Chapter 1

The Past and Future Role of Infrastructure in Asia's Development

**Abdul Abiad, Rana Hasan, Yi Jiang, and
Epictetus Patalinghug**

I. Introduction

This chapter documents the evolution of infrastructure in developing Asia over the last 50 years, how the region's infrastructure needs are likely to grow between now and 2030, and how these needs can be met. The focus here is on physical infrastructure, in particular the network infrastructure of transport, power, water supply and sanitation, and telecommunication.

In a region as diverse as developing Asia, it is natural to find that, over the decades, different economies have prioritized infrastructure to different degrees. It is also not surprising that countries have taken different approaches to planning and implementing infrastructure projects. Some countries integrated infrastructure provision into national and local development plans and followed through on those plans, whereas in other countries national or local plans were not followed, or there were no plans at all. As a result, some countries improved their infrastructure dramatically over the past half-century, while others fell behind.

Developing Asia will need to invest \$26 trillion from 2016 to 2030, or \$1.7 trillion per year, if the region is to maintain its growth momentum, eradicate poverty, and respond to climate change (Asian Development Bank [ADB] 2017a). In many countries, levels of investment in infrastructure are

not sufficient, and additional resources for infrastructure investments need to be found. For some countries, fiscal reforms on both the revenue and expenditure side can help narrow the infrastructure gap. But a large part of the gap will have to be filled by increased private involvement.

II. Infrastructure Provision in Developing Asia: Then and Now

Fifty years ago, there were wide variations in infrastructure stocks across developing Asia. This was due to several factors, including prior development, conflict, and colonial legacies. Many economies invested in infrastructure more rapidly than others. And these differences have been found to be associated with superior economic performance (World Bank 1993).

This section compares infrastructure 50 years ago with that of today. At the beginning of the period, there were already substantial differences across developing Asia (Figure 1.1)—in generated electricity (panel A), fixed telephone subscriptions (panel B), rail kilometers (km) per capita (panel C), and road kilometers per capita (panel D). Coverage of economies is limited and varies in each panel because many countries do not have data on infrastructure stocks going back that far.

One factor influencing initial levels of infrastructure was the varying levels of economic development in these economies at the time. Figure 1.2 shows three different measures of real gross domestic product (GDP) per capita as of 1965 from Penn World Tables, in selected economies in developing Asia. Hong Kong, China was the richest economy in developing Asia, followed by Singapore; Malaysia; the Philippines; and Taipei, China. These initial levels of per capita income correlate well with levels of infrastructure provision at the time.

Another factor that shaped historical infrastructure provision involved colonial legacies. Studies on the colonial origins of comparative development show that countries with better institutions invest more in physical and human capital and achieve higher income levels. But these institutions were shaped by different Western colonization strategies. Where colonizers established institutions that protected private property rights and enforced the rule of law, settlements prospered. But where colonizers developed extractive institutions—mostly to take advantage of the native population and natural resources—communities stagnated. Moreover, institutionally weak societies could not deal with economic and political problems which could

Figure 1.1: Initial Infrastructure Stock (beginning of period)

Notes: km = kilometer; Numbers in parentheses indicate initial year with available data. Asterisk (*) indicate interpolated values.

Sources: ADB 2017b; and International Telecommunications Union. 2016. *World Telecommunications/ICT Indicators Database* 2016. Geneva.

lead to civil war, resolution, or internal unrest (North 1981, Acemoglu et al. 2001, 2004).

Apart from influencing levels of development, colonization had a direct impact on infrastructure provision. The amount of infrastructure built in the

Figure 1.2: Real Gross Domestic Product per Capita, 1965

Notes: RGDP per capita = real gross domestic product per capita, PWT = Penn World Tables.

Source: Penn World Tables, version 9.1.

various colonies in Asia varied greatly, usually depending on the products sent back home—plantation crops, extracted metals, or (later) oil. Rail networks tended to be more expansive in former colonies such as Indonesia and India. Donaldson (2018) used archival data from colonial India (today’s Bangladesh, India, and Pakistan) to show that the construction of a vast railroad network by the British reduced trade costs and raised real incomes. Although the British rulers planned an additional 11,000 km of railroad lines, they were never built because surveys revealed they would incur higher costs than anticipated.

Five decades later, relative levels of infrastructure provision had changed somewhat (Figure 1.3). Panels A and B show that, in electricity and telephones, economies such as Singapore and Hong Kong, China stayed ahead; some like the Republic of Korea (ROK), the People’s Republic of China (PRC), and Taipei, China caught up; while others, such as India, Indonesia, and the Philippines, were left behind. Panel C shows that rail infrastructure, as measured by rail kilometer per capita, generally failed to keep pace with population growth, with the PRC being a notable exception. And panel D shows that many countries expanded their road infrastructure.¹

¹Singapore is *sui generis* because, as a city-state, it does not have much room to expand its road network, and instead focused on expanding its mass transit system, which it has done very effectively.

Figure 1.3: Infrastructure Stock (initial year versus 2014)

Notes: km = kilometer; Numbers in parentheses indicate initial year with available data. Asterisks (*) indicate interpolated values.

Sources: ADB 2017b (for 1965 data); Energy Information Administration. 2014. *Total Installed Capacity Data*. Washington (for 2014 data); R.C. Feenstra, R. Inklaar, and M.P. Timmer. 2015. The Next Generation of the Penn World Table. *American Economic Review*. 105(10). pp. 3150–3182 (available for download at www.ggdc.net/pwt); authors' estimates; International Road Federation. 2016. *World Road Statistics 2016* Alexandria VA; International Telecommunications Union. 2016. *World Telecommunications/ICT Indicators Database*. 2016. Geneva; Government of India—Ministry of Road Transport and Highways *Basic Road Statistics of India*; and World Bank. 2018. *World Development Indicators*. Washington, DC.

Consistent with the earlier observation of a strong association between infrastructure provision and per capita incomes in 1965, the economies which managed to catch up in terms of infrastructure provision are the same economies that raised their per capita income levels substantially over the subsequent five decades, such as the ROK and Taipei, China. The tight relationship between infrastructure provision and level of development is likely a two-way street—infrastructure provision enables countries to grow more rapidly, and growth and development also enable greater provision of infrastructure.

A third factor that has shaped historical patterns of infrastructure provision is war or internal conflict, which has affected a number of countries in the region, including Cambodia, the Lao People's Democratic Republic, the ROK, Sri Lanka, and Viet Nam.² Armed conflict imposes economic and social costs on the countries involved. A conflict diverts substantial resources from productive activities to violence. The increase in military spending shuts off the use of these budgetary resources away from public goods such as education, health, and infrastructure. Thus, conflict inflicts a double loss on any affected country: the opportunity cost from foregoing or expanding productive activities due to diverted resources; and the damage caused to physical capital (buildings, machinery, and infrastructure), and human capital (casualties, lost employment opportunities, and population displacement).

Conflict impedes mobility, economic activity, and development in affected provinces. An average developing country in conflict spends an additional 2.2% of GDP on military expenditures (Collier et al. 2003). The figure does not include resources rebel groups control (in the case of an internal conflict), which are likewise diverted from productive use. The diversion of resources and the targeted destruction of infrastructure mean that on average countries affected by conflict have much less infrastructure, of poorer quality, than nonconflict countries. Authors' estimates using the infrastructure index of Donaubauer et al. (2016), which measures both the quantity and quality of infrastructure provision, find that conflict-affected countries have infrastructure that is roughly half as good in terms of quantity and quality as what one would find in countries spared from conflict (Figure 1.4).

²Schwartz et al. (2004) defined conflict countries as "countries where internal conflict causes at least 1,000 combat-related deaths per year. To distinguish wars from massacres, both government forces and an identifiable rebel organization must suffer at least 5% of these casualties" (page 1). The Department of Peace and Conflict Research at Uppsala University has defined war with a lower threshold of 25 battle-related casualties.

Figure 1.4: Conflict and Infrastructure

Note: The infrastructure index is based on a composite of transport, energy, and information and communication technology infrastructure from Donaubauer et al. (2016), and is transformed monotonically to be on a 0–1 scale.

Source: Authors' calculations based on Donaubauer et al. (2016).

The reduction in resources allocated to infrastructure often extends into the post-conflict period. Expenditures on infrastructure typically receive lower priority because post-conflict governments often continue to allocate higher levels of military spending than before a conflict. Conflict-affected countries also have limited absorptive capacity to implement and manage infrastructure projects because conflicts weaken skills, institutions, and human capital. Infrastructure investment in post-conflict countries in recent years generally follows a sequence. Telecommunications (including mobile telephony) often can be built soon after conflict because its services are chargeable, making its provision more attractive even to private providers. Power generation, transport (railways, roads, seaports, and airports), and water and sanitation projects only emerge sequentially after several years. While these would normally be the initial, basic infrastructure investments in nonconflict countries, they are the last investments made in post-conflict countries (Collier et al. 2003; Schwartz and Halkyard 2006).

One interesting historical example—and an illustrative one considering the awful initial conditions and the extent of the recovery—was the experience of the ROK following the peninsula's devastating international 1950–1953 conflict (ADB 2017a, p. 38). At the time of the armistice, there was little infrastructure left on the peninsula. Electricity that had mostly been

generated above the 38th parallel was no longer available. Only 2.4% of roads in the ROK remained paved. Limited financing prevented large-scale power plants from being built or roads from being constructed or rehabilitated. It was the First Five-Year Plan of 1962–1966 that prioritized infrastructure investment in support of the government's planned economic development. With the top priority to create an export-oriented economy, many new power plants were built in the 1960s and 1970s to supply electricity for manufacturing. Several new expressways and expanded ports provided good, low-cost logistics, including the Gyeongbu Expressway, which connected manufacturers in the capital of Seoul to the port of Busan. Road rehabilitation—both national and local—took a back seat. New, modern infrastructure was the priority, along with the creation of industrial complexes. This targeted, continuous rapid economic development in the 1970s and 1980s brought more infrastructure investment. As a share of GDP, it remained relatively low; for example, transport was 1.38% of GDP and electricity was 2.67% of GDP in 1980. But it was efficient and focused on priority areas.

As with conflicts between countries, the impact of domestic or internal conflict on infrastructure depends on the nature of the conflict itself. The war in Viet Nam (1960–1975) destroyed infrastructure, displaced people, disrupted schooling, and damaged productive agricultural land. The United States (US) bombed Viet Nam about 15 times more heavily than during the Korean conflict, with the bombing concentrated in specific regions. Despite this, a study by Miguel and Roland (2011) on the long-run impact of this bombing finds that the damage did not become a barrier to postwar recovery and growth. In contrast, the 12-year civil war in neighboring Cambodia (1967–1979) was countrywide and highly intense, inflicting massive infrastructure losses. And the disruption to economic activity lingers today, many decades after the conflict. An estimated 4–6 million mines and unexploded ordinance remain in Cambodia, have caused an estimated 64,000 casualties and 40,000 amputees, and have impeded rural development.³

III. Factors Shaping Infrastructure Provision

The quantity and quality of infrastructure investment over the past five decades has been a critical factor shaping the evolution of infrastructure provision in the region. It is not easy to obtain data over such a long period,

³See Cambodian Mine Action and Victim Assistance Authority at <http://www.cmaa.gov.kh/en>.

Figure 1.5: Infrastructure Investment in Developing Asia, Latin America, and Sub-Saharan Africa, 1965–2015

Notes: ADB = Asian Development Bank, DMC = developing member country, GDP = gross domestic product, GFCF (GG) = general government component of gross fixed capital formation. Sources: International Monetary Fund, Investment and Capital Stock dataset (general government component of GFCF), and World Bank, Private Participation in Infrastructure Project database.

but one available measure of infrastructure investment over this historical period is the sum of the general government component of gross fixed capital formation (GFCF [GG]), from the International Monetary Fund's Investment and Capital Stock Dataset, and private and public–private partnership (PPP) infrastructure investment from the World Bank's Private Participation in Infrastructure (PPI) Project Database.⁴ Based on this measure, developing Asia invested at least 5% of GDP annually during 1960–2015 (Figure 1.5).

As a share of GDP, Asia invested much more in infrastructure than other regions over the past 50 years. Infrastructure and investment rates in the region were only slightly above Latin America and the Caribbean (LAC) and Sub-Saharan Africa (SSA) in the 1960s and 1970s. All three regions saw infrastructure spending rise in the 1970s and early 1980s. In LAC and SSA, much of this increase in infrastructure investment was financed by external borrowing sourced from post-oil crisis “petrodollars” in search of investment opportunities. With the exception of the Philippines, most of Asia did not use

⁴The advantage of using GFCF (GG) and PPI is that both databases have long time series. GFCF (GG) could overestimate infrastructure investment because it includes noninfrastructure investment. It can also understate infrastructure investment because it generally excludes self-financed investment by state-operated enterprises. On the other hand, PPI may double-count investment if projects with at least 50% private participation include investments from government enterprises (ADB 2017a).

Figure 1.6: Infrastructure Investment in the People's Republic of China, the Rest of Developing Asia, Latin America, and Sub-Saharan Africa, 1965–2015

Notes: ADB = Asian Development Bank, DMC = developing member country, GDP = gross domestic product, GFCF (GG) = general government component of gross fixed capital formation, PRC = People's Republic of China.

Sources: International Monetary Fund, Investment and Capital Stock dataset (GFCF [GG]); and World Bank, Private Participation in Infrastructure database.

external borrowing at the time because domestic saving rates were generally higher in the region, and because banks in the US and Europe were more focused on lending to LAC and SSA at the time than to Asia.⁵

Following the 1980s debt crisis LAC and SSA infrastructure investment dropped significantly, whereas developing Asia's investment rates continued to rise. But when one disaggregates developing Asia into the PRC on the one hand and the rest of developing Asia on the other, it becomes evident that this divergence was due to the PRC's high Asia's developing economies invested about the same as other regions (Figure 1.6). The PRC's high rate of infrastructure investment is a key factor in explaining how its infrastructure provision improved dramatically (as documented in Figure 1.1), despite not yet having the same levels of per capita income as the ROK or Taipei, China.

A number of factors have shaped how much countries decide to invest in infrastructure. One factor is political and policy shifts. As noted in the

⁵At the time, US banks had stronger linkages with Latin America, and European banks with Sub-Saharan Africa, than with developing Asia. Cross-country bank lending to developing Asia was primarily from Japanese banks.

previous section, the ROK's push toward greater infrastructure investment was ensconced in its First Five-Year Plan of 1962–1966. President Park Chung-hee made the construction of the Seoul–Busan Highway one of the centerpieces of his 1967 presidential election campaign, and on taking office he took a direct hand in supervision of the highway's construction (Jeon 2010). More recently, one has seen similar shifts in politics leading to large shifts in the rate of infrastructure investment, including Philippine President Rodrigo Duterte's “Build Build Build” program and a similar infrastructure investment push by Indonesian President Joko Widodo.

A second factor that exerts a great influence on the rate of infrastructure investment is macroeconomic conditions, including the incidence of financial crises. The impact of the Asian financial crisis on infrastructure investment is a case in point. Financial and capital account liberalization in the late 1980s and early 1990s, along with strong optimism about Asia's “miracle economies” led to large capital inflows into several Asian economies. This helped finance increases in infrastructure investment rates in Indonesia, Malaysia, the Philippines, Thailand, and Viet Nam in the 1990s (Figure 1.7).

Figure 1.7: Infrastructure Investment, Selected Southeast Asian Countries, 1960–2015

Notes: GDP = gross domestic product, GFCF (GG) = general government component of gross fixed capital formation; Infrastructure investment is the sum of public investment (International Monetary Fund data) and private infrastructure investment (World Bank data).

Sources: International Monetary Fund, Investment and Capital Stock dataset (2017); World Bank Private Participation in Infrastructure database (2018); World Development Indicators; and authors' estimates.

Unfortunately, much of the credit also found its way into unproductive investments in property and real estate. And with poorly regulated finance sector and exchange rates that were effectively fixed against the United States dollar, there was a rise in maturity and currency mismatches that made these countries vulnerable to a speculative attack. When the Asian crisis hit in 1997–1998, many of these economies saw sharp depreciations and output contractions. The finances of many governments took a hit as activity slowed, borrowing costs rose, and finance sector had to be restructured. Partly as a result, infrastructure investment in Indonesia, the Philippines, and Thailand declined sharply after the crisis and stayed low in the decade and a half that followed.

Finally, while the rate or quantity of infrastructure investment is undeniably an important factor, the efficiency with which countries invested also matters. The authors estimated how efficiently countries in the region invested in infrastructure using the method of data envelopment analysis. Data envelopment analysis allows one to examine how efficiently inputs are converted into outputs. In this case, the inputs consist of how much countries invested in infrastructure over a five-decade period—the average infrastructure investment as a share of GDP in 1961–2010. And the output is measured by the quantity and quality of the country's infrastructure stock in 2010, as measured by the infrastructure index of Donaubauer et al. (2016).

As shown in Figure 1.8, economies such as Singapore; Hong Kong, China; and the ROK were very efficient in their investing, delivering good infrastructure with moderate levels of infrastructure investment. This is consistent with the observation in the previous section that the ROK's infrastructure investment was a relatively small share of GDP, but delivered a lot because it was well targeted toward priority projects.

IV. Differences in Public and Private Participation in Infrastructure

This section looks at cross-country and cross-sector differences in PPP in infrastructure investments. The public sector provides over 90% in overall infrastructure investment in Asia (ADB 2017a). Figure 1.9 shows that private participation varies across types of infrastructure. Telecommunication sees the largest private participation, as service provision is excludable and chargeable, which makes private provision feasible. Energy infrastructure has the next highest rate of private provision, as it is likewise excludable and chargeable. Even here, though, because of high initial investment costs and a

Figure 1.8: Investment Efficiency in Selected Developing Asian Economies

Note: Output efficiency scores are computed using variable returns-to-scale data envelopment analysis with average general government component of gross fixed capital formation from 1961 to 2010 as inputs and infrastructure index as outputs. The infrastructure index is based on a composite of transport, energy, and information and communication technology infrastructure from Donaubaauer et al. (2016), and is transformed monotonically to be on a 0–1 scale.

Sources: Authors' calculations based on Donaubaauer et al. (2016) and International Monetary Fund, Investment and Capital Stock dataset (2017).

desire of many governments to provide electricity at rates below cost recovery (for equity reasons), the public sector accounts for about 60% of energy infrastructure provision. Finally, transport infrastructure and water and sanitation are still predominantly provided by the public sector.

Figure 1.10 shows private participation for selected countries in developing Asia. Part of what drives differences in private participation across countries is government views toward PPPs. Private participation is highest in the Philippines and India, two countries that have historically been more open to using PPP modalities for infrastructure provision. In contrast, private participation is lowest in the PRC, where infrastructure investment has been government led in support of its economic development strategy.

PPI can also be greatly influenced by macroeconomic conditions. Table 1.1 shows PPI data from 1990 to 2016 by region. The adverse impact of the Asian financial crisis on private investment in infrastructure is evident for the East Asia and Pacific region—a World Bank country grouping that includes the Southeast Asian countries hit by the crisis.

Finance development also matters for private participation. The Philippines, India, and the ROK are among the nations in Asia that have

Figure 1.9: Public and Private Infrastructure Investment, by Income Group, 2011

Notes:

- Figures in brackets indicate investment levels in billion (in 2015 prices).
- Low to lower middle-income countries include Armenia, Bhutan, Cambodia, Indonesia, Kiribati, Mongolia, Nepal, Pakistan, Papua New Guinea, the Philippines, Sri Lanka, and Viet Nam. Upper middle- to high-income countries include Fiji, Georgia, Malaysia, and Maldives.

Sources: Country sources; Private Participation in Infrastructure database, World Bank; World Development Indicators, World Bank; and ADB estimates.

Figure 1.10: Infrastructure Investment in Selected Asian Countries, 2011–2015
Average

Notes: GFCF (GG) = general government component of gross fixed capital formation, PPI = Private Participation in Infrastructure; Infrastructure investment is the sum of public investment (International Monetary Fund data) and private infrastructure investment (World Bank data). Sources: International Monetary Fund Investment and Capital Stock dataset (2017); World Bank Private Participation in Infrastructure database (2018); World Development Indicators; and authors' estimates.

Table 1.1: Investment in Infrastructure Projects with Private Participation (\$ billion)

Region	1990–1998	1996	1997	1998	2011–2015	2015	2016
Latin America and the Caribbean	236.5	27.4	45.1	66.3	49.8	33.4	33.2
East Asia and the Pacific	147.2	31.5	37.6	9.5	16.7	17.3	24.8
South Asia	38.1	11.4	13.7	2.3	8.6	5.2	4.9
Sub-Saharan Africa	9.6	2.0	3.5	2.3	6.4	6.4	3.3
Middle East and North Africa	12.8	0.3	5.2	3.6	2.31	2.5	1.8
Europe and Central Asia	52.0	10.7	15.3	11.3	25.7	49.1	3.4

Sources: Roger (1999) and World Bank (2017).

conducive financial markets for PPPs that can provide local currency and longer-tenor loans to fund infrastructure projects. Not surprisingly, PPI is usually concentrated in profitable projects and may result in underprovision of connectivity to the hinterland, aggravating the sharp divide between rural and urban coverage within countries. Thus, many governments have made concerted efforts to provide infrastructure in rural areas, which has helped reduce poverty dramatically. Promotion of private financing for infrastructure might require “deal sweeteners” for financiers and builders in the form of land grants, concessional rights of way, and ancillary revenue opportunities (e.g., commercial property development for retail space leasing and sale of advertising space) to alleviate the dearth of cash flow in the initial years before the project becomes operational (Yoshino and Stillman 2018).

V. Asia's Future Infrastructure Needs and How to Meet Them

Authors' work, which was presented in ADB (2017a), provided updated estimates of Asia's infrastructure investment needs for 2016–2030, and these are summarized here. Table 1.2 shows that developing Asia needs to invest \$22.6 trillion (at 2015 prices) or equivalently \$1.5 trillion per year in infrastructure (5.1% of its regional GDP) from 2016 to 2030. This estimate increases to \$26 trillion or \$1.7 trillion per year (5.9% of regional GDP) when the baseline estimate is adjusted to take into consideration the implications of

Table 1.2: Estimated Infrastructure Investment Needs by Region, 45 Developing Member Countries, 2016–2030
(\$ billion in 2015 prices)

Region	Projected Annual GDP Growth	2030 United Nations Population Projection (billion)	2030 Projected GDP per Capita (2015 \$)	Baseline Estimates		Climate-Adjusted Estimates ^b			
				Investment Needs	Annual Average	Investment Needs as % of GDP	Investment Needs	Annual Average	Investment Needs as % of GDP
Central Asia ^a	3.1	0.096	6,202	492	33	6.8	565	38	7.8
East Asia	5.1	1.503	18,602	13,781	919	4.5	16,062	1,071	5.2
South Asia	6.5	2.059	3,446	5,477	365	7.6	6,347	423	8.8
Southeast Asia	5.1	0.723	7,040	2,759	184	5.0	3,147	210	5.7
The Pacific	3.1	0.014	2,889	42	2.8	8.2	46	3.1	9.1
Asia and the Pacific	5.3	4.396	9,277	22,551	1,503	5.1	26,166	1,744	5.9

Note:

^a Afghanistan and Pakistan are included in South Asia.

^b Climate-adjusted estimates include climate mitigation and climate proofing costs, but do not include other adaptation costs, especially those associated with sea level rise.

Sources: 2015 Revision of World Population Prospects, United Nations; and ADB estimates.

climate change adaptation and mitigation. East Asia (particularly the PRC) accounts for 61% of the required estimate reflecting its high share of regional GDP, population, and infrastructure stock.

Table 1.3 shows the breakdown of the overall infrastructure investment needs, by sector. Power and transport are the two largest sectors, accounting for 52% and 35%, respectively, of total infrastructure investments for the baseline projections; and 56% and 32%, respectively, of total climate-adjusted investments. Telecommunication and water and sanitation are relatively small, accounting for 9% and 3%, respectively, of total climate-adjusted investments. However, the figures for these two sectors by no means suggest they are less important for the economy or for overall welfare.

Climate mitigation costs are estimated at \$200 billion annually. These primarily come from the power sector, which is particularly important in controlling carbon emissions through investments in renewable energy, smart grids, and energy efficiency. The transport sector is also important for mitigating climate change through shifts from more carbon-intensive modes of travel (private cars) to less carbon-intensive modes (public transit and railways). However, over the longer term, these shifts in transport should be promoted by policy and regulations and are unlikely to incur additional costs over baseline transport estimates. Countries may need to invest more in railways, but less in highways; thus, aggregate investment can be even lower.

The costs of climate proofing, a subset of climate adaptation, are estimated at \$41 billion annually. Transport accounts for the majority of climate proofing investments—estimated at \$37 billion annually. Countries must ensure that their infrastructure is resilient to the projected impacts of climate change, as phenomena such as sea level rise and intensified extreme weather can damage infrastructure and affect its longevity and performance. This can be done by measures such as elevating road embankments, relocating upstream water intake and treatment works, and enhancing design and maintenance standards.

Focusing on 25 developing member countries (DMCs) and the 5-year period from 2016 to 2020, the gap between current and needed investment levels works out to \$330 billion (baseline) or \$460 billion (climate-adjusted) annually. Information from government budgets and the World Bank's PPI Project database for 25 DMCs with adequate data and covering 96% of the region's population suggest the region invested \$881 billion in infrastructure in 2015 (Table 1.4). This is well below the estimated \$1.2 trillion (baseline) or \$1.3 trillion (climate-adjusted) annual investment needs over the 5-year period from 2016 to 2020 for the 25 DMCs. The baseline infrastructure

Table 1.3: Estimated Infrastructure Investment Needs by Sector, 45 Developing Member Countries, 2016–2030 (\$ billion in 2015 prices)

Sectors	Baseline Estimates			Climate-Adjusted Estimates			Climate-Related Investments (annual)	
	Investment Needs	Annual Average	Share of Total	Investment Needs	Annual Average	Share of Total	Adaptation	Mitigation
Power	11,689	779	51.8	14,731	982	56.3	3	200
Transport	7,796	520	34.6	8,353	557	31.9	37	—
Telecommunication	2,279	152	10.1	2,279	152	8.7	—	—
Water and sanitation	787	52	3.5	802	53	3.1	1	—
Total	22,551	1,503	100	26,166	1,744	100.0	41	200

Note: — = data not available.

Source: ADB (2017a).

Table 1.4: Estimated Infrastructure Investment Needs and Gaps, 25 Developing Member Countries, 2016–2020
(\$ billion in 2015 prices)

	Estimated Current Investment (2015)	Baseline Estimates			Climate-Adjusted Estimates		
		Annual Needs	Gap	Gap (% of GDP)	Annual Needs	Gap	Gap (% of GDP)
Total (25)	881	1,211	330	1.7	1,340	459	2.4
Total without PRC (24)	195	457	262	4.3	503	308	5.0
Selected Central Asia countries (3)	6	11	5	2.3	12	7	3.1
Selected South Asia countries (8)	134	294	160	4.7	329	195	5.7
Selected Southeast Asia countries (7)	55	147	92	3.8	157	102	4.1
Selected Pacific countries (5)	1	2	1	6.2	2	2	6.9
India	118	230	112	4.1	261	144	5.3
Indonesia	23	70	47	4.7	74	51	5.1
PRC	686	753	68	0.5	837	151	1.2

Notes: GDP = gross domestic product, PRC = People's Republic of China;

1. Numbers in parentheses refer to the number of selected countries.

2. The gap as a percent of gross domestic product is based on the annual average of projected gross domestic product from 2016 to 2020.

3. The 25 DMCs covered here are: Afghanistan; Armenia; Bangladesh; Bhutan; Cambodia; PRC; Fiji; India; Indonesia; Kazakhstan; Kiribati; Kyrgyz Republic; Malaysia; Maldives; Marshall Islands; Federated States of Micronesia; Mongolia; Myanmar; Nepal; Pakistan; Papua New Guinea; Philippines; Sri Lanka; Thailand; and Viet Nam.

Sources: ADB (2017a); country sources; Investment and Capital Stock Dataset, 1960–2015, International Monetary Fund; Private Participation in Infrastructure Database, World Bank; World Bank (2015a, 2015b); World Development Indicators; World Bank; and ADB estimates.

investment gap is around \$330 billion, equivalent to 1.7% of projected GDP of the 25 DMCs. If climate-related needs are included, the gap is around \$459 billion, or 2.4 % of the projected GDP.

These aggregate figures mask wide variations in infrastructure investment gaps across the region. The PRC has a gap of 1.2% of GDP using climate-adjusted estimates. Without the PRC, the gap in the climate-adjusted scenario as a share of the remaining economies' GDP is much higher at 5%. In general, lower-income economies tend to have larger gaps. Thus, the South Asia climate-adjusted gap is 5.7% of projected GDP—or 1.6% points higher than that of more developed Southeast Asia. But factors other than income levels are also at work, such as the prospects for economic growth.

The gap should be filled by both public and private sectors. Public finance reforms could generate additional revenues estimated to bridge around 40% of the gap (or 2% of GDP) for the 24 economies (excluding the PRC) in the climate-adjusted scenario. For the private sector to fill in the remaining gap (or 3% of GDP), it would have to increase investments from about \$63 billion today to as high as \$250 billion a year over 2016–2020.

Governments in many DMCs can increase public investment in infrastructure by raising more revenues, reorienting spending, and through prudent borrowing. Policymakers must evaluate how much fiscal space is available to increase infrastructure investment under various options for reforming public finance. Many countries in developing Asia can increase revenues through tax reform (including improving tax administration). There is also scope to reorient budget expenditures toward public investment by cutting energy subsidies, for example, and by borrowing prudently while keeping debt levels manageable.

Innovative approaches exist to expand government funds available for financing infrastructure development. Given that increases in private infrastructure finance of the amounts needed will likely increase gradually, innovative ways to bolster government finance for infrastructure will be needed. For example, these include using “land value capture” to finance infrastructure, or capital recycling (selling brownfield assets and auctioning concessions, and allocating proceeds to finance greenfield infrastructure). At the same time, other actions, like setting user charges for infrastructure services with greater regard to cost recovery will also help.

Private investments are particularly important in telecommunication and power generation. In telecommunication, around 49% of investments have been made by the private sector in low to lower middle-income countries, while it is much higher for upper middle-income countries, at around 99%.

For the power sector, the private share of investment averaged around 40% for both sets of DMCs. Especially in the subsector of power generation, independent power producers play an important role in some countries. Private finance in the transport and water supply and sanitation sectors tends to be far more limited. However, there are subsectors in transport and water where relatively high feasibility and desirability of cost recovery make private financing possible. Examples include airports, seaports, toll roads, and some types of water supply and treatment facilities.

Public finance reforms are estimated to cover a little less than half of the infrastructure gap, implying that private finance for infrastructure will have to increase dramatically. This is best seen by examining data for selected DMCs. Public finance reforms can create extra fiscal space in many countries—increasing public infrastructure financing from the current \$133 billion to \$254 billion annually for the selected DMCs as a whole, an increment equivalent to 2% of projected GDP (Figure 1.11, first and third bars from the left in both panels). With current private financing at around \$63 billion (second bar from the left in both panels), an additional \$141 billion–\$187 billion annually will be needed from private sources, depending on whether climate-related costs are included or not. This is equivalent to 3.0% of future GDP.

Figure 1.11: Meeting the Investment Gaps: Selected ADB Developing Member Countries,^a 2016–2020

Notes:

^aCountries include Afghanistan, Armenia, Bangladesh, Bhutan, Cambodia, Fiji, India, Indonesia, Kazakhstan, Kiribati, the Kyrgyz Republic, Malaysia, Maldives, the Marshall Islands, the Federated States of Micronesia, Mongolia, Myanmar, Nepal, Pakistan, Papua New Guinea, the Philippines, Sri Lanka, Thailand, and Viet Nam.

Future public investments are based on the 50% fiscal space assumption. Numbers in brackets indicate investments as a percentage of gross domestic product. Numbers may not sum precisely because of rounding.

Source: ADB (2017a).

As described in greater detail in ADB (2017a), an enabling environment that delivers well-prepared, viable proposals for private investment is critical for PPPs. PPPs are an important modality for attracting private investment in infrastructure. However, to meet their potential, they need to be structured within a regulatory and institutional environment conducive to private investment and better project preparation capabilities that generate a robust pipeline of bankable PPP projects. Many countries are moving in this direction. For example, recent PPP reforms involve enacting PPP laws, streamlining procurement and bidding processes, using PPP tool kits, introducing dispute resolution mechanisms, building capacity for planning and managing projects, and establishing independent PPP government units.

Deepening bond markets is also critical to attract long-term institutional investors. While banks will remain important finance vehicles, increased capital requirements (like Basel III) and the inherent maturity mismatch related to long-term project lending implies bond financing must assume a greater role to complement banks. Credit enhancement through bond guarantees can allow long-term contractual investors like pension and insurance funds to invest in infrastructure bonds. More generally, to promote deeper and more liquid bond markets, countries need to introduce reforms such as strengthening bankruptcy laws and credit rating agencies.

A well-functioning, multistakeholder institutional “ecosystem” for infrastructure development is essential (Figure 1.12). Close coordination across government levels—national, provincial, and local—is essential for infrastructure development. Also required is the capacity for high-quality planning and project design, feasibility studies and project implementation to get projects done on time and within budget. This “ecosystem” not only helps ensure that public investments in infrastructure are efficient but it also helps attract private investment by creating a pipeline of “bankable” projects.

VI. Conclusion

This chapter documented the evolution of Asia’s infrastructure over the past five decades, the factors that shaped it, and the role it played in supporting development. A country’s level of development influenced, and was also influenced, by its infrastructure provision. Other important factors included colonial legacies, and the effects of war and internal conflict. The rate of infrastructure investment varied substantially across countries and over time, being influenced by politics and policy, as well as by macroeconomic conditions and events such as financial crises. And countries also differed in

Figure 1.12: An Ecosystem for Planning and Implementing Infrastructure Projects

Notes: CBO = community-based organization; NGO = nongovernment organization; PPP = public-private partnership; SPV = special purpose vehicle.
Source: ADB staff conceptualization.

how efficiently they invested in infrastructure. PPI also varied across countries and sectors, reflecting country preferences and objectives, levels of finance development, and differences in financial attractiveness.

Finally, the chapter looks forward at Asia's infrastructure investment needs to 2030. These investment needs are large, especially when one takes into account climate change adaptation and mitigation, and they outpace the actual levels of infrastructure investment in many countries in the region. The challenge now is how to address this gap between investment needs and actual investment. The following chapters explore possible solutions to this challenge.

References

- Acemoglu, D., S. Johnson, and J. Robinson. 2001. The Colonial Origins of Comparative Development: An Empirical Investigation. *American Economic Review*. 91(5). pp. 1369–1401.
- Acemoglu, D., S. Johnson, and J. Robinson. 2004. Institutions, Volatility, and Crises. In T. Ito and A. Rose, eds. *Growth and Productivity in East Asia*. Chicago: University of Chicago Press.
- ADB. 2017a. *Meeting Asia's Infrastructure Needs*. Manila.
- ADB. 2017b. *Asian Development Outlook 2017: Transcending the Middle-Income Challenge*. Manila.
- Collier, P., V.L. Elliot, H. Hegre, A. Hoeffler, M. Reynal-Querol, and N. Sambanis. 2003. *Breaking the Conflict Trap: Civil War and Development Policy*. Washington, DC: World Bank.
- Donaldson, D. 2018. Railroads of the Raj: Estimating the Impact of Transportation Infrastructure. *American Economic Review*. 108(4–5): pp. 899–934.
- Donaubauer, J., B. Meyer, and P. Nunnenkamp. 2016. A New Global Index of Infrastructure: Construction, Rankings and Applications. *The World Economy*. 39(2). pp. 236–259.
- Energy Information Agency. 2014. *Total Installed Capacity Data*. Washington, DC.
- Feenstra, R.C., R. Inklaar, and M.P. Timmer. 2015. The Next Generation of the Penn World Table. *American Economic Review*. 105(10). pp. 3150–3182. www.ggd.net/pwt.
- Government of India, Ministry of Road Transport and Highways. 2015. Basic Road Statistics of India 2013–14 and 2014–15. New Delhi. <http://www.morth.nic.in/showfile.asp?lid=2445&key=basic%20road%20statistics&n=1> (accessed 24 May 2018).
- International Monetary Fund. 2017. *Investment and Capital Stock Dataset 1960–2015*. Washington, DC. <https://www.imf.org/external/np/fad/publicinvestment/data/data122216.xlsx> (accessed 24 May 2018).
- International Road Federation. 2016. *World Road Statistics 2016*. Geneva.
- International Telecommunications Union. 2016. World Telecommunications/ICT Indicators Database 2016. <https://www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx>.

- Jeon, C. 2010. A Road to Modernization and Unification: The Construction of the Gyeongbu Highway in South Korea. *Technology and Culture*. 51(1) (January). pp. 55–79.
- Miguel, E. and G. Roland. 2011. The Long-Run Impact of Bombing Viet Nam. *Journal of Development Economics*. 96(1). pp. 1–15.
- North, D. 1981. *Structure and Change in Economic History*. New York: W.W. Norton & Company.
- Roger, N. 1999. Recent Trends in Private Participation in Infrastructure. *Public Policy for the Private Sector*. Note No. 196. Finance, Private Sector, and Infrastructure Network: World Bank.
- Schwartz, J., S. Hahn, and I. Bannon. 2004. *The Private Sector's Role in the Provision of Infrastructure in Post-Conflict Countries*. Public-Private Infrastructure Advisory Facility. Washington, DC: World Bank.
- Schwartz, J. and P. Halkyard. 2006. Postconflict Infrastructure: Trends in Aid and Investment Flows. *Viewpoint Series*. Note No. 305. Washington, DC: World Bank Group, Private Sector Development Vice Presidency.
- United Nations. 2015. *Revision of World Population Prospects*. New York. <https://esa.un.org/unpd/wpp/> (accessed 1 December 2016).
- World Bank. 1993. *The East Asian Miracle*. New York: Oxford University Press.
- World Bank. 2015a. *Technical Note: Estimating Infrastructure Investment and Capital Stock in Indonesia*. Jakarta.
- World Bank. 2015b. High Expectations. *Indonesia Economic Quarterly*. Jakarta. <http://www.indonesia-investments.com/upload.documents/World-Bank-Indonesia-Economic-Quarterly-March-2015-Indonesia-Investment.pdf>.
- World Bank. 2017. *2016 Private Participation in Infrastructure (PPI): Annual Update*. Washington, DC.
- World Bank. 2018. World Development Indicators. Washington DC. <http://data.worldbank.org/indicator> (accessed 24 May 2018).
- Yoshino, N. and G. Stillman. 2018. Back to the Future: Instructive Features from Past Innovations in Raising Private Finance for Infrastructure. In N. Yoshino, M. Helble, and U. Abidhadjaev, eds. *Financing Infrastructure in Asia: Capturing Impacts and New Sources*. Tokyo: ADBI.