDI and Calderon and Serven (2005). Data for India was obtained from the Ministry of Shipping, Road Transport and Highways and was adjusted to meet the above definition of paved surface. Maldives was excluded from the model, since there is no available information about its road network. A unit cost of US\$425,000 reflects the price per kilometer of

¹⁵ This 3 percent was suggested by SASEI technical staff as the closest figure for India.

a two-lane paved road in the region. It was obtained from the Road Costs Knowledge System (ROCKS) of the World Bank. Replacement corresponds to 2 percent of the stock value.

The share of manufactures in GDP and the percentage of people in urban areas were excluded from the set of explanatory variables because they showed a non-significant and counter intuitive sign that was not consistent with the pair-wise and total correlation between them and the dependent variable.

The model for rail lines use the length of railway route available for train service, irrespective of the number of parallel tracks. Data was obtained from WDI, UIC-International Railways Statistics and SASEI's databases. Stocks are valued at US\$900,000, which is the price per kilometer of rail, including associated rolling stock. Replacement is considered as 2 percent of the stock value. Afghanistan, Bhutan and Maldives have been excluded from the model due to lack of data on rail routes.

The negative effect of density on the stock implies that demographic concentration reduces the demand for this infrastructure service.

Water and Sanitation. Data for water and sanitation was obtained from the WDI and several country reports using the following definitions: (i) Access to an improved water source refers to the percentage of the population with reasonable access to an adequate amount of water from an improved source, such as a household connection, public standpipe, borehole, protected well or spring, and rainwater collection. Unimproved sources include vendors, tanker trucks, and unprotected wells and springs. Reasonable access is defined as the availability of at least 20 liters a person a day from a source within one kilometer of the dwelling. (ii) Access to improved sanitation facilities refers to the percentage of the population with at least adequate excreta disposal facilities (private or shared, but not public) that can effectively prevent human, animal, and insect contact with excreta. Improved facilities range from simple but protected pit latrines to flush toilets with a sewerage connection. To be effective, facilities must be correctly constructed and properly maintained.

The data was used to create a quinquennial panel. All countries were included in the regressions. Best practice unit costs imply US\$400 for water and US\$700 for sanitation, per connected household. Stock replacement corresponds to 3 percent of the physical stock of both water and sanitation, with an implied 23-year lifetime.

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